

The Road Rally Handbook

**Digital
Edition**

The Complete Guide to Competing in
Time-Speed-Distance Road Rallies



Clint Goss



The Road Rally Handbook – Digital Edition

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Time-Speed-Distance Road Rallies***

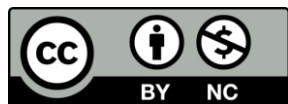
Clint Goss

Publisher



**6 Fieldcrest Road
Westport, CT 06880**

The Road Rally Handbook: The Complete Guide to Competing in Time-Speed-Distance Road Rallies



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The print edition of this book was produced in 1993 and printed on Windows-based and Sun Microsystem systems using Ventura Publisher on an HP Laserjet III with PacificData's Postscript cartridges. Most of the text in the book was set using fonts developed by Hermann Zapf. It took 3 years to produce.

This digital edition of this book was developed from the original text and images in June 2020 on a Windows system running at 1,000 times the speed, with 500,000 times the main memory, and 1,000,000 times the disk space as the 1993 system on which the First Edition was produced. The fonts are my own open-source Kurinto fonts. It took 3 weeks to produce.

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Preface

*Outside of a dog, this book should be
the rallyist's best friend.
Inside a dog, it's too dark to see anyway.*

— with apologies to Groucho Marx

This book was begun the day we ran our first Road Rally. Really!

Because we did not understand the basic term “Transit Zone” on this first event, we made some spectacular blunders (as told in the **There We Were** story at the start of Chapter 1).

That evening, after we understood our blunders, I scribbled a note to myself: *Rally Book – Transit Zones*. This note eventually took residence with the hundred other notes I had accumulated on various lifetime projects that I would someday undertake. On every rally, I would scribble more notes and add them to the pile.

Then, several cultural and socio-economic factors conspired against me and forced me to actually begin the book. First, the company for which I was working went belly-up, giving me ample time between jobs. Second, although there were many excellent books on the topic, most were out of print or outdated enough so that a fresh

look was called for. But, most important, there was a large contingent of rallyists who had done a number of events and were becoming adept at the basics of the sport, but did not know where to go next. Their results would plateau and the prospect of devising a navigation system and selecting a competitive class after running Novice for a year was daunting.

So, this book is written not as a how-to-rally, but primarily as a how-to-do-better in rallying. We begin with an introduction to the sport and how to get into your first event. Then, the book follows with a series of chapters on topics that are roughly in the order we became interested in them over the years. Some of the later topics are fairly esoteric. It might seem incredible to a novice that anyone could be concerned that their tires are heating up at a slower rate than those of the car which measured the course. But, five years later when you're trying to break out of a four-way tie for first place on a National Rally, these things suddenly become very important!

This book is suitable for a wide range of rallyists, from beginners looking to get into their first event, to the teams interested in getting out of Novice class, and as a reference for experienced teams.

Now for a couple of caveats: First of all, I am a navigator (I drove a rally once, but this is the last you will hear of *that* endeavor!). As such, this book has a Navigator's view of the sport.

The second caveat is that this book is out of date, or at least is bound to be by the time you read it. The sport moves rather quickly, both because of creative rallymasters and the advances in available technology.

Finally, much of my rally experience has dealt with events run in the Northeast US. Many of the conventions and customs described have a Northeastern flavor, which may differ in some ways from events put on in other areas.

A large number of people helped this book happen. My thanks go to the following people for providing advice and information on various areas in this book: Roger Barr, John Buffum, Bill Caloccia, Fred Cochran, Andy English, Mark Evangelista, Jim Friedman, Mike Friedman, Bill Hall, Dave Hannum, Dave Head, Stu Helfer, Gene Henderson, Jerry Hines, Mark Lees, Max Logan, Ian MacLennan, Bob Morseburg, Matt Murray, Steve Novatne, Benny Pollak, Ed Rachner, Bob Radford, Bob Ricker, Peter Stevens, Loyal Truesdale, Kerry Voll, Richard Welty, and Steve Zoeller.

Each of the chapters of this book underwent technical proofing by people who are “specialists” in that area. In addition to providing extensive information, these people spent a tremendous amount of time scrutinizing and re-scrutinizing the details of

each chapter (earning the title of “Official Checkers”), or, in some cases, proofreading the entire book: Bob Benson, Barb Ciesla, Tom Ciesla, Jack Christensen, John Driver, Karin Driver, Glenn Folsom, Mary Beth Folsom, Marc Goldfarb, Deb Golen, Ric Golen, Marie Goss (mom), Rich Kamo, Pego Mack, Steve Miller, Jim Mirrieles, Dave Nolan, Jan Smola, Vera Shanov, Bill Shrader, Herb Suessenbach, Victor Stankiewicz, W. David Teter, Christopher Yates, and Dennis Yates.

Jonathan Reduker drew the illustration on the cover. Jonathan, Bob Benson, and Jack Christensen assisted me in the art of book design, which was done entirely on PC-based systems, using Ventura Publisher and Corel Draw under Microsoft Windows 3.1. My thanks also for the superb fonts of Hermann Zapf and their fine digital rendering by Bitstream and Adobe. Masters of the text and cover were printed on an Hewlett-Packard Laserjet III with Postscript cartridges by Pacific Data Products.

This book is printed on acid free, 50% recycled paper. It is bound using the RepKover[®] lay-flat binding system developed by Otabind International. You can open this book to any page, run a finger down the spine, and the pages of the book will lay flat with no damage to the spine.

Finally, in the greatest tradition of book authors, I wish to thank my wife, Vera, for encouraging this effort and driving me to write this book.

— Clint Goss, March 1993

Preface to the Digital Edition

After printing 4,600 copies of the book over the last 27 years, we decided to go digital and release the book under a permissive open-source license.

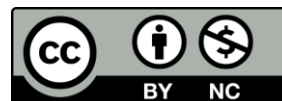
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Most of the text was directly from the original 1993 edition, typeset in Microsoft Word using my open-source Kurinto fonts (www.Kurinto.com). Many of the line-art images were from the original Corel version 2 design files, imported through Corel versions 6, 10, and 13 into Corel version 18, exported in Postscript, and imported as line art into Word. Some of the images which could not be imported or recreated were scanned from the best available source material.

As noted in the colophon, this edition was produced in 1/50th the time of the 1993 edition, on a machine with 1,000 times the speed, 500,000 times the memory, and 1,000,000 the disk space. Of course, the text still describes 1993 rally technology ... your mileage may vary!

— Clint Goss, January 2020



About this Book

The Road Rally Handbook is divided into seven parts. This first part is designed to help you get started in the sport. The next part is designed for teams competing in Novice Class and should be read as you are running your first five or ten events. Part III concentrates on specialized rally equipment and Part IV carries out detailed discussions on staying on time in each of the advanced classes. Parts V and VI go into two specialties within the sport, performance rallies and trap rallies. Finally, Part VII provides a reference on where to obtain rally equipment, a list of organizations, and a list of other rally publications.

Advertisement

All the formulas used throughout this book as well as the important tables and other information relevant to rally navigation have been collected into the “companion” publication, *TSD Road Rally Pocket Reference*, available from the publisher.

Throughout this book you will find a thread of **There We Were** stories to enlighten, amuse, and otherwise punctuate the text. And while every effort has been taken to ensure the factual correctness of the dry portions of the text, **There We Were** stories subscribe to a slightly looser set of rules

we'll call “poetic license”. In some cases (where noted), the story did not even happen to us, but was relayed to us by another rallyist subscribing to similar rules of “poetic license”.

Finally, please remember that the idea of this sport is to get out and run these events, not read about them. This book will not teach you all about rallying any more that a book on swimming will keep a non-swimmer afloat. So, if you read more than the first two chapters before your first rally, you will certainly lose out on the fun of discovering this sport.

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Disclaimers and Cautions

This book discusses a form of competitive motorsport, usually undertaken on public roads in street-legal vehicles. This book does not, in any manner, suggest or imply that you should, at any time, violate any law or operate any vehicle in an unsafe manner.

Selection, installation, and adjustment of Road Rally equipment in vehicles are also outlined. These procedures are meant for people qualified to perform this type of electrical and mechanical work. If you are not qualified in these areas, engage a person who is qualified to perform or oversee the work. Failure to do this can result in serious injury. Injuries have been caused by:

- failure to use approved vehicle supports under a raised vehicle. Bricks, tire

changing jacks, lumber, cinder blocks, and wheel rims are neither approved nor safe.

- improperly epoxied components (such as magnets) flying off wheels when they are being dynamically balanced.
- improperly installed equipment dislodging or otherwise presenting an additional hazard during an accident.
- improperly located equipment interfering with vehicle safety or control features such as air bags, seat belts, wheel alignment, or steering systems.
- improper electrical installations causing shorts and fires.
- selection of inappropriate tires or suspension components for road conditions or inappropriate modifications to tires for the given conditions.
- installation of equipment that blocks the driver's view.
- installation or adjustment of external lighting that blinds other drivers.

This book shows many current-production items available for the sport. They are shown for the purpose of informing readers of the models and features which are generally available. I do not review, evaluate, or recommend any particular model. Please contact manufacturers and distributors of this equipment for exact features and specifications and talk to other competitors and enthusiasts for recommendations on selection.

Throughout this book, I have used graphic line art to show electronic units and other rally-related equipment, rather than

photographic representations. I feel that this gives a clearer representation of the equipment than would otherwise be possible. However, the graphic may not show all the detail of a particular unit.

Printing

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Clinton F. Goss

Vera Shanov

Part 1 – Getting Started



What is a Road Rally?

There We Were on our first road rally. We had traveled 300 miles the day before on the strength of an event flier and a whim. The rallymasters¹ were kind enough to give us an impromptu class on rally basics and we were off. We set out on the rally course not caring that it was a heavily trapped championship event. The whole idea seemed rather grand as dozens of cars criss-crossed our path, each convinced that they were following the course correctly.

Things wore a bit thin when we found ourselves on an interstate at 25 mph – we had not understood one of the basic rally terms and decided to ignore it in our written route instructions. As it turned out, our delay on the highway almost exactly canceled a “trap” that lurked in the course, and we got a near perfect score for that portion of the event. The Blind Luck Rally Team was born!

The finish of the event featured a lobster bake and hours of **“There We Were”** stories from other competitors. We found out where we had gone wrong and, just as often, where we had followed the course correctly for the wrong reason! When the results were announced, we landed in the middle of the Novice class and actually walked away with a small trophy.

Before this rally, neither of us had imagined we would ever compete in an automotive event. Sure, we kept our somewhat sporty cruiser in reasonably good shape. We enjoyed long weekend drives. Occasionally, on a clear summer evening, we drove the long way home from work so we could take some scenic or interesting roads. But compete? Us?

Yet, after one TSD Road Rally, we were hooked on the sport. Why?

Our rather limited concept of motor sports had mostly been developed for us by the media. It consisted totally of track or off-road racing. And the message was clear: highly trained drivers in high-priced machines taking high risks for high stakes.

¹ Howard and Patti Mikkelsen

TSD Rallying was very different from our concept of motor sports. Each car was given a set of written instructions and sent off at intervals on public roads. Each team tried to follow the course as well as maintain a given average speed, which was always legal. Sprinkled around the course were checkpoints where our arrival time was clocked. We were given a score based on how close we came to arriving perfectly “on time”.

For a nominal entry fee and almost no risk to car, life, or limb we got to drive the most scenic roads in the area and compete on the basis of precision driving and navigation. We were a team on an adventure designed by an experienced rallymaster. We were a team competing not based on the amount of muscle in our car, but on the sharpness of our minds and driving skill. But most of all, we had fun – from the people and places to the competition and sense of discovery.

Types of Road Rallies

Beyond this broad description of our first Road Rally lies a whole range of events to suit every kind of rallyist. But the basic idea of most Road Rallies is the same: each competing team, consisting of a driver and a navigator, is given a set of written instructions which are used to follow a pre-determined course. Each team drives the course independently, usually at one minute intervals, following the written instructions, or **route instructions**, exactly.

The events range from the Sunday afternoon Gimmick Rally, usually run by a car club

which maps out a scenic route ending at a restaurant or a picnic, through the highly competitive Pro Rallies, run at high speeds over roads closed to the general public. This book concentrates on the most prevalent and popular events which fall in the middle of this range: Time-Speed-Distance (TSD) Road Rallies in which the route instructions have assigned speeds and teams are scored based on their ability to maintain these speeds precisely over public roads.

Gimmick Rallies

The first event many teams enter is often some type of **Gimmick Rally**. These events are not scored on any speed factor, but on some special Gimmick Rule defined by the organizers.

Many Gimmick rallies have no checkpoints. You are scored based on information you find on the course. One long-standing annual event in the Northeast has teams count turkey-shaped signs placed along the course. If you see the correct number of signs, you found the entire correct course. A bit more involved format, called **Course Marker Rallies**, is used on the West Coast. The rallymaster places signs along the intended route – some signs have information which you copy onto your scorecard (for scoring) and others have course-following information. The markers you copy on your scorecard distinguish among teams who unravel the gimmicks.

Another Gimmick format, the **shortest-distance rally**, challenges competitors to visit various locations while traveling the fewest miles. The team usually has to

answer some question at each location to prove that they actually visited each spot (*“What year was the church on the corner of Main and Elm dedicated?”*)

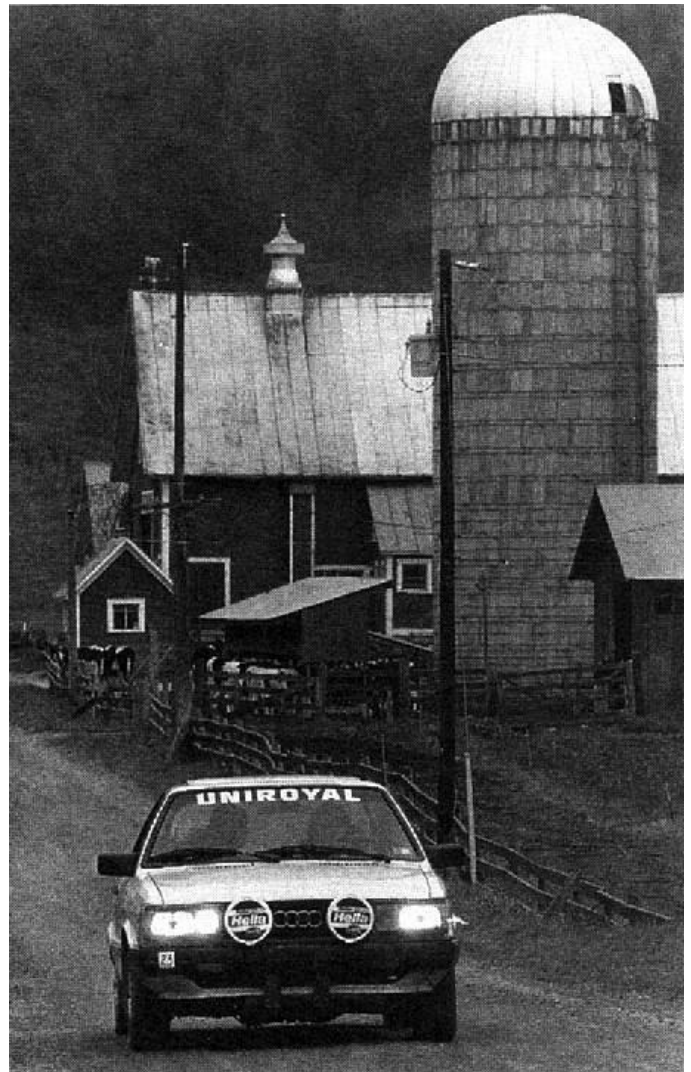
Still another format, called the **economy run**, seems to pop up whenever there is a gas crunch. Teams attempt to drive the course while getting the best gas mileage. Scoring for one past event factored in the weight of the vehicle in order to equalize the advantage of smaller cars. The team which took this event ran in a gargantuan cement truck – and described their vehicle on the entry form as a “Sport Mixer”. They did poorly on miles-per-gallon but easily won based on ton-miles-per-gallon.

Gimmick Rallies can be great fun and are ideal for first-time teams or competitors who run once or twice a year. However, few rallyists make a career out of Gimmick Rallies. Because of their nature, there is often an element of luck and a lack of preciseness in these events which makes a team's results somewhat a matter of chance.

Pro Rallies

At the other end of the competitive scale from Gimmick Rallies is a class of events which is a form of racing. The route is described by route instructions, but there are sections of the course, known as **special stages**, where you drive closed roads at maximum speed. Your score is based primarily on your speed on these Special Stages.

Naturally, you cannot jump into a Pro Rally in your stock family cruiser. However, by



racing standards, Pro Rally is inexpensive and a very accessible form of racing. The driver and navigator are required to have a helmet and (usually) a fire suit and you can run the cruiser with a roll cage, fire extinguisher, competition seat belts, and other safety equipment installed.

This form of Rallying is generally what you hear about when people talk about European Rallying, Stage Rallies, or Safari Rallies.

TSD

In a Time-Speed-Distance Rally, the Route Instructions, in addition to information to keep a team on course, also give assigned

speeds. These speeds are always legal, and often are below the posted speed limit. A TSD rally is a competition of precision driving – it is not a race!

The goal of a rally team is twofold: to stay on the prescribed course and to drive at exactly the given speed. The perfect team would be on course, on time at any given point along the route. To score teams against this goal, **checkpoints** are sprinkled throughout the course at unspecified locations. Each team is timed by a crew at the checkpoint (also called the **control**) and their time is compared against a **perfect time** (computed from the assigned speeds and exact distances measured before the event). Each team receives a score based on its time for that portion, or leg, of the course. For each fraction of a minute early or **late**, the team is given points. The team with the lowest total score for all the legs wins. However, each leg is independent: time late or early on one leg cannot be “made up” on subsequent legs. After being timed by a checkpoint crew and receiving a score, the team is assigned an out time to begin driving the next leg.

A variation on the TSD theme is called a **regularity run**. In this event, the team is free to select any speed within a given range. Teams run the same course multiple times with the checkpoints being hidden the first time around. On second and subsequent runs of the course, the team must match its times exactly to the first run.

Why Rally?

TSD rallies have become popular in North America because of the many people who enjoy driving. Most TSD rallies have a Novice Class designed for first-time competitors. The other classes, which allow varying amounts of rally equipment, provide keen competition for experienced rallyists. Many top competitors today began in Novice Class with no more than a speedometer of questionable accuracy, a wristwatch, and a hazy understanding of rally basics.

For the driver, there is the opportunity to use a skill which most people spend years developing, but which few ever get to hone or test. But, unlike other motor sports, the skill does not involve outright car performance. More muscle does not necessarily help, so there are no artificial factors of performance to plague the rules of rallying. In fact, the rules which define the rally classes tend to be quite simple and provide a level playing field for competition.

Another thing which sets TSD rallying apart from other sports is its unique team aspect. In no other sport does a pair of people need to work so closely together, yet do fundamentally different things. Of course, when a team first starts rallying, both driver and navigator are simply concentrating on staying on course. Beginning teams do the timing by feel or some very simple calculations. But as a team gains experience, the driver and navigator begin to take on specific tasks.

As the team's coordination continues to improve, so do its results. After a while, the team graduates to more difficult events where the course challenges them to their limits, not because of outright speed, but because of the frequency and difficulty of instructions, traps, or density of speed changes and timing problems. It is these events that can give a team a deep sense of satisfaction.

For all competitors, a rally provides a day, weekend, or week get-away, driving a course that often makes use of the most scenic roads of the area, and is usually followed by a social event to round out the weekend. Some say that a road rally is merely an excuse for a party!

The Car

So you want to do a rally but cannot bring yourself to drive the family cruiser in anything close to a competitive event. Why?

My car is too slow. Almost any car can keep up the average speeds of most rallies. If the event features brisk speeds or is advertised as a performance rally, you should not consider running it as a first event.

I have to drive to work on Monday and I might break it. Not likely, if you go by past history. The fact that (organizer) insurance for these events is relatively inexpensive shows that competitors tend to be quite safe while competing in most TSD events. Consider how alert a team is on a rally compared with driving the same-old-route-home-after-work. In terms of doing

mechanical damage to your car, remember that these events don't involve speed driving, but rather precision driving.

It's too ugly. Don't let your car hear that or it might start giving you mechanical trouble!

In fact, people rally in almost every conceivable form of automobile, with notable extremes including the “biscuit-tin” sized Mini-Cooper, a “stretch” Porsche Targa elongated to the size of a limousine, and a fire truck built in 1912. The car is only the tool to get you on the adventure, and if you happen to jump into the sport driving something less than “sporty”, it will only make for a better story when you become a well-known rallyist.

2. Your First Rally

Don't get lost!

— Queen Isabella
to Christopher Columbus
in a private conversation,
Friday, August 3, 1492

In order to enter a rally, you first have to find a rally. If you know anyone involved in a car club or motor sport competition of any kind, start by talking to them. If not, check the yellow pages for car clubs in your area or look in a newspaper that gives a calendar of upcoming events. Also try some of the clubs and organizations listed in Appendix A.

Finally, you can get in touch with the Rally Board Chairperson for your region of the Sports Car Club of America. The SCCA is a national organization with an extensive Rally program run on a national, divisional, and regional basis. Call the national office (see Appendix A) to get your Chairperson's name and number. That person will provide you with a list of the Regional Rallies being presented that year and will be able to put you in contact with a local club which organizes smaller-scale Club Rallies.

Selecting an Event

There are many types of TSD rallies and it is important to pick an appropriate event for your first time out. The majority of rallies are straightforward events with Route Instructions that are easy to follow and a course of 60 to 150 miles. However, a portion of the rally schedule each year is given to endurance events – generally over 200 miles and often run at night. Also on the schedule are trap events, in which the course following aspect is deliberately tricky and based on a precise reading of the rule book. While most endurance and trap rallies have a Novice Class, they are not ideal for first-time rallyists.

As a first-time competitor, you should look for a straightforward rally which lists a Novice Class. Often, there is a special Novice school the evening before or day of the event to go over some rally basics. It is also a good idea to choose a club or regional level rally, rather than a divisional or national. Even if a larger scale rally lists a Novice Class, the course was probably designed to challenge more experienced teams in some way.

So, if the event flier contains any of the words *National*, *Trapped*, *Night*, *Endurance*, or *Pro*, it is best to pass that one up for your first event. If that flier has all those words, call me – I want to spectate that one!

What You Need to Rally

Once you have found a suitable event, see if you can pre-register by mail. You often get a discount on the entry fee and you can get some of the paperwork done in advance. If the rally is held away from your home, you may decide to make reservations at nearby accommodations.

If you pre-register, you may receive a document known as the **general instructions** by mail before the event. The general instructions, or **generals**, give you more information about the event than the original flier or application. They describe how to get to the start, detail the format of and define any special terms used in the Route Instructions, define any special scoring rules, etc; it helps to read these over before the morning of the event. When you arrive at the start, all you need to do is pick up any extra registration materials not sent by mail.

Some rallies have a safety or **tech inspection** prior to the start. Cars are required to be registered, in generally safe condition, and the driver must have a license and insurance². Usually the tech crew will check head lights, brake lights,

signal lights, brakes, tire tread, wipers, horn, etc., and ensure that your assigned car number is properly displayed on the car. Some tech crews check that nothing has been added to windows, lights, or mirrors that might cause a driving hazard (such as stickers).

The tech crew will also check that your car has no equipment which violates the limitations of the class in which you are running. In most areas, Novice Class teams are limited to using only the stock odometer and speedometer, and probably a calculator. Clocks and watches are always allowed. What is typically disallowed are precision odometer or rally computers. Some cars are equipped with trip computers which can show your average speed. If these are disallowed, you will need to tape over their display.

Aside from being safe, your car should have a working speedometer and odometer. (The odometer is the instrument which reads how many miles you have gone.) Many recent cars have a trip odometer which is a separate odometer that can be reset to zero by pushing or turning a small knob or button. This feature is helpful because mileage on rally instructions start at zero.

The remainder of this book assumes that your car has a trip odometer. If it does not, you will have to use your main car odometer and, when told to zero your odometer, simply have the Navigator write

² Some areas require a specific minimum level of insurance coverage.

down the current reading on the main odometer. Then, whenever a mileage reading is needed, the Navigator will need to subtract out this initial mileage reading. While this sounds like a major hassle, there are really very few times when a first-time rallyist needs to take a mileage reading.

Other items you may find useful on your first event:

- A properly inflated spare tire. Nothing is worse than getting a flat in the back woods, opening the trunk, and discovering a deflated spare.
- A full tank of fuel. Your gas mileage will be much worse on a rally than on any other type of normal driving.
- A wrist watch, preferably a digital one which reads in seconds. You should know how to set it, so practice this at home.
- A simple calculator. One with a large display and large keys would be nice, but anything will do since you are likely to be using it only a few times. All it needs are the basic four functions. Stay away from the solar powered ones.
- A clipboard. This helps you stay organized and gives you a good writing surface in the car. Besides, a clipboard is a symbol of a “real” navigator.
- Pencils and two or three different color highlighters for marking important items in the route instructions.
- Masking tape. The paint on some cars can be damaged by the adhesive backing on any car number or other stickers to be placed on your car.

- Food and drink. Some people tend to get hungry frequently on rallies, so you might want to pack a few snacks and re-closable drinks in a small cooler jammed behind your seat. In longer events, you might want to pack something which can substitute for lunch if you find that you don't have enough time at the designated lunch break for a sit-down meal.
- Maps. Many teams carry a book of maps that covers the area where they usually rally. A map can help you find the finish if you get hopelessly lost or the event is somehow interrupted (e.g. a bridge is out). However, you should not try to use the map to plot out the course from the route instructions – this would be far too confusing.

One item you do not need: Rally Computers. You may have seen some of the sophisticated rally computers of advanced teams. You may think you need one to run a rally. Forget it. These units assume a solid understanding of the mathematics of rally navigation (timekeeping). Your goal for your first event will be just to stay on course and a rally computer will not help in that area. Besides, having a computer will probably make you ineligible to run in Novice Class.

Your First Rally

Every region, every club, and every rallymaster has their own idea of how a TSD rally should be staged. There are numerous formats for writing route instructions to describe the course, dozens of ways to score

an event, and countless lists of special terminology which can be used in route instructions. Any attempt in this book to describe exactly what to expect on your first event is guaranteed to lead you astray.

The good news is that, if you set aside the differences in the way courses are described, most TSD events are conceptually the same. So, the rest of this chapter talks about the basic rally concepts and touches only lightly on the areas of the sport which tend to change between events or regions.

Who Should Drive?

This issue comes up soon after you decide on your first event. With some teams, it remains an issue for their entire rally career.

For your first event, it is better to ask yourself the question *Who should navigate?* Then let the other person drive. The navigator should be the person who is more comfortable with numbers – the one who balances the checkbook every month and who didn't go to summer school to get through high school algebra.

If the choice is still not obvious, then simply swap roles half way through the event (swapping after every leg is probably too disorienting). After you get some experience, you may decide who navigates based on the type of event (e.g. trap rallies vs. performance or endurance events). Some teams swap roles every year. You will also

gain an appreciation for the role of your partner.

The Generals and The Regs

Sometime before the start, either the week before or on the morning of the event, you will get the general instructions and, possibly, a set of rules which I will call **The Regs**. Both of these, together, define the rules under which the event will run. While the rallymasters and the club running the event have undoubtedly put great effort into these documents, possibly refining The Regs over years of rallying, they are largely of little use to the first-timer³. If you flip through them, you will see numerous definitions, description of what tire pressure was used in the car that measured the course, and the correct format for submitting protests (you, as a first-timer, will not be submitting protests).

So what are the general instructions good for? They can give you the answers to a few questions before you start your first rally:

When do I start? As you will see later, cars leave the start at defined intervals based on what car number they have been assigned. Usually, the interval is one minute. The general instructions will tell you when the first car leaves and you can figure your start time from that.

What do the route instructions look like?

The written instructions that describe the

³ Because they attract large novice fields, some clubs have gone to a simple one-page format for their General Instructions and Regs when putting on local events. These

generally avoid the problems of more complete sets of rules for first-time competitors and should be read reasonably carefully.

course can be done in any number of formats. We will look at two popular ones in a couple of pages. Whatever the format, you should understand how to follow the course based on them.

Where should I drive if I cannot execute a route instruction? The route instructions usually don't describe every intersection on the course. Instead, there is always some underlying rule, such as:

If you cannot execute a route instruction at an intersection, proceed Straight as Possible.

or

... proceed on the obvious extension of the road you are on based on yellow centerline road markings or curved arrow signs.

What is the maximum distance between route instructions? To keep teams from getting very lost if they miss a turn, some rallies specify a maximum distance between any two consecutive route instructions. If you go more than the maximum distance without finding the next instruction, you have missed something!

What special terms do I need to know to complete the rally? The generals or Regs usually have a glossary of terms which are used in the route instructions. It is a good idea to read through the glossary several times – not to memorize the precise definitions but to become familiar with the particular shorthand used. If you forget the meaning of a particular abbreviation, the

navigator can always look it up as you are running the event.

What types of roads can be used during the rally? Many events limit the roads a rallyist can consider when looking to execute an instruction. For example, the general instructions might say:

A rally road is public, paved, and legal to enter.

If you are on the course and looking to take your next left, you can pass up any unpaved roads, roads marked “Private drive”, and ones which are “One Way” in the wrong direction. As far as rallyists are concerned, these roads simply don't exist for this event.

What do I do at a checkpoint? Checkpoint operation varies greatly from event to event. The general instructions or Regs should describe



checkpoint procedures. In some rallies, you simply get timed as you pass a checkpoint sign and you keep going. Some events require you to stop shortly after the checkpoint and walk your scorecard back to the crew or pull up at a table set up on the side of the road after a timing line. In one event we ran, there was no checkpoint procedure at all – the checkpoints and their crews were so well hidden that we usually did not know when we had passed one!

What do I need to do with my scorecard? If you get a scorecard and can decipher how to score yourself at each checkpoint, great.

However, it is better for your first event not to worry about scoring and just do the minimum required to complete the event. This often consists simply of handing your scorecard to each crew at each checkpoint and reading the time they give you to start the next leg.

As mentioned, some organizers hold a rally school or novice seminar before the start. If you are fortunate enough to have one of these at your first event, you can probably get away with skimming the Regs and general instructions. However, if there is no school, it is a good idea to answer as many of the above questions as possible by reading the Regs and general instructions before arriving at the event.

Before the Start

If you have driven a significant distance to the start, remember to top off your fuel tank.

It is a good idea to get to the start at least an hour before your start time. This gives you time to register and look over your route instructions. You will probably be unfamiliar with some of the terms in the route instructions. Look them up in the general instructions and, if you're still confused, ask a more experienced competitor.

Getting to the start early also saves you from a fate such as happened to a late-arriving team at one of our recent events. They saw the example route instructions placed on a blackboard during a first-timer's class and

copied them onto their route instructions as corrections. They never did find any checkpoints that day, arriving at the finish with a perfect maximum score.

You will be given some kind of car number to put on your car to identify you to checkpoint crews along the route. Find out where the organizers expect you to place it on your car and, if you are concerned about the paint in that location, use masking tape to secure the number and then remove it immediately after the event.

Don't forget to set your watch. The organizers should provide a master clock at registration or at the starting point of the event so that competitors may precisely set their clocks.

After these things, you can sit down with the route instructions and read them over. The idea is to make sure you understand all the instructions and any special terms. If you're unsure about something, flip through the general instructions and/or the Regs to try to find it. If you are still unsure, ask a rally official or another competitor. But remember that they are probably hard pressed for time – they either are working on the route instructions themselves or have some function to perform on the course, so their answers will be much more brief than if you asked the question earlier or the evening before!

Finally, before you head out on the course and at every break you get during the event: Use the rest room facilities!

The Route

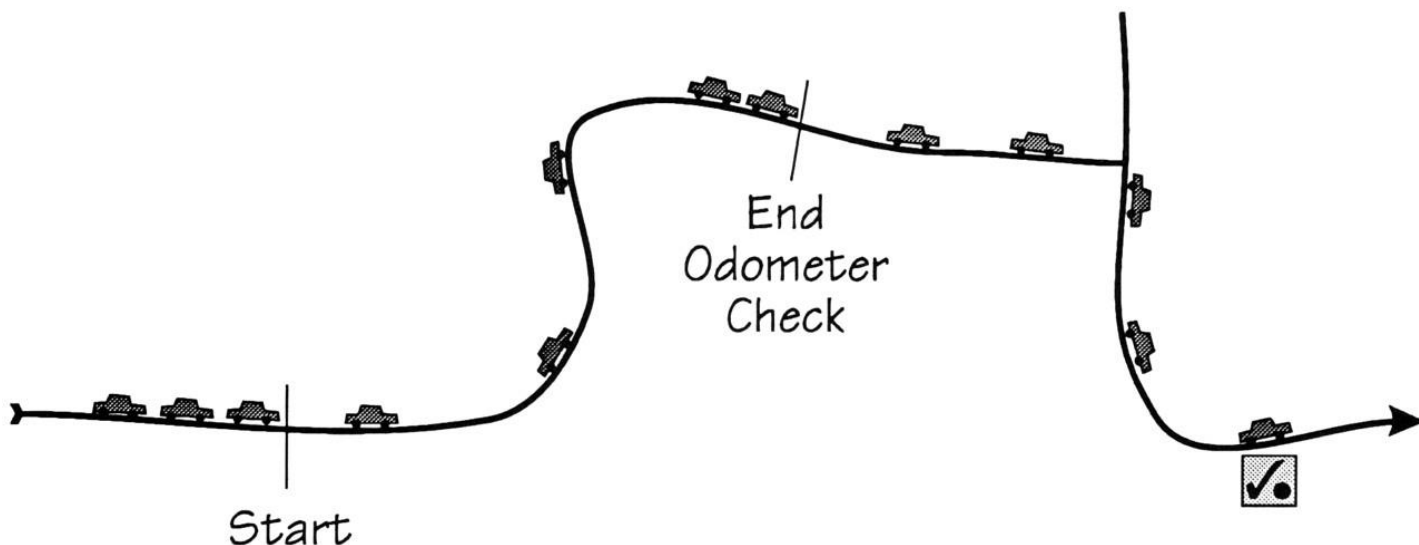
To get an idea of how a TSD rally works, imagine you are in a helicopter hovering over the course as the event is being run. As the departure time for the first car approaches, cars begin leaving the start at one minute intervals, but typically travel at no assigned speed for the distance of the odometer check. The odometer check is often designated as a **transit zone**, which is done for a number of reasons. First of all, the start of the event is often a congested area and it would be unfair and unsafe to ask teams to maintain an assigned average speed through town or in a congested area. Furthermore, the odometer check gives teams a chance to see how closely their odometer matches the mileage readings taken by the car which measured the course.

The teams are usually given a specific period of time to cover the odometer check, and this is usually more than ample time to cover the distance comfortably. From your helicopter vantage point you see the cars

bunch up at the end of this odometer check, awaiting the transit time to run out.

And now the real rally starts. The cars leave the end of the odometer check exactly at one minute intervals, in car number order. Each travels exactly at the assigned speed, so that (theoretically) each car maintains an even time interval from the car in front and the car behind. As the first car executes some instructions, its assigned speed changes, but so does the speed of each succeeding car in turn. The distance changes between the cars depending on the assigned speed, but the spacing is always a minute.

At several points along the course, checkpoints are located along the side of the road, identified by some sort of checkpoint sign. Several people are waiting for the competitors to arrive. As each car passes these checkpoints, they are timed very precisely using special rally clocks. Depending on the format for the rally, cars either pull over just past each checkpoint or continue on with the route.



Route Instructions

There are many ways to describe the course to the competitors, and each has its merits for different types of events. We could not begin to describe every format of route instruction, or detail the nuances of each.

We will just show you a sample of two

from the last time you zeroed your odometer. Mileages in the second column (in *italics* in this sample) are called **delta mileages** or, in some rallies, **incremental mileages**. These give a distance from the previous instruction to that instruction.

Aside from the special terminology in

The Rally of Oz			Page 1 of 6
Mile	Delta	Instruction	
0.00		1. Begin Rally at "The Kansas Inn" (at exit from parking lot). Leave at 10:00.00 plus your car number in minutes. Zero your odometer. Begin odometer check. Begin Transit Zone of 30.00 minutes. Left.	
1.83		2. Right onto Scarecrow Road.	
3.43		3. "Caution - Tornado area" (road may become unpaved).	
	2.14	4. Straight at signalized intersection.	
8.10		5. End odometer check at "Oz Town Line". End Transit Zone. CAS 30.	
	0.85	6. Left at island ("Dorothy"). CAS 36.	
		7. Right after "C & V Rallye Shoppe". Pause 50.	
12.82	2.60	8. Right at T. CAS 32.	

popular formats to give you an idea of what course following is all about.

The first format is simply called **text route instructions**, and below is a sample of this format from some mythical rally:

In this format, you have mileages in the first two columns followed by **Numbered Route Instructions** (NRIs). Mileages in the first column are **overall mileages** – a distance

from the last time you zeroed your odometer. Mileages in the second column (in *italics* in this sample) are called **delta mileages** or, in some rallies, **incremental mileages**. These give a distance from the previous instruction to that instruction.

Another popular format for route instructions is called **tulips**. The name comes from the Tulip Rally in Holland which first pioneered this format. The

following is a rendition of the same rally shown above, but described by tulip diagrams.

A tulip gives you an overhead view of an intersection or place to execute an instruction. You enter the tulip from the bulb (usually at the bottom of the tulip) and exit the tulip at the arrow. An ✕ is often used to mark the location of a sign, with the text of the sign given in the last column. Dashed lines may be used for unpaved, as in NRI 3.

Which format is better? That depends on the type of rally you are running. Events that run at night or which have brisk speeds often use tulip instructions because it is easier to identify an intersection by its shape rather than to hunt for a quoted sign under these conditions.

Whichever format is used, there are two important things to do in your first rally when you execute an instruction:

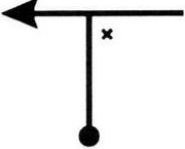
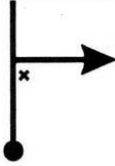
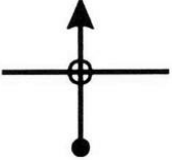
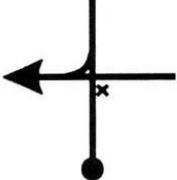
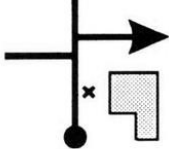
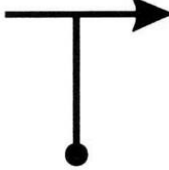
- The navigator writes down the time when you execute an instruction. This shows you what instructions you have already executed and will help later if you go off course. Just the minutes and seconds are enough. If you miss noting the time, at least check the instruction off so you don't lose your place in the route instructions.
- Immediately read the next instruction. Successive NRIs can come up very quickly (as little as one inch under some rules). It is unnerving to realize that you might have missed the next instruction while you were congratulating yourselves about how

well you executed the last instruction! Some teams like to keep aware of the next two instructions. However, if you do this, you must make sure that you don't skip an instruction. All NRIs must be executed in order and each must be fully completed before going on to the next. If you decide to read ahead, it is very easy to skip instructions.

Mileages and the Odometer Check

Some route instructions may reference overall or official mileages. These are the mileages measured by a very precise odometer in the car which set up the course. But, just because the rallymaster's odometer is precise does not mean it will agree with the odometer in your car.

That is what the ***odometer check*** is for – to give competitors a chance to compare their odometer with the rallymaster's. So what should a first-time team do with the odometer check? Simply drive the distance and, at the end, compare your odometer with the official mileage. If your odometer is reading higher or lower, it will continue to do so, by about the same percentage, for the rest of the event.

NRI	OM	Delta	Tulip	Timing	Other Information
1	0.00			Begin Transit 30.00 min	"The Kansas Inn"
2	1.83				"Scarecrow Road"
3	3.43				"Caution - Tornado Area"
4		2.14			Signalized Intersection
5	8.10	0.85		End Transit CAS 30	End odometer check at "Oz Town Line"
6				CAS 36	"Dorothy"
7				Pause 50	"C & V Rallye Shoppe"
8	12.82	2.60		CAS 32	

If you are adept with a calculator and have the time at the end of the odometer check, the navigator can come up with a **correction factor**. Simply divide the mileage shown on your car odometer by the official mileage:

Of course, if you should happen to take a wrong turn between the end of the odometer check and NRI 8, and then get back on course, your odometer can no longer be used in this way. Another fine reason to stay on course!

Formula 1. **Correction Factor**

$$\frac{\text{Car Mileage}}{\text{Official Mileage}} \rightarrow \text{Correction Factor}$$

As you can see in our sample Rally of Oz, the odometer check has an officially measured distance of 8.10 miles. Say your odometer reads about halfway between 8.4 and 8.5 at the end of the of the odometer check. You can **interpolate** between the two numbers to approximate the hundredths and get a mileage of 8.45 (this is discussed more in [Chapter 6](#)). Then $\frac{8.45}{8.10} \rightarrow$ yields a correction factor of 1.043 (or 4.3%).

This correction factor can be used to convert all the official mileages in the route instructions to a corresponding mileage as

Aside from relating the official miles to your car miles, the correction factor gives you some information about running on time. The rallymaster uses the official miles to calculate when you should arrive at each checkpoint. The variation between your car miles and official miles is one of the issues that will make you arrive early or late. A simple rule many people use is that if your miles read longer than official miles, you will arrive late; if your miles read shorter, you will arrive too soon (early).

Long = Late Short = Soon

Formula 2. **Converting Seconds ⇔ Cents**

$$\text{seconds} \times 1.666667 \rightarrow \text{cents}$$

$$\text{cents} \times 0.60 \rightarrow \text{seconds}$$

measured by your car. Simply multiply each official mileage by your correction factor. So, you can expect NRI 8 to come up at about $12.82 \times 1.043 \rightarrow 13.37$ on the car odometer.

In our example above, you can think of your car odometer as reading about 4.3% longer than official miles. You will tend to arrive late (from this particular issue) by about 4.3%.

Speeds and Timing

Minutes in most road rallies are not divided into 60 seconds, but into 100 hundredths-of-a-minute or **cents**. A time period of 25 means $\frac{25}{100}$ of a minute, or one-quarter of a minute, or 15 seconds.

Why do rallyists time in decimal parts of a minute (cents) rather than seconds? Since there are more cents in a minute than seconds, timing in cents gives added precision to calculations and timing at

checkpoints. Also, when the navigator is doing timing calculations, it is far easier to add and subtract minutes and cents than to keep carrying and borrowing 60s when doing math on minutes and seconds. Throughout the remainder of this book, I will use the term “cents” to mean hundredths of a minute.

Because rally timing is done in cents, one of the most convenient items to have for a rally team is a clock that reads in minutes and

Cents → Seconds							
Cents	Seconds	Cents	Seconds	Cents	Seconds	Cents	Seconds
1	0.6	31	18.6	61	36.6	91	54.6
2	1.2	32	19.2	62	37.2	92	55.2
3	1.8	33	19.8	63	37.8	93	55.8
4	2.4	34	20.4	64	38.4	94	56.4
5	3.0	35	21.0	65	39.0	95	57.0
6	3.6	36	21.6	66	39.6	96	57.6
7	4.2	37	22.2	67	40.2	97	58.2
8	4.8	38	22.8	68	40.8	98	58.8
9	5.4	39	23.4	69	41.4	99	59.4
10	6.0	40	24.0	70	42.0	100	60.0
11	6.6	41	24.6	71	42.6	101	60.6
12	7.2	42	25.2	72	43.2	102	61.2
13	7.8	43	25.8	73	43.8	103	61.8
14	8.4	44	26.4	74	44.4	104	62.4
15	9.0	45	27.0	75	45.0	105	63.0
16	9.6	46	27.6	76	45.6	106	63.6
17	10.2	47	28.2	77	46.2	107	64.2
18	10.8	48	28.8	78	46.8	108	64.8
19	11.4	49	29.4	79	47.4	109	65.4
20	12.0	50	30.0	80	48.0	110	66.0
21	12.6	51	30.6	81	48.6	111	66.6
22	13.2	52	31.2	82	49.2	112	67.2
23	13.8	53	31.8	83	49.8	113	67.8
24	14.4	54	32.4	84	50.4	114	68.4
25	15.0	55	33.0	85	51.0	115	69.0
26	15.6	56	33.6	86	51.6	116	69.6
27	16.2	57	34.2	87	52.2	117	70.2
28	16.8	58	34.8	88	52.8	118	70.8
29	17.4	59	35.4	89	53.4	119	71.4
30	18.0	60	36.0	90	54.0	120	72.0

Table 2-1

Seconds → Cents					
Seconds	Cents	Seconds	Cents	Seconds	Cents
1	1.66	21	35.00	41	68.33
2	3.33	22	36.66	42	70.00
3	5.00	23	38.33	43	71.66
4	6.66	24	40.00	44	73.33
5	8.33	25	41.66	45	75.00
6	10.00	26	43.33	46	76.66
7	11.66	27	45.00	47	78.33
8	13.33	28	46.66	48	80.00
9	15.00	29	48.33	49	81.66
10	16.66	30	50.00	50	83.33
11	18.33	31	51.66	51	85.00
12	20.00	32	53.33	52	86.66
13	21.66	33	55.00	53	88.33
14	23.33	34	56.66	54	90.00
15	25.00	35	58.33	55	91.66
16	26.66	36	60.00	56	93.33
17	28.33	37	61.66	57	95.00
18	30.00	38	63.33	58	96.66
19	31.66	39	65.00	59	98.33
20	33.33	40	66.66	60	100.00

Table 2-2

cents rather than minutes and seconds. Such a clock is called a **decimal clock** or hundredths-reading clock. Unless you have one of the specialized rally clocks you will have to convert all times given in the route instructions and elsewhere from cents to seconds. You can either use the formula below or consult Tables 2-1 and 2-2.

To keep cars running on time, rallies use a mixture of transit zones and assigned speeds. Our Rally of Oz begins with a transit zone which ends at NRI 5 (note that the transit zone is also the odometer check). To run the transit zone, simply note your time at its beginning (in this case, the same time

as your start time for the rally) and follow the route instructions to the end of the transit zone. Add the time for the transit zone (30 minutes) to your start time and this gives you the time to leave the end of the transit zone.

8.10 **5. End odometer check at "Oz Town Line". End Transit Zone. CAS 30.**

Let's say you are car 17. You begin the rally at NRI 1 at 10:17.00 exactly. Adding the time for the transit zone means that you should leave the "Oz Town Line" sign in NRI 5 at exactly 10:47.00.

NRI 5 assigns you your first average speed, CAS 30. This means that, until told otherwise, you are to commence (or change to) an average speed of 30 mph.⁴ You might think that slavishly keeping the speedometer needle on 30 or using the cruise control would guarantee low scores. Unfortunately (or fortunately, depending on your viewpoint), rallying is not so simple. You may not be able to maintain 30 mph because of curves in the road. Also, unless explicitly noted, no time is allotted for slowing to cross or turn at intersections. Indeed, even though you must obey posted signs (e.g. come to a full stop at a stop sign), time is not always provided in the route instructions and the seconds/cents lost must be made up. Finally, just like your odometer readings must be corrected to agree with the rallymaster's odometer, your speedometer readings need to be corrected.

So how can a beginning team hope to stay on time? First, remember that the time you will lose if you get lost is far more than the error you accumulate in trying to maintain your average speed. So, first and foremost, stay on course. Other popular reminders:

Where before When

Better Late than Lost

Some beginning teams do well simply by adding a blanket 5% or 10% to each assigned speed for turns, curves, and speedometer correction. They travel at these

adjusted speeds whenever it is safe and does not exceed the speed limit.

**0.85 6. Left at island ("Dorothy").
CAS 36.**

**7. Right after "C & V Rallye
Shope". Pause 50.**

In NRI 6 you take a left and commence a new average speed of 36 mph. Then, instruction 7 takes you right and asks you to **Pause 50**. A **pause** is added by the rallymaster to give you time to complete an instruction that may be at a busy intersection or through a congested area. There may be a traffic light at the C & V Rallye Shoppe, or just the sheer volume of traffic entering and exiting this establishment may make any delay unreasonable or unsafe to make up over and above an average of 36 mph.

Pause 50 says to figure in a delay of half a minute (remember – timing is given in cents). A **Pause 100** indicates a full one minute delay.

This leaves us only to talk about how to actually execute NRI 7. As you begin to slow down for the turn, the navigator notes the time and adds 30 seconds. Then, after you make the turn, you should still have some time left before your restart. As you restart, begin accelerating smoothly up to your

⁴ Some areas use CAST for Change Average Speed To or BAS for Begin Average Speed.

speed. This method will keep you reasonably close to staying on time.

Checkpoints/Controls

After a while, you will encounter your first checkpoint. These are usually marked by a sign reading “✓•” with a crew located at or just past the sign. The sign identifies the checkpoint **timing line**. This marks the end of the first **leg** of the rally.

When you see a ✓• sign, remain calm.

Drive past the sign at your assigned CAS and then do whatever is called for in this event (keep going, pull up to the timing table, pull over and walk your scorecard back, etc.). Unless explicitly told otherwise, do not stop at the checkpoint timing line. Also, if the checkpoint crew is a distance from the timing line, never pull in between them and the timing line (thereby blocking their view).

If you are not supposed to stop at checkpoints, the route instructions will contain all the information you need to continue on to the next leg of the event.

If you are supposed to stop, the checkpoint crew will give you a record of your arrival time at that checkpoint and assign you a start time for the next leg. They will also give you a **checkpoint slip** with lots of information, most of which is not important to you as a first-timer. After you visit the



checkpoint crew and are back in your car, you should do the following:

- Note your starting time for the next leg (written on your scorecard or checkpoint slip) and pay attention to the following information on the checkpoint slip:
- Note what your assigned speed is for the start of the next leg.
- Note what instruction number you should be seeking to execute.
- Read any additional instructions which may be contained on the slip.
- Depart the restart point for the next leg about four seconds prior to your start time to give yourself adequate time to accelerate.

Be especially careful when opening your door to get out – other rally cars are entering and exiting the area. When you pull out after exchanging paperwork and getting a new start time, be very wary of cars trying to maintain CAS and entering the checkpoint area behind you. Also, never back up in the checkpoint area.

Doing Well

Your first rally can either be great fun or a big disappointment, depending mostly on your expectations. If you go out looking for a day of fun, a bit of adventure, and are prepared for some good-natured ribbing if you get lost, you will probably enjoy the event. Teams which see their first event as a test of driving skill or a race, or are looking for a high placing, often don't return to a second event.

So how do you know if you have done well? While scoring varies widely from event to event, there are a few standards which most rallies use:

- Scoring runs leg to leg. Time early or late at one checkpoint cannot be “made up” at another checkpoint.
- At most events, you get 1 point for each cent early or late at each checkpoint.
- Most rallies have a maximum score (a **max**) you can get on a leg. The cap is usually between two and five minutes (200 to 500 points).

A good goal for beginning teams is to try to stay on course for the day and not to max a leg. But if it takes a number of events to reach this goal, don't worry – we max'd at least one leg on every event we ran for the first year!⁵

In terms of how to do well on your first event, nothing can be stressed more than Queen Isabella's advice: *Don't get lost!*

Calculations should only be a supplement to the primary job of finding the turns. If you forget this, even years after running your first event, you may find yourself running perfectly on time on a rally course of your own design.

Rally Etiquette

Finally, a few notes on rally manners:

A rally is not a race! Calling it a race in public and treating it as such on the course can only hurt the sport.

Checkpoints are very congested. Keep alert for pedestrians when entering a checkpoint and, if necessary, sacrifice a couple of points if it means avoiding a person or another vehicle.

When rallymasters construct rally courses, they anticipate that you will cross the checkpoint timing line at the assigned CAS, so do not slow down or stop at the line. Drive past the line and pull off the road after a safe distance. You should give cars entering the timing line the right-of-way, even if you are due to leave as they are arriving.

If you feel that assigned CAS is too fast to be driven safely, then slow down. A CAS is an assigned average speed. Giving up a few points in the interest of safety makes common sense.

⁵ Requests for refunds on this book are no longer accepted after you read this sentence.

If another rally car wants to pass you, they will come up behind you, flash their lights, and briefly honk. This is not rude, but just a request to take care as they pass safely. Pull over and/or slow down where it is safe for them to pass. When overtaking another car, do not intimidate them or force your way. Also, spraying them with gravel as you blast past is not considered very friendly or wise.

Please treat local residents with consideration. Many rallies are run on roads which see little traffic. The sight of sixty cars in an hour on a road which would not normally see as much traffic in two days can be unsettling. Pass local residents with care, allow them to pass you when appropriate, and always wave *“Hello”* whenever you can. This especially applies to families “out for a walk”, with pets, or on horseback.

If you have a problem on the event, don't take it out on the workers. Don't take it out on the organizers, even if it is their fault. They put an incredible amount of effort into setting up and running the rally, and almost never get paid for their efforts. Going out of your way to express your appreciation for the good things that they have done will go a long way to assure that they will continue to put on events for you.

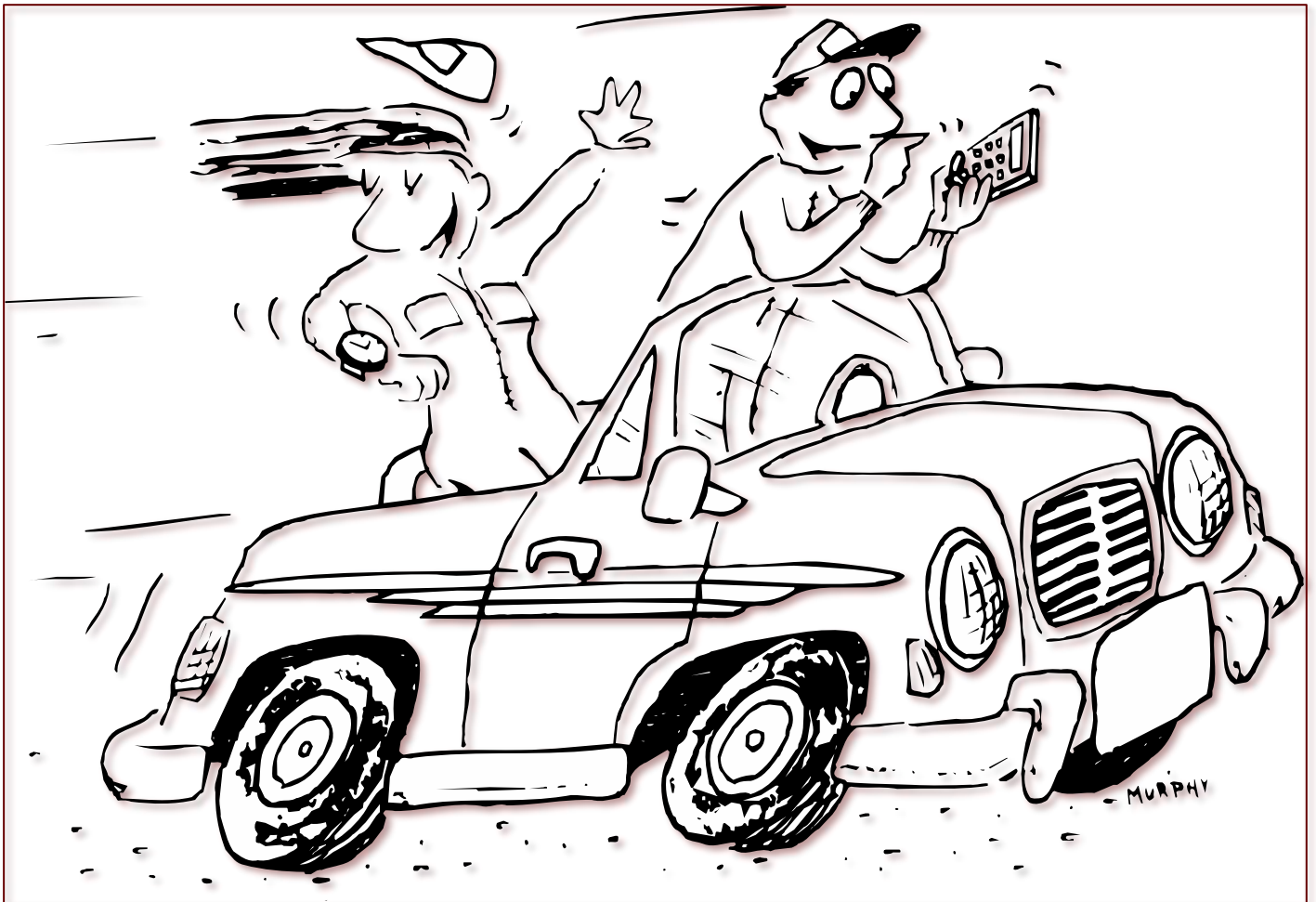
Most organizers construct rallies so that their friends can go out and have a good time. Yelling at the organizer tells them that you didn't have a good time. So why should they put the event on next year? Instead of

“You gallactically stupid piece of &\$?@@!**, don't you know LEFT from RIGHT?”

... why not try:

“It was a great event and gee, was that 'Left at T' supposed to be a 'Right', and, by the way, it was a great event”.

Part 2 – Running Novice Class



3. Novice Basics

Don't Panic!

— Douglas Adams,
The Hitchhiker's Guide to the Galaxy

Aside from learning to do the fundamental calculations, which will be described in detail in Chapters 4 and 5, the events you run in Novice Class are mostly spent learning some basic rally techniques and learning how to work together as a team. The latter is probably the most rewarding aspect of the sport.

This chapter offers suggestions on a number of diverse areas and sheds light on the problems you are likely to see in your first few events.

Common Confusions

Under most Regs, you are expected to execute an instruction, which contains no overall or delta mileage, at the first **opportunity**. Thus, instruction 118 instructs you to take your next available left.

	118.	Left.
2.43	119.	"Leaving Kansas".

Some instructions, such as NRI 119, have no action at all. They simply quote some sign that you are supposed to **observe** along the course. They confirm that you are on course and you can use them to compare your odometer against the official mileage.

Also, remember to execute each instruction in order, and to complete each instruction fully before going on to the next NRI. It is easy to skip instructions when you see a sign which is repeated three NRIs down the page. This problem becomes especially dangerous when you run an event through an area you know well. When the navigator gets the feeling that "I know where the rallymaster is taking us", an off-course is in the making. In these cases, ignore your instincts and just follow the route instructions.

Many teams have trouble with **multi-part route instructions**, such as

149.	Left onto Kumquat Lane, then right.

Forgetting to do the right will send you off course just as fast as missing any other instruction. The next section has some suggestions on how to avoid this problem.

Illustrating the Routes

Most civilized rallies give you some time between when you get the route instructions and your start time. This time is very important for all competitors, especially Novices.

This gives you a chance to partake in a ritual that some rallyists have raised to an art form: illustrating the routes.

It starts like this: you did great on your first rally, except that you missed a CAS change⁶ from 25 to 48 and max'd the leg. Solution: highlight all CAS changes so you will not miss them on this event. Then, on another event, the navigator forgot to note the time at the start of several Pause instructions. Highlight them as well, but in a different color to avoid confusion. Then you get the idea that it would make life easier if the range of route instructions which are in a transit zone (from the begin transit zone to the end transit zone) were also marked, so a bold highlight is used along the side of the route instructions in these areas. Finally, you almost won Novice Class in the last event, except that you missed the second half of a two-part instruction and wound up taking an off-course excursion into the next state! So, you busily scan the route instructions looking for any two-part NRIs and boldly highlight each one, in a different color, of course. You might try to establish a convention of yellow for “CAS”, pink for directional information, etc. From event to

event you will get accustomed to your own color code.

The end result is a work of art which may or may not be more helpful than the bland original. Try it for an event or two and see if your eyes become trained to the colors, or are they just another distraction.

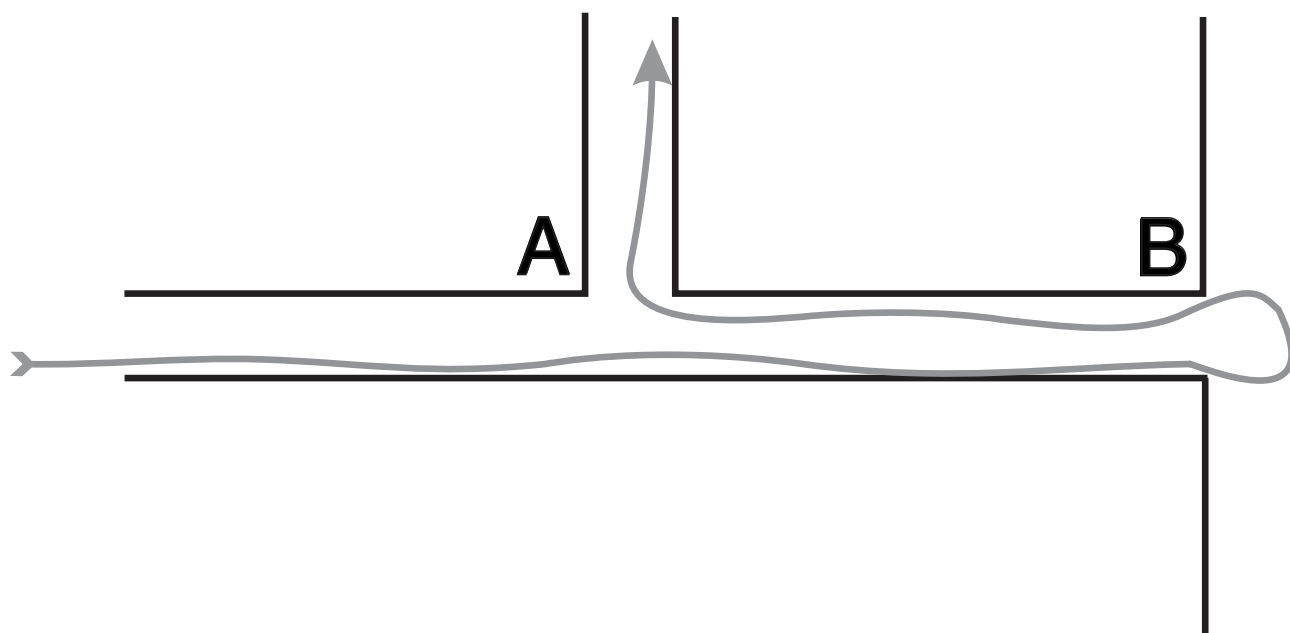
An additional aid is to know the distance between successive NRIs. If the route instructions have official mileages for two consecutive NRIs, be sure to subtract the first from the second to see if they are .25 or 2.57 miles apart! This helps prepare for a rapid sequence of instructions.

Time Allowances

Most rallies have some kind of **time allowance** rule. Time allowances, or TAs, are a way to handle a major lateness. However, they require that you know exactly how late you are. The idea is that you can declare where you were delayed and by how much. From that point to the next checkpoint or some other specified point (such as the lunch break), you stay late by exactly that amount.

Most rallies require you to take TAs on the half minute (e.g. 1½, 2½, 3½, ... minutes). Remember that, if everyone runs perfectly, there should be a car running exactly 1, 2, 3, ... minutes behind you. Taking a time allowance on a half minute should place you between two cars. When the organizers

⁶ This book extends the definition of “CAS” to include the meaning “Current Average Speed”. This allows us to use the term “CAS change”.



A typical off-course excursion

score the event, your declaration is taken into account and your times at any affected checkpoints are adjusted according to your TA request.

There is usually some penalty for taking a TA. Some rallies charge 25 or 50 points while others double your score up to some maximum penalty. (The latter is called a **disappearing TA penalty** – if you do well on the leg on which you took a TA under this system, you can still get a zero!) Because of this penalty, TAs are sometimes called **bought time**. But, regardless of the penalty, it is better than getting a certain max on the leg.

A common reason to take a TA is if you are unavoidably delayed, such as unusually heavy traffic as you wait to turn left onto a major road. In this case, simply note the length of the delay. If you are delayed a full minute and the first available increment for

taking a TA on the event is 1.50 minutes, simply wait half minute more and running late 1.50 minutes. Then declare your TA request to checkpoint crews or other officials at the next opportunity.

Another common reason to take a TA: You Are Lost.

You Are Lost usually becomes obvious when you get to an intersection at which you must have an instruction (such as a T) and the NRI on which you are working cannot be executed.

Panic ensues. The first instinct is to hang a U-turn and speed back down the road to find the course.

Bad move. Consider that you now need to find the turn you missed, but you are now approaching it from the wrong direction. This job is not made any easier by speeding.

In order to figure out how much time you were delayed, many teams write down the time when they execute each instruction. This allows them to drive back to a previous instruction and restart at exactly a known amount of time later.

However this does not always work. In the example below, you were supposed to turn left at **A**, but missed the turn and discovered your error at **B**.

To handle this situation, after you make the U-turn at **B**, write down the time as you start back. Then, travel back at the same speed you were driving before. When you discover where you went wrong, stop and note the time again.

Say you started back from **B** at 2:12.50 (2:12:30) and found **A** at 2:16.75 (2:16:45). It took 4.25 minutes to drive back, so you can assume that it also took 4.25 minutes to drive from **A** to **B**. Furthermore, assume it took 50 cents/30 seconds at **B** to scratch your head, decide you were lost, panic, and make the U-turn. So, when you get back to the intersection at **A**, you are running late by $4.25 + 4.25 + .50 \rightarrow 9.00$ minutes.

So, simply wait another 30 seconds/50 cents, until 2:17.25 (2:17:15), and continue rallying on course. Then, at the appropriate time, declare your 9½ minute TA request as per the Regs.

If you have no idea how long you were lost, chances are you will get a max score anyway, unless you declare some TA. In this situation, there is no harm in guessing “10½ TA” and hoping for a lucky break.

At some time in your rally career, you will forget to request your time allowance at the appropriate time. Every team seems to do this at least once. Try putting your TA on a Post-It and pasting it over your scorecard.

One final word on getting lost. When you go back and find your error, you often feel frustrated, angry, and convinced the event is over for you. It is easy to mentally give up and let your frustrations turn into max scores or more off-course excursions on the following legs.

But what if the route instructions actually had an error? The organizers might throw the leg! Or maybe the entire field is taking a similar unintended route, each taking a TA in turn. So, whenever possible, POR⁷, and you will someday be rewarded for your competitiveness.

Callbacks

Despite what you may think about rallymasters, their goal is not to get you lost (trap rallies notwithstanding). So, to keep you from winding up at the Restaurant at the End of the Universe if you miss an instruction, many rallies have a **callback** policy. Callbacks limit how far you can go

⁷ Press On Regardless, which is also the name of a famous rally in Michigan.

before finding the next NRI or the next checkpoint.

In one system, there is a maximum distance between two consecutive NRIs. If the limit is, for example, three miles, this rule is then called the **three-mile rule**. If the course contains two turns which are more than the limit, the rallymaster will intentionally insert an NRI between the two turns which just has you observe some sign along the course. This sign confirms that you are still on course and have not missed the second turn. An example of this type of confirmation instructions is NRI 3 on the Rally of Oz (Chapter 2), which requires that you simply observe a sign.

For competitors, this type of rule means that they should see the next instruction within the specified mileage from the last instruction. You could write down the car mileage as you execute each instruction, but this becomes tiresome after a while. It is far easier to write down the time you execute each instruction. Then, if you take too much time to find the next instruction, you have missed it. How much time? It depends on your speed. At CAS 30, it takes 6 minutes to cover 3 miles. At CAS 20, it takes 9 minutes. Some teams avoid calculating the exact time and just use 6 minutes for any CAS of 30 or over and 9 minutes for CAS assignments in the 20s.

Sometimes the general instructions tell you the maximum distance between checkpoints or the checkpoint slip tells you a maximum distance to the next checkpoint. Teams write down their mileage at each checkpoint and

use the maximum distance to determine if they go too far and miss a checkpoint.

Hacks

One question which seems to come up often is what to do when you see another rally car. There are very few roads where two on-time cars can catch sight of each other. Under some circumstances, seeing another car may be normal: a course which crosses itself, sends cars on the same section of road twice, or which sends cars in opposite directions down the same road.

Also, an unusually low CAS will cause successive cars to catch sight of each other. Remember, cars should be 1.00 minutes apart. At CAS 30, cars are a half mile apart. At CAS 15 they are only 0.25 mile apart!

Except for these situations, if you see another rally vehicle, one of you must be off course or off time.

When you do see another car, the question then becomes what to make of the situation. Do you trust that you are running on time and ignore them, or try to use their car to get yourself back on time? The latter is called a **hack** – the art of timing another car on the course and using their time in your calculations.

As a simple example, let's say that you are car 17 and you catch up to car 16, which you know is running a minute ahead of you. Furthermore, you know them to be a national-level rally team with rally computers on board, and you decide to trust

their calculations over your own (lack of) calculations. Simply note the time they pass a landmark or cross a shadow ahead of you. When you get to that point, stop. One minute after they got to that point, resume your speed and continue the rally.

Other situations require a bit more ingenuity. As a beginning rallyist, if car 18 catches you, and you sense that you have fallen behind, you might consider waiting 30 seconds and taking a 1½ minute time allowance. But, before you go ahead and blindly trust another team, consider that they might have messed up, or might, themselves, be running on a time allowance.

There We Were⁸ on a TSD event across Ontario Province, Canada. We were using a new rally computer of somewhat dubious design which fried itself on the morning of the event. Fortunately, the road crested a number of ridges and the terrain was tree-less, allowing us to catch sight of other cars as they crested each ridge. We were also fortunate to have a national-level competitor running one minute ahead of us, so we noted their time at each ridge and adjusted our speed to pass the ridge one minute later.

Unfortunately, their computer had also fried. They were looking back and using the same tactics with us!

After years of kicking ourselves when we made the wrong decision in taking a hack,

we finally settled on the following ***hack rule***: If you get any information which is in addition to the route instructions, such as sighting another car, simply let it be a flag that you might have goofed. Look back in the route instructions to see if you missed a speed change or a pause. If so, try to recover on your own. If that is not possible (e.g. you do not know where the speed change occurred) and you trust the other team, then take a hack. On the other hand, if you can find no reason why you should not be on time, regardless of who the other team is, then ignore them. Nothing is worse than discovering that you were right, but came in a minute off because you trusted another team who were themselves not running on time.

Some rallyists have a moral aversion to taking a hack. They feel that it goes against the basic concept of each car running the course independently. From our hack rule above, it is obvious that I feel a rally team can use any information they can obtain, within legal and ethical bounds.

Pre-registration

Note that all competitors don't necessarily have the same opportunity to take hacks. A novice team running the entire event between two teams competing in the computer class is far more likely to be able to make use of this technique than a novice team running among a pack of other slightly to way-off novices.

⁸ This story is from the rally chronicles of Fred Cochran and Dave Hannum, told to us one evening on the 1991

MG 1000, a 5-day, 1000 mile brisk TSD rally through New York, Pennsylvania, and Ontario.

This points out one of the advantages of pre-registering for an event. Sending in your entry form early increases your chances of running with the more experienced teams, since they tend to pre-register. Many organizers assign car numbers in the order that entries were received or assign car numbers by lottery to those cars pre-registered as of several weeks before the event.

Another major advantage of a low car number is that it gives you a cushion of time in case you have to take several TAs. If you are at the back of the field and take multiple TAs, you may be running so late that the checkpoint crews have packed up and gone!

Types of Checkpoints

Many rallyists and event organizers banter about terms which describe the various types of checkpoints. Although the terms are not completely standard, I give a list of descriptions here in the hope of standardizing their usage. The word **control** is also used interchangeably with checkpoint. You are usually told in the Regs or general instructions how to handle various checkpoints.

Open Checkpoint: A checkpoint where you stop well after the timing line and exchange information with the checkpoint crew. There may be a table you drive up to or you may have to park and walk back to the crew. It is less confusing if only one of you goes back to the timing crew. Don't forget to bring your scorecard if one was issued to you. Also, it is usually preferable that you

approach the timing car on the side that is farthest from the road – for obvious safety reasons.

Closed Checkpoint: A checkpoint where you do not stop.

Flying Checkpoint: Same as a closed checkpoint.

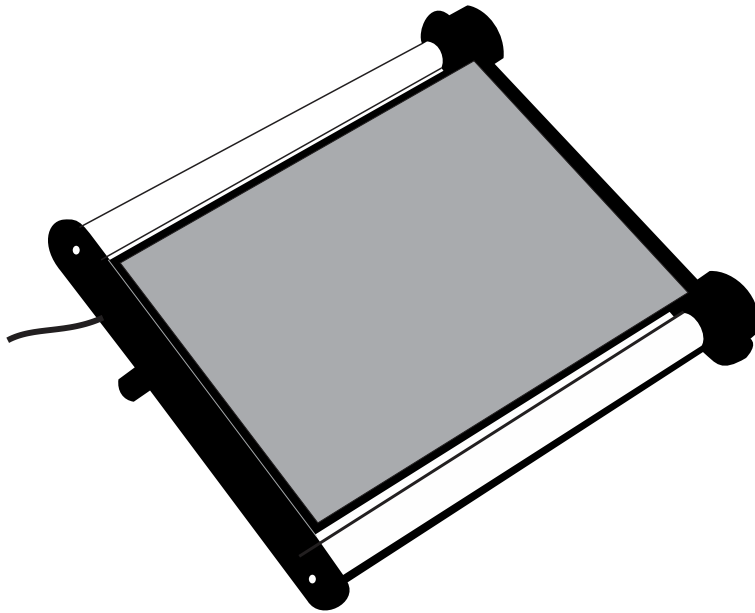
Monte Carlo Checkpoint: A closed checkpoint whose location and perfect time of arrival is given in the route instructions. These events are sometimes done as **map rallies** where you are given no explicit course, just the locations of the checkpoints and their arrival times.

Hidden Checkpoint: You don't know the location of these checkpoints as you pass them on the course.

Do-It-Yourself (DIY) Checkpoint: A checkpoint with no crew. You arrive at a point specified in the route instructions and record your own time on the scorecard. This may be your actual time of arrival or a time you calculate. You then assign yourself a start time for the next leg, as instructed in the route instructions or the general instructions.

Since DIY checkpoints are so different from regular manned checkpoints, a team's strategy can change for DIY legs. First, you don't need to report the time you actually arrived, but the time you calculate as the perfect arrival time. This is not cheating – it is standard practice. This means that, if you know you are on a DIY leg with no possibility for a manned checkpoint, you

don't have to run the leg at the speed specified in the route instructions. You can run at any speed and calculate based on a different speed. All you really need are the mileages at the speed changes to be able to calculate the perfect arrival times.



The Stevens Rally Reader

Second, a DIY leg is often followed by a leg with a manned checkpoint. If you have to take a time allowance on one of the two legs, use it on the leg where you think you will get a lower score (and adjust your DIY leg arrival time accordingly). If you have to take a time allowance on both legs, consolidate them into one leg. Never take a time allowance on both a DIY leg and a following leg with a manned control, unless you have exceeded the maximum time allowance on one of the legs.

Passage Checkpoint: Usually called a “passage control”. These are used on trap rallies to simply record the contestant's passage, but not the particular time they

arrived. Off-course loops sometimes have these checkpoints to assign penalty points to a team, or points may even be given for missing them.

This term is also used as a synonym for closed checkpoints.

Observation Checkpoint: Usually called an “observation control” or “obs control”. A checkpoint where the contestants are observed to ensure they are not violating any motor laws or rally rules. Usually, you do not stop at an “obs”.

Novice Equipment

Although the next part of this book goes into great detail on all manner of rally equipment, I mention two items in which many Novice teams invest early in their careers.

Is your navigator tired of reading every instruction to you (four times)? A dashboard-mounted **rally reader** allows the current instruction to be in view at all times by both teammates. Most designs use two rollers – the pages of the route instructions are taped end-to-end and wound onto the bottom roller. As each instruction is completed, one of you turns the upper roller and scrolls the next instruction into view. A window of several instructions can be viewed, with a line or marker to highlight the current instruction (very important). For night rallies, some front or back lighting is also needed. A rally reader is a great basement project to build, but you should

look at the design of some of the commercially available (and generally inexpensive) units.

If you don't have a rally reader, you can rig up a substitute with a clipboard and some suction cups to hold it to the dash or windshield. One inventive team⁹ used a flat board and taped each page of the route instructions with a single piece of tape, starting from the last page. The tape for each page was in a different position, so the driver could simply tear off each page as it was completed.

The other item you might buy, rent, or borrow is an inexpensive rally clock which displays minutes and hundredths/cents.



The Westbend model 40007 kitchen timer

Many of the older units such as the Zeron 66, Chronar T-100, or Zeron 80 are perfect for running Novice – their lack of features compared to current production clocks has made “pre-owned” units inexpensive. Even a model which cannot be frozen is fine – as

long as it can be set easily to the official time of day and does not drift excessively.

If a clock requires external power, you can hook it up to a cigarette lighter plug. While this setup will not be acceptable for more sophisticated equipment, it should be fine as long as:

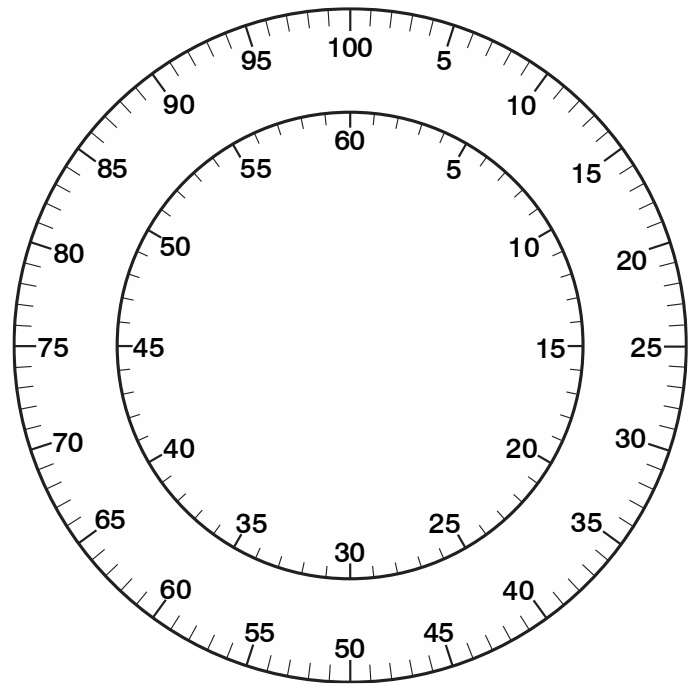
- you keep your wristwatch set as a backup,
- you make sure that the lighter is “hot” at all times, and
- the cigarette plug fits very snugly (you can add duct tape around the sides to help here)

An inexpensive alternative to a clock designed for rallying is a stopwatch designed for racing. Most run for months or years off a small battery. Some models have a mode which counts time of day in thousandths of a minute, which is better than seconds for rallyists. There is a model available through Edmund Scientific (see Appendix A) which stores 9 splits and retails for less than \$30. Other watches designed for race timing are available through Pegasus (also in Appendix A).

Another choice is a Westbend kitchen timer. The clock can be set to any time (in seconds) and counts down to zero when started. The clock shown has a single timer. Another model has three timers. These clocks are available from kitchen supply stores and are also listed in the Edmund Scientific catalogue.

⁹ Helen Smith and Linda Vargo in the 1992 Cape Codder’s Courageous, one of their first road rallies.

If you are really on a budget, you can build your own hundredths-reading clock from a watch or clock with a second hand. The clock face shown has cents on the outer scale and seconds on the inner scale. All you need to do is duplicate this clock face, mount the clock in the center of the face (either behind the face or on the front of the face), and build an extension for the second hand so that it reaches the outer scale.



Clock face for cents and seconds

Communication

This book has made (and will continue to make) a big deal of the teamwork aspect of rallying. A key element in teamwork is how well the driver and navigator communicate.

As a team gains experience, the task of staying on course falls more and more into the

driver's domain. The navigator can concentrate more on trying to keep them on time. Assuming the driver can read the rally reader, the navigator can completely “tune out” of the course-following aspect during



Chris Yates, with a good basic navigation setup, before the start of an event.

periods when some quick calculating can improve their score. Unless the navigator hears a cry of *Help!*, the driver can be trusted to stay on course.

That trust is returned when the navigator comes back from the calculator with the reading *Late 15* indicating that they have to make up 15 cents. Regardless of how the driver feels about whether they are on time, this is the navigator's job and, in the long run, the navigator has the best shot at keeping them on time.

However, when you are navigating and you go off doing some calculating, let your partner know what you are up to. At least give them a *You're on your own* and *I'm back* when the calculations are caught up.

One consideration when a driver and navigator communicate is to keep things as brief and unambiguous as possible. To indicate a turn we say *Left* or *Right*. If we encounter a sideroad on the right and I (as navigator) blurt out *Right!*, that's where we go, if safe, and figure out why after the turn.

However, in answer to a question, we say *Correct*, to avoid confusion with a right turn.

Some teams designate a captain to arbitrate decisions. This works well in “either-or” situations where any decision is preferable to sitting and arguing. Most teams agree that the various tasks should be clearly defined. For example, it might be the navigator's job to figure out the distance to any instructions with an official mileage.

Brisk Events

Running your first rally that is advertised as *brisk* or *performance* can either be a real adventure or a nightmare. The important thing to remember is that you will generally be asked to do everything at a much higher pace. Depending on your ability, car, and tires, you may not be able to keep up the CAS in some sections. Take this in stride and simply do the best you can without risking an accident. If you have patience, you will grow in skill and learn proper car set-up.

Most navigators have problems, at one time or another, sticking to their area of expertise. After all, when the navigator blows it, the team simply gets a bad score. But if the driver really blows it, there are those big magnetic trees (usually on the navigator's side of the car). The result is that the navigator offers a series of “suggestions” regarding driving technique, often spewed out at the apex of the turn in question when driving on the loose pebbly stuff.

Unfortunately, a stream of expletives in the driver's right ear will not improve the odds of avoiding an accident. Drivers already know that their prime job is to keep both sides of the car out of the trees. Constant “suggestions” merely aggravate the situation and take concentration away from the job at hand.

There are a number of additional precautions that you should consider. Take care to tie down or eliminate any loose objects which might become projectiles. Investigate some of the basic car preparation

items discussed in [Chapter 16](#) which can make your car safer, especially competition seat belts. Also, encourage the driver to take periodic advanced driving courses ([Chapter 24](#)).

If things get too fast during the event or you become significantly late, either partner should feel free to suggest taking a Time Allowance. No rally is worth exceeding the limits of your car or your ability. Remember, you drive to work tomorrow in the same car you rally with today!

There We Were on our second rally, which turned out to be a “brisk” event which ran mostly on grass-infested unpaved roads. Our cruiser, equipped with the special low-budget/low-tread summer tires, was not up to the task and we wound up taking 6 time allowances. This netted us third in Novice and a long list of suggestions from experienced rallyists for better tires and suspension components!

Finally, take heart that the situation always seems worse from the navigator's side of the car. This is especially true in right hand curves and turns when the driver can see significantly further into the turn than the navigator. Also, consider that stuffing it at 30 mph on a rally is considerably less dangerous than crashing at 60 mph on an Interstate, where the deceleration forces are four times greater.



Getting Help

A great aspect of this sport is that most experienced competitors are happy to help a novice team. After the last checkpoint of the day, think of the things which caused confusion on the event.

“Why did we go left when the course went right?” “What did that term mean?” “What went wrong with our time allowance?” “Why didn't the rallymaster tell us to bring our passports?”

Ask these questions at the finish and, on top of the answers, you will get to meet some new people and probably hear some stories from their novice days.

Working Events

After you run several events, you should consider working one. Don't worry about your lack of experience. If you notify them ahead, the rallymaster will place you on a checkpoint crew with an experienced worker and you will get some “on-the-job” training.

Aside from supporting the sport, working checkpoints has a number of benefits for novice teams:

- Many rally series require competitors to work at least one event in order to qualify for a year-end trophy.
- You will get some experience with at least one model of a “real” rally clock.
- You will learn how scoring works, if you do not already understand these details.
- You will observe how the experienced teams handle checkpoint procedures.
- You will get a much better appreciation of the work that goes on behind the scenes to put on an event.
- As you learn about the sport from the inside out, your understanding of how the game is played will undoubtedly improve your scores.

More Issues

This section mentions situations which may be a bit more embarrassing than the usual off-course excursion. Accordingly, I have collected them and buried them at the end of this chapter, so you can lock yourself in

and read about them *in cognito* in one sitting.

First is the left-right problem.

There are two types of people in the world: those who can instantly point left and those who have to think a bit. The instant folks tend to place the others somewhere on the scale between imbecile and cretin. However, the problem really has nothing to do with intelligence. In most situations, thinking for a second which way is left is not a problem for the non-instant folks. However, in rallying, especially for the driver, the recognition must be instantaneous.

I once teamed up on a fun-event with a driver of some reputation. I was a bit apprehensive about not screwing up when I noticed him sitting in the corner of the registration area intently scrutinizing the back of his hands. When I got closer and peered over his shoulder, I found that he had etched a large

L and **R** on the back of each thumbnail. Problem solved.

Now that I have picked on drivers for a while, let's talk about a problem which is almost exclusively a navigator's: motion sickness.

Given enough provocation, everyone will get queasy. It is only a question of when. And nothing takes the fun out of a rally quicker than even the slightest queasiness.

Fortunately, there is a cure: drugs. The old standard, Dramamine, is an antihistamine which is available over the counter. It works

quite well for many people, but causes an upset stomach in some people. An alternative is Bonine, which is a brand name for another antihistamine, meclizine. Some people who don't tolerate Dramamine do well on Bonine. Both these drugs are available over-the-counter.

Be aware, however, that a common side effect of antihistamines is drowsiness. This can be a problem on an all-night event or if the navigator has to do some driving later in the event.



The Scopolamine patch

A newer drug, Scopolamine, is available in an unusual delivery system which infuses the drug directly through the skin behind your ear. You simply apply a dime-sized patch behind your ear and a miniscule amount of the drug is absorbed at a constant measured rate. This system, called Transderm Scōp, is available by prescription from most drug stores. In practice, the scopolamine “patch” seems to work well for rallying, as long as it is installed at least four hours before the start of the event. Even the

queasiest navigators are immunized while they are wearing the patch and the side effects tend to be minimal. This drug is currently available under prescription only.

An alternative to drugs is acupressure. A pressure point on the wrists, called P6 or nai-kan, eliminates nausea in many people. Some who are very prone to motion sickness are completely cured by pressure on this point. National Marine Products distributes AcuBand – two ¾” wrist bands which provide constant pressure on these points on each wrist. This product is also available at retail marine supply stores such as E&B Marine.

The Big Botch

Finally, a word about the Big Botch.

Maybe the driver couldn't read the **L** and **R** on the back of his thumbs and turned the wrong way at a T. Maybe the navigator added two and two and got three. (I did this once. Sigh.)

Whatever happens, remember that the person who botched feels bad. Really bad. So, don't yell. Let them stew and take comfort in knowing that, the worse the botch, the bigger the story you get to tell in the bar after the event!

4. Fundamental Navigation

*There were 40 cars in that rally,
and I had to compete against
39 drivers and 40 navigators!*

— Larry Reid,
A New Guide To Rallying, 1969

The largest stumbling block faced by many teams in TSD rallying is the problem of developing a strategy of navigation.

Up to a point, it is satisfying to simply run an event without going off course or maxing a leg. But, as a team turns more of its effort to getting consistently low leg scores, the method for staying on time is strewn with obscure formulas and a bewildering array of special rally equipment to compute those formulas. Rallies for the novice navigator may begin to feel like a bad dream where they are suddenly back in high school algebra class on the morning of a surprise exam.

Many teams respond by never learning to navigate – they simply run the course with little or no timing calculations and take the scores they get. With no way to calculate, they have no idea why they arrive early or late at each checkpoint and have no real

basis on which to improve their scores. Their results plateau and they begin to lose interest in the sport.

Some teams that have the bucks go straight into a specialized rally computer and hope to match the consistent zeros and ones of the top Computer Class teams. And their scores do improve, but only to a point. Without a depth of understanding, the navigator is just acting by rote – “plugging in the numbers” in the standard rally situations. This will yield low leg scores, but often twos and threes rather than ones and zeros. If the situation becomes non-standard, such as an emergency speed or other calculation problem, the max is still lurking.

So, one of the primary goals of this book is to help teams develop a strategy of navigation.

Some teams feel that doing any “serious” navigating will take the fun away from rallying. However, after an initial period of several events spent learning a system, navigating becomes far easier with a good strategy. In the common rally situations, the team knows exactly what to do and is able to devote more time to considering the event as a whole, working on traps, or just enjoying the scenery. In the long run, the

team has a shot at top placings and this, for many, adds a great sense of satisfaction.

In the end, each team has to decide how much effort they want to put into the sport and how far they want to go towards improving their scores.

Navigation Strategies

What is a navigation strategy? It is a system you use before and during a rally to keep you on time. To be worthwhile and useful, it must be:

Practical. Whatever you plan to do in each rally situation, you have to be able to actually carry it out under rally conditions. The most perfect strategy might keep you on time to the millisecond but, if it requires the navigator to write down a gaggle of numbers at each route instruction, throw banks of switches, or solve Ph. D. level math formulas, it is not practical.

Complete. You want a strategy which covers all the situations you are likely to find on rallies. You should also be able to expand your strategy to meet new situations if they arise frequently.

Understandable. Even the best strategy is of limited use in the long run if the navigator and, to a lesser degree, the driver don't understand the underlying principles

on which it is based. It might seem nice to have a strategy where you could always just “plug in the numbers”, but there are always situations where you must improvise. When the course turns from smooth tarmac to mud, the team which understands the dynamics of course measurement keeps their scores low. When the instruction says:

17. Right. From here to the next ✓•, average 20 mph half the distance and 40 mph the other half of the distance.

the navigator who understands the basic TSD formulas will realize that, in this particular situation, a CAS of 30 will not work because you cannot add or average CAS assignments.

So, before I can launch into our first navigation strategy, I will take a few pages to cover the fundamental formulas on which the sport is based.

T, S, and D

Everything that happens in rally navigation revolves around two characters that have, for our purposes, a rather intimate relationship with each other: Time and Distance. There is not a single formula which does not include at least one of them

Formula 3. *Basic TSD Formula*

$$\frac{\text{Distance}}{\text{Time}} \rightarrow \text{Speed}$$

and the two of them will be combined in almost every way imaginable.

Speed

The first thing you can do is divide one by the other to get the most common measure we associate with cars – Speed.

Of course, you always measure speed in miles/kilometers per hour. So, if you ever forget this most basic of all TSD formulas, just remember Speed is miles/kilometers over hours.

However, in rallying, we almost always measure time in minutes and, since Speed would be ridiculous to measure in miles per

To put Formula 4 to work, say that we have traveled 15 miles in 25 minutes. Our speed is:

$$\frac{Distance_{miles} \times 60}{Time_{minutes}} \rightarrow Speed_{mph}$$
$$\frac{15_{miles} \times 60}{25_{minutes}} \rightarrow \frac{900}{25} \rightarrow 36_{mph}$$

While Formula 4 is occasionally useful, you don't often have rally situations where we know Time and Distance and need to find Speed. However, using high school level algebra, you can massage Formula 4 into some other interesting forms.

Formula 4. *Calculating Speed*

$$\frac{Distance_{miles} \times 60}{Time_{minutes}} \rightarrow Speed_{mph}$$

minute, we have to throw in a factor of 60 to get the math to work out:

All the formulas in this book are written with the calculation on the left hand side of the → and the item we are trying to compute on the right of the →. While *result = calculation* is the usual format for equations, the *calculation → result* format makes it easier to figure these formulas directly on a calculator.

Distance

Say we know our Speed and Time and want to find out how far we have gone.

We can use Formula 5 to solve a problem which pops up occasionally:

**63. Right at T. CAS 32.
Left in 2.12 minutes.**

How far away is the Left? Since we have Speed and Time, we can get the Distance:

Formula 5. *Calculating Distance*

$$\frac{Speed_{mph} \times Time_{minutes}}{60} \rightarrow Distance_{miles}$$

Formula 6. *Calculating Time from Distance and Speed*

$$\frac{Distance_{miles} \times 60}{Speed_{mph}} \rightarrow Time_{minutes}$$

$$\frac{Speed_{mph} \times Time_{minutes}}{60} \rightarrow Distance_{miles}$$

$$\frac{32_{mph} \times 2.12_{minutes}}{60} \rightarrow \frac{67.84}{60} \rightarrow 1.13_{miles}$$

Time

Finally, the most useful variant is to be able to calculate a **perfect time** to cover a

used by rallyists for quick computation. It is the inverse of Speed – where speed gives you distance-per-time, Rate gives you time-per-distance.¹⁰ So, instead of Speed in miles-per-hour, we have Rate in minutes-per-mile.

To get the Rate for a given Time and Distance, [Formula 4](#) for Speed is simply inverted:

Formula 7. *Calculating Rate from Time and Distance*

$$\frac{Time_{minutes}}{Distance_{miles}} \rightarrow Rate_{minutes-per-mile}$$

Distance at a given Speed:

This version is so useful that it is the heart of most rally computers and printed tables. On almost every rally you will be able to use it many times before the start as we will see in the next chapter.

Rate

Finally, we will look at a fourth member of the clan of fundamental quantities: Rate. This measure is far less intuitive, but often

Notice that there is no need for a factor of 60 because Time and Rate are both measured in minutes.

Another way to get Rate is to use the Speed directly:

So, for any given Speed, there is an equivalent Rate.

Why is Rate useful? Say you are assigned CAS 30. This works out to a Rate of

Formula 8. *Calculating Rate from Speed*

$$\frac{60}{Speed_{minutes-per-mile}} \rightarrow Rate_{minutes-per-mile}$$

¹⁰ There are many common names for Rate. You will often hear of a minutes-per-mile factor for any given speed, but

this is too easily confused with correction factors for my taste.

$$\frac{60}{\text{Speed}_{\text{minutes-per-mile}}} \rightarrow$$

$$\frac{60}{30} \rightarrow 2_{\text{minutes-per-mile}}$$

This means that, at CAS 30, you should take exactly 2 minutes to go each official mile. All you would need to do is start a stopwatch when the odometer rolled over to the top of a mile and, as each mile rolled over, simply confirm that close to two minutes has elapsed. (This assumes you had the good fortune to have an odometer which read very close to official miles.)

Also notice that $\frac{60}{\text{Speed}_{\text{mph}}}$ is part of [Formula 6](#). Normally, it takes a multiplication and a division to calculate Time using [Formula 6](#). However, once you know the Rate for a particular Speed, you can get the perfect time to cover a distance with just one multiplication:

The Puzzle

As a final look at the fundamental TSD formulas, we will work out the problem mentioned before:

17. Right. From here to the next ✓, average 20 mph half the distance and 40 mph the other half of the distance.

A straightforward way to calculate a problem such as this is to work a simple example and plug in some numbers. Since the route instruction did not say the distance to the checkpoint, it is likely that the problem can be solved regardless of the distance. You can try two distances and see if you get the same number. First, assume the checkpoint was 2 miles away. You can figure the time to the checkpoint driving one mile at CAS 20 and one mile at CAS 40. Using [Formula 6](#):

$$\frac{\text{Distance}_{\text{miles}} \times 60}{\text{Speed}_{\text{mph}}} \rightarrow \text{Time}_{\text{minutes}}$$

$$\frac{1.00_{\text{miles}} \times 60}{40_{\text{mph}}} \rightarrow 1.50_{\text{minutes}}$$

$$\frac{1.00_{\text{miles}} \times 60}{20_{\text{mph}}} \rightarrow 3.00_{\text{minutes}}$$

Total: 4.50_{minutes}

So, if the checkpoint was 2 miles away, you would drive 1.50 minutes at CAS 40 and 3.00 minutes at CAS 20 and should take

Formula 9. *Calculating Time from Distance and Rate*

$$\text{Distance}_{\text{miles}} \times \text{Rate}_{\text{minutes-per-mile}} \rightarrow \text{Time}_{\text{minutes}}$$

4.50 minutes to get there. Now using **Formula 4** we can get the average Speed to drive.

$$\frac{Distance_{miles} \times 60}{Time_{minutes}} \rightarrow Speed_{mph}$$
$$\frac{2.00_{miles} \times 60}{4.50_{minutes}} \rightarrow 26.6_{mph}$$

Notice that running at CAS 30 rather than the correct CAS 26.6 would get us to the checkpoint 50 cents early for every 2 miles that you traveled.

Try this method using another distance to the checkpoint. You will get the same result.

Using the Formulas

Is all this math required? Is it all worthwhile?

The previous formulas are almost incomprehensible to a new navigator. You would have to read them at least several times to understand them and it is still virtually impossible to remember the formulas. Understanding the solution to the Puzzle above takes even more work.

However, since you have gotten this far, you apparently have enough interest in learning to navigate to have at least scanned through this chapter once.

You can now take heart – the worst is over! The good news is that you don't actually have to memorize those formulas. Just understand what they can do for you and be able to look them up when needed.

Remember that all the important formulas in this book as well as many of the tables

are in the *TSD Road Rally Pocket Reference*. The formulas will become especially important in **Chapter 28** when we look at Phantom Car traps, the solutions to which are almost entirely based on the fundamental formulas.

Try to take away two things from your struggle with the formulas in this chapter:

- An understanding that, if you know any two quantities from the set of {Time, Speed, and Distance}, you can look up a simple formula which will give you the third.
- A belief that we can build a strategy based on the formulas which will keep you, at least theoretically, perfectly on time. We will begin developing such a strategy in the next two chapters.

5. Calculating Perfect Times

I'm on course. Are you on time?

— Vera Shanov,
Driver, Leg 10, The Quahog Rally,
November 14, 1987, 10:12.89 PM

In sailboat racing, the time before the start of a race is spent maneuvering to be in the best position when the starting gun is fired. This phase of a race is so important that the entire outcome is sometimes decided before the race “starts”. To get mentally prepared, the crew often says that they are racing as of 10 minutes before their start.

Rallying is much the same. The time between when you receive the route instructions and when you “start” can be the most important part of the event, and a busy time for the navigator. When you receive the route instructions, you are rallying.

We have already talked about illustrating the route instructions in Chapter 3. If you have invested in a rally reader, you will need two sets¹¹ of the route instructions – one for the reader and one for the navigator's clipboard. Both will need to be

highlighted and the set for the reader will need to be taped end to end and loaded onto the rollers.

We have also given the formulas needed to pre-calculate the perfect time to cover a known distance between two instructions. Finding places in the route instructions where you can apply this and other tricks to pre-calculate perfect times is the best way to lower your score in Novice Class. And doing these calculations before the start, in a quiet place such as your hotel room or a table away from the registration area, is far easier than trying to juggle a calculator during the event.

However, pre-calculating perfect times is not possible in all rallies. Events with almost no mileages provided in the competitive sections of the route instructions offer little opportunity for using the techniques in this chapter.

At the other end of the spectrum are rallies, especially brisk events, where you are given an official mileage at every instruction. You can literally pre-calculate the perfect time to every turn. This kind of event is known as a

¹¹ A few events limit each team to one set of route instructions.

perfect-time rally. If you don't make any calculation errors and stay on course in a perfect-time rally, it is reasonable to try for single-digit scores on every leg, even in Novice Class!

The previous chapter looked at the formulas. This chapter will look at how to use the formulas to pre-calculate the route instructions.

Finding the Deltas

The first step is to locate opportunities to calculate perfect times. We will use the route instructions from the Rally of Oz, with a few additional NRIs to get some more examples:

The idea in pre-calculating is to find as many overall and delta mileages as possible.

Because of the delta mileage in NRI 6 we can get the official mileage to NRI 6. Also, from the delta and official mileages in NRI

The Rally of Oz			Page 1 of 6
<u>Mile</u>	<u>Delta</u>	<u>Instruction</u>	
0.00		1. Begin Rally at "The Kansas Inn" (at exit from parking lot). Leave at 10:00.00 plus your car number in minutes. Zero your odometer. Begin odometer check. Begin Transit Zone of 30.00 minutes. Left.	
1.83		2. Right onto Scarecrow Road.	
3.43		3. "Caution - Tornado area" (road may become unpaved).	
	2.14	4. Straight at signalized intersection.	
8.10		5. End odometer check at "Oz Town Line". End Transit Zone. CAS 30.	
	0.85	6. Left at island ("Dorothy"). CAS 36.	
		7. Right after "C & V Rallye Shoppe". Pause 50.	
12.82	2.60	8. Right at T. CAS 32.	
		9. Left at T. CAS 36.	
		10. "Children". Pause 30 over next 0.50 miles.	
	2.11	11. Right at "King Pin". CAS 28.	
		12. "Speed Limit 40". Gain 60 over next 1.00 miles.	

8.10	5. End odometer check at "Oz Town Line". End Transit Zone. CAS 30.
8.95 0.85	6. Left at island ("Dorothy"). CAS 36.
10.22 1.27	7. Right after "C & V Rallye Shoppe". Pause 50.
12.82 2.60	8. Right at T. CAS 32.
	9. Left at T. CAS 36.
	10. "Children". Pause 30 over next 0.50 mile.
2.11	11. Right at "King Pin". CAS 28.
	12. "Speed Limit 40". Gain 60 over next 1.00 mile.

8, we can back-figure both the official mileage and then the delta mileage for NRI 7. Writing this information in on the route instructions gives us:

The first thing you should do with all the delta mileages you have is to highlight any particularly small deltas. We highlight anything less than 0.30 mile in red to make sure that we don't miss the instruction.

Intervals

Now we can figure the perfect time to get from NRI 5 to NRI 6 using [Formula 6](#):

$$\frac{Distance_{miles} \times 60}{Speed_{mph}} \rightarrow$$

$$\frac{0.85_{miles} \times 60}{30_{mph}} \rightarrow$$

$$1.70_{minutes}$$

and the same for NRI 6 to NRI 7:

$$\frac{Distance_{miles} \times 60}{Speed_{mph}} \rightarrow$$

$$\frac{1.27_{miles} \times 60}{36_{mph}} \rightarrow$$

$$2.12_{minutes}$$

Finally, we can do the same for NRI 7 to NRI 8, but we have to add in the time for the **Pause 50** in NRI 7:

$$\frac{Distance_{miles} \times 60}{Speed_{mph}} \rightarrow$$

$$\frac{2.60_{miles} \times 60}{36_{mph}} + 0.50_{minutes} \rightarrow$$

$$4.83_{minutes}$$

Each of the zones with a delta mileage and a single known speed is called an **interval**. We use the notation

$$0.85 @ 30 \rightarrow 1.70min$$

8.10	5.	End odometer check at "Oz Town Line". End Transit Zone. CAS 30. <i>0.85 @ 30 → 1.70min</i>
8.95 0.85	6.	Left at island ("Dorothy"). CAS 36. <i>1.27 @ 36 → 2.12min</i>
10.22 1.27	7.	Right after "C & V Rallye Shoppe". Pause 50. <i>2.60@36 → 4.33+.50 → 4.83min</i>
12.82 2.60	8.	Right at T. CAS 32.
	9.	Left at T. CAS 36.
	10.	"Children". Pause 30 over next 0.50 mile.
2.11	11.	Right at "King Pin". CAS 28.
	12.	"Speed Limit 40". Gain 60 over next 1.00 mile.

to mark each interval and record the calculation from [Formula 6](#). We can then combine the intervals together to get perfect times across a large range of route instructions. Our annotated route instructions might look like the annotated route instructions above.

Pause over Distance

Rather than changing CAS for short sections of road with varying conditions, rallymasters will often give a pause over a distance. In NRI 10 we have a **Pause 30 over 0.50 mile**.

One easy way to handle this is to figure out how long it should take to cover the distance (0.50 miles) and then convert this into a new (reduced) CAS for that distance. This technique is called an **averaged pause**. The time you spend running at the slower speed is simply the time you would normally take to run the distance at normal CAS plus the time for the pause. Using the fundamental formula for Time, we get Formula 10 below.

Remember to add in the $Time_{pause}$ in minutes! For the example in NRI 10, we get

Formula 10. Averaged Pause: How long to run at reduced speed

$$\frac{Distance_{pause} \times 60}{CAS} \mp Time_{pause} \rightarrow Time \text{ at reduced speed}$$

$$\frac{Distance_{pause} \times 60}{CAS} + Time_{pause} \rightarrow$$

$$\frac{0.50_{miles} \times 60}{36_{mph}} + 0.30_{minutes} \rightarrow$$

$$1.13_{minutes}$$

Normally, we would have covered the half

Gains

Another item which appears occasionally is a **gain**. It is the inverse of a Pause – you are supposed to make up the specified time. Since it is impossible to make up time at a single point in space, gains are always given over a distance, such as in NRI 12.

Formula 11. **Averaged Pause: Calculating the reduced speed**

$$\frac{Distance_{pause} \times 60}{Time \text{ at reduced speed}} \rightarrow \text{Reduced speed}$$

mile at CAS 36 in 0.83 minutes. Adding the 0.30 minutes for the pause gives us 1.13 minutes to cover the half mile. To figure out

You can handle a gain over a distance like a pause over a distance, calculating an amount of time to run and a new (faster)

Formula 12. **Gain: How long to run at increased speed**

$$\frac{Distance_{gain} \times 60}{CAS} - Time_{gain} \rightarrow \text{Time at increased speed}$$

how fast to go, simply use the fundamental formula for Speed:

So, in this example, the reduced speed is

$$\frac{0.50_{miles} \times 60}{1.13_{minutes}} \rightarrow 26.5_{mph}$$

If we travel at 26.5 mph for 1.13 minutes when we see the “Children” sign, we should nail this portion of the leg perfectly.

speed to run. First, the time:

For NRI 12, we get

$$\frac{Distance_{gain} \times 60}{CAS} - Time_{gain} \rightarrow 26.5_{mph}$$

$$\frac{1.00_{miles} \times 60}{28_{mph}} - 0.60_{minutes} \rightarrow 1.54_{minutes}$$

Formula 13. **Gain: Calculating the increased speed**

$$\frac{Distance_{gain} \times 60}{Time \text{ at increased speed}} \rightarrow \text{Increased speed}$$

At CAS 28 we would have covered the mile in 2.14 minutes. With the gain, we only have 1.54 minutes to cover the distance.

Finally, we figure how fast to go to cover the mile in this reduced time:

So, in this example, the gain calls for 1.54 minutes of driving at

$$\frac{1.00_{\text{miles}} \times 60}{1.54_{\text{minutes}}} \rightarrow 39.0_{\text{mph}}$$

Our final annotated instructions might look like these route instructions:

8.10	5.	End odometer check at "Oz Town Line". End Transit Zone. CAS 30. <i>0.85 @ 30 → 1.70min</i>
8.95 0.85	6.	Left at island ("Dorothy"). CAS 36. <i>1.27 @36 → 2.12min</i>
10.22 1.27	7.	Right after "C & V Rallye Shoppe". Pause 50. <i>2.60@36 → 4.33+.50 → 4.83min</i>
12.82 2.60	8.	Right at T. CAS 32.
	9.	Left at T. CAS 36. <i>26.5mph for 1.13min</i>
	10.	"Children". Pause 30 over next 0.50 mile. <i>2.11@36+.30 → 3.82min</i>
2.11	11.	Right at "King Pin". CAS 28. <i>39.0mph for 1.54min</i>
	12.	"Speed Limit 40". Gain 60 over next 1.00 mile.

6. A Basic Strategy

Nitwit ideas are for emergencies. You use them when you've got nothing else to try. If they work, they go in the Book. Otherwise you follow the Book, which is largely a collection of nitwit ideas that worked.

— Larry Niven and Jerry Pournelle,
The Mote in God's Eye

This chapter develops a navigation strategy suitable for running in Novice Class in most events. It is based on the formulas developed in the last two chapters and assumes the following navigation equipment:

- **Stock speedometer.**
- **Time-of-day clock.** It should read in minutes and cents – you can still use a watch reading in seconds, but you will need to do the conversions.
- **Auxiliary stopwatch.** This will be used to measure intervals of time. The Westbend 40007 will work, but you will need to convert seconds to cents. The Seiko model 020 will also work nicely, but at more

cost. Both these timers are described in [Chapter 9](#).

- **Basic calculator.** There are many definitions for what is allowed for a calculator in Novice Class. We will assume that it has the 4 functions (+, −, ×, ÷). You should check with the organizers that your calculator is legal in your class.
- **Stock odometer.** A tenth reading resettable (trip) odometer. This is the least important of the instruments in this strategy – it will be used only occasionally.

Whatever equipment you select, remember that you will not be running Novice Class forever. If you purchase equipment, try to consider its usefulness in running the advanced classes, especially your time-of-day clock.

The Concept

The basic idea of this navigation strategy is to keep the car running on time at all times and to have a bag of tricks for recovering from small deviations.

Since this is the first navigation strategy, the primary emphasis is on keeping it simple. Towards this end, we will be taking a few

short cuts and making some assumptions and approximations which give this strategy some inherent inaccuracies. However, you should improve your scores over the “I think we’re a bit late” method. Just remember – it will take a few rallies to become familiar with the details.

As with all navigation strategies, we will develop the method based on what to do in the common rally situations. Then we include a checklist at the end of the chapter as a quick reminder during the event.

After running this strategy for a few events, a team should be able to average 3 to 4 points per competitive TSD mile.¹²

Before the Start

Of the suggestions given in the last three chapters, pre-calculating the route instructions is probably the most important. Other than this, there is nothing specific to do before the start of the event for this navigation strategy.

Many events allow competitors to begin the odometer check prior to their official start time. Find out if you can do this and, if so, depart when you have made sure the route instructions are complete and legible. However, remember that this will not change the correct time you should leave the end of the odometer check.

The Odometer Check

Once you have finished highlighting and pre-calculating the route instructions and it is time to start your run, pull up to the starting point, zero your odometer (see [Chapter 10](#) for notes on stock odometers), and head off on the odometer check. If the event has many opportunities for pre-calculating, the navigator may still be busy. This is OK as long as the driver can stay on course and the navigator is not prone to motion sickness.

At the end of the odometer check, pull up to the landmark and take a careful reading of the odometer.

Reading a Stock Odometer

If you have a mechanical odometer, you can interpolate between tenths. As the last digit is rolling up, try to determine a mileage reading to the hundredth of a mile. For example, a good guess for:



... might be 8.38 miles. With practice, you can reliably read many mechanical stock odometers to the hundredth of a mile.

If you have a digital tenth reading odometer, the best you can do is to stare at the odometer as you approach the end landmark and see how far before the landmark it flips over. Remember that a

¹² Standard Disclaimer: This depends on the style of the event, number of speed changes per mile, number and complexity of intersections, etc. This estimate is given as

a very rough standard. Remember that your goal is to improve your scores and placings, not measure your scores against an arbitrary standard.

tenth of a mile is 528 feet, or about 37 car lengths, so you can approximate the hundredths. If you forget to do this, use a hundredths of “5” to take a middle-of-the-road guess.

Correction Factors

Now we can figure the Correction Factor using [Formula 1](#). With our example car mileage of 8.38:

$$\frac{\text{Car Mileage}}{\text{Official Mileage}} \rightarrow \frac{8.38}{8.10} \rightarrow 1.0346$$

Since we are not generally using mileages in this navigation strategy, you may not want to go down the route instructions and

or subtract from the CAS to get corrected car speed. For example, the navigator might write a table and tape it to the dashboard:

CAS	Car Speed (CF = 1.0346)
20	20.7
30	31.0
40	41.4
50	51.7

So, in this case, we would add 1 mph for CAS assignments in the 20s and 30s and 1.5 mph for CAS assignments in the 40s and 50s.

Running a Leg

So finally we get to run a leg! You are

Formula 14. *Corrected Car Speed*

$$\text{CAS} \times \text{Correction factor} \rightarrow \text{Corrected car speed}$$

correct all the mileages. However, the Correction Factor is very useful for getting corrected speeds. We make the assumption here that the speedometer runs on the same correction factor as the odometer. In practice, this is a rough approximation, but is not too damaging in Novice Class. We simply apply the correction factor to all CAS assignments to get corrected speeds:

Since the Correction factor is usually a number near 1.0, we can take a shortcut in correcting speeds. Simply calculate the corrected car speed for CAS 20, 30, 40, and 50 and use these as a guide for what to add

probably remembering back to the beginning of this chapter when I said that this first navigation strategy was simple. And you may have peeked at the last several pages concluding that it is anything but. However, all the calculations so far are done before the start or at the end of the odometer check, not in the middle of a leg. Also, keep in mind that the calculations up until now have been a bag of independent tricks, and you can decide which ones to apply or discard in any situation.

Running a leg is where all the pre-calculations pay off.

Getting Up to Speed

The first problem at the end of the odometer check is to get up to speed so that you are on time when you arrive at CAS. This problem comes up at all restart points including the end of transit zone, leg restarts after open controls, etc.

One easy way to handle getting up to speed on time is to pull ahead a certain distance from the landmark. You usually need to do this anyway in order to give other rally cars and local traffic enough room to pass. Departing from further along the course than the official restart point can make you early by exactly the lateness caused by the acceleration. The following guideline is based on an average car accelerating smoothly and briskly from a dead stop up to the target CAS.¹³

Target CAS	Car Lengths from landmark
20	4
30	11
40	17
50	25

Of course, this table assumes that you begin accelerating at your restart time exactly and are accelerating from the road and not from the shoulder and that you are already in gear with the parking brake off.

Accelerating up to speed predictably is important when running this strategy

¹³ Tests for this table were made in a 1991 Ford Tempo automatic and assumes a car length of 14 feet.

because an error here will go uncorrected throughout the leg. Doing so also means that your score on a quickie leg should be quite low.

Handling NRIs

Once you are up to speed, there is relatively little to do until you execute an instruction. Whenever you execute an instruction:

- Write down the time you executed it on the Route Instructions. This is very important if you later go off course and need to come back and take a time allowance.
- If you have the perfect time between that NRI and the next NRI, you can calculate the perfect time to the next NRI.

Looking at NRIs 10 and 11 from the Rally of Oz:

9. Left at T. CAS 36.

26.5mph for 1.13min

10. "Children". Pause 30 over next 0.50 mile.

2.11@36+.30 → 3.82min

2.11 11. Right at "King Pin". CAS 28.

We do not know the perfect time for NRI 10. But, once we execute it, we write down the time and assume that we are on time. The navigator calls "Speed 26.5" as they pass the sign and writes down the current time. Then

1.13 minutes can be added to get the time to resume CAS 36 and the 3.82 minutes can be added to get the perfect time for NRI 11. Assuming you execute NRI 10 at 10:27.15, the marked-up route instructions might look like:

9. Left at T. CAS 36.

26.5mph for 1.13min

**10. "Children". Pause 30 over
next 0.50 mile. 27.15**

2.11@36+.30 → 3.82min

**2.11 11. Right at "King Pin". CAS 28.
exact: 30.97**

At the "Children" sign, you slow to 26.5 mph until 10:28.27 (10:27.15 + 1.13). The navigator calls "Speed 36" at 10:28.27. You find the Right in NRI 11 at 10:30.97. To help the driver with NRI 11, the navigator can count down the time to the turn.

It is important to keep all the notes you add to the route instructions sorted out. You should pick a simple convention to help stay organized. For example, you can put perfect time-of-day figures in a box and the actual time-of-day readings in a circle. It is also a good idea to use a green pen so your notes stand out. Red pens also work great until you get on a night rally – the red cockpit

lights used to preserve night vision make red ink invisible on white paper!

If the instruction has a CAS change, there is no real work to do – just make sure you change speed to the corrected car speed for that CAS.

If you have a pause assigned:

- Note the time as you have slowed halfway from CAS to a stop. Alternately, use the perfect time for the instruction, if one is available. Add the time of the pause to get your restart time.
- Make the turn or pull across the intersection. Try to space yourself the appropriate distance from the execution point of the instruction¹⁴ for the CAS at which you will depart. Make sure that you are well clear of the intersection and are in a position to get a good smooth restart.
- Then, at the appropriate time, accelerate to CAS and rally on.

To run a Transit Zone, simply note your time at the Begin Transit Zone point as you would with any other instruction. Then add the time for the Transit Zone and depart the End Transit Zone point as you would at any other restart. If you take significantly less than the allotted time to run the Transit Zone, you might catch sight of one or more cars leaving the End Transit Zone point. Note their time and consider if you want to use their time(s) for a hack (see Chapter 3).

¹⁴ This point should be defined by the Regs. It could be the beginning of the intersection, the apex of the turn, or some other well-defined spot.

If you have a **Free Zone** where you have a perfect time to traverse from the beginning to the end, you have a choice. You can treat it like a Transit Zone and drive it faster than the CAS (where legal and safe). This gives you the time to handle delays, such as slow traffic or traffic lights. Your other choice is to run at CAS, giving you the opportunity to expose any gross calculation error (*gasp!*) that the navigator may have made.

Checkpoints

Finally, you get to a checkpoint. If it is a **closed control** or **flying control** (one at which you do not stop), simply note your time at the checkpoint line and keep on going. Oh yes, wave at the crew – they are probably lonely.

For an **open control**, note your time and car mileage as you cross the timing line. Also, add up any time allowances you might have taken on the leg.

Pull over after crossing the line and passing the crew and either walk your scorecard back or pull up to a table and hand it in. Make sure to request any Time Allowances for that leg as you hand in your card, if that is the proper procedure. When you get the checkpoint slip back (and your scorecard, if the event uses them), there are a number of things to do in a rather short time.

- Ensure that the finish time on the scorecard agrees with your reading. If it is off by a few cents, don't worry. However, if the discrepancy is larger, find out why. You may have accidentally been given

some other car's arrival time or maybe your clock needs to be re-set.

- Verify that any TA you requested has been recorded correctly.
- Note your start time and where the restart point is, and make sure that the start time allows sufficient time to reach the restart for the next leg.

Then go back to your car. Some events use **out-markers**, which are points past the timing line of the checkpoint where the next leg starts. If the next leg starts at an out-marker, you should move there. Then read the checkpoint slip carefully.

- Note the number of the instruction you are seeking to execute.
- Note the CAS at which to start the next leg. The CAS sometimes changes at checkpoints.
- Take note of any special instructions on the checkpoint slip.
- Pre-calculate the next interval, if possible. Checkpoint slips at most events tell you the official mileage at the checkpoint. If the next NRI also has an official mileage, you can figure the perfect time at that instruction.
- Finally, if you have time, figure your score on the last leg. If you can do this for several legs and get a trend of consistently early or late, then you can build a factor into your speeds to try to compensate.

To get a rough idea of how much to adjust your speeds, divide your score by the **competitive leg time**. The competitive leg time is the perfect time to run the leg after

transit zones, and other areas where you have the perfect time to travel, have been removed. Multiply this by 100 to get the percentage to further increase (if your were consistently late) or decrease (if you were running early) your speeds.

However, if you have been doing fairly well and all of a sudden seem to have an outlandish and unexplained high score, Don't Panic! A mistake may have been made in the rallymaster's calculations on the checkpoint slip and the leg time is wrong. Such situations will be corrected before scoring is done.

Adjustments

Up until now, we have discussed this strategy as if everything always proceeds perfectly. We have said nothing about what to do when you find yourself early or late by some known or unknown amount of time.

The Situation

The most common situation is a turn that has no pause time allotted in the route instructions. The goal is to determine how much delay the turn caused and then compensate for the delay in an orderly way. We will begin using the auxiliary stopwatch for delays.

To time the delay, start your stopwatch when the car slows halfway from CAS. Freeze the stopwatch when you have accelerated halfway back to CAS. Note the elapsed time. If you had to creep around the turn or across an intersection for any appreciable distance, subtract one cent for

every 2 car lengths (or one second for every 3 car lengths) you crept. The result is the time you were delayed.

If you have a perfect arrival time at an instruction and you got to the instruction after the perfect time, your delay is the difference between the perfect and actual times. (Of course, if you arrive early, just wait until the appropriate perfect time to depart.)

Another common problem is getting delayed by slow-moving traffic. You could decide to pull over and take a time allowance. If you keep going, it is best not to just trundle along on his bumper, 3 mph below CAS, fuming at the situation. Choose a different speed which is even slower and start your stopwatch. This may seem counter-productive, but it will allow you to determine your delay much more precisely. Stop the watch when the problem clears up and you can run at CAS.

What speed should you pick? Some convenient ones are to slow down by $\frac{1}{4}$, $\frac{1}{3}$, or $\frac{1}{2}$ your assigned speed. Your delay time is then $\frac{1}{4}$, $\frac{1}{3}$, or $\frac{1}{2}$ the time shown on the stopwatch, respectively.

For example, if your CAS is 30, try slowing down by $\frac{1}{3}$, giving you 20 mph to maintain. If the problem lasts for 36 seconds, you are now $\frac{1}{3}$ of 36 seconds, or 12 seconds late.

The Fix

OK, so you know how late you are and have an opportunity (good road, no traffic,

generous speed limit) to make it up. How fast do you go and for how long?

If you can go 10% over CAS, it will take 10 times as long as you are late to make up the delay. In the above example, traveling at 33 mph, 10% over 30, will make up the 12 second delay in 120 seconds, or two minutes.

At 20% over CAS it would only take 5 times the delay, or one minute at 36 mph to make up the 12 second delay over CAS 30.

At 33.3% (one third) over CAS it would take 3 times the delay, or 36 seconds at 40 mph.

At 50% over CAS it only takes twice as long to make up the delay.

Finally, at 100% over CAS (double the CAS), you make up a delay in the same time as the delay – 60 mph for 12 seconds compensates for a 12 second delay at CAS 30.

Recovery from a Delay	
How Fast	How Long to Recover
CAS + 10% CAS	Delay time × 10
CAS + 20% CAS	Delay time × 10
CAS + 33% CAS	Delay time × 10
CAS + 50% CAS	Delay time × 10
CAS + 100% CAS (CAS × 2)	Delay time

This recovery method can be used for any kind of delay where you know the amount of time you are late. Any situation where you have a perfect departure time and you depart late is a candidate for this method. These situations include the end of a transit

zone, the end of an interval with a single CAS and a known distance, or a Key Time (see below in One Final Trick).

A Shortcut

There is an even easier method for handling the #?&!-slow-traffic-in-front-of-you situation, but it has a shortcoming.

It turns out that, if you travel at a given number of mph below CAS for a time, you can make it up by traveling the same number of mph above CAS (the compensating speed) for the same amount of time. For example, at CAS 30, 45 seconds at 36 mph will exactly compensate for 45 seconds at 24 mph.

The shortcoming is that this method does not tell you how much time you are late after your delay, so you cannot pick a recovery speed from Table 6-1. If you cannot maintain the compensating speed above CAS, you can:

- do the recovery in sections, using stretches of the road where the compensating speed is safe and legal, or
- drive halfway between the CAS and the compensating speed for twice the time (1.30 minutes at 33 mph in the example).

You only have one speed with which to compensate and, if you cannot maintain that speed, you are out of luck!

DIY Legs

On a Do-It-Yourself leg, no recovery is needed since you can write in a calculated time at the end of the leg. As long as you are

not late for the start of the next leg, you can simply not compensate for minor delays. This avoids inaccuracies which an adjustment can introduce. Simply keep a running total of each delay and subtract it from your actual arrival time.

One common confusion happens the first time you need to take a TA on a DIY leg. Since you can write down a calculated rather than actual arrival time, just subtract the TA from your arrival time.

The one case where you may want to take a TA on a DIY leg is if the DIY is followed by an open or closed checkpoint and you cannot make it to the checkpoint on time. In this case, hold off writing in your DIY time till you get to the checkpoint. You will be taking a TA on only one of the two legs since most rules assess a penalty for each leg you take a TA. When you get to the second checkpoint, take a guess as to which leg you will get a better score on. Add all your TA time together and assign it to that leg, adjusting your DIY arrival time and start time for the second leg as appropriate.

Off-Course Situations

In Chapter 3 we described a strategy for handling an off-course excursion. It essentially involved doubling the time it took to find your way back to the turn and then taking a time allowance.

In our current strategy, we have a much better method. Since we write down our actual time or a perfect time for every NRI which is executed, simply go back to the last

NRI for which you have such a time and take a time allowance from there.

You did remember to write down the time at each instruction, didn't you?

One Final Trick

As a final item in our bag of tricks for this strategy, we will talk about a rather back-handed technique which is useful occasionally.

Some events use a concept called **key times**. A key time is the perfect passage time or departure time for car #0 at a given NRI. To calculate your arrival time, simply add your car number in minutes to the Key Time. For example:

	41. Left at T. <i>CAS 36. 37.1mph</i>
	42. Right onto Wayward Lane.
29.17	43. Straight at Stop. <i>Key Time</i>
	<i>11:20.72. Begin Transit</i>
	<i>Zone</i>
(30.20)	of 13.00 minutes.

This means that, if you are Car #17, you should get to the Stop in NRI 43 at exactly 11:37.72. Notice that you also have an official mileage at NRI 43. If you have gotten a good correction factor and your odometer has been matching other corrected official mileages in the route instructions, then you can expect that the corrected

mileage of 30.20 should be close (if you have not gone off course in the meantime!).

The trick is this: once you execute NRI 41, you can calculate backwards to get perfect times based on your odometer. Since the rallymaster will often place checkpoints closely before Key Times, this trick can be powerful on some rallies.

The easiest way to do this is to calculate how long it takes to go a mile at the corrected speed of 37.1 mph (1.62 minutes) and build a small table for each Key Time:

Car Mileage	Perfect Time
30.20	11:37.72
29.20	11:36.10
28.20	11:34.48
27.20	11:32.86
26.20	11:31.24

Simply type the Key Time into the calculator and keep subtracting out the time to travel one mile from the calculator to get the perfect time at each preceding car mileage.

A Checklist

With every navigation strategy, you should put together a checklist for use as a reminder of what to do when running the course. The next two pages show a checklist for the Basic Strategy which is meant to fit into a 5½" × 8" plastic holder (outside dimensions). The checklist is meant to be cut to 5" × 7½" and assembled back to back.

The purpose of the checklist is not as a how-to. It is a reminder when running the event of the things you need to do at various points.

See the checklist on the next two pages ...

TSD Rally Checklist - Basic Strategy

Before Event

- Read generals
- Review Regs
- Gas, oil, clean windshield
- Check all car lights
- Restroom

Before Start

- Affix car number
- Set clock to official time
- Fill out scorecard
- Check routes: page #, legibility
- Highlight routes
- Pre-calc intervals, pause over dist, gains

Start of Odo Check

- Zero car odometer, accounting for odo lag

End of Odo Check

- Note car odo
- Calculate correction factor
- Fill in corrected car speed table

Start of Leg, End Transit Zone

- Space from restart point based on CAS
- Restart at assigned/calculated time

NRI

- Note time

CAS Change

- Note time
- Look up corrected car speed for new CAS

Pause

- Note time decelerating through half speed
- Add in pause time to get restart time
- Space from restart point based on CAS
- Accelerate at restart time

Gain

- Note time as you accelerate
- Revert to prior CAS after calculated time

Begin Transit Zone

- Note the time you begin the transit
- Add in transit time to get restart time
- Note calculated restart time at ETZ

Off Course

- Return to prior NRI with a perfect or actual time
- Take a time allowance

Checkpoint - Closed (Flying)

- Note time

Checkpoint - Open

At the Line

- Note time
- Note car mileage
- Did you take a TA?

Hand In Card

- Request TA

Get Card Back

- Verify recorded arrival time
- Verify TA Request
- Check start time for Sanity

Move to Out Marker

- Note next NRI
- Note starting CAS
- Read any special instructions
- Space from out-marker based on CAS
- Precalc first interval, if possible
- Calculate your score

Checkpoint - DIY

- Note time
- Enter calculated/actual arrival time on scorecard
- Determine your next leg start time & enter on scorecard

7. Beyond Novice

At some point in your rally career, you get kicked out of Novice Class. Maybe you get a call from the regional pointskeeper informing you that you have accumulated too many points to run as a Novice anymore. Or maybe you are starting to feel funny about accepting your third Novice trophy in as many events – It's time to give some other Novice teams a chance.

So you begin staring at the array of LEDs, LCDs, senders, relays, and none-too-neat wiring in the dashboards of cars in the advanced classes as you attempt to figure out what you want or need to get and where to get it.

Classes

The first order of business is to decide which class to run.

One complication is that the class rules for each of the upper classes can vary widely from region to region or club to club. When

you consider the effort and expense a team puts into an advanced navigation strategy and its equipment, even subtle changes in class rules can be a problem.

To cover the myriad of class definitions, we will be looking at four advanced navigation strategies. One of them should be suitable for each of the classes in your region or club. The names in this book for each of the classes will not match your area's names, but it should be easy to find an appropriate strategy for the class you choose to run.

Stock Class

This class is often the default class for Novice refugees. It allows very little in the way of equipment. Accurate timepieces and calculators, together with stock (factory-available) odometers and speedometers are all that can be used.

Many areas call this Class C while others use the term SOP for Seat-of-the-Pants.¹⁵ We will develop a navigation Strategy for Stock Class which is an extension of the Basic strategy developed earlier.

¹⁵ Warning: avoid discussions with die-hard rallyists regarding SOP class rules. The term SOP has been applied to a mind-numbing variety of class rules and every rallyist

seems to covet their favorite definitions as the “right way to rally”.

Some areas limit the amount of calculating equipment you can have when running this class. So, in addition to the Stock navigation strategy, we will develop a variant which uses no calculating equipment, called the Limited-Stock navigation strategy.

Speedo Class

A few regions use a major variation on the Stock Class rules which prohibits the use of the stock odometer. Running under Speedo class rules is a fundamentally different style of rallying from the National-C rules since only speedometers can be used to keep you on time. Use of the stock odometer in events with a Stock Class allows the navigator to compute a cumulative 'early/late' reading while Speedo Class teams have no such luxury. This variation in the rules calls for substantially different navigation methods by the top teams.

Since areas which run a Speedo class also call it "Class C" or "SOP Class", there is often a great deal of confusion with Stock Class.

As with Stock Class, we will develop both a Speedo navigation strategy (with calculators and tables) and a Limited-Speedo navigation strategy (with no calculating equipment).

Odo Class

Most areas have a class which allows arbitrary mileage measurement equipment (precision odometers which can be calibrated) and slide-rules or tables. Our Odo Class strategy is suitable for this class.

This class is variously called Class B or Unequipped and there are a number of subtle variations in this class definition. Most notably:

- The use of a precision speedometer which can be calibrated may or may not be allowed.
- Some areas allow use of an accumulating calculator (such as a Curta).
- Some rules allow teams with just a stock odometer to run in the Odo Class with more calculating equipment than would otherwise be allowed.

In practice, precision speedometers and calculators are not necessary. Also, a hundredth-reading odometer which can be precisely calibrated provides a huge advantage in accuracy over a tenths-reading non-correctable stock odometer. Teams running with a stock odometer are at a disadvantage regardless of the calculating equipment they are allowed to use.

Computer Class

This class seems to be the haven for technophiles, computer freaks, and zero-heroes: anything goes in the way of calculating equipment. In practice most Computer Class teams run with one of the off-the-shelf **A-Boxes** available from a small number of manufacturers who specialize in these items. These units generally use a precision odometer (as in Odo Class) with the additional capability to input assigned speeds and pauses to provide a constantly updated reading (known as a **null unit**) for

Summary of Navigation Strategies														
Strategy	Chapter	National	New England Region	Metro	Clock	Stock Speedo	Custom Speedo	Stock Odo	Precision Odo	Computer	Simple Calculator	Cumulative Calculator	Slide rule/Tables	Cost
Basic	4, 5, 6	-	Class D	Novice	X	X		X			X			\$70-150
Stock	4, 5, 6, 10, 14, 15, 18	Stock	-	-	X	X		X					X	\$70-150
Limited-Stock	4, 5, 6, 10, 18	-	-	Class C	X	X		X						\$50-120
Odo	4, 5, 8, 9, 10, 11, 13, 14, 15, 19, 20	Unequipped	Class B	Class B	X				X				X	\$250-500
Computer	4, 5, 8, 9, 10, 11, 13, 14, 19, 21	Equipped	Class A	Class A	X					X	X			\$500-1400
Speedo	4, 5, 12, 14, 15, 22, 23	-	Class C	-	X	X						X	X	\$70-150
Limited-Speedo	4, 5, 12, 15, 23, 22	GAR [Ⓢ]	-	-	X		X							\$150-250

Table 7-1

- ① Great American Race – not really a national class, but since this popular event runs across the country, I stuffed it in this column.

the driver as to whether they are early, late, or on time.

Which Class?

Which class competitors choose is, unfortunately, often decided by what equipment a team can borrow/afford, when they graduate from Novice. When you consider the amount of time you spend rallying over the years and the amount of investment a good team has in their navigation method, it is worth spending some time choosing the best class for you.

One excellent way is to ride in the back seat of a top team in each class for a few miles of real or simulated rallying to get a feel for what skills are called for. At the very least, talk to some teams and try to get a feel for what they like and dislike about the rules under which they run.

Table 7-1 summarizes the navigation strategies covered in this book along with a quick outline of the chapters most relevant to that strategy.

Strategy, Philosophy, and More Etiquette

Before you jump off into one of the advanced classes, a few more words about the less tangible aspects of running as an “experienced rallyist”.

The Press On Regardless Pro Rally is known for some of the toughest conditions in the sport. It is also known for some of the toughest competitors. Overcoming adverse conditions is one thing, but overcoming your own mental barricades and excuses can prove even tougher. By now you probably understand that getting a 20 on a leg is disaster for a Computer Class team. Staring at the control slip and knowing that the error was your fault (&\$?@#!**) can mentally take you out of the competition. Psyching yourself out of giving up takes willpower. “Everyone else got a 25”. “They will throw the leg”. Whatever it takes, keep going.

Remember the help you got on your first rallies from more experienced teams? Pay that back by helping Novice teams who now look to you for advice. Include them in the conversation. Find out how they managed to zero two controls even though they max'd all the rest. Break the clique occasionally and help the sport grow.

If you talk to the press, you are immediately a spokesperson for the sport. Remember that they may understand little of the fundamentals of TSD rallying. They equate it with racing and issues of speed on public roads immediately come up. If you are

interviewed regularly, practice your interviews. If you are the driver, include the navigator – the man on the street does not understand drivers versus navigator roles. Also, stress the full range of the sport from Sunday afternoon novice rallies through adventures across Alaska.

Claims

One of the most troublesome areas of the sport is the claims process. A claim is a written request by a team for the organizers to adjust the team's score to compensate for some situation. Claims are typically allowed or denied by a committee made up of organizers as well as competitors (who have not, themselves, written claims).

The more you compete, the more you will begin to see or suspect situations where artfully written claims and back-room politics have as much to do with top placings as does skill. If you think you would never stoop to that level, wait a while.

It starts out very innocently: you blow a leg, but it gets thrown because of some unrelated issue. What Luck! A couple of rallies later you blow another leg. You feel frustrated and want nothing more than to “fix” the error. Then you find some technical inaccuracy in a later route instruction on that leg. You could put in a claim and, with the right argument, “cover your error”. If the technique is not obvious the first time around, it will be after you serve on the claims committee a few times and after you read how claims are written.

Drawing a moral line for yourself is difficult in the heat of competition. The pressure to win sprouts phrases like “Well, there was an error”, “Well, that team did the same thing last month”.

One answer to the claims process is a scrupulously clean event which leaves no opportunity for bad-faith claims.

Unfortunately, not all rallies are blessed with a rallymaster and checkers of enough experience and preciseness to make this happen.

After a lot of not-so-successful soul-searching, the one thing which really helped us with these issues was a line written long ago by the organizers of the MG-1000 rally: “Don't run to the Claims Committee to get a better score than you deserve”.

Part 3 – Rally Equipment



8. Equipment Basics

Take three months to prepare your machines and three months to complete your siege engineering.

— Sun Tzu,
The Art of War
(translated by Thomas Cleary)

Once you choose a class and have thought about the basics of a navigation strategy, it is time to select from among the various equipment components available. Some teams, especially in the Computer Class, choose a single box which has all the features and displays they need to navigate in their class. Other teams, especially in Stock Class, find they need to “roll their own” setup to suit their navigating style. In Odo Class, there are a number of off-the-shelf B-Boxes with dual correctable odometers and clocks, but many teams choose to add one or more clocks or odometers to the basic setup to handle special problems.

Before we go into the types of specialized rally equipment in detail, we will take a chapter to look at some of the basic considerations pertaining to all types of equipment.

Reliability

Nothing is more frustrating than to spend the time, energy, and expense to get to an event and then have your equipment flake out. Maybe your clock overheats and shuts itself off. Maybe your odometer decides to count mileage in time with the windshield wipers. Or maybe your car just decides not to compete in the afternoon section and refuses to budge from the lunch spot. Whatever fails, it becomes the weak link which puts you out of the event.

Avoiding such failures requires reasonable attention to the reliability of every component you use on a rally. Something as simple as a burned out flashlight on a night rally or a pen running out of ink could cause enough confusion to put you out of the running.

When it comes to specialized rally equipment, reliability should be high on the evaluation list. Talk to a sampling of competitors who use the equipment you are considering and get their experience with the units. Also, take extra care when installing the unit to ensure that all power and shielding requirements are more than adequately covered.

Consider the environment that these units live in: constant jarring, heat and cold, and noisy power input with occasional high-voltage static. Now consider how important these units will be to your enjoyment of rallying: trying to run Computer or Odo Class with a flaky odometer will quickly sour a team to the precision side of this sport! Talk to other owners of the unit you are considering to get a list of the known problems and general track record of the unit and the manufacturer.

Also, a great deal of information can be obtained from the owners manuals before you commit cash to these expensive units. Study them carefully to make sure that they have the features and functions you are looking for in your navigation system.

Also, consider the service which the manufacturer provides on the unit, again by getting other competitors experiences with the manufacturer.

Displays

There are three basic technologies a manufacturer can use to build an electronic display.

Incandescent displays use a set of 7 tiny light bulbs for each digit. Given the amount of variation in ambient light in rally situations, a display should be bright enough to read in bright daylight and be adjustable to a dim setting which is comfortable to read in deep blackness. Since the display will not be readable if direct sunlight is shining on it, a visor may be needed to

prevent this situation. One problem with incandescent displays is that the tiny bulbs can burn out just like any other light bulb. For this reason, this technology is rarely used in modern units.

Light Emitting Diodes (LEDs) glow. They work exactly like incandescent displays except that the diodes which form the segments of each digit have an absurdly low failure rate. The brightness issues are the same as for incandescent displays.

Liquid Crystal Displays (LCDs) are the usual choice for digital watches, since they can be inexpensive and require very little power. The segments of the digit don't glow – they turn black against a gray background. For this reason, LCDs are unreadable in low-light situations unless they have a backlight feature to illuminate the gray field. Also, some LCDs are difficult to read from certain angles. Make sure the display is readable from a given angle prior to permanently mounting it, or mount it on a swivel so that the angle can be changed.

Temperature is also an issue with LCDs. The contrast of these displays is reduced at low temperature, usually noticeable below 30°F. At over 130°F, the display will begin to darken and turn completely black. Since a dashboard can easily reach 160°F on a hot, sunny day, you need to take precautions against direct sunlight and lack of airflow. Even if the display does “black out”, the unit is usually not permanently harmed, and will still operate (if no other components are so temperature sensitive). However, you will

need to cool it down before you can read any data.

Finally, there is the issue that the LCD is composed of a toxic material encased in glass. While most designers will fit an unbreakable cover over the glass display, if the display should ever break, do not touch the LCD ooze!

Basic Functions

There are several basic functions which can be applicable to a variety of displays, whether they read time, distance, or some other quantity.

Initial Setting

The first function is to be able to set the display to some value. While this function seems obvious, some displays cannot be set as easily as others. If your navigation strategy requires a display to be set quickly in order to calculate an early/late reading, the ease of setting the display can be very important.

Consider a clock, for example. Some analog watches can only be set at the top of the hour. If you miss setting it, come back in 60 minutes! Many clocks can be set at the top of any minute, but even this capability may not be sufficient for certain applications.

Many clocks will tick in seconds or cents starting from when they are first turned on. The value they read may be adjustable, but the cadence is not. If you require a high degree of precision (such as in the Computer Class), such a clock will often be out of

phase with the time standard. This may require you to power the clock down and start it again. A clock which can be adjusted in increments which are finer than cents can be **bumped** so that the display is in exact phase with the standard.

Some units can synchronize a display automatically to some standard. For example, some clocks can be plugged into a master clock and **slaved** to the master to get it synchronized exactly. Other clocks can be slaved to a broadcast time signal.

Adjustments

If you must frequently add to or subtract from a display, you need a feature which allows you to do this while the display is still running. An example of this is a clock which you are using as an interval timer (such as for our Odo Class strategy described in [Chapter 20](#)).

One very useful feature in making adjustments is the ability to see how much is being added or subtracted from the display. Most units use one of two methods:

- You first enter the amount you want to add/subtract into an auxiliary display and then activate a master ADJUST switch to alter the main display.
- You first zero an auxiliary display and, as you directly adjust the main display, the amount of adjustment is also shown in the auxiliary display.

Direction

Another basic function is to be able to run the display in forward or reverse, or to stop

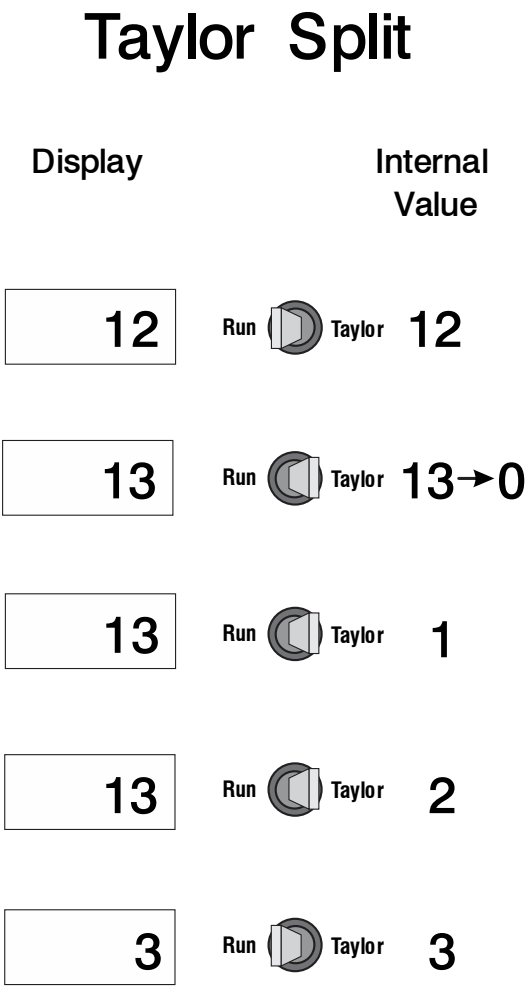
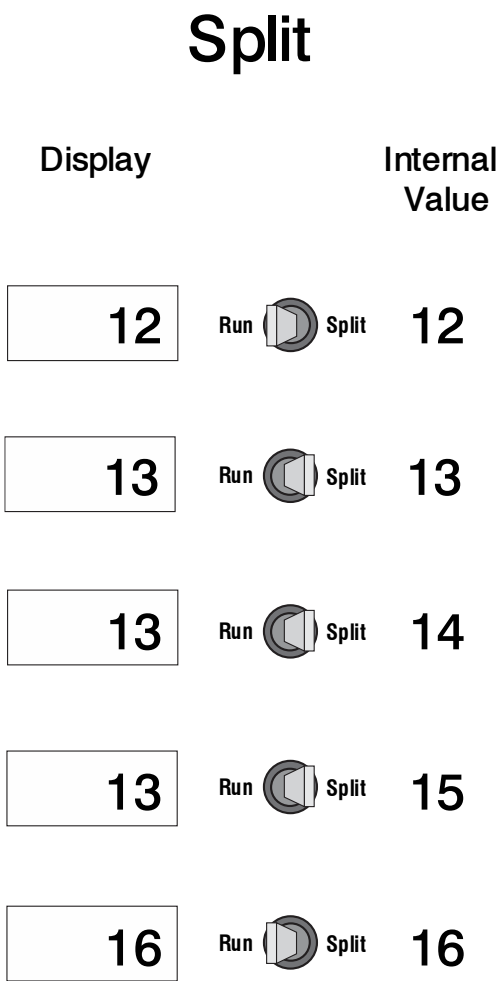
the display from counting. This is most useful on the odometer display for handling off-course excursions, but can also be useful for clocks used as interval timers, stopwatches, or count-up/count-down timers.

Split

The final basic functions involve freezing the display so that the value can be recorded or adjusted. The *split* function¹⁶ freezes the value shown in the display, but allows the

value to keep counting internally. This is accomplished by freezing the display when a switch is thrown to SPLIT and then returning the display to its normal counting mode when the switch is returned to RUN.

Another method is the dual *bank split*, which uses two displays: the normal display counts continuously and the bank display instantaneously records the value whenever a SPLIT switch is activated. You can see the running value while recording the split



Split vs. Taylor Split

¹⁶ The term “split” comes from a common feature on analog stopwatches, as discussed in the next chapter.

value shown in the bank display. Often, the bank can store many split values and they can all be reviewed by recalling them one by one from the bank. Such features are often found on clocks designed for checkpoint use or in competition computers which store the critical information at speed changes.

Taylor Split

A cousin of the split is the **Taylor** or **Taylor-split**. This function works just like the ordinary split function, except that the internal value is reset to zero when the Taylor split is activated. The value counts internally (from zero) while the display is frozen, just as in the ordinary split function.

Dependence

A display can function **independently**, or be **dependent** on some other display. The rally unit may allow you to select between these two modes.

An **independent** display counts some quantity, such as time or distance, by direct measurement. If you have an independent odometer and could see many digits to the right of the decimal point, you would see the far right digits (to the right of the 0.001 digit) change every few feet.

A **dependent** display is linked to some other display (on which it depends). A position in the dependent display changes whenever the corresponding digit in the other display changes. For example, if you have an odometer which is dependent on another independent odometer, the hundredths

position of the dependent odometer would change whenever the hundredths position of the independent odometer changed. Such an odometer is dependent at the hundredths position.

Power

How a unit is powered is an important consideration in choosing equipment. The basic choices are a battery-powered unit, one which requires external power, or some combination of the two.

Battery power comes in many flavors. If the unit draws little power, a replaceable battery may be sufficient. Replacement time is an important issue, as well as the cost of the replacement battery. One current production clock with many features runs for a year on several AA batteries. Because of the low cost of replacement and long lifetime, this unit does not even have an on-off switch! Such a power setup is currently only possible using LCD technology.

Units which draw more power usually use a rechargeable battery. Such units can either be recharged between uses, or continuously during use, from a 'trickle charge' if a car-battery power source is available (usually through the cigarette lighter).

In the case of Nickel-Cadmium (NiCad) rechargeable batteries, there are a few issues:

- Recharging the battery too fast causes excessive pressure inside the cells. To prevent an explosion, most NiCads have a

vent which bursts. Once the vent is open, the battery quickly dries out and is useless.

- NiCads can develop a “memory”. This happens if the battery is partially discharged to the same level many times and is never fully discharged. The battery “remembers” where that partial discharge point is and will not provide any more power after that point. The prevention is to occasionally discharge the battery fully before recharging.
- Finally, if you have a multi-cell pack of NiCads, if one cell is more discharged than the rest, it may reverse polarity. After this, the cell might recover with recharging, or it may be useless.

Units which require external power must be hooked into the electrical system of your car. While you may be told that this is as simple as “*just plugging it into the cigarette lighter*“, you will come to know better after reading [Chapter 11](#), which discusses permanent installation of these units. When it comes to competition, a bit of extra care in installation goes a long way in reliability!

Finally, there are units whose primary power is from an external source, but which have an emergency backup battery, in case of power or fuse failure. These batteries are often available as an option when you order the unit, and are highly recommended. Many will not have enough power to run the displays, but will allow the unit to save all the internal data and keep counting time and miles while you correct the problem.

Resolution, Accuracy, and Precision

There are two attributes of a piece of rally equipment which can directly relate to your score: resolution and accuracy. **Resolution** is simply the fineness to which you can read a measurement. For example, a sundial typically resolves to, at most, the nearest ten minutes while a digital wrist watch usually resolves to the nearest second.

The other desirable attribute of an instrument is that its measurement of a quantity agrees with some chosen standard, to the degree of resolution of the instrument. This is **accuracy**. At any given time you want your clock to agree with the “correct” time and your odometer to match official miles.

This book uses the term **precision instrument** when referring to instruments of some level of resolution and capable of being set accurately. For clocks, the resolution is to the cent and, for odometers, to the hundredth of a mile.

Attaining Accuracy

In general, resolution is a fixed attribute of an instrument, while getting an instrument to read accurately can be quite a science and, in some cases, an art. As you advance in the classes it will become apparent that success, especially in the computer classes, depends on your ability to measure distance with resolution (hundredths or thousandths of a mile) and accuracy (matching official miles).

So how do you get an instrument to read accurately? The easiest way is to set the

instrument to match your standard at some point and then get it to keep **pace** with the standard. Since setting the instrument is often straightforward¹⁷, the challenge is getting your instrument to keep pace correctly. This can be done in two ways: correction and calibration.

Correction

The first is to apply a **correction formula** to any reading the instrument produces. You plug the instrument's reading as well as other values into the correction formula to get a corrected reading. We saw a simple case of a correction formula when we applied a **correction factor** to a stock odometer reading to get an approximation of official miles. However, a correction factor is only a very simple case of a correction formula. You could imagine a situation where the correction factor changes depending on some other variable, such as the surface of the road. Say you discovered that official miles read 1.06 time car miles, but only as long as you were on pavement. On dirty roads, the correction factor changed to 1.07. Your full-blown correction formula would then take into account your car mileage and the road surface.

Why all this discussion of correction formulas and factors? Doesn't a simple factor suffice? In practice, a correction factor will get you good accuracy, but probably not enough to win trophies in the upper classes.

The story of competitors in the yearly Great American Race (GAR) demonstrates this point.

The GAR is a cross-country rally of antique cars and they must rely primarily on a speedometer for navigation. The team of Justus Taylor and Val Stegemoen compete in a 1936 Dodge Panel truck sponsored by Hemmings Motor News. They filled me in one day on what it had taken them to get accurate speedometer readings. When they started running this event, they would simply come up with a correction factor for the speedometer. This produced surprisingly poor results and they were puzzled until they figured out that the factor varied significantly with temperature. They expanded the correction formula to include a check of a thermometer near the back of the speedometer.¹⁸

This worked fine as long as they were on a flat course. When they ran a hilly leg, their scores would soar. Why? The speedometer was driven off revolutions of the rear wheels. When they went uphill, the rear wheels bore more of the weight of the 4000 pound truck and the balloon tires would squash out, decreasing their diameter and increasing the number of revolutions the wheel made per mile! Their correction formula was then expanded to include the gradient of the road.

¹⁷ with notable exceptions in the case of stock odometers, trip odometers, and speedometers

¹⁸ They later fitted the speedometer with a light bulb and a thermostat which kept the unit within a constant temperature range.

Calibration

One big problem with correction formulas is that they are done by hand. The navigator consults the instrument and then has to perform some calculation(s) to come up with an accurate reading. To get around this problem, various models of rally equipment allow you to enter a simple formula right into the instrument. To distinguish from a formula which is applied by hand, a formula which is entered into an instrument is called a **calibration formula**. These features are prevalent on rally odometers which let you enter a **calibration factor** into the unit to allow the unit to read in official miles.

Does all this mean that you have to start out in the upper classes by analyzing every item which could possibly affect your factor. No. Just keep in mind that many kinds of things can affect the accuracy of your instrument and be prepared to adjust your instrument and alter a simple correction factor as conditions vary.

9. Clocks

Time is an illusion perpetrated by the manufacturers of space

— Murphy's Laws of Computers

The first type of specialized equipment which we will examine in depth is the rally clock. Because rally timing is often done in cents and because of the special features many rally clocks provide, general-purpose clocks and watches are usually not suitable

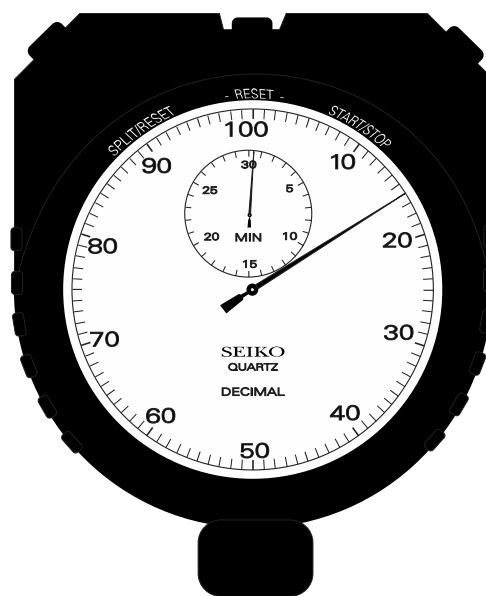


The Heuer model 11404

for rally use in the upper classes.

Analog Watches

Before the advent of small, low powered, and inexpensive electronic components, the standard rally timepieces were precision stopwatches. They are small and easy to operate, but have some serious drawbacks for modern rally use.



The Seiko model 020

The better ones are quite costly and require regular maintenance to keep them reading within the required degree of accuracy for the duration of an event. Also, many of the watches with a face marked off

in cents were designed for use only as a stopwatch. Some of these can be difficult to use as a time-of-day watch since they must be set on the hour. If you miss the top of the hour, you have to wait another 60 minutes to set the watch!

As strange as it may seem, a major problem with analog watches is in reading the time. Many watches have two hands which count off the cents in unison. When you want to record a time, you press a knob on the side of the watch. This causes one of the two hands to stop in place. It gives the impression of splitting the cents hand in two, which is where the term *split* originated.



The Chronar T-100 competition clock

After you split the stopwatch, you can read the cents from the frozen hand. However, you must read minutes from the minute hand which is still in motion, and this can lead to errors. If the split knob was pressed near the end of a minute, the minute hand will read close to or past the next minute and you can easily read the time as one minute later than the actual time that the stopwatch was split.

For these reasons, analog stopwatches are best used for measuring small intervals of time, such as a pause or a delay, or for use as a backup in case of electrical failure.

This Seiko stopwatch is an example of an electronically powered analog stopwatch which is in current production. These are useful as interval timers in some navigation strategies.

Aside from rally distributors, the Meylan Corporation (see Appendix A) is a source for a variety of clocks and stopwatches, as well as counters and other items of interest to rallyists.

Digital Clocks

Generally the first piece of equipment purchased by a rally team is a precision digital hundredth-reading clock. If nothing else, it eliminates the need to convert between seconds and cents. It is also legal in any class.

Modern rally clocks tend to be broken down into three categories, and you should be aware of the difference between them:

- Stand-alone clocks for use in competition,
- Stand-alone clocks designed for use at checkpoints, and
- Clocks which are integrated with odometers or rally computers

Clocks that are built specifically for competition usually have a way to set them precisely and a way to split the displayed time. The more complex (and more expensive) checkpoint clocks usually have

the ability to store multiple splits (to time closely-spaced cars arriving at the timing line) and allow the split times to be recalled in sequence.

Stand-alone Competition Clocks

This section looks at some competition clocks which are available new or on the used market.

One of the most basic clocks designed for rally competition is the Chronar T-100. Although it is quite simple, it has features useful in many navigation systems.

The sole incandescent display shows minutes and cents. Hours are not displayed, nor are they necessary. If you are an hour off, you have more problems than a rally clock can solve!



The Zeron 80 competition clock

The button on the front of the unit splits the time display, which resumes when the button is hit again.

Another clock of the same basic functionality is the Zeron-66. While these basic clocks are no longer in production, there are many serviceable models rattling around in rallyists' basements and they appear in dealers' stocks from time to time.

One step up from the Chronar T-100 and the Zeron 66 is the Zeron 80. This clock has a few added features which are useful in some situations or strategies.

The LED display shows minutes and cents. The switch at the lower left splits the display (it is labeled ✓•).

The knob at the lower right is used to set the clock and control the brightness. The Z position zeros both the minutes and cents, the S position “speeds” the clock at 36 times its normal rate, and the H position holds the clock at its current value. To set the clock, you align the time to an even minute or other convenient time using the S and RUN positions. The idea is to set the clock to a time in the near future and then select H (hold). At the appropriate moment you switch from H to RUN and the clock is set.

An interesting feature of this clock is the RC or “Recall” position. When the time is split, moving from RUN to RC allows you to see the running internal clock without losing the split time. This allows you to split the clock at a checkpoint and, if you don't agree with them as to your arrival time, show them both the split arrival time as well as your running time (demonstrating that the clock is set properly).

One more feature of this clock is remote activation of the split function. This consists of two wires which, when connected, perform the same function as hitting the split switch on the front. A *remote split* allows a clock to be tied in with other units, such as odometers, and allows them to all be split at once.

Finally, there is the model GCW-1001 clock made by Heath. This clock has rather limited features when it comes to rallying, with one unique exception: it sets itself automatically from WWV transmissions (see below). In practice, this does not prove to be terribly useful since it can take up to an hour to synchronize itself if the WWV broadcast signal is not strong and it may never set itself if the signal is weak. There



The Zeron 88 checkpoint clock

are also some rather bizarre issues about which particular time standard is actually used by this clock, as we shall see later in this chapter.

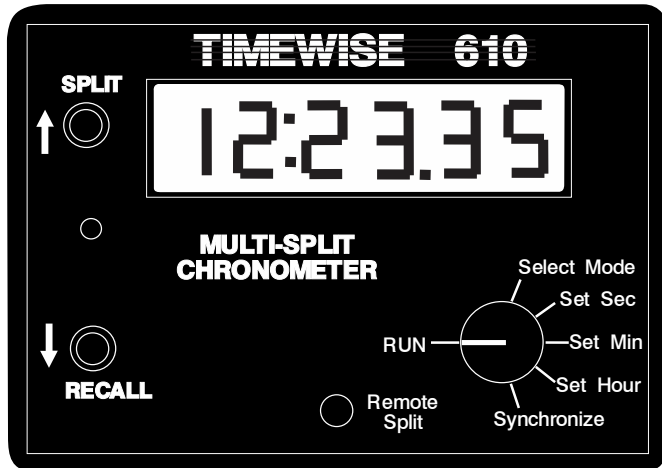
Checkpoint Clocks

The standard checkpoint clock for many years has been the Zeron 88 clock. This clock uses an LCD display and is powered by 4 AA batteries which last for about 500 hours of use.

Setting a Zeron-88 is a bit more complicated than the other clocks, but we include it here since this model is used so often at checkpoints:

- Turn the control knob to LO BAT. If your batteries are good, the display will go blank. Weak batteries cause the display digits to appear wavering or faint. Perform this test only momentarily, since the LO BAT mode uses about 1000 times more power than the RUN mode.
- Turn the control knob to ZERO.
- At the top of a minute, turn the control knob to SET. Since this knob may have a stiff feel, it helps to rock the knob from ZERO to SET and back, in cadence with the clicks which precede the top of the minute.
- Once the control knob is in SET, the cents begin counting. In addition, the minutes begin advancing at the same rate as the cents. The idea is to wait for the correct minute to appear in the minutes and immediately switch to RUN. This can

be an adventure if the minute is 0 or 1.
You will need some practice.

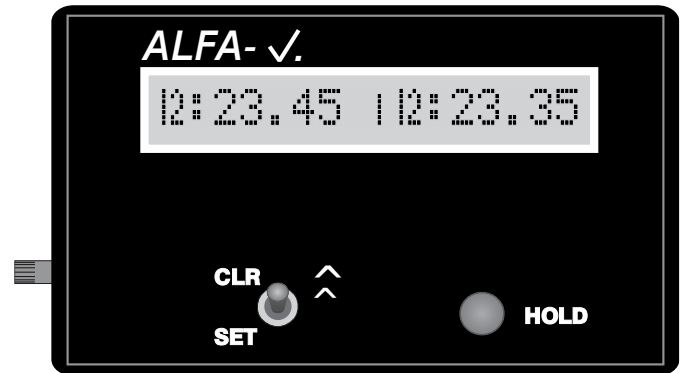


The Timewise 610 checkpoint and competition clock

Zeron-88 Operation

The two buttons on the right are used to split the clock (ENTER) and return it to run operation (RECALL). Two buttons are needed because multiple splits can be entered. This is useful at a checkpoint when several cars arrive in rapid succession.

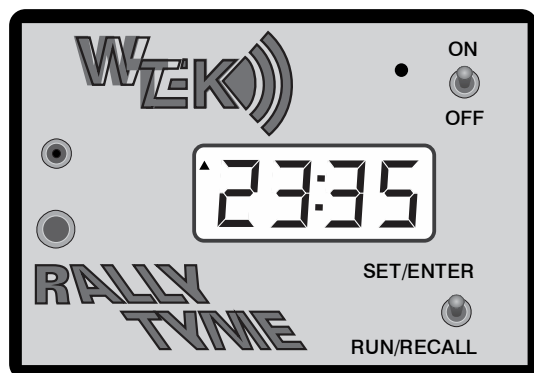
- As a car arrives at the timing line, press ENTER. The split time now appears in the display.
- Record the split time and press RECALL to return to time of day in the display.



The Alfa Checkpoint clock by Small Systems Specialists

- If more than one car arrives in a short time, press ENTER for each car as it crosses the timing line. Depending on the version of the clock, up to 16 times can be stored. The split time of the first car will be shown in the display.
- To recall each car after the first, press RECALL. Again, there are two versions of the clock which operate differently in this situation. One will give you the split time of each subsequent car every time you press RECALL until you have seen all the times. The other version displays time of day between each pair of split times, so you have to hit RECALL twice for each split time stored in the clock.
- The clock displays three vertical dots between the minutes and cents whenever split times are stored which have not yet been recalled.
- Three horizontal dots indicate that the clock's split memory is full.

- If you press RECALL when no split times are stored, the clock display goes blank. Press RECALL again to restore the time of day.



*The WesTek RallyTyme
checkpoint & competition clock*

Several stand-alone rally clocks have recently come on the scene which sport quite a few features. Although these clocks were designed for checkpoint use, they are versatile enough for use in competition and you may find some of their features useful in a navigation strategy.

Since it is not our purpose to review, evaluate, or recommend any particular model of equipment, we will show several current-production models along with a list of some of their advertised features not listed in the summary table. You can refer to the manufacturers and distributors in Appendix A to get more information.

- Dual time displays with a bank split feature.
- The time can be set to any hour and minute, then externally started by a trigger. This allows any number of clocks to be synchronized simultaneously to a time standard.

- Designed to work in conjunction with an infrared trigger to split the clock. The trigger senses the motion of cars passing in front of it. The infrared trigger works with any clock.
- Internal light for viewing in the dark.
- Extended operation (about a year) on AA batteries.
- No ON/OFF switch
- Incremental adjustment of time by tiny amounts
- Internal light for viewing in the dark.
- Operation to 0.001 minute (tenths of cents) and tenths of seconds on units after November 1992.



WeatherRadio Timekube® by Realistic®

Time Synchronization

This section looks at the details of getting your clock accurate with respect to a common time standard. We will look at the common methods first, and then get into some of the esoteric aspects of time synchronization.

Time via Radio

The common way rallyists set a clock is to use one of the small, portable, and inexpensive radios which pick up one or more frequencies on which a time standard is broadcast.

These radios receive **Universal Coordinated Time** (UTC) broadcasts transmitted over station WWV from Fort Collins, Colorado and station WWVH from Kekaha, Kauai, Hawaii. Both stations transmit on frequencies 2.5, 5, 10, 15, 20, and 25 MHz with the strongest broadcasts (10 kilowatts) on the 5, 10, and 15 MHz frequencies.

Each broadcast has an elaborate program which cycles every hour and includes major storm warnings, information on geophysical events (e.g. solar flares), and forecasts on the quality of the broadcast signal over the next 8 hours. The primary information on the UTC time standard is given as *ticks* on the seconds of each minute, with the ticks for the 29th and 59th seconds missing. An added *BEEP* overlays the *tick* at the top of the minute. The top of the minute is also preceded by a 7½ second voice announcement, which tells you which hour (in Greenwich, England) and which minute are coming up. A male voice is used on WWV and a female voice on WWVH to distinguish the two stations.

In Canada, station CHU transmits UTC from Ottawa on frequencies 3.330, 7.335, and 14.670 MHz, with 7.335 MHz carrying 10 kilowatts.

Time via Telephone

If you don't have a radio, you can get the time over the phone by calling one of the following numbers (all are toll calls):

- (303) 499-7111 – Boulder, Colorado number which is a copy of the UTC broadcast on WWV. This is limited to 3 minutes per call.
- (808) 355-4363 – Kauai, Hawaii number which is a copy of the WWVH broadcast. This is also limited to 3 minutes per call.
- (900) 410-TIME (8463) – From the U.S. Naval Observatory. Time is given every five seconds, with announcements alternating in local time and “Universal time”.

These numbers have an unpredictable delay due to the quirks of the phone system. This is usually less than 0.03 seconds – not a problem for rally applications.

Setting the Clock

Once you have a time standard, there is the matter of actually getting your clock to agree with the standard. Ideally this should be done electronically, but many clocks can only be synchronized manually. This typically yields discrepancies of, on the average, 0.2 cents on a sampling we took one day of identical (Alfa Checkpoint) clocks set by different people. This suggests that all checkpoint clocks should be set by one person.

One issue is the **anticipation problem**. Let us call the action which starts your clock moving **START**. The person setting the clock should not press **START** in response to the

time synchronize signal (the *BEEP*). They must anticipate the signal. If you are listening to a WWV broadcast, tapping your foot in time with the ticks can help. Also, some clocks are designed to allow you to rock the START switch back and forth in time with the ticks to give you a feel for the switch.

Clocks which can only be set on the top of the minute have a disadvantage since the 59th tick is missing and the announcement before the top of the minute is a distraction. If your clock can be set on any cent rather than just 00, you might find that selecting 10 (cents) and waiting for the 6th (second) tick after the top of the minute gives you better results. You also need to know whether the clock starts when the button or switch is pressed or released. Whatever you do, practice this before the morning of the event!

And now, on to the esoteric aspects of timekeeping we promised earlier:

About Time

Quick: *How many seconds are there in a minute?*

60? Usually, but sometimes there are 61 and there can even be 59! How this happens is based in the history of how we measure time. The story is not a simple one, especially if you are among the set of people such as astronomers and ocean navigators who need great resolution and accuracy against a cosmic standard such as the location of a star in the sky at a given instant.

As we learned to build clocks of increasing resolution and stability, in the early 1900s, a standard second was agreed upon by clock manufacturers. This was based on the time it took the Earth to go around the sun in the year 1900. The International Bureau of Weights and Measures (IBWM) keeps a herd of 64-pound cesium clocks running in order to provide the world with a time standard. This cesium based time is known as International Atomic Time (TIA).

Unfortunately, the exquisite stability of these clocks did not help astronomers very much. Due to several flukes in the cosmic ointment, the Earth is slowing down. The year is longer now than in 1900, so there are more beats of cesium in a year than before. To further complicate matters, the Earth rotates at different rates throughout the year because of wind patterns and the movement of the molten core of the planet. In fact, the cesium clocks beat with far more stability than the Earth rotates!

To satisfy the astronomers, a new standard called Universal Coordinated Time (UTC) was created in 1972. Like TIA, UTC always has seconds of the same duration.

Occasionally, UTC has a full second added or removed to keep it in line with the time needed by astronomers, which is called Universal Time One (UT1).

This errant second, called a **leap second** is applied to UTC (cesium based) when it diverges from the astronomical observations made by the U. S. Naval Observatory by about 0.7 seconds. Of course, the leap seconds have made UTC diverge from TIA,

which is the pure uncorrected cesium atomic time. A total of 16 leap seconds were added to UTC from the start of 1972 and prior to 1991. So, UTC and TIA counted exactly 16 seconds apart in early 1991.

But this scheme means UTC can differ from UT1 by as much as 0.7 seconds. This is not a good situation when you are trying to navigate using a star which travels over the equator at better than a statute mile every 4 seconds. To satisfy them, a scheme of double ticks is used on broadcast transmissions to inform you of how many tenths of a second to add or subtract from the UTC ticks to get UT1 accurate to within 0.05 seconds. You can hear these double ticks (called DUT1 ticks) on the first 16 seconds of broadcasts.

While all this techno-jargon might make great party conversation, what does it all mean for rallyists? It means that you had better know to what standard you and the checkpoint crew are synchronizing!

There We Were on One Lap of America, a 2600 mile “rally” lasting 4 (24 hour) days. Most of the event that year was based on performance runs on various race tracks, with a single precision TSD up and down Chimney Rock, North Carolina. We had a Heath “Most Accurate Clock” (GCW-1000) on board which had refused to synchronize itself until 5 minutes before the start of Chimney Rock.

Eureka! Now we've got “perfect time”!

In fact, the Heath had used the DUT1 ticks to synchronize itself to UT1 and the

checkpoint clocks were set manually to UTC. Murphy's Law dictated that these two standards were almost at their maximum (0.9 cents) divergence and we got a 1 on all but one of the six checkpoints.

Alas – like roads not legal to enter, “perfect time” does not exist.

Another issue: What happens if you are running on time when the folks at IBWM decide to throw in a leap second? One of your UTC minutes then has 61 seconds and, if the checkpoint crew resynchronizes and you do not, you will arrive 1.67 cents early.

To limit this problem to reasonable proportions, leap seconds only appear at the end of a month (usually June 30 or December 31) and with significant warning. If the number of double clicks you hear in the first 8 seconds of a minute is five or more, a leap second may be in the works for midnight UTC on the next June 30 or December 31. This could be anywhere from 4 PM to 8 PM local time in the continental U. S. depending on your time zone and Daylight Savings Time.

Clock Calibration

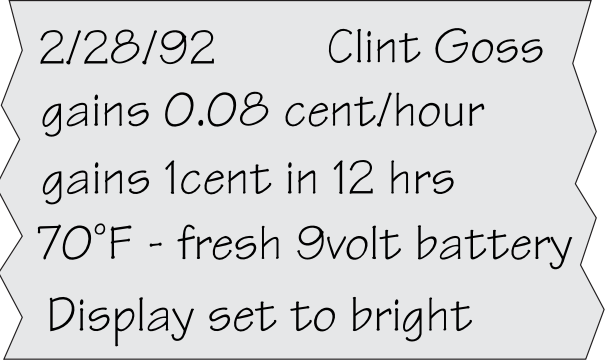
The first thing to do when you get a clock is to test it for drift:

- Carefully synchronize the clock with your time standard and let it run for several days. Keep the conditions of temperature and power supply constant during that period. Then compare the clock with the

time standard again and divide the error by the number of elapsed hours. Then note your measurements, with the following information:

- Date.
- Gains/loses # of cents per hour.
- Temperature.
- Power conditions.
- Any other conditions which might affect the pace of the clock.
- Your name.

Place this information on a sticker or tape on the back of the unit. Do not remove older stickers – they provide a basis of comparison.



2/28/92 Clint Goss
gains 0.08 cent/hour
gains 1cent in 12 hrs
70°F - fresh 9volt battery
Display set to bright

Summary

The tables which summarize equipment (here and in [Chapter 11](#)) list all known current-production models as well as units which are likely to be found on the used market.

Summary of Clocks																	
Make	Model	Hours	Seconds	Cents	Display	Power	Fuse (amps)	Battery Life	Size (inches) ^⑥			Splits	Ext. Split	Count Down	Master/slave	Approx# Made	Vintage
									Width	Height	Depth						
Alfa	Checkpoint	X	X ^①	X ^①	LED	12v or nicad		24 hr	7.0	3.7	2.7	10	X			50	'82-'88
	Checkpoint	X	X ^①	X ^①	LCD	12v or nicad		24 hr	7.0	3.7	2.7	99	X			100	'88-
Chronar	T-100			X	incand	12v ext	1	-	4.7	2.4	4.7	1	④			250	'75-'82
	T-200			X	LCD	9v bat	-		4.3	2.6	1.3	1				100	'83-'87
Heath	GCW-1000	X	X		LED	12v or 120v AC		-	9.0	3.9	6.3	0					'87-
	GCW-1001	X	X		LED	12v or 120v AC		-	6.0	2.6	5.8	0					'91-
Timewise	610	X	X ^②	X ^②	LCD	4 AA bat	-	1yr	4.0	2.9	1.6 ^⑥	21	X		X ^②	500	'91-
Westbend	40007		X		LCD	A76 bat	-		2.5	2.3	1.0	0		X			
WesTek	RallyTyme		X ^①	X ^①	LCD	4 AA bat	-	1yr	4.0	2.9	1.5	16	X		X ^①	250	'90-'92
Zeron	55			X	LED	12v ext	1	-	4.0	2.9	1.6	1					
	66			X	LCD	9v bat or 12v ext	1		4.0	2.9	1.6	1					'78-'80
	77			X	LCD	9v bat or 12v ext	1		4.0	2.9	1.6	1				250	'80-'82
	80			X	LED	12v ext	1	-	4.0	2.9	1.9	1	X				
	88		⑦	X	LCD	4 AA bat ^⑨	-	1yr	4.3	5.0	1.8	16	X			500	'82-'86

① Switchable between seconds and cents only when the clock is powered up or reset. Likewise for master/slave feature.

② Master/slave and switching between seconds and cents can be done during normal clock operation.

③ Some Zeron-88 clocks have been modified to use a single 9-volt internal battery.

④ Optional feature.

⑤ Including height of protrusions, except switches and knobs on the front panel.

⑥ 10 splits on units prior to December 1992.

⑦ Some Zeron 88 clocks have been modified to operate in seconds or cents, selectable by an internal switch.

10. Odometers

*Winding in and winding out
Leaves a lot of serious doubt
If the lout who built this route
Was going to hell or coming out*

— Author Unknown

This chapter takes an in-depth look at both stock and rally-specific odometers. We will look at how they are driven, how they operate, and how to calibrate them.

Rally-specific odometers are usually integrated into a box designed specifically for one of the advanced classes. These integrated boxes will be discussed in the next chapter. Suggestions on installation of sending units and odometers will be discussed in [Chapter 13](#).

Anatomy of Your Stock Odometer

Most rallyists start out by using the car's stock odometer and speedometer to keep on course and on time. For running Novice Class, a simple correction factor for both instruments is sufficient. However, moving up to Stock or Speedo Class calls for a bit

more sophistication and understanding of these instruments.

Your stock odometer and speedometer are driven by one of two systems: a **mechanical cable drive** or an **OEM¹⁹ sending unit**.

In the mechanical scheme, a flexible cable housed in a metal casing runs from the transmission or drive shaft to the back of the instrument panel. This cable, called the **speedometer cable**, drives an array of small gears, cranks, and ratchets. These are attached to the rightmost drum in the odometer. The rightmost drum is turned one tenth of a revolution for every tenth of a mile (assuming you have an odometer which resolves to tenths of a mile). As each drum rotates from its “9” to its “0” position, it nudges the drum to its left one tenth of a turn.

If you have a purely electronic odometer and speedometer, chances are you have an OEM sending unit. The sending unit may consist of a magnet and a **transducer**, both of which are usually installed in the transmission. These sending units are described later in this chapter.

¹⁹ OEM: Original Equipment Manufacturer

Stock Odometer Functions and Characteristics

Regardless of the type of drive you have, there are a list of questions you should ask about a car's stock odometer:

What is the resolution of the odometer?

Odometers which read only to the nearest mile are useless for rally purposes. You will need a tenth-reading odometer. Stock odometers with greater resolution than a tenth of a mile are usually not allowed in Stock Class.

Can the odometer be reset? This feature is usually available on a secondary odometer called a ***trip odometer***. In the absence of a RESET feature, life will become somewhat more difficult for the navigator, but still workable.

How does the reset knob work? Does it spring back on its own? Is the odometer reset when you push the knob or when you release the knob? What happens if you drive while holding the knob in the reset position?

Can you advance the mileage? Some trip odometers allow this.

Do the odometer drums turn smoothly or in steps? This is usually an issue with the rightmost drum. Some turn smoothly throughout their revolution, indicating that they are driven entirely by gears. Some ratchet driven drums click into position every tenth of a mile (or some other increment). Still others operate smoothly until the transition from “9” to “0”, where they pause and then jump to the “0”.

Does the trip odometer lag after it has been reset? In other words, the car covers a different distance from odometer reading 0.0 to 0.1 than from 0.1 to 0.2. If the odometer sits at 0.0 for a distance, this is called ***odometer lag***. Electronic odometers typically do not have odometer lag.

What happens when you go backwards?

Does the odometer stop, does it count backwards, or does it count forward? Yes, these are all real possibilities! Is there a lag before it starts counting backwards? Many have a lag which is similar to the lag after you select RESET. If there is a lag when you start going backwards, does it match the lag when you go from reverse to forward? Having the same lag switching from forward to reverse as reverse to forward is called ***balanced odometer lag***.

Can the intermediate readings be approximated?

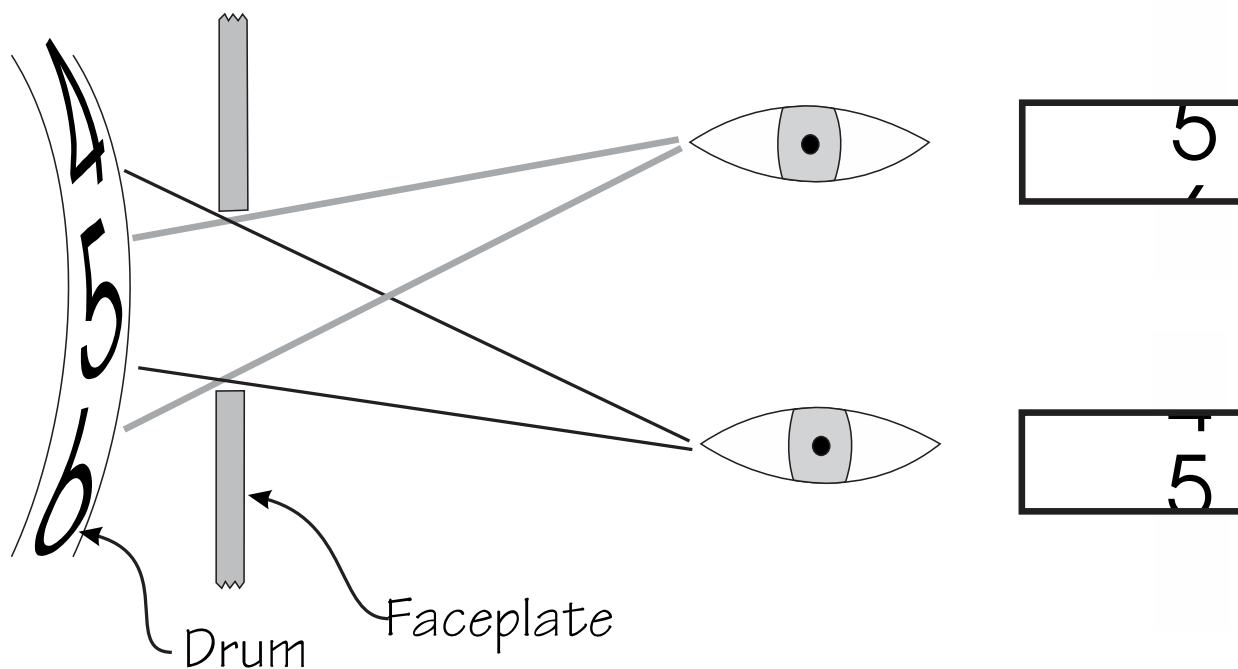
Approximating between two adjacent tenths digits is important in Stock class. Whether you can do this depends on the size, spacing, and shape of the digits inscribed on the rightmost drum. You also need to know which way the drums turn. For example, you will need to be able to tell at all times whether you are between a “0” and a “9” or a “5” and a “6”. The bottom of the “0” and “5” might be identical as well as the top of the “9” and “6”. Electronic odometers have the worst characteristics in this category. They tend to count tenths in discrete steps, with no opportunity to approximate with more resolution.

Can the navigator read the odometer without need of chiropractic care? The driver may be too busy to eyeball the odometer, especially if the navigator needs a reading at the apex of a turn.

Is it well lighted? Can you read it at night?

cannot afford these inaccuracies. Many top teams use one or both of these principles:

- Never reset the trip odometer. The odometer lag is too unpredictable.
- Always have one person read the odometer. This eliminates parallax issues



The heartbreak of parallax

Do you get the same reading from everywhere in the car? People observing the odometer from different positions will perceive different readings if the window in the face plate is not flush against the drum. This phenomenon is **parallax** and can account for two or three hundredths difference between readings.

When running Novice Class, many of the inaccuracies associated with stock odometers could be overlooked. However, advanced teams using a stock odometer as their primary mileage-measuring instrument

if the person always reads from the same position. The person reading the odometer is usually the driver.

Precision Odometers

Precision odometers can be calibrated to read distance at any rate you wish and are capable of reading to the hundredth of a mile or greater resolution.

Mechanical Odometers

When rallyists were first looking for high resolution in mileage readings, they began with a totally mechanical setup: an



The Halda Twinmaster

odometer cable was attached to the car's wheel or, using a **T-connection**, to the stock speedometer cable. The odometer cable caused a mechanical counter in the odometer to increment after so many revolutions of the cable. The rallyist calibrated the counters to official miles using a set of gears on the cable or within the odometer.

Several models of mechanical odometers are still used in all but the most competitive events. For example, the Halda Twinmaster has two odometers which can be run independently, in forward, park, or reverse, and which can be zeroed independently.

In general, entirely mechanical odometer setups have proven robust, but suffer several problems which limit their use:

- You must pack a large set of gears to cover a full range calibration factors, and working with the gears is cumbersome.

- Even with a full set of gears, there is a limitation on how far you can refine the calibration factor. In practice, you cannot attain the odometer accuracy needed for top results in the Odo and Computer Classes.
- Hooking these odometers up to computers is a problem if you want to run in the Computer Class.
- They tick when you are under way. This irritates some teams but gives others comfort by providing a consistent audible beat.
- Handling of the cable can be a problem: it cannot be bent at sharp angles and is subject to fraying, kinking, and jamming. You can install a mechanical “T” connection into your car's speedometer cable. However, this may cause your stock speedometer needle to bounce due to the extra drag of having to turn both the speedometer cable and the mechanical odometer cable.

Electric Counters

The next phase in the development of precision odometers used a mechanical switch to open and close an electric circuit on each revolution of the wheel. A simple counter recorded each cycle. The inexpensive counter shown in the left half of Figure 10-1 could be reset as well.

This new “technology” spawned a crop of home-grown computers for keeping a rally car perfectly on time. These early versions of rally computers used ingenious methods

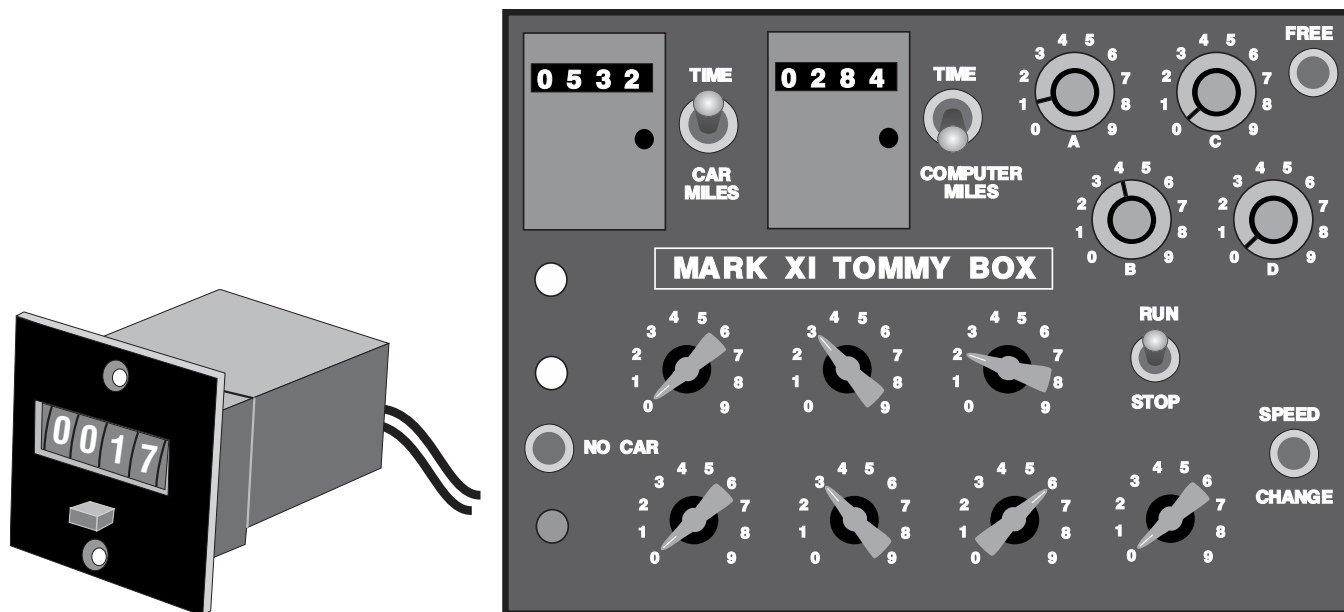


Figure 10-1: A simple electric counter and The Mark XI Tommy Box

to factor pulses into miles and convert into time.

“OK students, this week's shop class project is going to use lots of switches and counters and dials and wires. We're going to build the “Ridgemont High Rally Computer” so I can go out and smash the competition in next week's road rally ...”

One of the more popular models was the Tommy Box. It has two counters at the left and three rows of dials. The navigator sets the odometer calibration factor in the 4 knobs at the upper right (1.040 is entered in Figure 10-1). The current and next CAS are entered in the two banks of knobs at the lower left (032 mph and 036.0 mph). The lights on the lower left indicate which bank is currently active.

The most popular basic counters were the Stevens single and dual counters. Stevens offered a complete “off-the-shelf” setup for

rallyists which included speedometer-mounted and wheel-mounted switches and counters which were equipped with lights and re-zero capabilities.

While you occasionally see Stevens counters in use, the era of Electric Counters has passed. However, these units did provide the basic technology for more sophisticated systems. The basic opening and closing of an electric circuit could be recognized as a “pulse” by digital circuits and purely digital systems were born.

Digital Electronic Odometers

The most recent rally odometers use a system which is almost entirely digital: a **sending unit** (described later in this chapter) monitors car motion and sends an electronic **pulse** to the odometer every few feet. The odometer counts these pulses and updates the mileage readouts at a pace dictated by the calibration factor, entered digitally in the odometer.

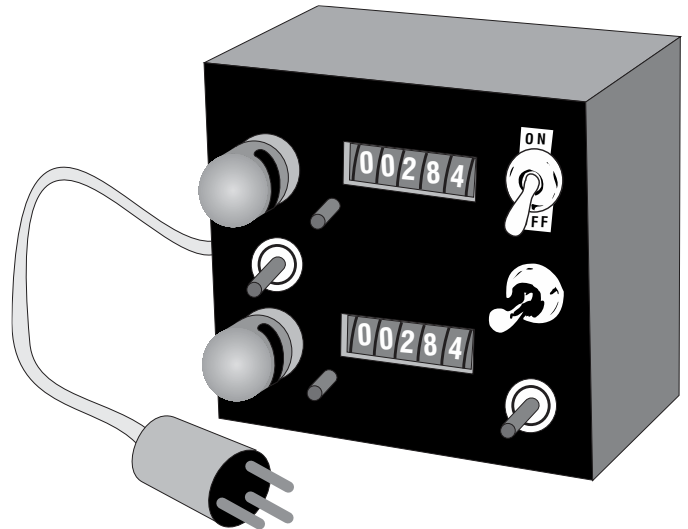
These systems have the advantages provided by the recent development of compact, low cost, and low-powered digital components. Since almost all the information is available in digital form, complex calculations can be performed instantaneously by computers built around these odometers.

However, advanced competitors should remember that these units are effectively converting a continuous measurement (distance) into discrete steps (pulses). Since all the Fundamental TSD formulas are based on continuous distance, digital odometers can introduce degrees of uncertainty for the top teams. These effects will be explored *ad nauseam* in [Chapter 19](#).

The most basic precision odometer produced today is the Terratrip 1. Its simplicity is unique since most precision odometers today are bundled with clocks and complex features into an integrated box (see the next Chapter).

Odometer Characteristics

Let's assume for a few pages that the odometer is installed and functioning. One of the first things you should investigate



The Stevens dual counter

about each odometer in your installation is its list of characteristics. These boil down to a list of questions:



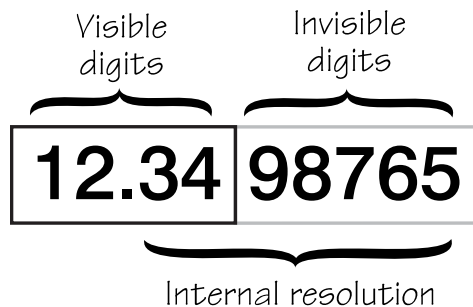
The Terratrip Model 1 odometer

What drives the odometer? The main odometer in a unit is driven by pulses from

the sending unit. Other auxiliary, interval, or alarm odometers may work ***independently***, each counting pulses. Another method is to have the auxiliary odometers triggered by the main odometer. If an auxiliary odometer always increments in unison with the main odometer, the auxiliary is ***dependent*** on the main odometer (see dependence in Chapter 8).

What is the visible resolution of the odometer? How many digits to the right of the decimal point are shown?

How many significant digits are in the calibration factor? The fact that the owner's manual says that a unit has, for example, a “six-digit calibration factor” does not give you the whole story. If the typical factor for your car is 050000, the leading zero is not significant in your situation. Such an odometer calibration factor has 5 significant digits.

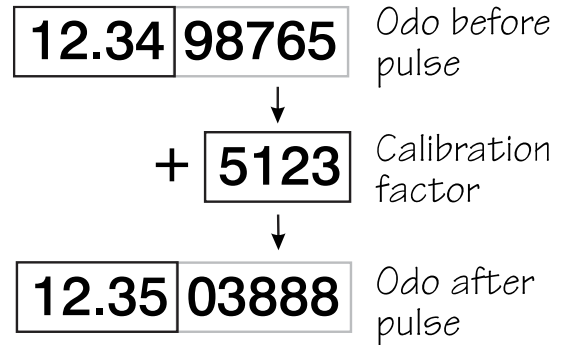


What is the internal resolution of the odometer? Odometers “think” with many more digits than are visible.

The odometer above has a visible resolution of 0.01 mile (2 digits) but an internal resolution of 0.0000001 mile (7 digits). The number of digits of resolution in an (independent) odometer is generally the

number of significant digits in the calibration factor plus 3.

What type of calibration factor does the odometer use? There are two types of calibration factors: ***additive*** and ***inverse***.



In the additive scheme, each pulse causes the calibration factor to be added to the rightmost digits of the odometer. If you want the odometer to count more mileage with each pulse, just increase the calibration factor.

A lower calibration factor will count fewer miles for a given number of pulses. Once this picture is in your mind, you will never forget which way to adjust the calibration factor.

Inverse calibration factors are not so intuitive. In these units, you set the calibration factor to the number of pulses per mile received by the odometer. If you get 2000 pulses each mile, that is your calibration factor. If this setting causes your mileage to come up short compared to official miles, it means you are getting fewer pulses per mile than you thought and you need to lower your calibration factor. This is exactly the opposite of the additive scheme.

[Chapter 19](#) will discuss how to revise both additive and inverse calibration factors during the odometer check.

What functions does the odometer have?

You should be familiar with how every switch or setting on a unit affects each odometer. Some of the common functions are:

- ***DIRECTION.*** Forward, park, and reverse (or off course).
- ***ZERO.*** Set all digits of the odometer to zero. Make sure that the ZERO function affects the internal digits as well as the visible ones. If not, you will need to do the next function as well.
- ***CLEAR.*** This is not the same as ZERO! CLEAR sets just the internal digits of the odometer to zero. This function is known by various names, such as SAFETY, RESET, or RESTART.
- ***SET or ADJUST.*** There are many methods used by different units for altering a setting. Some have a separate toggle to change each digit position. Some use a single switch to rapidly increment or decrement the reading, and the speed increases the longer the switch is held down. There is also the issue of whether you can tell how much you have added. Some units show this in a separate display. Finally, there is the issue of whether the unit keeps track of mileage driven while you are making adjustments.
- ***SPLIT.*** Reading the odometer “on-the-fly” is not reliable. You need a way to freeze

the value while it continues to count internally.

- ***TAYLOR SPLIT.*** Some odometers have this feature (a combination of SPLIT, ZERO, and CLEAR) for an auxiliary or interval odometer. Our navigation strategy for running Odo Class requires one odometer with this function. (See [Chapter 8](#) for a description of this function.)

What action on the unit causes a CLEAR?

Some boxes perform this when you switch directions.

Sending Units

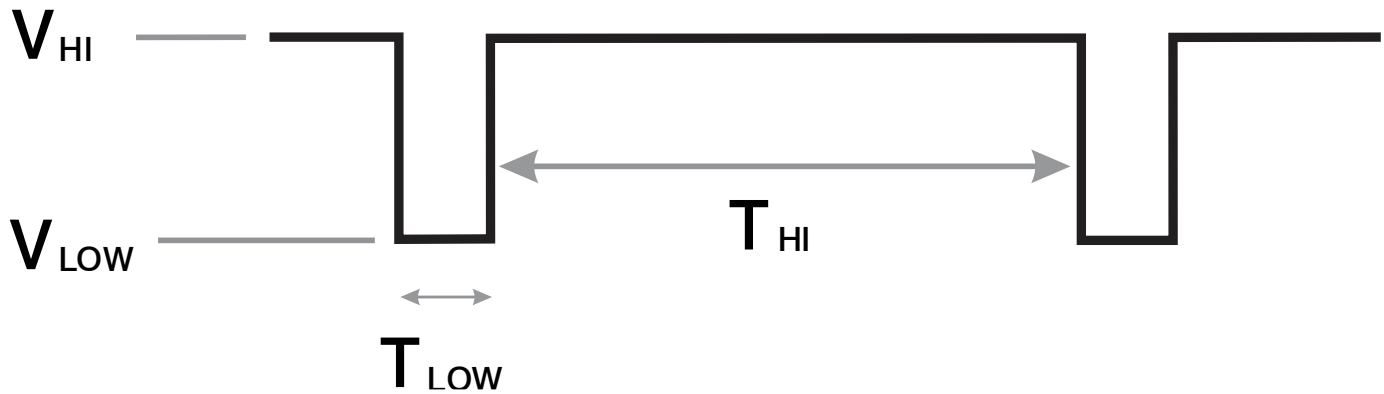
The starting point for all digital electronic odometers is a ***sending unit***. This electronic assembly is also known by the names ***pickup, probe, sensing unit, impulse unit,*** and ***transducer***. Sending units produce electronic pulses in pace with the passage of distance.

“This is the heart of your electronic counter system. If it fails, you are dead”.²⁰

Before we get into the various types of sending units, we will take a digression into the electronics of odometer pulses.

²⁰ from Stevens Rally Specialties, Catalog No 20.

Pulses



What is a pulse? Sending units are generally connected to digital electronic odometers with three wires. Two wires supply power and the third has a steady voltage (usually +5 volts, give or take a bit). The job of the sending unit is to drop the third wire voltage to zero (give or take a bit) for some minimum duration. Electronically, it looks like this:

The V numbers are voltages and the T numbers are times. A digital electronic odometer recognizes the voltage drop as a pulse if the characteristics of the voltage drop fall within certain bounds. For example, an odometer might require V_{HI} to be at least 4 volts and V_{LOW} to lie between -1 and +1 volt. The specifications for voltages are based on Transistor-Transistor Logic (*TTL*) specifications used for digital electronic equipment throughout the electronic industry.

The duration T_{LOW} (the amount of time the voltage is held low) and T_{HI} (the time between the edges of pulses) are critical. For example, the unit might require T_{LOW} to be a minimum of 0.0001 second (0.1

millisecond) to ensure that the pulse is registered.

The minimum allowable T_{HI} determines how many pulses can be processed by the odometer per second. For example, a minimum T_{HI} of 0.0039 seconds (3.9 milliseconds) might be specified. This combination of minimum times gives a minimum of 0.0040 seconds for each pulse and allows the unit to process up to 250 pulses per second. Another name for pulses per second is *Hertz*, so this would be a maximum pulse rate of 250 Hertz.

Mechanical Sending Units

The simplest approach to changing voltage on a line is to use a mechanical switch to close some electronic contact. The switch is tripped by the turning of a wheel or shaft. Magnetically operated *Reed switches* are often used in this application. Reed switches close due to the passing of a magnet. There is no mechanical contact between the rotating wheel or shaft and the reed switch.

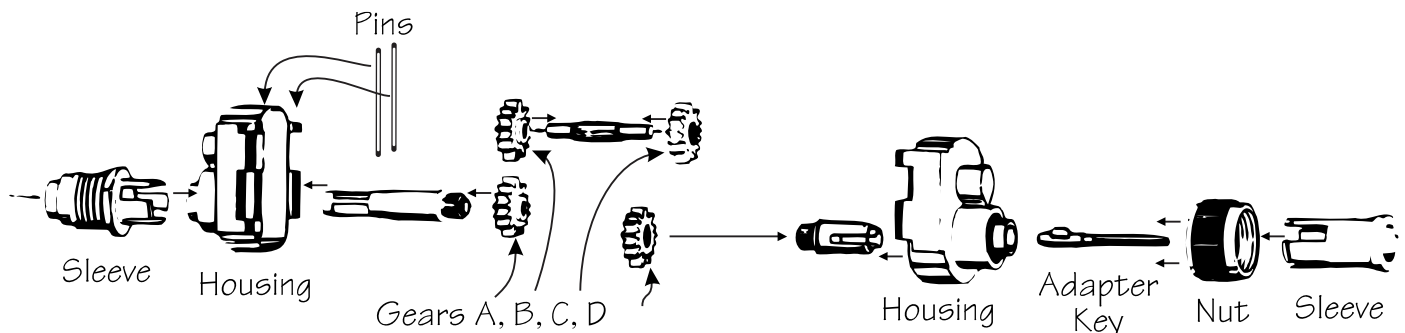
Although they are simple in design, they have problems in practice. First of all, most mechanical designs are subject to contact

bounce. Like accidentally hitting a key twice on a cheap electronic keyboard, these switches can generate multiple pulses instead of a single pulse. On bumpy roads, the switch may generate spurious pulses between “real” pulses. These problems might only occur at certain speeds or temperatures and be very difficult to diagnose.

Also, many of the common reed switches

Cable Drives

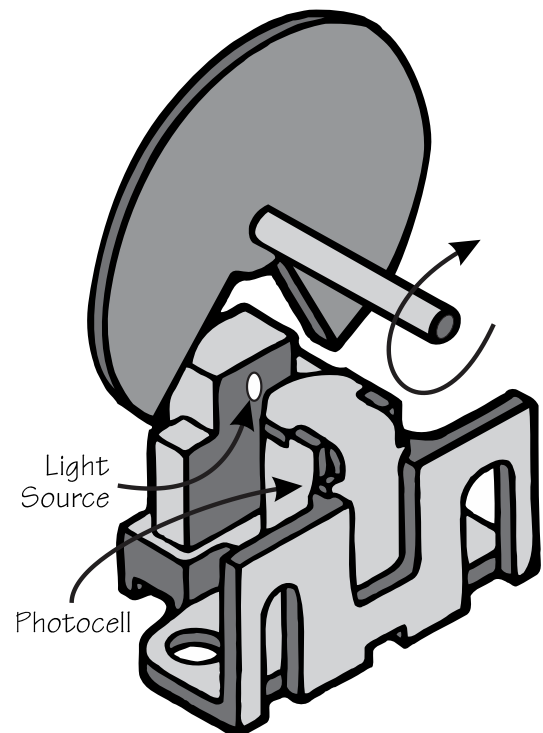
Although mechanical odometers have largely faded from the rally scene, cable drives are still useful: they can be used as the connection between the speedometer or wheel and an electronic sending unit. If, for example, you have a sending unit which does not fit behind the speedometer or which needs more protection than a mounting location on a wheel, an



Exploded view of an inline odometer cable gearbox

have a life of only 2 to 4 million cycles. If the switch is tripped once for each revolution of the wheel, this works out to a life of 5000 miles (at best). Given these limitations, you should not even think about considering this type of sending unit.

Recently, some manufacturers have begun producing reed switches with an expected life of 200,000,000 cycles. On a typical car, this works out to an expected life of 100,000 miles – sufficient for many rallyists. However, contact bounce is still an issue. You need to check with the rally distributor or manufacturer to determine if a reliable filtering circuit can be added to disregard multiple pulses.



Internals of a photoelectric sending unit

intermediate cable can allow the sending unit to be mounted almost anywhere.

Connecting the odometer cable to the car's speedometer cable can be done by splicing in a T-connection. If the pace of the cable's rotation needs to be changed, an inline gearbox can be spliced inline with the cable:

Photoelectric Sending Units

These units work like an “electric eye” in a security system. These self-contained (closed) units contain a small light source, a light-sensitive transistor or photocell, and a disk which separates the two. The disk rotates as the car moves. A slot in the disk lets light through once for each revolution. When light strikes the photocell, a pulse is sent.

One feature of these units is that the duration of **TLOW**, for a given rotation speed, can be changed by changing the size of the gap in the disk!

However, there are several issues to be dealt with when considering a photoelectric sending unit:

- Most units have an incandescent bulb as the light source. The bulb can burn out. Units which use a bulb rated for a higher voltage than it receives partially avoid this problem. However, you need to consider that the bulbs are subject to constant jarring and, when they decide to go *POOF!*, they will do so in the middle of the most important rally of the season. Units which use a LED rather than an

incandescent bulb largely eliminate the burn-out problem.

- They need to be installed in a location protected from the elements – usually in a splash-free location. They also need to be shielded from direct sunlight.
- Some units perform poorly at slow speeds. When the light just begins peeking through the slot in the disk, the light might be just at the threshold of the phototransistor. Some units will vacillate on and off several times in this situation, sending the equivalent of many pulses to the odometer. To prevent this syndrome, a circuit which introduces *hysteresis* is needed. This makes the phototransistor turn on at a higher light level than the light level where it turns off. (This is the same effect built into thermostats to prevent them from turning your heating unit on and off when the temperature hovers at a certain level).
- Finally, there is the issue that something must supply power to light the bulb. This is typically the odometer unit. Depending on the bulb, some odometers may not be able to provide enough current to light the bulb for proper operation of the sending unit. The problem lies in the protection circuitry which some units have against an accidental short on the transducer wires. This circuitry limits the current going to the transducer.

Magnetic Sending Units

These units consist of one or more magnets and a transducer which is sensitive to a magnetic field. When the transducer passes

through the magnetic field, it pulls the voltage low, causing a pulse to be sent.

These units work on one of two magnetic phenomena:

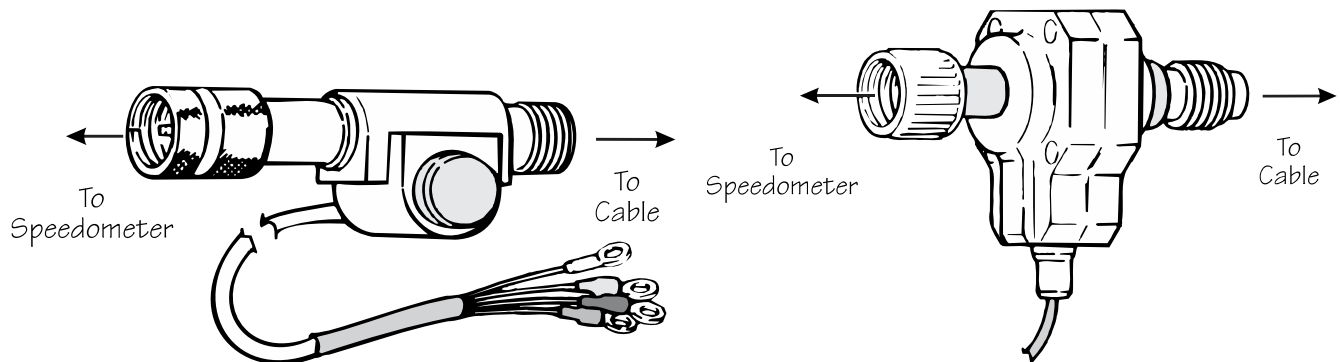


Figure 10-2: Closed sending units: Type A (left) and Type B (right)

- **Magneto-inductive effect.** When a coil of wire passes through a magnetic field, electric current is generated (induced) in the wire. This principle is the basis of generators and motors, which translate motion into electricity and vice-versa. Note that there actually has to be motion of the magnet or the coil to generate the electric current.
- **Magneto-resistive or Hall effect.** Certain materials have a level of resistance to electricity which changes in the presence of a magnetic field. No motion is necessary – the material either has a high or low level of resistance depending on whether it is sitting in the magnetic field.

In either case, the transducer has a wire coil or magneto-resistive material coupled with a small circuit (a transistor or chip) which monitors the material. The circuit usually provides its own hysteresis (see above) and possibly a pull-up resistor (described below). However, the difference between the two

types of transducers is important: Magneto-inductive transducers will not generate a pulse at very slow speeds, while Hall-effect transducers generate pulses regardless of the

speed.

Magnetic sending units are available either as a single self-contained (closed) unit or as a transducer and a magnet which are mounted separately (open units).

Closed Magnetic Sending Units

Figure 10-2 shows two popular models of closed magnetic sending units. Both are designed to be inserted in-line in a cable. A rotating shaft inside each unit contains one or more magnets which pass next to the transducer mounted off to the side of the shaft.

The left sending unit in Figure 10-2 we will call the Type A unit. This sending unit is actually constructed by modifying a T-gear produced by Halda.

The unit we call Type B was originally manufactured for commercial use where precise mileage measurement and/or speed control are required: taxicab operations and

low-speed farm equipment. The unit needs to be treated for use outside the passenger compartment, to protect it against moisture. This is usually done by the rally distributors selling these units.

Another style of closed unit has recently become available which is similar to the Type A units and screws directly into the transmissions of Ford, Chrysler, and AMC cars.

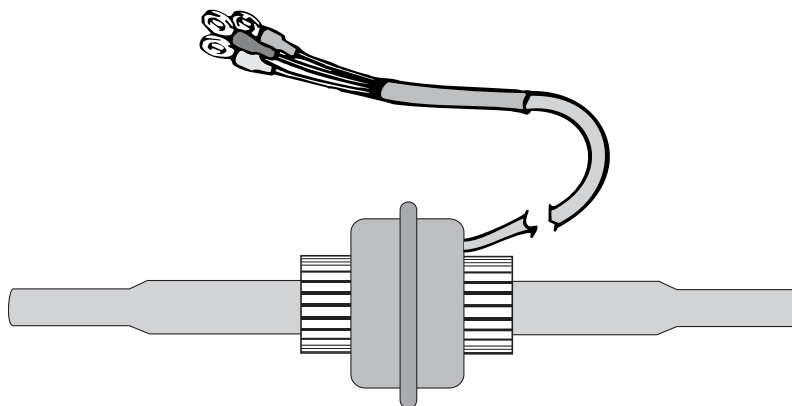
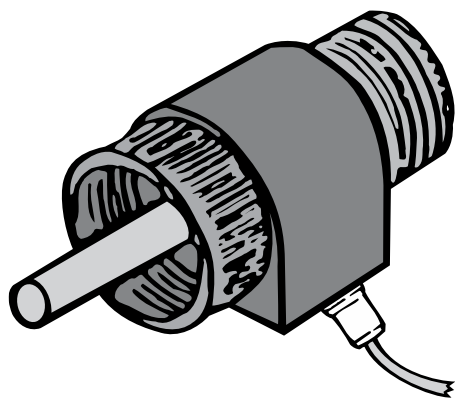


Figure 10-3: Closed sending units: Type C (left) and Type D (right)

The Type A and Type B closed sending units are available through many of the U. S. rally distributors and manufacturers, including Competition Limited, Small Systems Specialists, Timewise, and Chronar.

The Type D unit is installed by cutting the speedometer cable. This takes a bit of work, but allows you to install the sending unit at almost any point along the cable. The Type

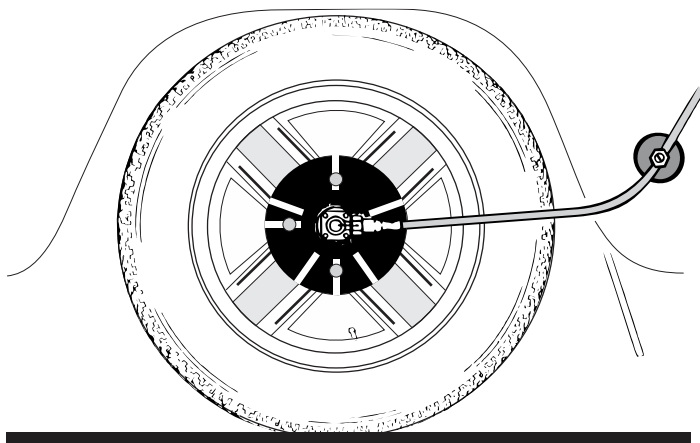


Fig 10-4: The UltraDrive portable sending unit, schematic and photo of our unit on its side.

D is Terratrip's "Universal Cable Drive Probe" and Leo's model LM16.

Several exterior models in the RJ line are distributed by Stu Helfer of T&D Rally Performance. They can be outfitted to generate two or four pulses per revolution and drive up to two odometers.

Ricker Rally Products also distributes a

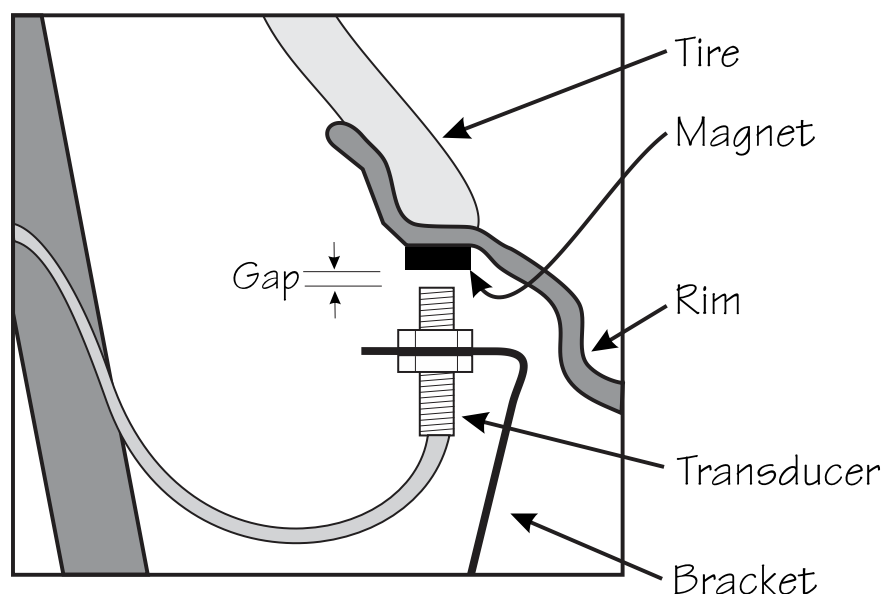


Figure 10-5: An open magnetic sending unit mounted on a wheel

small wheel-mounted unit which is relatively inexpensive and easy to install.

Another design, the UltraDrive (available from Bob Radford Enterprises), uses the Type B sending unit mounted to a round disk. The disk has slots for 4-bolt and 5-bolt wheels, and is attached to the car's wheel using special super-long lug nuts. These replace some of the wheel's stock lug nuts. The size of lug nuts for any car is listed in the *Wheel Application Guide* available at most tire dealers. Two sets of these lug nuts, with thread sizes 12mm $\times$ 1.50 and $\frac{1}{2}$ " $\times$

20, will cover the wheel studs on most production cars. Another source of this information is Wheel Mate Products, listed in Appendix A.

The photo on the right side of Figure 10-4 shows our portable setup. The UltraDrive unit is on its side, with four bolts attached to the disk. The Type B closed sending unit, which is part of the unit, has been

augmented with a backup open magnetic sending unit. Two magnets have been epoxied to the aluminum flange on the disk, with the cable running along the outside of the main odometer cable.

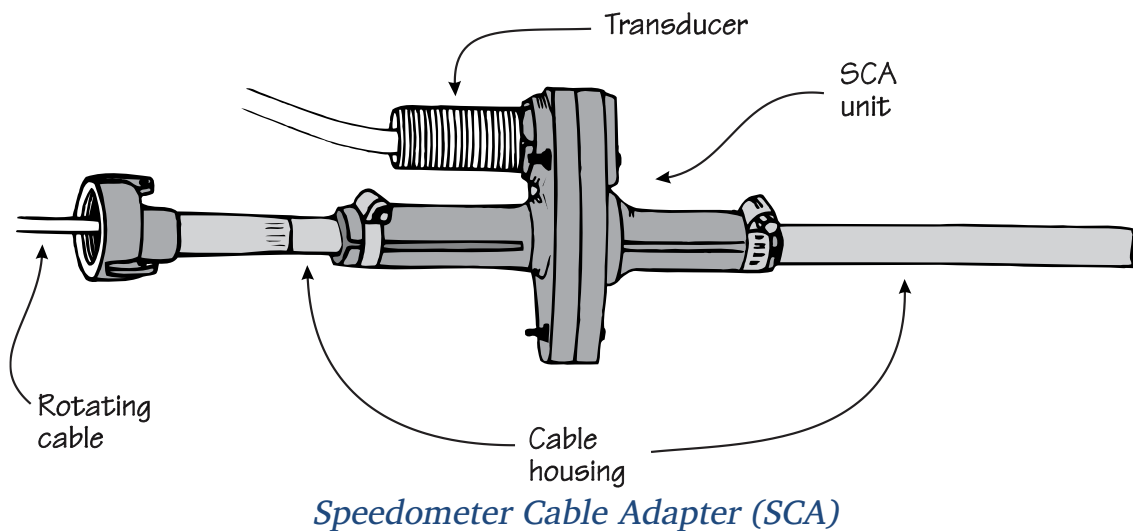
Any externally mounted units should be removed immediately after the event, as they don't stand up well to moisture.

One idea which might occur to you is to secure a closed sending unit to a flat plate, drill holes in the plate, and use the lug bolts or nuts to attach the plate directly to the wheel. This would place the plate between the lug bolt/nut and the wheel. You must not do this! Lug bolts and nuts have tapers which center the wheel as the bolt/nut is tightened. This is very important for wheel balance. Defeating this taper with an intervening plate allows the wheel to "swim", with potentially severe wheel balance problems, and places the full load on the remaining studs.

If you home-brew a portable setup, a better idea is to mount the sending unit to a plate and secure the plate to the wheel with nylon ties. Make sure that the weight of the unit is centered on the wheel, or you will have balance problems. Another system which has been used is to mount the sending unit on a hubcap designed for that wheel and then ensure the hubcap stays on with nylon ties. Any setup along these lines should be “over-engineered”, due to the tremendous forces which act on a wheel as you hit

transducer is mounted on a bracket secured to the brake shield (beyond the bottom of the figure). The magnet is epoxied to the rim.

There are two common types of transducers available for open magnetic sending units. The primary difference between the two is how sensitive they are to a magnetic field:



potholes.

Problems with closed units:

- Location of the sending unit is limited to where the speedometer cable can reach.
- If your cable is attached to a driven wheel, you will constantly have problems measuring mileage on events measured with an undriven wheel.

Open Magnetic Sending Units

Figure 10-5 shows installation of a typical open magnetic sending unit. Here the

Transducer type	Length	Diameter	Sensitivity	
			Pole	Minimum gap
Type 1	2"	3/8"	South only	1/8" – 1/4"
Type 2	1.5"	1/2"	North/South	3/4" – 1"

The maximum gap listed here is the approximate distance the transducer can be from the magnet and still work reliably (assuming a very powerful magnet). Type 2

transducers generally use less powerful magnets at closer range.

As far as transducer operation is concerned, there is no minimum distance between the transducer head and the magnet. However, you risk a collision if the gap is too small. On rough roads, any open installation will vibrate – a single “encounter” can destroy the entire installation.

Advantages of open units:

- Impervious to moisture
- Very flexible mounting location
- Probably the strongest argument for choosing an open unit is that it gives a great deal of freedom in choosing what source of motion to measure. With some ingenuity, these units can be mounted to measure drive shafts, half shafts, differentials, or any wheel.²¹ This lets you select mounting location(s) which give you the best chance of duplicating official miles during an event. [Chapter 19](#) discusses these issues in great detail.

Problems with open units:

- In cold weather, an ice bridge can form between the transducer and the magnet if they are near each other when you park. This could bend the transducer mount when you next move the car. Marking the location of your magnets on the outside of the rim helps avoid this problem.

- The wheel may need to be balanced after the magnets are installed.
- If the epoxy job is not done properly, the magnets may fly off.
- You will need to install magnets on your spare. If you do not, Murphy predicts you will get a flat on the critical wheel in the crucial event of each season.
- The bearings and bushings on the measuring wheel must be in good condition to keep the distance between the transducer and the magnets constant.

If you want to convert the transducer for an open magnetic sending unit to operate off the speedometer cable, Terratrip's Speedometer Cable Adapter (SCA) will accomplish this. You must get one with the correct threads for your transducer. See [Chapter 13](#) for the installation procedure.

Wiring

Most sending units work on a 3-wire system. Two wires supply power from the odometer to the sending unit and the third conducts the pulses from the sending unit back to the odometer:

²¹ You could even imagine bizarre applications having nothing to do with mileage: “Look, dear, sender #17 says that the front wheels caught air 23 times today.”

Sending Unit Wiring			
Name	Voltage	Standard Colors	English Convention
Positive power supply	+5	Red	Brown or orange
Negative power supply (also called Signal ground)	0	Black, brown, or bare wire	Green
Pulse signal	Normally +5, goes to 0 on a pulse	White, green, blue, or clear	White

The English convention is used on sending units manufactured by Terratrip and Leo.

There is one more connection which is often overlooked in installations: the **shield wire** or **drain wire**. Any wire entering the odometer can pick up radiated electrical noise (see [Chapter 13](#)). In order to protect an odometer from this interference, the cable from the odometer to the sending unit should be shielded and the shielding should be connected to the vehicle chassis. Some odometer units provide connections for the shield wire to drain through the unit and out into the chassis. Also, while the shield wire is at 0 volts, it should not be used as the negative power supply since that would introduce the electrical noise directly into the sending unit circuit.

If you are interested in more information on Hall Effect sending units, order *Hall Effect Transducers – How to Apply them as Sensors* from Micro Switch (part 85-05715). This company manufactures a line of position sensors and transducers. Their head office (Appendix A) will refer you to a local sales office.

Pull-up Resistors

For an odometer to function, the circuit connecting the odometer to the transducer must have a pull-up resistor somewhere. Most odometers have a pull-up resistor in the unit. Some, most notably Terratrip odometers, do not. Terratrip equipment assumes that the sending unit has a pull-up resistor. These odometers only work with transducers which have pull-up resistors (such as transducers produced by Terratrip). No problem exists if both the unit and the transducer have pull-up resistors, so other odometers can use Terratrip sending units.

If you need to add a pull-up resistor, use one between 1,000 and 10,000 ohms. Note that there is a tradeoff within this range: resistors at or below the low end of the range may not work with some odometers, while resistors at the high end of the range make the system more susceptible to electronic noise. A 5,000 ohm resistor is typically used in this application. The pull-up resistor is wired between the positive power supply (+5 volts) and the pulse signal wires. A convenient place may be inside one of the connectors in the circuit.

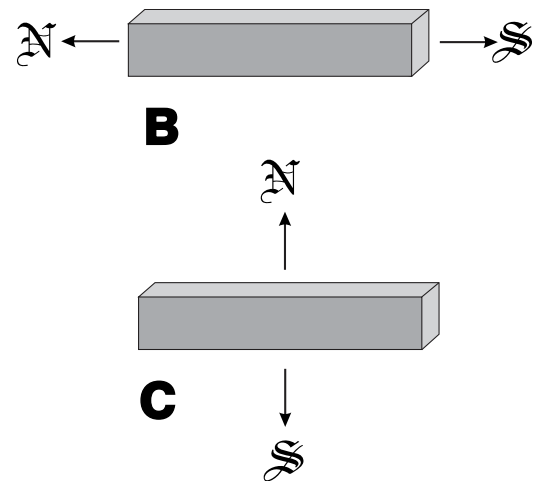
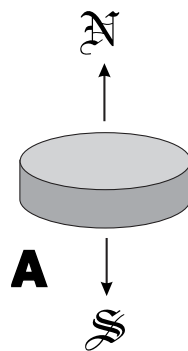
About Magnets

If you are using an open magnetic sending unit, you have the opportunity to select which magnet(s) you will install. The basic requirements are that:

- The transducer is exposed to a single pole of the magnet and
- The magnetic field strength is sufficient to trigger the transducer for **TLOW** time at the maximum speed you expect to drive.

The easiest type to work with are round “disk” or “button” magnets (shape A). These magnets usually have one pole on each of the two faces, which satisfies the first requirement above.

Unusual setups could make use of “bar” magnets. Shape B would only trigger the transducer if it were stood on end, a real hazard when the epoxied magnet is



Various magnet shapes and alignment of poles

revolving at high speed. Some rectangular magnets have their two poles on the long sides (shape C). These can be used if epoxied to a flat surface, but present a problem if the transducer is placed too close to the magnet (less than ½”). At this distance, the magnetic field is irregular and can trigger the transducer multiple times for each pass. At distances over ½”, the field becomes more rectangular and the problem disappears. Of course, this limitation requires the more sensitive Type 2 transducer.

Shapes such as a ring (donut) or magnetic sheet will not work because they have more than one pair of poles. Household “refrigerator magnets” are usually too weak for either type of transducer.

There are many sources for magnets, but it is sometimes difficult to know exactly what you are buying. Chronar stocks a selection of magnets specifically suited to rally applications. Radio Shack is also a convenient source, and many teams have had good luck with their tiny rare earth

magnet (part 64-1895). Edmund Scientific is also a source. For a really unusual situation, specialized magnets can be fabricated by Permag Corp at a price (see Appendix A).

Number of Magnets

How many magnets should you have per wheel revolution? While it would seem that “more is better” for accuracy and redundancy, there may be problems with more than a few. Every electronic odometer has a limit on the number of pulses it can process in a given time. This limit may be imposed by noise-protection circuitry, which guards against spurious voltage spikes on the line, or simply the worst-case processing speed of the components in the unit. If you exceed the maximum pulse rate you will lose pulses and come up short on your mileage.

Each odometer has its own maximum pulse rate. Check with the manufacturer to determine this number. You can then figure out, for your car and number of magnets, the maximum speed you can drive without losing pulses. Typically, with more than two magnets, it is feasible to go fast enough to lose pulses, especially if you have small tires.

So how much business does the rally dealer who advertises a sending unit with 20 magnets get? Maybe a rally with CAS assignments in inches per month or furlongs per fortnight would call for these units!

But what about accuracy? Some rallyists talk of a **zone of uncertainty** in your mileage measurement. This amounts to half your

wheel circumference with two magnets, or about ± 3 feet for typical tire sizes. With four magnets this uncertainty drops to about ± 1.5 feet. However, you have to weigh this against the **resolution** of your calibration factor.

Say your unit has an additive four-digit factor which is set to 5280 with two magnets. A change of 1 in your factor will alter your mileage read-out 1 foot every mile or 0.004 miles every 20 miles. This is arguably acceptable for top Computer Class results.

Adding two more magnets drops your factor to 2640. This means that you can only correct to the nearest 0.008 miles every 20 miles, a significant loss of odometer accuracy (again, for Computer Class purposes).

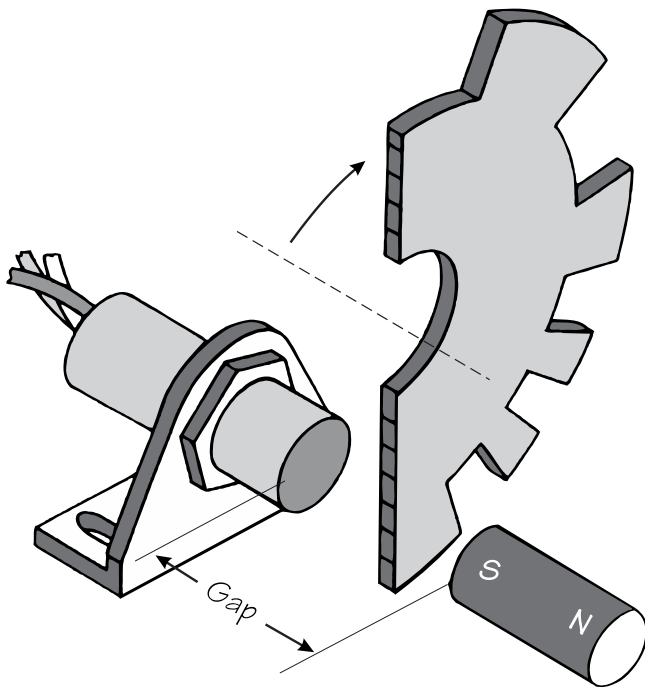
So why not use one magnet? Now you have to consider reliability. If you lose your one-and-only magnet – hello Stock Class! If you lose one magnet in a two-magnet system, you can limp along by

- doubling or halving your factor (for additive or inverse factors, respectively)
OR
- halving your CAS settings for calculation purposes.

However, you must make sure that, if you have an additive calibration factor, you can double your factor on your unit. If the unit has room for only 4 digits and yours is 5280 with two magnets, you are out of luck. In this situation, you might consider 3 magnets as a good compromise. This would give you

a normal factor of 3520 and 5280 in case you lost a magnet.

OEM Sending Units



OEM-style “vane” sending unit

Many car manufacturers now install electronic speedometers as an Original Equipment Manufacturer feature. The speedometer is typically driven by a magnetic sending unit installed in or near the transmission.

Rather than moving a magnet past the transducer, many OEM units have a fixed transducer and magnet, with a rotating slotted plate between to vary the magnetic field.

If the characteristics of the pulses produced by your car's OEM speedometer drive satisfy that of your odometer, you can tap into that signal directly.

However, you will need to check into some issues:

- Does the sending unit use a magneto-inductive transducer? This type will not work at very slow speeds.
- Some OEM transducers generate an inverse pulse, going to +5 volts for a short duration rather than from +5 to 0. This may appear to work on an odometer, but fail (lose pulses) at very high or very low speeds.
- What are the electrical characteristics of a pulse? You will need to check **TLOW** duration, voltages, etc.
- How fast are the pulses delivered at a given speed? The number of pulses from many OEM sending units exceeds the maximum pulse rate of many odometers, even at moderate speeds. One solution is to install a **pulse divider circuit** which produces one pulse for each 2, 4, or 8 incoming pulses. Timewise produces such a circuit.
- Are the pulses evenly spaced? If they are not, auxiliary functions such as calibrated speedometers may not function.
- What is the maximum current drain allowed by the OEM unit? Each odometer you add imposes a current drain. If the maximum current drain on the OEM sending unit is exceeded, your stock speedometer and/or your precision odometer may fail to function completely or intermittently.

11. Integrated Boxes

I enjoy working with people.

— HAL 9000, from *2001: A Space Odyssey*

While some odometers are available as stand-alone units, most come 'bundled' with other items into 'boxes'. The two most common types of boxes are classified as B-boxes, for running in Odo Class, and A-Boxes, for running in Computer Class.

The Standard Problem

Throughout the rest of this book, we will be using a Standard Problem to illustrate all the equipment, calculators, tables, etc. Here is the situation:

- You started a leg at 0.00 official miles at an out-time of 12:18.00.
- You have run the first 2.84 official miles at CAS 32.
- Your CAS at this point is changing to 36.
- Your correction factor (for situations involving a stock odometer) is 1.040, giving you a stock odometer reading of 2.9536 car miles. Your corrected speed is 33.28 mph.

Based on these numbers, your perfect time at this point is 5.325 minutes from the start of leg, or 12:23.325 time of day. For purposes of demonstration, we will also say that the actual time at this point is 12:23.35, and you are running 2.5 cents late.

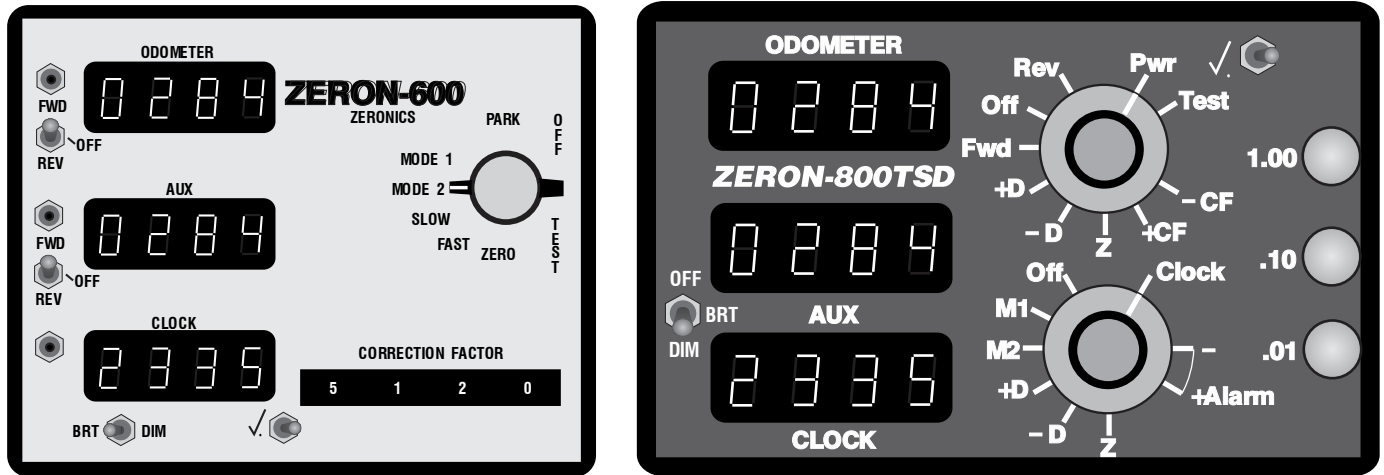
This example will be used to demonstrate the integrated boxes in this chapter as well as calculators, tables, and speedometers in the following chapters.

B-Boxes

The general name for an electronic unit which is designed to be of maximum use and legal for Odo Class is a B-Box. These units usually have one or more hundredths or thousandths reading correctable odometers, one or more hundredths reading clocks, and the controls to perform the typical functions. Some B-Boxes have a correctable speedometer, which may be useful for the driver. However, this feature is outlawed under some regulations. Which features you want in a B unit will depend strongly on the particulars of the navigation system you design for yourself. We have found it best to design a navigation strategy, then survey the owners manuals of the

various units to find one which most closely fits that system.

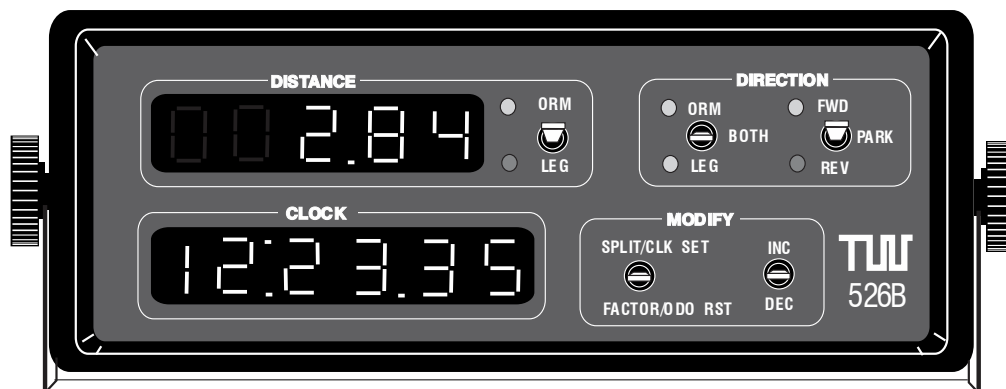
There are several B-Boxes in production today and quite a few others which are out of production, but still available on the used market. Some out-of-production models are shown in this section.



Zeron B-Box models 600 and 800TSD

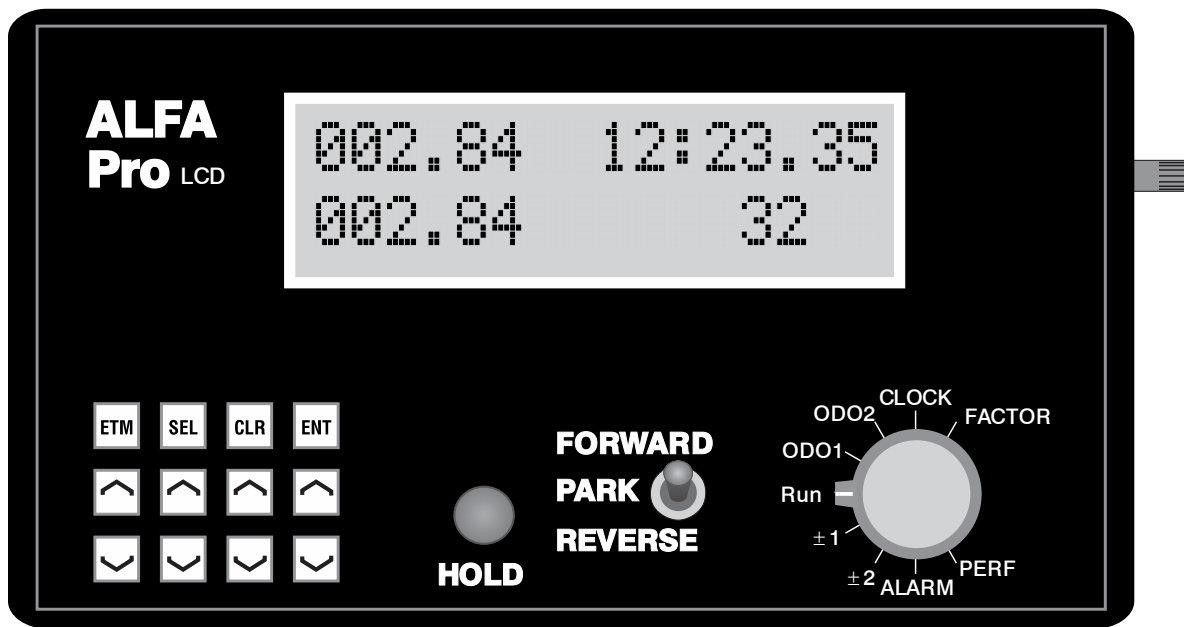
- The Zeron line is completely out of production, but many Zeron B-Boxes are still in use or available on the used market.

These are three popular B-Boxes in current production:



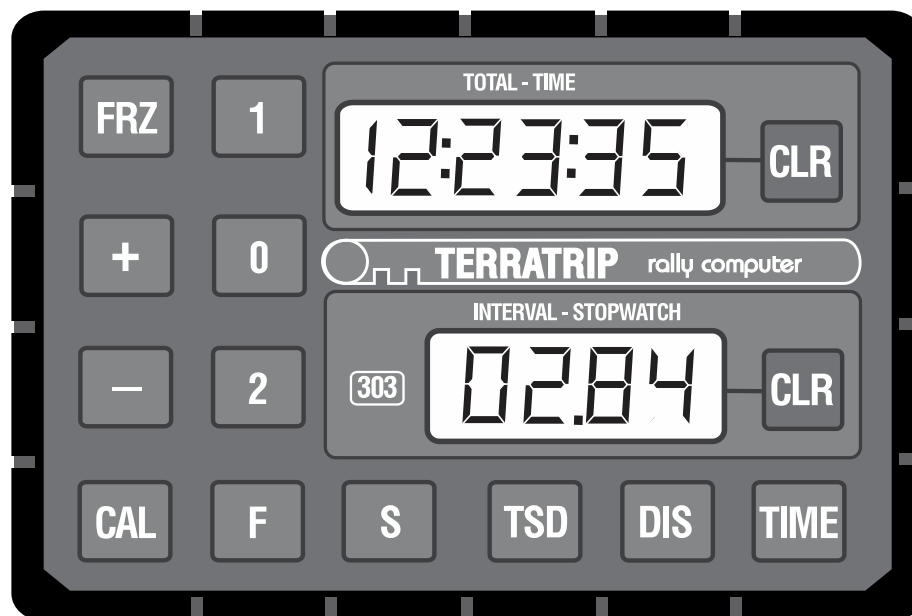
The Timewise 526B B-Box

- A separate driver's module is available which shows the overall mileage or corrected speed.



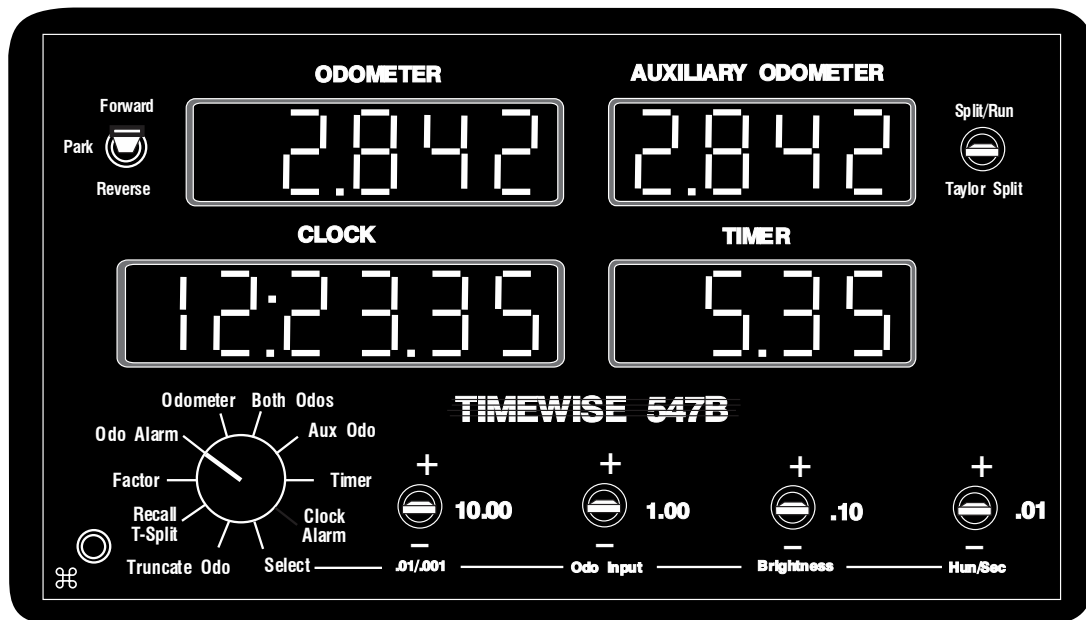
The Alfa Pro B-Box

- Switchable to thousandths mileage and time at any time.
- Performance mode which shows time from 0 to 60 mph.
- Two odometer inputs.



The Terratrip 303 B-Box

- Pressure sensitive switches under a plastic cover
- Requires a transducer with a pull-up resistor (see [Chapter 10](#)).
- Two odometer inputs.



The Timewise 547B B-Box

- Selection of independent or dependent interval mileage.
- Switchable to thousandths time and mileage at any time.
- Two odometer inputs.
- Driver's module which shows overall mileage.
- Incremental adjustment of time by tiny amounts.
- Remote park and Taylor split.

Summary of B-Boxes and Basic Odometers																
Make	Model	Display	Power	Fuse (amps)	Size (inches) ^②			# Odos		Main Odo Resolution		CF		# Clocks & timers	# Made	Vintage
					Width	Height	Depth	Independent	Dependent	Visible	Internal	signif digits	add/inverse			
Alfa	2	LED	12v ext	2	8.9	4.4	2.5	2	0	3+2	3+7	4	add	1	15	'81-'82
	Pro-LED	LED	12v ext	2	8.9	4.4	2.5	2	0	3+2	3+7	4	add	1	125	'82-'89
	Pro-LCD	LCD	12v ext	2	8.9	4.4	2.5	2	1	3+3 ^③	3+7	4	add	3		'89-
Halda	Tripmaster	Drum	-	-	4.0	3.0	2.0	1	0	3+2	3+2	-	-	0		
	Twinmaster	Drum	-	-	4.3	4.7	2.0	2	0	3+2	3+2	-	-	0		
	Computer	LED	12v ext	1	6.7	3.3	1.4	1	2	3+2	3+6	3	add	1		'84-
Leo	LT3000 ^④	LCD	12v ext	1	7.1	4.2	1.6	1	1	3+1	3+7	4	inv	3		
Terratrip	1	LCD	12v ext	2	4.7	4.0	1.9	1	0	2+2	2+6	3	inv	0		
	202	LCD	12v ext	2	5.8	4.0	1.9	1	1	2+2	2+7	4	inv	0		
	303	LCD	12v ext	2	5.8	4.0	1.9	1	1	3+2	3+7	4	inv	2		
Timewise	538B	LED	12v ext + nicad ^⑤	.75	6.4	3.4	2.0	2	0	2+2	2+7	4	⑥	1	100	'83-'86
	526B	LED	12v ext + nicad ^⑤	1.5	8.4	3.4	2.6	1	1	3+2	3+8	5	add	1	150	'85-'90
	547B	LED	12v ext	1	7.5	4.0	1.5	1	1 ^⑦	3+3 ^③	3+8	5	add	2		'93-
Zeron	600	LED	12v ext													
	650	LED	12v ext													
	700	LED	12v ext	3	6.9	5.3	3.3	1	1	2+2	2+7	4	inv	1	100	
	800TSD	LED	12v ext	3	6.3	3.8	3.5	1	1	2+2	2+7	4	add	1		
	800PRO ^④	LED	12v ext	3	6.3	3.8	3.5	1	1	2+2	2+7	4	add	1		
	850	LED	12v ext	3	6.3	3.8	3.5	1	1	2+2	2+7	4	add	1		

① Optional feature when unit is purchased.

② Including height of protrusions, except switches and knobs on the front panel.

③ Hundredths or thousandths mileages selectable.

④ This unit has a calculated time mode designed for use in transit zones on Pro Rallies. This feature makes the unit technically illegal for use under most Odo Class rules.

⑤ Inverse factor in original design – changed to additive in updated firmware.

⑥ Designed primarily for Pro Rally use. Operation only in seconds.

⑦ Auxiliary odometer can be set up to run dependent on or independent of the main odometer.

A-Boxes

A-Boxes take two from the set {Time, Speed, Distance} and continuously calculate the third. Anything which does this calculation continuously qualifies as Computer Class equipment. One example is a “trip computer” which constantly shows your average speed since it was last reset. The trip computer is converting a known Distance and Time into a Speed.

The odometer at the lower left can easily be read to the hundredth of a mile. Parallax is virtually eliminated since the face of the instrument is flush against the mileage drums. The odometer can even be calibrated by small amounts using the knob at the upper right.

During a rally, you set the assigned speed on the left dial. For speeds less than 25, you can select “½ scale” and position the pointer

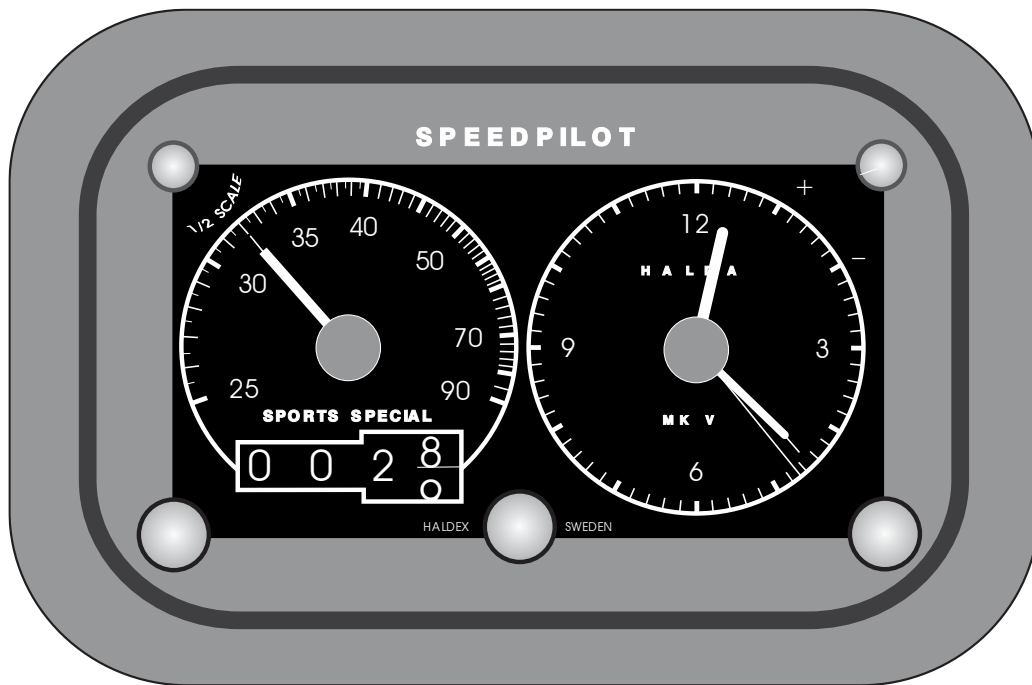


Figure 10-6: The Halda Speedpilot

In practice, most A-Boxes for TSD rallying take a known (assigned) speed and a traveled distance and produce a **computed time**. When the computed time is compared with the actual (clock) time, you can instantly tell whether you are early or late, and by how much.

The first A-Box useful for TSD rallying was the Halda Speedpilot.

to double the speed (40 for CAS 20).

The right dial shows both the computed time and time of day. The thick pointers serve as the normal hour and minute hands of a clock. The thin pointer sweeps around the dial at a rate determined by the speed you selected and the distance you have gone. Figure 10-6 shows that you are running early – the minute hand is behind the calculated time pointer.

In practice, the Speedpilot is not accurate enough for Computer Class competition. Too bad, since the simplicity of this instrument makes Computer Class intuitive for new rally teams. Early models (shown in Figure 10-6) were accurate to about half a minute. A later version was considerably more accurate.

A-Box Characteristics

Modern A-Boxes are basically B-Boxes with the added capability to take an assigned speed and constantly compute whether you are early or late based on that speed. Beyond that, A-Boxes have assorted features such as maintaining a log of all speed changes, the ability to change an earlier speed and alter the computed time automatically, multiple transducer inputs and calibration factors, etc. As opposed to B-Boxes, each A-Box is generally designed around some system which a team will adopt when they start using the unit.

Aside from learning the specific features and procedures of an A-Box, you need to know the answers to some basic questions about the unit (over and above the odometer characteristics discussed in [Chapter 10](#)):

How are calculations at speed changes carried out? Some units will calculate their perfect time based on the exact mileage registered at the point of the CAS change. Most A-Boxes keep mileage with far more internal resolution than the typical rallymaster calculates perfect times. This leads to timing errors, which can become large at very low speeds. Some units truncate the mileage to the hundredth of a

mile at a speed change. Some units add the truncated distance into the next CAS interval.

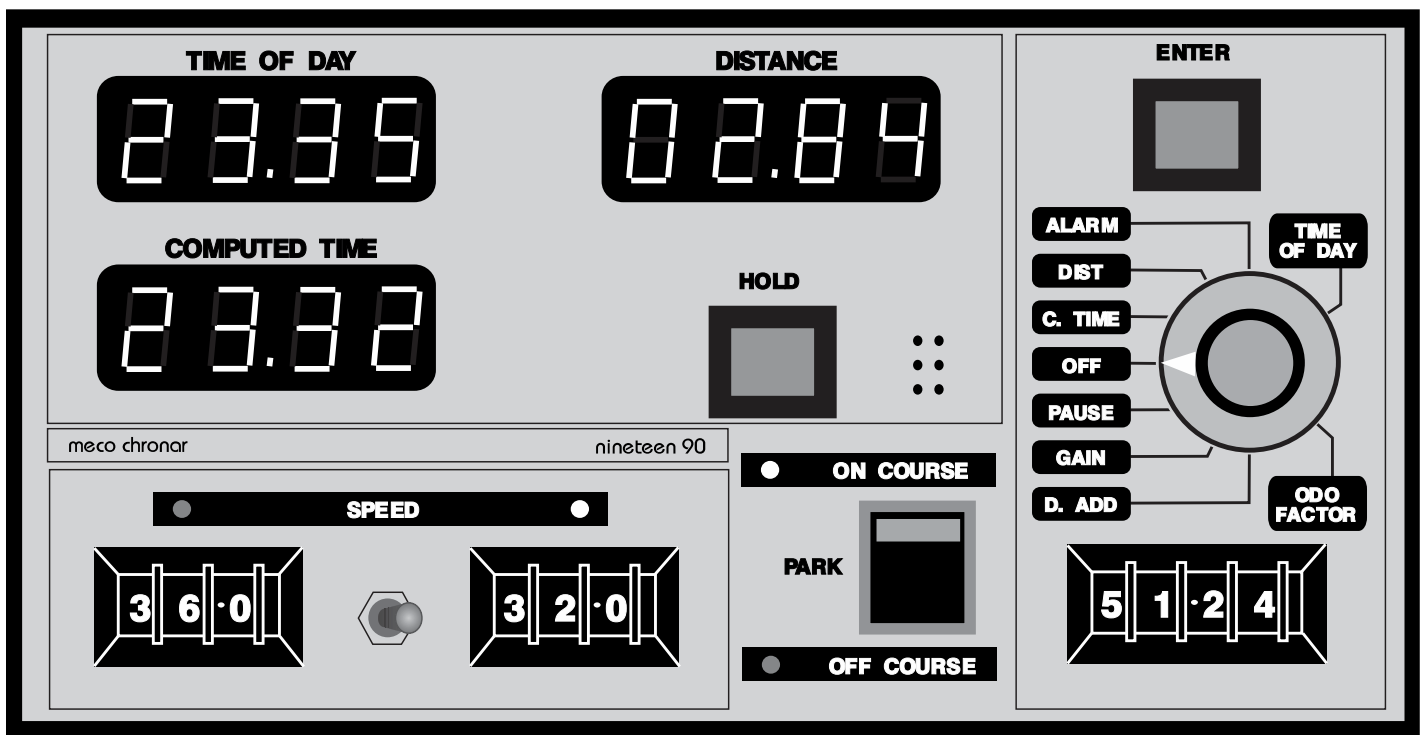
What if you change the active CAS on-the-fly? Some units will use the new CAS in calculations from that point forward (as if a CAS change had happened) and some recalculate using the altered CAS back to the last CAS change location.

What is the late indication of the null readout? The null unit shows the difference between the computed and clock times. This tells you how early or late you are. There are two methods of displaying a late reading, signed and unsigned. If, for example, you are running two cents late, a signed unit would display “- 0.02” and an unsigned unit would show “9.98”. While the signed display makes more “logical sense”, the unsigned display takes little adjustment for most drivers and has the advantage of providing a more apparent visual cue when you are late. Some manufacturers of signed null units now use three horizontal bars to display a late reading: “≡0.02”.

What are the exact characteristics of the null readout? At very competitive events, running the null unit to a higher resolution than one cent will get you closer to the perfect zero. Units which can display the null to three decimal places are ideal. Failing this, you will need to know exactly how the null works. What does the readout show if you are a quarter cent (0.0025 minutes) early? A half cent (0.0050) late? How about exactly on time? As an example, one A-Box we have used showed “0.01” if you were from 0.0050 early to 0.0149 early, “0.00” if you were 0.0000 to 0.0049 early, and “- 0.00” if you were 0.0001 to 0.0049

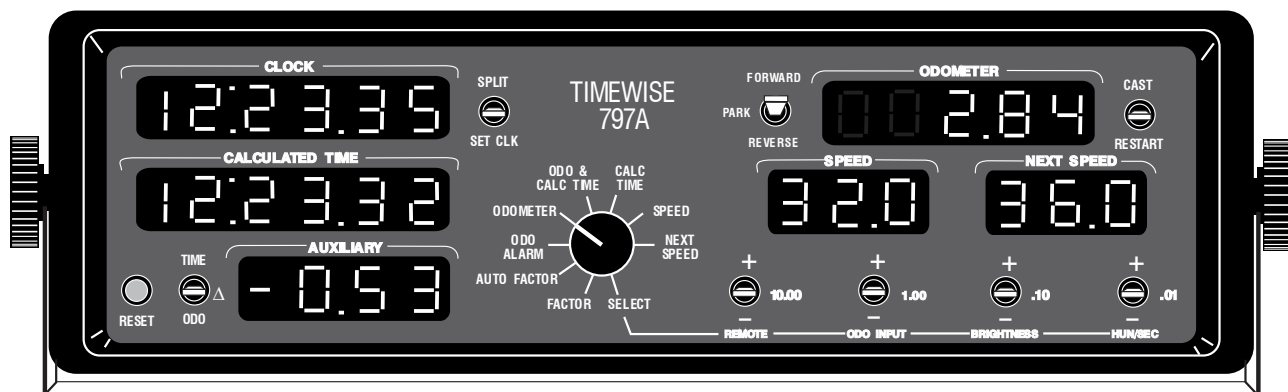
late. Perfectly on time is when “0.00” is showing with the “-” in front flickering.

Below we show some A-Boxes which are currently in production. Each of these models has a separate null unit (not shown) which reads the summary information to the driver.



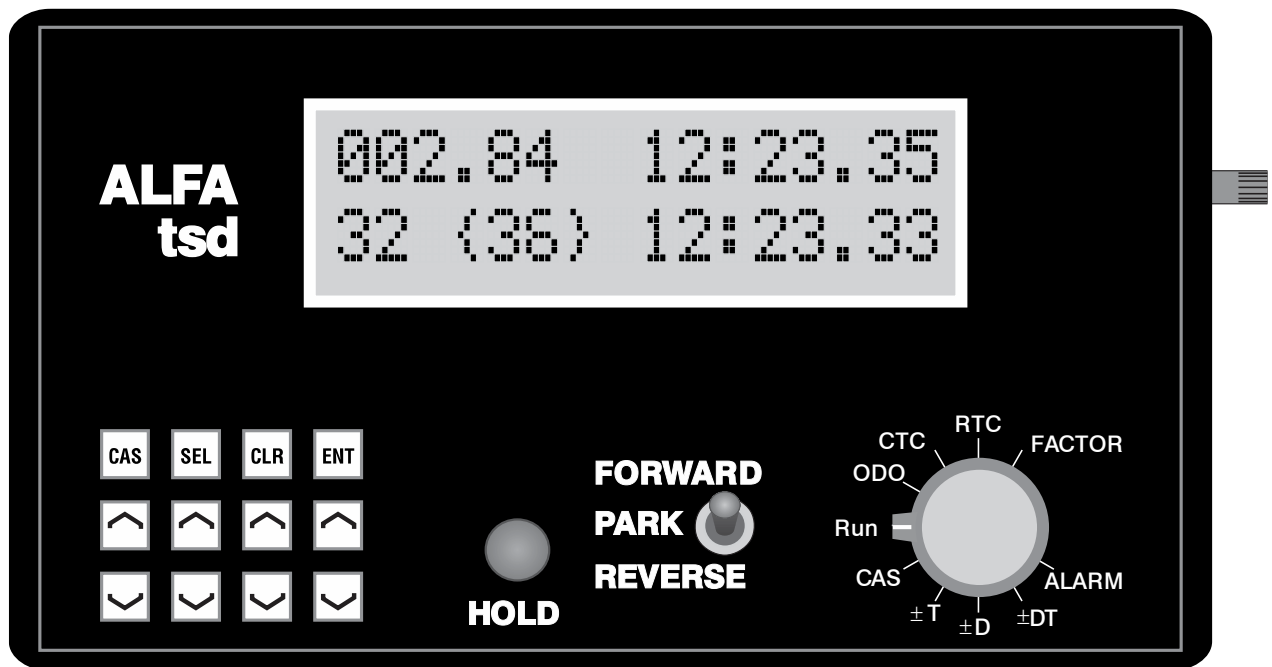
The Chronar Meco Nineteen-Ninety A-Box

- A unit designed with the highest priority on ease-of-use for the first-time navigator.
- Metal case construction.



The Timewise 797A A-Box

- A long list of options, including the ability to select T2 computations (see [Chapter 19](#)).
- Two odometer inputs and two calibration factors.
- Clock synchronization (fine tuning of the clock by small amounts).
- Odometer and calculated time CLEAR functions (called RESTART).
- Metal case construction.



The Alfa TSD A-Box

- The null unit of the Alfa TSD provides a great deal of information to the driver, including current CAS, overall mileage, and null reading (difference between calculated and clock time) with time to the cent. A precision mode is also available which shows the driver a graphic of where they are on the early/late scale with more resolution than one cent. This is useful in sight of a checkpoint.
- An extensive log feature keeps track of information on each speed change and other important events. The information can later be reviewed and compared against the official calculations.
- The unit can take inputs from two sending units and has a separate factor for each input.
- Newer units can save the correction factor even while the unit is turned off.

Summary of A-Boxes and Rally Computers																		
Make	Model	Display	Power	Fuse (amps)	Size (inches) ^③			# Odometers		Main Odometer Resolution		Null		CF ^⑤		# Clocks & timers	# Made	Vintage
					Width	Height	Depth	Independent	Dependent	Visible	Internal	detachable	signed/unsig.	significant digits	add/inverse			
Alfa	TSD	LCD	12v ext	1	9.7	4.3	2.3	2	1	3+3 ^④	3+8	y	s	5	ad	1	170	'86-
	Elite	LCD	12v ext	1	9.7	5.0	2.0	2	1	3+3 ^④	3+8	y	s	5	ad	1	10	'92-
Chronar	1980	incan	12v ext	5	8.7	4.7	3.0	1	0	2+2	2+7		u	4	ad	1	75	'76-'82
	1990	incan	12v ext	5	8.7	4.7	3.0	1	0	2+2	2+7		u	4	ad	1	60	'83-
Coralba	C-Rally ^②	LED	12v ext	1	5.1	1.8	2.1	2	0	3+3	3+7			4	in	1		
Halda	Speedpilot	drum	mech	-				1	0	3+2	3+2	-	-	-	-	1		
Terratrip	404 ^②	LCD	12v ext + nicad	1	6.5	4.4	1.9	1	1	3+2	3+7	⑥		4	in	2		
Timewise	785A	LCD	12v ext	.75	8.9	4.2	2.7	2	0	2+2	2+6	y	s	3	in	2	15	'82-'86
	796A	LED	12v ext	1.5	10.4	3.3	2.8	2	0	3+2	3+8	y	s/u ^①	5	ad		110	'86-'90
	797A	LED	12v ext + nicad ^①	1.5	11.4	3.3	2.8	2	0	3+3 ^④	3+8	y	s/u ^①	5	ad	1	125+	'90-
Woodhenge	A-Box	LCD	12v ext + nicad	1	8.5	5.0	2.5	1	1	3+2	3+8		s	6	ad	1	2	'90-
Zeron	110	drum		-	12.2	8.2	3.3						u	-	-			
	330	incan	12v ext					2	0	2+2	2+2		u	-	-	1		
	440	incan	12v ext										u					
	550	incan	12v ext					1	1	2+2	2+7	y	u	4	ad			
	660	incan	12v ext	5				1	1	2+2		n	u					
	770	incan	12v ext	3	8.5	7.5	3.0	1	1	2+2	2+7	n	u	4	ad	1		
	880	LED	12v ext	3	8.5	5.6	4.0	1	1	2+2	2+7	n	u	4	ad	1	100+	'85

① Optional feature when the unit is purchased.

② Designed primarily for Pro Rally.

③ Including height of switches, knobs, and protrusions, except switches and knobs on the front panel.

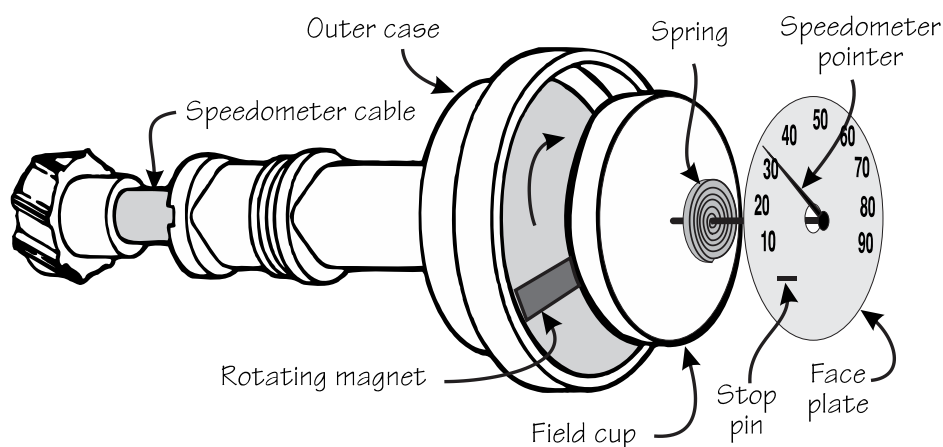
④ Hundredths or thousandths mileage selectable

⑤ Not including the computed time or the null time readouts.

⑥ No null unit/driver's display.

12. Speedometers

Sir, do you know how fast you were



The innards of a typical stock speedometer

going?

— private conversation with a
New York State Trooper

Depending on what class you run, the speedometer is either the focal point or the forgotten stepchild of the rally team's attention. This Chapter will look at both stock speedometers and custom add-on speedometers that you can purchase or build. We also go into the details of calibrating a speedometer prior to competition.

Anatomy of a Speedometer

Your car's stock speedometer is either the mechanical type or the newer electronic variety.

In the mechanical type, the speedometer cable (which drives both the odometer and speedometer) turns a magnet inside the back of the instrument. As the magnet turns, it sets up a rotating magnetic field.

Around the magnet is a movable cup, called a field cup. The speedometer pointer is attached to the back of this cup. Although the field cup is not directly attached to the cable or the magnet, it is affected by the rotating magnetic field. As the magnet rotates, it induces the cup to move in the same direction. To keep the field cup and the pointer from simply starting to spin, a spring is attached between the cup and the body of the instrument. This spring is also designed to dampen oscillations of the cup. The force on the cup, induced by the rotating magnet, is resisted by the spring. At a steady speed, the two

forces come into equilibrium, and the pointer rests on a given indicated speed.

As described in [Chapter 10](#), electronic speedometers and odometers are driven by a sending unit that generates electronic pulses. The speedometer measures the time between a set of pulses and usually displays a digital speed, although some speedometers convert the pulse rate back to an analog reading dial.

Stock Speedometer Characteristics

If you rely on your speedometer for scores, you should investigate these questions:

How much resolution can you realistically discern? If the speedometer covers a wide range of speed (e.g. 0 to 150 mph), it may be difficult to judge speeds to within even 2 or 3 mph. If your speedometer is digital, it probably reads to the nearest mph. Most rally regulations prohibit a speedometer with markings finer than 1 mph.

What is the minimum speed it registers? If speeds below 15 mph don't register or are very difficult to read, you will have problems on some events. The usual reason a unit won't register below some minimum speed is that there are stops somewhere on the face or inside the unit. The stops limit the pointer at the low end. Many have a stop on the face plate that you can see, but some have stops inside the unit. Simply removing this stop and adding a couple of marks often removes this limitation, but

may also re-classify the unit as non-stock under many rules.

Is the face of the instrument marked off in linear increments? Is the spacing between the 10s markings the same? Most markings on a stock face are linear, because that's the easy way to mass produce them. Non-linear marking on a stock unit indicate that the manufacturer knew of general irregularities in the unit and tried to accommodate them on the face. If this is the reason behind the non-linear markings, it means that your factor will vary less across a range of speeds. However, if its just a sloppy face, all bets are off. Calibration is the only way to tell the difference.

What is the parallax of the instrument? This is determined by how far the pointer is from the face of the speedometer. One way to judge parallax is to install a mirror behind the pointer. This trick, often used on custom speedometers, can be done by adding a strip or patch of aluminized Mylar to the instrument face. While the point of the needle is over the face markings, the needle body is above the Mylar mirror. If you see two needles, you have a bad case of parallax and need to reorient your position.

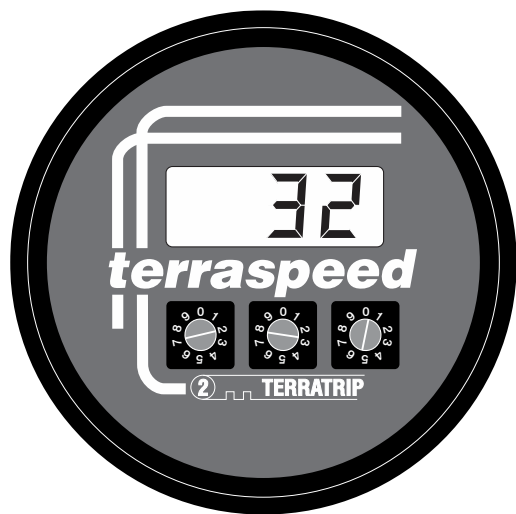
Custom Speedometers

Speedometers which are not stock equipment are found in several places.

Custom Digital Speedometers

A number of A-Boxes and B-Boxes have a calibrated speed feature that displays a digital speed, usually to tenths or

hundredths of an mph. This is done by measuring the time between the last several pulses (usually 3 to 5 pulses are measured). Speed is computed from the number of pulses, the time between them, and the calibration factor.



*The Terratrip TerraSpeed speedometer
with analog calibration*

There is one stand-alone digital speedometer in production today that is not part of an A-Box or B-Box – the Terratrip TerraSpeed. It takes pulses, like an electronic odometer, and has a three-digit calibration factor that can be dialed in on the front using a small screwdriver.

Custom Analog Speedometers

One well-known use for custom speedometers is the Great American Race. The antique cars are allowed a single analog speedometer with a sealed face of not over 6" diameter. Since there are no odometers of any kind allowed in the event and calculation equipment is not allowed, a

precise speedometer is critical for good scores.

The top teams running the Great American Race usually fall into two camps for their custom speedometer. The first camp uses a mechanical speedometer manufactured by Jones Instrument Corp. These units use a completely different mechanism than stock speedometers for translating cable revolutions into a speed reading. There is a governor inside the unit which controls the pointer consistently across a broad range of conditions.

The other camp runs thermally stabilized units that are built from stock speedometers. You can purchase one from a custom builder, such as Roadrunner Tire and Automotive listed in Appendix A, or you can undertake the project yourself.

The objective in building a custom speedometer is to create an instrument that is stable and linear in its readings under all anticipated rally conditions. Stable here means that any given absolute speed will register the same on the instrument in all conditions, whether its 30°F at 40 mph in the mountains or 125°F at 40 mph in the desert. Linear means that the factor correcting indicated speed to the rallymaster's speed is the same across the entire range of rally speeds, from 5 mph to 55 mph. Of course, you want those readings to be as close to statute mph as possible so that the corrections are small.

There are two main factors to control when customizing a standard speedometer, both

related to the coil spring holding the speed cup. The first and most obvious is the most difficult to handle: physics and engineering aside, the spring rate is not linear, particularly over a full 360° deflection. Second, the spring material, and hence the spring rate, is highly temperature sensitive. The first problem is addressed by calibrating the unit and the second problem is addressed by the design and construction of the instrument.

The construction objective is a unit that can be heated to around 130°F and held there within $\pm 2^\circ\text{F}$. The exact temperature isn't important, as long as it's above any temperature that will be encountered during competition, measured where the unit is installed. The stability of that temperature is extremely important. Some unstabilized units will shift their reading by over 1 mph due to only a 10° temperature change.

The brand of unit is not too important. Many are built up using new Stewart-Warner units. Experience has shown that VDOs work just as well (and you can strip one out of a junked VW bug easily). Open the unit and discard the odometer and any internal stops. At this point, make sure the final design provides for some sort of non-glare instrument lighting. The unit will do you no good if you can't read it in low light situations.

Install the heaters inside the speedometer case so that they don't interfere with operations. The heaters can be just large resistors straight off the rack at Radio Shack. Their part #271-135, 100 Ohm, 10 watt

power resistor is a good choice, and you can use two or three depending on the unit you need to heat. Then determine how you will regulate them. This may be a thermometer on the unit's face with a simple on/off switch (not recommended), or a potentiometer, or some sort of thermistor circuit. Bi-metal strip thermostats are generally not a good idea due to the bouncing and vibration in the car. Power comes from the car battery and should be fused and switched independent of the master ignition switch.

The speedometer case is then surrounded with material that can serve both as a thermal insulator and a heat reservoir. A thermal rosin works satisfactorily. Be sure that either access is left on the back for the speedometer cable and the electricals (heater and instrument light) or that these are extended from the case back through the insulation. About two inches of insulation is adequate. One simple design centers the case inside a large diameter PVC pipe and fills the space between the case and the pipe with insulation.

The face is as simple as a ring of thin plywood, painted to enhance contrast between the face plate and the numbers. Most of the center can be covered with aluminized Mylar (to help judge needle parallax), with the edge left clear for marking numbers. A clear cover sits over that, usually mounted using a ring cut from a PVC pipe end cap.

Now install a ratio adapter on the speedometer cable. All speedometers display

more range than a rallyist needs. And most units do that using less than 270° of their face. Select a ratio adapter that gives the face needle just under a 360° turn as it runs up to 65 mph. This gives you the greatest sensitivity without making it difficult to read, covering only that speed range you need for competition.

The final part of the design is the installation. This depends on the details of both the car and the instrument. The mounting must not allow the unit to rotate, so that the calibration step can properly handle the nonlinearities of the spring and needle coupled with gravity. Installation may be on the steering column, in the dash, on the cowl, etc.

Speedometer Calibration

Unlike odometers, most speedometers don't have a linear calibration. On an odometer, if you are short 1 mile in 50, you will be short 2 miles in 100, 4 miles in 200, and so on. The corresponding situation for a speedometer would be for it to read 1 mph low at 20 mph, 2 mph low at 40 mph and 3 mph low at 60 mph. Unfortunately, this nice relationship rarely holds true.

Why? One problem is that the spring which dampens the field cup does not provide a perfect linear drag. Another problem is the weight of the pointer itself. At low speeds the pointer is usually horizontal and gravity pulls down on the end of the pointer. This effect gets less and less as the pointer approaches vertical in the middle or upper speeds. Finally, the markings on the

instrument itself tend to introduce their own inaccuracies.

The solution to these issues is to calibrate the instrument at a number of speeds and use a sliding scale or calibration table. Many teams try to do this during the odometer check, but you never have enough time to do that properly.

The best way to handle these problems is to calibrate the instrument prior to the event. What method you use depends on how you are allowed to mark or alter your speedometer under your rally regulations. We will look at calibrating the following varieties of speedometers:

Unmarked Stock Speedometer. The most restrictive rules require use of a stock speedometer and prohibit any markings to be added to the face or covering window.

Marked Stock Speedometer. You are allowed a stock speedometer, but are free to add markings.

Custom Analog Speedometer. This is an add-on or replacement unit of given specifications upon which you are free to mark or build a face of your own design. The regulations may specify that the face cannot be rotated during competition, but this would not be an advantage in any case. A face which reads uniformly 1% low would need to be stretched 1%, not rotated, in order to make it read correctly at all speeds. This class of rules is essentially the requirements for the Great American Race.

Approaches

Here are two basic approaches to calibrating any of the speedometers mentioned above:

On-board A-Box. One method is to install an A-Box in the car you are calibrating. This is also useful later when you are developing performance graphs for various situations and practicing running Limited-Speedo Class. However, this approach is unsound if you are using expandable bias-ply tires. The reason? Your speed affects the mileage measurements of the A-Box's odometer due to tire stretch. Courses are measured by rallymasters using non-expandable tires and any mileage measurement you do in calibrating your speedometer must simulate this using non-expandable tires.

Measured course approach. Using a measured course for calibration is, arguably, the best approach. The course can be set up by you and measured by someone with a precision odometer. If no precision odometer is available, a stock odometer can be used, but it will be less accurate. The most accurate way is to hand measure a distance with a steel tape, under known conditions. This may seem like overkill, but it eliminates the zone of uncertainty (see [Zone of Uncertainty](#)) and other precision odometer inaccuracies.

An important issue is to have the precision odometer in the A-Box calibrated as closely as possible to a statute mile. If you must use a stock odometer, you should try to get one which is known to read close to statute miles.

One technique which seems workable is to use an A-Box with a calibrated speedometer. This does not work out so well in practice. Even though some calibrated speedometers resolve to the hundredth of a mph, they are not really accurate to that degree. Because they are measuring the time between a small number of pulses to get time, the granularity of the speed readout is often much larger than 0.01 mph. If, for example, you are reading 31.60 mph, the next higher reading might be 31.73 mph. The box simply cannot produce a reading between those numbers. This accuracy is not enough for our purposes.

Custom Analog Calibration

To calibrate a custom unit, install it, turn on its heater and leave it at least overnight. This is very important. While much of the unit will come up to temperature in an hour or so, it is important that the bearings that carry the magnet are up to temperature. They can't be thermally stable until the magnet is. The magnet, due to its mass and thermal losses down the speedometer cable, takes the longest time to stabilize. This means you need to turn on the heater the day before the rally, and not turn it off at all during multi-day events.

Calibration now involves marking the face. Choose a quiet, level, straight section of road.

If you are using an on-board A-Box and radial tires, set up the calibration factor for statute miles. Then, for each 5 mph increment:

- Mark an “appropriate” place on the scale for the speed you are calibrating. This location is a guess for the first time at a speed.
- Set the assigned speed to the calibration speed and place the A-Box in “Transit Zone” mode. In this mode, the Time-of-Day will run, but the computed time is frozen. It does not really matter what the two times are.
- Perform whatever special function is available on your A-Box to clear out any unseen digits in the computed time. This is the CLEAR function described in [Chapter 10](#), also known as RESTART or SAFETY on different A-Boxes.
- Allow the driver to settle in on the calibration speed, keeping the speedometer pointer on the mark.
- Wait for the hundredths digits on the Time-of-Day to match the computed time. At that instant, take the A-Box out of “Transit Zone” mode. The computed time will now start running.²²
- If you are perfectly on time the hundredths of both the Time-of-Day and the computed times will tick in unison. If you are running faster than the calibration speed, the computed time will run faster than the Time-of-Day. If you are running too slow, the computed time will lag. Of course, you could use the null unit of the A-Box to indicate whether you are fast or slow, but it may not be precise enough. Many null units only read in cents. By

comparing the cadence of the two clocks, you can easily assess a thousandth of a minute drift.

- When you establish the error, determine the percentage and go back to the first step. Repeat the steps until you are sure that the mark is accurate. With practice, you can zero in on a mark in four or five tries.

It is not unusual to find different spacings between the marks you measured. If the spacings are very different in one range, you may want to measure additional speeds in that range, and slightly above and below it.

After your run, go home and carefully interpolate marks between what you timed, but no finer than allowed by the rules, usually 1 mph increments.

If you are using the measured course approach, set up the course on a long, flat stretch of deserted road. Note the location of signs, outstanding fence posts, notable trees, substantial prairie dog holes, etc, so that you have a landmark every 0.5 miles or so. Choose a starting point so that you have ample distance to get up to speed.

Have the car with the precision odometer set a statute calibration factor, warm up their tires, and measure the course. It's a good idea to have them record mileages in both directions so that you can avoid “driving back to the start of the course”. You cannot simply use one measurement run for both directions – the distances are not the

²² With practice at this method, you can use just the hundredths digit on both clocks. This will cut down on

how long you have to wait for the two clocks to get synchronized.

same! If possible, have them measure the course to the thousandth of a mile, on two or three runs.

Now convert the mileage at each landmark to a time for each speed in 5 mph increments. Rather than rally time in cents, convert to seconds and hundredths of a second.

Now set yourself up with a digital stopwatch reading in hundredths of a second. Start driving those steady speeds and marking the face, repeating each speed many times until you can hit the landmarks right on schedule.

There are other things that can be done, but these are the basics. The result of this exercise is a speedometer calibrated to that car with those tires. Tires? Yes, that's part of the reason the face markings on the calibrated unit will not show uniform spacing. Tire stretch has been accommodated on the face of the speedometer, as have the irregularities caused by the needle sitting at different angles at different speeds, and the irregularities in the spring rate. The unit will end up having linear behavior, and the unit's readings will be repeatable and stable across a wide range of conditions. All of which add up to a lot of things the driver and navigator don't have to worry about in the heat of battle.

Marked Stock Calibration

Marking a stock speedometer is very similar to marking a custom speedometer. You will not be able to do as precise a job, because of the smaller face, the lack of temperature

control, parallax issues, etc. However, you can get surprisingly good results.

Rather than placing pencil marks on a face of your own design, you will be adding markers to either the face of the instrument or a clear cover over the pointer. In either case, use small wedges of tape, color coded for 10 mph and 5 mph increments.

After your calibration run, you can add 1 mph markings with very narrow strips of tape. One issue with marking the cover of the instrument is that many covers sit far from the pointer. Some even curve out from the instrument at the top. This often introduces unacceptable parallax. You will need to remove the cover and mark the face of the speedometer in these cases.

Un-Marked Stock Calibration

If you are not allowed to add your own markings to the speedometer, life becomes a bit more complex in Speedo Class. What we will do is to determine what percentage each speed on the speedometer varies from the equivalent statute speed. This will require one additional step for the navigator on the road when running an event.

If you are calibrating with an on-board A-Box and radial tires, set up the calibration factor for statute miles. Warm up your tires. Then, for each 5 mph increment:

- Set the assigned speed to **one tenth** the calibration speed. For 35 mph you would enter 3.5 mph as the assigned speed. Place the A-Box in "Transit Zone" mode. In this mode, the Time-of-Day will run, but the

computed time is frozen. It does not really matter what the two times are.

- Set the computed time to an even minute, using a Pause or Add-Time feature.
- Perform whatever special function is available on your A-Box to clear out any unseen digits in the computed time. This is the CLEAR function described in [Chapter 10](#), also known as RESTART or SAFETY on different A-Boxes.
- Allow the driver to settle in on the calibration speed, keeping the speedometer pointer on the existing mark on the speedometer for that speed.
- Wait for the top of the minute on the Time-of-Day. At that instant, take the A-Box out of “Transit Zone” mode. The computed time will now start running at about 10 times the rate of the Time-of-Day.
- After exactly one minute on the Time-of-Day, SPLIT the box. Write down the computed time and UN-SPLIT. If your speedometer happens to exactly match statute miles/hour at that speed, the computed time will have accumulated 10.00 minutes during 1.00 minute on the Time-of-Day clock. If the computed time is high, your speedometer is reading below statute mph. If the computed time is below 10.00, your speedometer is reading above statute mph. For example, if you record 9.86 as the computed time, your speedometer is reading 1.4% high at that speed.

- Repeat the reading at 2, 3, and 4 minutes. Make sure the numbers produce consistent results at that speed.

If you are using the measured course approach, set up the course as described above. Determine the perfect time to reach a number of landmarks at each calibration speed and record your actual time of arrival at each landmark. Run each speed at least twice, verifying that the times at each speed match closely. Look for variations in the times and repeat any speed which did not get consistent times. Do not use the same distance between landmarks going in both directions on the road – the distances are not the same. Instead, measure the return separately and record the time for the two directions separately.

Calculate the percentage variation between your speedometer and statute mph at each speed, carrying each calculation to the nearest 0.1% or 0.01%.

Finally, take the raw data home and build a table of **bias** percentages for each speed. The bias is what percentage your speedometer reads above or below the equivalent statute mph. The bias is positive if your speedometer reads below statute speed and negative if your speedometer reads above statute speed. The Variation will be filled in during the event, based on tests you make during the odometer check or speedometer check.

Speedometer Calibration		
Speed	Bias	Variation
10	-0.9%	
15	-0.7%	
20	-0.7%	
25	-0.4%	
30	-0.1%	
35	+ 0.2%	
40	+ 0.7%	
45	+ 0.9%	
50	+ 1.5%	
55	+ 1.4%	

Note how the bias varies across the speed range in the example above. Now you are ready to run an event.

13. Installation

It's the thrifty man who spends the most.

— Tom & Ray Magliozzi,
hosts of *Car Talk*

This chapter talks about how to install the units described in the previous chapters. The big issues are:

- Mounting location and attachment
- Power connection
- Isolation from electronic noise

Caution: Before you begin installation, consider whether you are qualified to perform the work (see “Disclaimers and Cautions” at the beginning of this book).

Sources

One of the vexing problems in doing an installation is finding what parts and components are available which might be useful, and locating a source for them which does not impose a hefty minimum order. For those unfamiliar with installing electronics, a walk through a local Radio Shack is a good starting point. While this chain does not carry everything, it stocks the basic parts in almost every area you will need to consider.

For items outside Radio Shack's inventory, Appendix A lists a number of suppliers. A particularly useful source is Newark Electronics, which stocks items from a huge number of manufacturers. Their mail-order catalog is worth having, both as a source of parts and a place to get ideas when designing an installation. Another very useful source is Digi-Key, which sells connectors from a wide range of manufacturers. Their policy of “no order is too small” makes them an excellent source when installing equipment.

For really special parts, you may need to find a manufacturer who sells to a very specialized market or can custom-build a part. The best place to start a search such as this is the Thomas Register. This encyclopedia of manufacturers has listings broken down by category, so it is reasonably easy to get a list of companies working in a given area. Most libraries have the Thomas Register available for reference.

Electrical Noise

Electrical Noise is the electronic equivalent of pollution. It is generated by every electronic device and can subtly alter or

temporarily disable your rally equipment.
Scary stuff!

We had never even heard of the problem until another team spent an entire year trying to track down their mysterious odometer problems. It went something like this:

March: “It only happens when it rains.”

June: “It only happens when we run the windshield wipers and it's damp out.”

August: “It happens when it's damp out, but not cold and damp, or when we open the right door and the heater is on, but you don't have to open the door as long as the windshield wipers are going and its night and the headlights are on or you signal for a left (but not right) turn.”

November: “We're not really sure when it happens”

Electrical noise is also called Electromagnetic Interference (EMI) or Radio Frequency Interference (RFI). Typical sources of electronic noise which may affect electronic rally equipment:

- Commercial band and business band radio transmitters
- Radar detectors
- Relays installed in custom rally setups. Several relays I tried from Radio Shack in one installation generated a huge amount of noise on the wires connected to them.
- Static discharges

- Motors (windshield wipers, fans, oil and fuel pumps, electric windows and mirrors, electric seats, etc)
- Electronic trip computers and instrument panels
- Ignition systems (nearby cars as well as your car!)
- Electronic fuel injection systems
- Alternators and voltage regulators

There are two types of electronic noise: conducted noise, which travels through wires, and radiated noise, which is transmitted like a radio broadcast. Both types of electronic noise can be very elusive, causing problems only under very specific conditions.

One team had problems only when cornering hard to the right – a heater motor wire swung close to the power leads. Symptoms plagued another team only when the engine temperature was cold – their sending unit cable was near the oil pump wire and this motor apparently worked harder when the oil was thicker. Yet another team's odometer became a very expensive maintenance reminder – it failed whenever the car was overdue for a tune-up.

The symptoms can range anywhere from extra pulses received by the unit, to a change in the unit's internal clock speed, to a complete “brain fry” with nonsense data or even impossible digits in the display. But before you dismay, there is some good news: electronic noise can be detected, reduced, filtered, and units can be shielded from it.

Detection is most easily done with an AM radio, preferably an inexpensive one without RFI filters. Set the radio to a station at the low end of the band and listen for a ticking. This is the sound of your ignition system. If you hear a “whining” which speeds up when you increase the RPM, your alternator is probably the culprit. Now disconnect the antenna and do these same tests. If the noise(s) persist, the radio is picking up the electronic noise through its power wires as conducted noise. Otherwise, it is picking up radiated noise. Now experiment with heaters, air conditioners, power seats, power windows, power mirrors, windshield wipers, windshield washers, and anything else you can think of. Any noise on the radio indicates a large level of electronic noise. However, absence of noise does not indicate absence of electronic noise – the radio may be filtered or may not be in the correct position to register the problem.

To reduce the sources of electronic noise and shield against the remainder:

- Make sure that the negative terminal of the battery is firmly connected to the chassis of the car as well as the ground strap from the chassis to the engine block. A weak connection reduces the power supplied to your instruments (you will be grounding equipment to the chassis) and increases reception of radiated electronic noise.
- Unshielded solid spark plug wires must be replaced, since they generate a great deal of radiated electronic noise. You must use

carbon resistance wires or shielded solid wires.

- The spark plugs themselves generate electronic noise. Using suppressor resistor spark plugs or spark plug caps with resistors will cut down on this source.
- Carefully plan how you will attach power to the unit. These considerations are discussed in the next section.
- Alternators, generators, and voltage regulators generate electronic noise which can be filtered by noise suppressing chokes or capacitors. Most cars have these installed as standard equipment. If your car does not have these components, Radio Shack sells a number of items for this purpose. Part number 270-051 is recommended by one rally manufacturer. Also, consult people who install car stereo systems – they are generally familiar with these problems.
- To guard against conducted noise, some manufacturers install ferrite beads where power leads enter the unit.
- The cable between the sending unit and the odometer can pick up radiated electronic noise. To guard against this, use three conductor cable, with all three conductors enclosed in a shield. You must not use the shield as one of the conductors. Check the cable supplied with the sending unit and replace the cable if it is unshielded or it uses the shield as a conductor (typically to conduct the 0 volt power supply). Also, you must ground the cable shield to the vehicle ground at one end only. Belden's 8735 cable is an

excellent sending unit cable (see Appendix A).

- If you have a problem with static electricity, it will affect your units. A static discharge when you touch a unit is 100 times more voltage than is necessary to fry some electronic components! Computer stores sell spray-on chemicals which reduce static electricity. Of course, these chemicals are to be sprayed on fabric seats, carpets, etc., and not on electronic components.
- Many units are designed to dissipate a static charge to the front of the unit past the internal components and into the body of the car. You attach a short heavy gauge wire from a grounding point on the unit to the car chassis. The key here is short (one foot or less) and thick.

Finally, a word about nuclear explosions. These events generate a huge amount of electronic noise. They can permanently alter the programming and data in your unit (along with all data in every other computer – bye, bye, bank records). So, if your unit is exposed to a nearby nuclear explosion, whether during an event or just parked in your garage, have it checked out by the manufacturer or any other (remaining) electrical engineer at the first opportunity, and certainly prior to the next rally.

Power and Other Connections

When you are connecting a unit to a power source, a bit of planning can save a great deal of trouble in the long run. Even a short interruption of power will cause you to lose

data. This issue primarily applies to units which are driven directly off that power source. Units which are primarily battery driven, and which use the external power source to continuously recharge the battery are not so sensitive to this problem.

Power Source

Whatever you select for a power source, you must consider:

Power interruption. You must select a source which is never interrupted (as long as the vehicle's battery is connected). In particular, any circuit you use must not be affected when you start or stop the engine.

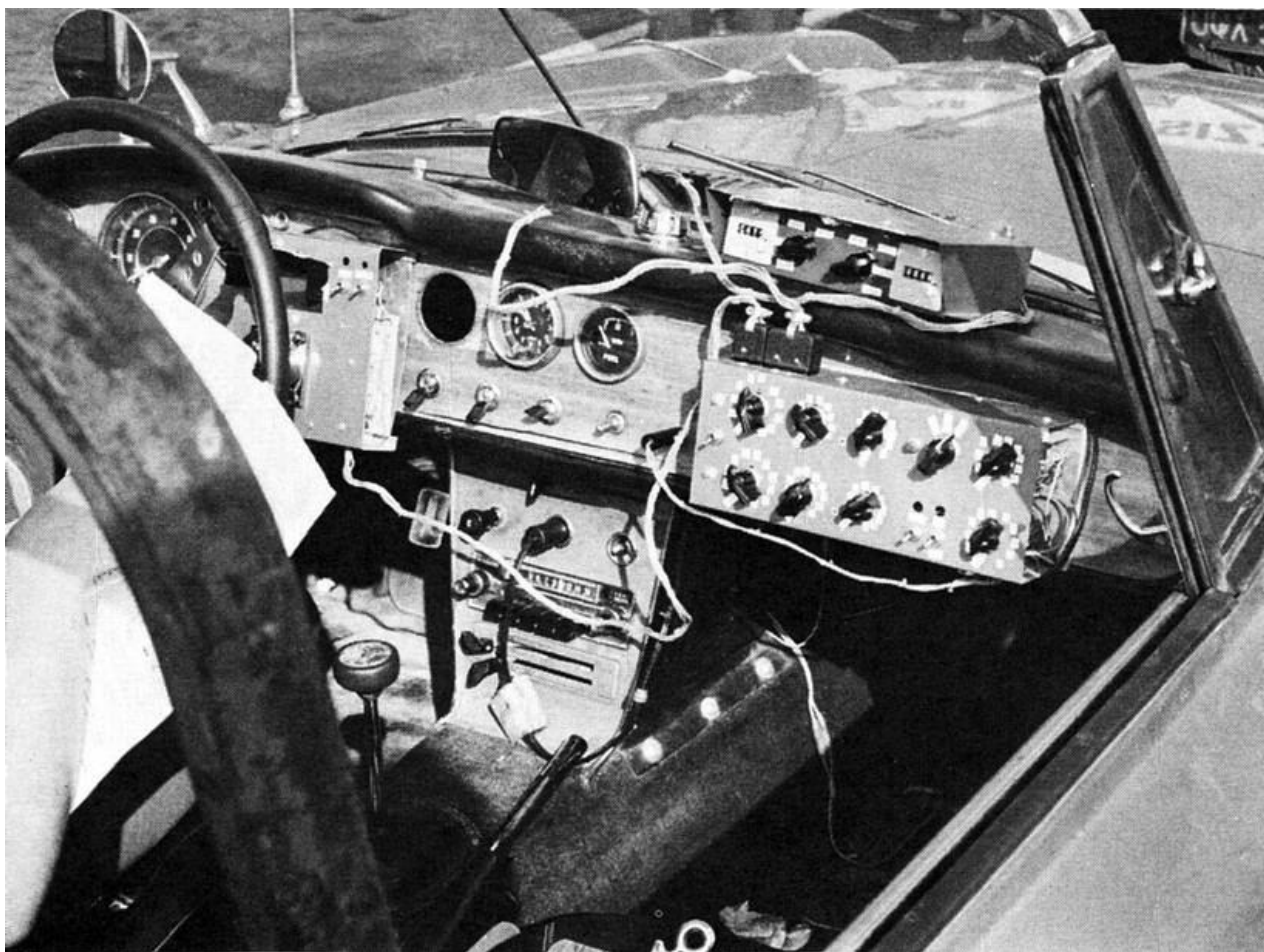
Fuses. You must use a fuse somewhere in the circuit. If you tap into a circuit which has other equipment and a fuse, you have to make sure that the fuse which is installed covers the load of the additional units. You must also consider that a short on the other equipment on that circuit will blow the fuse and cut power to your rally units.

For a direct battery connection (which avoids the problems just mentioned), you can choose what type of fuse to use. The most common choices are “automotive” spade fuses (ATC type) or the cylindrical glass fuses in 1¼” × ¼” (AGC type) or the smaller 5 × 20mm sizes (GMA type). You can install an in-line fuse holder (such as Radio Shack 270-025 (1¼” × ¼” 2-lead with connectors), 270-1281 (1¼” × ¼”, one lead, no connectors), or 270-1238 (5 × 20 mm, one lead, no connectors)). However, a problem with in-line holders is locating the holder when the fuse blows (typically on the

most important event of the year). A better choice is one of the panel-mounted holders (Radio Shack 270-364 (1¼" × ¼") or 270-362 (5 × 20 mm)). ORA Electronics distributes a fuse holder for ATC type spade fuses which has connections for 6 separate circuits (part #AFB400).

Noise cancellation. Electronic noise which is picked up by power leads can be canceled by a simple technique: twist the positive and negative wires around each other, one twist per inch. This is one of the best procedures to follow when installing a power cable.

Monitor. If you are concerned about the



A none-too-neat rally installation.

Contact points. The points where the positive and negative power leads are connected must be close together. Any distance between the positive and negative wires creates an antenna which picks up radiated electronic noise.

voltage level of your power source, you can install a monitor. Datel, Inc. manufactures a line of digital meters suitable for these applications. Their model DMS-30LCD-2-9B is a small, low-power meter with a backlit LCD display which shows ± 20.00 volts.

Polarity. The effects of accidentally reversing the positive and negative power wires can range from undetectable to catastrophic. It all depends on the particular units you are installing. Some units (notably many “Alfa” units designed by Small Systems Specialists) work regardless of the polarity. Other units (most Timewise designs) do not function, but are not damaged. A few units (many Zeron designs) require repair in this situation. You must be extremely careful not to mis-wire power to these units.

Connection to the source. The actual connection must be impervious to vibration and free from contaminants such as dirt, paint, or grease. If you solder a connection, make sure that it is done properly. If you use a screw or bolt fitting, tighten it down to a secure point, but don't over-tighten it to the point of breaking the strands of wire inside the connector. Using a cigarette lighter plug for a unit which requires continuous power is really asking for trouble – they are prone to falling out on rough roads.

Some locations you might consider for tapping into battery power are:

- the fuse box
- an accessory which receives continuous power (such as a clock)
- the battery terminals themselves

Connection to the battery terminals is the best choice to reduce radiated electronic noise. If you use shielded cable and properly ground the shield, you will virtually eliminate this source of radiated noise.

Voltage. While most electronic rally equipment uses 12 volts, some units run on lower voltages. For a 6 volt or 9 volt unit, you can convert from 12 volts using Radio Shack's DC power adapter #270-1562.

Connectors

One rule of installing rally units is that *neatness counts*. A tangle of unlabelled wires, punctuated with fuse holders, switches, and patches of solder connections, stuffed up between the computer and the heater vent is not only ugly, it is probably unreliable. If you find yourself looking at a tangle of wires and tugging at wires to see which wire going into the tangle is connected to which wire coming out the other side, its time to consider a re-design.

One aid to cleaning up an installation is a good choice of connectors. You want to select one which is easy to work with, connects and disconnects quickly, and offers a firm connection. For most applications, you want a connector which is polarized so that it cannot accidentally be plugged in “backwards”, reversing the contacts.

This book uses terminology for connectors which may not agree with a particular manufacturer's terminology:

Plug: A connector mounted on the end of a cable.

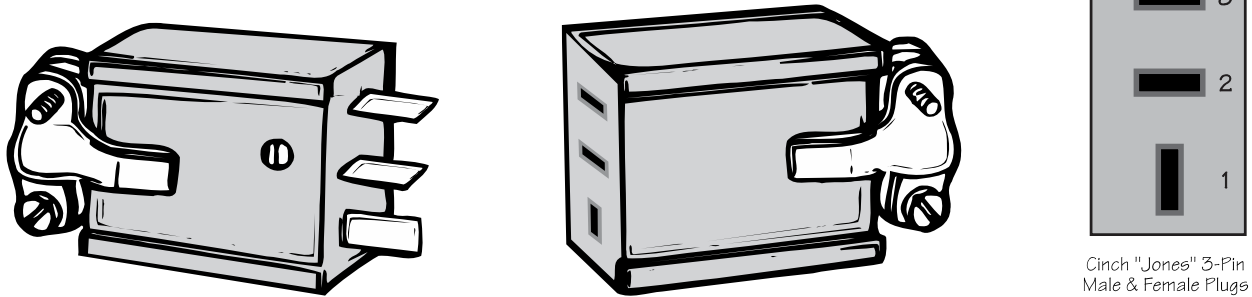
Socket: A panel-mounted connector.

Male: Any connector with pins, even if they are recessed behind a collar.

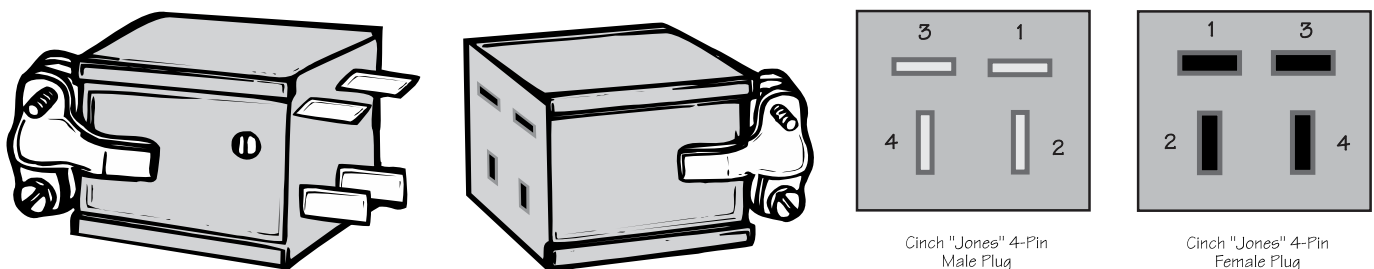
Female: Any connector which mates with a male connector.

Here is a list of some of the connectors commonly used with rally equipment:

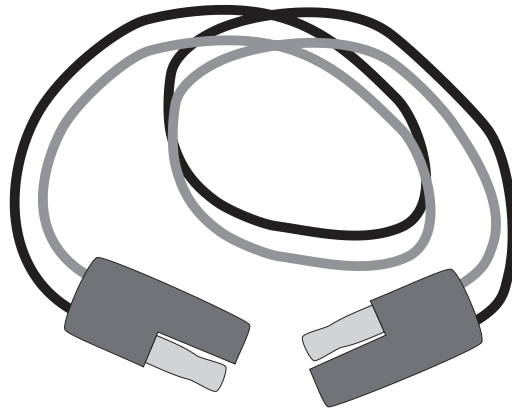
Many situations call for a male and a female plug – as when two cables must be connected. This is called an ***in-line*** connection.



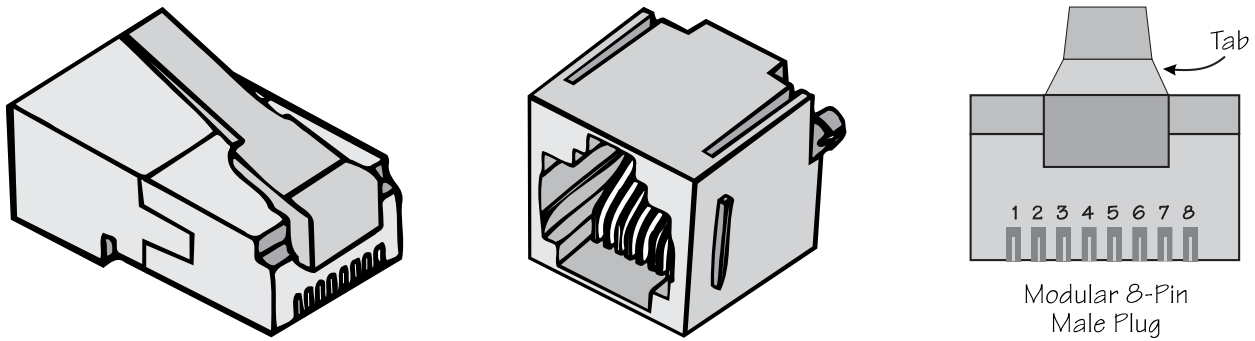
Cinch connectors. Cinch manufactures the “Jones” connectors which are often used for transducer connections. The connector has a male plug and female plug which can be solder-connected onto the end of a cable. The contacts are flat blades which vary in size or orientation to provide polarity. The 2-conductor connector has a round body and the larger connectors all have rectangular bodies. The most common found in rally applications is the 3-conductor version, which is used for sending unit connections. The male plug is typically used on the sending unit side and the female plug is used on the odometer side. Note that the Cinch Corporation was owned for a time by TRW, so these connectors are sometimes known as TRW connectors.



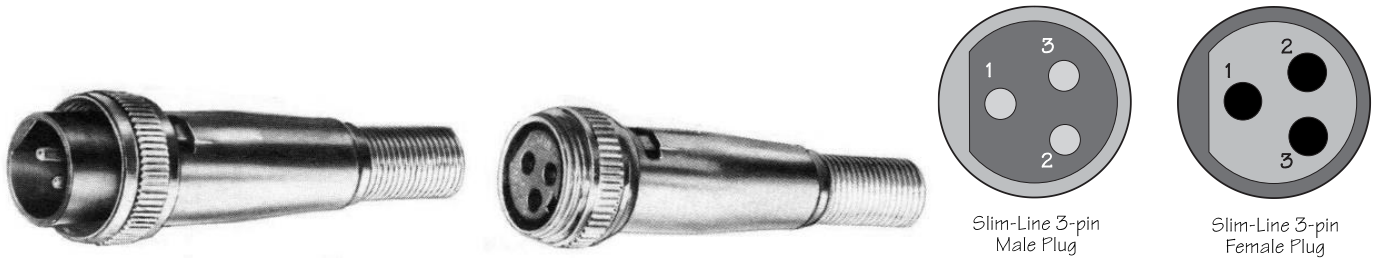
Some Zeron units used the 4-conductor version for their power hookup, running two conductors on positive and two conductors on negative, for redundancy. One negative of Cinch connectors is that they are not “locking”. Two mating plugs can separate if jiggled. You can use nylon ties to secure them together.



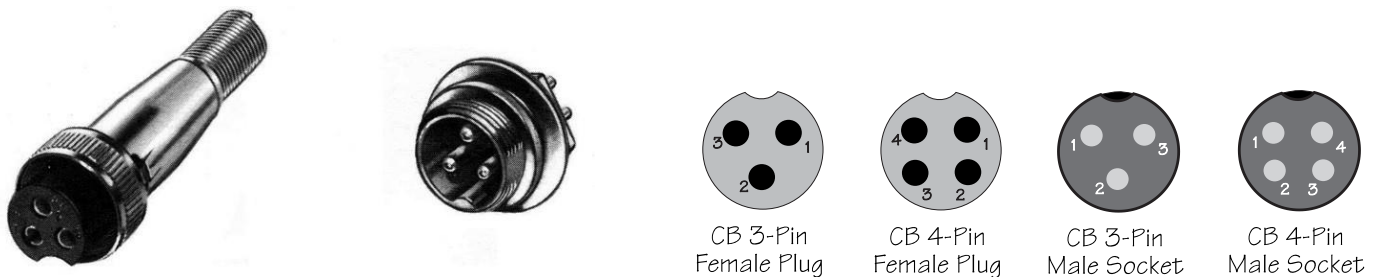
“Quick connect”, “Trailer connectors”, or “2-Way Kit/Splice”. The common name for 2 or 4-conductor connectors which are often used for 12 volt DC power (as in hooking up trailer lights). The connectors are manufactured by Electro-Transfer Systems, Inc. The 2-conductor version is often used for a power hookup. The connector is unusual in that you need to pay attention to both the color of the wire leads and the sense of the connectors. The 2-conductor version is sold in sets of 2 connectors assembled in a 12” cable. After cutting the cable, one connector is used for the supply side (coming from the battery) and one is wired to the equipment side. On both sides, the convention is red for +12 volts and black for ground. In addition, the convention is to wire the connectors so that the female on the supply (car) side and the male on the equipment side is +12 volts. This reduces the possibility of a short when the connector is unplugged. The CalTerm brand listed in Table 13-3 is distributed through auto parts stores. Radio Shack sells a version of this connector which avoids the confusion. Their part #270-025 is a set of two Quick Connectors, with a fuse holder on the supply (car) side.



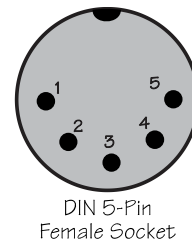
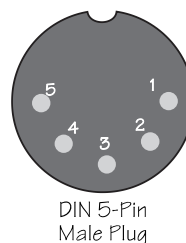
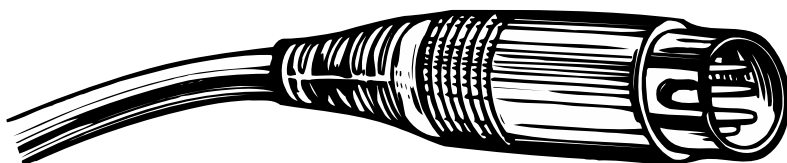
Modular connectors are used on modular phone systems. Versions with 4, 6, and 8 conductors are available through several manufacturers. Timewise equipment uses the 8 conductor version manufactured by AMP. Note that plugs and sockets with different number of conductors are not interchangeable – you will damage the connectors if you try! Also note that the AMP modular crimping tool (expensive) is the only one which works reliably with AMP modular connectors. This connector is one of the few which accommodates the shield wire of the transducer cable. The shield pin should be connected to the vehicle ground. It should not be used for the negative power supply since its job is to drain away radiated electric noise. The pins on this connector which are not listed in Table 13-2 have various uses, including duplicates of other pins and cross-overs from other circuits.



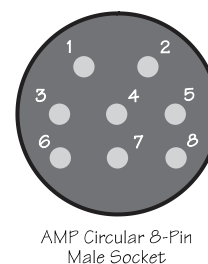
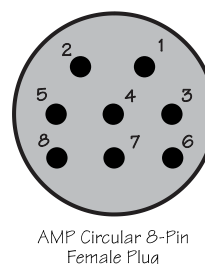
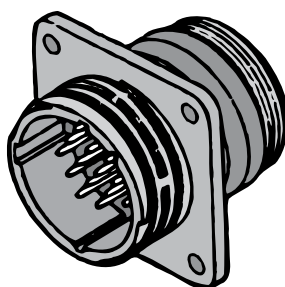
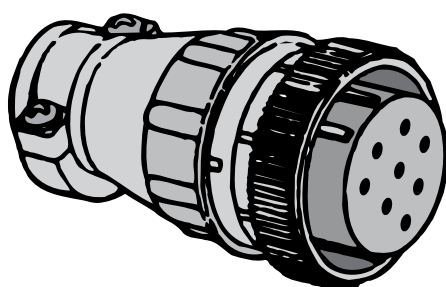
Slim-line connectors. These circular, 3-conductor connectors were sometimes used for sending unit hookups. They are manufactured by Switchcraft, Inc. and are not interchangeable with the popular “XLR” microphone connectors available from Radio Shack (and also manufactured by Switchcraft, who calls them “Q-G” connectors).



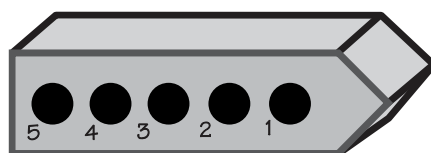
CB microphone connectors. These circular, 3- and 4-conductor connectors are easy to locate, jiggle-proof, simple to work with, and make for a neat installation. Although no rally manufacturers use this connector currently, many rallyists have used them in homegrown installations. The female plug terminates a cable and the male socket is designed to be panel mounted. An alignment tab provides polarity and a locking ring ensures that the plug will stay in place. They are manufactured by Switchcraft, Inc. and the 4-conductor version is available from Radio Shack.



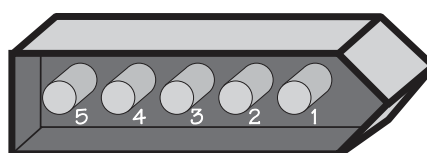
DIN connectors. A circular male plug which can be mated to either a circular in-line plug or a panel-mounted socket. The 5-conductor connectors are used on some Alfa equipment for charging and remote splitting. A variety of DIN-to-DIN cable assemblies and DIN-to-dual-DIN adapters are available from ORA Electronics.



AMP Circular connectors. This is an 8-conductor connector used on some Chronar equipment. The female plug connector shown is what you need to mate with the male socket connector on the back of such Chronar units. This plug connector is assembled from three separate parts, listed in Table 13-3. Note that Amp's terminology is different from the plug/socket terminology used in this book. Also note that both plugs and sockets can be ordered in male and female versions.



Molex 5-Pin
Female Plug



Molex 5-Pin
Male Socket

Molex connectors. A plastic connector with a wide variety of configurations. The 5-conductor version was used on older Alfa equipment for both the power and sending unit connections.

Pin Assignments for Power Connections				
Connector	Conductors	Used on	+ 12 volts Positive Power Supply	0 volts Negative Power Supply Signal Ground
Quick connect	2	Common	Red female (supply side) male (equip side)	Black male (supply side) female (equip side)
Cinch "Jones"	4	Zeron	Pins 1 & 3	Pins 2 & 4
DIN	5	Alfa <u>Clocks</u> ^①	Pin 5	Pin 1
		Older Alfa	Pin 5 & 4	Pin 3
CB microphone	3	Custom ^②	Pin 3	Pin 1
	4	Custom ^②	Pin 4	Pin 1
Molex	5	Older Alfa	Pin 1	Pin 2

Table 13-1

① Pins 2 and 3 on Alfa Checkpoint Clocks provide a remote split when the two pins are connected.

② No standard has been set. These conventions are the ones used in installations I have seen. On 4-pin connectors, pins 2 and 3 are used for a remote split function.

Pin Assignments for Sending Unit Connection						
Connector	Conductors	Used on	+5 volts	0 volts	Pulse Signal	Shield
Cinch "Jones"	3	Common	Pin 2	Pin 1	Pin 3	-
Slim-line	3	Zeron	Pin 2	Pin 1	Pin 3	-
CB Microphone	3	Custom ^①	Pin 2	Pin 1	Pin 3	-
	4	Custom ^①	Pin 2	Pin 1	Pin 3	Pin 4
Modular	8	Timewise	Pin 2	Pin 7	Pin 4	Pin 1
AMP Circular	8	Chronar	Pin 3	Pin 2	Pin 1	-
DIN	5	Older Alfa	Pin 2	Pin 3	Pin 1	-
Molex	5	Older Alfa	Pin 3	Pin 5	Pin 4	-

Table 13-2

① No standard has been set. These conventions are the ones used in installations I have seen.

Table 13-3 on the next page gives sources for connectors in the sizes commonly used for rally applications. Most connectors come in different sizes and pin configurations – check with the manufacturers or distributors. For convenience, your local Radio Shack store is the best bet when looking for connectors. If they don't stock a particular connector, try Digi-Key. They are an excellent source for rallyists since they are one of the few distributors willing to accommodate small orders.

Switches and Ties

When routing wires, it is important to consider what will hold the wire in place and how much slack to allow. Nylon cable ties (Radio Shack #278-1632 (4”), -1631 (5”), -1642 (8”)) are useful in permanent installations. For removable installations, self-stick clips which open to accept a temporary cable routing are useful (Radio Shack #278-1639, -1640, -1641, -1647).

Various switches are available from Radio Shack for constructing custom rally installations. Toggle switches are classified by abbreviations such as SPST (“single pole, single throw”) and DPDT (“double pole, double throw”). Assuming a switch has two positions, a double throw switch provides contacts to recognize both positions while a single throw has contacts for only one position. Single pole switches have one contact for each position and double pole switches have two contacts for each position. Other useful switches include “momentary” ones which spring back to one position and “center-off” switches with three

positions, where the center position disables all connections.

Mounting Location and Attachment

When designing your installation, presume you will be involved in a serious accident. Do nothing in the installation process that interferes with the proper operation or functioning of any of the installed safety equipment, including all belts and airbags. Install nothing that, in the violence of an accident, might become a lethal edge, knife, or projectile.

There are as many methods of installation as there are rally units and cars. The best way to get ideas on how to mount equipment is to look at a large sample of cars running in the upper classes.

Summary of Connectors			
Style	Conduc tors	Part	Source/Part number
Cinch "Jones"	3	male plug	Cinch #P-303-CCT Digi-Key #CJ103P-ND
		female socket	Cinch #S-303-CCT Digi-Key #CJ103S-ND
	4	male plug	Cinch #P-304-CCT, Digi-Key #CJ104P-ND Radio Shack #274-204
		female socket	Cinch #S-304-CCT, Digi-Key #CJ104S-ND Radio Shack #274-205
Quick connect	2	universal connector	Radio Shack #270-026 (2 connectors per unit) Radio Shack #270-025 (with fuse holder) CalTerm #23020 (P-302)
	4		Radio Shack #270-027 (2 connectors per unit) CalTerm #23040 (P-304)
Slim-line	3	male plug	Switchcraft #SL-40-3M
		female plug	Switchcraft #SL-41-3F
CB Microphone	3	female plug	Switchcraft #CB-3F
		male socket	Switchcraft #CB-3M
	4	female plug	Switchcraft #CB-4F, Radio Shack #274-001 ORA #MCP416
		male socket	Switchcraft #CB-4M, Radio Shack #274-002 ORA #MCP416-SC
Modular	8	plug	AMP #5-554739-3, Digi-Key #A9094-ND
		socket	AMP #520251-4/#520259-4 Digi-Key #A9044-ND/#A9074-ND
		crimping tool	Digi-Key #A9900-ND
DIN	5	male plug	Cui-Stack #SD-50, Digi-Key #CP-1050-ND Radio Shack #274-003
		female jack (in-line)	Cui-Stack #SD-50J, Digi-Key #CP-1150-ND Radio Shack #274-006
		female socket (panel mount)	Cui-Stack #SD-50SN, Digi-Key #CP-1250-ND Radio Shack #274-005
Molex	5	male plug	Molex #03-06-2055, Digi-Key #WM1224
		female jack	Molex #03-06-1056, Digi-Key #WM1234
AMP circular	8	female plug	① AMP #205838-2 (plug), #206062-1 (clamp) #66569-3 (sockets)
		male plug	① AMP #205841-2 (receptacle), #206062-1 (clamp) #66570-3 (pins)

Table 13-3

① These three parts together make up the female or male connector. The female connector plugs into the back of some Chronar equipment. The male connector can be used to build adapter cables.

The first thing you must decide is whether you want a permanent installation (one which remains in a car at all times), a removable installation (one which can be easily installed and removed from a particular car), or a portable setup (one designed to be installed in any car). Even if you rally often and don't mind having the equipment installed in the car at all times, there are some advantages to a removable setup. You can set all your equipment, including rally reader, null unit and fuse box, on one removable tray which fits on the dash. Also, a removable setup does not have to be quite as "neat" as a permanent installation.

Before you take a drill to your prized Louis XIV mahogany dashboard, some careful planning is in order. The positions of all units should be as ideal as possible. This trite-sounding suggestion is often overlooked until after several rallies when a "gee, wouldn't-it-have-been-nice-if" list starts to grow. The best approach is to temporarily install the equipment for an event or two and take notes on ideas during the event.

Make sure that all switches used with any regularity can be reached without moving from your normal seat positions and without fully extending your arm. A minimum of a 45° bend at the elbow is needed for comfortable long-term use.

The position of the rally reader is the most important. We installed our rally reader in the center of the dash, canted toward the driver so that it is perpendicular to the sight

line, but still visible to the navigator (assuming the navigator has his own set of route instructions). We also added a wire across the front of the reader to act as an instruction marker. Some people like to install a shortened reader on the steering wheel, using a rotating bearing to keep it upright during turns. I feel that this position is too far from the driver's normal line of sight.

Try to get items which the driver looks at frequently within the same field of glance. If the reader is on the dash, you can install a computer null-unit to the left of the reader, with any overall mileage reading right next to the active route instruction. If you are lucky, this will place both the route instructions and the null unit near the speedometer.

Before installing equipment, make sure that nothing interferes with the driver's view of the road, or any line of sight to or through any mirror.

For the navigator, try to take the navigation strategy into account. We used several units in Odo class, and positioned them so that the two displays which get compared in a typical reading are next to each other. We even went as far as to design our navigation log so that the numbers which need to be recorded in a speed change are in the same position on the dash as they are on the logsheet.

Some rallyists install units right into the dashboard. If you use such a cutout, carefully consider the air circulation and

cooling requirements for the particular unit. Also remember that any switches on the sides or rear of the unit will be inaccessible and will have to be re-wired.

If you are building a portable setup, you can try to mount all your equipment on a lapboard. We managed this for running Odo Class, but it was tight.

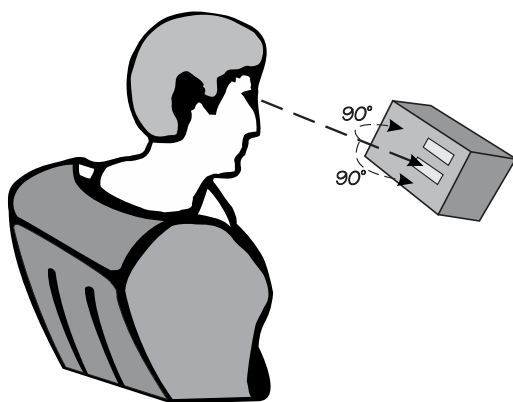
Another approach is to mount units on a base, which is held on the dash with bungee cords hooked into defroster vents, glove box edges, dash board lips, or sturdy supports. You can rig a portable rally reader with suction cups to stick to the dash or base of the windshield. The notepad clipboards sold for use in cars have a suction cup with an adjusting lever. A pair of these can be rigged onto the back of a rally reader with a bit of ingenuity.

slightly from 90°. If the display face is canted down, you will lose contrast.

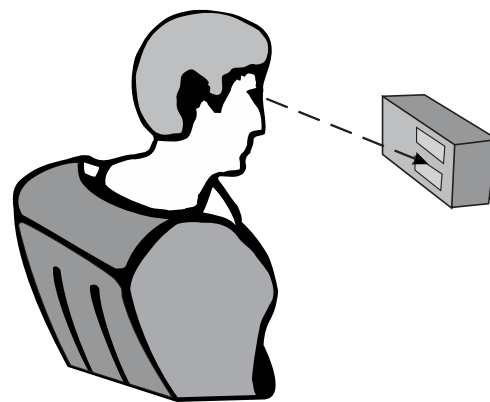
For night events, it is a good idea to keep anything which does not have a black matte finish, especially route instructions on a rally reader, from reflecting in the windshield. A cover above any equipment which is painted with a flat black finish will also work.

For day events, make sure that nothing shiny can possibly catch the sun and reflect in either of your eyes.

If you have problems reading the displays when the sun shines on them, you may need to construct a hood. The hood should be just large enough to block the sun from any angle. You should make the hood from a material which will present no danger whatsoever during a crash. Metal or wood



Yes



No

Proper orientation of equipment with LCD displays

If your equipment uses LCD displays, the angle at which you view the display may be important to contrast and readability. The ideal angle is 90° to the eye, or canted up

(even balsa) are not acceptable. Even corrugated cardboard can be a hazard if you strike it edge-on.

When attaching a unit directly to the dash, you should try to make the connection as firm as possible. A loose attachment may actually transmit more vibration to the unit than a positive attachment. If your unit has a bracket, you can screw or bolt the bracket directly to the dash in a permanent installation. Select screws or bolts which will not interfere with the free movement of the unit in the bracket. Also, use short

If you prefer to Velcro a unit to the dash, use the self-adhesive Velcro. The bond formed on dashboards is more positive than with the glue-on Velcro. However, substituting contact cement for the Velcro glue can form an even better bond. Before applying the Velcro, make sure that the surface is completely clean. Vinyl conditioners, Armor-All, oil, and grease all render Velcro adhesive useless. Rather than



Cockpit of the Mike Friedman / Marc Goldfarb rally car

screws and drill shallow holes so as not to interfere with any controls or wires below the surface of the dashboard. If possible, select a mounting location where the holes will not be obvious – along a trim or behind a removable logo.

apply a single long strip, several shorter strips will accommodate a slightly curved dashboard surface.

A good alternative to Velcro is Scotch brand mounting tape. This product is $\frac{1}{16}$ " thick foam with adhesive on both sides. It is available in $\frac{1}{2}$ " rolls (Scotch catalog #110)

or as flat squares (Scotch #108) and provides a more rigid attachment than Velcro. Do not use other brands or the new Scotch permanent foam tape – they are very hard to remove cleanly.

And now, in this photo, the winner of the *neatness counts* rally installation, complete with dual rally computers. The rotary switches below each computer allow the navigator to select which of the six sending units to feed to each computer. A fuse, labeled with the correct replacement fuse amperage, is mounted on a panel between the rotary switches, easily accessible in case of an overload. Finally, note the power switch – a key-operated lock. The key cannot be removed when the power is off. This prevents losing it when you want to start up the units. With the power on, the key is removable, preventing accidental shutdown.

Sending Units

Closed Sending Units

If you are using one of the closed sending units, installation is straightforward (comparatively). Each of the common models can be installed

- in-line on your speedometer cable, either behind the speedometer or where the speedometer cable exits the drive train;
- at the end of a cable attached to a wheel or split off the speedometer cable using a T-gear;
- affixed directly to a wheel with the proper hardware.

If you are going to mount one of these units outside the passenger compartment, make sure it was designed for exposure to moisture and high levels of light (a consideration for photoelectric models) and temperature (both hot and cold).

If you mount the sending unit at the end of a cable rather than in-line, be sure to plug up the left end to keep out dirt and moisture. Mounting the sending unit directly on a wheel, can be very portable, but exposes the unit to weather and road hazards.

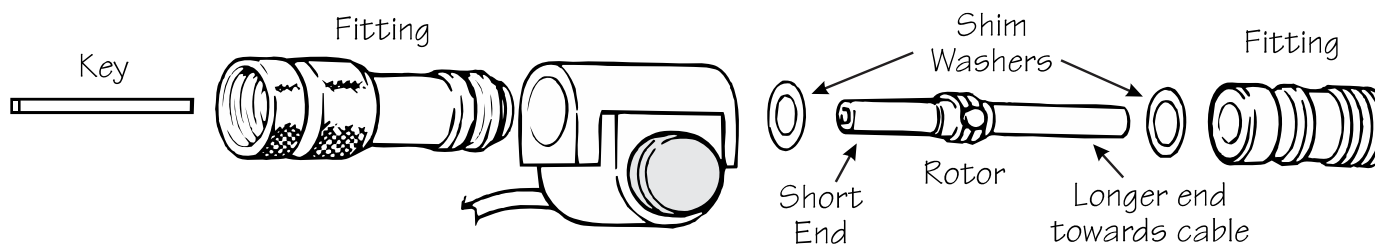


Figure 13-1: Internals of the Type A sending unit

Figure 13-1 shows the internals of a common closed sending unit which we call the Type A unit (made by modifying a Halda T-gear, a task usually done by rally manufacturers and distributors). The cable driving the unit enters from the right side of Figure 13-1. The left side is for an “output” cable going to the speedometer. Be aware that Halda T-gears are no longer imported into the US. Thus, rally distributors no longer have a source for the “raw materials” for the Type A sending unit.

Another style, the Type B model, is shown in Figure 13-2 with various adapters which may be required. The short cable adapter on the left is used if there is no room for the sending unit behind your speedometer. This cable allows you to place the sending unit behind the instrument panel. Again, the cable driving the unit comes in from the right side.

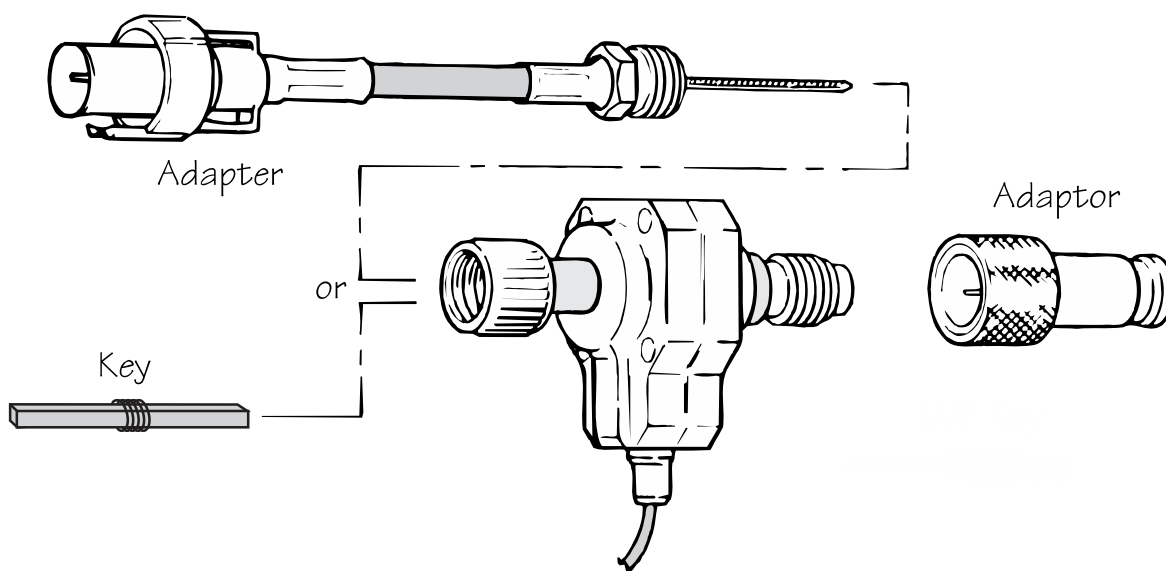


Figure 13-2: Internals of the Type B sending unit

Figure 13-3 shows a Type B sending unit mounted on the back of a Volkswagen speedometer. The speedometer/odometer assembly is on the left, sitting upside down. The sending unit is also upside down, with an adapter on the side which mates to the speedometer cable. This setup fits (barely) behind the instrument cluster in the dashboard of a VW Golf.

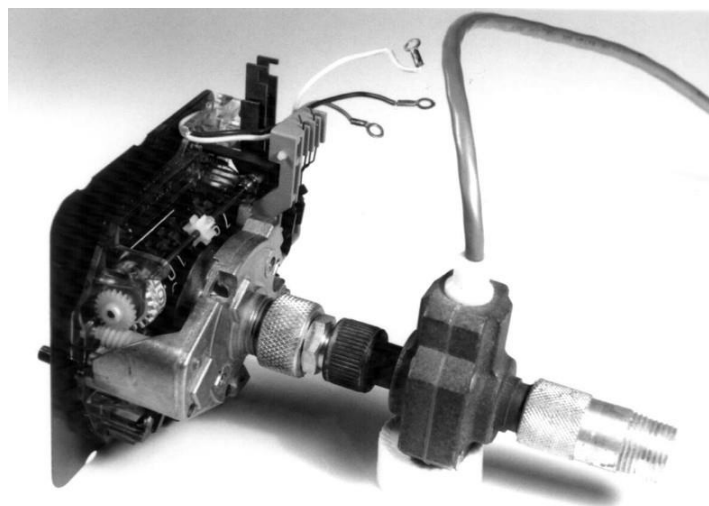


Figure 13-3: Type B sending unit on the back of a VW speedometer

Attachment of a Type C sending unit (see Chapter 10) is straightforward. You simply unscrew the speedometer cable from its transmission fitting, insert the sending unit, and screw the speedometer cable to the back of the sending unit.

Installing the Type D sending unit requires surgery on the speedometer cable. You select the location on the speedometer cable and cut only the cable housing. You then pull the entire length of the core of the cable (the part which rotates) from the housing,

thread it through the Type D sending unit (a tight fit), and thread it back through the cable housing, as shown in the Figure 13-4.

After attaching the transducer, make certain none of the cables are kinked or bent at a sharp angle. A carefully considered re-route is usually enough to solve this problem, although extreme cases may require you to purchase a cable of a different length.

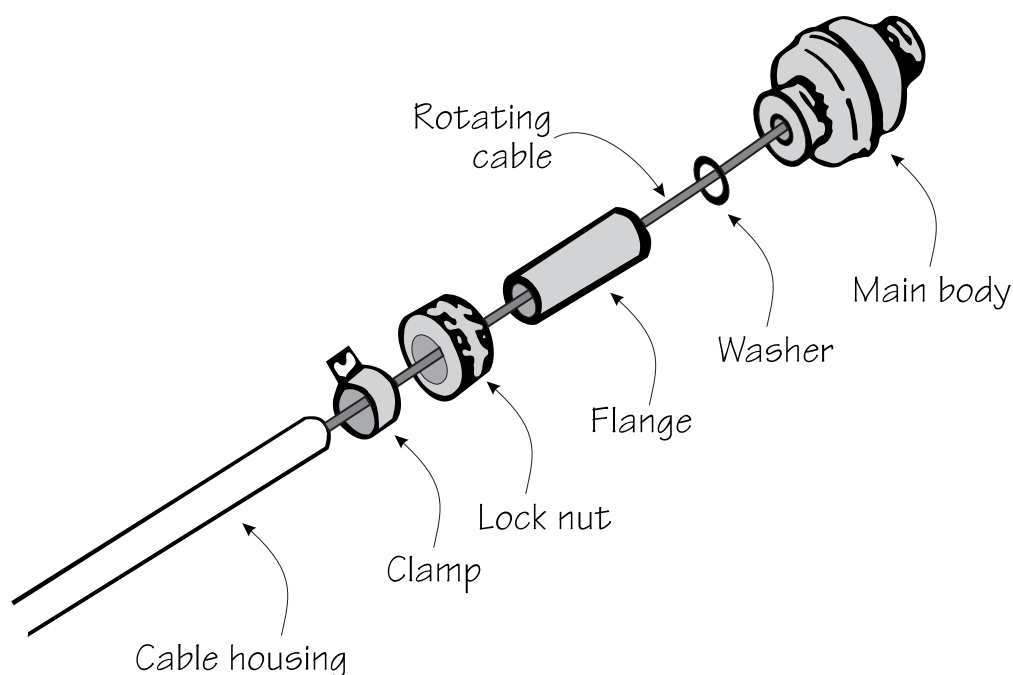


Figure 13-4: Type D sending unit installation

Open Sending Units

In contrast with closed sending units, installing an open magnetic sending unit can be an adventure. Still, their advantages have made them the most popular type of odometer sending unit.

It's important to start with an attitude that the job will be done right.

Since each car's suspension functions differently, some experimentation and creativity might be needed to get a reliable installation. Do not show up at an event as the route instructions are being handed out and expect to hook up your magnets and transducer before your out-time!

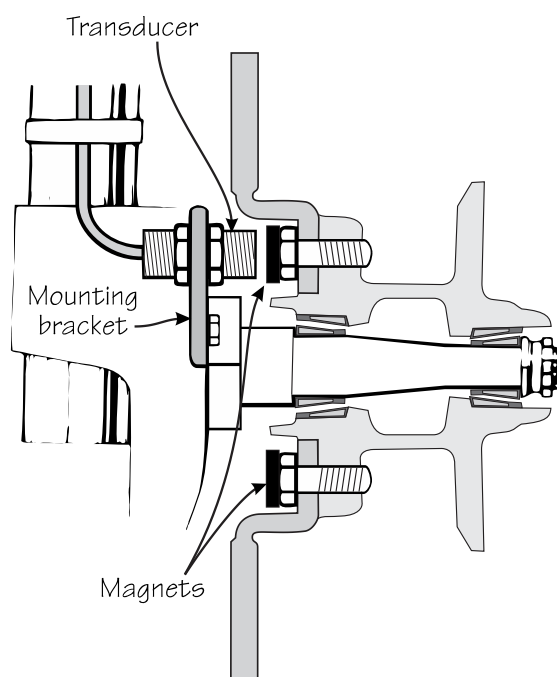


Figure 13-5: Sending unit installation in the hub

The first issue is to select a mounting location. If you intend to measure wheel rotation, you can position the magnet in the hub, somewhere on the rim, or on an axle. The most important thing to consider in any wheel installation is the movement of the transducer and magnet with relation to each other. The transducer must be completely immobile in relation to the magnets.

Also note that an apparently ideal location when the vehicle is quietly resting in your garage may change radically when the

suspension is unloaded (airborne), under hard cornering, or during extreme road conditions.

Installation in the hub is shown in Figure 13-5. The transducer is mounted on a bracket attached to the strut tube. You can also mount the bracket on the disc dust cover. Terratrip recommends a minimum thickness of 3mm (0.12 inches) for such

brackets. The magnets are epoxied onto the brake rotor. As you might imagine, this setup is subjected to a great deal of heat. In Pro Rallying, the brake disks typically get red hot and it is not unusual for the pads to catch fire. While you will probably not be braking that aggressively, you have to allow for this level of heat.

The two parts of a hub installation which are affected most by heat are the magnets and the epoxy which holds them on. You must use a magnet which will not be demagnetized by the high temperatures inside the hub. **Rare earth** magnets made of Samarium-Cobalt are virtually impervious to hub temperatures. Both epoxies recommended in the [Mounting the Magnet discussion](#) will withstand hub temperatures. You can also use black GE Autoseal.

Rim-mounted magnets deserve some special considerations. Aside from the problems of flat tires, flying magnets, and buildups of snow, mud, and ice, you must consider wheel flex. Some rallyists mount the magnet and transducer as shown in the lower enlargement (B) of Figure 13-6. This will fail under hard cornering since the rim itself actually flexes.

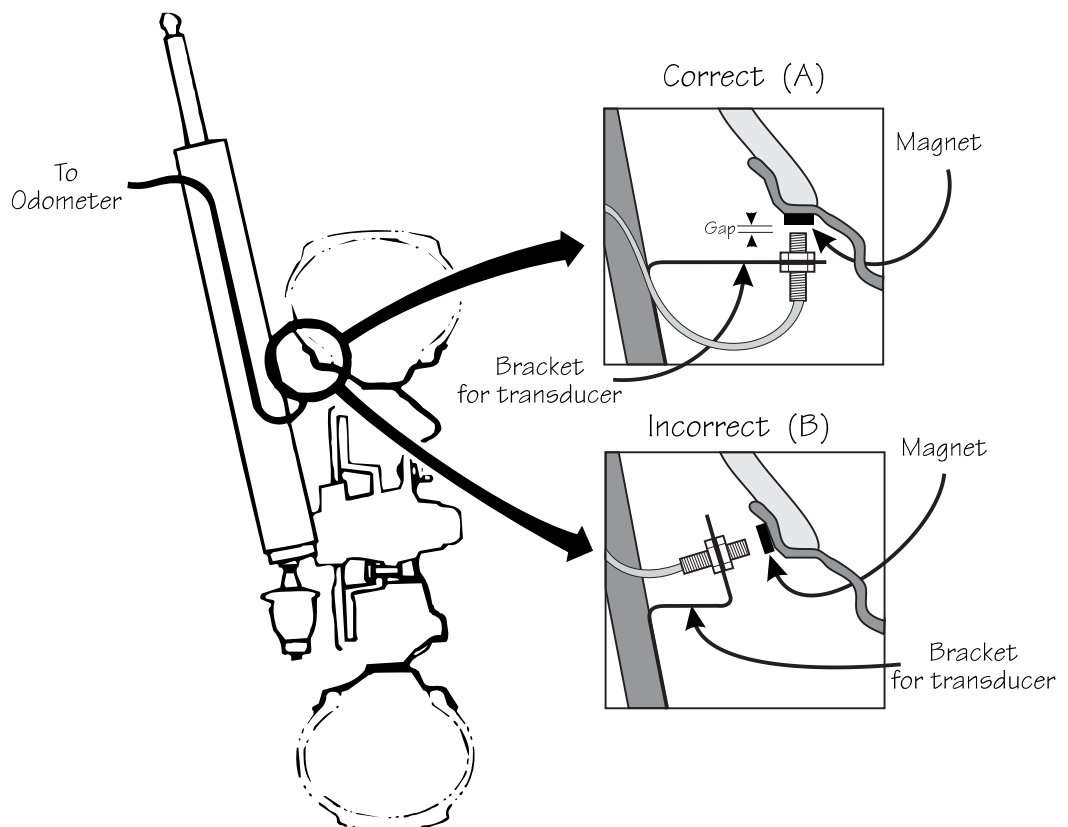


Figure 13-6: Proper wheel installation of an open sending unit

debris and avoids the problems of flex at the top and bottom of the wheel.

The upper enlargement (A) shows correct placement of the magnet inside the rim. As always, you should consider how rocks and other debris are thrown up by the wheels. Position the transducer and route the wires to minimize the chance of damage.

Figure 13-7 shows an open sending unit mounted on the left rear wheel of Steve Miller's VW Rabbit. The large black tube at the left is the trailing arm, the main component of the suspension. The aluminum transducer bracket is held onto the trailing arm with a large exhaust pipe clamp.

Note that the transducer faces forward. This location shields the transducer from flying

Half-shaft installation



Figure 13-7: A wheel-mounted transducer installation

If you plan to measure drive axle or half-shaft rotation, consider how these components flex over bumps and twist during acceleration. In general, mounting

the transducer on the chassis and mounting the magnet on the shaft is a poor idea – transmission components are attached to the chassis with rubber bushings and the shaft will twist and vibrate as you accelerate.

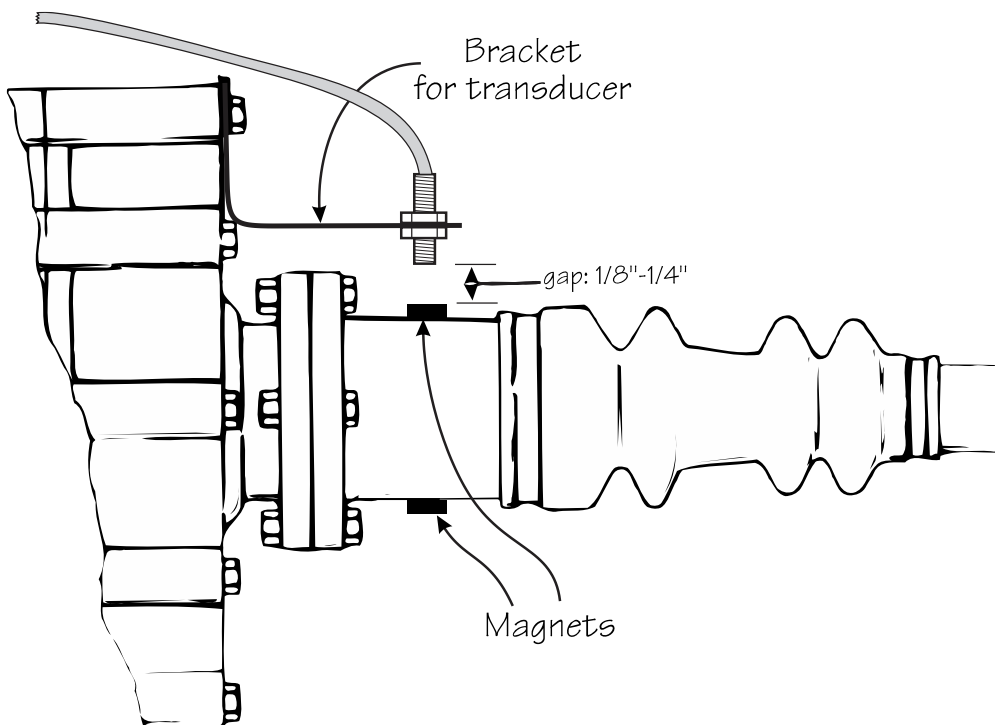


Figure 13-8: Sending unit installation on the drive shaft

Figure 13-8 shows the transducer mounted on the transmission housing with the magnets mounted directly on the shaft before the constant velocity joint. This version works well since both components will vibrate

together and the transducer is protected from road debris.

Mounting the Transducer

Once you have selected the exact mounting location, you are (finally!) ready to begin the installation. First, position the magnets and hold them in place with tape. Do not epoxy them until the transducer is mounted.

Next, determine the exact path to route the transducer cabling. Avoid routing it near other electrical cabling to cut down on electric noise. Avoid interfering with the steering system. A good strategy is to follow a brake fluid or fuel line – these are usually protected from debris. You will usually need to route through a hole in the firewall or, for a rear wheel mounting, through the inner fender panel into the interior of the vehicle near the rear seats. Make sure there is enough cable length to allow for slack where needed along the route.

Now route the cable. Start from inside the car and push the transducer along the routing path. The transducer is usually smaller and more durable than the connector at the other end. Before going through holes in metal plates, insert a rubber grommet in the hole to protect the cable. Alternately, you can cut off the connector 6" from the end and route the cable from the outside. Once the wire is in position, use silastic sealer to seal any holes in the fender panel.

At the site of the installation, you will probably need to fashion a mounting plate for the transducer. Hardware stores stock a

variety of steel mending plates which you can bend, cut, and twist into shape. Design one as short as possible to cut down on vibration which could cause multiple pulses or a transducer-magnet strike. Unusual situations might need a support plate to prevent this problem.

If you use any bolts which are part of the brake or suspension system to hold a bracket, you may need to replace it with a longer bolt. For any bolts removed, reapply any thread locking or anti-seize compound recommended by the manufacturer when re-installing them. Always replace loosened expansion bolts with new ones. Consult the shop manual or a mechanic for the correct torque to re-tighten the bolt.

After the transducer is mounted, use nylon cable ties at intervals along the cable. Allow enough slack to accommodate full suspension travel.

Mounting the Magnet

After securing the transducer, you are ready to attach the magnets. See [Chapter 10](#) for a discussion on how many magnets to use.

In general, when working with magnets, you need to be careful to preserve their magnetic strength. If you drop a magnet it may shatter. If it does not, it may lose a good portion of its strength. If the magnet is not the proper size or shape, you cannot cut, drill, machine, or grind it – the shock will partially demagnetize it.

Before installing the magnet(s), you need to determine the South pole and point that end

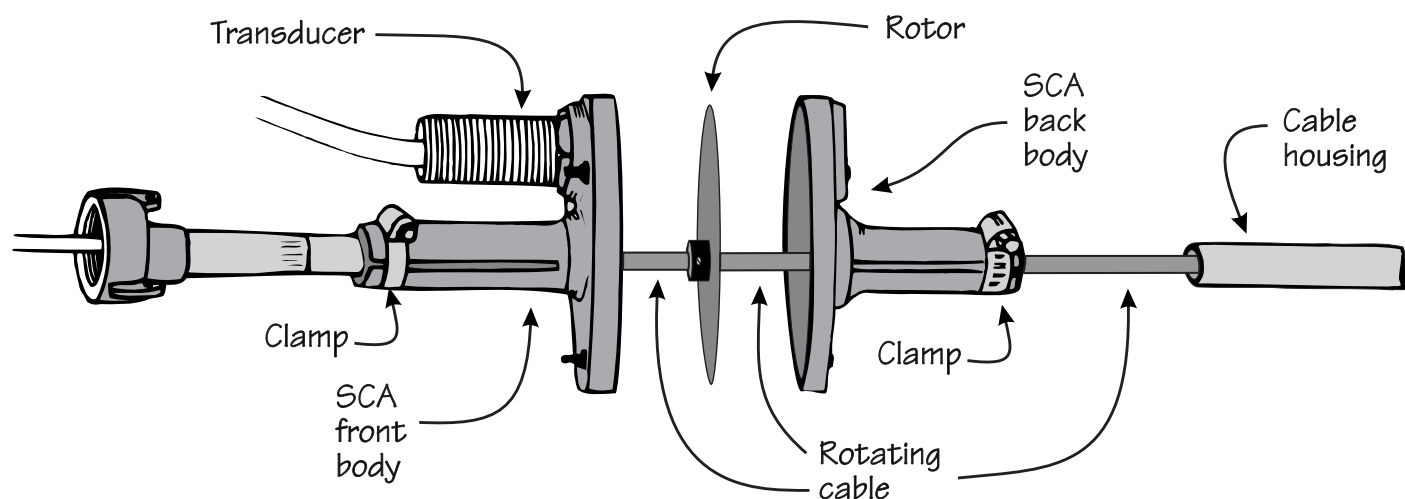
toward the transducer. Even if you have a transducer that is activated by both North and South poles, you should still face the South pole toward the transducer in case you later switch to a South-only transducer. To determine the South pole, place a compass next to the magnet. If it is a compass with a pointer, the South pole of the magnet will attract the pointer that normally points at the Earth's North pole. If you are using a nautical or automotive compass with a rotating plate or ball marked with the direction you are heading, the South pole of the magnet will attract the “S” designation on the rotating portion.

Now you are ready to epoxy the magnet onto the surface. First, remove the magnet and mark the location. Next, clean both the magnet and the surface thoroughly. If either surface has rust, remove it with naval jelly or vinegar. Sand both surfaces lightly with emery paper until they are free of contaminants. Finally, clean both surfaces with alcohol to remove all residue.

If the mounting surface is an aluminum or magnesium rim, additional steps must be

taken. These surfaces form an thin oxide layer (the aluminum equivalent of iron rust) very quickly after sanding or cleaning. If you epoxy to the oxide layer rather than the actual metal surface, the oxide will peel off the base metal and the magnet will fall off. To combat this situation, clean the surface with a stronger solvent than alcohol – acetone or Methyl Ethyl Ketone (MEK) are good for this purpose. Then begin applying the epoxy immediately.

When selecting an epoxy, avoid the “5-minute” products. The Loctite Weld and J-B Weld brands are known to work well. Both are 2-part epoxies and are suitable for the high temperatures of a hub installation. Prepare the epoxy as directed and apply a thin layer to both the magnet and mounting surface. A flat toothpick makes an excellent “spreader”. You only need enough to coat the surfaces and fill in any small gaps – too much may degrade the bond or cause the magnet not to lie flat. Then place the magnet precisely in position. Finally, add liberal amounts of epoxy around the edges to form a “seat” for the magnet. However,



SCA Installation

don't use so much epoxy that it rises above the upper surface of the magnet.

After the epoxy is fully cured, test it. Try to remove it with your hand. Pull really hard. Now pull harder. A properly epoxied magnet can only be removed by striking it with a hammer or other such tactics.

If the magnet is mounted on a shaft, you can add a band of tape over the magnet to protect it from debris. Nylon reinforced tape is good for this job. You must wrap the tape in the opposite direction from the normal turning motion of the shaft. If you fail to do this, the tape may unravel and jam between the transducer and the magnet.

After the magnets are installed, replace the wheel (on a rim installation) and carefully adjust the transducer to the correct gap from the magnets. The body of the transducer is threaded along its entire length for this purpose. Apply a thread locking compound to the threads and tighten down the nuts and lock washers gently but firmly on the transducer.

If you are mounting your transducer on the speedometer cable using a Speedometer Cable Adapter (SCA), these are Terratrip's installation instructions:

- Remove the speedometer's inner rotating cable and cut a 30mm (1.2 inch) section from the cable housing with a fine tooth hacksaw. Some cars have sealed odometer cables. In these cases, remove the rotating cable by removing the ferrule from the sealed end of the cable. This is usually at the gearbox end of the speedometer cable.

- Place the SCA front body which is tapped to carry the transducer onto one of the sections of the cable housing. Clamp it into position. Do not overtighten the clamp.
- Replace the rotating cable through the SCA front body. Slide the thick spacer, followed by the rotor, onto the rotating cable. Position the rotor so that it is flush with the SCA front body. Tighten the two grub screws on the rotor.
- Screw the transducer into the SCA front body until it just touches the rotor. Turn the transducer counterclockwise, 1 ¼ turns to provide a gap between the transducer and the rotor. Tighten the transducer locknut.
- Lubricate the inner parts of the SCA with light grease. Do not over-lubricate.
- Slide the thinner spacer and then the SCA back body over the rotating cable and fasten the SCA body together. Replace the remaining cable housing and clamp it onto the SCA body.

Sending Unit Splitting

Sometimes you need to split the signal from one sending unit to drive two odometer units. You need to build a special cable with one connector attaching to the sending unit and two connectors to the two odometers. This table indicates which pin connections to make and which to omit:

Pin from sending unit	Pin to unit 1	Pin to unit 2
shield wire	shield wire	shield wire

+ 5 volts	+ 5 volts	-
0 volts	0 volts	-
pulse signal	pulse signal	pulse signal

In practice, this type of operation is risky. Each odometer imposes a current drain on the transducer. The sum of the current drain imposed by both odometers may make one or both of the odometers lose pulses or fail to operate entirely. With any odometer, it is possible to reduce the current drain on the transducer (best handled by the manufacturer of the odometer). However, reducing the current drain directly increases the odometer's susceptibility to electronic noise. There's no free lunch!

Also, consider that failure of the single sending unit will disable both odometer units. A better approach is to use one sending unit for each odometer input.

Verifying Correct Installation

After your sending unit is installed, you need to check that it is functioning reliably. If your A-Box or B-Box has a speedometer feature, find out how many pulses are averaged into each speed reading. Let's say your unit averages five pulses. Get a navigator and go driving. Have the navigator watch the speedometer for any unusual readings. A dropped pulse will register as a momentary drop in speed of one fifth. Drive some rough roads. Take some hard corners. This will smoke out problems having to do with suspension travel.

Now check for correct operation of the transducer at low speeds. Set the calibration factor to read a very high mileage for a given distance traveled (use a very high calibration factor for an odometer with an additive calibration factor). Find a section of little-used road with landmarks about a mile apart. Warm up your tires, then take various runs along the distance, starting and stopping the odometer at the landmarks. Measure the distance very precisely by coming to a stop alongside each landmark and measuring the point when the landmark is abreast the navigator (as opposed to the front bumper). Run the section at normal speed, then slowly, then with numerous smooth stops throughout the run. If no pulses are lost, the mileages should match almost exactly.

14. Calculators

Machines work, people should think.

— Troutman's 6th Law of
Programming, 1980

There are many different designs for mechanical and electronic calculators for navigating TSD rallies, but they all have the same general purpose: to take any two from the set {Time, Speed, Distance} and produce the third. Some of these devices are legal for use in Odo Class.

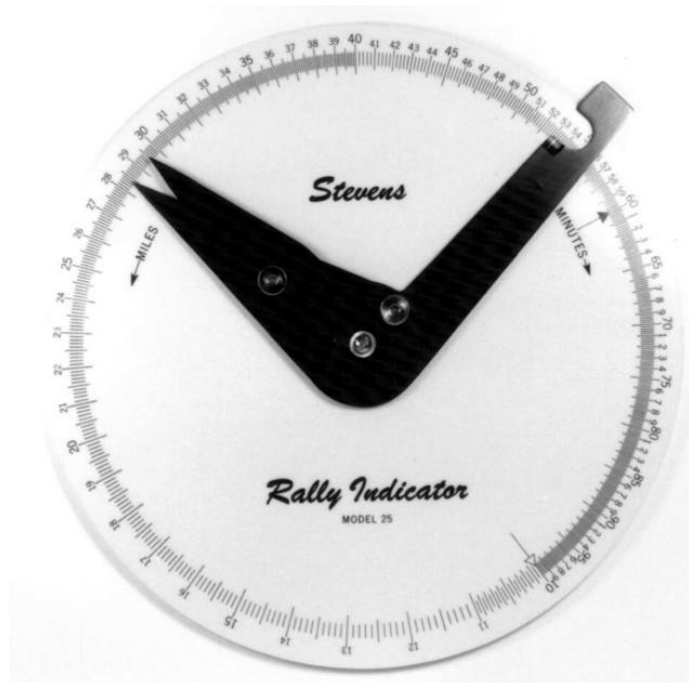
The Stevens Wheel

The most common mechanical calculator is the circular slide rule. They are inexpensive, allow fairly quick results, and provide a reasonable degree of resolution (three significant digits, usually).

The most common slide rule is called a **Stevens Wheel** and few would argue with the statement that *The Stevens* is the most versatile and useful tool for basic TSD navigation. This calculator is a circular board etched with a scale and three movable pointers. It can be used to solve many of the basic TSD formulas as well as handling a correction factor. Considering its cost

(\$18-\$25), it is a must for any team if for nothing else as a backup. Note that there are two sizes, the 6" personal size (model 16) and the 9" (model 25) competition size – we recommend the larger.

The largest pointer is marked T and is usually used for reading Time. The two short pointers are for reading mileage – M for the official mileage and E for the "Error" or car mileage. There are two thumb screws, one which locks the M and E pointers together and the other locks those pointers to the large T pointer.



The Stevens model 25 (9")

Correction Factors

The first thing you can use the Stevens for is your correction factor. At the end of the odometer check, loosen the M-E thumbscrew, place the M on the Official mileage and E on the distance your car registered for the odometer check. Then lock down the M-E thumbscrew very tightly (you will probably want it tight for the rest of the rally). From then on, move the M and E pointers together, maintaining their distance from each other for some basic calculations:

- To convert official mileages to car mileages, place M on the official mileage and read the car mileage off E.
- If you assume that the speedometer is calibrated with the odometer (see [Chapter 12](#) for a discussion of this) you can place M on the CAS and read corrected car speed off E. Some Stock and Speedo class drivers like to keep a Stevens tucked in the visor with these two pointers peeking out. At each CAS change, the navigator simply moves both pointers and the driver always has a reminder for both CAS and corrected speed.
- To go from car mileage to official mileage, place E on the car mileage and read official mileage off M.
- To get your odometer correction factor (as a number), place M on “10” and read the correction factor off E.

One issue with the Stevens, as with all slide rules, is that you must keep track of the scale you are using. The marking “23” on the Stevens can mean 23, 2.3, 0.23, or 230, depending on your intentions. If you come

up with an answer which does not make sense, scale it up or down by a factor of ten until it becomes sensible.

Another issue is that the E pointer is physically constrained to within $\pm 7\%$ of the M pointer. If your odometer correction factor is not between about 0.93 and 1.07, you're out of luck!

Finding Time

Now on to the fundamental TSD formulas. The most common use is to go between Distance and Time at a given CAS. Place the M pointer on your CAS and loosen the central thumbscrew (the one which locks M and E to T). Hold M (and E) with your left thumb and rotate T to 60 (there is a large black arrow to remind you). After locking down the central thumbscrew, you can move all three pointers in unison to any place on the board:

- To convert Distance to perfect Time at that CAS, place M on the official distance or E on the car distance. Read the perfect time off the T pointer, remembering to scale as appropriate.
- If you know the Time and are looking for perfect distance, place T at the time and read official or car distance off M or E, respectively.

One issue with the Stevens is resolution. If you are converting distance into perfect time, your time readings have less resolution as the distance increases. One solution is to use Hammond's Rule to keep the distances small (see [Chapter 17](#)).

Another limitation of the Stevens is that a CAS above 6 mph and below 10 mph or above 60 mph cannot be set. Also, if your correction factor is greater than 1.07, a CAS above 56 may be in jeopardy. If you rely on the Stevens for navigation, you can solve these problems by reversing the pointer.

Conversion Factors

Finally, you can use the Stevens to convert values from one unit of measure into another. In [Chapter 17](#) we provide tables of conversion factors for units of time, speed, and distance. Once you get a factor, you can use it on the Stevens.

For example, say you are converting from miles to kilometers. The table in [Chapter 17](#) says to multiply miles by 1.60935 to get kilometers. Place M on 1.0 and T on 1.609... and lock them down. You can then place M on any mile value (the *input value*) and read kilometers off T (the *output value*).

For some conversion factors between 6 and 10 or 0.6 to 1.0, it is easier to place T on 1.0 and M on the conversion factor and reverse the input and output pointers. Just remember that whichever pointer is placed on 1.0 becomes the input pointer.

Basic Calculators

Under some rules, you are allowed a “basic calculator”. Exactly what “basic” means can vary widely. Some rules allow only the basic 4 operations (+, −, ×, ÷) and no memory. Other areas allow one memory, but prohibit the ability to accumulate two quantities (e.g. distance and time) simultaneously.

Whatever you get in the way of a calculator, it should work well in the car. Things to look for are:

- A huge display and gargantuan buttons. Trying to enter a number on a rough downhill switchback is bad enough without having to use your pencil point to hit the keys.
- A battery that lasts forever.
- Room to tape a spare battery to the back (no battery lasts forever).
- A place to glue rubber feet or Velcro on the back (and still allow you to replace the battery).

The formulas in this book have been designed to work on a normal basic calculator, just by reading the formulas left to right. Practice at home with each of the formulas you are likely to need during the event.

The Curta

Another ingenious device is called the **Curta**. The Curta is a mechanical calculator which looks like a pepper mill. It was designed in the 1950's for use in accounting and was produced in Europe until electronic calculators made these beautifully crafted tools obsolete.

After you learn how to use it for rally navigation, it's hard to believe that the Curta was not designed specifically for the sport. The instrument allows the basic formulas to be computed with as much resolution as you would ever need with the added benefit of allowing cumulative calculations. Not only



Curta Model II

can you figure the perfect time to a point on the course from your last CAS change, you can add that time into the perfect overall leg time and quickly get a perfect leg time reading.

Because it is so useful, we will look at how to operate a Curta in some detail. Of course, it helps to have one in hand when reading this description.

The instrument has a solid body and an upper carriage which can be lifted and rotated. There are three “dials” on the instrument:

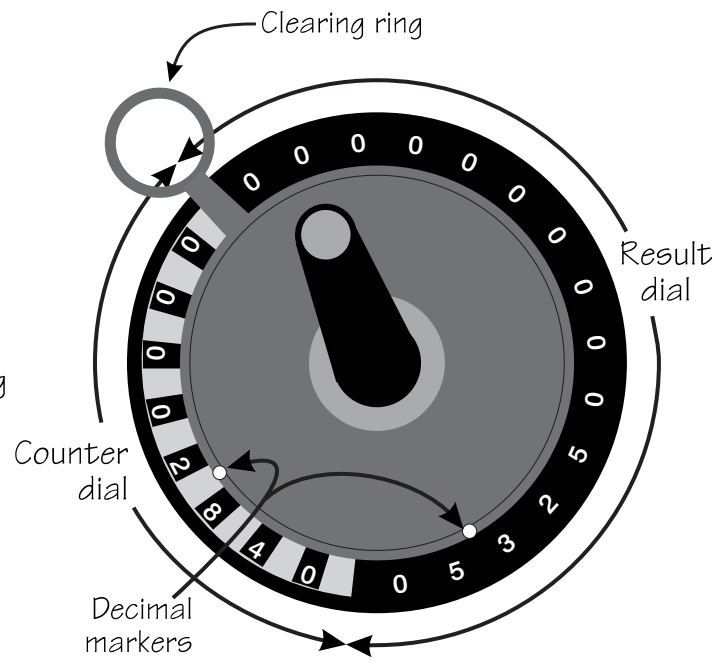
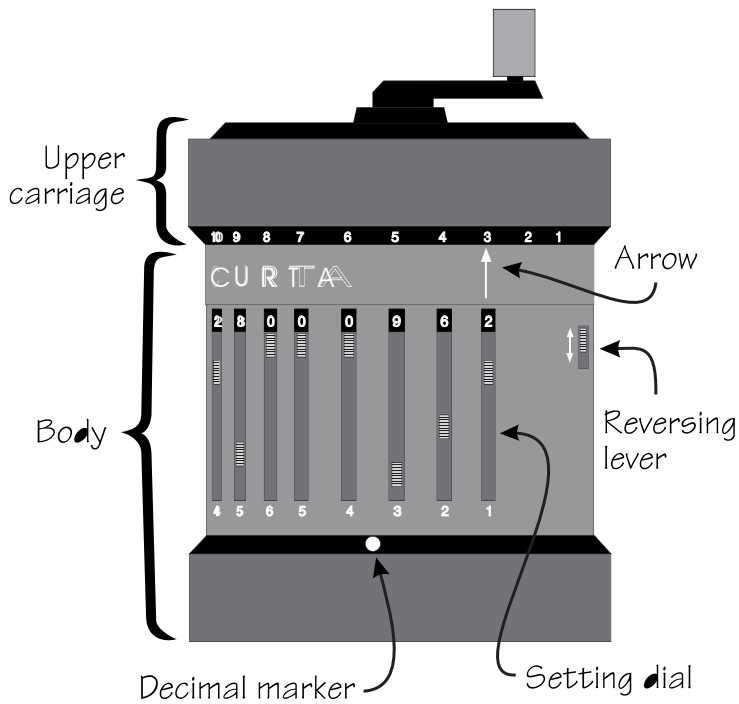
- The setting dial on the body of the instrument. Each digit in the setting dial is controlled by a vertical slide below the digit.
- The result dial on the top carriage, with a black face.
- The counter dial on the top carriage, with a silver face.

Each of the dials has several decimal markers. These silver “dots” can be moved to indicate the position of a decimal point.

Two models of Curtas differ only in the number of digits in each of their dials and their relative value as an antique.

Model	Setting Dial	Result Dial	Counter Dial
I	8 digits	11 digits	6 digits
II	11 digits	15 digits	8 digits

The Model II is somewhat more useful for rallying, and we will be using this model for all our examples.



Basic Curta Operation

The basic operation is straightforward:

- First, set the instrument up by making sure that the crank at the top is lowered (not showing a red ring) and the reversing switch on the back of the instrument is up.
- To clear the result and counter dials, lift the carriage and move the clearing ring one full revolution clockwise. Return the clearing ring to its original position and make sure the carriage is seated back on the body.
- Now set a number in the setting dial using the vertical slides.
- Next, rotate the crank at the top one full revolution clockwise and look at the result and counter dials. The crank placed a “1”

somewhere in the counter dial and added the number from the setting dial into the result dial.

- Now rotate the crank again. The counter now has a “2” and the result has twice the number in the setting dial. The result dial shows the product of the counter times the setting dial.

What happens if you want to multiply the setting dial by a large number? You could keep cranking that many times.²³ However, there is a better way! Since you can shift the entire upper carriage containing both the result and counter dials, you can add the setting dial into almost any position in the result.

Say you already have 2 times the setting dial and really want 42 times the setting dial. Lift the carriage and rotate it one position

²³ and earn the title of “Crank Curta” or “Curta Cranker”.

counter-clockwise. Now crank 4 times. You now have 42 in the counter and 42 times the setting dial showing in the result.

Basic Curta Calculations

Now we'll see a rally application. Let's say, for simplicity, that you start a leg at the top of the hour with a zero odometer. The first CAS is 32. Let's also simplify the problem by assuming a correction factor of 1.000 (or a calibrated precision odometer).

First clear the result and counter as before.

- Counter dial: just to the left of the third digit from the right;

Next, lift and rotate the upper carriage. The arrow on the side of the main body of the instrument should point to the “tenths” position in the counter dial (third from the rightmost digit). This places the decimal marker just to the left of the arrow.

Finally, enter the minutes-per-mile rate for CAS 32 into the left end of the setting dial. You get 1.8750 from [Formula 8](#)) and the setting dial should look like Figure 14-1. You are now ready to rally.

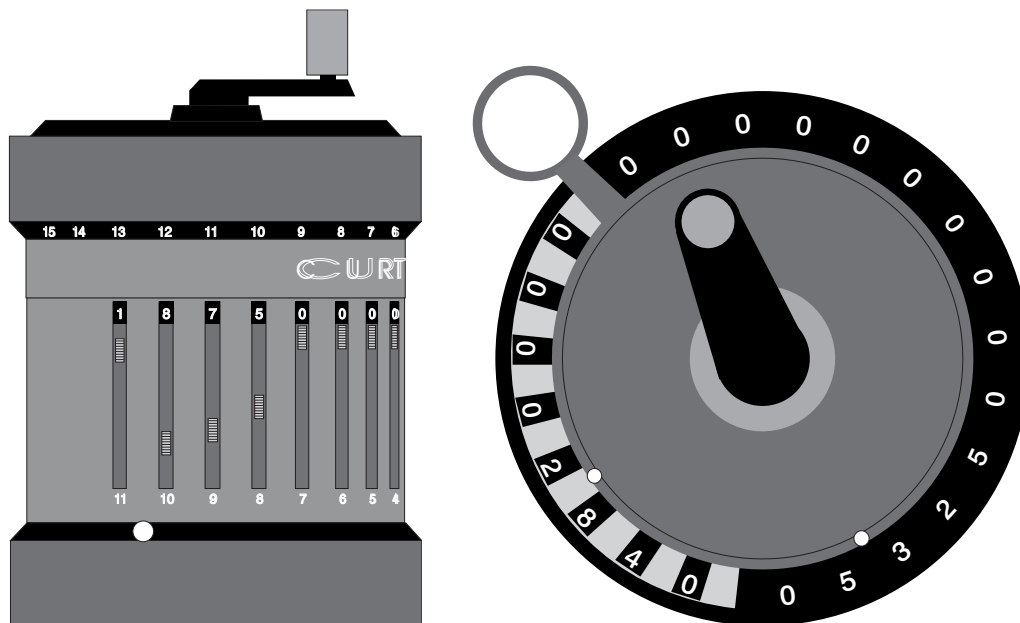


Figure 14-1

Now position one decimal marker on each of the three dials as shown in Figure 14-1 (the other decimal markers can be moved out of the way):

- Setting dial: just to the right of the first digit (between positions 10 and 11);
- Result dial: just to the right of the second digit from the left;

Every tenth of a mile, crank once. The mileage shows in the counter and the perfect time accumulates in the result. If you crank just before reaching the mileage, you can glance at the result and, when the odometer reaches that mileage, compare the result with the clock: if the perfect result is

less than the clock, you are late; if the result is greater than the clock, you are early.

What if you want to give a reading every mile? Pick the carriage up and point the arrow on the counter to the “ones” position.

At the speed change in our “Standard Problem”, the result and counter dials will look like Figure 14-1. You have gone 2.840

half the upper carriage simply by moving the clearing ring half way around.

What if you are starting the leg with a non-zero mileage? Enter zero in the setting dial (to keep from altering the time). Then enter the starting mileage into the counter by positioning the carriage to each place and cranking the correct number of times.

Formula 15. *Corrected Rate from Official Rate*

$$\frac{\text{Official rate}}{\text{Correction factor}} \rightarrow \text{Corrected rate}$$

miles, shown on the counter dial, and the perfect time to cover that distance is 05.325 minutes, shown on the result dial. One nice feature of this setup for the Curta is that the car mileage and perfect time are next to each other on the top dials and can both be read in one glance.

What if your starting time is not at the top of the hour? Set your starting time in the setting dial and crank once to enter it in the result as your starting time. However, note that the counter will register some mileage. You can cure this by first clearing half the upper carriage (the result dial), setting the start time, and then clearing the other half of the carriage (the counter). You can clear

We have now eliminated all the simplifications except the correction factor of 1.000. If you are using the Curta with a calibrated precision odometer, this simplification is fine since your car odometer should match official miles. For a non-calibrated odometer, one additional step is needed to get correct time readings. Remember that everything about this Curta method works with car miles. Just like adjusting car speeds based on a correction factor ([Formula 14](#)), you need to adjust the input minutes-per-mile rates. However, if your speed is adjusted up from an assigned CAS, the rate gets adjusted down. If you are starting from a rate in a table, you can

Formula 16. *Corrected Rate from CAS*

$$\frac{60}{\text{CAS} \times \text{Correction factor}} \rightarrow \text{Corrected rate}$$

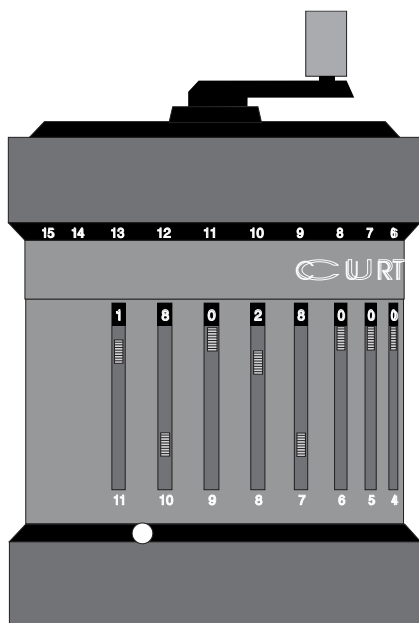


Figure 14-2

divide by the correction factor to get the corrected rate in Formula 15

Or, if you go from speed to corrected rate on a calculator, as in Formula 16.

Note: to calculate this formula many times on a 4-function calculator, it is simpler to figure out the sub-formula $\frac{60}{\text{Correction factor}}$ one time after you get your correction factor. Write this number down. Then, for each CAS, take that number and divide it by the CAS to get corrected rate.

In practice, you build a table before the start listing each separate CAS in the NRIs. After you run the odometer check, you come up with a factor. Then apply [Formula 15](#) or [Formula 16](#) to fill in the table of corrected rates.

For example, a correction factor of 1.040 gives you a corrected rate of

$$\frac{\text{Official rate}}{\text{Correction factor}} \rightarrow \frac{1.875}{1.040} \rightarrow 1.8028$$

You enter this into the left side of the setting dial instead of the uncorrected rate.

One more trick can be used with the Model II which makes use of some of the unused digits at the right end of the setting dial. Since all your rates are now adjusted by your correction factor, your counter dial reads in car miles. The Curta can keep track of official miles at the right end of the result dial. All you do is figure out the number $\frac{1}{\text{Correction factor}}$ and enter it at the right end of the setting dial. The ones place goes in position 4 on the setting dial and three more places are entered to the right, using the four rightmost digits of the setting dial:

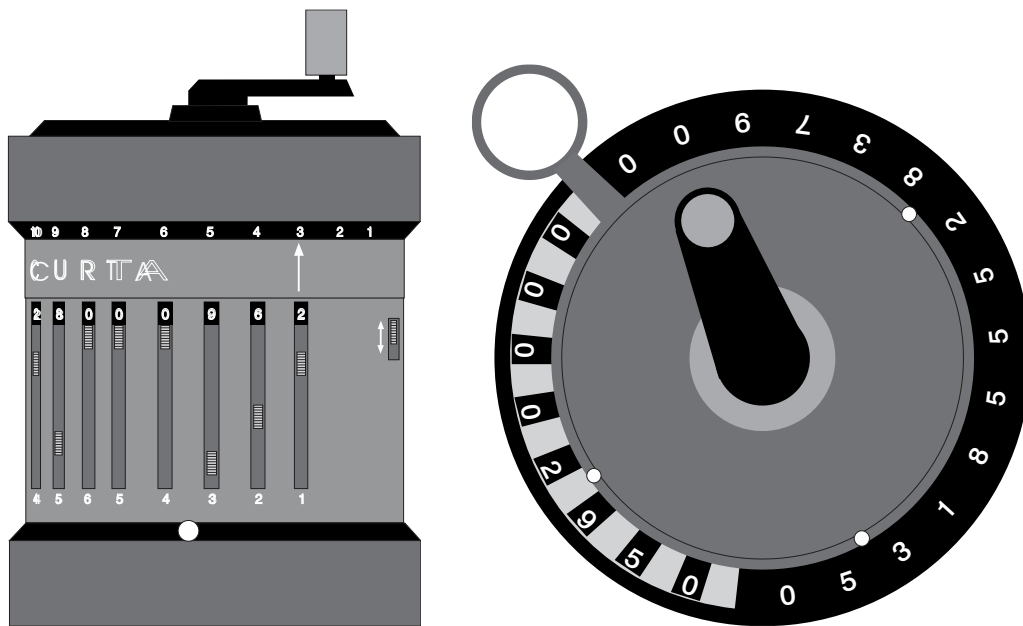


Figure 14-3

Then place one of the decimal placeholders just to the left of the six rightmost digits in the result dial. Now, whenever you crank, the rightmost digits of the 15-place result show official miles. Figure 14-3 shows the top dial using this setup. The counter shows the car mileage of 2.95 miles, with the corresponding official mileage of 2.8379 showing on the right side of the result dial. The left end of the result dial still shows the perfect time at this point.

Cumulative Curta Calculations

Up till now, we have done operations which could easily be carried out with tables or a simple calculator such as the Stevens wheel. But where the Curta shines is in cumulative calculations such as totaling time across CAS changes and handling off-course excursions.

To do a CAS change, note the car mileage at the CAS change point, then bring the

counter to that exact mileage (to the nearest hundredth). This will usually involve raising and rotating the carriage so that the pointer beneath the counter points to the hundredth place.

If you have cranked past the CAS change mileage – No problem! Just pull the crank arm up from the carriage so that the red ring shows at the base of the crank arm. The Curta is now in “subtraction” mode. Each turn of the crank will now lower the result dial and decrement the counter (mileage) dial. Push the arm back down to return to normal “addition” mode.

Once you have the exact mileage, change the setting dial to the (corrected) rate for the new CAS and crank the hundredths place up to the next even tenth. Then adjust the carriage to point to the tenths position and crank until the counter again matches

your car odometer. You can now give readings as before.

Pauses and gains are simple: change the (corrected) rate at the left end of the setting dial for a single turn of the crank. For example, say you have a corrected rate of 1.8028, a pause 40, and the carriage is positioned so that you are adding 0.10 miles per turn of the crank. The pause of 0.40 minutes can be incorporated into the perfect time by changing the rate to 5.8028 for one turn, then changing it back.

Even off-course excursions are a breeze! When you discover you are off course, turn around and note the mileage at the turn-around point. After updating the mileage in the counter, set the crank in the “subtraction” mode by pulling it up so that the red ring shows. If you are running with an odometer that cannot be reversed (such as a stock odometer), you also need to switch the reversing lever on the side of the instrument to its down position. Teams running with an odometer that can be reversed to count mileage down should not change the reversing lever. The effect is that time and official mileage will be subtracted from the result dial. The counter will increase for stock odometer teams and decrease for teams with reversible odometers. When you rejoin the course, return the crank and reversing lever to their normal position. Note that this method keeps the official mileage correct at the right end of the result dial, if you are using that feature. Of course, you will need to take

a time allowance, using one of the pause methods outlined previously.

Unfortunately for rallyists, Curta calculators have become a collector's item. They are fairly expensive and difficult to locate. Try the rally dealers listed in Appendix A, especially Historical Technology, a dealer of antique scientific instruments.

Programmable Calculators

A wide range of low-cost programmable calculators are available, and all can be set up to help with the calculations. However, they are often only permitted in classes that allow “unlimited computation equipment”. This usually means Computer Class or, possibly, Speedo Class.

There are two approaches to using a programmable calculator: program one yourself or buy a program. Programming a calculator yourself can be fun and instructive, but it does mean you will have to learn some basic programming. We will look at programs for two simple programmable calculators as well as an advanced program for a palm-top computer.

Texas Instruments TI-55 II

An early calculator to be subjected to TSD programming was the TI-55 II. If you still have one around, you can try out this program, developed in 1982 by Ed Rachner of Chronar. It allows you to enter an initial time, CAS, and initial mileage. Then you enter a later mileage and it produces a calculated time at that mileage. You change CAS by changing the stored CAS value in a

register. There are 4 registers used by this program:

Register	Use
0	Last calculated time (in minutes)
1	CAS
2	Last mileage
3	Next mileage (stored by program)

To use the program:

- Partition the memory allocation by pressing 2nd Part 4.
- Load the program steps:
LRN, STO 3, RCL 1, (2nd) Pause, (, RCL 3, -, RCL 2,), ×, 60, ÷, RCL 1, =, STO, +, 0, RCL 3, EXC 2, RCL 0, RST, LRN
- Press RST to reset the program to the beginning.
- Load the appropriate data into registers 0, 1, and 2.
- Enter the next mileage to which you want a calculated time and press R/S to start the program.
- The display will momentarily pause at the CAS being used and then continue on and hold at the calculated time for the entered mileage.
- Repeat the last two steps as the mileage progresses. At a change in CAS, bring the calculator mileage up to the new CAS mileage point, get a calculated time, then store the new CAS into register 1. Then proceed as before.

The mileages you enter will typically increase, but they don't have to. You can go down in mileage and, as long as you don't go back across a CAS change, the program will produce the correct calculated time.

Texas Instruments SR-52

A somewhat more advanced calculator was the SR-52, which greatly expanded the memory and registers, but kept the same programming concepts. The program for the SR-52 is similar to the TI-55 program.



Location	Code	Location	Code	Location	Code
000	STO	016	X	032	0
001	0	017	6	033	3
002	3	018	0	034	EXC
003	RCL	019	÷	035	0
004	0	020	RCL	036	2
005	1	021	0	037	RCL
006	HLT	022	1	038	0
007	(	023	+	039	0
008	RCL	024	RCL	040	HLT
009	0	025	0	041	GTO
010	3	026	0	042	0
011	-	027	=	043	0
012	RCL	028	STO	044	0
013	0	029	0	045	
014	2	030	0	046	
015	)	031	RCL	047	

This version of the program functions much like the TI-55 version, with a few exceptions:

- You don't need to partition memory.
- All the registers on the SR-52 are named with two digits (e.g. register 03 rather than register 3).

Of course, this program does not use anywhere near the full capabilities of the SR-52. For example, rather than changing CAS by STO 01, you can reduce it to one keystroke with the following program addition:

Location	Code	Location	Code
045	LBL	050	HLT
046	A	051	GTO
047	STO	052	0
048	0	053	0
049	1	054	0

Now all you need to do is enter your new speed and hit the A key to change CAS. With a bit of practice and imagination, you can incorporate a huge number of factors into an SR-52 program. You can include a correction factor, bias distance for off-course excursions, and conversion between CAS and corrected speed, cents and minutes, and official and corrected car mileages.



Turbo Kurta

The **Turbo Kurta**[™] is a Texas Instruments TI-74[™] Palm-sized computer with a memory module which gives it a TSD “personality”. It can handle just about any calculation you would ever want from a TSD calculator, and can think in official miles or car miles, overall or delta miles, and cents or seconds.

The idea is that you update the indicated mileage to match your car mileage and the calculator updates the time and official

mileage. You can instantly get a time reading as well as comparison against an official mileage in the route instructions to verify that your correction factor is on target.

Pauses and gains are handled with a few keystrokes. Special features include automatic factor calculation, computation of your score at a checkpoint, handling of emergency speeds, CAS reductions by percentage, and biasing of your calculated time at checkpoint in perfect-time rallies.

15. Tables

You can't take three from two, two is less than three so you look at the four in the eight's place. Now that's really four eights, so you make it three eights, regroup, and change the eight to eight ones and you add it to the two and that makes ten minus three, that's seven ... Everybody get that?

— Tom Lehrer, *New Math*

There are many tables throughout this book which give information you might need during an event. This chapter is devoted specifically to tables which are designed to answer the basic question, “*Are we on time?*”

Why use tables as a primary means of navigation? In Computer Class, they are obviously not needed. However, in other classes which strictly limit calculation equipment, the choice often comes down to a simple calculator (such as the Stevens) or a set of tables. A well-designed set of tables can win out over simple calculators for speed and ease of use.

Primary navigation tables answer the “*Are we on time?*” question in two ways:

- **Rate Tables.** Given a CAS and an odometer correction factor, find a corrected rate in minutes-per-mile. This type of table is used in a system which has a calculator (such as Curta or 4-function calculator) to convert the rate into a perfect time for distances of other than one mile.
- **Time Tables.** Given a CAS, an odometer correction factor, and a distance, find a perfect time to cover that distance. These tables are used in systems without a calculator to get perfect time to cover a distance directly. Obviously, time tables are larger than rate tables, since they have at least 10 time values (mileages 1 to 10 or 0.1 to 1.0) where rate tables have one value (for 1.0 miles).

To maximize the usefulness of a set of tables, their design is critical. They need to closely fit into a navigation strategy, answering the basic question quickly, with minimal effort, and to the resolution called for by the strategy. An extra second needed to come up with a number, if done 5 or 10 times per mile, adds up to a great deal of time. A slightly inconvenient format leads to (more) calculation errors. Even the font and point size of the numbers affects eye strain and fatigue.

For these reasons, there are a great variety of table formats. Many experienced navigators have invested the time to “roll their own” tables, using a personal computer. This is what I suggest if you decide to use tables as a primary means of navigation. There are two easy ways to produce tables:

- Develop a spreadsheet, using some basic formulas to fill in the numbers. You can start with a spreadsheet produced by someone else (see Lotus Spreadsheet Tables in the Bibliography) and play with the format.
- Write a program in any accessible computer language such as BASIC or C to generate the numbers.

These methods have the advantage of being flexible. You can decide how much detail you want and how much bulk you are willing to put up with. You can start with a few test pages and try them out on a practice rally before running off a full set of tables. If you see a way to improve the table format, just make some adjustments and run off another set of tables. Once you are satisfied with the format, take your spreadsheet/program to a computer with a laser printer and toss your dot-matrix printouts.

Aside from organization and format, there are some gotchas to watch out for when programming your own tables. Many spreadsheets and computer languages give you choices in how to handle numbers. You can do calculations to several degrees of precision, and round or truncate numbers at

certain points. Most setups provide default settings for these choices, which may not be the most appropriate for your needs. The best thing to do is to check the numbers output from a program carefully for accuracy. Use a calculator with lots of digits and see if the program's numbers agree with the calculator. This is especially important in table entries involving very small or large distances with very low or high speeds.

When developing a set of tables, you can choose how much detail to include. More detail means less math calculations for the navigator, but more bulk. If the navigator will be required to help follow the course, you may have to accept less accuracy if your tables have less detail.

Other considerations are sizing and binding. The easiest binding to deal with is a 5½” × 8½” format with a three-ring or five-ring binder. You can dismember an inexpensive binder and attach the spine to a lapboard. Also, if you have many pages, printing a page at regular intervals (like pages for CASs divisible by 5) on different color paper or using tabs can really help locating a page.

So, after advocating that navigators should develop their own tables, why is this chapter filled with tables? To give you lots of ideas on organization and format, of course! We look at samples of the tables which have been published over the years and give a few of our own.

Notation and Precision

Before we launch into the tables, we need a digression into the notation used for numbers in the tables. This notation only applies to tables specific to this book (not samples of tables from other publishers).

For very large or very small numbers, a superscript is used to denote a repeated digit. Thus,

250^4 means 250000 and

0.0^617 means 0.00000017.

A group of digits which repeat are printed with a line over the repeating digits:

$0.8\overline{33}$ means 0.8333333...

$0.6\overline{17}$ means 0.6171717...

Each of the tables in this book gives numbers to a certain precision.

- If a number has fewer digits than other numbers in the table, it is exact.
- If a number ends in a group of digits with a bar over them, expanding those repeating digits gives a value of arbitrary precision.
- Otherwise, the number is rounded off to the least significant digit shown.

Rate Tables

The first tables we will look at give you the perfect time to cover 1 mile.

Speed → Rate

The simplest version of a rate table gives you the answers to [Formula 8](#) for speeds

from 1 to 120. Table 15-1 works for mph → min-per-mile as well as kph → min-per-km.

Speed → Rate							
MPH	Min/Mile	MPH	Min/Mile	MPH	Min/Mile	MPH	Min/Mile
1	60	31	1.93548	61	0.98361	91	0.65934
2	30	32	1.87500	62	0.96774	92	0.65217
3	20	33	1.81818	63	0.95238	93	0.64516
4	15	34	1.76471	64	0.93750	94	0.63830
5	12	35	1.71429	65	0.92308	95	0.63158
6	10	36	1.66666	66	0.90909	96	0.62500
7	8.57143	37	1.62162	67	0.89552	97	0.61856
8	7.50000	38	1.57895	68	0.88235	98	0.61224
9	6.66666	39	1.53846	69	0.86957	99	0.60606
10	6.00000	40	1.50000	70	0.85714	100	0.60000
11	5.45454	41	1.46341	71	0.84507	101	0.59406
12	5.00000	42	1.42857	72	0.83333	102	0.58824
13	4.61538	43	1.39535	73	0.82192	103	0.58252
14	4.28571	44	1.36363	74	0.81081	104	0.57692
15	4.00000	45	1.33333	75	0.80000	105	0.57143
16	3.75000	46	1.30435	76	0.78947	106	0.56604
17	3.52941	47	1.27660	77	0.77922	107	0.56075
18	3.33333	48	1.25000	78	0.76923	108	0.55555
19	3.15789	49	1.22449	79	0.75949	109	0.55046
20	3.00000	50	1.20000	80	0.75000	110	0.54545
21	2.85714	51	1.17647	81	0.74074	111	0.54054
22	2.72727	52	1.15385	82	0.73171	112	0.53571
23	2.60870	53	1.13208	83	0.72289	113	0.53097
24	2.50000	54	1.11111	84	0.71429	114	0.52632
25	2.40000	55	1.09090	85	0.70588	115	0.52174
26	2.30769	56	1.07143	86	0.69767	116	0.51724
27	2.22222	57	1.05263	87	0.68966	117	0.51282
28	2.14286	58	1.03448	88	0.68181	118	0.50847
29	2.06897	59	1.01695	89	0.67416	119	0.50420
30	2.00000	60	1.00000	90	0.66666	120	0.50000

Table 15-1

How is Table 15-1 useful? It saves you from having to perform a division to get Rate from Speed. However, it is really only useful in special situations.

Say you have a precision odometer and are limited to (or simply use) a calculator which is not very good at divisions (like a Curta). Table 15-1 will give you Rate. However, almost all calculators can perform divisions easily and any good programmable calculator program will let you enter your CAS directly.

If you are running in Stock Class, you will have to correct the Rate using your correction factor, using [Formula 15](#) or [Formula 16](#).

Floyd's Factors

The design of the Speed → Rate table was expanded by Floyd Stone in the 1950s. Floyd's Factors (Table 15-2) gives time in mils (thousandths of a minute) for traveling one mile at each speed to the hundredth of a mph. The idea is that you get a corrected speed for each CAS ([Formula 14](#)) at the end of the odometer check and look up the corrected rate using the corrected speed.

Is this an improvement? It may be more intuitive to correct your CAS by a correction factor first to get a corrected speed, then look up the corresponding rate. You can also use the corrected speed for the speedometer.

However, you still need to do a multiplication or division for each separate CAS in the event. There is a loss of precision when you approximate to the nearest

hundredth of a mph, but this error is negligible for many rally situations. Also, these tables have 100 more entries per mile than the first table.

Cone's Tables

Some of the problems with the above tables were addressed by a completely different table developed by Norman Cone in 1967 (Table 15-3). Instead of correcting each CAS, you only need to come up with one correction factor. Each page in Cone's table gives you the rate for all reasonable CAS

MPH	TIME	MPH	TIME
33.00	1.818	33.50	1.791
.01	1.818	.51	1.791
.02	1.817	.52	1.790
.03	1.817	.53	1.789
.04	1.816	.54	1.789
.05	1.815	.55	1.788
.06	1.815	.56	1.788
.07	1.814	.57	1.787
.08	1.814	.58	1.787
.09	1.813	.59	1.786
33.10	1.813	33.60	1.786
.11	1.812	.61	1.785
.12	1.812	.62	1.785
.13	1.811	.63	1.784
...	...	...	...
.47	1.793	.97	1.766
.48	1.792	.98	1.766
.49	1.792	.99	1.765

Table 15-2

SPEED	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	SPEED
2	28.860	27.486	26.236	25.096	24.050	23.088	22.200	21.378	20.614	19.903	2
3	19.240	18.619	18.037	17.491	16.976	16.491	16.033	15.600	15.189	14.800	3
4	14.430	14.078	13.743	13.423	13.118	12.827	12.548	12.281	12.025	11.780	4
5	11.544	11.318	11.100	10.891	10.689	10.495	10.307	10.126	9.952	9.783	5
6	9.620	9.462	9.310	9.162	9.019	8.880	8.745	8.615	8.488	8.365	6
7	8.246	8.130	8.017	7.907	7.800	7.696	7.595	7.496	7.400	7.306	7
8	7.215	7.126	7.039	6.954	6.871	6.791	6.712	6.634	6.559	6.485	8
9	6.413	6.343	6.274	6.206	6.140	6.076	6.012	5.951	5.890	5.830	9
10	5.772	5.715	5.659	5.604	5.550	5.497	5.445	5.394	5.344	5.295	10
11	5.247	5.200	5.154	5.108	5.063	5.019	4.976	4.933	4.892	4.850	11
12	4.810	4.770	4.731	4.693	4.655	4.618	4.581	4.545	4.509	4.474	12
13	4.440	4.406	4.373	4.340	4.307	4.276	4.244	4.213	4.183	4.153	13
14	4.123	4.094	4.065	4.036	4.008	3.981	3.953	3.927	3.900	3.874	14
15	3.848	3.823	3.797	3.773	3.748	3.724	3.700	3.676	3.653	3.630	15
16	3.607	3.585	3.563	3.541	3.520	3.498	3.477	3.456	3.436	3.415	16
17	3.395	3.375	3.356	3.336	3.317	3.298	3.280	3.261	3.243	3.225	17
18	3.207	3.189	3.171	3.154	3.137	3.120	3.103	3.087	3.070	3.054	18
19	3.038	3.022	3.006	2.991	2.975	2.960	2.945	2.930	2.915	2.901	19
20	2.886	2.872	2.857	2.843	2.829	2.816	2.802	2.788	2.775	2.762	20
...	...	...	...	...	...	...	...	...	...	...	...
56	1.031	1.029	1.027	1.025	1.023	1.022	1.020	1.018	1.016	1.014	56
57	1.013	1.011	1.009	1.007	1.006	1.004	1.002	1.000	0.999	0.997	57
58	0.995	0.993	0.992	0.990	0.988	0.987	0.985	0.983	0.982	0.980	58
59	0.978	0.977	0.975	0.973	0.972	0.970	0.968	0.967	0.965	0.964	59
60	0.962	0.960	0.959	0.957	0.956	0.954	0.952	0.951	0.949	0.948	60

Table 15-3

assignments. Each rate entry in the table takes your correction factor into account.

MINUTES PER MILE AT INDICATED SPEED
IF CORRECTION FACTOR = 0.962

CORRECTION FACTOR IS OFFICIAL MILES
DIVIDED BY ODO MILES

At the end of the odometer check, you develop a correction factor and select a single page for the rest of the event to give you rate values. Of course, you must still do the math or use a calculator to solve your problem of 2.9 miles at CAS 32.

Note that the Correction Factor mentioned in Cone's Tables is exactly the inverse of the Correction Factor used by this book ([Formula 1](#)). Thus, if “our” correction factor is 1.04, Cone's Table for the factor of 0.962 (shown above) is the correct table. This fact is noted at the bottom of each page of Cone's tables.

Bob Radford published a set of tables almost identical to Cone's in 1986. They are currently sold out and are not scheduled for reprinting unless there is sufficient demand.

Mike Stimson also published a similar set of tables in 1970, using a speed range of 10.0

to 59.9 by 0.1 mph. Tables are provided for correction factors from 0.900 to 1.100, by 0.001, published in 101, 5½” × 8½” pages. Stimson's Factors used the “normal” correction factor used throughout this book, with the “inverse” factor of Cone in parentheses.

Table III in Gene Henderson's *Rally Basics* is the same as Stimson's, in 204, 8½” × 11” pages.

When designing your own tables, you should consider one issue about this last group of tables. Since they take your correction factor into account, why do they give rates for tenths of a mph? After all, you are not correcting your speed, but looking up the rates using the CAS directly from the route instructions. You have already accounted for the correction factor by selecting the correct page. Giving fractions of a mph accommodates unusual events with CAS assignments in tenths of a mph, but you must decide whether this unusual situation warrants missing out on a factor of 10 decrease in the size of these tables.

Time Tables

Now we move on to tables that read time for any distance, not just the minutes for one mile. The idea of these tables is that you can get by without a calculator – just a pencil and paper for some simple addition operations.

Table 15-4 allows you to find the perfect time to cover a distance in hundredths using two additions. First, look up the time to

cover the whole miles in the table. Look up the time to cover tenths, move the decimal one place to the left, and add it in. Do likewise for hundredths, moving the decimal two places to the left.

For example, 2.84 miles at CAS 32:

2.00 miles at CAS 32	3.750
0.80 miles at CAS 32	1.500
(8 miles and move '.' one digit)	
0.04 miles at CAS 32	<u>0.075</u>
(4 miles and move '.' two digits)	
Total	5.325 minutes

Table 15-4 can be used to come up with perfect times for intervals, as long as you use the official mileages and the CAS assignments. You can use these tables to pre-calculate your route instructions. However, since these tables don't accommodate a correction factor, running with a stock odometer requires a more sophisticated table.

Bob Radford Tables II

Bob Radford published a set of tables in 1986 (Table 15-5) that gave you the same answers without having to do any additions. The tradeoff was carrying a small book rather than two pages. His tables give you time to cover every hundredth of a mile for every whole mph from 5 to 65. Each table goes up to 6 miles. We show the page for CAS 32, reduced from the 11” × 8½” to fit on a page of this book.

Larry Reid's Tables

To handle running with a stock odometer, a set of tables was published in 1959 by Larry Reid (15-6). The idea is that, after you run the odometer check and come up with a correction factor, you adjust each CAS in the route instructions to a corrected speed (using [Formula 14](#)). Reid's Tables give you a perfect time based on the car odometer and the corrected speed. That is the reason that speeds are given to tenths of a mph.

To get a time at CAS 32 with a correction factor of 1.04, you first get a corrected speed of 33.28. For 2.9 car miles, just add the time for 2 miles at 33.3 to 0.9 miles at 33.3.

Of course, there are several problems with Reid's design for modern use. The most obvious is that times in seconds is not useful for most teams. More subtle is the precision provided. What happens if your corrected speed works out to 33.25 mph? Selecting 33.3 will give you an error of about 3 cents every 10 miles. This may not be significant, but you should be aware of the issue.

Time to Travel										
CAS	1 mile	2 miles	3 miles	4 miles	5 miles	6 miles	7 miles	8 miles	9 miles	10 miles
1	60	120	180	240	300	360	420	480	540	600
2	30	60	90	120	150	180	210	240	270	300
3	20	40	60	80	100	120	140	160	180	200
4	15	30	45	60	75	90	105	120	135	150
5	12	24	36	48	60	72	84	96	108	120
6	10	20	30	40	50	60	70	80	90	100
7	8.57143	17.14286	25.71429	34.28571	42.85714	51.42857	60.00000	68.57143	77.14286	85.71429
8	7.50000	15.00000	22.50000	30.00000	37.50000	45.00000	52.50000	60.00000	67.50000	75.00000
9	6.66666	13.33333	20.00000	26.66666	33.33333	40.00000	46.66666	53.33333	60.00000	66.66666
10	6.00000	12.00000	18.00000	24.00000	30.00000	36.00000	42.00000	48.00000	54.00000	60.00000
11	5.45454	10.90909	16.36363	21.81818	27.27272	32.72727	38.18181	43.63636	49.09090	54.54545
12	5.00000	10.00000	15.00000	20.00000	25.00000	30.00000	35.00000	40.00000	45.00000	50.00000
13	4.61538	9.23077	13.84615	18.46154	23.07692	27.69231	32.30769	36.92308	41.53846	46.15385
14	4.28571	8.57143	12.85714	17.14286	21.42857	25.71429	30.00000	34.28571	38.57143	42.85714
15	4.00000	8.00000	12.00000	16.00000	20.00000	24.00000	28.00000	32.00000	36.00000	40.00000
16	3.75000	7.50000	11.25000	15.00000	18.75000	22.50000	26.25000	30.00000	33.75000	37.50000
17	3.52941	7.05882	10.58824	14.11765	17.64706	21.17647	24.70588	28.23529	31.76471	35.29412
18	3.33333	6.66666	10.00000	13.33333	16.66666	20.00000	23.33333	26.66666	30.00000	33.33333
19	3.15789	6.31579	9.47368	12.63158	15.78947	18.94737	22.10526	25.26316	28.42105	31.57895
20	3.00000	6.00000	9.00000	12.00000	15.00000	18.00000	21.00000	24.00000	27.00000	30.00000
21	2.85714	5.71429	8.57143	11.42857	14.28571	17.14286	20.00000	22.85714	25.71429	28.57143
22	2.72727	5.45454	8.18181	10.90909	13.63636	16.36363	19.09090	21.81818	24.54545	27.27272
23	2.60870	5.21739	7.82609	10.43478	13.04348	15.65217	18.26087	20.86957	23.47826	26.08696
24	2.50000	5.00000	7.50000	10.00000	12.50000	15.00000	17.50000	20.00000	22.50000	25.00000
25	2.40000	4.80000	7.20000	9.60000	12.00000	14.40000	16.80000	19.20000	21.60000	24.00000
26	2.30769	4.61538	6.92308	9.23077	11.53846	13.84615	16.15385	18.46154	20.76923	23.07692
27	2.22222	4.44444	6.66666	8.88888	11.11111	13.33333	15.55555	17.77777	20.00000	22.22222
28	2.14286	4.28571	6.42857	8.57143	10.71429	12.85714	15.00000	17.14286	19.28571	21.42857
29	2.06897	4.13793	6.20690	8.27586	10.34483	12.41379	14.48276	16.55172	18.62069	20.68966
30	2.00000	4.00000	6.00000	8.00000	10.00000	12.00000	14.00000	16.00000	18.00000	20.00000
31	1.93548	3.87097	5.80645	7.74194	9.67742	11.61290	13.54839	15.48387	17.41935	19.35484
32	1.87500	3.75000	5.62500	7.50000	9.37500	11.25000	13.12500	15.00000	16.87500	18.75000
33	1.81818	3.63636	5.45454	7.27272	9.09090	10.90909	12.72727	14.54545	16.36363	18.18181
34	1.76471	3.52941	5.29412	7.05882	8.82353	10.58824	12.35294	14.11765	15.88235	17.64706
35	1.71429	3.42857	5.14286	6.85714	8.57143	10.28571	12.00000	13.71429	15.42857	17.14286
36	1.66666	3.33333	5.00000	6.66666	8.33333	10.00000	11.66666	13.33333	15.00000	16.66666
37	1.62162	3.24324	4.86486	6.48649	8.10811	9.72973	11.35135	12.97297	14.59459	16.21622
38	1.57895	3.15789	4.73684	6.31579	7.89474	9.47368	11.05263	12.63158	14.21053	15.78947
39	1.53846	3.07692	4.61538	6.15385	7.69231	9.23077	10.76923	12.30769	13.84615	15.38462
40	1.50000	3.00000	4.50000	6.00000	7.50000	9.00000	10.50000	12.00000	13.50000	15.00000

Table 15-4a

Time to Travel										
CAS	1 mile	2 miles	3 miles	4 miles	5 miles	6 miles	7 miles	8 miles	9 miles	10 miles
41	1.46341	2.92683	4.39024	5.85366	7.31707	8.78049	10.24390	11.70732	13.17073	14.63415
42	1.42857	2.85714	4.28571	5.71429	7.14286	8.57143	10.00000	11.42857	12.85714	14.28571
43	1.39535	2.79070	4.18605	5.58140	6.97674	8.37209	9.76744	11.16279	12.55814	13.95349
44	1.36363	2.72727	4.09090	5.45454	6.81818	8.18181	9.54545	10.90909	12.27272	13.63636
45	1.33333	2.66666	4.00000	5.33333	6.66666	8.00000	9.33333	10.66666	12.00000	13.33333
46	1.30435	2.60870	3.91304	5.21739	6.52174	7.82609	9.13043	10.43478	11.73913	13.04348
47	1.27660	2.55319	3.82979	5.10638	6.38298	7.65957	8.93617	10.21277	11.48936	12.76596
48	1.25000	2.50000	3.75000	5.00000	6.25000	7.50000	8.75000	10.00000	11.25000	12.50000
49	1.22449	2.44898	3.67347	4.89796	6.12245	7.34694	8.57143	9.79592	11.02041	12.24490
50	1.20000	2.40000	3.60000	4.80000	6.00000	7.20000	8.40000	9.60000	10.80000	12.00000
51	1.17647	2.35294	3.52941	4.70588	5.88235	7.05882	8.23529	9.41176	10.58824	11.76471
52	1.15385	2.30769	3.46154	4.61538	5.76923	6.92308	8.07692	9.23077	10.38462	11.53846
53	1.13208	2.26415	3.39623	4.52830	5.66038	6.79245	7.92453	9.05660	10.18868	11.32075
54	1.11111	2.22222	3.33333	4.44444	5.55555	6.66666	7.77777	8.88888	10.00000	11.11111
55	1.09090	2.18181	3.27272	4.36363	5.45454	6.54545	7.63636	8.72727	9.81818	10.90909
56	1.07143	2.14286	3.21429	4.28571	5.35714	6.42857	7.50000	8.57143	9.64286	10.71429
57	1.05263	2.10526	3.15789	4.21053	5.26316	6.31579	7.36842	8.42105	9.47368	10.52632
58	1.03448	2.06897	3.10345	4.13793	5.17241	6.20690	7.24138	8.27586	9.31034	10.34483
59	1.01695	2.03390	3.05085	4.06780	5.08475	6.10169	7.11864	8.13559	9.15254	10.16949
60	1.00000	2.00000	3.00000	4.00000	5.00000	6.00000	7.00000	8.00000	9.00000	10.00000
61	0.98361	1.96721	2.95082	3.93443	4.91803	5.90164	6.88525	7.86885	8.85246	9.83607
62	0.96774	1.93548	2.90323	3.87097	4.83871	5.80645	6.77419	7.74194	8.70968	9.67742
63	0.95238	1.90476	2.85714	3.80952	4.76190	5.71429	6.66666	7.61905	8.57143	9.52381
64	0.93750	1.87500	2.81250	3.75000	4.68750	5.62500	6.56250	7.50000	8.43750	9.37500
65	0.92308	1.84615	2.76923	3.69231	4.61538	5.53846	6.46154	7.38462	8.30769	9.23077
66	0.90909	1.81818	2.72727	3.63636	4.54545	5.45454	6.36363	7.27272	8.18181	9.09090
67	0.89552	1.79104	2.68657	3.58209	4.47761	5.37313	6.26866	7.16418	8.05970	8.95522
68	0.88235	1.76471	2.64706	3.52941	4.41176	5.29412	6.17647	7.05882	7.94118	8.82353
69	0.86957	1.73913	2.60870	3.47826	4.34783	5.21739	6.08696	6.95652	7.82609	8.69565
70	0.85714	1.71429	2.57143	3.42857	4.28571	5.14286	6.00000	6.85714	7.71429	8.57143
71	0.84507	1.69014	2.53521	3.38028	4.22535	5.07042	5.91549	6.76056	7.60563	8.45070
72	0.83333	1.66666	2.50000	3.33333	4.16666	5.00000	5.83333	6.66666	7.50000	8.33333
73	0.82192	1.64384	2.46575	3.28767	4.10959	4.93151	5.75342	6.57534	7.39726	8.21918
74	0.81081	1.62162	2.43243	3.24324	4.05405	4.86486	5.67568	6.48649	7.29730	8.10811
75	0.80000	1.60000	2.40000	3.20000	4.00000	4.80000	5.60000	6.40000	7.20000	8.00000
76	0.78947	1.57895	2.36842	3.15789	3.94737	4.73684	5.52632	6.31579	7.10526	7.89474
77	0.77922	1.55844	2.33766	3.11688	3.89610	4.67532	5.45454	6.23377	7.01299	7.79221
78	0.76923	1.53846	2.30769	3.07692	3.84615	4.61538	5.38462	6.15385	6.92308	7.69231
79	0.75949	1.51899	2.27848	3.03797	3.79747	4.55696	5.31646	6.07595	6.83544	7.59494
80	0.75000	1.50000	2.25000	3.00000	3.75000	4.50000	5.25000	6.00000	6.75000	7.50000

Table 15-4b

0.01 = 0.02	0.51 = 0.96	1.01 = 1.89	1.51 = 2.83	2.01 = 3.77	2.51 = 4.71	3.01 = 5.64	3.51 = 6.58	4.01 = 7.52	4.51 = 8.46	5.01 = 9.39	5.51 = 10.33
0.02 = 0.04	0.52 = 0.98	1.02 = 1.91	1.52 = 2.85	2.02 = 3.79	2.52 = 4.73	3.02 = 5.66	3.52 = 6.60	4.02 = 7.54	4.52 = 8.48	5.02 = 9.41	5.52 = 10.35
0.03 = 0.06	0.53 = 0.99	1.03 = 1.93	1.53 = 2.87	2.03 = 3.81	2.53 = 4.74	3.03 = 5.68	3.53 = 6.62	4.03 = 7.56	4.53 = 8.49	5.03 = 9.43	5.53 = 10.37
0.04 = 0.08	0.54 = 1.01	1.04 = 1.95	1.54 = 2.89	2.04 = 3.83	2.54 = 4.76	3.04 = 5.70	3.54 = 6.64	4.04 = 7.58	4.54 = 8.51	5.04 = 9.45	5.54 = 10.39
0.05 = 0.09	0.55 = 1.03	1.05 = 1.97	1.55 = 2.91	2.05 = 3.84	2.55 = 4.78	3.05 = 5.72	3.55 = 6.66	4.05 = 7.59	4.55 = 8.53	5.05 = 9.47	5.55 = 10.41
0.06 = 0.11	0.56 = 1.05	1.06 = 1.99	1.56 = 2.93	2.06 = 3.86	2.56 = 4.80	3.06 = 5.74	3.56 = 6.68	4.06 = 7.61	4.56 = 8.55	5.06 = 9.49	5.56 = 10.43
0.07 = 0.13	0.57 = 1.07	1.07 = 2.01	1.57 = 2.94	2.07 = 3.88	2.57 = 4.82	3.07 = 5.76	3.57 = 6.69	4.07 = 7.63	4.57 = 8.57	5.07 = 9.51	5.57 = 10.44
0.08 = 0.15	0.58 = 1.09	1.08 = 2.03	1.58 = 2.96	2.08 = 3.90	2.58 = 4.84	3.08 = 5.78	3.58 = 6.71	4.08 = 7.65	4.58 = 8.59	5.08 = 9.53	5.58 = 10.46
0.09 = 0.17	0.59 = 1.11	1.09 = 2.04	1.59 = 2.98	2.09 = 3.92	2.59 = 4.86	3.09 = 5.79	3.59 = 6.73	4.09 = 7.67	4.59 = 8.61	5.09 = 9.54	5.59 = 10.48
0.10 = 0.19	0.60 = 1.13	1.10 = 2.06	1.60 = 3.00	2.10 = 3.94	2.60 = 4.88	3.10 = 5.81	3.60 = 6.75	4.10 = 7.69	4.60 = 8.63	5.10 = 9.56	5.60 = 10.50
0.11 = 0.21	0.61 = 1.14	1.11 = 2.08	1.61 = 3.02	2.11 = 3.96	2.61 = 4.89	3.11 = 5.83	3.61 = 6.77	4.11 = 7.71	4.61 = 8.64	5.11 = 9.58	5.61 = 10.52
0.12 = 0.23	0.62 = 1.16	1.12 = 2.10	1.62 = 3.04	2.12 = 3.98	2.62 = 4.91	3.12 = 5.85	3.62 = 6.79	4.12 = 7.73	4.62 = 8.66	5.12 = 9.60	5.62 = 10.54
0.13 = 0.24	0.63 = 1.18	1.13 = 2.12	1.63 = 3.06	2.13 = 3.99	2.63 = 4.93	3.13 = 5.87	3.63 = 6.81	4.13 = 7.74	4.63 = 8.68	5.13 = 9.62	5.63 = 10.56
0.14 = 0.26	0.64 = 1.20	1.14 = 2.14	1.64 = 3.08	2.14 = 4.01	2.64 = 4.95	3.14 = 5.89	3.64 = 6.83	4.14 = 7.76	4.64 = 8.70	5.14 = 9.64	5.64 = 10.58
0.15 = 0.28	0.65 = 1.22	1.15 = 2.16	1.65 = 3.09	2.15 = 4.03	2.65 = 4.97	3.15 = 5.91	3.65 = 6.84	4.15 = 7.78	4.65 = 8.72	5.15 = 9.66	5.65 = 10.59
0.16 = 0.30	0.66 = 1.24	1.16 = 2.18	1.66 = 3.11	2.16 = 4.05	2.66 = 4.99	3.16 = 5.93	3.66 = 6.86	4.16 = 7.80	4.66 = 8.74	5.16 = 9.68	5.66 = 10.61
0.17 = 0.32	0.67 = 1.26	1.17 = 2.19	1.67 = 3.13	2.17 = 4.07	2.67 = 5.01	3.17 = 5.94	3.67 = 6.88	4.17 = 7.82	4.67 = 8.76	5.17 = 9.69	5.67 = 10.63
0.18 = 0.34	0.68 = 1.28	1.18 = 2.21	1.68 = 3.15	2.18 = 4.09	2.68 = 5.03	3.18 = 5.96	3.68 = 6.90	4.18 = 7.84	4.68 = 8.78	5.18 = 9.71	5.68 = 10.65
0.19 = 0.36	0.69 = 1.29	1.19 = 2.23	1.69 = 3.17	2.19 = 4.11	2.69 = 5.04	3.19 = 5.98	3.69 = 6.92	4.19 = 7.86	4.69 = 8.79	5.19 = 9.73	5.69 = 10.67
0.20 = 0.38	0.70 = 1.31	1.20 = 2.25	1.70 = 3.19	2.20 = 4.13	2.70 = 5.06	3.20 = 6.00	3.70 = 6.94	4.20 = 7.88	4.70 = 8.81	5.20 = 9.75	5.70 = 10.69
0.21 = 0.39	0.71 = 1.33	1.21 = 2.27	1.71 = 3.21	2.21 = 4.14	2.71 = 5.08	3.21 = 6.02	3.71 = 6.96	4.21 = 7.89	4.71 = 8.83	5.21 = 9.77	5.71 = 10.71
0.22 = 0.41	0.72 = 1.35	1.22 = 2.29	1.72 = 3.23	2.22 = 4.16	2.72 = 5.10	3.22 = 6.04	3.72 = 6.98	4.22 = 7.91	4.72 = 8.85	5.22 = 9.79	5.72 = 10.73
0.23 = 0.43	0.73 = 1.37	1.23 = 2.31	1.73 = 3.24	2.23 = 4.18	2.73 = 5.12	3.23 = 6.06	3.73 = 6.99	4.23 = 7.93	4.73 = 8.87	5.23 = 9.81	5.73 = 10.74
0.24 = 0.45	0.74 = 1.39	1.24 = 2.33	1.74 = 3.26	2.24 = 4.20	2.74 = 5.14	3.24 = 6.08	3.74 = 7.01	4.24 = 7.95	4.74 = 8.89	5.24 = 9.83	5.74 = 10.76
0.25 = 0.47	0.75 = 1.41	1.25 = 2.34	1.75 = 3.28	2.25 = 4.22	2.75 = 5.16	3.25 = 6.09	3.75 = 7.03	4.25 = 7.97	4.75 = 8.91	5.25 = 9.84	5.75 = 10.78
0.26 = 0.49	0.76 = 1.43	1.26 = 2.36	1.76 = 3.30	2.26 = 4.24	2.76 = 5.18	3.26 = 6.11	3.76 = 7.05	4.26 = 7.99	4.76 = 8.93	5.26 = 9.86	5.76 = 10.80
0.27 = 0.51	0.77 = 1.44	1.27 = 2.38	1.77 = 3.32	2.27 = 4.26	2.77 = 5.19	3.27 = 6.13	3.77 = 7.07	4.27 = 8.01	4.77 = 8.94	5.27 = 9.88	5.77 = 10.82
0.28 = 0.53	0.78 = 1.46	1.28 = 2.40	1.78 = 3.34	2.28 = 4.28	2.78 = 5.21	3.28 = 6.15	3.78 = 7.09	4.28 = 8.03	4.78 = 8.96	5.28 = 9.90	5.78 = 10.84
0.29 = 0.54	0.79 = 1.48	1.29 = 2.42	1.79 = 3.36	2.29 = 4.29	2.79 = 5.23	3.29 = 6.17	3.79 = 7.11	4.29 = 8.04	4.79 = 8.98	5.29 = 9.92	5.79 = 10.86
0.30 = 0.56	0.80 = 1.50	1.30 = 2.44	1.80 = 3.38	2.30 = 4.31	2.80 = 5.25	3.30 = 6.19	3.80 = 7.13	4.30 = 8.06	4.80 = 9.00	5.30 = 9.94	5.80 = 10.88
0.31 = 0.58	0.81 = 1.52	1.31 = 2.46	1.81 = 3.39	2.31 = 4.33	2.81 = 5.27	3.31 = 6.21	3.81 = 7.14	4.31 = 8.08	4.81 = 9.02	5.31 = 9.96	5.81 = 10.89
0.32 = 0.60	0.82 = 1.54	1.32 = 2.48	1.82 = 3.41	2.32 = 4.35	2.82 = 5.29	3.32 = 6.23	3.82 = 7.16	4.32 = 8.10	4.82 = 9.04	5.32 = 9.98	5.82 = 10.91
0.33 = 0.62	0.83 = 1.56	1.33 = 2.49	1.83 = 3.43	2.33 = 4.37	2.83 = 5.31	3.33 = 6.24	3.83 = 7.18	4.33 = 8.12	4.83 = 9.06	5.33 = 9.99	5.83 = 10.93
0.34 = 0.64	0.84 = 1.58	1.34 = 2.51	1.84 = 3.45	2.34 = 4.39	2.84 = 5.33	3.34 = 6.26	3.84 = 7.20	4.34 = 8.14	4.84 = 9.08	5.34 = 10.01	5.84 = 10.95
0.35 = 0.66	0.85 = 1.59	1.35 = 2.53	1.85 = 3.47	2.35 = 4.41	2.85 = 5.34	3.35 = 6.28	3.85 = 7.22	4.35 = 8.16	4.85 = 9.09	5.35 = 10.03	5.85 = 10.97
0.36 = 0.68	0.86 = 1.61	1.36 = 2.55	1.86 = 3.49	2.36 = 4.43	2.86 = 5.36	3.36 = 6.30	3.86 = 7.24	4.36 = 8.18	4.86 = 9.11	5.36 = 10.05	5.86 = 10.99
0.37 = 0.69	0.87 = 1.63	1.37 = 2.57	1.87 = 3.51	2.37 = 4.44	2.87 = 5.38	3.37 = 6.32	3.87 = 7.26	4.37 = 8.19	4.87 = 9.13	5.37 = 10.07	5.87 = 11.01
0.38 = 0.71	0.88 = 1.65	1.38 = 2.59	1.88 = 3.53	2.38 = 4.46	2.88 = 5.40	3.38 = 6.34	3.88 = 7.28	4.38 = 8.21	4.88 = 9.15	5.38 = 10.09	5.88 = 11.03
0.39 = 0.73	0.89 = 1.67	1.39 = 2.61	1.89 = 3.54	2.39 = 4.48	2.89 = 5.42	3.39 = 6.36	3.89 = 7.29	4.39 = 8.23	4.89 = 9.17	5.39 = 10.11	5.89 = 11.04
0.40 = 0.75	0.90 = 1.69	1.40 = 2.63	1.90 = 3.56	2.40 = 4.50	2.90 = 5.44	3.40 = 6.38	3.90 = 7.31	4.40 = 8.25	4.90 = 9.19	5.40 = 10.13	5.90 = 11.06
0.41 = 0.77	0.91 = 1.71	1.41 = 2.64	1.91 = 3.58	2.41 = 4.52	2.91 = 5.46	3.41 = 6.39	3.91 = 7.33	4.41 = 8.27	4.91 = 9.21	5.41 = 10.14	5.91 = 11.08
0.42 = 0.79	0.92 = 1.73	1.42 = 2.66	1.92 = 3.60	2.42 = 4.54	2.92 = 5.48	3.42 = 6.41	3.92 = 7.35	4.42 = 8.29	4.92 = 9.23	5.42 = 10.16	5.92 = 11.10
0.43 = 0.81	0.93 = 1.74	1.43 = 2.68	1.93 = 3.62	2.43 = 4.56	2.93 = 5.49	3.43 = 6.43	3.93 = 7.37	4.43 = 8.31	4.93 = 9.24	5.43 = 10.18	5.93 = 11.12
0.44 = 0.83	0.94 = 1.76	1.44 = 2.70	1.94 = 3.64	2.44 = 4.58	2.94 = 5.51	3.44 = 6.45	3.94 = 7.39	4.44 = 8.33	4.94 = 9.26	5.44 = 10.20	5.94 = 11.14
0.45 = 0.84	0.95 = 1.78	1.45 = 2.72	1.95 = 3.66	2.45 = 4.59	2.95 = 5.53	3.45 = 6.47	3.95 = 7.41	4.45 = 8.34	4.95 = 9.28	5.45 = 10.22	5.95 = 11.16
0.46 = 0.86	0.96 = 1.80	1.46 = 2.74	1.96 = 3.68	2.46 = 4.61	2.96 = 5.55	3.46 = 6.49	3.96 = 7.43	4.46 = 8.36	4.96 = 9.30	5.46 = 10.24	5.96 = 11.18
0.47 = 0.88	0.97 = 1.82	1.47 = 2.76	1.97 = 3.69	2.47 = 4.63	2.97 = 5.57	3.47 = 6.51	3.97 = 7.44	4.47 = 8.38	4.97 = 9.32	5.47 = 10.26	5.97 = 11.19
0.48 = 0.90	0.98 = 1.84	1.48 = 2.78	1.98 = 3.71	2.48 = 4.65	2.98 = 5.59	3.48 = 6.53	3.98 = 7.46	4.48 = 8.40	4.98 = 9.34	5.48 = 10.28	5.98 = 11.21
0.49 = 0.92	0.99 = 1.86	1.49 = 2.79	1.99 = 3.73	2.49 = 4.67	2.99 = 5.61	3.49 = 6.54	3.99 = 7.48	4.49 = 8.42	4.99 = 9.36	5.49 = 10.29	5.99 = 11.23
0.50 = 0.94	1.00 = 1.88	1.50 = 2.81	2.00 = 3.75	2.50 = 4.69	3.00 = 5.63	3.50 = 6.56	4.00 = 7.50	4.50 = 8.44	5.00 = 9.38	5.50 = 10.31	6.00 = 11.25

Table 15-5

MPH 33.0			33.1		33.2		33.3		33.4		MPH
Mi.	Min	Sec	Min	Sec	Min	Sec	Min	Sec	Min	Sec	Mi.
0.1	0	11	0	11	0	11	0	11	0	11	0.1
0.2	0	22	0	22	0	22	0	22	0	22	0.2
0.3	0	33	0	33	0	33	0	32	0	32	0.3
0.4	0	44	0	44	0	43	0	43	0	43	0.4
0.5	0	55	0	54	0	54	0	54	0	54	0.5
0.6	1	05	1	05	1	05	1	05	1	05	0.6
0.7	1	16	1	16	1	16	1	16	1	15	0.7
0.8	1	27	1	27	1	27	1	26	1	26	0.8
0.9	1	38	1	38	1	38	1	37	1	37	0.9
1	1	49	1	49	1	48	1	48	1	48	1
2	3	38	3	38	3	37	3	36	3	36	2
3	5	27	5	26	5	25	5	24	5	23	3
4	7	16	7	15	7	14	7	12	7	11	4
5	9	05	9	04	9	02	9	01	8	59	5
6	10	55	10	53	10	51	10	49	10	47	6
7	12	44	12	41	12	39	12	37	12	34	7
8	14	33	14	30	14	27	14	25	14	22	8
9	16	22	16	19	16	16	16	13	16	10	9
10	18	11	18	08	18	04	18	01	17	58	10
11	20	00	19	56	19	53	19	49	19	46	11
12	21	49	21	45	21	41	21	37	21	33	12
13	23	38	23	34	23	30	23	25	23	21	13
14	25	27	25	23	25	18	25	14	25	09	14
15	27	16	27	11	27	07	27	02	26	57	15
16	29	05	29	00	28	55	28	50	28	45	16
17	30	55	30	49	30	43	30	38	30	32	17
18	32	44	32	38	32	32	32	26	32	20	18
19	34	33	34	26	34	20	34	14	34	08	19
20	36	22	36	15	36	09	36	02	35	56	20
21	38	11	38	04	37	57	37	50	37	43	21
22	40	00	39	53	39	46	39	38	39	31	22
23	41	49	41	42	41	34	41	26	41	19	23
24	43	38	43	30	43	22	43	15	43	07	24
25	45	27	45	19	45	11	45	03	44	55	25
26	47	16	47	08	46	59	46	51	46	42	26
27	49	05	48	57	48	48	48	39	48	30	27
28	50	55	50	45	50	36	50	27	50	18	28
29	52	44	52	34	52	25	52	15	52	06	29
30	54	33	54	23	54	13	54	03	53	54	30
31	56	22	56	12	56	01	55	51	55	41	31
32	58	11	58	00	57	50	57	39	57	29	32
33	60	00	59	49	59	38	59	28	59	17	33
34	61	49	61	38	61	27	61	16	61	05	34
35	63	38	63	27	63	15	63	04	62	52	35
36	65	27	65	15	65	04	64	52	64	40	36
37	67	16	67	04	66	52	66	40	66	28	37
38	69	05	68	53	68	40	68	28	68	16	38
39	70	55	70	42	70	29	70	16	70	04	39
40	72	44	72	30	72	17	72	04	71	51	40

Table 15-6

SPEED	33.0	33.1	33.2	33.3	33.4	33.5	33.6	33.7	33.8	33.9
DIST	Time to Distance									
0.1	0.182	0.181	0.181	0.180	0.180	0.179	0.179	0.178	0.178	0.177
0.2	0.364	0.363	0.361	0.360	0.359	0.358	0.357	0.356	0.355	0.354
0.3	0.545	0.544	0.542	0.541	0.539	0.537	0.536	0.534	0.533	0.531
0.4	0.727	0.725	0.723	0.721	0.719	0.716	0.714	0.712	0.710	0.708
0.5	0.909	0.906	0.904	0.901	0.898	0.896	0.893	0.890	0.888	0.885
0.6	1.091	1.088	1.084	1.081	1.078	1.075	1.071	1.068	1.065	1.062
0.7	1.273	1.269	1.265	1.261	1.257	1.254	1.250	1.246	1.243	1.239
0.8	1.455	1.450	1.446	1.441	1.437	1.433	1.429	1.424	1.420	1.416
0.9	1.636	1.631	1.627	1.622	1.617	1.612	1.607	1.602	1.598	1.593
1.0	1.818	1.813	1.807	1.802	1.796	1.791	1.786	1.780	1.775	1.770
2.0	3.636	3.625	3.614	3.604	3.593	3.582	3.571	3.561	3.550	3.540
3.0	5.455	5.438	5.422	5.405	5.389	5.373	5.357	5.341	5.325	5.310
4.0	7.273	7.251	7.229	7.207	7.186	7.164	7.143	7.122	7.101	7.080
5.0	9.091	9.063	9.036	9.009	8.982	8.955	8.929	8.902	8.876	8.850
6.0	10.909	10.876	10.843	10.811	10.778	10.746	10.714	10.682	10.651	10.619
7.0	12.727	12.689	12.651	12.613	12.575	12.537	12.500	12.463	12.426	12.389
8.0	14.545	14.502	14.458	14.414	14.371	14.328	14.286	14.243	14.201	14.159
9.0	16.364	16.314	16.265	16.216	16.168	16.119	16.071	16.024	15.976	15.929
10.0	18.182	18.127	18.072	18.018	17.964	17.910	17.857	17.804	17.751	17.699

Table 15-7

Henderson's Rally Basics

This basic table design was updated by Gene Henderson in 1988 in his book *Rally Basics* (make sure you get a corrected copy). Table 15-7 is a sample from Table II of *Rally Basics*. It gives times to mils (thousandths of a minute) rather than seconds and the times are correctly calculated and rounded. However, the precision problems in selecting a corrected speed are still an issue.

One thing you notice about Henderson's design is that the times for mileages 0.1→1.0 are the same as the times for mileages 1.0→10.0, with the decimal point moved one place and one more digit of resolution added. When designing your own tables, you could cut the size in half by listing just 1.0→10.0, but this makes the tables a bit harder to use.

33.3										33.3
EASY-ZERO ZOMBIE CHART										
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	0.0	1.8	3.6	5.4	7.2	9.0	10.8	12.6	14.4	16.2
.1	18.0	19.8	21.6	23.4	25.2	27.0	28.8	30.6	32.4	34.2
.2	36.0	37.8	39.6	41.4	43.2	45.0	46.8	48.6	50.5	52.3
.3	54.1	55.9	57.7	59.5	61.3	63.1	64.9	66.7	68.5	70.3
.4	72.1	73.9	75.7	77.5	79.3	81.1	82.9	84.7	86.5	88.3
.5	90.1	91.9	93.7	95.5	97.3	99.1	100.9	102.7	104.5	106.3
.6	108.1	109.9	111.7	113.5	115.3	117.1	118.9	120.7	122.5	124.3
.7	126.1	127.9	129.7	131.5	133.3	135.1	136.9	138.7	140.5	142.3
.8	144.1	145.9	147.7	149.5	151.4	153.2	155.0	156.8	158.6	160.4
.9	162.2	164.0	165.8	167.6	169.4	171.2	173.0	174.8	176.6	178.4

Table 15-8

Zombie Charts

One issue with all the time tables so far is that two additions must be done to get time for a mileage to the hundredth. Steven Plant designed a set of tables (15-8) known as the “Easy Zero Zombie Charts” which gives the times (in cents) for all hundredths up to 0.99 miles.

The Zombie Charts reduce the number of additions from two to one, reducing the chance of an error. This gain was obtained at the cost of dealing with a set of 600 cards.

Speeds are given in tenths of a mph, so you can use a correction factor to get adjusted speeds, but you still have the inaccuracy of

choosing an approximate speed. This also requires that you correctly compute the adjusted speeds. (Remember that time tables are useful for systems which prohibit a calculator.)

Also, these tables have no time for 1.00 mile. Moving the decimal point for the 0.10 mile value can get this number, but you lose precision.

Stock Tables

With the benefit of seeing the pros and cons of the tables that have been designed over the years, we can try to get a most appropriate design for time tables to be used without a calculator in Limited-Stock Class and Odo Class.

CAS	Speed	1	2	3	4	5	6	7	8	9	10	CAS
23	23.920	2.508	5.017	7.525	10.033	12.542	15.050	17.559	20.067	22.575	25.084	23
24	24.960	2.404	4.808	7.212	9.615	12.019	14.423	16.827	19.231	21.635	24.038	24
25	26.000	2.308	4.615	6.923	9.231	11.538	13.846	16.154	18.462	20.769	23.077	25
26	27.040	2.219	4.438	6.657	8.876	11.095	13.314	15.533	17.751	19.970	22.189	26
27	28.080	2.137	4.274	6.410	8.547	10.684	12.821	14.957	17.094	19.231	21.368	27
28	29.120	2.060	4.121	6.181	8.242	10.302	12.363	14.423	16.484	18.544	20.604	28
29	30.160	1.989	3.979	5.968	7.958	9.947	11.936	13.926	15.915	17.905	19.894	29
30	31.200	1.923	3.846	5.769	7.692	9.615	11.538	13.462	15.385	17.308	19.231	30
31	32.240	1.861	3.722	5.583	7.444	9.305	11.166	13.027	14.888	16.749	18.610	31
32	33.280	1.803	3.606	5.409	7.212	9.014	10.817	12.620	14.423	16.226	18.029	32
33	34.320	1.748	3.497	5.245	6.993	8.741	10.490	12.238	13.986	15.734	17.483	33
34	35.360	1.697	3.394	5.090	6.787	8.484	10.181	11.878	13.575	15.271	16.968	34
35	36.400	1.648	3.297	4.945	6.593	8.242	9.890	11.538	13.187	14.835	16.484	35
36	37.440	1.603	3.205	4.808	6.410	8.013	9.615	11.218	12.821	14.423	16.026	36
37	38.480	1.559	3.119	4.678	6.237	7.796	9.356	10.915	12.474	14.033	15.593	37
38	39.520	1.518	3.036	4.555	6.073	7.591	9.109	10.628	12.146	13.664	15.182	38
39	40.560	1.479	2.959	4.438	5.917	7.396	8.876	10.355	11.834	13.314	14.793	39
40	41.600	1.442	2.885	4.327	5.769	7.212	8.654	10.096	11.538	12.981	14.423	40
41	42.640	1.407	2.814	4.221	5.629	7.036	8.443	9.850	11.257	12.664	14.071	41
42	43.680	1.374	2.747	4.121	5.495	6.868	8.242	9.615	10.989	12.363	13.736	42
43	44.720	1.342	2.683	4.025	5.367	6.708	8.050	9.392	10.733	12.075	13.417	43
44	45.760	1.311	2.622	3.934	5.245	6.556	7.867	9.178	10.490	11.801	13.112	44
		1	2	3	4	5	6	7	8	9	10	
CF=1.040												

Table 15-9

A first impulse might be to go for all the advantages of the previous designs. Why not combine the resolution of Floyd's Tables (to the hundredth of a mph) with the usefulness of the Reid or Plant designs? Simply put, it expands the size of the tables by a factor of 10, making them somewhat unwieldy. This approach was tried by a team in the late 1960's, who would literally visit their trunk at the end of the odometer check to select the correct books from among the "library".

After weighing the alternatives, we came up with a compromise between ease of use and practicality:

- Assume only that a correction factor can be obtained. Deal with CAS assignments directly, as in the Cone design, rather than corrected speeds.
- Settle for performing 3 additions to get the perfect (corrected) time to cover a distance measured to the hundredth.
- Organize the tables so that only a few sheets/cards are needed after determining the correction factor.

These criteria lead us to the following design. Each correction factor has three 5½" × 8½" sheets covering speeds from 1 to 66 mph. Table 15-9 is the sheet covering the most-used middle speeds.

To use Table 15-9, you run the odometer check and come up with a correction factor. Then pull out the three pages for that correction factor. Determining time to a distance is done just like the Time to Travel Table 15-4, except that you now have corrected time.

For example, 2.84 miles at CAS 32:

2.00 miles at CAS 32	3.606
0.80 miles at CAS 32	1.442
(8 miles and move '.' one digit)	
0.04 miles at CAS 32	<u>0.072</u>
(4 miles and move '.' two digits)	
Total	5.120 minutes

Rich Kamo's Stock Tables

If you are willing to use a much larger set of tables, you can get numbers to the hundredth of a mile with less math than the Stock Tables above. Rich Kamo designed Table 15-10 for his own use when navigating Stock Class. There is one page for each CAS at each correction factor. These tables are generated from an Excel spreadsheet.

Table 15-10 shows CAS 30 with a correction factor of 1.015 (car odometer reads 1.5% high). The upper half of the table gives corrected times for every hundredth of a mile from 0.00 to 0.99. The lower half gives every tenth from 0.0 to 9.9.

Near the bottom of Table 15-10, times for whole miles are given up to 19 miles. The very bottom shows what adjustments to make for correction factors near 1.015. For example, if your factor is really 1.014, you would use this table and subtract 1 cent every 4.95 miles. This trick reduces the number of tables you need by a factor of five.

This table format has undergone many revisions to fine tune it for running Stock Class. It shows how many of the basic features of spreadsheets can be used to pack a lot of information onto a page and still keep it readable. There is some duplication of information, but this allows readings to be given with less math.

	CAST	30		Factor	1.015					
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0203	0.0406	0.0609	0.0812	0.1015	0.1218	0.1421	0.1624	0.1827
0.1	0.2030	0.2233	0.2436	0.2639	0.2842	0.3045	0.3248	0.3451	0.3654	0.3857
0.2	0.4060	0.4263	0.4466	0.4669	0.4872	0.5075	0.5278	0.5481	0.5684	0.5887
0.3	0.6090	0.6293	0.6496	0.6699	0.6902	0.7105	0.7308	0.7511	0.7714	0.7917
0.4	0.8120	0.8323	0.8526	0.8729	0.8932	0.9135	0.9338	0.9541	0.9744	0.9947
0.5	1.0150	1.0353	1.0556	1.0759	1.0962	1.1165	1.1368	1.1571	1.1774	1.1977
0.6	1.2180	1.2383	1.2586	1.2789	1.2992	1.3195	1.3398	1.3601	1.3804	1.4007
0.7	1.4210	1.4413	1.4616	1.4819	1.5022	1.5225	1.5428	1.5631	1.5834	1.6037
0.8	1.6240	1.6443	1.6646	1.6849	1.7052	1.7255	1.7458	1.7661	1.7864	1.8067
0.9	1.8270	1.8473	1.8676	1.8879	1.9082	1.9285	1.9488	1.9691	1.9894	2.0097
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	0.0000	0.2030	0.4060	0.6090	0.8120	1.0150	1.2180	1.4210	1.6240	1.8270
1	2.0300	2.2330	2.4360	2.6390	2.8420	3.0450	3.2480	3.4510	3.6540	3.8570
2	4.0600	4.2630	4.4660	4.6690	4.8720	5.0750	5.2780	5.4810	5.6840	5.8870
3	6.0900	6.2930	6.4960	6.6990	6.9020	7.1050	7.3080	7.5110	7.7140	7.9170
4	8.1200	8.3230	8.5260	8.7290	8.9320	9.1350	9.3380	9.5410	9.7440	9.9470
5	10.1500	10.3530	10.5560	10.7590	10.9620	11.1650	11.3680	11.5710	11.7740	11.9770
6	12.1800	12.3830	12.5860	12.7890	12.9920	13.1950	13.3980	13.6010	13.8040	14.0070
7	14.2100	14.4130	14.6160	14.8190	15.0220	15.2250	15.4280	15.6310	15.8340	16.0370
8	16.2400	16.4430	16.6460	16.8490	17.0520	17.2550	17.4580	17.6610	17.8640	18.0670
9	18.2700	18.4730	18.6760	18.8790	19.0820	19.2850	19.4880	19.6910	19.8940	20.0970
	10	20.3000	12	24.3600	14	28.4200	16	32.4800	18	36.5400
	11	22.3300	13	26.3900	15	30.4500	17	34.5100	19	38.5700
	1.013		1.014				1.016		1.017	
	-0.01	2.4800	-0.01	4.9551			+0.01	4.9451	+0.01	2.4700

Table 15-10

Odo Tables

Finally, we look at a table design for running with a precision odometer.

The requirements are quite different than for the Stock Tables:

- No correction factor is needed since the calibration makes the odometer read official miles (hopefully).
- The table should provide readings for each hundredth of a mile without requiring any additions.

For each CAS, there are four $5\frac{1}{2}'' \times 8\frac{1}{2}''$ tables, covering distances in hundredths of a mile from 0.00 to 9.56 miles. Table 15-11 works very efficiently if you have the

interval distance from the last speed change. You can read off the perfect time and compare it directly with an interval timer started at the last speed change.

	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	
0.0	0.000	0.019	0.037	0.056	0.075	0.094	0.112	0.131	0.150	0.169	0.0
0.1	0.188	0.206	0.225	0.244	0.263	0.281	0.300	0.319	0.337	0.356	0.1
0.2	0.375	0.394	0.412	0.431	0.450	0.469	0.488	0.506	0.525	0.544	0.2
0.3	0.563	0.581	0.600	0.619	0.638	0.656	0.675	0.694	0.713	0.731	0.3
0.4	0.750	0.769	0.788	0.806	0.825	0.844	0.863	0.881	0.900	0.919	0.4
0.5	0.938	0.956	0.975	0.994	1.013	1.031	1.050	1.069	1.087	1.106	0.5
0.6	1.125	1.144	1.163	1.181	1.200	1.219	1.238	1.256	1.275	1.294	0.6
0.7	1.313	1.331	1.350	1.369	1.388	1.406	1.425	1.444	1.463	1.481	0.7
0.8	1.500	1.519	1.538	1.556	1.575	1.594	1.613	1.631	1.650	1.669	0.8
0.9	1.688	1.706	1.725	1.744	1.763	1.781	1.800	1.819	1.837	1.856	0.9
1.0	1.875	1.894	1.913	1.931	1.950	1.969	1.988	2.006	2.025	2.044	1.0
1.1	2.062	2.081	2.100	2.119	2.138	2.156	2.175	2.194	2.213	2.231	1.1
1.2	2.250	2.269	2.288	2.306	2.325	2.344	2.363	2.381	2.400	2.419	1.2
1.3	2.438	2.456	2.475	2.494	2.513	2.531	2.550	2.569	2.588	2.606	1.3
1.4	2.625	2.644	2.663	2.681	2.700	2.719	2.738	2.756	2.775	2.794	1.4
1.5	2.812	2.831	2.850	2.869	2.888	2.906	2.925	2.944	2.963	2.981	1.5
1.6	3.000	3.019	3.038	3.056	3.075	3.094	3.113	3.131	3.150	3.169	1.6
1.7	3.188	3.206	3.225	3.244	3.263	3.281	3.300	3.319	3.338	3.356	1.7
1.8	3.375	3.394	3.413	3.431	3.450	3.469	3.488	3.506	3.525	3.544	1.8
1.9	3.563	3.581	3.600	3.619	3.638	3.656	3.675	3.694	3.713	3.731	1.9
2.0	3.750	3.769	3.788	3.806	3.825	3.844	3.863	3.881	3.900	3.919	2.0
2.1	3.938	3.956	3.975	3.994	4.013	4.031	4.050	4.069	4.088	4.106	2.1
2.2	4.125	4.144	4.163	4.181	4.200	4.219	4.238	4.256	4.275	4.294	2.2
2.3	4.313	4.331	4.350	4.369	4.388	4.406	4.425	4.444	4.463	4.481	2.3
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	

CAS 32

Table 15-11

Each page has readings to the thousandth of a minute at a given CAS for mileages down to the hundredth of a mile. The pages are printed on two sides of a 5½" × 8½" sheet, with two sheets covering mileages up to 9.56 miles. To get a reading, simply select the proper page for your CAS, locate the mileage to the hundredth, and read the perfect time.

Rate → Speed

Finally, we give a rather special-use table. Table 15-12 shows the exact CAS for even Rate values. Rallymasters sometimes like to assign these unusual speeds simply because they have a Rate value which is easy to use in checkpoint slip calculations. This table can also be used to find corrected speeds when executing a pause or gain over a distance.

Rate → Speed					
Min/ mile	MPH	Min/ mile	MPH	Min/ mile	MPH
60.00	1.0000	4.15	14.4578	2.30	26.0870
50.00	1.2000	4.10	14.6341	2.25	26.6666
40.00	1.5000	4.05	14.8148	2.20	27.2727
30.00	2.0000	4.00	15.0000	2.15	27.9070
20.00	3.0000	3.95	15.1899	2.10	28.5714
15.00	4.0000	3.90	15.3846	2.05	29.2683
14.00	4.2857	3.85	15.5844	2.00	30.0000
13.00	4.6154	3.80	15.7895	1.95	30.7692
12.00	5.0000	3.75	16.0000	1.90	31.5789
11.00	5.4545	3.70	16.2162	1.85	32.4324
10.00	6.0000	3.65	16.4384	1.80	33.3333
9.50	6.3158	3.60	16.6666	1.75	34.2857
9.00	6.6666	3.55	16.9014	1.70	35.2941
8.50	7.0588	3.50	17.1429	1.65	36.3636
8.00	7.5000	3.45	17.3913	1.60	37.5000
7.50	8.0000	3.40	17.6471	1.55	38.7097
7.00	8.5714	3.35	17.9104	1.50	40.0000
6.50	9.2308	3.30	18.1818	1.45	41.3793
6.00	10.0000	3.25	18.4615	1.40	42.8571
5.50	10.9090	3.20	18.7500	1.35	44.4444
5.00	12.0000	3.15	19.0476	1.30	46.1538
4.95	12.1212	3.10	19.3548	1.25	48.0000
4.90	12.2449	3.05	19.6721	1.20	50.0000
4.85	12.3711	3.00	20.0000	1.15	52.1739
4.80	12.5000	2.95	20.3390	1.10	54.5454
4.75	12.6316	2.90	20.6897	1.05	57.1429
4.70	12.7660	2.85	21.0526	1.00	60.0000
4.65	12.9032	2.80	21.4286	0.95	63.1579
4.60	13.0435	2.75	21.8181	0.90	66.6666
4.55	13.1868	2.70	22.2222	0.85	70.5882
4.50	13.3333	2.65	22.6415	0.80	75.0000
4.45	13.4831	2.60	23.0769	0.75	80.0000
4.40	13.6363	2.55	23.5294	0.70	85.7143
4.35	13.7931	2.50	24.0000	0.65	92.3077
4.30	13.9535	2.45	24.4898	0.60	100.0000
4.25	14.1176	2.40	25.0000	0.55	109.0909
4.20	14.2857	2.35	25.5319	0.50	120.0000

Table 15-12

Summary of Navigation Tables								
Author/Table Name	Type	Resolution of Result	Pgs	Size (in)	Ranges			Year
					Speed	Distance	Correction Factor	
Speed → Rate	Rate	0.001 cent	1	3.3x7.4	1→120 by 1	1 mile	-	1992
Floyd	Rate	0.1 cent	②	②	by 0.01		-	1960
Allstate	Rate	1 second	55	②	by 0.1		-	1960
Cone	Rate	0.01 cent or 0.001 cent	122	8.5x11	by 0.1		0.700→1.300 by 0.01	1967
Radford Tables I								1986
Stimson	Rate	0.1 cent	101	5.5x8.5	10.0→59.9 by 0.1		0.900→1.100 by 0.001	1970
Henderson Table III	Rate	0.1 cent	204	8.5x11	10.0→59.9 by 0.1		0.900→1.100 by 0.001	1988
Time to Travel	Time	0.001 cent	2	7.1x8.2	1→80 by 1	1→10 by 1	-	1992
Radford Tables II	Time	1 cent	61	11x8.5	5→65 by 1	0.01→6.00 by 0.01	-	1986
Reid	Time	1 second	96	5.5x8.5	12.0→59.9 by 0.1	0.1→1.0 by 0.1 1→40 by 1	-	1959
Henderson Table II	Time	0.1 cent	30	8.5x11	10.0→70.9 by 0.1	0.1→1.0 by 0.1 1→10 by 1	-	1988
Steven Plant/Easy Zero-Zombie Chart	Time	0.1 cent	②	②	②	0.01→0.99 by 0.01	-	1971
Stock Class Tables	Time	0.1 cent	63	5.5x8.5	1→66 by 1	1→10 by 1	0.900→1.100 by 0.01	1992
Rich Kamo Stock Tables	Time	0.01 cent	①	11x8.5	①	0→1by 0.01 1→10 by 0.1 11→19 by 1	①	1992
Odo Class Tables	Time	0.1 cent	280	5.5x8.5	1→70 by 1	0.01→10.30 by 0.01	-	1992

Summary of Navigation Tables

① Based on your needs.

② Unknown.

16. The Well-Dressed Car

*Louis drives a beat up '69 Dart,
swears it's the statue of Mary
keeps the car from falling apart*

— Billy Falcon, 1991

Preparing your car for the rally can be as simple as checking the oil or as complex as the extreme preparation taken on Pro Rally cars. How far you go depends largely on how dedicated you are to the sport and how many brisk or endurance events you run. Comfort on the all-night endurance event requires a bit more car preparation than comfort on the Sunday picnic rally.

Good car preparation helps in two ways: the car handles better on loose surfaces at brisk speeds, allowing you to maintain the speeds with greater safety and less effort, and you get less fatigued. Regardless of your enthusiasm at the start of an event, it is the fatigue factor which causes many of the mistakes on endurance events, and good car preparation can reduce fatigue and help you enjoy the rally.

In this Chapter, we will look at how to set up the car for comfort and safety. Areas

relating to suspension and handling will be covered in [Chapter 25](#). Also, some additional details relating to night events are mentioned in [Chapter 26](#).

The Cockpit

When you set up the cockpit of the rally car, you should primarily be thinking about comfort and safety.

The first consideration is seat position and comfort. Few rallyists are willing to go to the hassle and expense of finding the “perfect” seat. Most stick with the stock seats, relying on a few after-market additions to improve comfort.

Foot Bracing

One addition is called a “dead pedal” for the driver's left foot. The idea is that, when your left foot isn't doing anything else, it can press against a fixed pedal to the left of the clutch or brake to give you added stability. Now instead of trying to stay in the seat with your back muscles or, worse, holding onto the steering wheel, you learn to push with your left foot to press your back into the seat. Some cars have this feature built in while most other cars can be retrofitted with such a setup.

The same principle applies to the navigator. Adding a foot plate to the floor allows the navigator to get a great deal of stability just by pressing against the plate. Several manufacturers provide aluminum plates which can be installed under the carpet so that they are adjustable and removable. You can also fashion one from ½” plywood.

Cockpit Lighting

The proper interior lighting for night events is critical. You want to get all the items lighted for the navigator and driver without affecting the driver's night vision.

The driver's ability to see well at night is affected greatly by white light shining in his eyes. The negative effects last for up to 20 minutes. Pure red light has no effect on night vision, so most teams install red filters on the cockpit lights and blinders on white lights to completely shield the source and lighted areas from the driver. To be really effective, a true red filter that allows only red-wavelength light to pass through is needed. These filters can be made from red gelatin sheets or camera filters. However, this setup cuts down substantially on the amount of light coming through the lens and you will need to use a higher wattage bulb. A common red cellophane filter does not cut down the light as much, because it lets through some non-red light that affects the driver's vision, although less than a plain white light. In most cases, the cellophane filter is perfectly adequate. If you use a red filter, don't use a red pen – the red ink will be invisible!

The best way to get the right items lighted for the navigator is to use a number of smaller adjustable lights rather than one wide-angle area light. Hella produces a variety of add-on lamps with swivel heads, adjustable goosenecks of different lengths, and various mounting hardware. Their red filters are not the gelatin-type, but do filter out most of the non-red light. Another popular light is the aircraft zoom light. They have no gooseneck, but the width of the lighted area is adjustable. They are often available from aviation surplus outlets.

One neat trick is to mount an adjustable light on top of the navigator's sun visor. Many navigators like to lower the visor at night and this makes the perfect spot to mount an overhead light. It also means you don't need to remove the light to convert your car back into its street personality.

Having a lighted rally reader is a real advantage. The standard Stevens model backlights the route instructions with an even red glow. You can add a rheostat to adjust the brightness.

However you mount the interior lights, make sure they are secure enough not to bounce or flicker on bumpy roads. This can cause navigator queasiness. To test your interior lighting, go on a simulated rally or small local event at night. Be sure the navigator has white paper on their lapboard, since most route instructions are provided on white paper. Discover the problems before running that all-night here-to-the-end-of-the-universe rally.

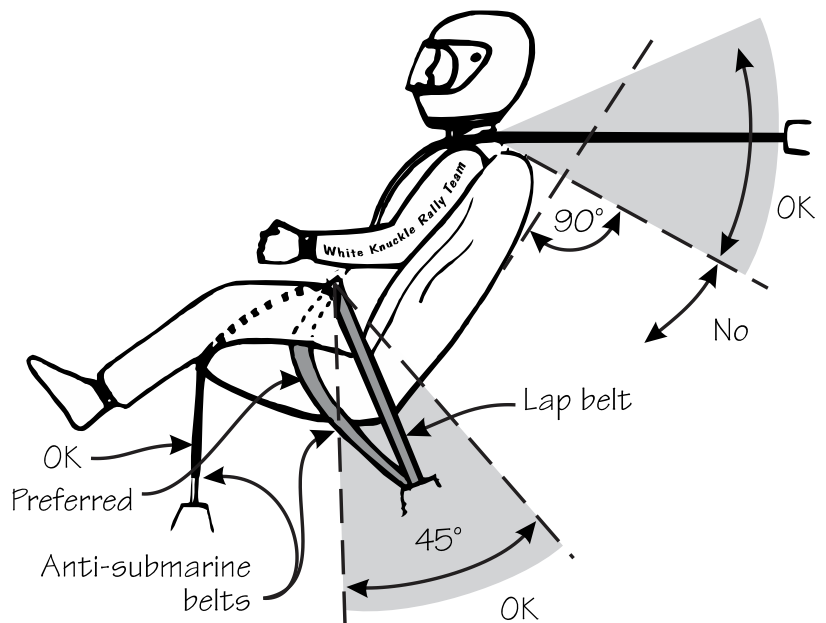
Restraints

Seat belts and harnesses serve two purposes:

- They allow the driver to maintain better control of the vehicle.
- They keep you from thrashing about in an accident or on rough roads.

The common stock seat belt/shoulder harness combination is designed only for the first case. Most are loose except in a quick deceleration situation, when they lock in place. They will not help on sharp corners and are useless in roll-over situations.

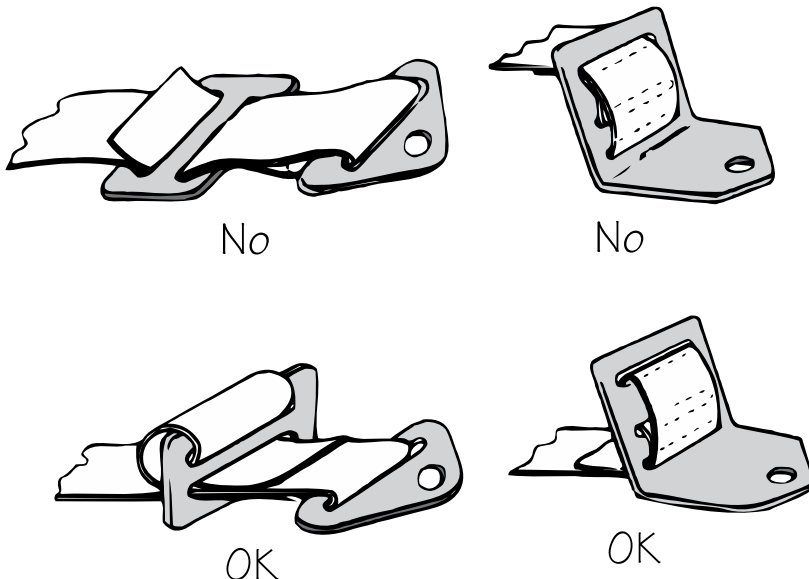
The main reason to add competition belts or harnesses is to allow you to stay in your seat without holding onto anything or using your back muscles. When the car turns, jolts, or brakes, you just lean against the harness and



Proper competition harness installation angles

keep on doing your job. If you are driving, you can still keep a light grip on the steering wheel to feel the suspension.

To be truly safe and effective, the choice of attachment points is critical. You should read the installation instructions with the add-on belts, but the key thing is the angle of the shoulder harnesses behind the shoulders. If you roll over, it is the job of the lap belt to keep you from coming up (actually, down) out of your seat. If the shoulder belt angles down behind your shoulder, you could wind up resting on your shoulder harness and get a spinal compression injury. Also, mounting the shoulder harness at a high angle puts less strain on the shoulder during normal use.



Correct buckle lacing

How you thread the belt through fittings is important. An improper thread will slip out or bend the fitting under stress. Most racing organizations such as SCCA have rule books which specify proven installation methods. You may wish to consult tech inspectors of these organizations while visiting an event!

One problem with competition belts is that they are an absolute restraint. If the radio knob is out of reach, no amount of straining is going to allow you to reach it. One excellent compromise is a harness made by Schroth, which has two modes. Applying power to the electrically driven rear mounting point for the shoulder belts makes them give like a stock inertial shoulder belt. With no power, the unit locks in place like a normal competition belt. A simple switch for each seat allows you to engage and disengage the lock feature.

The Engine Compartment

When it comes to TSD rallying, horsepower is the most overrated engine attribute, at least among people with little or no rally experience. Sure, twice as much horsepower might have gotten you a few less points last year at that “impossible” checkpoint, but how would it affect the driver's overall on-time control? Would small applications of throttle producing rapid speed changes affect the driver's ability to hold an assigned speed? Would the added weight of a larger engine impair handling in corners? Is the added horsepower going to reduce reliability?

After a few years in the sport, most rallyists look for an engine that is, above all else, dependable and predictable. This is most often satisfied by the car's stock engine, maintained with greater care than you might give the “family cruiser”. Of course, keeping the engine well maintained is the best way to preserve the horsepower rating that the engine had when it was new.

If you are purchasing a car for rally use, you might want to consider whether to get a turbocharged engine. Turbocharging gets extra power out of a given engine by compressing the air before it enters the engine. This allows more air to enter the cylinders per stroke and, when combined with more fuel, produces more horsepower. While there is little weight penalty, the internal pressures on a turbocharged engine are greater and these engines run hotter, tending to reduce reliability. Adding a skid plate underneath the oil pan of a turbocharged engine may make the engine run too hot. Also, consider that turbochargers don't provide even power. They are driven by the exhaust gasses produced by the engine and the extra power they provide tends to “lag” behind the normal acceleration, usually coming on strong above 3000 RPM. This is not the ideal situation for most TSD rally situations.

Also, consider the size of the alternator and battery system. The battery is like a reservoir which holds electric power. Appliances and lights draw current from the battery as they need it. The alternator constantly re-charges the battery while the

engine is running. If the current drawn by the appliances exceeds the current capacity of the alternator, the battery will discharge. How long it takes to discharge depends on the net current drain and the capacity of the battery.

If you are adding auxiliary external lights, you can easily exceed the capacity of the alternator. To determine how much power is being drawn, add up all the amperage ratings of your equipment. If you only have a wattage rating for a light, divide it by the voltage to get the current in amps

$$(average\ drain = \frac{wattage}{voltage}).$$

For example, adding four 100 watt driving/fog lights to a 12 volt system adds a 33 amp drain on the battery. Assume it takes 20 amps to run the car and 10 amps for other additional equipment such as cockpit lights, rally computers, clocks, and those nifty neon flashing dice hanging from your mirror. You have a night drain of 63 amps. If your alternator is rated at 45 amps, you have a net drain of 18 amps. Now say your battery is rated at 50 amp hours. It will take less than 3 hours to completely drain a fully charged battery.

In terms of maintenance, you should do it with extra diligence and care. The first several thousand miles of engine life are the most critical.

External Lighting

Many of the brisk events are run at night. Organizers consider this a safety feature – you can see oncoming cars on a back road

far more easily at night due to their headlights. From a competitive angle, good external lighting really helps to maintain a brisk CAS.

For rallyists, the idea of forward lighting is to turn night into day. Since the amount of light needed to accomplish this could easily blind oncoming drivers, most stock headlights are designed as a compromise between visibility for the driver and safety for other drivers.

You've seen them on the highway: the drivers who have not quite figured out the purpose behind high-beams and low-beams. They just run with high-beams all the time because “they can see better”. It is for those people that the stock headlight wattages, spread patterns, and aiming specifications were designed.

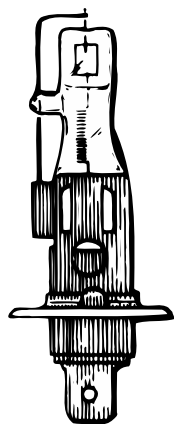
So, given that you are well aware of your responsibility not to blind other drivers, how do you turn night into day? First, you can replace your stock headlights with improved lamps. Second, you can augment your setup with auxiliary lighting. Third, you can do both.

Whatever you choose, you will likely be using lamps with replaceable bulbs rather than an “American” sealed-beam lamp. The “European” style lamp systems give you a wider choice of spread-patterns and wattages. You can then use Quartz-Iodine bulbs which are commonly known as Halogen bulbs. There are (currently) four styles of Halogen bulbs used in headlights, and each is available in a range of wattages.

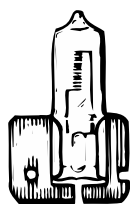
Typical sizes for each style are 55, 100, and 130 watts. The H4 style has two filaments and is used in combined high/low beam lamps. H4 bulbs come in 55/60, 55/100, 80/100, and 90/130 wattages.

One very important thing to remember about Halogen bulbs: they must be scrupulously clean when they are lit. If you touch the glass housing, even slightly, during installation, the oil from your skin will heat and cause the bulb to crack. If you do accidentally touch the bulb, clean it thoroughly with alcohol.

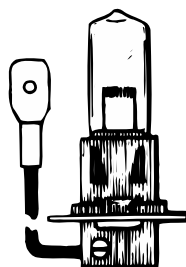
somewhat useful for illuminating a turn. A greater use is to show the road surface and the sides of the road. Since they are traditionally mounted down low, they add depth to rocks and pebbles by making highlights and shadows. In snow or fog, fog lamps may be the only lights you can use without getting a blinding reflection. Yellow lenses are popular in Europe because yellow light has the right wavelength to travel between water droplets and penetrate further in fog. I personally have not seen an advantage to yellow lenses.



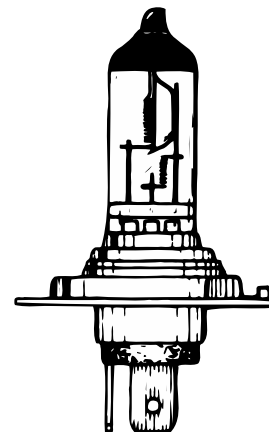
H1



H2



H3



H4

The four styles of Halogen bulbs

The configuration of add-on lamps is a matter of endless conversation and experimentation. The idea is to cover as much of the road as you need to see as far away as possible. The width of the beam thrown by a particular light is the critical issue:

- Fog lamps throw an extremely wide angle beam a very short distance. They are

- Driving lamps throw a narrow beam a greater distance. They are narrower and longer reaching than most stock high-beam headlights. This category is the best all-around lamp for rallyists. Some rallyists use four of these, rather than two driving and two fog. They mount the outside pair lower down and aim them across the front of the car towards the

opposite side of the car to illuminate into a turn.

- Pencil-beam or spot-beam lamps throw an extremely narrow beam a very great distance. They are not too useful on twisty roads, but become more of an advantage as roads get straighter and/or speeds get faster. Many pro rally competitors use these lights.

There is one issue with the short range lamps: your attention tends to focus where the light is. If you have primarily short range lamps (fogs), you will be concentrating too close to the car for anything but the slower speeds.

Another issue is the size of the bulb. Many lights come with 55 watt bulbs and some rallyists immediately replace them with 100 watt bulbs. This almost doubles the power requirement on your alternator. However, light output goes up with the logarithm of the wattage. A 100 watt bulb produces only about 15% more light than a 55 watt bulb. Even worse, the 100 watt bulbs have larger filaments. If the lamp's reflector was not designed for the larger filament, the light generated by the 100 watt bulb will not be focused correctly and will be wasted.

After you mount the lamps, aiming them is critical to get the best coverage. Position your car about 10 feet from a wall (a garage door is fine). Mark the exact location on the ground using the spot your wheels are resting on the ground. Now aim the lights, using the pattern they throw on the wall, and go out at night to test them out. Keep tweaking and experimenting. You can drive

up from 20 feet to as close as 3 feet to see how the light patterns spread. Some teams angle their two driving lights at different vertical angles. This aids in seeing up an upcoming hill and down over a crest. When you are satisfied with the setup, mark the light pattern on the wall so you can duplicate it in the future.

If your budget and alternator can handle a few extra lights, a rear red fog light is useful. In foggy conditions, this light is visible at a far greater range than regular tail lights, reducing the chances of a rear-end collision. Also, an old driving or fog light with a white lens can be mounted in the rear as a auxiliary back-up light.

Since heavy-duty lighting can be dangerous to other drivers, temporarily blinding them in the worst situation, most states outlaw non-approved lighting on vehicles. This makes for a touchy legal situation. Check your state/county laws. Most rallyists settle for a removable set of lights. Another issue is the switches used to control how the lights are dimmed. Some states require all lights except low beam headlights to be dimmed by a single switch. Other states require the dim switch to turn the fog lights on when dimming the headlights. To be legal, you would have to re-wire your lighting system at the border! Always remember: the more lighting you add, the more responsibility you bear in not blinding other drivers.

When you install a set of external lights, each light or pair of lights must have a separate relay and fuse. The relay allows the

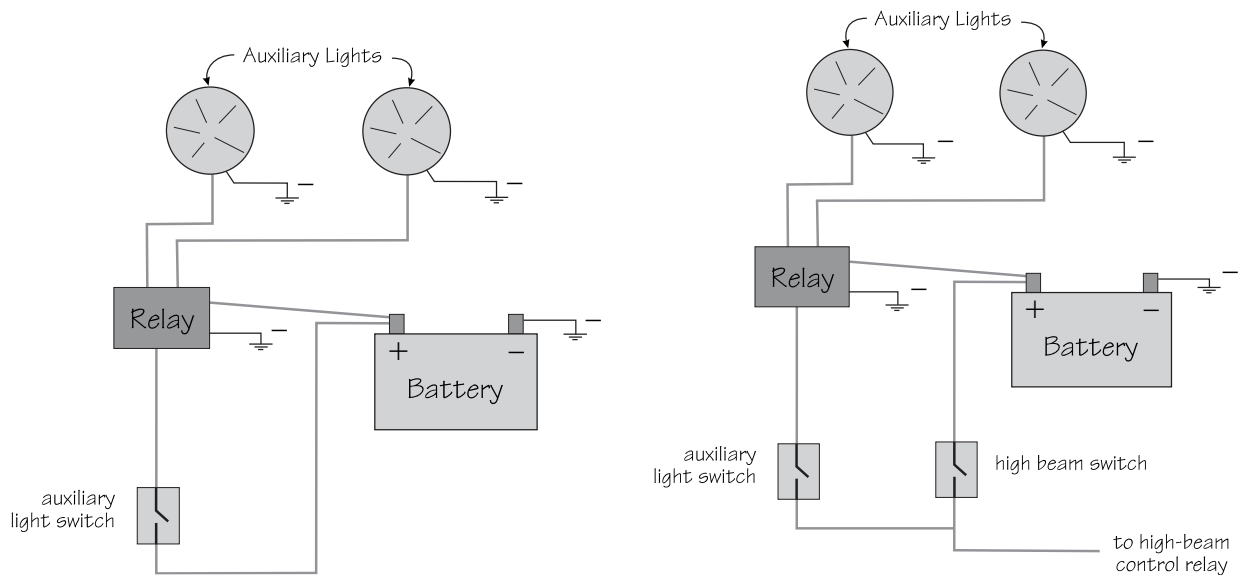


Figure 16-1

on-off switch for the light and the power to the light itself to be on different circuits. This is a must. Without a relay, the high current draw of the light must be matched by the switch.

The left half of Figure 16-1 shows a setup which makes the auxiliary light independent of any other circuit. The single switch controls the auxiliary light. We started out this way, with a single switch for the driving lights, a switch for the fogs, and the normal setup for the high-beam/low-beam headlights.

There were several problems: it was illegal and we had to fiddle with three switches when we encountered oncoming traffic or a checkpoint at night.

The improved setup shown in the right half of Figure 16-1 (designed by Matt Murray) incorporates the high-beam switch. Now the auxiliary lights are lit when you have your auxiliary switch on and the high-beams are

lit. The high beam switch dims the headlights as well as dousing the auxiliary lights. The high beam circuit can usually be found by tapping into wires on the steering column.

Windshield Care

Another area which deserves added care when you set up a rally car is the windshield. Maintaining your windshield generally means three things: keeping it clean, reducing the impact of rain, and minimizing fogging.

A clean windshield starts before the event by removing everything: dirt, grease, and old applications of windshield products. This is best done with one of the commercial windshield care solutions or sprays which are high in ammonia. Really tough deposits of sap, adhesive, etc., might require a solvent such as Carbona.

One problem with cleaning your windshield in this way is that, under some conditions, your windshield may actually look worse after you clean it. The tiny pits that have accumulated over time will be more noticeable in the sun after the oil has been stripped from them. However, this minor annoyance is more than made up at night by a lack of distracting halos.

Keeping the windshield clean during an event is a matter of windshield wipers and washer fluid. There are a few tricks with windshield wipers to maximize their effectiveness:

- Avoid using the “sport” double windshield wipers. The effectiveness of a wiper is related to how much pressure it has on the windshield. The double wiper cuts the pressure on each blade in half.
- In winter, try to find the special cold-weather wipers which have their skeleton enclosed. This reduces the build-up of slush/ice in the pivot points at temperatures near freezing and allows the blade to flex and conform to the curves of the windshield.
- If your wipers start to streak, first try cleaning the blades with soap and water. Then try alcohol. If those methods fail, try lightly sanding the blade with a “V” of very fine sandpaper. This may cut down on the grooves making the streaks. At worst, you will destroy the blade which was in need of replacement anyway.

Rain can have a big effect on your visibility. An excellent product which improves your visibility is Rain-X. Available in auto-parts stores, this solution disperses rain on your windshield the way wax disperses rain on your car body.

Keeping your windshield clear of fog may seem to be a minor priority until you get a bad case of the hazies on a performance event.

There We Were²⁴ on the Jersey Bounce, a brisk night event run in the Pine Barren lands of Southern New Jersey. Things turned sour when the inside of our windshield started fogging relentlessly. I was wiping furiously with one hand, throwing defroster switches with the other, and trying to calculate in my head. Vera had taken to driving with her head out the window while I was desperately trying to think of something to do to stop the windshield from fogging. Something had to be done to prevent the mist from clinging within seconds of every wipe.

Then Yours Truly was struck by the most absurd idea I have ever had in my life. We had several slices of greasy pepperoni pizza in the back seat left over from dinner. Wouldn't the oil stop the fog from forming? The answer was: Yes. The fog was replaced by a swath of white grease as I smeared the pizza from right to left. Our vision was completely blocked and the two pieces of pepperoni that were stuck to the windshield underscored the

²⁴ A true story.

absurdity. This forced an immediate stop – not from the fog/grease but because we were both laughing uncontrollably.

While episodes as severe as this one are rare, windshield fog can be annoying and dangerous. To control the problem, it helps to understand what makes fog and dew. Air always carries some moisture and the relative humidity is a measure of how much. When the relative humidity gets to 100%, the air is fully saturated with moisture. The moisture falls out of the air as fog, dew, mist, or rain.

How does the air get saturated? You can add moisture or you can cool it. Cool air holds less moisture than warm air. Cooling 80°F air with 80% relative humidity to 73°F will make it 100% saturated.

Our problem on the Jersey Bounce was that we were running the heater and the windshield was cold from the outside air. The heater took in the moist air from inside the car and sent it out the defroster vents onto the inside of the windshield. The warm moist air was cooled by the windshield and immediately formed fog.

Armed with this knowledge, you can see what causes as well as fixes fogging problems. If the outside air is warm and moist, you will get fog on the outside by cooling the windshield. Air conditioning routed through the defroster vents will cause outside fog under these conditions. If the window fogs on the inside, you need to get warm, dry air onto the inside of the windshield. Since the air conditioner

removes moisture from the air, running both the air conditioner and the heater on maximum at the same time is often an excellent cure.

Finally, there are some products which you can apply to the inside of your windshield to retard fog. If you have a weak defroster system and/or no air conditioner, try Anti-Fog, which was developed by the same folks who invented Rain-X.

Protection

If you run lots of brisk events on unpaved roads, things begin to happen to the bottom of your car. “Things” include caked mud, abrasions from stones, and dents from bulging rocks. Although the mud may seem the least serious, it can cause extensive rust if it stays semi-moist on a permanent basis. This can freeze the nuts and bolts of your suspension system.

To prevent these problems, some people raise the car's suspension to get more ground clearance. These issues are discussed in Chapter 25.

Adding protection to the bottom of the car is another approach. The first thing many people add is a skid plate covering the oil pan. After all, if you puncture or rip off the oil pan, you are out of the event and possibly out an engine. The skid plate must be sturdy enough and mounted so that the full weight of the car slamming into the plate will not damage the car. This means that you can use it to jack up that end of the car!

If your differential protrudes down far enough, you may also want a skid plate there to prevent it from being ripped out.

Another approach is to line the bottom of the car with a shielding to protect it from mud and rocks. Rather than covering the entire bottom of the car, you might just want to protect critical areas such as fuel lines and pumps, brake lines, transducer cables, and low areas. You should also consider mud flaps. Check with shops which specialize in modifying cars for Pro Rally for suggestions on how to do this.

The Rally Box

We used to spend time before each rally tossing all the things we ever needed during an event into the trunk. We would always forget something. So we finally got smart and packed a “rally box” with almost everything we needed for a typical event, and a note on the outside reminding us of other items (such as food). Our rally box includes:

- A towel (sage advice from Douglas Adams – see quote at the start of Chapter 3).
- *TSD Road Rally Pocket Reference*.
- Navigation equipment – tables, Stevens wheel, calculator, whatever.
- Checklists and logsheets.
- Time radio.
- Scotch tape, for taping route instructions together.
- Pens and highlighters.
- Clipboard or lapboard.
- Batteries for your calculators, if you use them.
- The Regs. Even if you've memorized them, take a copy along.
- Flashlights and cockpit lights. We always carry these. You never know when the day rally will go till 9 PM due to a last-minute course diversion (spare bulbs and batteries are in the parts box below).
- Stapler. Great for (re-)organizing the stacks of paper you get at some events. You can try the mini-sized one, but they don't work so well and replacement staples may be difficult to find. I settled for a shortened version of the normal desktop stapler.
- Backup watch. It never hurts to have too much time.
- OK sign. This item gets put at the bottom of the clipboard. It has the large letters “OK” on one side and a large red cross on the other. If we have a problem, navigational, timing, mechanical, gastrointestinal, or otherwise, putting OK in our window stops other rallyists from having to ask us if we need assistance and possibly disrupting the leg. Of course, a real problem would call for the red cross.
- Tire pressure gauge.
- Anti-fogging cloth. These have a special chemical which retards fogging.
- Post-Its.
- Camera & film.
- Duct tape. Also called gaffer's tape, racer's tape, and 100 mph tape, this substance is amazingly versatile. It will hold almost

anything to anything else, on a temporary basis. On the negative side, it can peel off a layer of paint and the glue residue is difficult to remove. Many commercial solvents will remove it, but you have to make sure they don't destroy the finish underneath. Some off-the-shelf solvents you might experiment with are Carbona, Williams Letric Shave, WD-40, bug and tar remover, and plain rubbing alcohol.

- Electrical tape.
- Drugs. The medicine chest includes No-Doz, Scopolamine patches, and Bonine. We also carry a first-aid kit.
- Spare car number material. In case our car number falls off or the organizers run out (it has happened!).
- Tools. A small bag with some small tools which come in handy in many situations. Our bag includes:
 - ▶ miniature crescent wrench
 - ▶ a selection of allen wrenches
 - ▶ miniature vice grips
 - ▶ various screwdrivers, including tiny ones
 - ▶ soldering iron (solder in the parts box below)
 - ▶ needle-nose pliers
 - ▶ wire stripper and cutter
 - ▶ razor in a holder
 - ▶ nylon ties
 - ▶ Krazy Glue
 - ▶ piano wire
 - ▶ set of $\frac{3}{8}$ " sockets and ratchet
 - ▶ small triangular file.
- Parts box. We keep a closable plastic box with 2" × 1.7" × 1.5" compartments to

hold small electrical and mechanical parts. Our box includes:

- ▶ solder
 - ▶ electrical crimp terminal and wire nuts
 - ▶ assorted small switches and connectors
 - ▶ washers (metal and rubber)
 - ▶ assorted small bolts
 - ▶ screws and nails
 - ▶ spare lug nuts
 - ▶ extra staples
 - ▶ spare light bulbs for cockpit lights, turn signals, backup lights, brake lights, and auxiliary driving lights
 - ▶ 4 fuses of each type in the car
 - ▶ rubber bands, and
 - ▶ assorted hose clamps.
- Flares. One is always available to the navigator, with 3 more in the trunk. The navigator can then hop out immediately and place a flare if you are disabled. Use caution in forests not to start a fire. Some organizers explicitly prohibit the use of flares in certain events.
 - Triangle. This is a folded reflective triangle which pops up to warn oncoming cars of a blockage. We carry three. In a road block situation, you want to place them very very far behind the vehicle, far further than you would think when standing on the road.

Items we always carry in the trunk:

- Extra oil, a funnel and, if needed, a can opener.
- Brake and hydraulic fluid.
- Jumper cables.
- Spare windshield wipers.

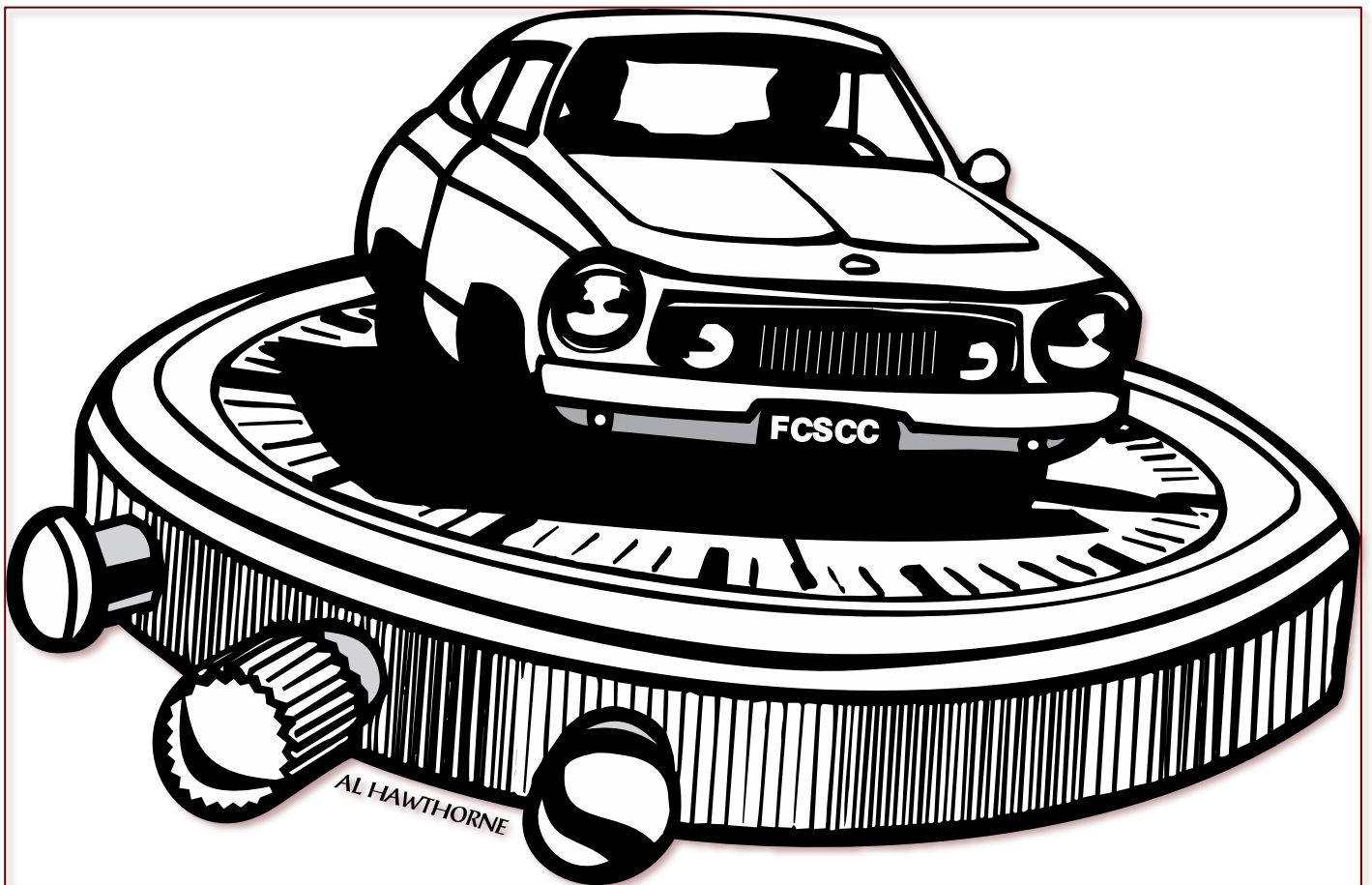
- Windshield washer fluid.
- Tow rope.
- Fire extinguisher. Many teams mount a fire extinguisher in the car so that it is accessible to both the driver and navigator. If you choose to have a fire extinguisher in the passenger compartment, make sure that its mounting is extremely secure.
- Jack.
- Rain gear.
- Breaker bar. A long-armed ½” drive socket wrench with a deep-throw socket which fits our lug nuts.
- Torque wrench. A ½” wrench which measures torque for properly re-installing wheel lug nuts.
- Spare tire(s). The donut spare which came with your car goes straight to the trash. The spare should preferably be the same make and size as the other tires, inflated to the same pressure.
- First-aid kit.
- A blanket.
- Toilet paper. One never knows!

Other items we make sure to take along are:

- License (driver and navigator), car registration, and insurance card.
- Food and drink. We tend to get famished three legs into most events. We tried donuts, but the mess and the sugar high were usually good for a blown leg or two. The best food we have yet found: grapes. They are self-packaged, rarely messy, and are not (as yet) environmentally unsound.

Another favorite: gorp – ⅓ raisins, ⅓ peanuts, and ⅓ M&Ms (no fair picking out the M&Ms).

Part 4 – Rally Navigation



17. More Navigation Basics

Deb, will you marry me?

— Ric Golen,
Leg 2, 1989 Covered Bridge Rally

*OK, we'll get married ... you're down 5
and you just missed your left!*

— Deb Golen,
Leg 2, 1989 Covered Bridge Rally

Try describing, to a person who has never done it, the simple task of tying your shoelaces. Write out a step-by-step procedure for them and you will induce befuddlement, feelings of inadequacy, and a run on loafers at the local shoe store.

Something similar happens when Novices begin reading about one of the advanced navigation strategies in this part of the book. However, as with shoelaces, the details are far simpler than they sound on paper.

The key is the “bit of practice” part – no team will nail down all the aspects of a new strategy their first time out. Most teams will not feel really comfortable until five or ten events have been run.

So, when you try a new class or navigation strategy, be patient. Sit down and try to understand the basics of the strategy and avoid getting overwhelmed in the details. Then give it some time.

More Useful Formulas

There are several formulas and tricks which are not part of any specific strategy, but occasionally come in handy in almost any strategy.

Speed Differences

The first has to do with differences between speeds. Say you are zooming along in Computer Class and suddenly discover you have the wrong speed in the A-Box. Arrggh!

Formula 17. *Timing Error*

$$\frac{CAS - \text{Actual speed}}{CAS} \times \text{Time} \rightarrow \text{Timing error}$$

How much time are we off? Formula 17 is the general formula for error, given two speeds and an amount of time:

This turns out to be an incredibly useful formula in navigation strategies based primarily on time rather than on distance. Notice that the CAS + 10%, 20%, ... rules given in [Chapter 6](#)) are special cases of this general formula.

There is another way to calculate timing error: to get the difference in time between two speeds, subtract their rates. Say we wanted 40 mph but had 48 in the box. The rate for 40 mph is 1.5 min/mile and the rate for 48 mph is 1.25 min/mile. The difference is 0.25 minutes per mile traveled. Simply change to the correct speed after a while number of miles have elapsed and add 0.25 minutes to the computed time for each mile traveled.

Hammond's Rule

Another neat trick I call **Hammond's Rule of 60s**: Every 60 cents/36 seconds you should travel $\frac{CAS}{100}$ miles. Every 6 minutes you should travel $\frac{CAS}{10}$ miles.

This rule is useful in many places. Say you are using a Stevens wheel to convert miles into time. After the 10 minute mark, the resolution of the Stevens goes down

considerably. So, when $\frac{CAS}{10}$ miles comes up, simply reset your interval odometer, adding 6 minutes to all subsequent time readings.

Hammond's Rule can be used to eliminate tables or calculators altogether! Simply give readings at 0.60, 1.20, 1.80, 2.40, ... minutes since the last speed change. Each time, add your CAS divided by 100 to the running interval total to get the perfect mileage at the next 0.60 step.

Pause Equivalents

Some events frequently use instructions like the following to deal with extreme curves or dangerous road conditions:

29. "Slow Children". CAS 23 for 0.10 mile.

One handy thing you can do in some navigation strategies is to convert these instructions into pauses. This is far better than doing two CAS changes in a tenth of a mile. For example, if the base CAS in the above instruction was 40, a pause of 11 would be in order.

The general formula for converting a CAS over distance into its equivalent pause is:

Formula 18. Pause Equivalent

$$\frac{Distance \times 60}{Temporary\ CAS} - \frac{Distance \times 60}{Base\ CAS} \rightarrow Pause\ equivalent$$

There are several issues with this technique:

- The pause is not likely to work out to an even cent. In a class which requires a high degree of precision, rounding to the nearest cent may not be precise enough.
- If the base CAS changes after you calculate

The following is the equivalent formula which can be done directly on a calculator:

Formula 18A. *Pause Equivalent*

$$\frac{(Base\ CAS - Temporary\ CAS) \times Distance \times 60}{Base\ CAS \times Temporary\ CAS} \rightarrow Pause\ equivalent$$

the Pause Equivalent Formula, you must recalculate the pause equivalent. This can happen if the CAS is changed at an open checkpoint after you have already calculated the pause equivalent.

- Formula 18 cannot be done directly on a calculator without a memory. You must write down the number you get from the expression on the left side of the '-' before calculating the expression on the right side of the '-'.

Conversion Factors

The tables in this section give you conversion factors from one unit of measure to another. See [Notation and Precision](#) for a description of the superscripted bar notation used in these tables.

To convert from unit A to unit B:

- Find where column A meets row B.

By \ To get		Distance Conversion - Multiply								
		mm	cm	inch	foot	yard	meter	km	mile	N. mile
	mm	1	10	25.400	304.80	914.40	1000	1000000	1609347	1852000
	cm	0.1	1	2.5400	30.480	91.440	100	100000	160935	185200
	inch	0.03937	0.3937	1	12	36	39.37	39370	63360	72913
	foot	0.0032808	0.032808	0.0833	1	3	3.28083	3280.83	5280	6076.1
	yard	0.0010936	0.010936	0.0277	0.33	1	1.09361	1093.61	1760	2025.4
	meter	0.001	0.01	0.0254	0.30480	0.91440	1	1000	1609.35	1852
	km	0.000001	0.00001	0.0 ⁴ 2540	0.0 ³ 3048	0.00091440	0.001	1	1.60935	1.852
	mile	0.0 ⁶ 62137	0.0 ⁵ 62137	0.0 ⁴ 15782	0.0 ³ 1893	0.0005681	0.00062137	0.62137	1	1.15078
	N. mile	0.0 ⁶ 53996	0.0 ⁵ 53996	0.0 ⁴ 13715	0.0 ³ 16458	0.00049373	0.00053996	0.53996	0.86898	1

- Take the conversion factor where they meet and multiply A units by the conversion factor to get B units.

If not exact, all conversion factors are rounded off to the least significant digit shown.

Distance

- Measures of inch, foot, yard, and mile are US measures.
- N. mile is International Nautical Mile (1/60 degree of latitude)

Speed

- A knot is a Nautical Mile per hour.

By \ To get		Speed Conversion - Multiply				
		mph	kph	knots	ft/sec	m/sec
To get	mph	1	0.62137	1.15078	0.68181	2.23694
	kph	1.60934	1	1.852	1.09728	3.6
	knots	0.86898	0.53996	1	0.59248	1.94384
	ft/sec	1.466	0.91134	1.68781	1	3.28084
	m/sec	0.44704	0.277	0.5144	0.3048	1

distance from a restart point. This skill is also useful at Monte Carlo checkpoints where you know the perfect time at the checkpoint, but may have to judge the remaining distance in order to arrive on time.

One good technique is to use car lengths as a guide – visualizing a string of bumper-to-bumper cars marking off distance. Using an average of 14 feet for car lengths, you get 3.8 cars per hundredth, or 15 cars every 4 hundredths. In practice, most people tend to over-estimate the distance in hundredths, so you might use a measure of 3 car lengths per hundredth to compensate.

If you have access to a car with a precision odometer, measure out 10 hundredths from a turn, dropping a small rock at each hundredth. Look back and get a mental picture of the distances. Then try dropping rocks at another turn and use the odometer to see how close you came.

Time

- A cent is 1/100 of a minute; a *mil* is 1/1000 of a minute.

Judging Distance

One useful skill in the advanced classes is the ability to judge distance accurately. This is especially important in running Speedo Class, when estimating your

By \ To get		Time Conversion - Multiply				
		mil	cent	sec	min	hour
To get	mil	1	10	16.66	1000	60000
	cent	0.1	1	1.66	100	6000
	second	0.06	0.60	1	60	3600
	minute	0.001	0.01	0.0166	1	60
	hour	0.0 ⁴ 166	0.000166	0.000277	0.0166	1

Formula 19. *Emergency Speeds*

$$\frac{\text{Old Speed}}{1 + (\text{Increase}\% / 100)} \rightarrow \text{New Speed}$$

Emergency Speeds

Table 17-1 is useful for determining a corrected CAS when given an instruction such as *Increase leg time by 20%*. These situations often arise in an emergency situation or conditions of bad road conditions or weather.

For example, increasing the leg time by 10% involves multiplying speeds by $\frac{1}{1.10}$ or 0.90909.

Aside from adjusting speeds, you must remember to increase all pauses, transit zones, and gains. Be aware that the times of all gains are increased in these situations (see [Chapter 28](#) regarding traps).

Practice Runs

One interesting thing you can do to improve your scores is to set up a practice run. This is simply a short rally course that you design for your own use. There are many uses for such a course:

- You can run it from time to time as a warm-up before a big event or as a shakedown before the first event of the season.
- You can test out new equipment or a new navigation strategy.

- You can use it to re-calibrate your odometer or speedometer.
- You can show your friends what a rally is all about.
- You will get experience in what it takes to set up a rally course.

Simply lay out a course close to home, with a (very) short odometer check and instructions typical of the events you run. Have it measured precisely and you can calculate perfect times to landmarks along the course for use as pseudo-checkpoints.

Rabbit Runs

A Rabbit Run is a very useful variation on the practice run. Developed by Ev Newton, the idea of a Rabbit Run is for the driver to learn speed control without any calculations from the navigator.

To set one up, lay out a basic course and produce two sets of route instructions. The driver's routes simply have course following and timing (CAS, pause) instructions. The navigator's route instructions have lots of additional landmarks, together with the perfect time of passage (key time) for each landmark. The times assume a start at the top of the hour.

Before each run, you pick a start minute and the navigator goes down and adds that minute to each key time. Then, as you travel around the course, the navigator can easily

give an up/down reading by comparing the perfect and actual times at each landmark. The driver quickly learns how much time is lost in each turn and what it takes to get back on time. After numerous runs, the driver should be able to stay on time with virtually no readings.

You can vary the game by having several sets of route instructions with different speed settings and changing the pause times. Try throwing in a gain. See what happens when the driver compensates for slow traffic.

Emergency Speed Reductions							
CAS	10%	20%	30%	CAS	10%	20%	30%
1	0.9090	0.8333	0.7692	41	37.2727	34.1666	31.5385
2	1.8181	1.6666	1.5385	42	38.1818	35.0000	32.3077
3	2.7272	2.5000	2.3077	43	39.0909	35.8333	33.0769
4	3.6363	3.3333	3.0769	44	40.0000	36.6666	33.8462
5	4.5454	4.1666	3.8462	45	40.9090	37.5000	34.6154
6	5.4545	5.0000	4.6154	46	41.8181	38.3333	35.3846
7	6.3636	5.8333	5.3846	47	42.7272	39.1666	36.1538
8	7.2727	6.6666	6.1538	48	43.6363	40.0000	36.9231
9	8.1818	7.5000	6.9231	49	44.5454	40.8333	37.6923
10	9.0909	8.3333	7.6923	50	45.4545	41.6666	38.4615
11	10.0000	9.1666	8.4615	51	46.3636	42.5000	39.2308
12	10.9090	10.0000	9.2308	52	47.2727	43.3333	40.0000
13	11.8181	10.8333	10.0000	53	48.1818	44.1666	40.7692
14	12.7272	11.6666	10.7692	54	49.0909	45.0000	41.5385
15	13.6363	12.5000	11.5385	55	50.0000	45.8333	42.3077
16	14.5454	13.3333	12.3077	56	50.9090	46.6666	43.0769
17	15.4545	14.1666	13.0769	57	51.8181	47.5000	43.8462
18	16.3636	15.0000	13.8462	58	52.7272	48.3333	44.6154
19	17.2727	15.8333	14.6154	59	53.6363	49.1666	45.3846
20	18.1818	16.6666	15.3846	60	54.5454	50.0000	46.1538
21	19.0909	17.5000	16.1538	61	55.4545	50.8333	46.9231
22	20.0000	18.3333	16.9231	62	56.3636	51.6666	47.6923
23	20.9090	19.1666	17.6923	63	57.2727	52.5000	48.4615
24	21.8181	20.0000	18.4615	64	58.1818	53.3333	49.2308
25	22.7272	20.8333	19.2308	65	59.0909	54.1666	50.0000
26	23.6363	21.6666	20.0000	66	60.0000	55.0000	50.7692
27	24.5454	22.5000	20.7692	67	60.9090	55.8333	51.5385
28	25.4545	23.3333	21.5385	68	61.8181	56.6666	52.3077
29	26.3636	24.1666	22.3077	69	62.7272	57.5000	53.0769
30	27.2727	25.0000	23.0769	70	63.6363	58.3333	53.8462
31	28.1818	25.8333	23.8462	71	64.5454	59.1666	54.6154
32	29.0909	26.6666	24.6154	72	65.4545	60.0000	55.3846
33	30.0000	27.5000	25.3846	73	66.3636	60.8333	56.1538
34	30.9090	28.3333	26.1538	74	67.2727	61.6666	56.9231
35	31.8181	29.1666	26.9231	75	68.1818	62.5000	57.6923
36	32.7272	30.0000	27.6923	76	69.0909	63.3333	58.4615
37	33.6363	30.8333	28.4615	77	70.0000	64.1666	59.2308
38	34.5454	31.6666	29.2308	78	70.9090	65.0000	60.0000
39	35.4545	32.5000	30.0000	79	71.8181	65.8333	60.7692
40	36.3636	33.3333	30.7692	80	72.7272	66.6666	61.5385

Table 17-1

18. Stock Class Navigation

*Well I'm on my way
I don't know where I'm going
I'm on my way I'm taking my time
But I don't know where*

— Paul Simon, 1971

This chapter expands on the Basic Navigation Strategy developed in Chapters 4, 5, and 6. We will develop a Stock Class Navigation Strategy which can be applied to one of the advanced classes (probably called Class C or SOP in most areas).

When we discussed the Curta calculator in [Chapter 14](#), we outlined most of the elements of a navigation strategy using the Curta and a stock odometer. However, few areas allow use of a cumulative calculator such as the Curta in Stock Class. So, the strategy described in this chapter assumes that you are allowed use of the stock odometer and speedometer as well as a rally clock and a Stevens wheel or a set of tables. No cumulative calculators are needed.

In order to improve your scores over the Basic Navigation Strategy, we will be eliminating the major inaccuracies in that strategy. However, in doing so, the

navigator will be busier doing calculations during the event. We are assuming the driver is better at staying on course than when you ran in Novice Class!

The Concept

The biggest flaw in the Basic Navigation Strategy is that it is non-cumulative. There is no overall accumulated calculation of how early or late you are running in the Basic Strategy. Any error or inaccuracy at any point goes undetected until you get to the checkpoint.

To correct this flaw and make the Stock Navigation Strategy cumulative, we will be making use of the stock odometer. The navigator will come up with a calculated odometer reading from time to time. The **calculated odometer** is the odometer reading for an on-time car at a given point in time. You simply compare it against your actual car odometer to see if you are early or late. Alternately, you can compare your time when you reach the calculated odometer with the perfect time in order to get a reading. Either way, the reading will uncover the sum of all the errors you have made up to that point. In order to accomplish this feat, we will introduce a

navigation log on which the navigator's calculations can be accumulated.

This navigation strategy uses the following equipment:

Stock speedometer. While maintaining the proper speed is still important, it is far less critical than in the Basic (or Speedo) Navigation Strategies. Any error in the speed will be caught by the cumulative calculations, so precise speedometer calibration is not necessary.

Stock odometer. This is the main instrument used to get low scores in this strategy. Because of this, you should read the section in [Chapter 10](#) on stock odometers before jumping into this strategy. Ideally, you should have a mechanical odometer which reads in tenths of a mile and is reasonably visible to the driver and navigator under all light conditions. Electronic stock odometers will make approximations of the hundredths very difficult – the system is still workable but may not get you top placings in this class. If your car odometer does not read tenths, get another car or run another class!

Stevens Wheel. We will use this versatile tool for developing correction factors, giving readings, and producing cumulative calculations. You should be familiar with The Stevens as described in [Chapter 14](#). As an alternative to the Stevens, you could use Stock navigation tables such as Table 15-9 or 15-10.

Timing Log. This is for keeping track of the navigator's calculations, which will be

converted periodically into a calculated odometer.

Precision decimal clock. Other than the features to set it properly, it needs a single split feature.

The goal of this strategy is to attain the best scores, limited only by the degree of resolution of the stock odometer. Since these can usually be read to within ± 0.01 mile with practice, scores averaging 1 point per competitive mile are attainable. We have done as well as 5 points on a 6-leg brisk rally using this strategy (and placed third!).

Before the Start

After receiving the route instructions, the team can pre-calculate perfect times as described in Chapter 5. This will be important not so much to reduce the workload during the event but to improve accuracy when possible. Of course, without a calculator, you will have to use the tables, Stevens wheel, or whatever method you use to get perfect times given Speed and Distance.

Because we are doing cumulative calculations, some of the calculations done for the Basic Strategy are not as important in Stock Class. Computing averaged pauses over a distance and gains may be useful, but are not critical. However, pre-calculating pause equivalents for a CAS given for a short distance is very useful.

The Odometer Check

As you pull up to the start, you can zero your trip odometer or simply note the reading, interpolating the hundredths digit carefully. Zeroing the trip odometer (see [Chapter 10](#) for the best way to do this) should only be done if you know the odometer lag characteristics of your trip odometer very well. Many teams simply never zero their trip odometer.

As you run the odometer check, record the car odometer at several points where you are given an official mileage. You can record these readings directly on your route instructions.

At the end of the odometer check, pull up to the line and read the odometer, approximating the hundredths digit very carefully. After recording this reading on your route instructions next to the official mileage for that instruction, pull ahead a short distance. Then:

- Calculate a correction factor using your Stevens as described in [Chapter 14](#). After you have locked the M and E pointers together, move the M pointer around to other official mileages in the odometer check and verify that E agrees with your car mileage taken at each of those locations.
- Change any official mileages in the upcoming portions of the route instructions to the car mileage you expect at that point, based on your odometer at the end of the odometer check and your correction factor.

- Set up your timing log for the first leg and set the Stevens wheel for the first CAS (M on CAS, T on 60, lock down the thumbscrew).
- Finally, calculate a perfect time 0.20 mile from the start of the leg to get set to give an early reading.

The Log

The purpose of the navigation log is to provide an organized worksheet for keeping track of the cumulative calculations. It is arranged very carefully to minimize the steps required to handle the common situations such as CAS changes, Pauses, and Transit Zones.

- The first column is simply to record your assigned CAS.
- The second column keeps track of your car mileage at the start of a leg, CAS changes, Begin and End Transit Zone points, and at the checkpoints.

<u>Stock Navigation Log Sheet</u>				Leg: _____
<u>CAS</u>	<u>CM</u>	<u>ΔCM</u>	<u>Calc Time</u>	<u>Actual Time</u>
	____.____		____:____.____ (start)	
_____		____.____	+ ____.____	
	____.____		____.____	____.____
_____		____.____	+ ____.____	
	____.____		____.____	____.____
_____		____.____	+ ____.____	
			< is Late	

- The ΔCM column holds the Delta Car Mileage between two Car Mileage readings.
- The Calc Time column provides a running Calculated Time.
- Finally, the Actual Time column is a place to record your actual arrival time at each point where you have an entry in the log.

As you gain experience, you can streamline your logsheet to eliminate unneeded detail. Some experienced navigators just use a blank sheet of paper with a column or two of numbers.

Running a Leg

Before we get into the details of running a leg, a word of caution about using the Stevens: it is very easy to mix up the M and E pointers in this strategy. Remember to use M for official mileages and CAS assignments and E for car mileages and corrected car speed. You might want to tape an “official” label on M and a “car” label on E.

To see how the strategy works, we will use some sample instructions:

0.00	1. Begin at Key Time 11:00.00. CAS 36.
	2. Left at T. CAS 28.
	3. Right at Stop. Pause 30.
	4. Left onto Warthog Road. CAS 42.

Assume you are car 17, so the Key Time in NRI 1 is 11:17.00 for you. Also assume your car correction factor is 1.05 (our car mileage reads 5% above official mileages) and that the odometer is not zeroed (due to odometer lag) and reads 12.90. To begin a leg, enter your start time at the top of the Calc Time column, the car odometer at the start point at the top of the CM column, and your first CAS in the first column. Then start your run the same way you did in the Basic Navigation Strategy (see [Chapter 6](#), “Getting

Up to Speed”). At the start of the leg, your log looks like this:

<u>Stock Navigation Log Sheet</u>				Leg: <u>9</u>
<u>CAS</u>	<u>CM</u>	<u>ΔCM</u>	<u>Calc Time</u>	<u>Actual Time</u>
	<u>12.90</u>		<u>11:17.00</u> (start)	
<u>36</u>		—:—	+ —:—	
	—:—		—:—	—:—
—		—:—	+ —:—	
	—:—		—:—	—:—
—		—:—	+ —:—	
				< is Late

NRI

In the Basic Strategy, you noted the time at every NRI. This allowed you to come back later and take a time allowance, if needed.

In this strategy, noting the car mileage is more useful. The car mileage allows you to compute the perfect time to the instruction, if a time allowance is needed later.

CAS Change

At the action point of NRI 2, you need to get the odometer (car) mileage and time at the turn. The driver is usually the one who reads the odometer, to avoid issues of parallax. The navigator:

- Splits the clock at the action point.
- Records the odometer in the next available CM slot and records the split time display in the Actual Time slot on the same line.
- Unsplits the clock.

The log might look like this:

<u>Stock Navigation Log Sheet</u>				Leg: <u>9</u>
<u>CAS</u>	<u>CM</u>	<u>ΔCM</u>	<u>Calc Time</u>	<u>Actual Time</u>
	<u>12.90</u>		<u>11:17.00</u> (start)	
<u>36</u>		—.—	+ —.—	
	<u>14.73</u>		—.—	<u>20.12</u>
—		—.—	+ —.—	
	—.—		—.—	—.—
—		—.—	+ —.—	

< is Late

Now the navigator calculates the perfect time they should have done the speed change:

- Figure out the entry for Δ CM (Delta Car Miles) by subtracting the last two CM entries.
- Use the Stevens (which should already have the proper CAS set with M on the CAS and T on 60) to compute the calculated time for that Δ CM: Place E on the Δ CM (1.83 miles) and read the time off T (3.05 minutes). Enter that time in the Calc Time column next to Δ CM.
- Add the Calc Time column to come up with the calculated time you should have executed that instruction.
- Set the Stevens for the next speed.

Your log now looks like this:

Otherwise, you were early. The note “< is Late” at the bottom of the log reminds you which way the comparison goes. In our example, the navigator would call out “Seven late at the turn”.

If you happen to have a perfect time for an interval, enter that perfect time in the Calc Time column rather than the time computed from your odometer. Otherwise, everything else remains the same.

Pauses and Gains

To handle a pause, such as in NRI 3:

- Add a new line with 0.30 as the Calc Time and add it into the overall Calc Time.
- Check off the pause on the route instructions immediately after it has been entered in the log.

<u>Stock Navigation Log Sheet</u>					Leg: <u>9</u>
<u>CAS</u>	<u>CM</u>	<u>ΔCM</u>	<u>Calc Time</u>	<u>Actual Time</u>	
	<u>12.90</u>		<u>11: 17.00</u> (start)		
<u>36</u>		<u>1.83</u>	+ <u>3.05</u>		
	<u>14.73</u>		<u>20.05</u>	<u>20.12</u>	
—		—.	+ —.		
	—.		—.	—.	
—		—.	+ —.		< is Late

Now you can give a reading: if your actual Time was greater than the Calc Time (as in this example) you were late at the speed change. If they match you were on time.

Gains are entered by subtracting them from the Calc Time column.

To do the Pause, the driver or navigator can simply look at the clock and quickly figure a restart time based on the running time of day. We will see later how to get back on time precisely with intermediate readings.

Transit Zones

To handle a transit zone, simply treat it like a CAS change with a big pause attached. Remember to log the car mileage at the end of the transit zone.

Checkpoints

At all checkpoints, you need to:

- Split the clock and read the mileage. Record these on the next CM/Actual Time line. Do not un-split the clock.

If it is an open checkpoint:

- Hand in your scorecard, requesting any time allowance you wish to take.

When you get the scorecard back, immediately:

- Verify that the recorded arrival time agrees with your split clock ± 0.01 cent. If it does not, settle the issue on the spot, using your split clock.
- Verify that any TA you requested has been recorded by the crew.
- Quickly check that the start time you have been assigned allows sufficient time to reach the restart for the next leg.

Back in your car:

- If the rally uses out-markers rather than starting a leg from the timing line of the last checkpoint, move past the out-marker.

Otherwise, you will be starting a distance past the checkpoint timing line.

- Un-split the clock.
- Read the checkpoint slip. Note the next NRI, starting CAS, and any special instructions on the slip.
- If the CAS has changed, beware! Some of your upcoming pre-calculations may be wrong. You may, for example, have calculated a pause equivalent based on a CAS that is now incorrect.
- Set up the log for the next leg.
- Calculate your start time. This is usually given to you, but you might need to calculate it if the distance from the checkpoint to the out-marker is included in timing calculations.
- Change any official mileages in the upcoming portions of the route instructions to the car mileage you expect at that point, based on your odometer at the end of the odometer check and your correction factor.
- Since you now have the official mileage to the out-marker or checkpoint timing line, you will be able to pre-calculate the perfect time to the next speed change, if that speed change has an official mileage.
- Calculate a perfect time 0.20 mile from the start of the leg to get set to give an early reading.
- Finally, calculate your score for the leg just completed. Look for a trend in your scores and, if appropriate, change your correction factor. However, if your score seems wildly off, toss the calcs in the back

seat and assume the checkpoint slip is wrong. There is nothing worse than running a leg wondering why you got 1486 points on the last leg!

Intermediate Readings

Until now, we have talked only about giving readings at speed changes. The reason is that a team should probably just work with the Stock Navigation Strategy as we have described, for at least an event or two. After you are comfortable with the log and the Stevens, you can add intermediate readings between speed changes.

Intermediate readings in Stock Class are based on a calculated odometer. This is the perfect odometer reading at a given time.

The key to using the calculated odometer to stay on time is communication. The driver and navigator must develop an interplay that enables them to see how close they are to the calculated odometer at any given time. Here are some communication styles:

- The navigator calls out the calculated odometer at the perfect time. The navigator might say “13.8 ... NOW“. The driver glances down and eyeballs whether they have yet to reach 13.8 and need to speed up, or are past 13.8 and need to slow down.
- The navigator tells the driver what mileage will be used for the next reading. The driver glances down and calls out “NOW!“ at that mileage. The navigator then compares the current time to the

perfect time at that mileage and gives a reading.

- The navigator reads the odometer and gives time readings. In cars where the front passenger cannot see the odometer, the navigator might consider sitting in the back seat.

To demonstrate these type of readings, we will continue the example above. Say we just executed NRI 2 at car mileage 14.73. First, set the Stevens for the new CAS 28. Since it is most practical to give calculated odometer readings to the driver in even tenths, the easiest thing to do is add in hundredths on your timing log to bring your calculations up to a higher tenth that is easy to work with.

In our example, we might add in 27 hundredths of a mile to get a calculated time for car mileage 15.00:

Stock Navigation Log Sheet

Leg: 9

<u>CAS</u>	<u>CM</u>	<u>ΔCM</u>	<u>Calc Time</u>	<u>Actual Time</u>
	<u>12.90</u>		<u>11:17.00</u> (start)	
<u>36</u>		<u>1.83</u>	+ <u>3.05</u>	
	<u>14.73</u>		<u>20.05</u>	<u>20.12</u>
<u>28</u>		<u>0.27</u>	+ <u>0.58</u>	
	<u>15.00</u>		<u>20.63</u>	<u> </u> .
<u>28</u>		<u> </u> .	+ <u> </u> .	

< is Late

Now you have a perfect time of 20.63 at car mileage 15.00. If you are past car mileage 15.00, roll the E pointer to, say, 0.50 of a mile and read the time of 1.07 minutes. Add this to 20.63 (in your head) to get 21.70. Then use one of the methods described before to translate 15.50 miles and a perfect time of 21.70 into an early/late reading. Then roll the Stevens another tenth or two and concoct another reading in the same way.

Do the addition in your head? It sounds difficult, but it will get easier with practice. Besides, when you are reasonably on time, you only need to add the cents portion of each number, since it is unlikely you will be off by a minute.

Pauses get added into your Calc Time on the log. The navigator can do this some time before the pause is actually executed. To get on time after a pause or gain, simply rely on intermediate readings based on the new Calc Time.

Stock Navigation Log Sheet

Leg: 9

<u>CAS</u>	<u>CM</u>	<u>ΔCM</u>	<u>Calc Time</u>	<u>Actual Time</u>
	<u>12.90</u>		<u>11: 17.00</u> (start)	
<u>36</u>		<u>1.83</u>	+ <u>3.05</u>	
	<u>14.73</u>		<u>20.05</u>	<u>20.12</u>
<u>28</u>		<u>0.27</u>	+ <u>0.58</u>	
	<u>15.00</u>		<u>20.63</u>	____.____
<u>28</u>		____.____	+ <u>0.30</u>	
	____.____		<u>20.93</u>	____.____
____		____.____	+ ____.____	

< is Late

Perfect-Time Rallies

Compared to events which don't have a mileage at every instruction, perfect-time rallies are a breeze in Stock Class. The critical part is to pre-calculate the perfect time to each instruction and not make any mistakes. You can almost always do without a formal log – just do the calculations neatly on the route instructions and keep a separate sheet just for calibration factor notes and a log of checkpoint information.

Then, at every instruction where you have a perfect time, note the time and car mileage. Compare your time with the perfect time you have in the route instructions. You can almost immediately give a reading at the instruction. Then, using the car mileage at the instruction, come up with the perfect time at the next whole car mileage, as

described when doing a CAS change above. Then you can give intermediate readings until the next instruction with your calculated perfect time.

One complication crops up if you have open checkpoints, where you will stop and be assigned a restart time. All your perfect times will be wrong after this. A solution is to figure the perfect time from one NRI to the next, but not add them up until needed on the course. This technique also handles the problem of taking a time allowance, which would also disturb your pre-calculated times.

Off-Course Situations

Off-course excursions in this strategy are not a disaster for one basic reason: we don't really use official mileages once we start a leg (we only use them to calculate perfect interval times).

If you are in a situation of just missing a turn, you may be able to back up and make the turn with no changes in the navigator's calculations. You can do this if the stock odometer runs backwards with a balanced lag, as described in [Chapter 10](#).

If you are seriously off course or don't have such an accommodating odometer, go back to a previous NRI and take a TA based on the time you recorded when you executed that NRI. If this is not practical, you will need to use the full-blown recovery technique. Let's say you have missed a turn.

- Make a U-turn and note the odometer as you make the turn. Call it A.
- Retrace your route to the location where you went off course and take an odometer. Call it B.
- Pull over. Calculate your off-course mileage. This is $2 \times (B - A)$.
- Simulate a speed change at this point. However, when you figure the perfect time, don't include the off-course mileage. Now figure a reasonable TA and add this into your Calc Time. Depart at your new Calc Time and resume with intermediate readings.

Running in Limited-Stock Class

Some areas restrict their Stock Class competitors to pencil and paper. No calculators, tables, or slide rules. This makes everything we have done in this chapter with a Stevens difficult.

Some navigators in Limited-Stock Class memorize the rate values for all reasonable CAS values. This is not as difficult as it sounds, since there are a number of patterns and many values are simple multiples of other values.

What does memorizing the rate from Table 15-1 buy you? It enables you to do a series of additions, by hand, to produce a reading from official mileages (as in a perfect-time rally). Of course, you will not be able to give nearly as many readings per mile. A reasonable target is probably one reading per mile.

If you are giving readings off the stock odometer, you will need to scale every reading by the correction factor. This can be done using approximations rather than precise arithmetic.

Another trick is to make heavy use of Hammond's Rule of 60s (see [Chapter 17](#)). You can give a reading every 0.60 cents using corrected speeds for your additions. The odometer's correction factor can even be handled by incorporating it into the "0.60 cents" number used in Hammond's Rule.

19. Precision Course Measurement

*Small wheel turn by the firing rod,
big wheel turn by the grace of God,
every time that wheel go round,
bound to cover just a little more ground*

— Robert Hunter, 1972

The issue of course measurement was never very important to us, running in Odo Class, until the first event we ran **clean**. We had competed at the regional level against a top team of some 15 years experience. Until then, we always managed to screw up somehow – go off course or commit some breathtaking blunder with a calculation. Being rather short-sighted, we were lulled into the belief that our wonderfully precise odometers implied unbeatable accuracy. We felt that a run with none of these blunders guaranteed a win.

In the first event we ran clean, we looked over our logs and found not a single point which was assignable to anything we did wrong. But we lost with double our competitor's score! They zeroed our ones and aced our deuces. I was, for the first time in the sport, devastated.²⁵

“How did you do it??”, was answered with a barrage of facts, fictions, gossip, rumors, and opinions about everything from the temperature of their tires to the reputed speed of the trigger finger of each checkpoint worker on the event. Only occasionally did we run clean after that day. But, when we did, the evening usually had one of these discussions thrown in.

So this chapter, rather than a scientific analysis of precision, is more of a collection of these discussions, with an honest attempt to eliminate the fictions, gossip, and most of the rumors. We will be looking at two sets of issues, which affect how you and the rallymaster measure mileages and how leg times are calculated. Where possible, we have undertaken our own “quasi-scientific studies” to support our statements.

But before we start, remember the real goal is to get good scores at the checkpoints. This may be subtly different than purely running on time. The bottom line is to get each checkpoint crew to record a time for you which matches the time on the checkpoint slip calculations, and we may do some unexpected things to achieve this.

²⁵ but only until the bar opened!

Finally, please remember that the topics discussed in this Chapter apply only if you actually do run without course-following or procedural blunders. I have most often forgotten this maxim after getting to a certain level of proficiency in a class and then switching partners or classes for an event. We are usually rewarded with lots of ones and zeros, with a few max leg scores thrown in to snatch defeat from the jaws of victory. It's also really embarrassing at the awards ceremony. On one event we were leading with 3 points after 4 legs. We were then so intent on adjusting our calibration factor that we missed several turns and never found the rest of the course! We even had to ask directions to find the finish.

Matching the Mileages

The first half of precision measurement is to match your mileages to the official measurements. Matching the mileages as closely as possible is extremely important in the Odo and Computer Classes - every error of 0.01 miles will get you 2 points at CAS 30 and 3 points at CAS 20, both of which are sufficient to put you out of the competition if it happens with any regularity.

Now, remember back in [Chapter 8](#) when we talked about accuracy? We said that an instrument was accurate when it agreed, to the resolution of the instrument, with some chosen standard. In the case of mileage measurement, the standard is the mileages read by the measuring car. Nothing says that the measuring car had any degree of accuracy with respect to any other standard.

Nor is this necessary. In fact, after reading this section, you may well wonder if there is any such thing as a totally accurate course measurement.

To help competitors match their mileages with the measuring car, many organizers publish the conditions under which the course was officially measured. For example:

The course was measured in a 1957 Turbo Sheepsmaasher GT on a dry course under clear skies with temperatures ranging from 65°F–75°F. Tires were 255/20R30 B. F. Yokoroyal Nailseeker Specials inflated to 84 psi (cold). The tires were warm from a 10 mile warm-up prior to the odometer check. Mileages were read off the left front (undriven) wheel.

This information is extremely important, but is, unfortunately, not the whole story! We shall see in the coming sections that there are many unpublished aspects of the measuring run which are important.

The rest of this section will examine the important issues, one at a time.

Tire Size

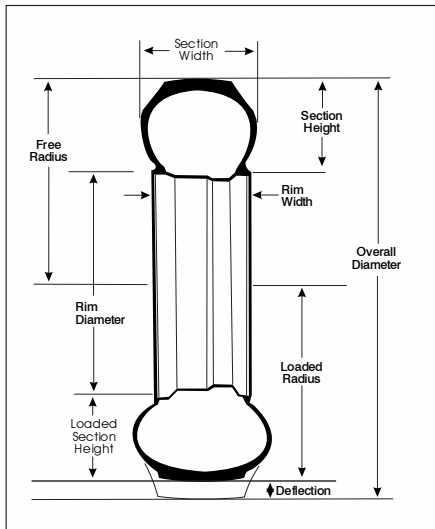
The first issues we will look at relate to the dynamics of your tires and how they measure the road. Of these, the most obvious is tire size. And while the (specified) size of your tires does not change during a normal run, if you ever have to switch to a spare of a different size or (*gasp!*) a “space-saver donut” spare, this section can enable you to estimate a revised

calibration factor without running a new odometer check.

The numbers given in a tire specification correspond to measurements on the wheel. To make things confusing, one of the measurements is metric, one is English, and

This formula uses straight math to get the theoretical diameter of a wheel. No allowance is made for the effect of the weight of the car on the tire.

There are two versions of the revolutions-per-mile formula: one for a theoretical



185/70R14
 Section width (mm) → 185
 Aspect Ratio (series) → 70
 Rim diameter (inches) → R14

Formula 20. *Wheel Diameter*

$$\text{Rim diameter}_{\text{inches}} + \frac{\text{Section width}_{\text{mm}} \times \text{Aspect ratio}}{1270} \rightarrow \text{Overall diameter}_{\text{inches}}$$

one is a ratio of two other numbers.

wheel under no load and a version that approximates the effect of load on the tire.

Formula 21. *No-Load Revolutions per Mile*

$$\frac{20168}{\text{Overall diameter}_{\text{inches}}} \rightarrow \text{No Load revolutions per mile}$$

Our goal is to calculate the number of revolutions of a wheel per mile. The Aspect Ratio figure given in tire specifications is the ratio of Section Height to Section Width, or $\frac{\text{Section height}}{\text{Section width}} \times 100$.

The version of this formula that accounts for the effect that car weight has on the tires introduces a correction factor of 3.1%. This is an industry-standard figure, based on the maximum allowed tire pressure and tire load allowed, driven at 50 mph.

Table 19-1 shows a range of tire sizes, with their two revolutions per mile. The No-Load values match [Formula 21](#), while the Loaded figures were obtained from actual tire tests and may vary slightly from [Formula 22](#).

Formula 22. ***Loaded Revolutions per Mile***

$$\frac{20800}{\text{Overall diameter}_{\text{inches}}} \rightarrow \text{Loaded revolutions per mile}$$

Tire Revolutions per Mile								
Tire spec	No load	Loaded	Tire spec	No load	Loaded	Tire spec	No load	Loaded
125/70R15	921	952	195/70R15	783	809	225/70R16	710	734
145/80R12	954	981	195/60R13	908	939	225/60R14	819	847
145/80R13	911	937	195/60R14	869	898	225/60R15	787	814
155/80R12	927	953	195/60R15	833	861	225/60R16	757	783
155/80R13	886	911	195/50R14	930	962	225/50R15	845	874
155/70R12	982	1014	195/50R15	889	920	225/50R16	811	839
155/70R13	936	967	205/70R13	830	857	235/70R15	722	745
165/80R13	862	886	205/70R14	797	823	235/70R16	697	720
165/80R14	827	850	205/70R15	767	792	235/70R17	673	696
165/70R13	913	943	205/70R16	739	763	235/60R15	773	799
165/70R14	873	902	205/60R13	889	919	235/60R16	744	769
175/80R13	840	863	205/60R14	852	880	235/60R17	718	742
175/80R14	806	829	205/60R15	817	845	235/50R16	799	826
175/70R13	891	920	205/60R16	785	812	235/50R17	768	794
175/70R14	853	881	205/50R15	874	904	245/60R15	759	785
185/80R13	818	841	205/50R16	838	866	245/60R16	731	756
185/80R14	786	808	215/70R14	780	806	245/60R17	706	730
185/70R13	869	898	215/70R15	751	776	245/50R15	818	846
185/70R14	834	861	215/70R16	724	748	245/50R16	786	813
185/60R13	928	959	215/60R14	835	863	245/50R17	757	783
185/60R14	887	917	215/60R15	802	829	255/60R15	746	771
195/80R13	798	820	215/60R16	771	797	255/60R16	719	744
195/80R14	767	789	215/50R15	860	889	255/60R17	694	718
195/80R15	739	760	215/50R16	824	852	255/50R15	805	833
195/70R13	849	877	225/70R14	764	789	255/50R16	775	801
195/70R14	815	842	225/70R15	736	760	255/50R17	746	771

Table 19-1

Tire Pressure

Another important item relating to course measurement is tire pressure. The more pressure, the larger the loaded radius/diameter of your tires and the less car miles you will read per overall mile. However, we will see that, at least for modern radial ply tires with steel belts, this effect is far less than one would imagine. For “antique” bias-ply non-radial tires, the effect can be profound.

(about 0.0011 mile). This graph tells us a number of things:

- Changes in mileage measurement vary linearly with respect to changes in tire pressure, at least within the range of tire pressures tested.
- For each increase of one psi, you read about 0.047% less mileage. This means that, over a 10 mile odometer check, a difference of 5 psi will yield a measurement difference of about 0.024

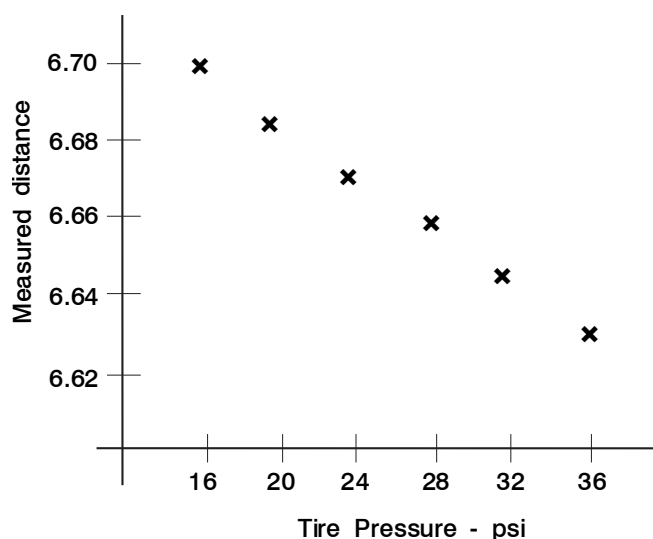


Figure 19-1: How tire pressure affects course measurement

To get a handle on this issue we set up a little experiment. We ran a course under carefully controlled conditions²⁶ while varying only the tire pressure on each run.

Figure 19-1 shows the results, plotting car miles against tire pressure. It should be noted that several of the runs were done twice and never varied by more than 6 feet

miles.

Tire Temperature

But who cares about tire pressure changes, you ask? I'm not pumping up my tires during the odometer check.

But you are! As a tire is run, heat is produced from the friction of the tire with

²⁶ 1987 Audi 4000 Quattro (four wheel drive) measuring from the front differential; Dunlop qualifier 185/65R14 steel belted radial snow tires (almost new), on a 6.5 mile

smooth asphalt course with one stop sign, at 58°F on a dry, sunny day. Measurements were truncated to the next lower 2 feet (about 0.00038 mile).

the road, the flexing of the tread and sidewalls as they cycle from their unloaded to loaded shapes, and by other factors. Much of this heat is absorbed by the air inside the tires resulting in increased tire pressure.

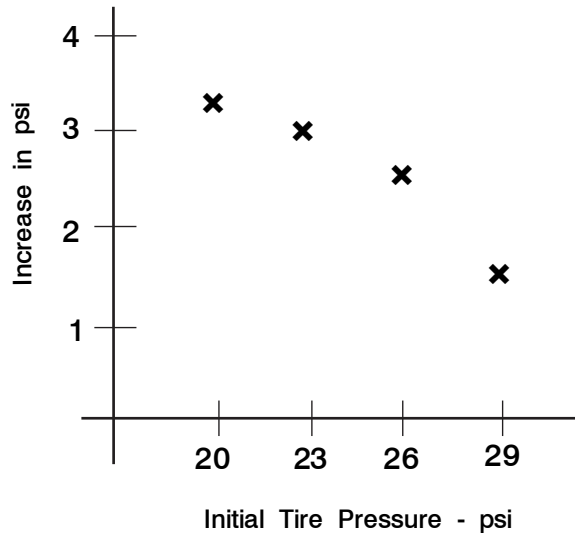


Figure 19-2: Change in tire pressure during the tire warmup

From basic physics we know that the pressure increase is proportional to the temperature increase if you measure the temperature from absolute zero ($0^{\circ}\text{Kelvin} = -459.67^{\circ}\text{Fahrenheit} = -273.15^{\circ}\text{Celsius}$).²⁷

You also need to remember that tire pressure gauges really measure the amount of pressure above the surrounding air pressure. So, tire air at 30 psi is really exerting 45 psi from the inside of the tire against about 15 psi on the outside of the tire (at sea level under standard conditions). For anyone involved in hillclimbs, the

outside air pressure drops roughly $\frac{1}{2}$ psi per 1000 feet of altitude gain, up to 10,000 feet.

The issue is this: a tire will heat up by a different amount depending on its starting pressure. Tire flex is far more significant than friction of the tire with the road under normal TSD rally conditions (reasonably infrequent skidding – at least on the odometer check). Since tires flex more at lower pressures, tires will get hotter and gain more psi at lower pressures (just see how hot a flat tire gets if you drive on it).

This graph is from another simple study done on a range of initial tire pressures over a 13 mile course under the same conditions described earlier. It shows how much tire pressure increases during the tire warm-up depending on your pressure at the start of the warm-up.

Assume that you start the odometer check with cold tires at 26 psi and the measuring car started with warmed tires. Also assume that it takes the length of the odometer check to warm your tires. When you start your first leg you will have gained 2.8 psi while the measuring car gained no pressure. If the first leg is 15 miles, you will read about 0.01 mile short, just because you failed to pre-warm your tires.

Even if you and the measuring car both start with cold tires, you can introduce error if you don't start at roughly the same tire pressure. Remember that you will gain more

²⁷ This is roughly true for tire air under rally conditions: a gas contained in an essentially constant volume, not

under extremely high pressures, not about to become a liquid (like steam), and other assorted caveats.

pressure if you start from a lower pressure. If you start with, say, 20 psi cold and the measuring car starts with 32 psi cold, you will gain 2 psi more than the measuring car. You will start the first leg with 1 psi more than your average odometer check pressure compared to the measuring car and will be short 0.01 mile every 21 miles.

There is another source of tire temperature worries for the navigator: the temperature of the road surface. Blacktop can reach 150°F on a sunny day, even if the air temperature is only in the 90's. Cloud cover can lower the blacktop by 40°F and rain can send the blacktop from 150°F to 80°F almost instantly.

How much does a 70°F drop in temperature affect your mileage measurements?

Assuming the air in the tires also drops from 150°F to 80°F and your tires are at 30 psi above outside air pressure at 150°F, they will be at 24.8 psi at 80°F. From the earlier study on tire pressure, we found an increase of 0.047% in measured miles for each psi decrease in pressure. That gives an increase of 0.244% or 0.0244 miles per 10 mile run.

Under conditions of widely varying road temperature, you could consider having “hot” and “cool” or “dry” and “wet” calibration factors.

Expandable Tires

Until now we have assumed that the physical dynamics of your tires versus the rallymaster's tires are the same, for course measurement purposes. This seems to be

largely true, as long as you both stick to modern steel-belted radial ply tires.

But what about the older bias ply tires? They are called expandable tires because they do just that: expand. The degree by which they expand due to temperature changes, pressure changes, and speed is far greater than for modern steel-belted radial ply tires.

Correction Chart for Expandable ↔ Non-expandable Tires											
Leg Speed	Odometer Check Speed										
	10	15	20	25	30	35	40	45	50	55	60
10	0	.05	.10	.18	.27	.38	.50	.65	.78	.92	1.05
15	.05	0	.05	.13	.22	.33	.45	.60	.73	.88	1.02
20	.10	.05	0	.08	.17	.28	.40	.55	.68	.83	.97
25	.18	.13	.08	0	.08	.20	.32	.47	.60	.72	.93
30	.27	.22	.15	.08	0	.12	.23	.38	.52	.68	.80
35	.38	.33	.27	.20	.12	0	.12	.27	.42	.57	.77
40	.50	.45	.38	.32	.23	.12	0	.15	.30	.45	.60
45	.65	.60	.55	.47	.40	.27	.15	0	.15	.33	.48
50	.80	.75	.70	.62	.55	.43	.30	.15	0	.18	.37
55	.98	.93	.88	.80	.73	.60	.48	.33	.18	0	.20
60	1.17	1.12	1.07	.98	.92	.78	.67	.52	.37	.18	0

Table 19-2a

You have →	Expandable Tires	Non-Expandable Tires
Rallymaster had →	Non-expandable Tires	Expandable Tires
Leg speed greater than Odo check speed	You will run early, adjust speeds slower, or bias timing calcs longer	You will run late, adjust speeds faster, or bias timing calcs shorter
Leg speed less than Odo check speed	You will run late, adjust speeds faster, or bias timing calcs shorter	You will run early, adjust speeds slower, or bias timing calcs longer

Table 19-2b

Of course, as with all situations where you are trying to match mileages, having the same tires as the rallymaster will eliminate this issue. If you have expandable tires and the rallymaster used non-expandable tires, or vice versa, you may need to compensate. If you both run the odometer check at the same speed and the leg is also run by both cars at the same speed as the odometer check, no correction is needed. However, the problem comes in when the speed on the odometer check and the leg speed differ. The non-expandable tires change in circumference by a smaller amount than the expandable tires.

Since I had no access to older bias-ply tires, I will include a table derived from Gene Hammond's *The Sports Car Rally Handbook*. Table 19-2 lists the percentage of timing error to expect based on the difference between the odometer check speed and the leg speed. This table was apparently derived from experiments done over several years. To use Table 19-2 note the difference between the speed on the odometer check versus the leg in the upper table. Use the lower part of the table to tell whether to add or subtract the percentage.

Sending Unit Placement

After being subject to years of advertisements by tire companies, motorists build an image of the tire-to-road connection as something akin to an almost inseparable interlocking bond. The tire's grip on the road is broken only in a skid induced by the most extreme road conditions and/or radical driving maneuvers. However, while

it usually does take extremes to get a full-blown skid going, the tire's grip on the road under “normal” driving conditions is anything but absolute – various tires on a car will slip, spin, slide, and skid small amounts. While these tendencies are not normally felt by most drivers as a loss of handling, they do affect the accurate measurement of distance from that wheel.

So all the conscientious Odometer and Computer Class teams read the general instructions and attach their sending unit to an undriven wheel, inflate their tires as specified, and hope for a nice day just like the day the course was measured. But this is not enough! We now start to look at factors about the measuring run which were not published.

Consider how a conscientious rallymaster performs a “careful” course measurement – driving at or near CAS but slowing smoothly and carefully at each corner and accelerating gingerly back up to CAS to avoid wheel slip. Now watch a zero-hungry Computer Class team – accelerating hard when they see a corner and then braking late and hard, then accelerating hard to get up to speed with as little time lost as possible in case there is a “surprise” checkpoint coming up soon. How does this affect mileage? Again we did some tests.

After distilling (a mountain of) raw mileage measurements, we came out with Table 19-3.

Mileage Variation					
Car	Wheel	Paved		Unpaved/loose surface	
		Careful	Aggressive	Careful	Aggressive
Mazda 626 (FWD)	Rear	0.0	-0.006	0.0	-0.024
	Front	+0.010	+0.010	+0.010	+0.016
Audi 4000 Q (4WD)	Diff	0.0	+0.002	+0.004	-0.006
	Front	+0.002	+0.004	+0.004	+0.008
	Rear	-0.004	-0.004	-0.002	-0.004

Table 19-3

Table 19-3 compares mileage readings taken over the same course on the same day, varying only the vehicle, measuring wheel, and driving aggressiveness (not average speed or driving line) to gauge how much wheel slip/spin occurred. The boxes with dark shading indicate the “standard” runs to which other runs were calibrated – they can be thought of as the official runs. Light shading indicates runs which were calibrated to the dark shaded runs. All the other boxes indicate mileage gained (+) or lost (-) over a 10 mile run as compared with the appropriate shaded box. The important comparisons to look at are the careful measurement versus the aggressive measurement for each set of conditions.

Table 19-3 tells us a number of things:

- Front wheels read more mileage than rear wheels, all other things being equal. We will look at this issue below.
- Undriven wheels read significantly less mileage when driven aggressively on loose surfaces – braking tends to make them skid or drag.
- Driven wheels tend to read significantly higher mileage when driven aggressively on loose surfaces. Apparently the acceleration slippage is greater than the skidding when braking.
- The differential in the four-wheel drive Audi reads more from the front wheels than the rear wheels.
- The smallest variations between careful and aggressive driving are on the 4WD rear wheel and differential. Note that the Audi's primary drive is to the front wheels. Gene Henderson of Competition Limited reports that (begin rumor) he gets excellent results from the front wheels of

his BMW IX, whose primary drive is the rear wheels (end rumor). He hypothesized that the viscous coupling, which drives the secondary wheels, provides sufficient power to that wheel to reduce skidding under moderately aggressive braking.

However, if the odometer check is on a highway and leg one follows hairpins up the side of a mountain (yahoo!), front versus rear wheel can make a big difference.

The difference between measuring from the left and right wheel can also be significant.

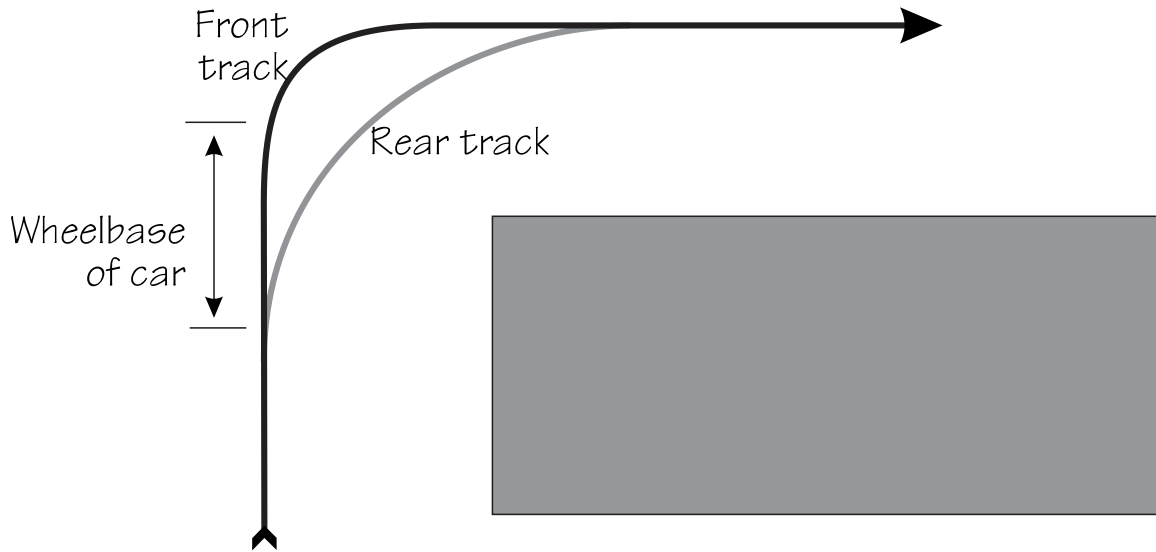


Figure 19-3: Driving line of front versus rear wheels (exaggerated)

One thing we noticed when making the measurements was their consistency. Several of the runs were done twice with a maximum variation of 4 feet on paved and 8 feet on unpaved. This indicated that, under conditions which were truly carefully controlled, a high degree of repeatability was possible.

Now back to the issue of front versus rear wheel driving distances. Imagine the path that your front wheels take on a sharp corner versus your rear wheels. Figure 19-3 shows an (exaggerated) diagram of the rear wheels short-cutting the course. If the odometer check matches the rest of the course in curviness, there is no problem.

Unlike the front versus rear wheel situation above, the difference between left and right is independent of the sharpness of curves. The distance between the left and right wheels (the car's "track") and the net angle of turn determine the difference in distance. For each 90° change of direction, the inside wheel travels $\frac{\pi}{2} \times \text{Track}$ less than the outside wheel. For a typical car's track of 5 feet, the inside wheel travels about 8 feet less than the outside wheel on a 90° curve. If the leg has a 360° loop, the difference is 32 feet or 0.0061 miles.

Weather and Road Surface

Now that we have analyzed the issues of tire dynamics to death, you wake up on the

morning of the rally to torrential rains pelting an already water-soaked course. These are the worst rains in 178 years and the course, of course, was measured on a bone-dry day!

Naturally, you will not be able to match mileages as closely as you could with better weather. Your tire temperatures will vary in ways very different from the measuring car and wheel slip/skid will run rampant. However, all the competitors face the same conditions and you simply need to beat them at the measurement game.

A few points to look for on wet days:

- Take particular note on steep inclines – both uphill and downhill. If the surface is slick or chattery, you may want to adjust your mileage to account for skid (downhill) or slip (uphill) that you feel you are doing over and above the measuring car.
- Your tires are constantly being cooled by the water. They will reach their operating temperature sooner and stay cooler/smaller all day.

As we saw in the study above, every aspect of wheel slippage is accentuated on loose surfaces. This includes unpaved roads, broken pavement, washboards, and any surface which varies the tires' downforce on the road.

Driving Technique

Despite all our talk of tire dynamics and much to the chagrin of most Odo and Computer Class navigators, a good portion of accurate course measurement is up to the

driver. The goal is to match the driving style and temperament of the person at the helm of the measuring car.

One primary issue is the driving line. Did the measuring car cut corners? Hug the right? Hug the center line? Use the “whole road”?

How can you tell? While most organizers don't give you these specifics, you can take some educated guesses. How much performance driving has the driver done? This may tell you whether they ran on the high or low side of CAS during course measurement. How large/small are the car and driver? Our belief is that (begin rumor) large drivers in large cars tend to take a straighter line through corners than small drivers in small zippy cars, if they run at the same speed (end rumor).

One fact is that driving significantly faster than the measuring car quickly accumulates a shortage in mile measurement. You get a double whamy: your tires heat up, getting larger and turning less per mile and you take a straighter line on curves.

Another significant issue is how the measuring car handled steep hills on loose surfaces. It may be difficult to guess how much wheel slip they got on the uphill, but you might try to find out whether they used the brakes or downshifted on the downhills.

Lane Change Errors

When we first started in Odo Class, I would go slightly bezerk whenever Vera needlessly changed lanes on the odometer check. I

would fume, “*The Mileage!*” between clenched teeth as she drove around a slow car on the highway or passed on a back road. Finally, she asked, “*Can’t you just adjust for it?*” What a concept!

So, before the next event, I went out and measured the distance added by a normal lane change. Using an odometer calibration factor which provided readings to the nearest 2 feet I changed lanes fairly sharply to the left lane and back the right over a short straight paved dry course. No mileage difference! So I did two pairs of lane changes. Still no difference! Finally, four pairs of lane changes registered a 4 foot increase and seven pairs yielded a 6 foot increase in distance.

change happens in about 0.0167 miles or 87 feet. **A** is 87 feet. Since **C** and **A** form a right angle, we get the length of **B** from the old Pythagorean Theorem:

$$B^2 = A^2 + C^2$$

$$B = \sqrt{A^2 + C^2}$$

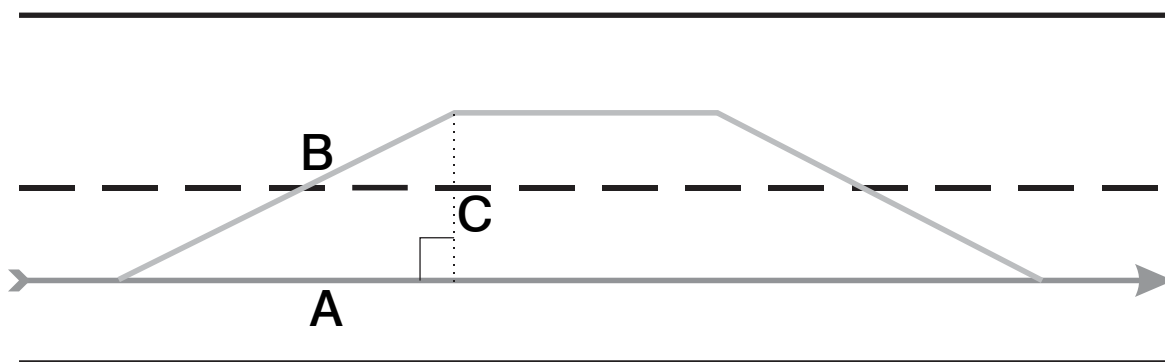
$$B = \sqrt{87^2 + 10^2}$$

$$B = \sqrt{7569 + 100}$$

$$B = 87.57$$

So **B** is 0.57 feet longer than **A** and changing lanes “back and forth” turns out to increase your mileage measurement about 1.15 feet, agreeing with our measurements.

In the end this experiment solved one of our rally problems – no more slightly bezerk



Lane change geometry

This confirmed a bit of high-school geometry I should have done in the first place:

We are looking for how much longer **B** is than **A**. Assume that you move 10 feet to the left during a lane change. **C** is 10 feet. Now assume that it takes about 4 cents to change lanes and you are going 25 mph. The lane

navigator. The only problem was that Yours Truly had to fiddle in an “adjustment” whenever a lane change occurred, at least until the left seat discovered that nothing was being fiddled at all!

Calibration Factors

As we discussed in [Chapter 10](#), there are two types of calibration factors, additive and inverse. Odometers that use additive calibration factors simply add the value of the calibration factor to the rightmost (invisible) digits of the odometer with every pulse from the sending unit. If your odometer is coming up short, increase the factor, and if it comes up long, decrease the factor. The formula for a revised calibration factor on an additive odometer is Formual 23.

Before the event, there is one thing you can do to help during the odometer check: calibrate your precision odometer to the car odometer. If your precision odometer reads distance from the same wheels as the car odometer, you have a built-in sanity check. Regardless of tire pressure, wheel slippage, etc., your car odometer should match your precision odometer (except if you go in reverse). This allows you to test for missed pulses or other electrical problems at the start of each event.

Formula 23. *Additive Calibration Factor Adjustment*

$$\frac{\text{Official mileage}}{\text{Car mileage}} \times \text{Old calibration factor} \rightarrow \text{Revised calibration factor}$$

The formula for a revised calibration factor is the inverse of the additive formula in Formual 24.

There is one shortcut which skips the math for odometers with inverse calibration factors:

- Set the calibration factor to 100.
- Zero the odometer and run one mile.
- The correct calibration factor is now shown in the odometer.

Some A-Boxes have an automatic calibration feature. You enter the official mileage and run the odometer check. When you activate the automatic feature at the end of the odometer check, the A-Box:

- Calculates a new calibration factor.
- Installs it.
- Sets the odometer to the official mileage.

This may be convenient, but I still like to do the calculations by hand as a backup.

Finally, there is a trick you can do with an A-Box to get mileage to the thousandths on

Formula 24. *Inverse Calibration Factor Adjustment*

$$\frac{\text{Car mileage}}{\text{Official mileage}} \times \text{Old calibration factor} \rightarrow \text{Revised calibration factor}$$

the odometer check: Set the CAS to 6 and zero the calculated time. The calculated time will then read in thousandths of a mile, up to 5.999 miles. For 6 miles and beyond, you need to convert each hour shown into 6 miles.

The Odometer Check

The design of the odometer check (by the rallymaster) has a large effect on the way you come up with a calibration factor. If there is no tire warm-up prior to the odometer check, you may need to eliminate the early portion of the odometer check from your calculations. If there is a substantial unpaved section, you may want to develop two calibration factors – one for paved and one for unpaved.

The best way to track the changes is to build a log. This particular log lists the formula for an odometer with an additive calibration factor:

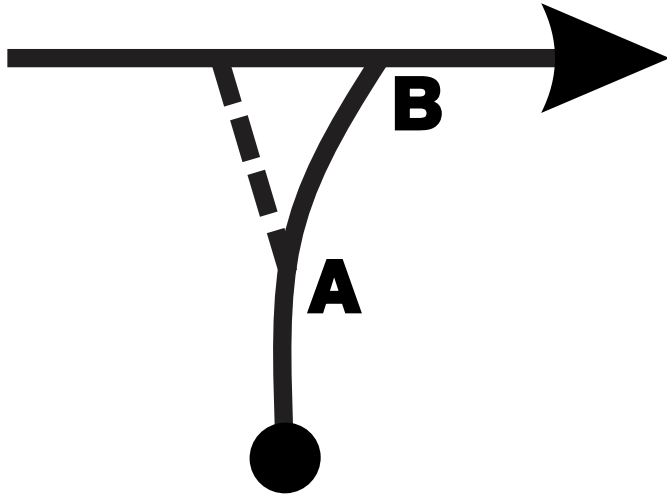
At each NRI where you have an official mileage, calculate a new calibration factor. Ideally, both official and odometer readings are in thousandths of a mile. If not, you may be able to compensate to get some reasonable numbers. If, for example, official mileages are truncated to the hundredth of a mile, add 0.005 to each to get a better guess as to the actual mileage at that point. This technique allows the navigator to check the factor at multiple locations and plot a trend in the factor.

Where to Throw the Switch

Another issue is where to actually take the mileage on the course. A variety of rules are used by rallymasters, often in various combinations that form a (hopefully short) list of priorities. Some are well defined (*“the front of the car abreast the leading edge of the landmark”*) while others are less precise

Calibration Log Sheet				
Event: _____		Date: ____/____/____		$\frac{\text{Official}}{\text{Odometer}} \times \text{Old factor} \rightarrow \text{New factor}$
Tire pressure: _____		Temperature: _____	Weather: _____	
<u>NRI</u>	<u>Official</u>	<u>Odometer</u>	<u>Calibration Factor</u>	<u>Surface</u>
			_____ (initial)	
_____	____.____	____.____	_____	_____
_____	____.____	____.____	_____	_____
_____	____.____	____.____	_____	_____
_____	____.____	____.____	_____	_____

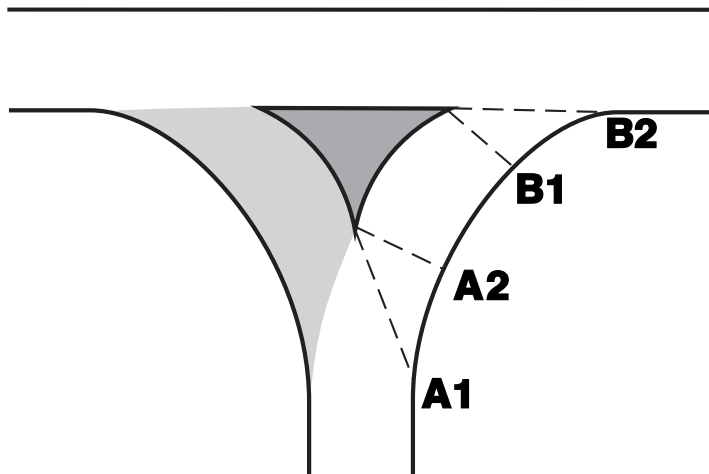
in some situations (“the beginning of the intersection” or “the apex of the turn”).



One has to wonder at this tulip when, according to the general instructions:

Mileages were taken at the center of the first intersection depicted in the tulip, regardless of road surface.

Did they really take the mileage at **A**? In reality, there are even more choices for where to throw the switch:



Even if it is clear exactly where to throw the switch, you can introduce substantial errors if the assigned speeds are very low. We will see later in this chapter that you must be very precise when changing to or from a

very low CAS or at the beginning or end of a transit zone. In these situations, you are usually given the official mileages for action points involving low speeds in the route instructions. It is best to calculate these intervals by hand using the official mileages.

Off-course Measurement

So now you are busy thinking about all the obscure things discussed so far in this Chapter and blow past your turn. Assuming you know how to rejoin the course, the question is how to do it with the least impact on your mileage.

If you have just missed the turn and can back up safely:

- Stop without skidding and put the odometer into REVERSE or OFF-COURSE.
- Back up to a point prior to the turn from where you can make a normal turn.
- Stop smoothly and put the odometer in FORWARD.
- Proceed ahead as before and make the turn.

This assumes that your odometer preserves its internal resolution when you switch out of REVERSE and into FORWARD (see [Chapter 10](#)).

We did this once on a rally where we were very confused about which way to go at a particular intersection. Actually, we visited the same intersection six times, making as many turn-arounds in the process. We still managed to get a zero (adjusted for our hefty time allowance)!

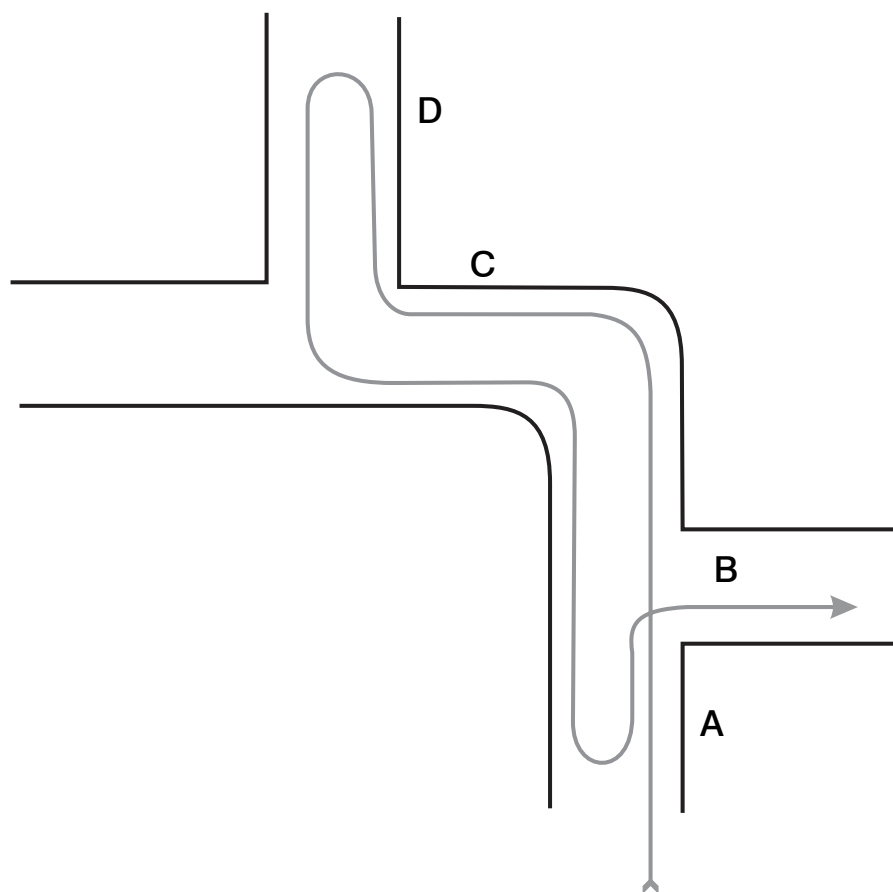


Figure 19-4: Off-course recovery accounting for the radius of curves

If your odometer does not preserve its internal resolution, you will have to add the following step before switching directions:

- Creep (forward or backward) until the odometer just clicks over to the next digit.

If you have gone too far to simply back up, you will need to turn around. You could simply throw the odometer from FORWARD to REVERSE at the apex of your U-turn, but this can lose precision, especially if you are making a broken U-turn. It is better to PARK the odometer at a landmark, turn around, then switch into REVERSE abreast the landmark in the other direction. Do the same thing at another landmark once you pass the turn which you missed, this time switching from REVERSE to PARK to

FORWARD. If your odometer does not preserve internal resolution, you will have to use the creeping maneuver mentioned above and judge how far you are past the landmark when coming from the other direction.

One complication is that you need to be aware of any curves on your off-course excursion.

In Figure 19-4, the team sails past the right turn at **B**. If they were to use **C** as their landmark to reverse direction, the distance **A** → **C** would be longer than **C** → **A** because of the first curve. Your odometer would wind up reading long.

How much? Some simple tests on narrow 2-lane roads turned up a difference of about 15 feet for curves and 25 feet for a 90° turn. As the road widens, this effect is exaggerated.

To fix this problem, the team goes right down a sideroad and uses landmark **D** to reverse direction. In general, the rule is: At the landmark where you switch out of FORWARD (**D** above) and the landmark where you switch into FORWARD (**A** above), you should be facing the same compass heading. You should also not go in a complete circle (“around the block”) to get to the same compass heading.

Matching the Times

Back in [Chapter 4](#) we looked at the fundamental relationships between time, speed, and distance that drive this sport. And throughout this book we have strived to build navigation strategies, precision, and accuracy in order to attain those perfect theoretical relationships out on the course. But now, it turns out that reality does not quite live up to the theoretical formulas. The rallymaster is not really using those beautifully simple TSD formulas, but rather a subtly different and far more complex variation of them.

Not that there is any intentional deception going on – just the realities of real-world mileaging which conspire to make the official leg times sometimes very different from the “perfect leg time” one would get from the fundamental formulas.

These realities also apply to your equipment and calculations. The variations may cancel, especially if your methods match the official ones. Or the variation could compound to give “unaccounted” errors.

As an example, take how the rallymaster places checkpoints. Assume that official mileages are truncated to the hundredth, as we do in the New England region. The checkpoint location itself can introduce a big source of error.

Assume that no special care has been taken to placing the checkpoint with respect to mileage measurement. The checkpoint occurs at a random place within the hundredth. If you are running theoretically on time, you will be on time at the start of the hundredth and will be on time at the checkpoint only if it happens to be placed right at the start of the hundredth. The official calculations effectively assume that the checkpoint was really at the start of the hundredth. The further the checkpoint is placed into the hundredth, the later you will be. The lower the CAS, the later you will be. The nightmare of CAS 10 with the checkpoint $\frac{5}{6}$ of the way to the next hundredth gets you a 5 late, according to the rallymaster's calculations. Unless mileage reverts to zero between checkpoints, you will have the inverse problem on the next leg.

In the face of situations like these, we could throw up our hands and say that Computer Class placings for teams that run clean and have accurate mileaging is just a lottery. But

what about a team which understood the above problem and chose to run 3 early when they saw the checkpoint coming at CAS 10? They would reduce their maximum error from 6 to 3 and effectively halve the impact from this problem, on a probabilistic basis. This team is running further from the theoretical TSD formulas, but closer to the rallymaster's version of the TSD formulas. Certainly they have a competitive advantage over the team that simply runs at the theoretical on-time. Over the long run, the placings of these two teams will be settled with no help from a lottery.

But before we dig into the issues, we need a shorthand. The terms “truncated to two decimal places” and “rounded to four decimal places” come up so often that we use the terms T2 and R4 for these two types of phrases. In the above example, we say that mileages at checkpoint locations are T2. A third shorthand, E, is used for exact mileages or times. If, for example, the rallymaster in the above example had taken the care to place each checkpoint at a place where the hundredth-reading odometer had just clicked to a new hundredth, then checkpoint locations would be E2 - “exact to 2 decimal places”.

Shorthand	Meaning
T2, T3, ...	Truncated to two, three, ... decimal places
R2, R3, ...	Rounded to two, three, ... decimal places
E2, E3, ...	Exact to two, three, ... decimal places

Armed with this shorthand, this section looks at a collection of issues which affect the official leg time. Here's the way the tables in this section work: Imagine you are the perfect rally car running the perfect rally – both the perfect rally car and the measuring car measure mileages to the billionth of a mile and never vary from each other; both the rally car and the checkpoint crews have accurate clocks of infinite resolution; finally, the official calculations are carried out to ridiculous precision. Each entry in each table in this section looks at the effect of a single deviation from this perfect situation. A worst case and average case impact on the leg score of the perfect car is given for that deviation in isolation of all other considerations. How to compensate for these issues is suggested at the end of this section.

Official Mileaging

Table 19-4 summarizes how Late or Early you will be timed under various Truncation/Rounding/Exact mileaging procedures (across the top) at various points along the course (down the left). Table 19-4 looks at the worst case and the average case over a large number of occurrences.

Darkened boxes indicate a situation which is very difficult for a rallymaster to achieve on most events (such as locating all CAS changes at a mileage which is E2).

Effects of Official Mileage Truncation and Rounding									
Location	Conditions	T2		R2		E2		T3	
		Worst	Avg	Worst	Avg	Worst	Avg	Worst	Avg
Checkpoint	CAS 30	2L	1L	1E/L	0	0 ^①	0	0.2L	0.1L
	CAS 15	4L	2L	2E/L	0	0	0	0.4L	0.2L
Out-marker	CAS 30	2E	1E	1E/L	0	0 ^②	0	0.2E	0.1E
	CAS 15	4E	2E	2E/L	0	0	0	0.4E	0.2E
CAS change	CAS 15→30	2L	1L	1E/L	0			0.2L	0.1L
	CAS 30→15	2E	1E	1E/L	0			0.2E	0.1E
Begin transit	from CAS 30	2L	1L	1E/L	0			0.2L	0.1L
End transit	to CAS 30	2E	1E	1E/L	0			0.2E	0.1E

Table 19-4

① E2 mileages can be achieved at checkpoints by placing the timing line at a point where the official mileages have just clicked over to a hundredth.

② E2 mileages at out-markers can be done by zeroing all digits in the odometer past the hundredth place. Some odometers have this function (the Timewise RESTART or Zeron SAFETY – see [Chapter 10](#)). Note that this means mileaging is not “continuous”, which is required by some Regs. Alternately, the rallymaster can zero official mileages at each out-marker.

Some observations:

- Although T2 looks far worse than R2, the errors in T2 tend to balance out in the average case. Since every transit zone has a beginning and an end, the errors cancel out. Likewise with out-marker/checkpoint pairs.
- A leg which is generally mileaged T2 but that begins with a re-zero loses this balancing effect because there is no early bias to balance the late bias at the checkpoint location. On the average, perfect cars will be late on these legs.
- While the average cases of R2 and even T2 (with balancing) don't look bad, the average case only works for a large number of samples. However, each leg only affords a small number of intervals. The result is that most T2 and R2 legs have in the neighborhood of 1 point of error due to this phenomenon.
- E2 is impractical as a general strategy due to problems locating CAS changes and transit zone endpoints at just-clicked locations.
- T3 and R3 effectively eliminate these problems, but many competitors resist T3 and R3 because their equipment cannot read in thousandths of a mile.

One very important thing to note in Table 19-4 is that the errors escalate as the CAS goes down. The error at CAS changes goes up as the lower of the two CASs goes down. For very low CAS assignments, the timing error can be substantial. For example:

	143. CAS 60 at “Ice Cream Ahead”.
18.00	144. CAS 10 at “Ice Cream around the corner”. Begin Free Zone.
	145. Pause 12.00 minutes at “Ice Cream Shoppe”.
18.60	146. CAS 60 at “You have just passed the Ice Cream”. End Free Zone.

If calculations are done T2 and your A-Box is calculating (for example) T6, you might measure anywhere from 0.590001 to 0.609999 miles for the CAS 10 interval. All this happens inside the box, even though the mileage readouts showed the correct mileage (to the hundredth) at the CAS changes. This gives you an arbitrary error in the range from 5 late to 5 early.

To avoid these types of problems, you should carry out calculations involving very low speeds by hand, using official mileages, if given. Of course, if the rallymaster uses T3 mileages, these issues are ten times less significant.

Official Calculations

Table 19-5 shows how truncation and rounding in the rallymaster's time

calculations and checkpoint clocks affect the leg scores of the perfect car. For checkpoint clock time, a checkpoint clock reading in cents and set correctly is running as T2 – any time of 0.000 to 0.009 is read as 0.00.

One observation: To balance checkpoint clock times which are T2 (the usual case), applying T2 to the final leg time would seem to cancel out this inaccuracy. However, most Regs specify R2.

Checkpoint Timing

The last issue we will look at is how the timing is actually handled at the checkpoint timing line. Aside from organizers who have apparently set their checkpoint clocks with a sundial, we are assuming that the clock itself is set correctly (see [Chapter 9](#)). Table 19-6 shows differences in the way the clock is triggered.

Effects of Time Truncation and Rounding								
Time or Calculation	T2		R2		E2		T3	
	Worst	Avg	Worst	Avg	Worst	Avg	Worst	Avg
Final leg time	1L	0.5L	0.5E/L	0			0.1L	0.05L
Checkpoint clock time	1E	0.5E	0.5E/L ^①	0			0.1L	0.05L
Key Times	1E	0.5E	0.5E/L	0	0 ^②	0	0.1E	0.05E
Intermediate Calcs ^③	1E	0.5E	0.5E/L	0	0 ^④	0	0.1E	0.05E

Table 19-5

- ① Checkpoint clock times can be made R2 by setting the checkpoint clock $\frac{1}{2}$ of a cent early (fast). However, competitors might take exception to this practice!
- ② Key times in the instructions which are anything but E2 are called **dirty key times**. Such a situation is usually due to rallymaster oversight in the official calculations.
- ③ This effect is accumulated once for each interval on the leg. However, most Regs require calculations to be carried out R4 or at least T4. With T4, 20 intervals on a leg will yield an average of 0.1 cent early.
- ④ This is possible only if the rallymaster assigns speeds which have whole-number Rate values: CAS 60, 30, 20, 15, 12, 10, and so on.

To measure the effect, we did some tests:
We set up a checkpoint with all the following timing methods and ran repeated tests; taking the light beam trigger broken by the front of the car as a standard:

Table 19-6: Type of timer		Avg Timing (cents)
A.	Light-beam trigger	0
B.	Hose trigger (actual) 30-45 mph	0.18 late
	Hose trigger (theoretical) CAS 30	0.10 late
	Hose trigger (theoretical) CAS 15	0.21 late

C.	Hand timed at line, anticipating car arrival	0.08 late
D.	Hand timed 20 feet past the line, anticipating car arrival	0.16 late
E.	Hand timed using a mirror at the line angled at 45° to the road – no anticipation	0.46 late
F.	Flag dropped at line, clock hand triggered from flag drop – no anticipation	0.62 late
G.	Secret checkpoint, hand timed from up a sideroad – no anticipation of car arrival	0.44 late

The B tests on hose triggers used a pneumatic hose that triggered a diaphragm to close the external split circuit of the clock. It was done on a road with cars passing at about 30 to 45 mph. The theoretical quotes are calculated based on a distance of 33" from the front bumper to the wheel contact point. The fact that the actual test on hose triggers shows a greater delay than the theoretical delay at 30 mph indicates a lag in the triggering mechanism itself.

The big difference in the various types of hand timing seems to be whether the person doing the timing can anticipate the arrival of the car, or whether they are responding to something which announces the car's arrival.

The Fix

To compensate for the issues discussed in this section, some teams use a rather controversial technique: biasing their time-of-day clock! Here's how it works:

- Examine all the issues discussed in this section and figure out how they were or are going to be done in an event.
- Add together the average cases and come up with a total which you, as the perfect rally car, will get as a score.
- Bias your time-of-day clock in the other direction.

For example, assume you are running an event with the following attributes:

- T2 mileages

- Legs start from an out-marker with a zero mileage
- Intermediate calculations done T4 – assume 10 intervals per leg
- No Key Time – leg start times are given at open checkpoints
- Checkpoint timing is T2
- Final leg times are R2
- Average speeds are CAS 30
- Checkpoints are timed by method D above

Out-marker mileage – E2	0
Checkpoint mileage – T2	1.000 cents late
Intermediate calcs – T4	0.050 cents early
Checkpoint timer – T2	0.500 cents early
Final leg time – R2	0
Checkpoint timing method – D	0.160 cents late
Total	0.610 cents late

On this rally, the perfect car would average 0.61 cents late, or be 1 cent late 61% of the time. Setting your clock early (fast) 6 mils or $\frac{6}{10}$ of a cent compensates for this.

20. Odo Class Navigation

Your mileage may vary

— Environmental Protection Agency

In this Chapter we will look at a navigation strategy for competing in a class that exists under most classification systems. The class usually allows precision odometers and clocks and a minimum of calculating equipment. In some areas this class is called 'Unequipped', although we will see that a good setup will make your dashboard look anything but unequipped. The navigation strategy we will explore allows a team to get within striking distance of the scores in the Computer class on a regular basis.

This is also the navigation strategy Vera and I have used over the last several years in New England Regional events in Class B and on the National Touring Rallies in Unequipped Class. Because of this, the navigation strategy presented in this Chapter is described in more detail than other navigation strategies in this book. It is also described in a more cookbook fashion. We will actually describe two variations on this navigation strategy, one based on time of day and the other based almost entirely on interval time.

The Concept

The strategy uses a pair of odometers and a pair of clocks, with either tables or a Stevens wheel for calculations. More specifically, you will need:

Overall Odometer. A hundredths-reading odometer with a calibration factor. This is used to track the overall mileage and is primarily for use by the driver in finding official mileage references (e.g. turns, landmarks). You must be able to zero and calibrate this odometer as well as split its display and change its value by small amounts on the fly.

Interval Odometer. A hundredths-reading odometer with a calibration factor. This odometer tracks the mileage since the last speed change and is mostly used by the navigator for intermediate readings between speed changes. You must be able to calibrate this odometer and Taylor Split its display. Whether the interval odometer is independent or dependent on the overall odometer is important in very competitive events. If mileages are T2, you want an interval odometer which is dependent at the hundredth place on the overall odometer.

R2 or T3 mileages call for an independent interval odometer.

Both odometers need a forward-park-reverse feature that affects the two odometers simultaneously.

Clock. A time-of-day clock that reads minutes and cents. It should be easy to set and needs a split feature.

Interval Timer. A clock which can be Taylor Split and whose value can easily be adjusted by small amounts. This clock is used by the navigator together with the interval odometer to give intermediate readings between speed changes.

TSPLIT Switch. This is a two-position switch which is wired so that, when activated, it

- Splits the overall odometer;
- Taylor-splits the interval odometer;
- Splits the clock; and
- Taylor splits the interval timer.

When deactivated, all the displays are updated and count as normal.

Some B-Boxes have a built-in TSPLIT capability. Many others can be wired to a remote TSPLIT switch which also controls a second clock or timer.

Stevens Wheel. This is the primary tool for calculations, if you are not using tables.

Tables. A set of tables which give you readings for time based on mileage at a given CAS. These tables are very specific to this method and are designed to simplify the

system to a point where 20 readings per mile are attainable (if needed). The tables are used in substitute for the Stevens wheel, but you should always pack a Stevens just in case!

Lapboard. A well organized lapboard really helps in this strategy.

The goal of this strategy is to come close to the capabilities of a rally computer using precision odometers, clocks, and tables. This tends to keep the navigator quite busy giving intermediate readings. However, scores averaging 1.5 to 3 points per leg are attainable with practice.

Before the Start

Pre-calculating for this strategy is standard, except that it has to be done without a calculator. For determining the perfect time to cover an interval, the tables or Stevens are about as easy as the calculator.

However, subtracting the overall mileages to get delta mileages can be a real chore since these will need to be done by hand. If the event is a perfect-time rally with the official mileages at every turn and no delta mileages given in the route instructions, the navigator will be quite busy pre-calculating. However, this will pay off handsomely when running the event.

Pre-calculating averaged pauses and gains does not need as much attention before the start. As we shall see, you will be able to give readings while running these distances, so finding a reduced or increased speed is not necessary. However, pre-calculating

pause equivalents for a CAS given for a short distance is very useful.

The Odometer Check

Before you pull up to the starting line, you will have set up the equipment with certain default settings:

- Clock set to the official time.
- Overall and interval odometers zero and in PARK.
- Calibration factors set to your default values. You may want to use a calibration factor that you know will closely match your stock odometer as an equipment check (see [Chapter 10](#)). Alternately, you may have some information which lets you pre-calibrate your odometer, so use that factor.

At the start line:

- Odometers in FORWARD.

As you drive the odometer check, it is a good idea to note the odometer reading at several points where you have an overall mileage. This gives you a backup in case you go off course before the end of the odometer check. Enter these figures on the route instructions and come up with some intermediate calibration factors. It is NOT a good idea to install these factors into the odometers during the odometer check. This is just too big an opportunity for a mistake. However, if the event has a tire warm-up which precedes the odometer check, you may want to effectively run two odometer checks.

At the end of the odometer check, pull up to the line, activate the TSPLIT switch, and then pull forward a short distance. Then:

- Record the overall odometer on the route instructions.
- Deactivate the TSPLIT switch. The interval odometer will now show your distance from the end of the odometer check.
- Calculate and enter a new calibration factor based on the formulas 20 or 21 from [Chapter 19](#). Of course, since you don't have a calculator, this will take some ingenuity. You could use a Stevens or figure it out by hand.
- Write down your new calibration factor.
- Set the overall odometer to the official mileage at the end of the odometer check PLUS the reading in the interval odometer.
- Set the interval timer so that it will count up and roll over to zero at exactly your restart time. The easiest way to set the interval timer is to set it to an even number of minutes before your restart time. This operation will be done many times throughout an event, so you should become adept at it.

If the new calibration factor is significantly different from the old one, you can introduce a significant mileage error. If, for example, your odometer was reading 10% low (short) on the odometer check and you (for some reason) had to pull ahead 0.10 miles from the end of the odometer check, your interval odometer will be 0.01 mile low. An easy way to handle this problem is to return to the end of the odometer check

and reset your overall odometer and interval odometers.

Returning to the end of the odometer check has another advantage on highly competitive events. Rather than sitting around at the end of the odometer check letting your tires cool down, you can take a short drive to keep them up to temperature and return to the end of the odometer check just before your start time.

Tables, the Stevens, and Readings

A major goal of this strategy is to give accurate readings as frequently as possible. Much of this depends on the ease with which a distance can be converted into a time at a given CAS. We promised earlier that you could give 20 readings per mile. The key is that the navigator is converting the interval odometer into a time, using tables or a Stevens, and comparing that time directly with the interval time display. No addition or subtraction is needed to give a reading.

If you use a Stevens, you will only use two pointers to give readings. Align the M and E pointers together, then set the M-E on your CAS, arc the large T pointer to 60 and lock them in place. To give a reading, rotate M-E to an interval mileage that will come up soon and read T. Say that number to yourself. When the interval odometer reaches the selected mileage, the interval timer should match the reading from the T pointer. If the timer is less, you are early by the difference. If the timer is more, you are late by the difference.

Rather than always working with the M-E pointers together, we simply removed the E pointer from our Stevens wheel when we started running this navigation strategy. We used a Stevens wheel for two years before switching to tables. The primary reason for the switch was resolution.

With tables, you can have as many digits of resolution as you wish. After a year of experimenting with various table designs,

<u>Odo Navigation Log Sheet</u>				Leg: ____
<u>CAS</u>	<u>ΔCM</u>	<u>Calc Time</u>	<u>Actual Time</u>	
		____:____.____ (start)		
____	____.____	+ ____.		
		____.		____.
____	____.____	+ ____.		
		____.		____.
____	____.____	+ ____.		
		____.		____.

< is Late

we finally settled on the Odo Tables (Table 15-11).

The Log

The primary navigation log for this strategy is used to keep track of overall timing at CAS changes, pauses, gains, and Transit Zones. The log is generally used on all rallies except perfect-time events where you have the perfect time at every NRI.

The Calc Time column is used to track the perfect time and to add in calculated times for intervals, pauses, gains, and Transit Zones. At the start of a leg you enter your start time in the first entry at the top of this column.

The first two columns are used for intervals – you enter the CAS in the first column and the mileage for that interval in the second column. Then, using the tables or Stevens, enter the perfect time to cover that distance in the third column. Adding this third entry

to the number above gives you a new perfect time. Pauses and Transit Zones can be entered directly in this third column and added to the running total. Gains are also entered here, but are subtracted from the total Calculated Time.

For example, take the following route instructions:

0.00	1. Begin at Key Time 11:00.00. CAS 36.
[1.83]	2. Left at T. CAS 28.
	3. Right at Stop. Pause 30.
[3.95]	4. Left onto Warthog Road. CAS 42.

Assume that you are car 17 and the overall mileages in brackets are not shown on the route instructions. If they were, this would be a perfect-time rally. After executing NRI 4, the log would look like this:

Odo Navigation Log Sheet				Leg: ____
CAS	ΔCM	Calc Time	Actual Time	
		11:17.00 (start)		
36	1.83	+ 3.05		
		20.05	20.12	
—	—	+ 0.30		
		20.35	—	
28	2.12	+ 4.543		
		24.893	24.91	
42	—	+ —		
		—	—	
				< is Late

What is the fourth column used for? Where the third column keeps track of the perfect time you should have executed an instruction, the fourth column holds the actual time it was executed. This side-by-side comparison gives you the early/late reading at the last CAS change.

Note the use of thousandths in the Calc Time column. The numbers entered in this column are taken off the Odo Tables, which round all time readings to mils. This provides sufficient precision in Odo Class. For trap rallies or other situations where this degree of precision is not needed, rounding to cents may be appropriate.

Running a Leg

In general, the navigator will be calculating off the interval odometer and interval timer. To get the car up to speed at the end of the odometer check or at any restart point, check the interval odometer for your distance from the restart point and look up the time at CAS to run that distance. Then subtract an estimated time that you allot for acceleration and call *GO!* when the interval timer reads that time. The acceleration time will vary depending on the CAS, the car, road surface, and driving technique, but should be in the neighborhood of 4 to 14 cents.

For example, you are 0.06 miles from the restart point, with a CAS of 30. The perfect departure time from this point is 0.12 minutes after your restart time, and you allow 5 cents for acceleration. You want to accelerate 0.07 minutes after your restart

time. Since the interval timer rolls over to 0.00 at your restart time, you begin accelerating when the interval says 0.07.

To give readings once you are up to speed, all you have to do is consult the interval odometer as described above in the section on giving readings.

Pauses

To execute a pause, you need to do two general things: update the calculated time on your log and adjust the interval timer:

- Write the pause time on the next available line in column 3 on the log and add it to the total. This can be done before you get to the pause location, by about half a mile or so. Then, and this is very important, put a check mark through the pause in the route instruction.
- At or just before the pause location, subtract the pause time from the interval timer. To make sure you remember that pauses are subtracted from the timer, you might want to place a small label near the switch position which subtracts time.

If you take a reading shortly after adding the pause, you will, of course, be early. If the pause is at a turn, you can handle this just like any other restart point. If the pause is given over a distance, just run at a reasonably slow speed until you “burn off” the pause time, then get back on time. Just make sure you are on time and back on CAS prior to the end of the distance given for the pause.

CAS Changes

A change in CAS involves several steps, but, with some practice, the navigator should be able to handle the standard CAS change by rote and fire off a reading in as little as 0.15 of a mile. Here is how it works:

- As you drive past the action point for the CAS change, activate the TSPLIT switch.
- Record two numbers on the next available line on the log: The interval mileage goes into column 2 and the time-of-day clock into column 4. Also, if the NRI has an overall mileage, jot the hundredths of your overall odometer down on the route instructions next to the listed mileage.
- Check the numbers you have recorded and deactivate the TSPLIT switch.
- Make sure the correct CAS is set in the Stevens or the correct table is selected. Look up the time to travel the interval distance (in column 2) and write that time in column 3.
- Total the new calculated time and compare this with the actual time in column 4. If the calculated time is less, you were late at the CAS change (this is likely if you had to slow down prior to the action point). If you forget which way the comparison goes, glance down at the bottom of the log between columns 3 and 4 for a reminder. At this point you can call something like *“Four late at the turn”*. Even though you are probably at least a tenth of a mile past the turn and the reading is not 'current', it can give the driver an indication of how to compensate until you get a current reading. If the

rallymaster is inconsiderate enough to place a checkpoint so close to the CAS change that you cannot get off another reading, this is better than nothing.

- Finally, you need to adjust the interval timer based on how early or late you were at the TSPLIT point. Remember that this was Taylor Split and counts from zero, as does the interval odometer. If you were on time at the TSPLIT, no adjustment is necessary. If you were early, you will need to subtract that much time from the interval time, or add the time if you were late. Again, you might want to label the “- time” and “+ time” switch positions with “Early” and “Late” tags.

If this all sounds busy, it is! But only until you get some practice. Then it becomes second nature and should take about 20 seconds. After you have finished with the speed change, flip to the table for the new CAS or enter it into the Stevens and write this new CAS on your log. Then you can start giving readings again.

There is a quicker way to accomplish the above, but it lacks some precision. Rather than using time of day at a CAS change, you could just keep on using the interval time. Record the interval mileage and interval time instead of time of day (you would use a different log format). Then, to get an early/late reading at the CAS change, use your frozen interval time just like any other intermediate reading. Adjust the interval time (after you un-TSPLIT) based on this reading.

Transit Zone

To handle a Transit Zone, simply treat it like a CAS change with a big pause. Do the same steps as a CAS change, adding in the transit zone time to the Calc Time. Once you are in the Transit Zone, you can calculate your departure time from the end of the Transit Zone and set your interval timer to a number (less than zero) so that it will roll over to zero at the instant of your calculated departure time. Free zones with a known time to transit can also be handled in this way.

Checkpoints

At a closed (flying) checkpoint, you simply need to record all the information and keep going. You can split the odometers and clocks and record all the numbers on your log, or on a separate checkpoint log.

Open checkpoints are a bit more complex. As you cross the line, throw the TSPLIT switch. Then, as you pull over:

- Record the interval mileage and time of day on the log in the normal places for a CAS change.
- Write the overall mileage somewhere on the log.
- Write down your time allowance, if needed.

You can then hand in your scorecard, including any time allowance. When you get the scorecard back, immediately:

- Verify that the recorded arrival time agrees with your split clock ± 0.01 cent. If

it does not, settle the issue on the spot, using your split clock, if needed.

- Verify that any TA you requested has been recorded by the crew.
- Quickly check that the start time you have been assigned allows sufficient time to reach the restart for the next leg.

Back in your car:

- If the rally uses out-markers rather than starting a leg from the timing line of the last checkpoint:
 - move to the out-marker
 - adjust your overall mileage to match the official mileage
 - zero the interval mileage
 - clear the line
- Un-TSPLIT.
- Record your assigned start time in the Calc Time on a new logsheet. Double check that you have the correct start time.
- Read the checkpoint slip. Note the next NRI, starting CAS, and any special instructions on the slip.
- If the CAS has changed, beware! Some of your upcoming pre-calculations may be wrong. You may, for example, have calculated a pause equivalent based on a CAS which is now incorrect.
- Note the official mileage at the checkpoint line. Adjust your calibration factor, if needed.
- Adjust your overall mileage so that it matches the official mileage, plus the distance from the checkpoint line or out-marker.

- Set the interval timer so that it will count up and roll over to zero at exactly your restart time.
- Since you have the official mileage at the out-marker or checkpoint timing line, you may be able to pre-calculate the perfect time to the next speed change.

Finally, calculate your score for the leg just completed.

Perfect-Time Rallies

Compared to events that don't have a mileage at every instruction, perfect-time events are a breeze in Odo Class with the equipment setup described at the start of this chapter. The critical part is to pre-calculate the perfect time to each instruction and not make any mistakes. You can almost always do without a formal log – just write the calculations neatly on the route instructions and keep a separate sheet just for calibration factor notes and a log of checkpoint information.

Then, at every instruction, activate the TSPLIT switch and compare your time-of-day clock with the perfect time you have in the route instructions. You can almost immediately give a reading at a turn. Then bias the interval timer accordingly. When in Free Zones or Transit Zones, you can simply set your interval timer so it reads zero at the correct time of day to leave the end of the zone.

Off-Course Situations

Going off course in Odo Class simply involves carefully measuring the return trip, as discussed in [Chapter 19](#) and probably taking a time allowance. If you are not running a perfect-time event, then you can simply add the time allowance into the Calc Time on your log as if it were a pause.

However, time allowances on a perfect-time rally can be a real bother. A time allowance means that you will have to add the time to your calculated perfect time on every instruction that you pre-calculated. What a pain! What a chance for a calculation error! Don't get lost!

Why Run Odo Class?

After reading this chapter, you might begin to wonder if Odo Class is simply a synonym for rally masochism. Why would anyone want to toil away all day slavishly spinning a Stevens and spewing out a long series of readings, especially when we have computers which can do it better?

The only justification that I can give is that Odo Class seems to call for the best balance of skills from some teams and a good forum for competition. Proficient navigators are often bored when running Computer Class or Speedo Class, because there is little to do between instructions.

Odo Class also challenges the driver. A good sense of being on time in the driver's foot, together with the ability to handle almost everything while the navigator crunches numbers, is a reward in itself.

Finally, Odo Class rules seem to minimize the luck factor involved in winning. In very competitive rallies such as National Touring Rallies, the precision of top Computer Class teams can exceed that of the rallymaster. When the top 8 places in Computer Class cover a spread of 5 points after 25 checkpoints, luck plays a big factor. On the other hand, Odo Class scores tend to be spread across a wider range than Computer Class score. Luck is less of a factor in who wins Odo Class.

A Radical Strategy

There is at least one method that adheres to the letter of the class rules for Odo Class and gets you nearly the equivalent of a computer null unit. Some would consider this against the spirit of the class.

Consider how easy it is to give readings at CAS 60. If you start with a zeroed interval odometer and interval timer, they will both count in unison when you are on time. If the timer is greater or less than the odometer, you are late or early by the difference. No tables. No calculations.

Now say we had a CAS change to 30. To preserve this very nice relationship between the timer and the odometer, all we have to do is change the calibration factor in the odometer so that it reads twice the distance traveled. On an additive odometer we would simply double the calibration factor.

Expanding this idea soon leads to a simple system where you use the Stevens to convert your initial calibration factor to an

appropriate factor, which we herein ordain the **null factor**, for each CAS. This is really the only calculation which is needed - one calculation for each different CAS in the event.

In the way of hardware, you need an interval odometer in which the calibration factor can easily and quickly be altered. Perhaps a setup with two factors – a “live” one and a “next” factor. The result is a pair of numbers which, when running in synch, means you are on time.

Finally, to conclude this section: No, we have never used this method.

The Checklist

See the checklist on the next two pages ...

TSD Rally Checklist - Odo Class

Before Event

- Read generals
- Review Regs
- Gas, oil, clean windshield
- Check all car lights

Before Start

- Affix car number
- Set clock
- Fill out scorecard
- Check routes: page #, legibility
- Highlight routes
- Pre-calc intervals
- Enter initial calibration factor
- PARK
- Zero both odometers

Start of Odo Check

- FORWARD

End of Odo Check

- TSPLIT
- Clear the line
- Record overall mileage
- unTSPLIT
- Calculate and enter new calibration factor
- Set overall mileage
- Set interval timer to roll over to zero at restart time

Start of Leg, ETZ

- Set overall mileage
- Set interval timer

CAS Change

- TSPLIT
- Record interval mile & time-of-day
- unTSPLIT
- Update Calc Time & compare
- Adjust interval timer

Pause

- Add pause to Calc Time on log
- Check pause off on NRIs
- Subtract pause from interval timer

Gain

- Subtract gain from Calc Time on log
- Check gain off on NRIs
- Add gain to interval timer

Begin Transit Zone

- TSPLIT
- Record interval mile & time-of-day
- unTSPLIT
- Calculate perfect time
- Add transit time
- Set interval timer to roll over to zero at restart time

Off Course

- Retrace course, using REVERSE odometers
- Take a TA, adding TA time into Calc Time

Checkpoint - Closed (Flying)

- Split odos, clock, and time
- Record all numbers

Checkpoint - Open

At the Line

- TSPLIT
- Record interval mile, time-of-day, and overall mileage
- Did you take a TA?

Hand In Card

- Request TA

Get Card Back

- Verify recorded arrival time
- Verify TA Request
- Check start time for Sanity

Move to Out Marker

- unTSPLIT
- Note start time on new log
- Note next NRI
- Note starting CAS
- If CAS changed, adjust pre-calcs
- Read any special instructions
- Adjust calibration factor
- Set overall mileage
- Set interval timer for start time
- Precalc first interval, if possible
- Calculate your score

Checkpoint - DIY

At the Line

- TSPLIT

Clear the line

- Record interval mile, time-of-day, and overall mileage
- Calculate perfect arrival time
- Enter perfect arrival time and TA on scorecard
- unTSPLIT
- Enter start time on scorecard
- Note start time on new log
- Set interval timer for start time

21. Computer Class Navigation

Navigators are driven.

— line from a non-existent bumper sticker

Running Computer Class is easy. You plunk down your \$1000 (give or take \$500), wade through the Chapter on Installation to wire up the A-Box, and you're off to run the event. The navigator is unburdened from most of the calculations and you can obtain absurdly low scores with ease. The brain fried navigator is replaced with one whose worst problem is toggle blisters on the finger tips.

The one hitch: Computer Class is just as easy for any other team. So, the absurdly low scores abound. Who would ever have thought that a 2 would be a “bad” score? But you rack up a number of them and find yourself in 6th place. Hmmm, Computer Class is not so easy.

Assuming you are running straightforward events with moderate speeds, doing well in Computer Class comes down to a battle of accuracy. As the speeds get brisk, teamwork comes into play, while trying to preserve as much accuracy as possible.

This chapter talks about a strategy for running with an A-Box which tries to eliminate as many of the inaccuracies as possible. It is a strategy aimed at winning. As with the Odo Class Strategy, it will take some practice to run cleanly. Most teams seem to need from 5 to 10 events to run blunderless in Computer Class. Of course, you have already sawed through [Chapter 19](#) on Precision Course Measurement.

The Concept

The central piece of navigation equipment in this class is, of course, the computer. Since there are so many designs, we could not hope to talk about the specifics of each A-Box. However, there are some general features and capabilities which are important:

- T2 CAS changes. As we discussed in [Chapter 19](#), many rallymasters calculate leg times with T2 mileages (truncated to two decimal places). To run on time, you must simulate this. Some computers have the ability to do this automatically. If your A-Box does not, you need to run in thousandths of a mile and make adjustments by hand to eliminate this source of error.

- Thousandths-reading mileage. There is currently a controversy about whether events should be measured and calculated to 2 or 3 places. Regardless, you need to have a thousandths-reading odometer, especially if you don't have the capability to do T2 CAS changes.

Aside from the A-Box and associated null unit, the following equipment is needed:

Calculator. Used primarily to fix errors and bring the calculated time in line with official calcs.

Backup clock. When the fuse blows or some other calamity arises, you need to be able to reset your clock. A digital wristwatch with a known drift is fine.

The Log

Many teams in Computer Class fail to keep a log. If you have one of the A-Boxes with a sophisticated log feature which records all the information at each CAS change since the start of an event, maybe you can get

away with it. In any other situation, you will come up short on a number of issues:

- The log helps you quickly verify the rallymaster's calculations for each leg. You must do this. A mileage error can easily go un-noticed at a CAS change from 35 to 32.
- There is not enough room on the route instructions for all the notations you may need.
- To help eliminate blunders, the log acts as a checklist. Did the pause go in? Did the mileage at the sign match the official mileage?
- The log makes locating errors post mortem easier.

This log is organized the way calculations typically appear on checkpoint slips. Check your log against each checkpoint slip and resolve any discrepancies.

- The first two columns simply record the NRI and Computer Mileage (to the thousandth, if you have it) at the start of a leg, CAS changes, Begin and End Transit

<u>Computer Navigation Log Sheet</u>							Leg: ____
<u>NRI</u>	<u>CM</u>	<u>Adj</u>	<u>OM</u>	<u>CAS</u>	<u>Pause</u>	<u>CalcTime</u>	<u>Adjustments to calc time</u>
____	____.____	____	____.____	____	____.____	____.____	_____
____	____.____	____	____.____	____	____.____	____.____	_____
____	____.____	____	____.____	____	____.____	____.____	_____
✓•: Calc ____:____.____ Clock ____:____.____ Crew ____:____.____ Official ____							

Zone points, and at the checkpoints. For a pause, you don't really need to enter the Computer Mileage.

- The Adj column records adjustments you make in your odometer, typically when you have an official mileage in the route instructions.
- The OM column records any official mileages you might get from the route instructions. The Computer Mileage and Official Mileage columns get filled in during the odometer check to give you a side-by-side record of how your mileages drift. During a leg, any time an official mileage is given, you should have a log entry, even if it does not mark a CAS change.
- The CAS and Pause columns show what CAS settings and Pause increments you entered in the computer.
- The CalcTime column records the calculated time showing on the A-Box at each critical point (CAS changes, Begin/End transit zones, etc).
- The Adjustment column is a place to record any changes you make to the computer's calculated time. You might use a calculator to come up with some adjustments. Enter them rounded to the nearest cent. The calculated amount goes before the slash and amounts actually entered into the calculated time go after the slash.
- The bottom is for recording checkpoint information. Calc and Clock are for the split time on your calculated and time-of-day clocks. It's the driver's job to make

them agree. The Crew entry is for recording the time that the checkpoint crew timed you. It should agree with Clock. The Official is for recording the perfect time off the checkpoint slip, for a quick reading on your score. Just the cents is sufficient – an error of a minute is best left undiscovered until you are at least near the bar at the end of the event.

For example, take the following route instructions:

0.00	1. Begin at Key Time 11:00.00. CAS 42.
[1.83]	2. Left at T. CAS 28.
	3. Right at Stop. Pause 30.
3.95	4. Left onto Warthog Road. CAS 36.

Assume that you are car 17 and the overall mileage at NRI 2 is not shown on the route instructions. Assuming that there is a checkpoint after NRI 4, the log would look like this:

Computer Navigation Log Sheet							Leg: ____
<u>NRI</u>	<u>CM</u>	<u>Adj</u>	<u>OM</u>	<u>CAS</u>	<u>Pause</u>	<u>CalcTime</u>	<u>Adjustments to calc time</u>
<u>1</u>	<u> </u>	<u> </u>	<u> </u>	<u>42</u>	<u> </u>	<u>17.00</u>	<u> </u>
<u>2</u>	<u>1.838</u>	<u> </u>	<u> </u>	<u>28</u>	<u> </u>	<u>19.63</u>	<u>+.0057/+1</u>
<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>0.30</u>	<u> </u>	<u> </u>
<u>4</u>	<u>3.941</u>	<u>+01</u>	<u>3.95</u>	<u>36</u>	<u> </u>	<u>24.44</u>	<u>+.0043</u>
<u>✓.</u>	<u>4.868</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>
<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>
<u>✓•</u> : Calc ____:____.____ Clock ____:____.____ Crew ____:____.____ Official ____							

Winning in Computer Class requires that you run with no blunders. Period. The best way to achieve that is to have a system for handling all the mundane things like CAS changes and pauses which is absolutely goofproof. You must have a system which ensures that you never miss a pause and that you can go back and check that everything has been done correctly.

Winning in Computer Class also requires that the navigator has lots of free time to consider issues of precision course measurement. If the navigator is worried about whether the last pause went in, he may miss that you gained 2 hundredths on the last hairpin because Happy Charlie there in the left seat decided to show off for the spectators.

Before the Start

Most Computer Class teams don't pre-calculate the route instructions. Why bother? Won't the A-Box do the calculating on the fly?

Yes, the A-Box will do all the interval calculations for you on the course. In an event with few official mileages or where extreme accuracy is not needed (such as a trap rally), there is no need to pre-calculate. However, what about a perfect-time rally? You could let the A-Box do the calculations on the course, but you are relying on the A-Box matching the official mileages perfectly. If the A-Box does not have T2 CAS changes and the official calculations are done T2, you will need to adjust the calculated time by small amounts at every CAS change.

While there is no need to pre-calculate pauses or gains over a distance, pre-calculating intervals in an event with lots of mileages is easy and gives you perfect times to every turn in a perfect time rally. Besides, you may already have the perfect calculator: the A-Box itself. Many current A-Boxes allow you to run through the mileages and CAS changes and write down the calculated time. Alternately, you could spring for a Curta, Turbo-Kurta, or some other cumulative calculator so that you can do the calculation on the odometer check while the A-Box is counting miles.

Also, pre-calculating pause equivalents for a CAS given for a short distance is very useful. This is done using [Formula 18](#).

The Odometer Check

I was wandering around the parking lot before the start of a recent National Touring rally, and happened to check my watch against another competitor's clock. It was off. About a full cent! I checked against another clock – about half a cent! And another – right on. Hmmm. Various Computer Class teams had set their clocks differently.

The event, as some teams had learned, was using checkpoints with two people to do timing: one to drop their hand at the line and the other to split the clock based on the first person. Some teams had elected to bias their clock so that they ran early all day. Hopefully, this would compensate for the inherent lateness in the checkpoint timing “system”. Before you decide to bias your

clock, you should read the various discussions in [Chapter 19](#) and decide how each item affects your time.

Before you pull up to the starting line, you will have set up the equipment with certain default settings:

- Clock set to the official time, plus any clock bias with which you want to run.
- Odometers zero, clear, and in PARK.
- Calibration factors set to your default values. You may want to use a calibration factor which you know will closely match your stock odometer as an equipment check (see [Chapter 10](#)). Alternately, you may have some information which lets you pre-calibrate your odometer, so use that factor.
- Select transit zone mode on the A-Box.
- Enter the first CAS (past the end of the odometer check)
- Set the calculated time to your departure time from the end of the odometer check.

At the start line:

- Odometers in FORWARD.

As you drive the odometer check, note the odometer reading at any point where you have an overall mileage. This gives you a backup in case you go off course before the end of the odometer check. Enter these figures on the log. It is NOT a good idea to install these factors into the odometers during the odometer check. This is just too big an opportunity for a mistake. However, if the event has a tire warm-up that precedes

the odometer check, you may want to effectively run two odometer checks.

You should calculate your calibration factor many times throughout the odometer check. These calculations show any trend for the calibration factor as discussed in [Chapter 19](#).

At the end of the odometer check, pull up to the line:

- Switch out of transit zone mode.
- Check that the start time and first CAS are set.
- Write down the overall odometer reading.
- Calculate a new calibration factor based on the [Formula 23](#) or [Formula 24](#). Enter it into all odometers. You may wish to take trend information into account or develop several factors for different types of road surfaces.
- Write down your new calibration factor(s).
- Set your overall odometer to the official mileage at the end of the odometer check. Do this without affecting the calculated time.
- Clear the line by moving forward a short distance.

If your calculations take longer than about 30 seconds, it could be dangerous, as well as inconsiderate to the next competitor, to park on the line. In this case the following procedure can be used:

- Pull up to the line and PARK the odometers.

- Clear the line by moving forward a short distance.
- Write down the overall odometer reading.
- Calculate a new calibration factor based on the [Formula 23](#) or [Formula 24](#). Enter it into all odometers. You may wish to take trend information into account or develop several factors for different types of road surfaces.
- Write down your new calibration factor(s).
- Set your overall odometer to the official mileage at the end of the odometer check. Do this without affecting the calculated time.
- Switch out of transit zone mode.
- Check that the start time and first CAS are set.
- Drive back to the end of the odometer check (two U-turns).
- Odometers in FORWARD.
- Again, clear the line to await your start time.

This second procedure for the end odometer check has an advantage on highly competitive events. Rather than sitting around at the end of the odometer check letting your tires cool down, you can take a short drive to keep them up to temperature and return to the end of the odometer check just before your start time.

Running a Leg

While you run a leg, the main job of the navigator is to keep the overall mileage/calculated time of the A-Box in line

with the official mileages/calculations. Most drivers figure their own lead time needed to get up to speed.

Pauses

To execute a pause or gain:

- Add (pause) or subtract (gain) the time to/from the calculated time in the A-Box.
- Note the time on the log.
- Check off the item on the route instructions.

If the pause (or gain) occurs along with a speed change, enter the pause (or gain) well ahead of the instruction. This frees the navigator to do the speed change.

Another trick is to ask the driver how much time was entered. The driver should be able to tell from the null unit and this provides an excellent way to double check how much time was entered.

CAS Changes

Changing CAS is absurdly simple on most A-Boxes. Just throw the switch. This also applies to the start or end of a transit zone.

However, if the odometer does not match the official mileage or your A-Box is not calculating time the way the official calcs were done, you are introducing inaccuracies. To handle issues of small mileage variation at these points, we will

have a new concept, the **target mileage**. The target mileage is the mileage we want the A-Box to use for the calcs.

We will look at several ways to get your A-Box to use the target mileage. First, is a complete method which will work in any situation. However, it is rather cumbersome and complex. You should understand this method and be prepared to use it if needed.

- Enter the new CAS in the computer and simultaneously split the A-Box. You will need to experiment with your A-Box to see if the CAS change takes effect with the A-Box split. If it does, you can throw both switches at the same time. If the A-Box cannot be split when you do a CAS change, you will need to ensure that you throw the CAS change switch slightly before SPLIT.
- Write down the NRI, car mileage, and calculated time on the log. If you have an official mileage, enter it on the log as well.
- Figure out the target mileage. The target mileage is the official mileage, if you have one. Otherwise, the target mileage is the odometer reading, rounded or truncated the way the rallymaster would round or truncate to get the official mileage at that point. If the rally uses T2 mileages, just drop anything past the hundredths to get the target mileage.

Formula 25. *Target Mileage Adjustment*

$$\frac{(Odo\ mileage - Target\ mileage) \times 60}{New\ CAS} - \frac{(Odo\ mileage - Target\ mileage) \times 60}{Old\ CAS} \rightarrow Adjustment$$

- Adjust your calculated time based on the target mileage. If the A-Box used exactly the same mileage for the CAS change as the target mileage, no adjustment is needed. However, if the A-Box used *Odo mileage*, you need to change the calculated time by adding the adjustment from [Formula 25](#). Some points:

- ▶ If you are leaving the end of the transit zone, the *Old CAS* is effectively ∞ , so the right fraction in the formula is 0. Likewise, if you are starting a transit zone, the left fraction is zero.
- ▶ Many A-Boxes have a feature that allows you to change both the mileage and calculated time simultaneously. This feature does not quite work in a CAS change situation because they use the *New CAS* rather than the *Old CAS* to make the adjustment. If the two speeds are far apart, the adjustment can be inaccurate. Some A-Boxes have a feature designed especially for this situation – they let you use any speed when making an adjustment.
- ▶ If you are making a manually calculated adjustment at a speed change when the last official mileage on the route instructions was given some great distance ago, you need to select *Old CAS* carefully. You need to look over the route instructions since you last corrected to official miles and pick an *Old CAS* which averages the CAS assignments used over that range.

- Finally, adjust your overall odometer to the official mileage, if you have one. Since

we have adjusted the time above, you need to change the odometer without affecting the calculated time.

As an example, say we executed NRI 2 (from a few pages back) at odometer 1.838. We do the CAS change on the A-Box, split the number, and enter a new line in the log. The event uses T2 calculations, so our target mileage is 1.830 – the mileage we expect to be used in the official calculations. The A-Box did the CAS change 0.008 miles too late. To adjust the calculated time, we use [Formula 25](#):

$$\frac{(1.838 - 1.830) \times 60}{28} - \frac{(1.838 - 1.830) \times 60}{42} \rightarrow +0.0057$$

An easier way is to use the shortcut suggested in [Chapter 17](#) for handling speed differences over an interval.

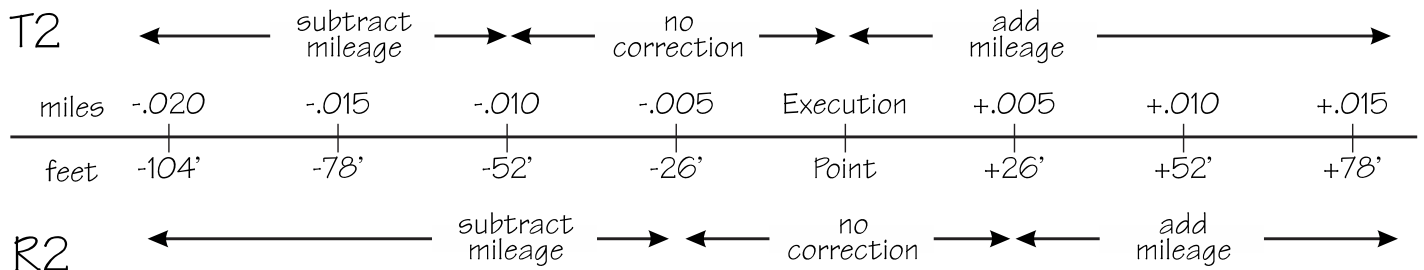
However, most calculated times cannot be adjusted in fractions of a cent. The best we can do here is to adjust by adding 1 cent to the calculated time and recording what we actually entered.

Now at instruction 4, we have a CAS change from 28 to 36. We also have an official mileage. The target mileage at this instruction is 3.950 and our odometer comes up 0.009 short. First, we calculate an adjustment to the calculated time:

$$\frac{(3.941 - 3.950) \times 60}{36} - \frac{(3.941 - 3.950) \times 60}{28} \rightarrow +0.0043$$

However, since we have already added 1 cent at NRI 2, we are fine here – the calculated adjustment exactly matches the actual adjustments made so far.

Mileages



Finally, we update our odometer by adding one hundredth, so that it tracks the official mileages. Since the odometer has drifted a full hundredth in only 4 miles, we need to watch if the trend continues and think about making a factor change.

CAS Change Shortcuts

The “complete” method for CAS changes presented above gets tiresome if you have to use it often. This section presents some tricks that have the same effect as the complete method, but require few calculations.

If you have no official mileage and the mileages are T2, do the CAS change at whatever point in the 52 feet (0.01 mile) prior to the execution point that the odometer rolls over to a whole hundredth. For R2 with no official mileage, do the CAS change 26 feet (0.005 mile) before or after the execution point as the odometer rolls over to a whole hundredth. This works if your calibration factor is accurate.

If you have an official mileage, you can always do the CAS change at the point where the A-Box's odometer rolls over to the

official mileage. You may have to correct your odometer, depending on where you did the CAS change:

The trick is to do the CAS change when the A-Box reads the official mileage, whether that point occurs before or after the execution point. In addition, you must read and record the odometer at the execution point. You will have to experiment with your A-Box to find out how to accomplish this in two cases: when the overall mileage rolls over before the execution point and when the execution point occurs before the overall mileage rolls over. Many A-Boxes have the overall mileage on the driver's null unit, which the navigator can read if the main unit is split.

Then all you need to do is correct the A-Box's mileage to the official mileage, as well as the time (many A-Boxes allow you to adjust both at the same time). If the official mileage rolls over within 52 feet before the execution point, for T2 mileages, or ± 26 feet, for R3 mileages, no adjustment is needed. Otherwise, you need to change the odometer by (*official mileage – odometer reading at the execution point*). If you consistently need to correct in the same direction, you may want to consider changing the calibration factor.

One note about tracking the target mileage with an A-Box: You have to know when it is appropriate. Figuring the time difference between the target mileage and actual mileage your A-Box uses is only important at certain times – when the difference in speeds is large, when one speed is very small or zero (a Begin or End Transit), or when the mileages are way off (very loose surfaces).

Checkpoints

At a closed checkpoint, you simply need to record all the information and keep going. You can split the A-Box and record all the numbers on your log, or on a separate checkpoint log.

Open checkpoints are a bit more complex. As you cross the line, SPLIT the A-Box. Then, as you pull over:

- Record the odometer on the next line of the log.
- Record your calculated time and time of day at the bottom of the log.
- Write down your time allowance, if needed.

You can then hand in your scorecard, including any time allowance. When you get the scorecard back, immediately:

- Verify that the recorded arrival time agrees with your split clock ± 0.01 cent. If it does not, settle the issue on the spot, using your split clock, if needed.
- Verify that any TA you requested has been recorded by the crew.

- Quickly check that the start time you have been assigned allows sufficient time to reach the restart for the next leg.

Back in your car:

- UnSPLIT.
- Read the checkpoint slip. Note the next NRI, starting CAS, and any special instructions on the slip.
- Ensure that the correct CAS is set in the A-Box.
- If the CAS has changed, beware! Some of your upcoming pre-calculations may be wrong. You may, for example, have calculated a pause equivalent based on a CAS that is now incorrect.
- Record your assigned start time in the Calc Time on a new logsheet. Double-check that you have the correct start time.
- Enter the start time as the calculated time.
- If the rally uses out-markers:
 - place the A-Box in transit zone mode
 - move to the out-marker
 - adjust your overall mileage to match that of the out-marker
 - take the A-Box out of transit zone mode
 - clear the line
- If the new leg starts from the timing line of the leg just completed, you will have to account for the distance traveled from the line:
 - Subtract the current overall mileage on the A-Box from the mileage you had at the line. Do this calculation to the thousandth. Jot down this distance from the line somewhere.

- ▶ Add to your calculated time the perfect time to cover the interval you just jotted down at the current CAS. If the CAS changed at the timing line, you may have to manually calculate the new interval time. This is a commonly overlooked situation!
- ▶ Set the odometer to read the official mileage at the checkpoint line plus the distance from the line. Do this without affecting the calculated time.
- Compare your mileage with the official mileage at the checkpoint line. Adjust your calibration factor, if needed.

Verifying the Calculations

After you get the official calculations, you need to verify that they match your calculations. At the lunch break or just after the event, see how closely your mileages on each log match each of the official mileages. Then compare your CalcTime column with the official accumulated times. If they don't match, find out why. If it is a calculation error on the organizers' part, it may show up as a few cents in the leg time. If you find a discrepancy, you should report it to the organizers.

22. Speedo Class Navigation

I watched the Indy 500, and I was thinking that if they left earlier they wouldn't have to go so fast.

— Steven Wright

Running TSD rallies without any odometer at all sounds bizarre, at first. How can you calculate? How could anyone get reasonable scores?

Yet many rallies have a class with exactly this limitation. And advanced teams running this class do surprisingly well – the Speedo Class (Class C) winner in New England Regional events often scores less than $\frac{1}{2}$ point per competitive mile. In the Great American Race, the top teams do even better – one point per hour in antique cars!

But there is more than just the novelty and lack of expense in running Speedo Class. Navigating without an odometer calls for fundamentally different driving and navigation techniques.

Top teams tend to divide up the workload between driver and navigator in a different way than in other classes. Since driving on-speed is critical to your score, the driver will concentrate far more on this aspect and

leave tasks such as looking for turns and signs, reading the next instruction, and even being alert for traffic and road hazards (within the limits of safety) to the navigator. In effect, the driver does more navigating and the navigator does more “driving” than in other classes.

And what about navigation? The first thing people tend to come up with when brainstorming ideas are ways to get mileage by some unusual means. You could count telephone poles and multiply by the average distance between poles in each township. You could count center-line dashes. These ideas sound better than they work.

Navigation strategies for running Speedo Class vary widely depending on many issues: Exactly what is allowed for a speedometer? What calculation equipment is allowed? Are mileages or perfect key times given in the route instructions? Is the event “busy”, with lots of speed changes and intersections, or “sedate”, with long stretches at one speed.

In this chapter and the next, we will look at two navigation strategies for running Speedo Class. This chapter covers a strategy which uses a calculator capable of accumulating a calculated mileage. The strategy for Limited-

Speedo Class presented in [Chapter 23](#) uses no calculator. But more than just the difference in calculating equipment, the two strategies are suited to very different types of events. The Speedo Class strategy is best suited to events in which overall mileages occasionally appear in the route instructions and is probably better for busier events. The Limited-Speedo strategy is more suited to events where a custom speedometer of high accuracy is allowed. Serious competitors will review both strategies and pick the most appropriate techniques to form their own strategy.

The Concept

The strategy we present for Speedo Class is based on these concepts:

- Careful calibration of the speedometer.
- Pre-calculating the perfect times to known intervals.
- Tracking all deviations from on time and compensating in a controlled way.
- Calculating a mileage from time and comparing it against any official mileage you get in the route instructions. This gets you an early/late reading whenever there is an official mileage.

The strategy presented in this chapter combines these somewhat independent approaches. You can use any or all of these tactics, or combine them with techniques described in the next chapter. The last tactic, calculating a mileage based on time provides you with a cumulative reading and

can be very powerful in events with an occasional official mileage.

This navigation strategy assumes the following equipment:

Stock or Custom Speedometer as discussed in [Chapter 12](#).

Time-of-day clock. You should be able to split it.

Auxiliary stopwatch. This is used to measure short intervals of time.

Cumulative calculator. This strategy assumes that you can use a Curta or some programmable calculator. This comes in handy when accumulating a calculated overall mileage. However, if you are only allowed a simple calculator, Stevens, or tables, the strategy still works. You just have to accumulate the overall mileage by hand. We discuss how to use each in a section below.

Preparation

Doing a really precise job in Speedo Class means some fairly thorough preparation before the event.

First, you need to get the speedometer calibrated as described in [Chapter 12](#). You should show up at the event with whatever speed correction tables you may wish to use already prepared and with the bias (if needed) already calculated.

Learning how much time various maneuvers take is key in Speedo as well as Limited-Speedo Class. However, since we are

concentrating on a cumulative calculator-based strategy in this chapter, we will save the details of how to time your maneuvers for the next chapter.

Before the Start

After you receive your route instructions, you will need to

- Check the route instructions to make sure you have all the pages and that they are legible.
- Highlight the route instructions and paste a copy on the reader board.
- Pre-calculate everything you can, as we did in the Basic Strategy. Pause equivalents, as discussed in [Chapter 17](#), are not a good idea.

Final Speedometer Calibration

In [Chapter 12](#) you calibrated your speedometer and eliminated the variations at different speeds. It should also be calibrated close to statute miles. The beginning of the event will have an odometer or speedometer check. On the check you will be bringing your calibration in line with the official miles.

Your goal is to precisely measure one thing: the percentage difference between the statute mile to which you calibrated your speedometer and an official mile. This percentage will be called the **variation** for this event. If your variation is positive, a mph reading on your speedometer is slower than the official mph. If your variation is

negative, mph readings on your speedometer have you traveling faster than official mph values.

There are three different Final Speedometer Calibration situations you can encounter:

The Speedometer Check

Rallies that prohibit use of the odometer for all competitors will usually give perfect times rather than mileages at various points throughout the initial portion of the event. The rallymaster has converted the official mileages to times at some given speed(s). The times are based on a given speed with a flying start and finish. The conventional odometer check becomes a ***speedometer check***.

To find your variation percentage for this event, simply run the speedometer check at the given speeds, as you would run a leg. Use a flying start, if possible. The navigator now records your actual time of passage at points on the speedometer check where you are given a perfect time.

At the end of the check, look over the perfect versus actual times. Do not consider portions of the course where you could not maintain speeds. For example, if a flying start was not practical, eliminate the beginning portion. If you got held up by traffic or a complex intersection, eliminate that portion. For the “reliable” portions, come up with the variation – the percentage your actual times are early or late compared to the perfect times.

If you are running later than perfect times, your variation is positive. If you are running early, your variation is negative.

Odometer Check

If you are running an event that has odometer as well as non-odometer classes, you will probably have official mileages to the instructions in the odometer check. Most of these events prohibit your use of the odometer for the entire event, including their odometer check.

For these events, you need to build your own speedometer check. Before the start, look through the route instructions for a likely place to do your speedometer calibration. A portion of the course near the end of the odometer check with many mileaged landmarks and few or no turns is usually a good bet. Experienced rallymasters know the needs of Speedo class cars and will usually include many mileaged landmarks on a section of road suitable for a speedometer check. Some rallymasters even indicate explicitly in the route instructions what portion of the odometer check you should use.

From the mileages, you can use the fundamental TSD formulas to determine perfect times to cover the distances at some speed you select. You might want to calculate times for two speeds and pick the most appropriate one when you arrive at that portion of the course.

Now you can treat the odometer check just like the speedometer check described above. Since you will only be using a portion of the

odometer check, you can head out on the course as early as is legal, take as many runs as possible over that portion of the course, and record your times.

Odometer Check with an Odometer

Finally, if the event has an odometer check with official mileages and you are allowed to use your odometer for the check, there is a very simple way to do the final calibration on your speedometer. Remember that you need to determine the variation – the percentage your statute mile varies from official miles. If you know how your odometer relates to statute miles, you can simply run the odometer check and see how your odometer compares to official miles. Then you can use [Formula 1](#) to get your variation (which is identical to the correction factor).

As a simple example, assume you calibrated your speedometer against a car with an A-Box (see [Chapter 12](#)). You had them set up their A-Box so that it measured miles close to some standard known to be close to statute miles. They also measured a course for you, giving you the statute mileages to points along the course. All you need to do is run that course with your stock odometer and compare your stock odometer readings to the statute mileage. Say your stock odometer reads 1.0% higher than statute miles.

Now assume that, when you run the odometer check, your stock odometer reads 1.0% lower than the official mileages given in the route instructions. This means that official miles read 2.0% higher than the

statute miles to which you calibrated your speedometer. Your variation is -2.0%. If official mileages were less than your statute mileages, your variation would be positive.

This method only works if you are using non-expandable (radial) tires, as noted in [Chapter 12](#) (Speedometers).

Completing the Calibration

If you are running a custom speedometer or marked stock speedometer, you are ready to run the event once you have determined your variation.

If you have an unmarked stock speedometer, you developed a table of *bias* values in [Chapter 12](#). Enter the variation you just determined in the table for the speed you were using on the speedometer check.

For example, say our variation is -1.0% measured at 25 mph. We were traveling 1.0% faster when reading 25 mph on our speedometer than a perfect official speedometer.

The actual variation at 25 mph is 0.6% less than the bias we determined when we calibrated the speedometer. This *difference*, -0.6%, must be added to each bias to get the variation at each speed:

Speedometer Calibration		
Speed	Bias	Variation
10	-0.9%	-1.5%
15	-0.7%	-1.3%
20	-0.7%	-1.3%
25	-0.4%	-1.0%
30	-0.1%	-0.7%
35	+ 0.2%	-0.4%
40	+ 0.7%	+ 0.1%
45	+ 0.9%	+ 0.3%
50	+ 1.5%	+ 0.9%
55	+ 1.4%	+ 0.8%

Using the Variation

Now that you know how your speedometer varies from the official speeds, what do you do with the information?

The obvious answer is to correct each CAS in the route instructions to get a corrected speed to drive on the course. For example, if your variation is +2.0%, driving 33.66 mph for CAS 33 would compensate.

While this approach is technically correct, it is not practical. With face markings at 1 mph increments, most units cannot be read closer than 1 mph or, at best, 0.5 mph. It is far more reasonable to ask a driver to hold the speedometer pointer on a mark, such as the 33 mph tick, than to keep it 66% of the way from 33 to 34 to try and get 33.66 mph.

So if we don't adjust the speeds to account for the speedometer variation, how do we stay on time?

Since we have been using percentages for corrections, there is a beautifully simple

navigation trick. You say your variation is + 2.0%? If you run the assigned CAS on your speedometer you will run 2.0% late. Every minute you will be 2 cents late. Every 100 seconds you will be 2 seconds late.

Instead of the driver attempting 33.66 mph and the navigator presuming that the driver is successful, have the driver run at CAS 33 and the navigator keep a tally of their accumulated error. When the error gets uncomfortably large, simply make a controlled correction, as described in [Chapter 6](#). If you get nervous at 6 cents late after 3 minutes, you could increase to 44 mph ($\frac{1}{3}$ over CAS) for 18 cents. Also consider that if you run at 44 mph for 36 cents you will be 6 cents early after the correction, a better place to be if a surprise checkpoint rears its ugly head over a hill. Then you only need to correct every 6 minutes rather than 3 minutes.

If the correction is negative, you would simulate a pause by that amount, rather than a gain, or go to 22 mph for 18 cents.

This technique transfers the responsibility for speed corrections from the driver, who has lots to worry about, to the navigator, who is running a simple time-only log. You have taken what is, at best, a difficult task for the driver and converted it into a completely equivalent and simple task which can be executed by the team with far more safety and precision.

Please note that, in order to keep the navigation strategy described in this chapter reasonably understandable, we have

removed the specifics of using the variation from the rest of the chapter. The Limited-Speedo strategy described in the next chapter uses the variation as described here fully.

The Calculated Mileage

We have mentioned the use of a ***calculated mileage*** above. Here's the way it works: From the start of each leg, you calculate, based on time and speed, what the official mileage should be. You primarily use the basic formula for Distance, [Formula 5](#). This is not the same as the calculated odometer we used in the Stock Navigation Strategy. The calculated odometer was compared against the car's odometer; this calculated mileage is compared against the official mileages listed in the route instructions.

The calculated mileage can be determined at any point on the course. If you do it at a point that has an official mileage, you can get a reading. At a point where you want a calculated mileage, record the time as you pass the point. Then run your cumulative calculator up to that time and determine what overall mileage corresponds to that time. Now compare your calculated mileage with the official mileage. If your calculated mileage is higher (longer) than the official mileage, you are late ("Long Late"). Otherwise, you are running early by the difference. Remember, however, that the difference is in miles, not minutes. Since you cannot "beam" yourself a distance up or down the road, you need to convert the distance error into a time error.

Formula 26. *Speedo Timing Error*

$$\text{Running time} \times \frac{\text{Distance Error}}{\text{Running distance}} \rightarrow \text{Time error}$$

The *Running time* and *Running distance* are measured from the last point you were on time. They should not include the time or distance of transit zones.

This method of converting a *Distance error* into a *Time error* assumes that the error was distributed evenly across the various speeds within the *Running distance*.

Using a Curta

In [Chapter 14](#) we talked about the Curta and described how to use it to keep a calculated time based on car mileage. Now we will look at a completely different method for using the Curta which makes it very useful for maintaining the calculated mileage. But before diving into this method, you should work through at least the basic calculations on the Curta discussed in [Chapter 14](#).

The idea is to use the result dial to keep track of calculated mileage rather than calculated time. The counter tracks time instead of car mileage. Here's how it works:

For each different CAS in the event, convert the miles-per-hour into miles-per-minute by dividing each CAS by 60. When you start a leg, enter the official mileage at the leg start into the result dial and your leg start time in the counter. Set CAS/60 in the setting dial.

When you are running, simply crank to keep the counter in pace with the time. The result

dial will show your calculated mileage, which will match the official mileage if you are running on time.

When you note the time at a speed change, crank the counter up to that exact time, enter the new CAS/60, and then crank the counter up to an even tenth of a minute for easy reading. Pauses and gains are done by zeroing the setting dial and cranking in the pause or subtracting out the gain (crank handle up).

Using a Calculator

The programmable calculators described in [Chapter 14](#) are ideal for keeping track of a calculated time based on mileage. A modification of the programs to take Time and produce mileage will work great.

Most pre-programmed TSD calculators are based on the conversion of mileage to time. They cannot directly handle the conversion of Time to Mileage. You may be able to augment their program or design your own to do the job. Alternately, if there is enough demand for these features, manufacturers of calculators such as the Turbo Kurta might be “encouraged” enough to add them.

One calculator you might consider for this job is the Hewlett-Packard model 48SX. It is rather expensive, but has a number of features which make it ideal for rallying. One feature is an internal clock which

allows you to get readings without typing in the current time. Bill Hall of Woodhenge Systems (see Appendix A) has developed a program for exactly this application.

Using a Stevens

You can use a Stevens to maintain a calculated mileage, but you will have to accumulate the mileage for each separate speed by hand. Set the CAS with M on the CAS and T on 60. To compute the calculated distance for a given time interval: Place T on the the time interval and read the calculated distance off M.

Getting up to Speed

There are a number of techniques for getting up to speed. The most precise method involves studying exactly how much time you lose for a given car, driver, target CAS, and road gradient. We will look at this technique in the next chapter, and present two widely used alternatives which require less preparation, but are less accurate.

Spacing Method

The technique of spacing yourself a certain number of car lengths from the restart point was described in [Chapter 6](#). However, the table given there applied to only one particular situation. To improve this technique, you will need to determine the numbers for your particular car. Here's how to do it:

- Before the start, measure the time it takes to reach various target speeds.

- Convert half that time into a distance at the target CAS, using [Formula 5](#).
- Convert each distance into car lengths. You can use 14 feet for a car length.

This gives you a table which looks something like:

Example Spacing Method			
CAS	Time to accelerate (cents)	Distance to travel $\frac{1}{2}$ time	Car Lengths
20	8.3	72'	5
30	11.6	153'	11
40	16.6	292'	21
50	23.3	510'	36

Anticipated Start

In this technique, you start from any point before, at, or after the restart point. The navigator determines the correct restart time from that point and tells the driver. The driver is then responsible for watching the clock and starting so that the car is accelerating through half-CAS at exactly that time. The acceleration must be smooth for this technique to work accurately.

How does the navigator determine the restart time? First, judge your distance from the restart point, in hundredths of a mile (see [Chapter 17](#)). Then calculate the time to cover that distance at your target CAS. Add that time to your restart time (or subtract, if you are starting before the restart point).

Running a Leg

To see how the strategy works, we will use some sample instructions:

0.00	1. Begin at Key Time 11:00.00. CAS 36.
	2. Left at T. CAS 28.
	3. Right at Stop. Pause 30.
3.95	4. Left onto Warthog Road. CAS 42.

Assume we are car 17, so the Key Time in instruction 1 is 11:17.00 for us. To begin a leg,

- Initialize your cumulative calculator with the starting time and CAS (uncorrected).
- Look up the variation for the first CAS.

Then start your run by whatever method you wish to use to get up to speed.

NRI

At each NRI without timing instructions, note the time you execute the instruction. This is so that you can come back later and take a TA from this point. You can note these times without splitting the clock. You can also note your calculated mileage, so you can resume your calculated mileage if you have to take a TA.

If the NRI has an official mileage, you can get a reading, as described in the section above.

CAS Change

As you approach the action point of NRI 2, the navigator does several things:

- Note the time on the route instructions for that NRI.
- If the instruction has an official mileage, the navigator can give a reading using the cumulative calculator.
- Look up the variation for the new CAS. If you are running a custom speedometer or marked stock speedometer, the variation is the same for all speeds. Running an unmarked stock speedometer requires the navigator to keep track of a different variation percentage for each speed.
- Note your calculated mileage at the instruction.
- Set the cumulative calculator for the new CAS.

For example, as you execute NRI 2, you note a time of 20.15. Since you started at 17.00, the time of 3.15 minutes at CAS 36 gives you a calculated mileage of 1.89 miles at NRI 2.

Pauses and Gains

To handle a pause such as in NRI 3:

- Note the time when you have slowed halfway from CAS to the Stop.
- Make the turn and add in the pause time.
- Restart as you normally do any restart, but use as your restart point the point on the course when you decelerated through half CAS. Any distance you judge should be in relation to that point.
- Check off the pause on the route instructions immediately after it has been executed.

- Subtract the pause time out of your cumulative calculator.

Gains are best handled, as in the Basic Strategy, by using an adjusted speed for a duration which you calculate. You also need to add the gain time into your cumulative calculator.

To handle a Transit Zone, simply treat it like a CAS change with a big pause attached.

Official Mileages

When you get an official mileage in the route instructions, it's time for a reading. Say your time at NRI 4 is 25.04. This is 4.89 minutes from NRI 2. Subtracting the pause in NRI 3 gives us 4.59 minutes at speed, or 2.14 miles at CAS 28. Added to the calculated mileage of 1.89 from NRI 2 gives you a calculated mileage of 4.03. You are 0.08 miles long, so you are late (*“Long Late”*).

To determine how late, use [Formula 26](#). The Running distance from the last on-time point is 1.03 miles and the Running time is 25.04 – 17.00 or 8.04 minutes.

$$\text{Running time} \times \frac{\text{Distance Error}}{\text{Running distance}} \rightarrow$$

$$8.04 \times \frac{0.08}{4.03} \rightarrow 16 \text{ cents late}$$

Adjustments for an early/late reading can be handled as they were in the Basic Strategy.

Checkpoints

At all checkpoints, you need to:

- Split the clock. Record the time on the route instructions. Do not un-split the clock.

If it is an open checkpoint:

- Hand in your scorecard, requesting any time allowance you wish to take.

When you get the scorecard back, immediately:

- Verify that the recorded arrival time agrees with your split clock ± 0.01 cent. If it does not, settle the issue on the spot, using your split clock, if needed.
- Verify that any time allowance you requested has been recorded by the crew.
- Quickly check that the start time you have been assigned allows sufficient time to reach the restart for the next leg.

Back in your car:

- If the rally uses out-markers rather than starting a leg from the timing line of the last checkpoint, move up to or past the out-marker, depending on your restart style.
- Un-split the clock.
- Read the checkpoint slip. Note the next NRI, starting CAS, and any special instructions on the slip.
- Set up the cumulative calculator for the next leg.
- Since you now have the official mileage to the out-marker or checkpoint timing line, you may be able to pre-calculate the perfect time to the next speed change.

- Finally, calculate your score for the leg just completed. Look for a trend in your scores and, if appropriate, change your correction factor. However, if your score seems wildly off, toss the calcs in the back seat and assume the checkpoint slip is wrong. There is nothing worse than running a leg wondering why you got 1486 points on the last leg!

Perfect-time rallies and off-course situations are discussed at the end of the next chapter.

23. Limited-Speedo Navigation

Less is more

— Mies Van Der Rohe,
on restraint in design,
New York Herald Tribune,
June 28, 1959

The quote which kicks off this chapter is, perhaps, the most appropriate in the book. Computer class teams, when told of the scores for top teams in the vintage car rallies which run Limited-Speedo class, invariably blurt out “*How do they DO that?*”.

Well, here's how.

The Concept

This strategy combines the following concepts:

- Extensive practice to measure how much time is gained or lost on each “maneuver”. A maneuver is any situation which is not simply driving at CAS.
- Careful calibration of the speedometer.
- Tracking all deviations from on time and compensating in a controlled way.

The strategy is really an extension of the Basic Strategy described in [Chapter 6](#). In the

Basic Strategy, we made some assumptions to simplify things. Those assumptions will be removed and the errors they produced will be eradicated.

This navigation strategy assumes the following equipment during the event:

Custom or Stock Speedometer as discussed in [Chapter 12](#).

Time-of-day clock. This should be visible to both team members.

Stopwatch. It should have at least one and, preferably, multiple splits.

Preparation

For top placings in Limited-Speedo class, preparation means absolutely everything.

First, you need to get the speedometer calibrated as described in [Chapter 12](#). If you are allowed a custom speedometer or can mark your stock speedometer, you will have markings that are calibrated to some standard. Otherwise, you will have a speedometer correction table prepared that gives the bias for each speed range. The navigator may have to memorize that table.

Learning how much time various maneuvers take is key in Limited-Speedo Class. When we ran the Basic Strategy in Novice Class, we simply timed how long it took to make a turn and assumed that was our delay. This works great except for one inaccuracy. The timed delay does not take into account the distance traveled when making the turn. This is not critical for Novice Class, but becomes an unacceptable source of accumulated errors for advanced teams.

Top teams build a set of **performance graphs** before the event that reflect how much time is gained or lost for each type of maneuver. A maneuver might be a CAS change from 25 to 36, a 25-36 maneuver. Starting up to CAS 36 (at the end of a Transit Zone) would be a 0-36 maneuver. A Pause 25 is another type of maneuver.

For example, let's look at a simple performance graph. Across the bottom are target speeds and the left side shows the time lost during acceleration or deceleration. To get the time, scan across the bottom axis for the target speed, go up to the curve, then left to the vertical axis to read the time lost. Of course, this particular graph only works for the particular car and driver.

The acceleration curve shows how much time is lost when you start from a dead stop, from the restart point, and at the perfect restart time. The deceleration curve plots the time lost decelerating to a point as compared with driving through that point on speed.

These two curves are used to predict your timing error in just about any situation on the course. The key in using these curves is

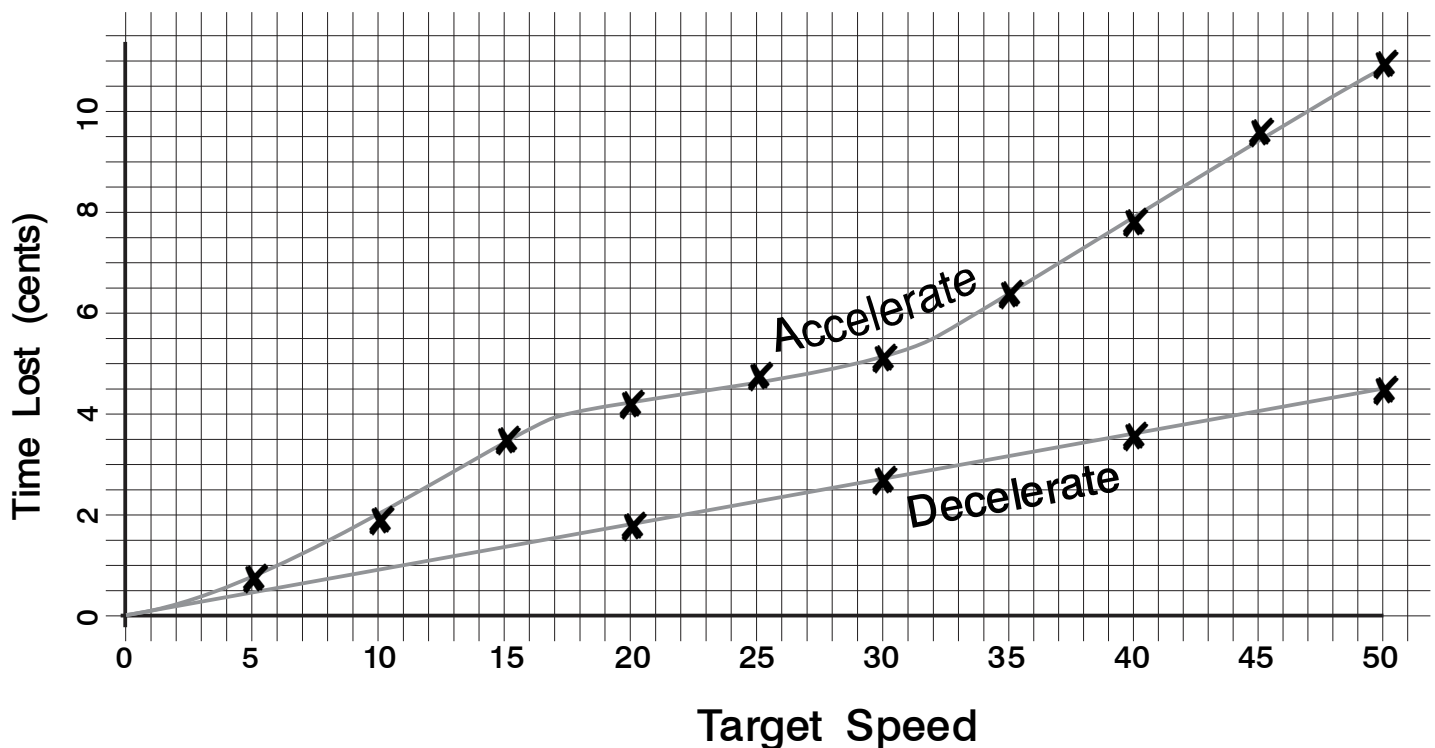


Figure 23-1: Performance Graph: time lost getting up to speed

that the driver must always speed up or slow down, in situations where the curves are used, at the same rates as when the curves are built. In addition, you must accelerate along portions of the curve as if you were using the whole curve. For example, you must begin a deceleration from 35 to 25 as if you were starting a deceleration from 35 to 0.

Navigating with the curves is simple. In a 0-36 maneuver, you read across the bottom axis to 36 mph, go up to the acceleration curve, and scan left in order to read time lost off the vertical axis: 6.7 cents. For a 36-0 maneuver, you do the same thing using the deceleration curve. This chart shows 3.3 cents for a 36-0 maneuver. A 36-0-36 maneuver delays you 10.0 cents. However, since it might be difficult for the driver to instantly begin accelerating after coming to a stop, you might want to delay an extra 5 cents and count on a 15.0 cent delay.

Even more practical, you could execute 36-0, start the stopwatch when the car stops, take however much time you need, split the stopwatch when you begin to accelerate, and execute 0-36. The delay is 10.0 cents plus the split time shown on the stopwatch.

How about a speed change? You use the same acceleration or deceleration curves for increases or decreases in speed, but the starting point is not zero speed, but some other speed. Take a 24-36 maneuver. Read the time lost accelerating to 36 and subtract out the time lost accelerating to 24. In our acceleration curve, this is 6.7 cents - 4.5 cents = 2.2 cents lost. For a 36-24

maneuver, use the deceleration curve: 2.1 - 3.3 = -1.2 cents.

Now, say you are running 20 cents late at CAS 24 and need to correct. You can use [Formula 17](#) or the rule about 50% above CAS to come up with 40 cents at 36 mph. However, you also need to account for the time lost in the 24-36-24 maneuver. If you count on 36 mph from the time you start accelerating, you lose 2.2 cents. If you count on 24 mph from the time you begin the 36-24 maneuver, you will be 1.2 cents early. You lose a net 1.0 cents in the 24-36-24 maneuver. Adding in the 20 cents late gives you 21.0 cents late. You need 41.2 cents at 36 mph. So, you start the watch as you begin to accelerate to 36 mph. You begin slowing back to 24 mph 42.0 cents later.

108. Right at sideroad.

Assume your CAS is 32 and NRI 108 cannot be taken at speed. As with everything in Limited-Speedo Class, a controlled maneuver with a known error is far better than an “approximate maneuver”. Assume you can take the turn at 10 mph. When you see the turn, execute a 32-10 maneuver and start the stopwatch at 10 mph. After the turn, begin a 10-32 maneuver and split the stopwatch. The performance curves show a loss of 1.9 cents for 32-10 and 3.5 cents for 10-32. You have lost 5.4 cents plus the error from running at 10 mph for the split time on the stopwatch.

How do you develop performance graphs for a particular car and driver? The best method is to use the measured course approach

described in [Chapter 12](#). You can time various maneuvers on the measured course to get data points along your two performance curves.

Before the Start

After you receive your route instructions, you will need to

- Check the route instructions to make sure you have all the pages and that they are legible.
- Highlight the route instructions and paste a copy on the reader board.

The speedometer or odometer check for this strategy is done exactly the same as for Speedo Class. We will make heavy use of the variation in calculations.

- Total error. This keeps track of the sum of the calculated errors. Again, negative numbers mean early and positive numbers mean late.

For the navigator, the event is nothing more than a series of maneuvers for which a simple formula or performance graph is (hopefully) available. (OK, maybe they get to look at the scenery occasionally). At the beginning and possibly the end of every maneuver, they note the time and the maneuver. Then they add in the pre-measured error for that maneuver and total it up. When the error gets uncomfortably large, they call for a compensation maneuver.

The Log

A log for this strategy is a simple list showing:

- Time of Day
- Calculated error (- for early, + for late)

Limited-Speedo Navigation Log Sheet			Leg: _____
<u>Time</u>	<u>Error</u>	<u>Notes</u>	
8:17.00	—.—	_____	
—:—.—	—.—	_____	
—:—.—	—.—	_____	
—:—.—	—.—	_____	

Running a Leg

First figure out how much you initially want to run up or down. Remember that you are running the assigned CAS, not adjusted speeds, and using the variation percentage to keep track of accumulated errors. This means you will run gradually earlier (negative variation) or later (positive variation) with time. If you have a positive variation of 2.0%, you will get 2 cents later every minute. You might decide to start out 8 cents early.

Consult your performance chart for your target CAS. Say it's +6.1 cents (6.1 cents late) to go from stopped to CAS 34. Now look at how far you are from the start point. Ideally you will start right at it, but this is not always practical. Say you are 6 car lengths/84 feet/0.016 miles past the line. At CAS 34 that works out to 2.8 cents early. If you started exactly at your restart time you would be 3.3 cents late when got up to speed. If your start time is 8:17.00 and you decide to start 8 cents before your restart time, you can log it as:

Limited-Speedo Navigation Log Sheet			Leg: _____
<u>Time</u>	<u>Error</u>	<u>Notes</u>	
<u>8:17.00</u>	<u>-.080</u>	<u>Start 8 cents early</u>	
<u> </u>	<u>+.061</u>	<u>0→34 maneuver</u>	
<u> </u>	<u>-.028</u>	<u>6 lengths</u>	
<u> </u>	<u>-.047</u>		
<u> </u>	<u> </u>		

By counting down to and starting at 8:16.92, losing 6.1 for the 0-34 maneuver, and gaining 2.8 for 6 lengths past the line, you are early 4.7 cents when you get up to speed.

NRI and Landmarks

At each NRI without timing instructions, note the time you execute the instruction. This is so that you can come back later and take a time allowance from this point. Prominent landmarks can also serve this purpose.

Variation

If your variation is -2.0%, you get later by 2 cents per minute. After 2.35 minutes, you are exactly on time (since you were 4.7 early when you got up to speed). However, there is nothing magic about being exactly on time (as long as there is no checkpoint)! The important thing for this strategy is to know your error as precisely as possible. It is far better to use a precise maneuver with a known error than a maneuver which will keep you “approximately” on time.

So, every once in a while, update your calculated timing error based on your variation. If your speedometer is calibrated close to official miles, this correction will be small. This is why competitors in this class are very interested in how the measuring car was calibrated. Imagine the nightmare of showing up to the event and discovering all speeds and times are based on kilometers per hour!

CAS Change

From the discussion of performance graphs, it is easy to see one way to do a CAS change: begin the maneuver at the execution point and read the timing error from the appropriate curve. However, by starting the maneuver before the execution point, you

can always make a flying CAS change with zero timing error. The trick is to start the maneuver at the right time, and this takes practice and skill.

If the speed change is small (e.g. one which requires no shift), you can ignore the performance graph and assume that the acceleration is uniform. Begin the maneuver so you are halfway to the new speed at the execution point.

If the speed change is large, especially for acceleration, you will need to consult your graphs. You need to find the speed whose timing error is halfway between the timing error of the old and new CAS. This is the speed you want to be accelerating/decelerating through at the execution point. In the performance graph in Figure 23-1, going from CAS 10 (1.9 cents error) to 50 (10.9 cents error) has a half-speed of 35 (6.4 cents error).

The only problem occurs if the driver fails to hit the half-speed at the execution point. To check this, the navigator must start and split the stopwatch at the actual half-speed point (called out by the driver) and the execution point of the speed change, regardless of the order of these points. How early or late you are is given by [Formula 17](#).

Early/Late Limited-Speedo Errors		
	Accelerating	Decelerating
Half-speed before execution point	early	late
Half-speed after execution point	late	early

For example, if you change speed to 28 at 8:22.25, your log might look like this:

Pauses

To handle a pause:

- Consult your performance graph and figure out how long the pause maneuver will take, given the current and, possibly, the subsequent CAS.
- Figure out how long to actually pause, based on:
 - how early or late you are currently running
 - how long the pause time is in the route instructions
 - the delay for the Old CAS-0-New CAS maneuver, and

Limited-Speedo Navigation Log Sheet			Leg: _____
<u>Time</u>	<u>Error</u>	<u>Notes</u>	
<u>8:17.00</u>	<u>-.080</u>	<u>Start 8 cents early</u>	
<u> : . </u>	<u>+.061</u>	<u>0→34 maneuver</u>	
<u> : . </u>	<u>-.028</u>	<u>6 lengths</u>	
<u> : . </u>	<u>-.047</u>		
<u> :22.25</u>	<u>+.105</u>	<u>5.25 min @ +2.0% variation, CAS 28</u>	
<u> : . </u>	<u>+.058</u>		

We accumulated the 10.5 cents from running late due to the speedometer variation. We are now running 5.8 cents late.

If the new speed has a different speedometer variation, we would start applying it now.

- how much you want to be running early or late after the maneuver
- Note the time when you finish slowing for the pause. This is more precise than using the half-speed method of the Basic Strategy.

- Restart at the time the navigator allowed for the pause. If you are delayed more than the pre-determined time, begin at a different (later) time without changing the way you normally accelerate.
- Update the log based on how the maneuver was actually done.
- Check off the pause on the route instructions immediately after it has been executed.

Adjustments

When your calculated error gets uncomfortably large, it's time to adjust. How big is “uncomfortable” depends on how competitive you are, and your sense of where there will be a checkpoint. Of course, you can run a larger amount early than late, since it is easier to lose time approaching a checkpoint than to make up time.

If you are substantially early, you can simulate a pause. You should have at least 5 cents actually stopped – an instantaneous “stop and go” is not very precise.

If you are running uncomfortably late, run over CAS for a time. How to do this with precision is described earlier in this Chapter.

Checkpoints

The corollary to Murphy's Law for Limited-Speedo Class is that the checkpoint will loom when you were just starting to think of making an adjustment. You are getting uncomfortable about how early/late you are running but have not yet figured out the adjustment.

It's time for some quick thumbnail calculations. If you are early, go to half CAS for double the time you have calculated and then accelerate back to CAS before the line. If you are late, try to get to 50% over CAS for twice your calculated lateness.

If you are driving and your navigator is thrown into a blithering panic by the sight of the checkpoint, it's time to guess! Make your best stab at the loud pedal for the remaining distance if you were running late, or guess at how long to go half CAS if you know you are early. Hope for the best and keep the errors smaller on the next leg.

At the checkpoint timing line, you need to:

- Record the time on the route instructions.

If it is an open checkpoint:

- Hand in your scorecard, requesting any time allowance you wish to take.

When you get the scorecard back, immediately:

- Verify that the recorded arrival time agrees with your arrival time ± 0.01 cent.
- Verify that any time allowance you requested has been recorded by the crew.
- Quickly check that the start time you have been assigned allows sufficient time to reach the restart for the next leg.

Back in your car:

- If the rally uses out-markers rather than starting a leg from the timing line of the last checkpoint, move to or past the out-marker.

- Read the checkpoint slip. Note the next NRI, starting CAS, and any special instructions on the slip.
- Set up your log for the next leg.
- Using information on the checkpoint slip, you may be able to pre-calculate the perfect time to the next speed change.
- Finally, calculate your score for the leg just completed. Look for a trend in your scores and, if appropriate, change your variation information. However, if your score seems wildly off, toss the calcs in the back seat and assume the checkpoint slip is wrong. There is nothing worse than running a leg wondering why you got 1486 points on the last leg!

Perfect-Time Rallies

Perfect-time rallies allow you to convert official mileage into a perfect time for each instruction. Do this without error and you can score very well.

One thing to remember is that you must account for the time to accelerate out of corners. Simply splitting the clock at the apex and using that time for comparison against the calculated time will make you run consistently late. An easy way to compensate is not to split the clock until you are halfway up to speed coming out of the corner.

One complication crops up if you have open checkpoints or need to take a TA. All your perfect times will be wrong after this. One solution is to figure the perfect time from

one NRI to the next, but not add them up until you are on the course.

Off-Course Situations

The most important thing to remember when you suspect you might be lost is not to lose your cool. Recovering in a controlled way is the only way to preserve a low score.

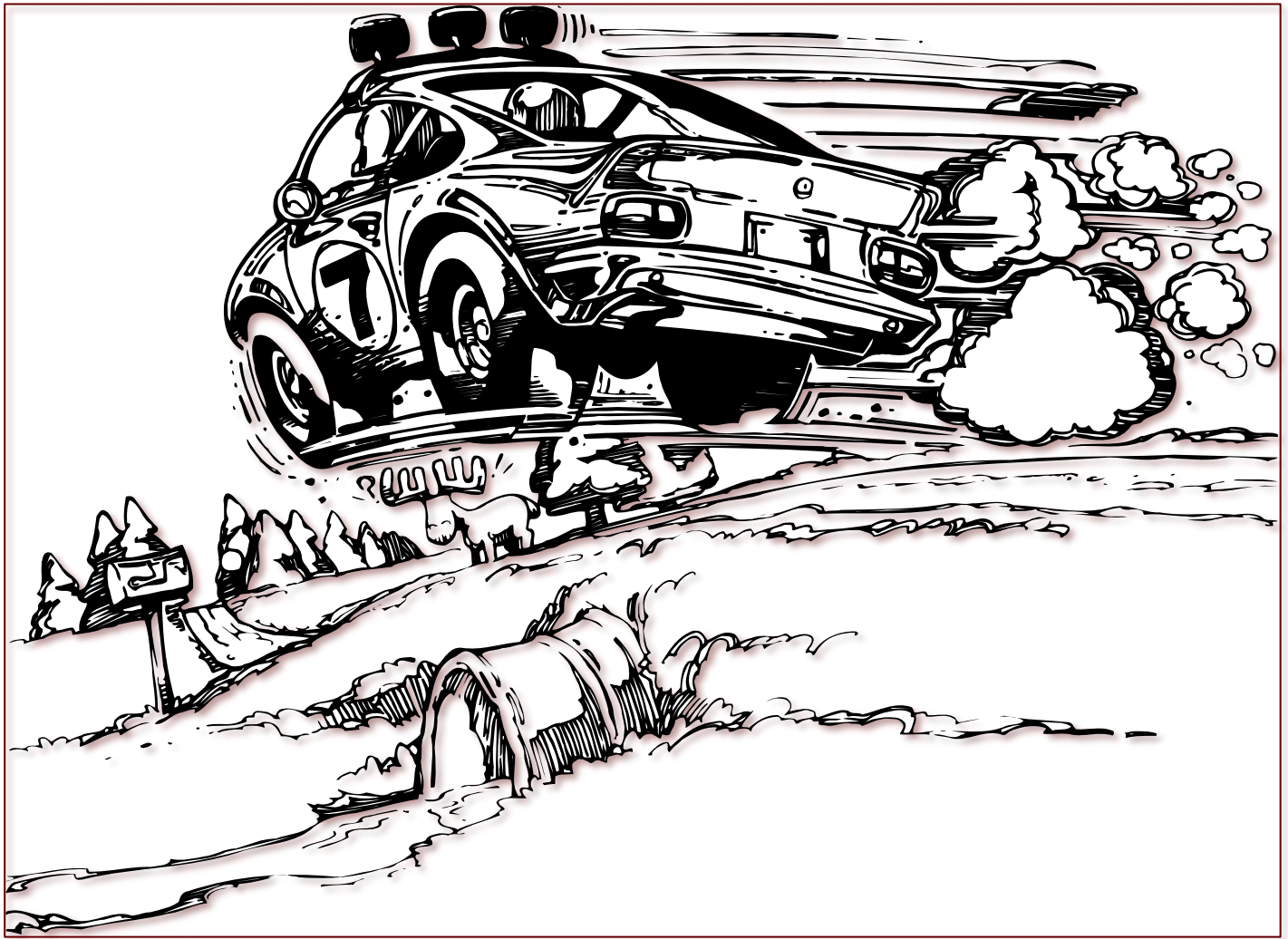
The best way to recover is to go back to a prior NRI where you have a time written and re-start after taking a Time Allowance.

If this is not possible:

- Start noting your time as you past landmarks.
- When you confirm that you have gone off course, turn around and proceed back at CAS, noting your time at each landmark as you retrace back.
- When you find the turn, note your time and stop.
- Determine the most recent landmark and determine how long it took to get from that landmark to the turn on the way back. Let this time be A.
- Now determine the time between when you first passed that landmark and when you passed it the second time. Call this time B.
- Your delay up until the time you found the turn is $(2 \times A) + B$. Calculate an appropriate TA and restart on course.

Part 5 – Rally Driving





24. The Well-Driven Car

Driver: The fellow who, with hands firmly planted on the steering wheel, foot on the accelerator, one eye on the road, one eye on his odometer, and one eye on the route instructions, grinds his molars in anguish and wonders when (Oh, When!) his partner will finish calculating and announce the next minute's reading.

— Gene Hammond, from
The Sports Car Rally Handbook, 1962

This part of the book goes into a collection of topics which usually fall into the driver's domain. This Chapter covers driving technique, with the next two chapters concentrating on car suspension and running night, winter, and endurance events.

Driver Position

The position of the driver's seat is quite important. You should be able to control the car with minimal fatigue, reach all the important switches and controls, and be able to read the route instructions easily. Despite how obvious this sounds, it is often overlooked. Some things to consider:

Where do your hands rest on the wheel?

The seat's fore-aft adjustment as well as the seat-back angle adjustment affect your upper body distance from the wheel. A rough guide to a good position is that when your arms are fully extended, your wrists should rest on top of the wheel.

How do your feet line up with the pedals?

Are your knees bent or extended excessively? Where do your knees rest and how are your legs supported sideways? Remember that your feet are busier than your hands under most rally driving situations. A bit of attention here can save a great deal of fatigue.

If you have a dead-pedal set up (see [Chapter 16](#)), is it at a comfortable distance and angle?

Do you know where all the switches are?

Sit in your car and close your eyes. Touch each switch and knob which you are likely to use during an event. Learn where they are without looking. How much effort does it take to reach each one? Do you have to strain against a competition harness to reach them? Even a small effort to turn the rally reader to the next instruction adds up to a major fatigue factor over the course of a long event.

Before the Event

Many teams practice the day before a big event. They go out on a 10 or 20 mile run to get the bugs out and regain rhythm.

Running a portion of the prior year's course is a good way to do this since it also reminds you of the particular style the rallymaster uses. Other teams use a local course which they set up, such as a Rabbit Run described in [Chapter 17](#).

Before the event – stay calm. You need to be fresh to deal with problems later. Don't get wrapped up in the navigator's tasks. Besides, some navigators have been known to bark at their drivers during the hour before the start!²⁸

Of course, you will need to highlight and tape your route instructions on the rally reader. When you tape up your route instructions, remember that most rally readers have a maximum number of pages they can reasonably accommodate. The Stevens Rally Reader holds about 18 pages at a maximum. You may need to tape the route instructions into several scrolls and switch at a break. Also, tape your routes edge to edge – overlapping pages make it difficult to roll the reader backwards. We have found that 3 or four small pieces of tape joining each pair of sheets works better than one long strip.

Highlighting is generally a mechanical process, but you should do it carefully to

eliminate mistakes. Remember that, after a while, you begin to rely on the highlights to flag turns, a CAS change, or a pause. A mistake in the highlighting can cause an off-course or missed timing instruction. Some drivers like to write the CAS in the margin next to the instructions if there are few CAS changes or they are buried in the instructions. This keeps the “*What's my CAS?*” questions to a minimum.

If you and your navigator have time before the start, review the highlighted portions of the routes together, just to make sure that nothing was missed.

Finally, remember the last time you were wandering around at the checkpoint on the last all-night rally looking for a bathroom? Use the facilities before the start! “*Fill the gas tank, empty the bladder!*”

TSD Driving Techniques

A good word which describes what a TSD driver does is multiprocessing. The driver reads the route instructions, stays on speed, looks for signs, and often figures out the traps on a trap rally. The driver has to keep all these things straight, while still giving due priority to really important items (like keeping your car from having an expensive “interaction” with all those magnetic objects lining the rally course).

Among all the books on how to drive, there is one that has a great deal to say about the

²⁸ The phenomenon of a barking navigator is only hearsay. This hearsay in no way reflects the personal experiences of the author or his driver.

mental aspects of the task. Zen Driving by K. T. Berger (actually two brothers, K. and T.) is directed at a mental attitude and philosophy which, although written for every-day street driving, is very appropriate for rally situations. Despite its esoteric-sounding title, the book is very down to Earth.

Having a simple system can help with some of the mundane items. One driver I know always runs with a pen in hand – he checks off each route instruction as it is executed. Another driver keeps a pen attached to the rally reader on a string. Other drivers keep a rubber band on their reader board and scroll the route instructions up after each instruction.

Intersections

The first timing trouble novice drivers experience is trying to keep on time across various intersections. From your novice days, you probably learned that you lose more time dealing with an intersection than you think. Most novice teams run late. The real problem is that a complex intersection presents a distraction. Drivers tend to lose their sense of time when presented with a driving decision.

When you move to the upper classes, especially one which gives you precision time readings, it might seem that staying on time at an intersection is not as important. Not so. Regardless of the class you run, your equipment/navigator will go belly-up at the most inconvenient time. It will be up to your foot to get you the last two miles, without

any readings, to the last checkpoint of the pivotal championship rally of the year.

In order to stay on time, you have to make up your mind to take each kind of intersection the same way each time. Creeping up to one and locking up your tires into the next won't get you consistency.

One of the best ways to learn to stay on time is to run with a navigator who can give precise readings. Running with an A-Box works great. As we mentioned in [Chapter 22](#) on running Speedo Class, go out and practice intersections. Find a looped course which has a variety of intersections that you can approach at various speeds. At each one, start from an on time position. Make the turn and accelerate back up only to CAS. Get a reading. Then try to compensate on your own and return to normal CAS. Get a second reading. The navigator can take notes on how you do, but the idea is to train yourself to stay on time without the navigator's help. If a Left at Stop has traffic coming, great! Try to deal with it and get back on time. When you get good, have the navigator throw “surprise” pauses at you, both before and after the intersection. This simulates a forgotten pause. Deal with it.

Some teams like to accelerate into stop signs. If you see that there is no checkpoint between you and the stop, it may be safe to accelerate before slowing down for the stop in order to cut down on how late you are coming out of the intersection. If you choose to do this, a whole new set of driver instincts need to be developed for staying on

time by feel. Once you find a method that works – stick with it!

The Open Road

Staying on time yourself when you are not negotiating an intersection is a whole different ballgame. There are a number of techniques.

Some drivers get the car on speed and use the sound of the engine from that point on, referring to the speedometer only occasionally. They run with the window open or slightly cracked. Others use the speedometer just to get on-speed and use the tachometer (tach) to maintain speed.

To deal with distractions, some drivers use the **phantom car** method. The idea is that you keep a mental picture of an on-time car. When something distracts you and causes you to be late, you maintain a picture of where the phantom car is on the course. When you dispose of the delay, you look up the road and “see” the phantom. Then all you need to do is catch him.

Whether to use cruise control is an issue for some. The idea of cruise control seems somehow “wrong” in the sport, but I know of no regulations that prohibit its use. In practice, a good cruise control can reduce driver workload on “boring” portions of the course and keep you fresh to handle the “interesting stuff”.

Before you use the cruise control on a rally, experiment with it and learn its characteristics: How well does it maintain a speed? On uphill? Remember that the

cruise control does not use the brakes to control speed. On a downhill, the car may accelerate well above the desired speed. Is there an accelerate feature on the cruise? What does it take to “bump” the speed up by one or two mph? Is there a “coast” feature?

Passing

Byrd's Seventh Law of Rallying states that *The slow traffic in front of you will always follow the rally course*. How you get past another car depends on whether it is another rally car or not.

Rally cars have developed an etiquette for passing, as mentioned at the end of [Chapter 2](#). Everyone knows the situation, so if the rally car in front is not pulling over, either it isn't safe to pass or they are a Novice who hasn't been filled in on rally protocol. If the problem is the latter, mention it to them courteously at the next checkpoint or break.

“Locals” are a whole 'nother matter. Rally cars mean race cars to the uninformed, and race cars don't mix well with the uninformed's grandmother, children, and pets. Rally cars scare them. And scared local drivers slow down and become self-righteously belligerent. This reaction is not a conscious choice on their part directed at you, but a basic human response. Scared people become belligerent. The fact that you are “on a mission” only makes matters worse.

How do you deal with it? First realize that you are bound to scare some people, even if you remain well within CAS and the bounds

of reasonable driving. And some percentage of the scared people will drive in the middle of the road, chop down trees to block the road, or call the police. Getting infuriated at them will only heighten the problem, making it worse for you or the cars behind you. When you see a slow local, try to gain some time before you are actually on their bumper. This will give you more time to have an opportunity to pass. Then try, in whatever way, to avert or mend the damage with a smile, a wave, or a thumbs-up. This may only help in a portion of the cases, but it does help.

Oh yes, there is one other passing situation:

There We Were on the 1988 MG-1000, a brisk 1200 mile event through New York State and Ontario province. The organizers ran rather lean on workers, so some checkpoint crews had to “catch up” with the first car when shuttling between checkpoints. Gary Webb, the rallymaster, was in such a situation, behind car #1 and getting quite close to the checkpoint location. There was no reasonable place to pass until they were within sight of the control location on a long, wide, straight road. So Gary punched it, pulled along side, had his co-driver hold a checkpoint sign out the open passenger window, and split the clock as they both passed the line. No problem!

Going Back

Some drivers hate going backwards. It's not so much the mechanics of the maneuver as the psychology: You (the driver) missed the

turn; We (the team) are now late; They (the organizers) most surely have a checkpoint right around the corner.

Often drivers are so intent on getting back on course that they give no regard to navigation. Recovering without the navigator being in step with whatever needs to be done to preserve the calcs is not very useful. As a driver, you need to know what the navigator needs to keep the calcs going. Have a drill and practice it. Do the drill once before each event so that it becomes a no-tension process. Remember: you may still be able to do well with a Time Allowance.

Another tension-filled time is when you take a Time Allowance. Even though you theoretically have lots of time, many good teams screw this maneuver up. This is the time to relax, add another minute or two and get your act together.

Watch the Mileage!

In order to score well in an advanced class that uses a precision odometer, matching the mileages is critical. It does not do the team any good if the navigator spends the time to hook up the sending unit, measure tire pressure, and wade through [Chapter 19](#), and then you go down the course pulling hand-brake turns and smoking the tires up the hillclimb.

A few areas of driving technique to consider in these classes:

- Should you brake or down-shift when going downhill on loose surfaces?

- How did the person who measured the course drive? What was their line? Did they cut corners? Did they maintain CAS aggressively or half-heartedly?

In the end, the success of how you (as a team) match mileages may be up to you (as a driver).

Communication Revisited

It is often said that the best rallyists are ones who have both driven and navigated extensively. One reason is surely that you know what the other person needs in each situation.

If switching roles on an extended basis is not practical, try to get a “brain dump” from the other person on what they do. Sit down and listen for a few minutes while your partner describes exactly what they do. This is not a teaching situation, but a monologue from which you can pick up ideas on how to back each other up. Here's a few gems from our own experience:

- The distance to the turn is very important for the driver on a brisk rally. We discovered it is more important than getting off a reading every tenth of a mile.
- Saying “Left in half a mile” does no good. It's forgotten by then. Saying “*Left in 10*” (meaning hundredths of a mile) is better, but 10 hundredths is a very different “distance” at CAS 23 versus CAS 43. The approach we use on really brisk events is to count down to the turn, from ten hundredths of a mile down to about five hundredths.
- On really brisk events, the driver may not even have time to look at the tulip. We sometimes revert to a Pro Rally style of communication. Two words: Left or Right, followed by the degree of the turn: shallow, square, sharp, or hairpin. Some teams use a number system to denote the sharpness of a turn depicted in the route instruction.
- One “communication” method we discovered is pointing. At very complex intersections, the navigator studies the instruction carefully and points through the intersection, changing where they point as you proceed.
- Timing items such as pauses, especially small ones, are easily left out of the calcs. “*Did you put in the pause?*” can help. You don't have to know exactly what that means, but you do know that it has to be “put in” the calculations.
- The need to know which NRI you are working on or what the current CAS is can often be critical. In our car, “NRI” and “CAS” gets an immediate response from the other person before all else.
- The navigator often works on several levels, vacillating between giving intermediate readings and doing some other calculations which will be useful down the road. Of course, these long-term calcs are not very useful when you are in sight of a control. However, the navigator may not even know the control is there. I have, more than once, unknowingly passed a control and continued to give readings after we had crossed the line and

were slowing down to pull over. So, when a control is in sight, a calm, quiet “*checkpoint*” is announced to switch me back into short-term mode.

- Sometimes a timing instruction, such as a CAS change, comes up as a surprise. Most navigation strategies require you to do something at a CAS change. Sometimes, the navigator is not even looking up. The driver needs to know under what situations to call “*Split!*” to get the navigator to throw the correct switch and record the event.
- Finally, have a plan for when you see the car that is supposed to be a minute in front or behind. It will happen, and the rally course is no place for a philosophical discussion on taking hacks.

As you learn to help each other, the division of tasks which you developed when you were running Novice Class becomes less rigidly defined. Depending on the situation and type of event, the driver can help with the navigating or the navigator can help with the “driving”.

One very important area is how you make important decisions as a team. Rallies are often won or lost in the space of a few seconds, so decision-making sometimes has to be done with very little “discussion”. If each member voices their opinion with a forcefulness which matches the strength of their assuredness, you can make an initial decision simply based on who speaks louder, and sort out the reasons afterward. Of course, you need to be willing to take responsibility commensurate with the

strength with which you voice an opinion. Sometimes, the other person is sure of something and speaks loudly, but you know why they are wrong. Simply saying that you understand their position but know why they are wrong can head off any bad feelings.

Performance Driving Skills

Driving is one of those endeavors which bears the burden of that mystical and mysterious trait: *Machismo*. Unfortunately, this means that many people believe their skill in driving is directly tied to the amount of *Machismo* they believe they possess. In fact driving skill is nothing more than that: a skill. One that can be taught, learned, practiced, and developed without any regard whatsoever for the “*M*” rating of the driver.

Who Should Drive, Revisited

When you get into the advanced classes, it may be time to re-examine the issue of who drives and who navigates. Now that you have learned what it takes to do each job and possibly been exposed to what it takes to be a good driver, you can make a “zero-based” assessment of your team's skills and chances for success with each of you in the driver/navigator seat.

In our case it was easy. Vera hates numbers and I like them (especially the digit which looks like an oval standing on end). We both like to drive, but she took the initiative to sign up for some driving courses. Together with lots of practice driving all types of rallies, I figure we have made about a dozen fewer trips to the body shop over the years than if I were driving.

Getting Skill

Acquiring driving skill can be done in many ways. Some drivers ascribe to the “crash and learn” school of driving. For those of us with less expansive budgets and fewer than 9 remaining lives, there are some more modest approaches:

Autocross is an excellent starting place. Most areas of the country have events called ***Solo II*** where you are timed around a course of pylons set up on a parking lot or an unused runway. You get several runs over the course throughout the day for a small



Autocross

fee. Cars run one at a time and speeds are lower than in road racing or time trials. The only special equipment you need is a helmet. There is also an abundance of people well-versed in the technical aspects of car handling and suspension. Many clubs which organize Autocross events will have a driving school at the start of the year.

Autocross will give you an education in where the right side of your car is, how tire pressure affects handling, and what understeer/oversteer is all about with respect to your car. It will also teach you how far you can push the car while rewarding smooth, but aggressive, driving. You will also have fun!

Many events have “dollar runs” after the competitive runs are complete. You pay a dollar and take a timed run. This setup is great because you can “experiment” with new techniques such as left-foot braking or radically different tire pressures without the onus of competition. Another great

opportunity is to take a bunch of dollars and go for rides with top drivers who run cars similar to yours. Pay for their run (they may burn off more than \$1 of rubber on an aggressive run) and watch how they work: not only their line, but their hand and footwork.

Another great sport for “Experimental Driving” is ***Time Trials on Ice***. The organizers (folks with the background and experience in this type of event) take a frozen lake, plow off a course far from any stationary objects, and send cars on timed runs. Sound absurd? Ice Trials are absurd in many ways. If you run on normal tires, your maximum speed will be quite slow. So slow, in fact, that you have an eternity to “adjust” the car in the corners. You can actually think about what you are doing and try different things to correct problems.

“Gee, my back end is really coming around. Maybe some more brake might help”.

“Now, that was a bad idea, how about some more steering input”.

“Hmm, I seem to be spinning. I wonder if this is on video tape”.

The result is that you can learn a lot from these events, making the trip “up North” well worth while.

However, there is one thing to remember in all these low-budget forms of competition: listening to other competitors has to be taken in context. They are not driving



Ice Trials

teachers nor are they likely to be at the same skill or competitive level as you. They may or may not be able to impart the things they have learned, and they may be concentrating on a whole different level than is appropriate for you. Also, their goal is generally to succeed at these types of events while you are trying to learn something to be applied under road rally situations, which will be very different.

Finally, let me mention the least reasonable place to learn driving at the car's limit: public streets. You cannot learn where the right side of your car is without bending metal and you cannot consistently push your car to and beyond the limits without risk to property, life, and the reputation of the sport.

This is not to say that driving back roads isn't good experience. In fact, it's great experience! Tim O'Neil, a top Pro Rally driver, says that he feels “alienated” and uncomfortable on anything with a centerline stripe. Becoming “at-home” on back roads

and unpaved surfaces only comes with lots of driving. Just don't push at the limit, unless you're on a Pro Rally.

Driving Schools

If the prospect of trying to learn from experience, books, and other competitors does not fit your style, you might consider a driving school. Courses are available in most parts of the country, oriented towards a wide range of goals. Many are on race tracks, but some are taught at airports and large parking lots. Many courses let you use their cars.

Road rally drivers should consider starting with an “advanced driving” course or one oriented towards “skid control”. While ones oriented towards racing can be a blast, they have a bit less to do with slide control, judging corners on roads you have not seen before, and handling loose surfaces.

Appendix A lists some of the many driving schools in business. There are a few specialty schools which have programs especially suited to road rally. If you are interested in trying out Pro Rallying, a school may be the best way to get started. Also, although we have not taken their course (yet), the Ford-Michelin Ice Driving School seems tailor made to the sport.

There are some noted driving techniques that you might try to experiment with during a driving school. One is **left-foot**



braking. This is used on corners where you apply both brake and throttle at the same time. The technique tends to keep front wheel drive cars more settled in corners and maintains engine RPM, especially important in turbocharged cars.

Another technique is the **handbrake turn**. In many cars, the handbrake retards one of the rear wheels. If you need to get the back end to come around in a tight turn (see the discussion of steering balance in the next Chapter), a touch of handbrake in the middle of the turn can accomplish this. Of course, really hauling up hard may reward you with a spin-out.

Why do I talk about these in the section on driving schools? Because that's exactly where you should learn about them! Not on the streets and not (*gasp*) on a road rally!

Pro Rally

The ultimate challenge for a rally driver is Pro Rally competition – “Real cars, on real roads, going real fast”. You compete against the clock on **special stages** – closed roads without the benefit of practice runs – fastest time wins. Transit zones on public roads shuttle teams between the special stages.



Compared with other forms of racing, you can get started in Pro Rally for a moderate investment. Most of the requirements pertain to safety equipment – roll cage, harness, fire suit, helmet, fire extinguishers, etc. Many beginning competitors dash about on Sunday and drive the same car to work on Monday!

Most Pro Rallies are organized as National or Divisional level events, categorized into **coefficients** by the amount of competitive stage miles:

Divisional Pro Rally Classification	
Coefficient	Stage Miles
1	10-25
2	40-75
3	65-100

Cars are categorized by their performance and how prepared they are. In addition, drivers are rated on their past performance record. You start out in seed 6 and earn your way into the higher (lower numbered) seeds.

If you are starting out on a limited budget or are not sure you want to make the investment to get started in Pro Rally, try working an event or two. Pro Rallies need a huge number of workers, and you will get a very close look at the sport. Many beginning workers are assigned to “crowd control” at one of the spectator areas. These are usually roped off areas near hairpins, water crossings, or other spots likely to produce a show.

Of course, if you have an unlimited budget, you could forget working and the U.S. scene altogether, build a car (or two or three), assemble a support team, and go to Africa for one of the World Safari Rallies!



25. Suspension and Handling

*The Wheel is turning and
you can't slow down
You can't let go and you can't hold on
You can't go back and you can't stand still
If the thunder don't get you
then the lightning will*

*Won't you try just a little bit harder
Couldn't you try just a little bit more
Little bit harder, just a little bit more
Little bit further than you've gone before*

— Robert Hunter, 1972

The catalogues of many dealers and distributors contain listings for “rally suspension kits”. *Great!* Then you read the fine print: lowers car approximately 1”. *Must be a misprint. Why would I want to lower my car for a rally?* Yes indeed, why would you? However, it is no misprint.

Then its time to change shocks. *Gee, this is a good opportunity to improve the cruiser's handling on brisk rallies.* So you go down to Mr. Macho's Auto Emporium and he sets you up with 4 super-stiff Turbo/Sport/Performance shocks made of the special alloy: unobtanium. You try them out on the next running of *The Rally of*

Doom. Your glasses migrate to your upper lip on the washboards, your navigator gets nauseous, and you need a wheel alignment every 100 miles. What gives?

Much of what is written on the science and art of car handling is aimed at track or street conditions. It is sometimes hard to translate the advice for those relatively smooth and controlled conditions into improvements for rally situations. That is the goal of this chapter. Rather than blindly signing up for a “rally kit” or particular “rally” components, you need to understand a bit about how your car's suspension works, and how that translates into car handling. But we will steer clear of most of the “techno-jargon” that accompanies typical discussions of suspension – there are really only a few basic ideas to grasp.

Goals

Why is suspension and handling an issue in the first place? While you can certainly compete successfully in most events without modifying your suspension, a car that handles better will make the events at the “brisk” end of the scale more fun and less fatiguing. In particular, you are looking to improve certain attributes of a typical car so

that it can better handle brisk rally conditions.

Ride height. Any modifications for rallying should never decrease the ride height and ground clearance. An increase in ride height will distance the bottom of the car from jutting rocks and flying mud and stones. However, taken to extremes, raising the car can degrade handling and increase the car's tendency to roll over. What you are looking for in most cars is a modest increase, maybe $\frac{3}{4}$ " to $1\frac{1}{2}$ ". This will be a substantial improvement for rally conditions.

Traction. Without traction, your engine just converts rubber into noise as your wheels spin. If you are braking without sufficient traction, the penalties are worse. What you want is a tire which combines good traction in the conditions you are most likely to encounter during an event, with acceptable levels for other conditions.

Rough road handling. The goal here is to preserve steering effectiveness and tire traction while transmitting as little vibration to the car and occupants as possible. If these sound like opposing objectives, they are not. Oh yes, we also want to prevent the car from bottoming out.

Cornering. This is the main goal of most discussions on suspension. However, for rallying, the goals of rough road handling and cornering are fairly similar. You are looking to safely make it through a corner that you discover rather late in the turn is riddled with washboards and potholes at the apex.

Latitude. Many race cars are notorious for spinning out with little warning. They go from high traction to no traction quickly and abruptly. Other cars lose road hold gradually, warning the driver through body roll, steering feedback, noise, and a gradual loss of traction. These latter cars have latitude, a very desirable rally trait.

Wear and tear. The sport will not be enjoyable if a long stream of repair bills accumulate. One of the goals of upgrading your suspension is to reduce the wear and tear on your car.

Steering Balance

Before we get into the specifics of upgrading a suspension system, a short discussion of cornering dynamics is in order. I'll try to make it as painless as possible.

When a car corners, either the front tires, the rear tires, or both sets may lose adhesion. When only one end of a car slides, it's a waste.

Let's say the front end slides before the back end. This means that the front end has exceeded its level of traction, but the back end has not. You are wasting the remaining traction in the back end which could be used by the front end. In the worst case, the front end may slide into some stationary, immovable, expensive object. The good news is that there are lots of ways to increase traction and reduce slide tendency in each end of the car.

When the front end slides first, its called **understeer**. In Figure 25-1, the VW is apexing a corner in an autocross. Much of the weight of the car has transferred to the right front corner of the car, and the front end is sliding away from the center of the turn far more than the rear end of the car.

Other common terms for understeering are pushing or plowing. Most cars arrive from the factory with a substantial understeer tendency. We shall see why.

When the back end loses traction first, it is called **oversteer**. If you remember old episodes of the Dukes of Hazzard show, all their stunt cars oversteer. They go around the corner with the back end fishtailing toward the outside of the corner. Yahoo!

The car in the Figure 25-2 is oversteering – its back end is sliding towards the outside of the curve far more than the front end. This is a photo of Hendrik Blok in the 1973 La Jornada Trabajosa Pro Rally taking Ron

Richardson's Datsun through a corner at about 95 mph.

The joke goes: Understeer is when the front end of the car hits the tree, oversteer is when the rear of the car hits the tree.

In race cars, drivers often talk of **neutral steer** or four-wheel drift. At the maximum point of traction on a corner, front and back wheels share the side force and both will slide at the same time.

Ah ha! you say I need to get my car to neutral steer! So you take your car back to Mr. Macho's Shoppe and try to get the part number for neutral steer. Read on, the story is not so simple.

Many things affect whether a car understeers/oversteers. Some you can buy, some you can adjust, and some of it results from the way you keep the car balanced with the brake and gas.



Figure 25-1: Classic understeer

Think about what would happen if you tried to corner with the rear end in the air. Not much traction. What if the rear were just lightly on the road. Pretty poor traction. As you increase downforce on one end, you get more traction (up to a point).

Now think about what happens when you brake. As the car begins to slow down, more weight is transferred to the front end. The front gets “heavier” and the rear gets “lighter”, as far as the tires are concerned. The rear end loses traction.

The opposite happens when you accelerate. The front end gets lighter and loses traction. You can feel this effect in a high-horsepower car with front wheel drive. As you “floor it” the steering gets “light”.

In a cornering situation, traction becomes adhesion. If you brake hard in a corner, the rear end will get light and lose adhesion. The car may tend to oversteer.

There are several problems with oversteer. With the back end sliding, the car is pointing more into the corner. From the car's viewpoint, this is increasing the sharpness of the curve. The fishtail tends to get worse. The car tends to spin out, winding up on the outside or inside of the curve, or possibly spinning in place and stopping in the road (you should be so lucky). To counteract oversteer, you must steer more toward the outside of the turn, toward the ever-more-threatening edge of the road. Not a normal driver reaction. Also, you have to get more weight onto the rear end to increase adhesion. This means more gas. The reaction of untrained drivers is to lift off the gas and brake in a tight situation. Braking rewards you with a spin of memorable proportions.

From an untrained driver's viewpoint, understeer is far friendlier. When you begin to feel the front end lose adhesion, you turn



Figure 25-2: Classic oversteer

more into the turn and de-accelerate. This gives more front end adhesion. Problem solved. This is why stock sedans are set up with an understeer tendency. However, the problem with serious understeer is that you are wasting back-end adhesion. Having your front end hit a tree which could have been avoided by borrowing some adhesion from the back end is certainly a waste.

So, you can see that the driver controls a fair amount of the under/oversteer balance on each corner. The idea is to get the car set up so that it is close to neutral steer. With some practice, the driver can then get the car to understeer or oversteer at will, using the brake and gas: If the back end slides, stay on the gas. If the front end slides, lift off the gas and/or apply brake.

So what can be done to alter the under/oversteer tendency? The following items are a start:

Adjusting Steering Characteristics			
Item	End	to Increase Understeer or Decrease Oversteer	to Increase Oversteer or Decrease Understeer
Tire pressure	Front	Lower	Higher
	Rear	Higher	Lower
Tire section	Front	Smaller	Larger
	Rear	Larger	Smaller
Wheel camber	Front	more positive	more negative
	Rear	more negative	more positive
Springs	Front	stiffer	softer
	Rear	softer	stiffer
Sway bar	Front	stiffer (thicker)	weaker (thinner)
	Rear	weaker (thinner)	stiffer (thicker)
Center of gravity		move forward	move back

So how do you put all this into practice? We simply found a dirt parking lot where we couldn't hit anything and played. You can try various combinations of turning, accelerating, and braking. You can experiment with gas and brake applied at the same time (left foot braking). You can move items around inside the car (like a toolbox and spare tire) to see the effect on steering. You can change tire pressures. Then you can go wash the car.

Suspension

After experimenting with your steering balance, you can start considering some of the other goals mentioned earlier. Realize, however, that modifications here impact the steering balance. If you want to play with your springs and shocks, the most important consideration is to maximize tire contact with the road on rough surfaces.

Think of a good skier. Their legs are kept somewhat bent to absorb small bumps without throwing their upper body off balance. Their legs flex up to absorb the bump and then immediately extend back down to keep the ski in contact with the snow. If they skied with straight legs, each bump would send them flying up, jarring them and lifting their skis off the snow.

Stiffer shocks have the same effect on a rough road. The car is jarred and the wheels spend more time in the air. If a brand of adjustable shocks is available for your car, this may be the best choice. Koni and Tokico make adjustable shocks for various cars. This allows you to change the “personality”

of the car somewhat if you run autocross as well as rally events.

For springs, you should look for ones which will give the car a greater ride height and are fairly soft over small bumps. The problem with soft springs is that you can bottom out on the really big bumps. The suspension will bottom out, hitting the bump stops. This is bad. If the suspension is on the bump stops, handling goes down the tubes. It's like having no springs or shocks at all. You can potentially damage the shocks if you bottom out too hard. One solution is to install a variable rate spring which is soft at the beginning and gets stiffer the more it is compressed. Whatever you do, avoid departing wildly from the specifications of the original springs and shocks – the rest of the suspension still has to work with the new components.

Another item to consider is a stress bar, especially for the front end. Despite the seemingly rigid structure of a car, the frame actually bends and twists quite a bit on bumpy surfaces. Because of the changing frame angles, the suspension does not work as designed. You can also develop stress cracks in the windshield due to body flex. A stress bar attaches to the tops or bottoms of the struts/shocks and transmits suspension loads equally to each side of the car.

Tires

If you went by the claims of some tire manufacturers, every one of their products is the perfect city, highway, dry, rain, snow, ice, gravel, dirt, and mud tire as well as

wearing forever and increasing your social status and sex life.

In practice, tire manufacturers make many compromises when developing a general-purpose “all weather” tire. If you are looking to improve traction in one particular area (packed dirt, gravel, snow, ice) and are willing to give up tire life or traction or handling in other areas (highway, tread life), a specialized tire may be the answer. The social status and sex life are other issues.

The first thing you should look at in a tire is the softness of the compound. Push against a tread block with your thumb or fingernail or check a quoted softness index. A very hard compound will wear longer but is stiff when it encounters small road irregularities.

Stones or gravel which become lodged in the tread are not released. A softer compound will conform to the road surface, giving better traction on uneven pavement, gravel, and dirt. However, tread life is reduced. Heat can also be a problem. When the polymers in a tire are heated above a certain point, they lose their elastic characteristics. Some older dirt tires actually melted at highway speeds in the summer. The ideal softness is a tire which is soft enough to conform to the road irregularities without excessive bending of the tread blocks which degrades traction.

Next, look at the tread pattern. The ultimate dry-pavement tire is a racing slick with no tread pattern. However, the tradeoffs are poor performance if the surface is not smooth, and a tendency to hydroplane in

wet conditions. Hydroplaning occurs when the tire rides up on top of a layer of water and completely loses contact with the road. At the other end of the scale are extremely knobby tires designed for sand or desert conditions. They claw through uneven terrain, never hydroplane, but have very little rubber contact on a smooth road. Tires designed for reasonably smooth unpaved conditions have many of the knobby tire attributes, but in moderation. The tread blocks have ample space in between to grab at dirt and stones. The sides of the blocks are angled so that stones are released as the tire flexes. An important feature are the small cuts, called *sipes*, which run through each block. Siping gives the tire more gripping edges, which improves traction in slippery conditions.

Some people like to make their own tread pattern. This is usually a pastime of Pro Rally enthusiasts. However, if you get the urge, all you need is a tool called a *groover*. The tip of the tool is a heated **U**-shaped cutter which swiftly cuts any tread pattern you want. Hoosier distributes such a tool.

The sidewall is also an important area. Many of the punctures on rallies happen when sharp rocks punch through the sidewall. The ultimate tires have steel cables formed into the outer sidewall to repel rocks.

Because they are out of the mainstream, tires which maximize performance under brisk rally conditions are sometimes difficult to locate. Popular models are manufactured

by Nokia (Hakkapeliitta), Gislaved, Bridgestone, and Michelin. Specialty distributors such as KT Motorsports are the best source for advice and mail-order purchase.

Avoid low profile tires when driving on rough roads. Those 50-series tires may look great, but a set of four dented rims and the risk of a blow-out are not worth it. Consider a second set of rims and tires for rallying. Also, use higher profile tires with smaller rims so that the outside diameters remain the same.

If you are running on ice, you might want to add studs. Many tires designed for use in the snow have holes for studs. However, you must install the studs before running on the tires – any dust in the stud holes will make the studs fall out easily. Also, be aware that studs are legal in many states only during certain months and are not legal at all in some other states. Before considering studs, you should also consider how they affect your traction on paved wet roads.

Finally, before the event, select a tire pressure which works best for your tires and the expected conditions. You may have to consider issues of course measurement accuracy (see [Chapter 19](#)) and weigh them against tire performance.

26. Night, Winter, and Endurance Rallies

These are the times that try men's souls

— Thomas Paine, 1737-1809

Running a tough event can be very satisfying. Staying on time on a brisk event requires a good driver, a cool navigator, and lots of teamwork. To make events even more interesting, rallymasters run rallies at night, in the winter, or over great distances. This chapter talks about how to survive and get to the “satisfying” part of these events.

Night Events

After setting up the external and internal lighting (as discussed in [Chapter 16](#)), go for a test run. Make sure the navigator's lights don't affect the driver. Make sure the cockpit lights don't reflect in the windshield. Tape up some sample route instruction on your rally reader and make sure they are readable. Then look for other annoying lights which might distract or affect night vision. Our blue high-beam indicator had a white light in the center which shone directly at the driver. A spot of masking tape cured the problem.

Try writing with various color pens and using various highlighters under your cockpit lights. Some colors will show as black and some (such as red pens) will be faint or invisible! Vera once highlighted all her turns with a blue highlighter which showed up black on the rally reader. It was a very long night!

Check out how your clothes and other items in the car reflect off the windshield. It is usually best to wear a dark shirt, but possibly with a light or reflective back as a safety measure for when you are walking around at night.

Try rallying a short distance with your backup flashlight. If your cockpit lighting goes out, the backup lights are what you will be running with. Is it acceptable? Would it be safe?

Also, get some experience with how your eyes react to the exterior lighting. There are two philosophies. One says to run with all the lights, as long as there are no other cars. Why not use the maximum lighting? The other argument is that your eyes grow accustomed to the level of light. If you run with some of your lights dimmed, you can get better visibility when you need it since your eyes are used to a lower level of light.

Whatever you do, be aware that, with a heavy-duty front end light setup, you can have the power to blind other drivers and cause them to hit things. Like your heavy-duty front end light setup.

All-Night Events

Most people take sleeping for granted. Most people have never done an all-night road rally.

Everyone reacts differently to staying up all night. The only way to acclimate is through experience. Coffee or caffeine tablets (No-Doz) work great for most people, to a point. Many people hit the crazy-hour at 2 AM and are fine an hour later. Others do fine as long as they get a 30 minute nap somewhere in the night.

How ever you survive, most rallyists share the exhilaration of running a brisk leg as the sun peaks up over the hills in the morning.

Winter Events

Running road rallies in the cold adds a whole new set of considerations. The basic question is: how cold?

Cold

If you are running between 0°F and +30°F, there are really very few things you need to do in the way of car preparation. Studded tires are an advantage when grabbing into ice. Tires made of a new hydrophilic compound which will not freeze are an advantage.

One of the big problems on events which are just below freezing is slush. The windshield

wipers can collect slush and freeze, raising the blades above the surface of the windshield. Under extreme conditions (freezing rain) it can take less than a minute to make your wipers worthless – try staying on time while jumping out of the car to clean the wipers every 45 seconds! You can combat this problem with special wipers where the arms are encased in rubber boots which do not collect slush as easily.

Another problem is frozen slush in your wheels. While you are driving, it usually accumulates evenly, causing little noticeable difference in handling. The problem happens when part of the frozen slush is removed or melts. If you park for lunch, your heated brakes could be enough to melt just the ice near the brake pads. This causes immediate and sometimes extreme unbalance in the wheel. The only cure is to remove the rest of the ice.

Very Cold

Below 0°F down to about -30°F, things get funny. The problems described above go away, because things never melt. The snow is drier, and, at the bottom end of this temperature range, becomes like hard sand. Studded tires are not really necessary any more.

Car preparation starts to become very important. Anything with water in it will slush or freeze:

- Water in your gas will crystallize, clogging fuel filters and fuel injectors. Adding 1 can of fuel drier (a methyl alcohol-based product) with each tank of fuel insures

against gas which may have been contaminated with water.

- Brake fluid attracts water. It will slush, making braking difficult, at best. Change your brake fluid yearly.
- Regular windshield washer, the kind guaranteed to -25°F, freezes at about +5°F. The really “good stuff” is mostly alcohol and can be purchased at stations in the North country. Be prepared to pay \$4 per gallon.
- Some teams add various devices to warm the windshield washer fluid. These either tie into the radiator or use a heater on the bottle of fluid. These have the problem that the fluid freezes when it hits the windshield.

Another problem area is lubricants. Oils become more viscous and flow poorly at colder temperatures. Most people in really cold areas use a synthetic oil, such as Mobil 1, which maintains its viscosity to very cold temperatures. Another company, Red Line, produces an entire line of lubricants for cold weather operations, including engine oil, transmission fluid, and differential fluid.

Starting your car in the morning after it has been “cold soaked” all night can be an adventure. The cold significantly reduces the cranking power of your battery as well as making its job harder. If the oil has congealed, you will wear your engine incredibly quickly trying to start it. One solution is electric heaters. J. C. Whitney (see Appendix A) sells a 500 watt heater plug which goes into your engine block. A 100 watt heater can be pasted on the side of

your battery. These plug into a 110 volt outlet, so bring an extension cord made with silicone rubber.

One problem with heaters is that, when several teams are plugged into one circuit, you can blow a fuse. This renders all the cars on that circuit cold soaked in the morning. Your car won't start, but at least you have company! One solution is to hook up a LED in-line with the heater which is visible from outside the car.

Absurdly Cold

Absurd cold requires absurd measures. Below -30°F teams remove their battery each night and keep it inside. Other teams simply let the car run all the time, night and day. Carry an extra set of keys and, when you stop for lunch, just lock the car with the keys inside.

The real issue at these absurd temperatures is survival. Jerry Hines, rallymaster of the ALCAN 5000 winter rally, advises competitors to drink frequently (water, that is). The air is extremely dry at very cold temperatures and dehydration reduces your ability to deal with the cold. Also, most people dress too warmly inside the car (causing sweating) and insufficiently when outside the car. Experienced teams often go in jeans and a heavy shirt or sweater and wear the parka and ski bib or a snowmobile suit when they get out.

Finally, make sure that the organizers have the experience to get you out of trouble – preferably with more than one sweep

vehicle so that you are virtually guaranteed of help within a reasonable amount of time.

Endurance Events

The word “endurance” can mean anything from a scenic tour covering multiple days and punctuated by rallies all the way to car-breaker, brain-buster, forget-about-sleep marathons. Sometime after you get established in the sport, you should consider running an endurance event for the experience, preferably at the “scenic tour” end of the spectrum.

Some of the more well-known endurance events include the ALCAN 5000 (Seattle → Anchorage → Seattle), One Lap of America (courses vary around the US), the MG-1000 (PA, NY, and Canada), the Grand Tour for Kids (Michigan, formerly MACA), and two vintage car rallies, La Carrera Pan American (Tuxtula, Mexico → Laredo, TX), and The Great American Race (across the US).

Endurance events provide a whole different level of challenges. The problem becomes one of management as well as rallying. The annoying little problems on a “short” rally can fatigue you into a DNF on an endurance event. Some maxims we try to follow:

- Map the event out beforehand. Having an overview of the course, with a good route for the long transit zones, can really help during the event.
- Eat right. For us this means simple easy-to-digest food with high carbohydrates and low in protein and fat. We usually pop a vitamin occasionally to compensate for

deficiencies. The joke is that we have to go on a one-week rally in order to eat well!

- Drink lots of fluids. It's very easy to get dehydrated.
- Service the car. This is easy to overlook when you're tired. At every gas stop we check the oil and washer fluid, clean the windshields and lights, and check the tire pressures.
- Pace yourself. Anticipate when you will need to be “on” and plan accordingly. In between, rest. Take short naps and don't drive beyond your limit.

And, finally, stay loose. Don't let your apprehension about a portion of the event take an extra toll on your energy.

Experienced competitors know the effect and will try to build up uneasiness in the rest of the field. Or the rallymaster might throw in:

**136. Right onto unpaved.
CAS 36.
Gain 75 over next 0.50
miles (caution for sharp
curves ahead).**

There We Were on the first DownEast rally organized by Karl Chevalier. We had run 10 rallies in the last 4 days and our sleep quotient averaged out at 2 hours per day. We were in the middle of the last rally and were starting to lose it. A missed turn and several botched calcs showed we were succumbing to weariness and the pressure to run clean.

Then, out of nowhere in her best horror-movie-Igor imitation, “Masteer, I need a

reeding”. Back came the Lily-Tomlin-operator reply “One ringy dingy, snort, snort, snort”. And so we went through an array of absurd impersonations. No one was safe. Bogart, The Duke, Nixon, Zsa-Zsa, and, especially, the organizers. The result? 3 zeros.

Finally, I include a list of items, over and above the Rally Box from [Chapter 16](#), which have served us well on endurance events:

- Overnight bag. I like to have one bag with everything I need for an overnight stop.
- Blanket and pillow. Keeps you warm, and fools you into thinking you are really asleep.
- Rain poncho. One of the super-thin plastic ones will work and saves space.
- Paper towels and small garbage bags. Neatness counts.
- Water bottle.
- Extensive maps with the route highlighted.
- Portable cassette player/walkman. If you have a cassette player in the car, great. However, take along one with headphones so the driver can listen while the passenger sleeps. Also, if you have some audio books, these may keep you more mentally alert and involved than just music.
- CB radio. These are often allowed on endurance events for safety.
- Clothes. An assortment of loose, comfortable, not-too-stylish clothes is in order. Leave the button-fly jeans at home!

Part 6 – Traps



27. A Well Laid Trap

*Once in a while
you get shown the light
in the strangest of places
if you look at it right*

— Robert Hunter, 1974

Historically, trap rallies started as straightforward rallies with **math traps** thrown in. Everyone would follow the same course, but some convoluted timing instructions would be thrown in to test the navigators' mathematical aptitude (or lack thereof). Many such math traps were in the form of a phantom car problem that we will look at in depth in the next chapter.

As the sport grew, rallymasters began to concoct traps based on some rule defined in the Regs, general instructions, or route instructions. Such traps are often implemented by a new form of instruction, called a **Lettered Route Instruction** (LRI). The idea is that once an LRI is activated and, as long as it is active, you execute it at every opportunity.

Initially, traps simply caused you to be off time. For example, **LRI A: Pause 10 at sideroad**. Not remembering that an

unpaved road does not exist and therefore does not qualify as a sideroad would cause you to pause too many times. When all contestants follow the same course, this is called a **timing trap**. These traps are somewhat limited since contestants are running at one minute intervals but, on many national level rallies, they are designed to yield maximum penalties for the unsuspecting rally team.

Then rallymasters discovered that they could build a trap event that involved course-following problems. Typically, contestants get to an intersection where they take one of two courses. One is correct (by a precise reading of the Regs, general instructions, and route instructions) and the other is wrong. The rallymaster sets the event so that both courses merge into a common course to the checkpoint. Contestants travel either the **on-course loop** or the **off-course loop**, arriving at the checkpoint at widely differing times depending on which course they took. In a well constructed **trap-loop event**, contestants on the off-course loop are not even aware of their blunder until they read the checkpoint handout.

Course following traps can be built around almost anything – a hidden route instruction buried in the general instructions, the subtle use of a definition, the interplay of several rules, etcetera. One class of traps is based on the concept of a **main road** – a single road out of an intersection determined by a set of rules. Main road traps are built on the precise interplay between the main road rules, and the route instructions. Many trap rallies, especially at the national level, are built entirely on main road traps, a topic we cover in [Chapter 29](#). Finally, [Chapter 30](#) covers a collection of miscellaneous traps used in events we have run over the years.

There We Were on the official check of the first rally we had laid out. The checkers were two of the most experienced rallyists in the area, Glenn Folsom and Terry Martin, who were well-known trap rally competitors. The first instruction of our first rally was “Left turn onto Post Road”. Now a Left was defined in our Regs as “a turn to the left of between 10° and 170°”. So, Terry made the Left and Glenn said “Gee, Terry, we’ve made the Left, now we’re looking for a turn!” As (my rotten) luck would have it, we were immediately at an opportunity to make a left at an intersection, so Terry made a second Left.

In the first two words of the first instruction of our first rally we had managed to uncover a trap which would be used many years later in putting on our first trap event. It was the start of a long, but interesting day.

This example of a course-following trap has some of the characteristics of what competitors usually consider a “good” trap. It required no setup – no suspicious special rules in the general instructions. The explanation on the checkpoint handout could have been done in two or three sentences. Competitors can grasp the trap almost immediately. Also, since the trap is at the very beginning of the event, it adheres to the trap rally **rule of greatest astonishment**. The competitor is taken completely unaware by a trap of great simplicity.

This story also points out one good reason for running trap events: they encourage people to read and understand the Regs. Obviously, this can be very valuable for potential rallymasters.

However, while trap rallies can be great fun, there are many pitfalls to laying out a trapped event:

- The traps themselves must be brutally correct. Traps based on information not found in the official information, or that are based on past experience, local knowledge, or personal association with the organizers have no place in a good trap event.
- When running a straightforward rally, competitors can allow a bit of “looseness” in the route instructions. While a truly clean event should not have such situations, real-world rallies sometimes get an “I know what he meant, even though it’s not precisely correct”. In a trap rally,

the rallymaster has no such luxury. The hardest part of laying out a trap event is in avoiding unintended traps in portions of the course which were supposed to be trap-free.

- Each trap is inherently a test of the competitor's intellect. Failing to execute a trap correctly can make you feel bad; failing to understand a trap after it is explained to you makes you feel stupid. If this situation happens too often, less experienced competitors will simply not come back for the next trap event.
- Finally, as rallymasters put on a number of trap events, they tend to see the event as a competition between them and the contestants. A team which runs clean, falling for none of their traps, has defeated the rallymaster. This leads to an event full of extremely convoluted traps that none but the most experienced competitors can understand. The extreme situation of a small clique of trap rallyists, each putting on events which only other members of the clique can appreciate, leads to a dead-end situation.

If you happen to run a poorly organized, “loose”, or overly convoluted trap event, don't abandon the sport. There are well-done trap events that provide competition for the experienced teams and allow novice trap rallyists the pleasure of getting some traps and a learning experience for more complex situations.

Getting Started

The next three chapters talk about various types of timing and course-following traps. But, as always, the best way to learn about trap events is to go out and run them. Then, when you have learned what they are all about, read about how to solve the math problems and recognize the trap loops in the instructions.

A couple of general guidelines for running trap rallies:

- You have to know the Regs cold. Good teams have the definitions memorized.
- Read the general instructions several times. Look for anything out of the ordinary, which might set up a trap. Become familiar with the overall organization of the generals, so you can look things up quickly on the course.
- Discuss the general instructions with another team from a different class. Raising some “*How about*”s and “*What if*”s over dinner the evening before the event can help your scores.
- Scrutinize not only the general instructions, but every single item handed out by the organizers. One rallymaster imprinted special instructions on pencils placed in each competitor's packet. Another had a rule printed on the inside of a balloon!
- Check your route instructions very carefully for completeness. A missing page can contain a single instruction, which you only get if you inquire about the missing

page from the organizers. Also, check for NRIs which are out of sequence.

- Use Post-Its. Most trap events have LRIs which are activated and de-activated at various points. Some use an “ONTO” rule (explained in [Chapter 29](#)) for course following. Some have changing lists of priorities or main road determinants. You can use Post-Its for each of these to keep what is currently active on the dashboard. In the case of LRIs or ONTOs, the navigator can copy each onto a Post-It prior to the event and keep them on the route instructions – when an LRI or ONTO is activated, just take it off the instructions and paste it on the dash.
- If you can use more than one navigation strategy, choose the simplest one. Trade off some TSD precision in favor of having more “think power” available.
- Try to get a picture of how the leg is structured. It is possible in many trap-loop events to get a picture of when the on-course and off-course loops diverge and merge back together. In other words, try to spot the trap ahead of time!

When scrutinizing the general instructions, be especially aware of seemingly harmless items that are stated for no apparent reason. A recent event's general instructions made the innocent-looking statement that *the course is divided into two sections, a morning and an afternoon section, of equal length*. The official mileage at the end of the morning section was given, but not the end of the afternoon. The course ran right past the headquarters hotel at the end of the

event, and many teams stopped there, assuming the event was over. In fact, the afternoon section continued several miles past the hotel, to the final checkpoint located exactly at the mileage given at the end of the morning section.

Another rallymaster buried a strange definition in the glossary: “Wrong: Left”. Then, at the end of the general instructions, centered and in boldface:

Make no wrong turns!

Without any wrong (left) turns, the course took on-course teams around the block, back into the start area, and past the ✓• sign displayed at registration. “On-course” teams were checked in, the remaining instructions were canceled, and scoring was done! The on-course teams and the organizers were well into the post-event party before the first off-course teams began filtering in.

One good way to get into the trap rally mentality is to “run” an armchair rally such as the St. Valentine's Day Massacre. When you enter this event, you get an atlas of the United States, a set of general instructions, a route to follow, and a list of questions. The rules are extremely precise and the entire “event” is very well put together, attracting as many as 2000 competitors each year. See Massacre under Organizations in Appendix A.



28. Math Traps

*Well it's a strange old game –
you learn it slow
One step forward
and it's back to go
Standing on the throttle,
standing on the brakes
In the groove
till you make a mistake*

*Sometimes you are the windscreen
Sometimes you are the bug
Sometimes it all comes together
Sometimes you're gonna to lose it all*

— Mark Knopfler, 1991

In Chapter 4 we looked at a puzzle that forms a simple math trap. The trick was to realize that you cannot simply average two CAS assignments, but must use rates or TSD formula calculations to come up with the correct average speed. Many math traps are like this – once you recognize that the instruction is a trap, solving it is easy. The big exception is the class of math traps called phantom car problems. But first, some relatively simple math traps.

Percentage timing

The instructions read:

50. "Speed Limit 50". CAS 50.

**51. Left at Stop. Decrease
average speed by 20%.**

**52. Right at T. Increase
average speed by 20%.**

Many competitors will revert to CAS 50 at NRI 52. Wrong! NRI 51 has you switch to CAS 40 ($50 - (20\% \text{ of } 50)$). In NRI 52, 20% of 40 is not 10 mph, but 8 mph. So your speed goes up to only 48 mph.

Gain Traps

The checkpoint slip had the instruction: *Increase the total leg time of the next leg by 10%*. Fine, this is an emergency speed. Then the next leg contains a Gain. Now the problem comes in when teams forget to increase the time of a gain when doing an emergency speed.

If increasing the time of a gain sounds wrong, try an example. Here is CAS 30 for a mile with a gain of 20 cents:

	<u>Normal</u>	<u>10% Emergency</u> <u>Speed</u>
1 mile at		
CAS 30	2.00	2.20
Gain 20	<u>-0.20</u>	<u>-0.22</u>
Total time	1.80	1.98

Since 0.18 is 10% of 1.80, the correct time is 1.98 minutes. So, increasing the gain from 20 to 22 cents is correct.

Phantom Cars

A large class of math traps fall into a category known as *phantom car problems*²⁹ The basic idea is that your car will be “met” at some point on the course by a “phantom”. At the meeting place/time, you take some timing action such as a pause or CAS change. The puzzle is to determine the meeting place and time.

Phantom car problems were once very common on trap rallies, before rallymasters discovered how to build trap-loop events. In recent years, they have faded from use in many areas and never appear in certain events, such as National level course rallies. Why? Once you have become familiar with them, they are easy!

However, these problems do rear their ugly heads in many local and regional trap events. Sometimes rallymasters use them as the traditional last DIY leg back to the hotel – the dessert wine at the end of dinner. The

following tongue-in-cheek example was developed by Ian MacLennan. It is paraphrased from a write-up on solving phantom car traps.

Control 53. You're feeling really good about this leg. You just got a 47, your best score of the day. You're also proud of the fact that you did all of the traps correctly, until you read the checkpoint slip and notice that there weren't any traps on the last leg. Your confidence is further shaken when you notice this is the leg that the phantom turkey is due to appear. At 4:06.00 PM you leave the control at the new CAS of 20 mph. Your navigator is frantically flailing away at his calculator while his notes are flying in your face. Your hands are clamped around the steering wheel. Five minutes after you leave the control the phantom turkey suddenly appears at the control and starts careening down the course (toward you) at 36 mph. When he catches you, you are instructed to change to CAS 36 and ride with him on your rear bumper to the checkpoint.

There are many ways to approach this problem:

- By slight-of-hand. You could simply start the leg five minutes late at CAS 36 and never worry about the speed change. But what if they place a surprise checkpoint

²⁹ Please note that many experienced rallyists feel that Phantom Car problems are outdated and “in poor taste”. They are presented in this book to help you solve them, if

encountered, and not to encourage their use by rallymasters.

before the speed change location? What if CAS 36 is too fast for the road?

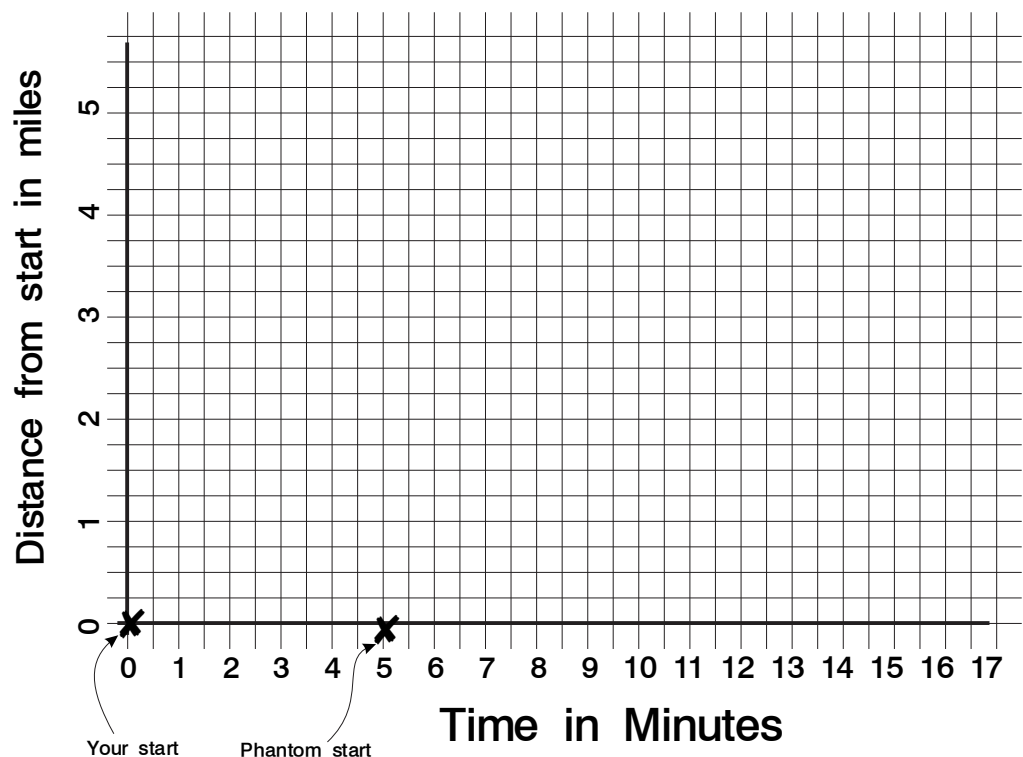
- By computer. If you are running in the Computer Class, you could run two computers, one for you and one for the phantom. Set the phantom's start time five minutes later than yours and run his computer at CAS 36. The phantom's null unit will read early until he catches you, at which time you change speed.
- By equations. You could figure out mathematically where you and the phantom will meet. In general, this math involves the high school level algebra transformations which we avoided in Chapter 4. While the transformations are straightforward, figuring out the equations while under the gun at a checkpoint can turn your brain into congealed oatmeal.
- By rates. You could convert all the speeds to rates and reason out a solution based on the differences between the rate values.
- Using a graph. The last choice is to draw a graph depicting the situation, and

solve the problem graphically.

In practice, the last approach is the most intuitive. It usually gives you an answer in which you can have some confidence. However, because it involves pencil lines on graph paper, it can lack precision. For these reasons, after working dozens of these problems (and getting some of them correct), we usually do the problem graphically, and then try to reason out a solution using rate values.

Using a Graph

First, take some graph paper and draw an axis across the bottom for Time and a vertical axis on the left side for Distance. Add two marks which represent your start time and the phantom's start time from the checkpoint (both at mileage 0 on the left):



Now we will add two lines on the graph that represent the time and distance traveled by you and the phantom. Your line starts at your ✖ (zero miles and zero time). The phantom's starts at the ✖ at zero miles and five minutes late. Since you start traveling at CAS 20, your line goes up one mile for every 3 minutes of time to the right (you can get this from the Rate of 3 minutes-per-mile corresponding to CAS 20).

The phantom's line goes up one mile for every 1.6666 minutes of time at CAS 36, so the two lines will meet at some point.

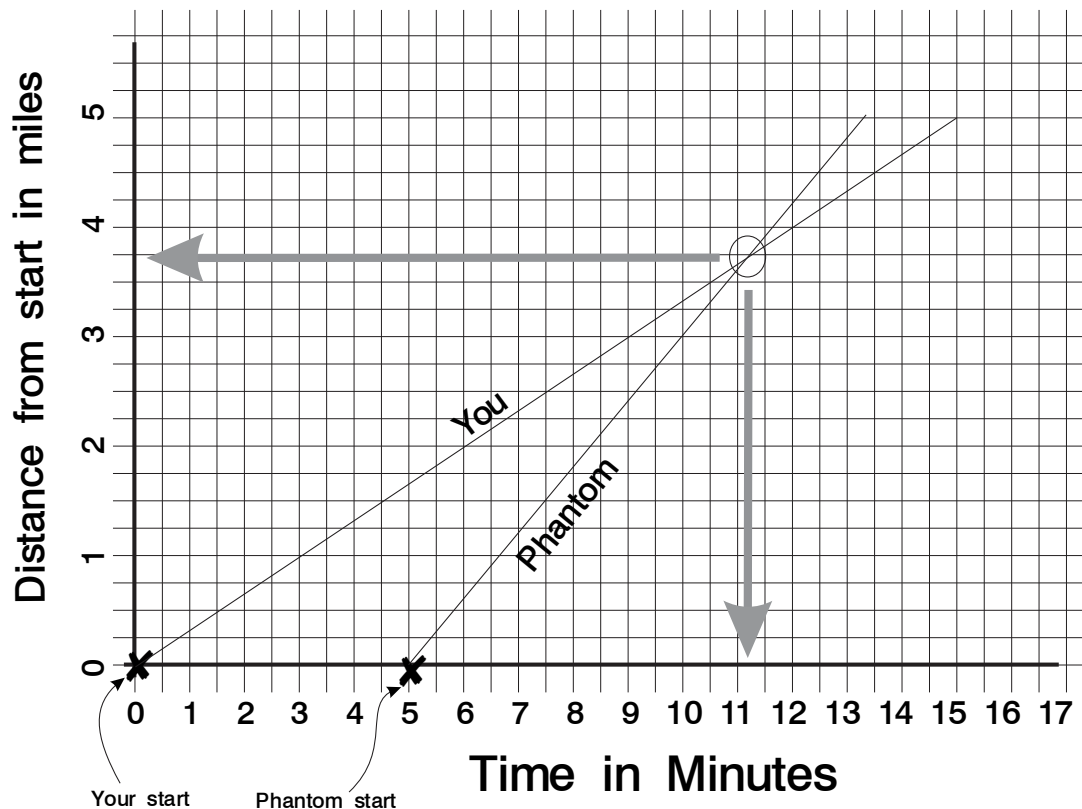
The point where the two lines meet represents where you and the phantom will meet in distance and time on the course. You can draw a line from the crossing point to the left to get the distance, or down to get the time that you will theoretically meet.

In our example above, we will meet the phantom 3.75 miles and 11.25 minutes into the leg.

Of course, since this is a book and I chose the example, the solution turned out to have some reasonably round numbers. In real life, the solution is more likely to have fractions of cents rather than be whole miles or minutes. This is where the graphic model falls down: the best resolution you are likely to get is to the nearest 0.1 mile or minute, which simply is not enough in Computer or Odo Classes.

By Rates

So, once you have built a graph and have a rough answer, you can fall back to math using the rate values for each speed. The important principle to remember is the rule for determining time based on the difference



between two speeds, as discussed in [Chapter 17](#). Here is the way the reasoning might go for the above problem:

The rallyist started out at CAS 20, using a rate of 3.00 minutes to go each mile. The phantom started at CAS 36 using 1.6666 minutes to go each mile. The difference in time “made up” by the phantom each mile is the difference in rates of 1.3333 minutes for each mile. To “make up” 5 minutes, it takes $5 / 1.3333$ miles or 3.75 miles.

By Equations

If you would still rather work out the equations, it is best to translate the graph into equations. Here is how it works: start with an equal sign in the center and build an equation on the left which represents your line on the graph and an equation on the right which represents the phantom's line on the graph:

$$\frac{Distance_{you} \times 60}{Speed_{you}} = \frac{Distance_{phantom} \times 60}{Speed_{phantom}} + 5 \text{ minutes}$$

The left side represents how much time you travel as a function of distance and the right side represents how much time the phantom takes as a function of distance. You will meet when the two times are the same, so we need to plug in the speeds and solve for Distance.

$$\frac{Distance_{you} \times 60}{20} = \frac{Distance_{phantom} \times 60}{36} + 5 \text{ minutes}$$

Remember that the equation will be solved when $Distance_{you}$ and $Distance_{phantom}$ will be the same. Thus, for this equation, $Distance_{you} = Distance_{phantom}$.

Algebra lets us move the $Distance_{phantom} \times 1.6666$ factor from the right hand side to the left hand side and change its sign.

$$(Distance \times 3) - (Distance \times 1.6666) = 5$$

$$Distance \times (3 - 1.6666) = 5$$

$$Distance \times 1.3333 = 5$$

$$Distance = \frac{5}{1.3333} = 3.75 \text{ miles}$$

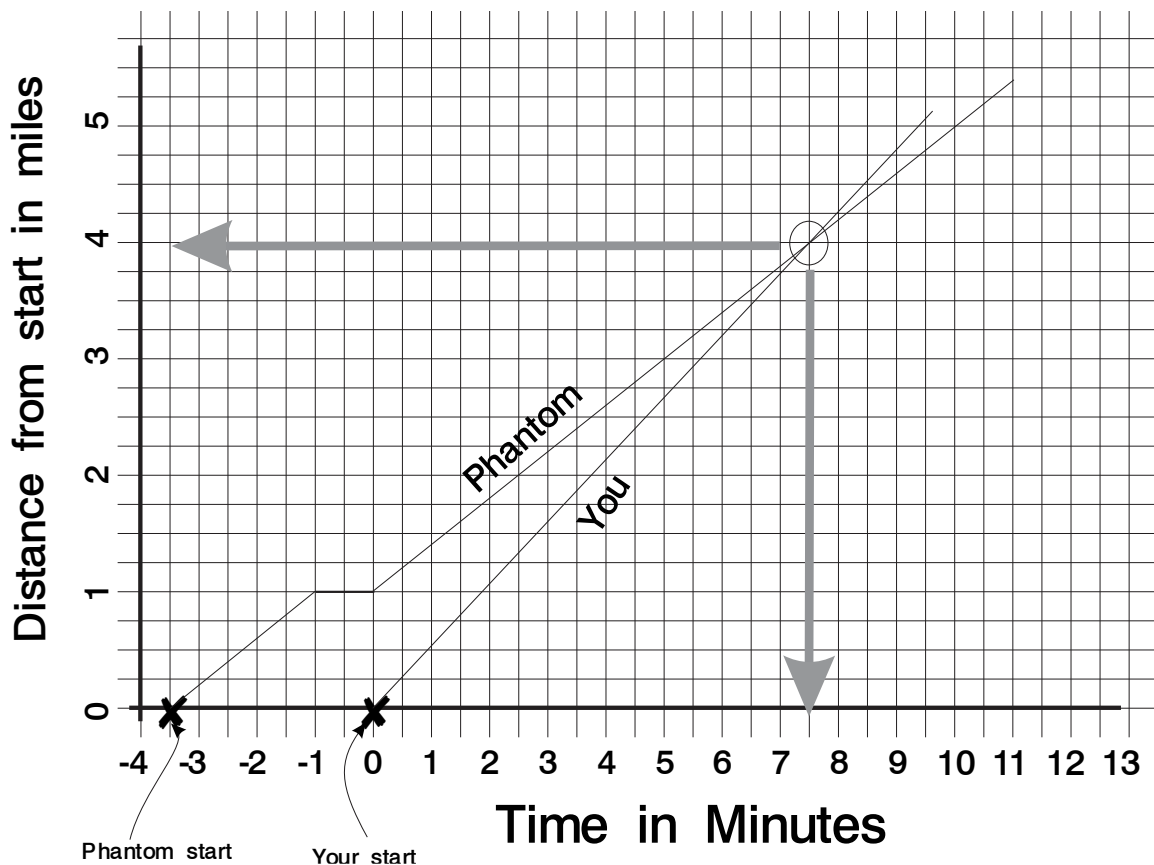
A More Complex Phantom

This more realistic phantom car problem comes from the 1989 Frost Heaves rally put on by Bill Hall and Nancy May:

A heavily loaded phantom Peterbilt has passed this control 3.50 minutes prior to your departure time. It is traveling along the rally course at 24 mph. At stop signs, it requires an additional 0.50 minute to stop and regain its speed.

You will depart this control at CAS 32. When you encounter this phantom, you will have no opportunity to overtake it. Pause to make your following distance 0.11 mile and follow the phantom to the finish (of the rally).

Since this was a DIY leg at the end of the event, we ran the course, taking mileages and counting stop signs, before ever trying to solve the problem. There were two stop



signs. We simply stuck them in the graph as two half-minute pauses after the phantom had traveled one mile (in 2.50 minutes).

And now for Bill's solution, a reasoned approach using rates:

There were two stop signs where the phantom paused, but the rallyist did not. Thus the phantom was only 2.5 minutes ahead of the rallyist. The rallyist traveled at 32 mph, using 1.875 minutes to go each mile. The phantom traveled at 24 mph, using 2.500 minutes to go each mile. The difference in time “made up” by the rallyist is the difference 0.625 minutes for each mile. To “make up” 2.5 minutes requires $\frac{2.50}{0.625}$ or 4.00 miles. The length of the leg is 4.67 miles. At the point where the rallyist “catches up”, he must pause to allow the

phantom to attain a lead of 0.11 miles (at 24 mph). This pause is 0.275 minutes. Then the rallyist travels the remaining 0.67 miles at 24 mph, using 1.675 minutes:

4.00 miles @ 32	7.500 min
Pause	0.275 min
0.67 miles @ 24	<u>1.675 min</u>
Total	9.450 minutes

A Post-Note

Since phantom car problems have fallen out of favor in many circles, you should be wary whenever you see one. Some rallymaster will give what appears to be a phantom car problem, but which, in reality, can never be executed. So, before you plunge into the math, read the entire problem and see if there is a built-in “escape”.

29. Main Road Traps

Confusion has its cost

— Steven Stills, 1969

This chapter looks at a class of traps that has become very popular, especially at the more challenging levels of trap rallying. The idea is fairly simple and based on a relatively small set of main road rules and priorities. The key is that every intersection on the course holds the potential for a trap.

Here's the basic idea: You are given a list of **main road determinants** (MRDs) – rules which uniquely determine a **main road** out of any intersection. Unlike a straightforward event, the main road might be very different from the road that is “straight as possible” or the “obvious extension” of the road you are on.

In addition to the MRDs, you have priorities which define the relationship between the main road and the NRIs and LRIs in the route instructions. A typical event might specify that you can only execute a course directing route instruction if it takes you on a unique course which is different than the main road at that intersection.

Main Road Determinants

The definitions of the MRDs are usually given in the Regs or general instructions, but the particular MRDs in use or their order might change from leg to leg. These MRDs are simplified versions of ones used on several regional trap events in New England. They do not relate to any particular set of rules, but are for example only.

T-Rule

The main road at a T is Left.

Of course, this MRD could specify Right. The T-Rule depends heavily on the definition of a T. For this chapter, assume that a T must be approximately 90°. Note that this is very different from the definition of a T in the National Regs, which allow a T to be slanted as much as 79° from perpendicular. In practice, however, slant Ts are seldom used on National rallies as the basis of a main road trap.

Alternating T-Rule

The main road at a T is Left if you are seeking to execute an odd numbered NRI

and Right if you are seeking to execute an even numbered NRI.

A common trap is to have contestants encounter a T when both even and odd NRIs are active. This situations occurs when execution of NRIs can overlap other NRIs. Since there is not a single road specified in this situation, this rule does not apply.

Protection

The main road is that single road leaving the intersection that has no Stop or Yield sign at the intersection.

For this MRD to apply, a single road must be “protected” from uncontrolled entrance from other roads. This is done by virtue of Stop or Yield signs controlling traffic on the “letter” roads. Contestants are usually required to recognize octagonal stop signs and triangular yield signs from the back. An important aspect of this rule is that the presence or absence of a stop or yield for the

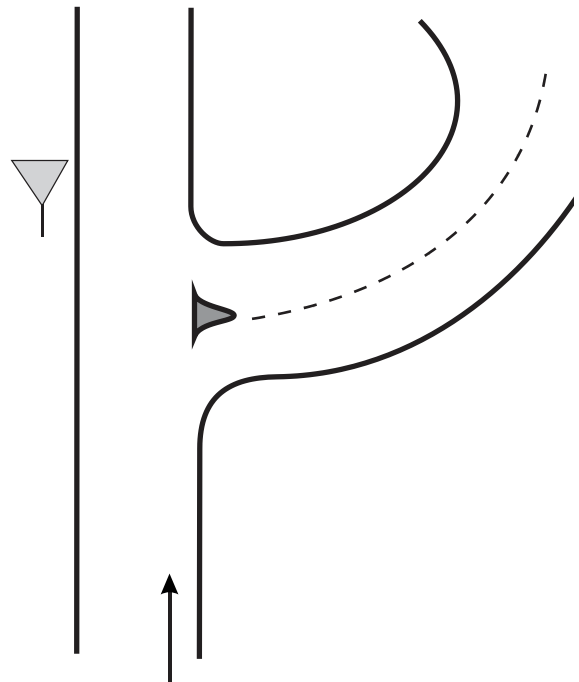
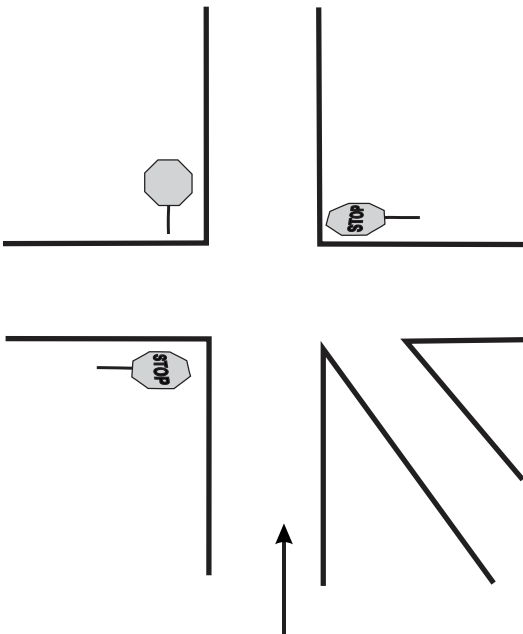
rally vehicle has no bearing on whether the intersection qualifies for protection.

This MRD is often used as the sleeper in trap rallies. You might not encounter a protection situation for many legs, and get lulled into forgetting to consider this MRD. Then you get to some innocent-looking intersection with stop signs all around, except for some inferior spur off at a sharp angle to your right with no stop sign. Gotcha.

Another sleeper situation is a highway entrance ramp. You fail to notice the yield sign for oncoming traffic at a harmless-looking highway crossover. The highway on-ramp becomes the main road!

Onto

After execution of an action in a route instruction that has directed the contestant to travel upon a road by use of (1) the term “onto” and (2) the name of



the road, and until a course-directing action is executed, the main road is the single road at an intersection whose designation matches the road named in (2).

Whew! What all this means is that, after executing a instruction like **Left onto Mahler**, any road identified as Mahler becomes the main road, if there is only one Mahler exiting an intersection. The ONTO has effect until another course-directing action is executed.

This rule began as a well-intentioned rule to eliminate unnecessary route instructions. Once “onto” a named road, you followed that road through intersections. This rule was used by rallymasters to eliminate the frequent situation of a small spur road off main route which was technically Straight As Possible.

The exact meaning of “*identified as*” must be defined. If the original instruction took you left onto Mahler Rd, would a Mahler St sideroad qualify? What about North Mahler Street?

There are many variations to the ONTO rule. Many versions allow road numbers or letters to be used in addition to names.

There are also many variations in what cancels an ONTO. Rather than a course-directing action in a route instruction, it could be

- A course-directing action in an NRI.
- A course-directing action which takes you off the ONTO road. (Careful here – the

ONTO road may have to be identified at the intersection where you turn off the ONTO road).

- A control (Careful here – an observation control qualifies as a control. A favorite trap is to place an obs control just before an obvious ONTO situation. On-course teams drop the ONTO at the obs control and follow other MRDs at the intersection.)

SAP

The main road is the road that appears to go straight as possible through an intersection.

This MRD is often given at the end of the MRD list so that, when combined with a T-rule, every intersection has a main road. You do need to be careful about one thing: when is an intersection judged for SAP-ness? – when you enter it, when you first see the intersection, or from some other position. This is normally covered in the general instructions.

Priorities

Many traps events have a basic set of priorities you are supposed to consider at each intersection. For example:

Priority List: Follow the rally route at each intersection by executing the highest (lowest numbered) priority that directs a unique course leaving the intersection.

1. Execute an emergency instruction.

2. Execute the course-directing action of an NRI with an official mileage.
3. Execute the course-directing action of an LRI as long as it takes you in a different direction from the main road.
4. Execute the course-directing action of an NRI as long as it takes you in a different direction from the main road.
5. Follow the main road.

Priority 1 allows the organizers to can get themselves out of a jam if lead car encounters the “unusual” during the final check of the course.

Priority 2 is often used to force teams in a certain direction, regardless of other priorities or the direction of the main road.

Once you get to priority 3, you must decide where the main road goes. This is usually determined by a separate list of MRDs, such as:

MRD List: the main road is determined by the highest (lowest numbered) MRD that directs a unique main road.

1. Left at T.
2. Protection.
3. SAP.

So, once you get to priority 3, you might use the following process in the above situation:

- Which way does the main road go?
 - Are we at a T? If so, the main road is left.

- Otherwise, is there a single unprotected exit from the intersection? If so, that is the main road.
- Otherwise, is there a SAP? If so, the main road is SAP.

- Is there an applicable course-directing action in an LRI here? Does it take us in a different direction than the main road? If so, that's the correct direction by priority 3.
- Otherwise, is there an applicable course-directing action in an NRI here? Does it take us in a different direction than the main road? If so, that's the correct direction by priority 4.
- Otherwise, follow the main road by priority 5.

It's easy to trap yourself by not working through a process such as this at each intersection.

Not confusing enough? Some rallymasters switch the order of MRDs at each checkpoint, or between route instructions on a leg. Teams write each of the priorities on self-stick note paper and switch their order as the determinants change.

The rest of this chapter looks at some typical main road traps based on the same priority list, but with different MRD lists.

ONTO Cancellation

MRD List

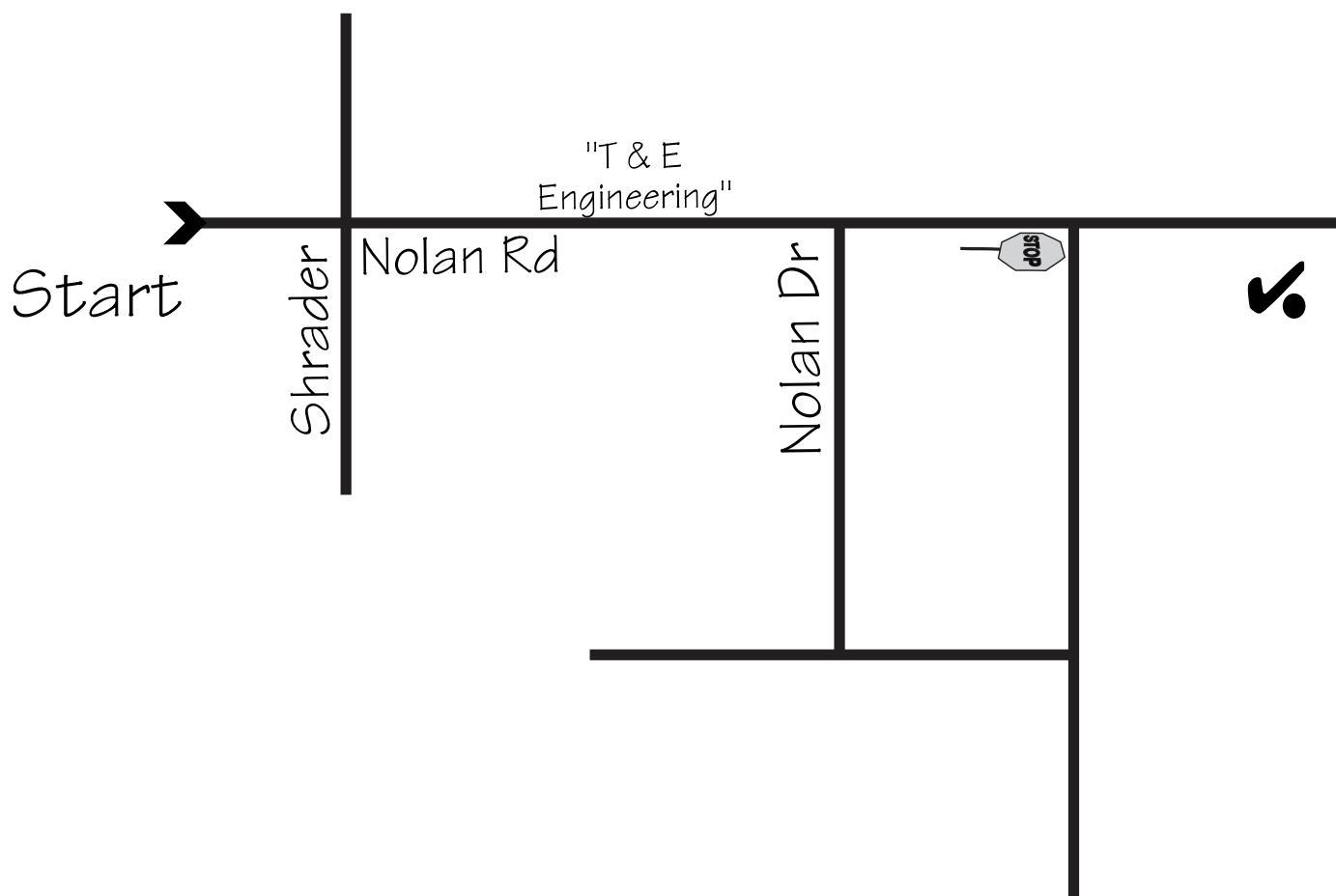
1. ONTO, canceled by executing priority 2 or entering a control.
2. Protection.
3. Left at T.
4. SAP.

11.00 11. Straight onto Nolan at Shrader.

12.00 12. CAS 34 at "T & E Engineering".

NRI 11 takes you across Shrader and activates the ONTO MRD for any road matching Nolan. The next instruction is at an official mileage, but it is not an execution of priority 2. This priority only applies to course-directing actions. Therefore, NRI 12 does not cancel the ONTO.

Off-course teams go straight into the checkpoint, while on-course teams proceed Right onto Nolan Dr, Left twice by T-rule, and Right by protection into the control.



Multiple ONTOs

MRD List

1. Right at T.
2. ONTO, canceled by an ONTO in a higher numbered NRI.
3. SAP.

**21. Right onto Able,
then Left onto Baker.**

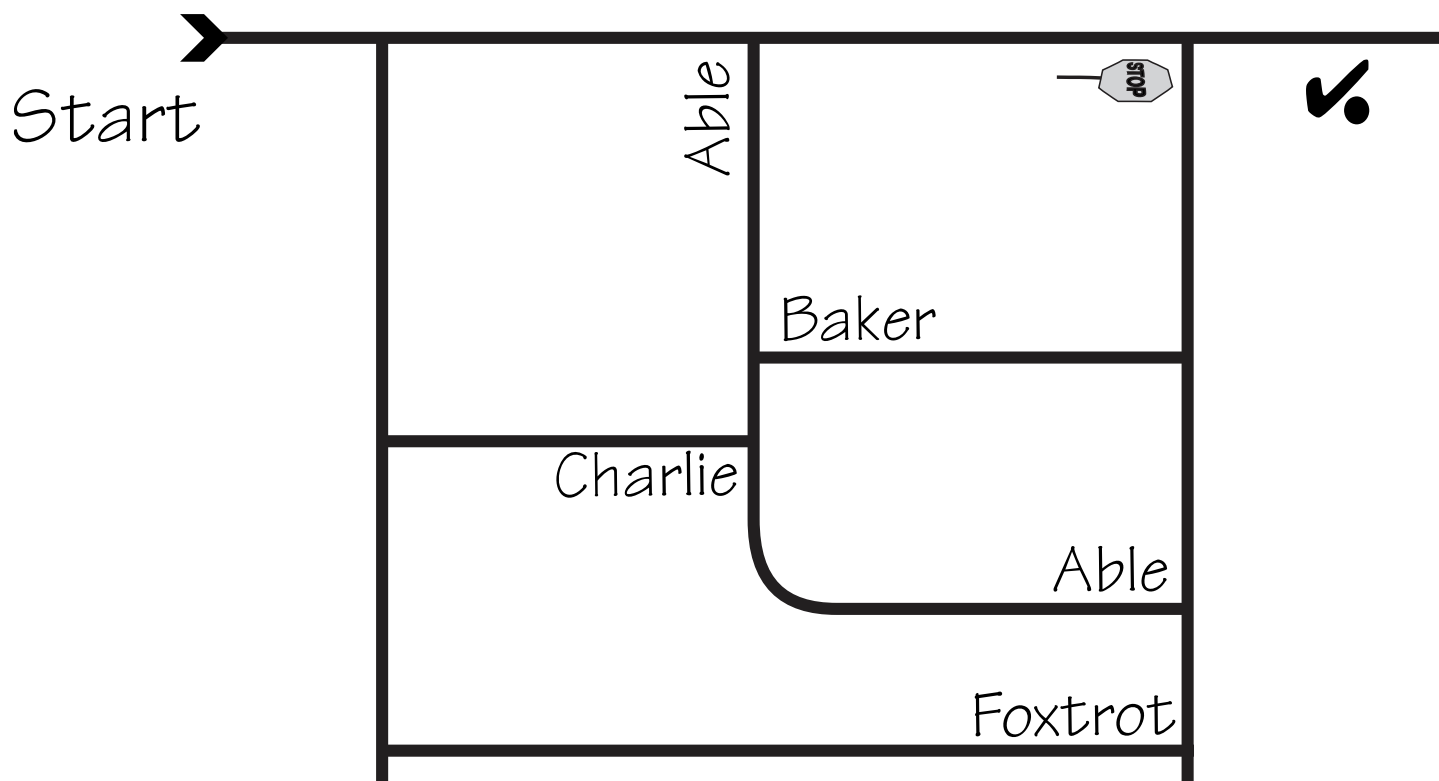
**22. Turn onto Charlie OR
Turn onto Foxtrot.**

NRI 21 takes you Right onto Able, then Left onto Baker. MRD 1 takes you Right at T. At this point, both Able and Baker are ONTO roads, since the cancellation of the ONTO must be done by a higher numbered NRI.

NRI 22 has an OR instruction, which is completed by executing either the portion before or after the OR.

On-course cars go right at Able by ONTO and left on Charlie to complete NRI 22. Off-course cars go past the second Able and complete NRI 22 by turning onto Foxtrot.

All cars execute the Right at T MRD twice into the checkpoint. This example shows how an OR instruction is often used to “close the loop”.



Split Instruction

MRD List

1. Left at T.
2. Protection.

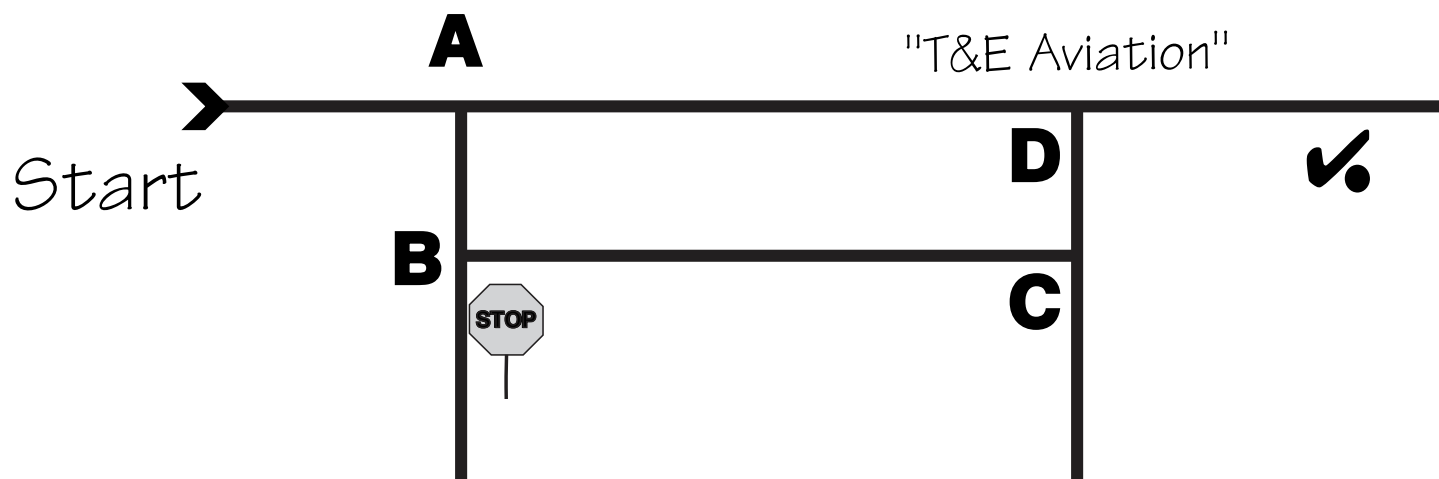
31. Right, then Left.

32. Right at "T & E Aviation".

Right at A by first half of NRI 31
Left at B by MRD 2
Left at C by MRD 1
Left at D by MRD 1
Left at A by second half of NRI 31
Left at B by MRD 2
Left at C by MRD 1
Right at D by NRI 32
Checkpoint

NRI 31 takes you Right at A, but protection applies at B. Since the main road goes left, you must hold the second half of NRI 31 until the next opportunity.

Off-course cars go Left at C by MRD 1 and Right at D by NRI 32 into the checkpoint. On-course cars have to wait a very long time to complete NRI 31:



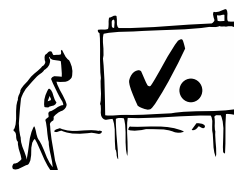


Minor Road Rule

The minor road is the single exit from the intersection which is not the main road.

In this devious variation on the main road rule, the minor road is only defined if there is a main road defined and if there is a single road which is not the main road. This allows you to immediately ignore intersections with three or more exits.

The use of the minor road may be done with an LRI active over a large section of a leg, but it could be worked into the MRD list or the NRIs.



30. Trap Potpourri

*Winding in and winding out
leaves a lot of serious doubt
if the lout who built this route
was going to hell or coming out*

— Author unknown

This last chapter is a collection of traps we have seen over the years on various events. We start with the more basic traps and work up to some real brain-busters.

Spelling

One of the most basic traps is to intentionally mis-quote a sign.

Sometimes, competitors fail to notice the difference in spelling. This happens to teams at all levels and the only way to guard against it is to religiously spell each sign – one member reads off the letters on the sign and the other checks it against the route instructions.

Another pitfall is to assume the rallymaster made a mistake. This should never happen to a team, even if you're beginning trap rallyists! If you find a discrepancy in the route instructions, assume it is a trap. If it turned out that the rallymaster goofed, you

have the basis for a legitimate claim at the end of the event.

Plug Traps

A variant on the basic spelling trap is a sign that is missing. Teams assume that they missed the sign and “plug” it, in their minds. They also “plug” a maximum score onto their scorecard.

The classic situation was exploited by Joe Coyle on a Cape Codder's Courageous Rally: You were on a transit zone down a highway and the route instructions quoted every single mile marker for 15 miles. The last mile marker was followed by an instruction to take a particular highway exit. The last mile marker also did not exist. The pole was there, but the sign was gone.

Most teams simply assumed that they missed the highway marker and got off the highway. On-course teams followed the highway, encountered a couple of rallymaster-erected signs, and looped on course over the Cape Cod Canal to join the course again.

More Sign Games

The bottom line with quoted material is that you must know the exact definition of what constitutes a valid sign. But even if you know that signs cannot be on movable vehicles, the huge billboard with the 14-foot high letters is bait for those who don't notice the inconspicuous but visible wheels which indicate that the billboard is transportable.

Sometimes the general instructions state that all signs must be on the right of the rally course. A seemingly valid sign on the far right corner at a square crossroad appears valid. However, if you turn to the right at the intersection, the sign will be on the left.

There are many variations on the “sign elimination” theme, with each subtle variation including or eliminating a different set of signs. Take the intersection in Figure 30-1, with the letters indicating sign locations and all labelled roads identified at the intersection. You are ONTO Left Ave and your main road goes Left.

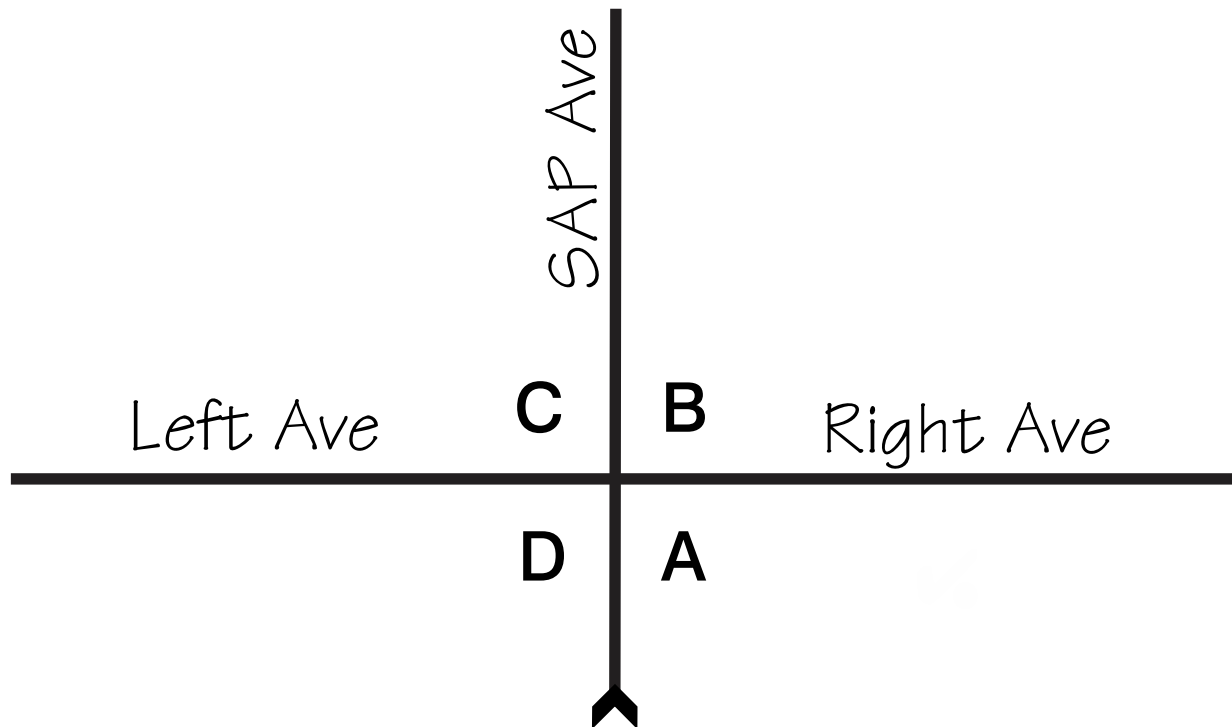


Figure 30-1: Sign elimination intersection

Sign Games					
Signs are on the right side of the ...	NRI	A	B	C	D
... course	Turn onto Right Ave	✓	X	X	X
... course you would have taken if you went SAP	Turn onto Right Ave	✓	✓	X	X
... course you would have taken if you followed the main road	Turn onto Right Ave	✓	✓	✓	X
... course you take as you follow the main road from the intersection	Turn onto Right Ave ^①	✓	X	X	X
... course you would have taken in the absence of the instruction	Turn onto Right Ave	✓	✓	✓	X
... course you would have taken in the absence of the quoted sign in the NRI	Right at "C"	✓	✓	✓	X

① Note that the main road after the NRI is Right.

Some even more devious situations were found by Stan Rabinowitz. The Regs stated that signs could not be on mailbox supports.³⁰ This obscure rule was forgotten by most teams as they noted the humongous letters painted on the side of an enormous barn. Teams carefully spelled the sign, but failed to notice the small mailbox attached to the far corner of the barn, qualifying the entire barn as a mailbox support.

Another Rabinowitz trap was based on the rule that signs in cemeteries could not be used. Teams executing **Left at “West Ave”** were greeted at the checkpoint with a large score as well as the photo at the right showing them the offending sign. Clearly, the sign is within the bounds of a cemetery!



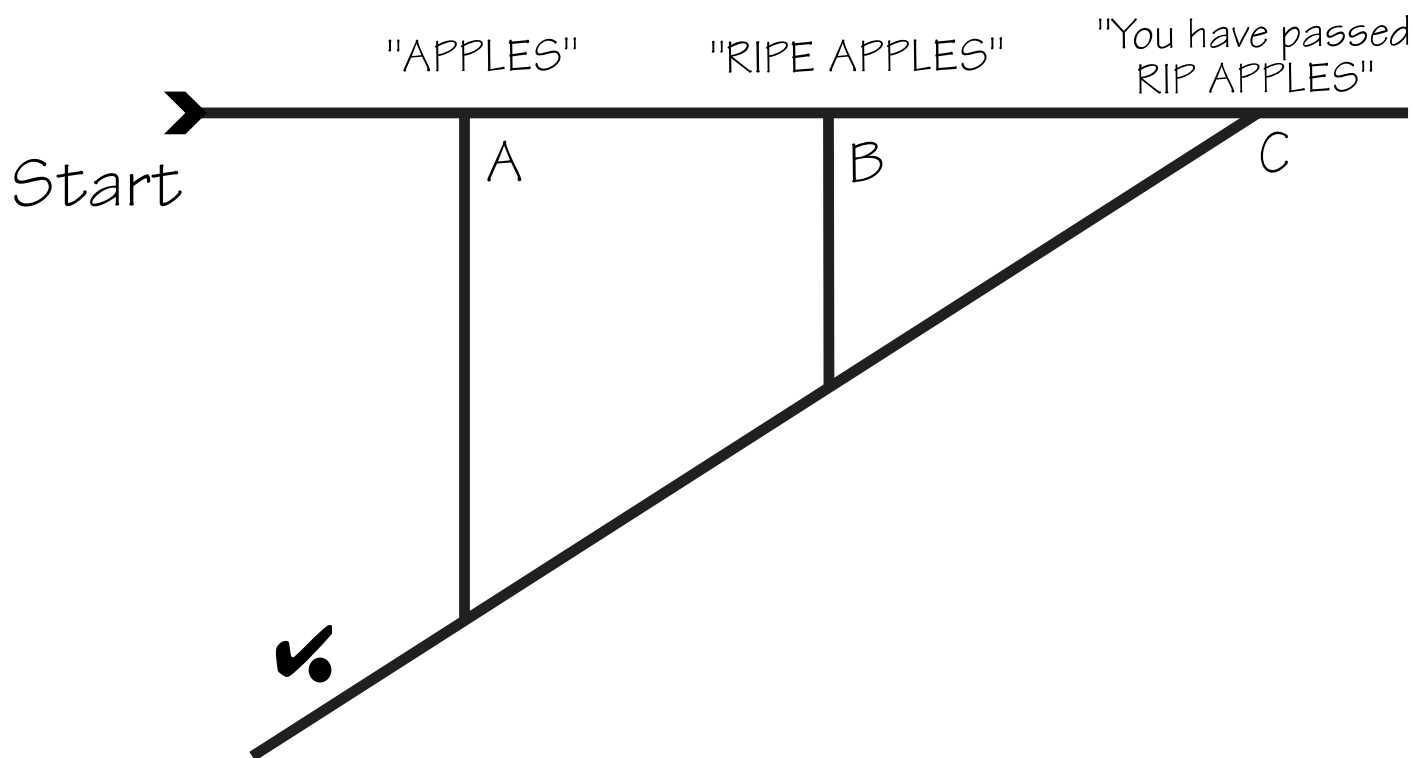
³⁰ The Earth being eliminated as a mailbox support.

Finally, a trap of classic simplicity.
Sherwood Martin's Witches' Brew of 1965 contained a simple rule that all signs would be quoted in full, unless the quoted material was preceded by RIP (meaning Reading-In-Part), in which case the quoted material must be part of the text of a sign.

Contestants were seeking:

44. Right at RIP "RIP APPLES".

The turn at C was the correct one (RIP "RIP APPLES"), but many teams turned at B. Some reached C and went back to B to execute the turn. Even contestants who did the trap wrong didn't get upset!



Recurrence

This type of trap works on the basic LRI rule that LRIs are repeatedly executed while active. **Pause 30 at “Exxon”** seems obvious enough. But what about:

**LRI E. Pause 30 when 0.10
mile from “Exxon”.**

Correct teams execute the pause twice for each “Exxon” since they are 0.10 miles from it both before and after encountering the sign.

After the Fact

**51. CAS 30 at last sideroad
prior to “Byrd”.**

Situations where you discover that you should have taken some timing action at an earlier point on the course fall into this category. You need to note the location of each sideroad and back-figure the speed change location when you find “Byrd”.

Definition

Somewhere in the Regs or general instructions is a glossary of defined terms. Teams must take each definition exactly as written, without slipping back into the common usage for the defined word. A team needs to have the definitions down cold and verbalize them like some chant when running the event.

This section will look at a few sample definitions and what can be done with them by a clever rallymaster.

Stop

An official octagonal stop at which the rally vehicle is obliged to stop.

50. Right at second “Stop”.

A common definition trap is to quote a defined word and reward teams who notice the quotes (enabling any sign containing the quoted text). For example, on-course teams might turn at the first official stop sign because it was preceded by a “Stop Ahead” sign.

55. Turn before Stop.

Is this instruction executable? Since you never reach the sign, the rally vehicle is never obliged to stop. Is it, or is it not, a Stop?

Before

In sight of and prior to the referenced navigational aid.

This definition means that any navigational aid identified by the use of the term “before” must be visible from the execution point of the instruction. This allows a checkpoint to be placed between the following two instructions, as long as the checkpoint is not in sight of the Stop.

**50. Right at T. Pause 100
before next NRI.**

0.80 51. Left at Stop.

You cannot pause until you are in sight of the Stop, but you cannot see that stop until you are past the control. So, you do not

pause, but many teams incorrectly do a portion of the pause prior to the checkpoint.

A far more devious version of this trap is to combine the “before” definition with the rule which states that you are to execute all instructions at the first opportunity. You come around the corner onto a straight section of road where you can clearly see both the checkpoint and the Stop. Since you are now in sight of the Stop you must use all the pause prior to the checkpoint. Teams must instantly decide whether to stop and risk a creeping penalty if they are wrong or enter the control and risk being early.³¹

Finally, an example of a “bad taste” trap, not used on a good trap rally: The general instructions repeat all the definitions from the Regs (“to help the Novices”), and then make some inconspicuous change, such as defining Left to be “a turn to the right”. Cheap but effective.

Blackjack Checkpoints

The sight of a checkpoint is a tremendous magnet for most teams. So much so that many teams will bypass the most obvious execution of an instruction, if it occurs when the checkpoint is visible. Most Regs allow teams to stop in sight of a control without a creeping penalty if they are legitimately investigating an intersection.

To combat this common trap, some teams routinely stop at any intersection once a

control is visible. They feel that the small timing penalty is preferable to the maximum penalty they would get for not making a turn and entering the luring checkpoint.

Control Depth Traps

This is the general name for traps between a control and the out-marker location for starting the next leg. Typically, some sign or an MRD immediately before or after the timing line of the control causes a turn prior to the out-marker. On-course teams make the turn and start the next leg at a different out-marker than off-course teams.

This trap can also work by executing an NRI or following an MRD between the timing line and the out-marker.

Overlap

Most rules specify that you must complete an instruction before considering another. Instructions such as:

61. Right at Stop. Pause 100 over next 1.00 mile.

62. Left on English Court.

can tempt teams into turning left at the first occurrence of English Court, 0.70 miles beyond the Stop. On-course cars go left on the second English Court (a loop road off the main road), encounter a checkpoint, and get to watch off-course cars enter the

³¹ Note that the 1987 New England Region Regs explicitly direct contestants to execute actions referenced to

“before” at the last opportunity, eliminating this particular trap.

checkpoint backwards to receive a large or maximum penalty.

A more subtle version of overlap, used by Carl Baker in the 1988 Annual Grande, involves an innocent-looking:

50. Right at first sideroad onto Route 2A, identified later.

LRI G: Pause 100 at Red Railroad Car.

You cannot activate LRI G and observe the Red Railroad Car until after Route 2A has been identified.

Sometimes, the rallymaster will allow overlap in situations that involve timing instructions. This opens the door for an interesting version of overlap:

1. Left at Stop. Take 30 minutes to complete NRI 15.

...

15. "Acme". Pause 5 minutes. CAS 40.

The 5 minute pause is included in the 30 minutes.

Multiple Active NRIs

Some rallymasters build entire trap events based on allowing overlap. This allows more than one NRI to be active at the same time. You can do this simply by re-defining when NRIs become active: "Each NRI becomes

active for consideration upon the initiation of the previously numbered NRI".

81. Right after "Herb's Saab Shop" onto Mack.

82. Left onto Fricke.

83. Right at "Barker".

After encountering "Herb's Saab Shop", NRI 82 becomes active. You are now looking for both Mack and Fricke. If you encounter Fricke, you execute your Left of NRI 82 and then both NRI 83 and the Right on Mack are active (unless your general instructions tell you to cancel the previously initiated instruction once you have completed the following instruction).

Complications arise when this feature is combined with an alternating T-rule MRD, since both an even and an odd NRI are active in the above example.

Complications also arise when you have to consider when LRIs are activated and canceled.

An LRI is activated at the completion of the previous NRI and canceled at the subsequent completion of the following NRI.

In the example above, an LRI appearing between NRIs 81 and 82 could only be activated after taking your right onto Mack (at the completion of NRI 81). What if the right onto Mack was executed after Left onto Fricke? The LRI would be active indefinitely, probably until explicitly canceled at the next control.

Existence

Many traps rely on whether some object or landmark exists, based on the rules. If roads other than paved, public, and through do not exist, simple traps can be built around roads marked as “private”. If the event runs on the first day of official winter, a road marked “Closed in Winter” will trap many teams.

Many rules specify that an object that is not a defined term must be identified by a sign. So you are looking to execute “Left after airport” and run 2 miles alongside the most obvious airport in the world – without a single sign identifying it as such, it is not an airport.

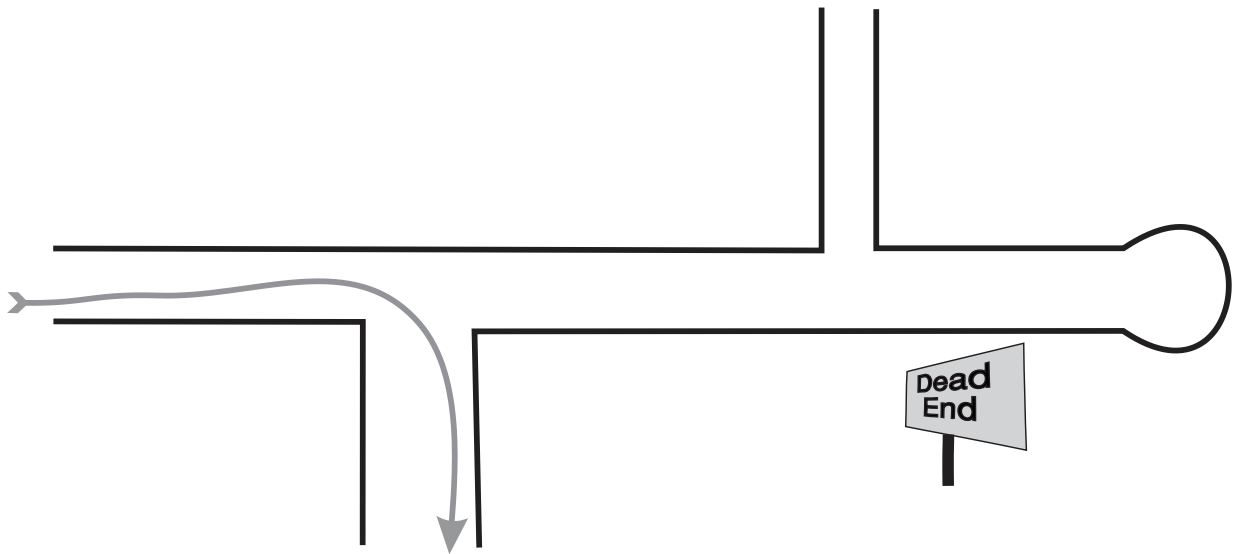
not exist, so it certainly is not a sideroad, so the Speed Limit sign does exist!

Forced Turns

A basic course following trap involves a turn that you must take because of some rule.

The general instructions say that assigned speeds will never exceed the posted speed limit. You are traveling at CAS 35 and can see a “Speed Limit 25” just past a sideroad. The sideroad has no posted speed limit. Forced turn. Note that the Regs for some regions explicitly prohibit this kind of trap for legal and safety considerations.

This most basic of course-following traps can be inverted in the following situation:



Many general instructions will say that *Speed Limit signs on sideroads do not exist*. This saves the necks of teams looking for an instruction clued to a Speed Limit sign. Now on the trap event, you pass by a Speed Limit sign down a sideroad, which happens to be unpaved. Of course, an unpaved road does

Teams see the obvious “Dead End” sign from the location of the obvious sideroad on their right and take that road. They fail to notice a not-so-obvious escape road just prior to the “Dead End” which is the correct course.

Confidence Legs

The idea of a **confidence leg** is to generate a bit of doubt in the competitors as to whether they missed the turn or reference.

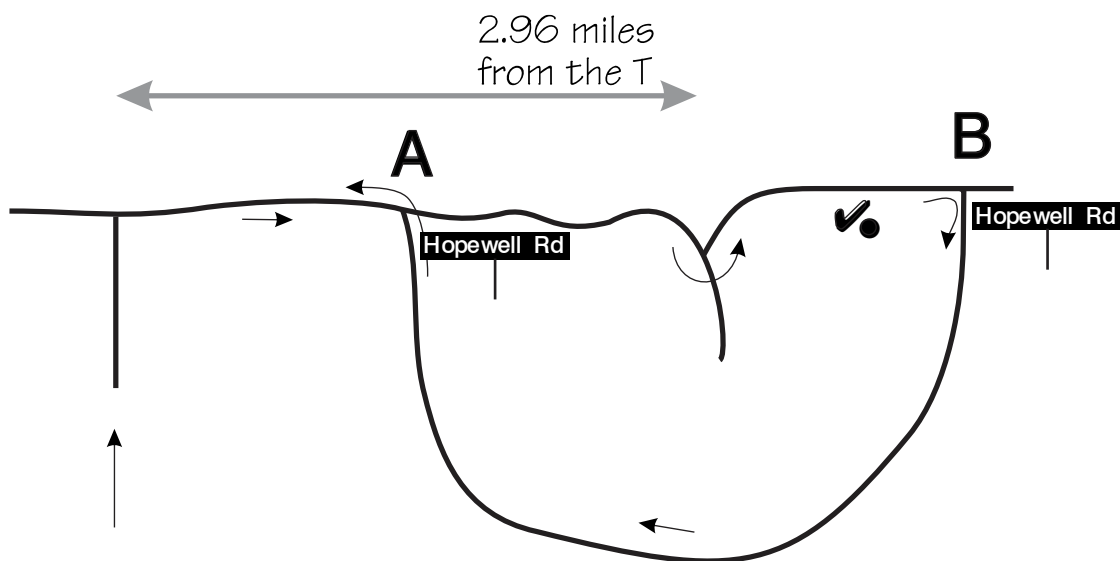
If the event has no callback rule, almost any type of instruction that takes competitors a

We had just executed the first part of NRI 94:

94. Right at T, then Left.

95. Right onto Hopewell.

96. Left at T.



significant distance can generate doubt. One night rally which ran in the 1970s was fond of instructions like:

69. Right onto Main St.

This instruction took contestants about 20 miles through three or four small towns. Each town looked ripe for at least one occurrence of Main St. All it took was one early-running competitor to turn around and the whole field soon followed.

However, even if a callback limit is in effect, a rallyist's confidence can be shaken. This was shown beautifully in a rally we recently ran. The general instructions specified a three mile limit between adjacent NRIs or between two actions in the same NRI.

As we ran down the road looking for our next left, rally cars were coming back down the road towards us, each apparently convinced that they must have missed the left turn. We looked harder for the left. As we neared two miles from the T, we began to worry. At 2.50 miles we figured that the rallymaster goofed and the route instructions had a serious flaw. We considered trying to execute NRI 95, Right onto Hopewell. *“Wait a minute – Didn't we see Hopewell back there??”*. In fact, we had. The urge to turn back was almost irresistible. If it were not for the heated discussion we were having, we would have gone back. At 2.96 miles, we found the left, which was soon followed by a checkpoint.

When we departed the checkpoint and immediately found a second Hopewell, the rallymaster's scheme became apparent:

Some cars had ignored the second half of NRI 94 and turned right at **A** (thinking it was NRI 95). They then executed NRI 96, Left at T, at **B** and came into the checkpoint from the wrong direction (getting some large penalty specified in the general instructions). Eventually, cars which ran the course correctly wound up running opposite to the rally traffic at **A** and baited the later running cars into turning around.

Aristotle

This class of traps named after the brainy Greek began with a very simple and well-intentioned rule in the Regs:

(Aristotle Rule:) No two consecutive NRIs can be executed at the same intersection.

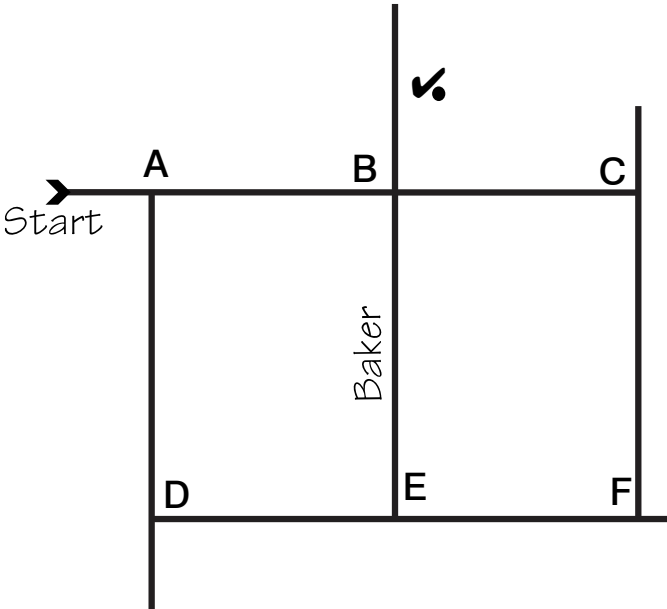
This eliminated the problem of executing both the following NRIs by traveling around the same island or triangle:

101. Right at Y.
102. Left.

Aristotle traps were born when some bright rallymaster discovered they could build a trap using this rule if they could get contestants back to the same intersection without any intervening NRIs. One easy way is with an automatic T rule such as:

At a T intersection, proceed Right in the absence of an applicable NRI.

Now consider the following course and NRIs:



91. Right on Baker.
92. Right on Baker.
93. Left on Baker. Pause 75.

The two possible courses are:

On Course	Off Course
Straight at A	
Right at B by NRI 91	
Right at E, D, and A by T rule	
Straight at B by Aristotle Rule: you cannot execute NRI 92 at the same intersection as NRI 91, so you go straight by default	Right at B by NRI 92
Right at C and F by T rule	Right at E, D, and A by T rule
Right at E by NRI 92	Left at B by NRI 93
Straight at B	Pause 75
Checkpoint	

Off-course cars run the left circuit twice. If all road segments are the same length, off-course cars arrive at the checkpoint 75 late because they did the pause in NRI 93. The checkpoint cancels NRI 93.

Not difficult enough? Try converting all the “on”s into “onto”s in the above NRIs, and activate an ONTO MRD. It is left as an exercise to figure out the correct course.

Was the basic Aristotle trap devious enough? A resounding *NO* was heard from rallymasters who came up with the following variations:

U-Turn Aristotle

The actual distance between the two times you encounter an intersection does not need to be long to catch many teams – just place a checkpoint between the encounters! This is usually played out with a U-Turn instruction:

**200. Right towards control.
Pause 25.**

The control slip gives you a special instruction to make a U-Turn at the cul-de-sac ahead, and you are now set up for the trap with an NRI:

**201. Right (caution for rally
traffic turning and
pausing).**

To “encourage” teams into this trap, the rallymaster places NRI 201 at the top of a new page of route instructions and adds the parenthetical information. You are supposed

to proceed straight as possible and look for another right.

Fuzzy Aristotle

Some rallymasters had trouble getting you back to the same intersection using main road determinants, so they made up some fuzzy versions of the basic rule:

No two consecutive NRIs can be executed within 0.10 miles of the same intersection.

or

No two consecutive NRIs can be executed within sight of the same intersection.

This is often combined with other forms of Aristotle to make them work.

Upside Down Aristotle

In this variation, Dave Gomberg figured out how to use Aristotle to affect the first of two NRIs rather than the second of a pair. The key is that the generals allow an NRI to become active upon any execution of the previous NRI (see Multiple Active NRIs) rather than the completion of the previous NRI.

**81. Right at “Kearsarge” after
Collier Road.**

82. Left. Pause 25 at Stop.

You get to Collier Road, observe it, and NRI 82 is now active along with the rest of NRI 81. You find a Left and then a Stop at which you pause 25, completing NRI 82. Then you follow some main road determinants for a

while and get to an intersection where you could still execute the Right in NRI 81. However, it happens to be at the same intersection as the Left in NRI 82 (or maybe the Stop). You cannot execute NRI 81 here because NRI 81 and NRI 82 are consecutively numbered. Aristotle strikes backwards!

Aristotles Forever

Possibly the ultimate in Aristotle absurdness (or drudgery) is the version that prohibits execution at an intersection if you have ever visited it before on the event.

Unusual TSD Formats

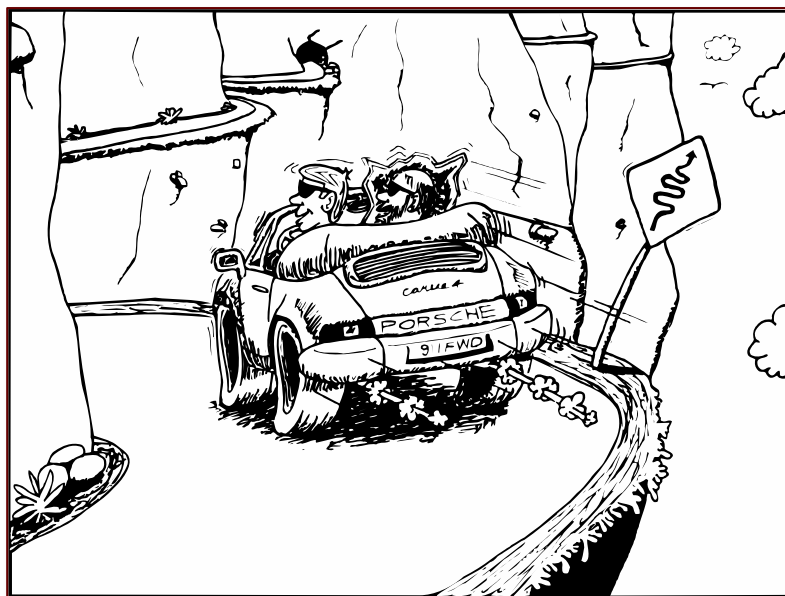
Some people feel that the inherent rallymaster-versus-competitor nature of traps invariably generates bad feelings among trap rally competitors. After all, the rallymaster goes over the course time and again looking for ways to sucker teams into traps. However, two types of events have been developed which seem to avoid these kind of bad feelings. Rather than using individual traps, their basic design is difficult enough to trap competitors into blunders. These last two types of events tend

to run (relatively) claim-free and post-event grumbling seems to be minimal despite the normally colossal scores most teams accumulate.

Map Rallies

The Monte is a **map rally**. This style of event, developed in the New Jersey area, is usually based on a gas company map that has been found to be quite accurate. The course is traced on a master map and each competitor copies the course onto their own copy of the map. The average speed is 30 mph for the entire event. Allowances are made for the few portions of the course with lower posted speed limits.

So you diligently copy down the course and head out looking for the roads. Of course, the map does not give the road names, so you need to measure the distance on the map and then scale to real-world miles. Most teams screw up by taking the wrong road of two approximately parallel roads. In the tradition of trap



loop events, the roads join without you realizing your error. Oh yes, the checkpoint was on the other parallel road.

There is another giant pitfall to avoid when running map rallies. This blunder caught the top national team of Rich Kamo and Jim

Mirrielees. They followed the map in the wrong direction, running the course backwards. It was a long way to the checkpoint!

Palindrome TSD

So a group of rallyists from the Valley Sports Car Club were sitting around one evening in the late 1960s and someone commented that *“the women should put on a rally”*. A quick retort was fired to the effect that *“the women could only put on half a rally”*. So they did.

You get the route instructions to lunch, but have to retrace the course on your own back to the start. Things become tricky when merge situations, which had no instruction, become Y situations on the return. This idea is the basis of the *Hokus* rallies run in New England as well as other events run from time to time in other areas.

CAS assignments for the afternoon follow a simple rule: at every point on the course, you use the same CAS in the afternoon as in the morning. This means that you are looking for landmarks from the back, and need to recognize signs from their shape.

The checkpoints in the afternoon are, of course, not in the same locations as the morning. So, if a CAS change is given at a checkpoint in the morning, you have to do a change in CAS in the afternoon with no landmark at the now-absent checkpoint!

This basic concept is usually enough to snare most teams into at least one or two blunders. However, the concept has been

taken further by adding course-following traps in the morning. Now, if you do the trap wrong in the morning, you get to read the explanation on the control slip and try to find the inverse of the correct course in the afternoon!

In practice, Palindrome TSD events are not very difficult. After running an event or two, most teams develop a system of writing route instructions for themselves during the first half that they can use for the return trip.

31. Epilogue

What a long, strange trip its been

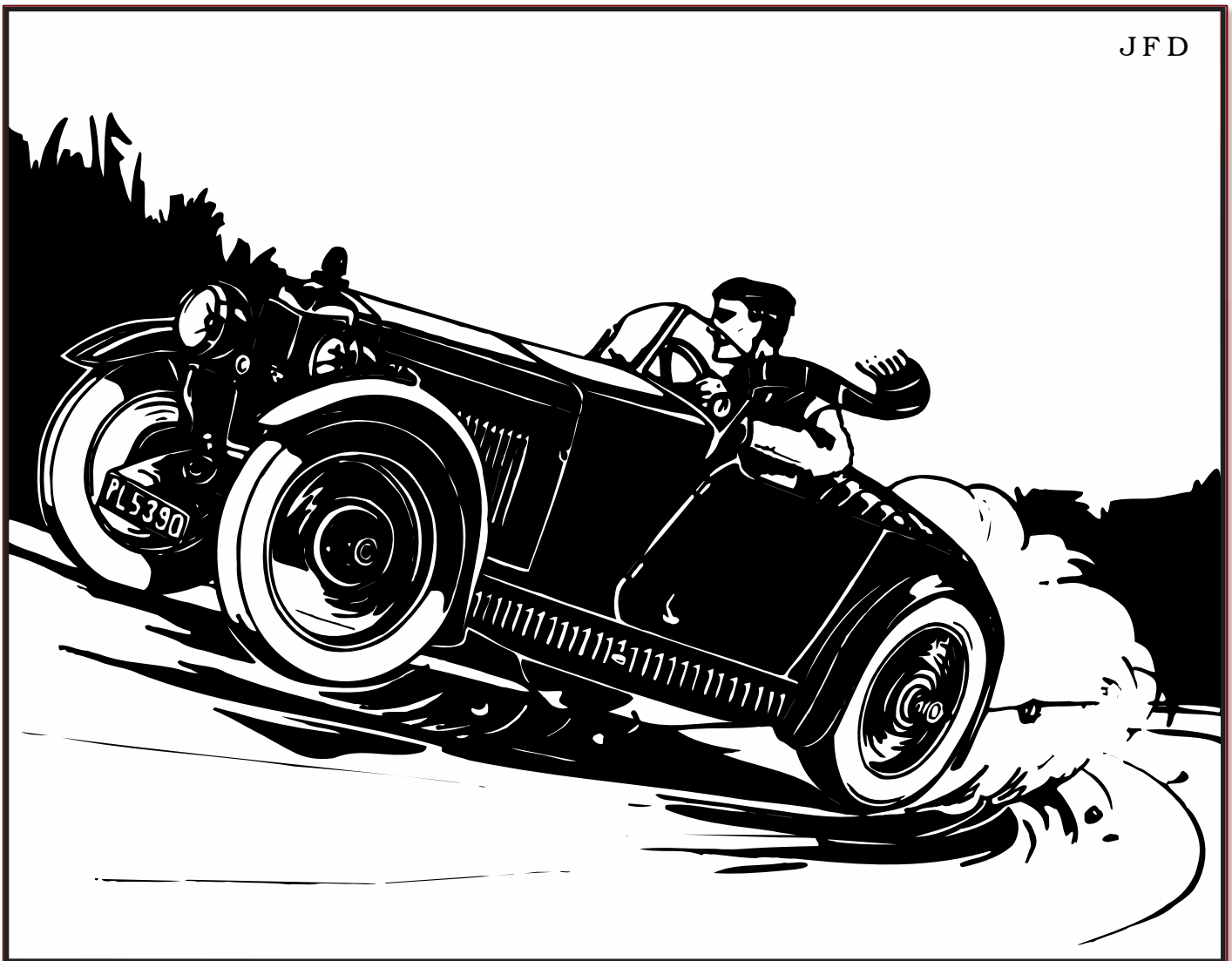
— John Barlow, 1978

There They Were at the start of the event. They were old. Quite old. One used a walker and the other had a paralyzed arm. Even though they could no longer compete they had shown up each year to work checkpoints.

And there they were at several controls, with lawn chairs and sun hats, timing each car using ancient watches that they got cleaned and calibrated each year for this event.

After the rally came their stories: '48 at the hillclimb, '54 at the track, '66 across Canada and Alaska, '72 in Baha. The stories of absurd situations, colorful characters, dire predicaments, free spirit, and camaraderie carried us well past awards and into the night. In the end, they measured their success not by where they had gotten, but by how they had gotten there.

Part 7 – Reference



J F D

A. Sources and Suppliers

Manufacturers

This section lists establishments that build equipment specifically for the sport.

Chronar System, 15202 164th Avenue N.E., Woodinville WA 98072. (206) 481-0748

Manufacturer: Chronar clocks, odometers, and rally computers

Owner Ed Rachner produces the Chronar line of TSD rally equipment. This line, designed by the late Mac Cornforth, has included clocks, odometers, and computers. Their current production model is an A-Box designed for Computer Class competition.

Coralba, Sweden

Manufacturer: C-rally computer.

The Coralba computer is generally designed for use as a Pro Rally odometer.

Echo Microwave, P. O. Box 727, Atkinson, NH 03811-0727. (603) 362-4664

Marc Goldfarb produces a memory module for the Texas Instruments TI-74 palmtop computer that turns it into the Turbo-Kurta TSD calculator. The module

is available with the computer or separately.

Halda, Ltd. Haldex AB, Box 250, S-301 04 Halmstad, Sweden. Tel. 46 35-11 85 60. Telex 38084

Halda, Ltd. Sales and production: Haldex AB, Box 250, S-301 04 Halmstad, Sweden. Tel. 46 35-11 85 60. Telex 38084

Head office: Haldex AB, Box 501, S-261 24 Landskrona, Sweden.

Great Britain office: Halda Ltd., 4 Brandon Road, York Way, London N7 9AE.

U. S. office: Halda Inc., P. O. Box 4080, 2925 North 7 Highway, Blue Springs, Missouri, 64015.

Manufacturer: Halda odometers and computers (mostly used in European Pro Rallying) and speedometer components (cables, T-gears, etc).

Heath Company, P. O. Box 8589, Benton Harbor, MI 49023-8589. (800) 253-0570

Manufacturer: clocks, electronic components, and kits.

Rally America!, 6 Fieldcrest Road,
Westport, CT 06880. (203) 454-1479

Publisher: rally publications and
software.

Roadrunner Tire and Automotive, 4850
Highway 377 South, Fort Worth, TX 76116.
(817) 244-4924

Manufacturer: precision analog
speedometers

Herschel Crump owns this outfit, which
has supplied several competitors in the
Great American Race with temperature-
controlled, precision speedometers.

Don Schade Speedometers, 8821 La
Entrada Avenue, Whittier, CA 90605. (310)
693-0579

Manufacturer: precision analog
speedometers

Don supplies custom-made precision
speedometers to Great American Race
competitors. His units are based on
tachometers designed for high-vibration
environments.

Small Systems Specialists, 16 Lincoln Drive,
Raymond NH 03077. (603) 895-9429

Manufacturer: Alfa clocks, A-Boxes and
B-Boxes.

Owner Mike Friedman is the
designer/manufacturer of the Alfa line of
TSD rally equipment. Current units
include computers designed for
Computer Class competition, correctable

odometers for Odo Class, and clocks for
checkpoints and competition.

Terratrip, Ship Farm, Horsley Road,
Horsley, Derby, DE2 5BR, England. Tel 011-
44-332-880-468

Manufacturer: Terratrip rally computers
(one model useful for Odo Class)

This group produces a line of rally
equipment designed for European Pro
Rallyists. Several of the units are
suitable for American TSD rallying,
particularly in Odo Class competition.
They also produce correctable
speedometers.

Timewise, 1119 Midway Road, Northbrook
IL 60062. (708) 291-1275 and -7275

Manufacturer: Timewise odometers,
rally computers, clocks, and sending
units.

Owner Jack Christensen is the designer
and manufacturer of a line of rally
equipment for TSD competition. The
units include TSD computers for running
in a Computer Class, units designed for
Odo Class competition, and competition
and checkpoint clocks. Jack can be
contacted for special-order equipment or
particular modifications desired for
Timewise equipment. Jack also repairs
older Zeron equipment and Curta
calculators. A wide selection of sending
units are available.

WesTek, 8528 Medicine Bow Run, Fort
Wayne, IA 46825. (219) 489-8855

Manufacturer: Checkpoint clocks and automatic triggers.

This company specializes in a line of clocks and infrared triggers for use by checkpoint crews. The triggers utilize a motion-sensitive photo-head which requires equipment on only one side of the road.

Woodhenge Systems, 218 South Road, Deerfield, NH 03037. (603) 463-7766 (IN-EPRM)

Manufacturer: Rally computers (A-Boxes).

Bill Hall developed a small, clipboard-mounted rally computer. Production is currently on a per-order basis. This unit is not currently available through any distributors, so call Bill directly to inquire.

Zeronics, P. O. Box 5191, Charlotte NC 28225. (704) 537-0712

Manufacturer (out of production): Zeron clocks, odos, & computers

Bill Gronning produced the Zeron line of rally computers, odometers, and clocks. He may be willing to repair or do maintenance on the equipment on a case-by-case basis.

Distributors, Importers, and Dealers

This section lists firms which stock rally or rally-related equipment from various manufacturers.

Autostorica, 34 Market Place, Kendal, Cumbria, LA9 4TN England. 011-44-539-734-313

Dealer: Antique rally equipment.

Paul Howcroft is building up a supply of historic and rare equipment. They list Halda computers, Twinmaster odometers, Curta calculators, and Heuer watches at some rather exotic prices.

Autotech, 32240-E Paseo Adelanto, San Juan Capistrano, CA 92675. (714) 240-4000

Dealer: Importer of Schroth competition belts and VW parts

Bob Radford Enterprises, 4969 Brookview Road, Rockford, IL 61107. (815) 398-0511

Dealer: Stevens (the 'Stevens Wheel'), Stevens Rally Reader, Clipboard lights, Chronar, Alfa, Timewise, Halda, Zeron, Curta, rally tables

Bob is a national level TSD rally competitor and carries many lines of rally equipment and auto accessories. He recently took over distribution of the Stevens line of rally equipment.

Competition Limited, 2243 Sosna Drive, Pinckney MI 48169. (313) 464-1458, Fax: (313) 878-5553

Dealer: Timewise, Alfa, Halda, Stevens, Zeron, Hella, IPF lights, Nokia

Owner and long-time competitor Gene Henderson has run this mail-order house specializing in rally equipment since 1969. His business is oriented toward

Pro Rally and TSD competitors and organizers. He also seems to be the best stocked TSD rally supplier. He also publishes *The Competitive Line*, a monthly newsletter which is “a collection of rumors, gossip, opinions, etc” and can be entertaining! Gene is usually available on the phone to discuss the merits of his products as well as technical questions and trivia.

Historical Technology, 6 Mugford Street, Marblehead, MA 01945. (617) 631-2275

Dealer: antique scientific instruments

Sol Moskowicz runs this shop, which seems to be the last word in this obscure market. He often has Curta calculators in stock. \$12 will get you two issues of his twice-yearly catalog.

KT Motorsports, P. O. Box 152, 71 Voorheesville Avenue, Voorheesville, NY 12186. (518) 765-2206

Importer/dealer: tires (Nokia-Hakkapeliitta).

Owner Tom O'Connor carries a wide selection of tires, many specialized for rally use. They also are negotiating to import the Leo line of rally computers, information on which was unavailable at press time.

Loki Motorsports, 1205 S. E. Reynolds, Portland, OR 97202. (503) 234-7843

Dealer: seats, driving lights, gauges, apparel for race and rally.

Owner Ben Bradley currently stocks racing and Pro Rally oriented equipment, but may take on some TSD equipment in the future.

Mega-Stat, 2836 Guadalajara, San Clemente, CA 92673. (714) 361-8564

Dealer: Terratrip, Peltor (intercom systems)

North Hollywood Speedometer and Clock Co., 6111 Lankershim Blvd, North Hollywood, CA 91606. (818) 761-5136

Dealer: Halda, variety of automotive instruments and devices.

This outfit is a subsidiary of Pacific Parts and Instruments, a supplier of a wide variety of automotive instruments and devices.

Pegasus Racing Supplies, 2475 South 179th Street, New Berlin, WI 53146. (414) 782-0880

Dealer: racing parts and accessories

This company distributes a wide selection of accessories for racing. Of particular interest to rallyists are fire extinguishers, windshield treatments, competition harnesses, books, and performance parts.

Potomac Rallysport, 9412 Holbrook Lane, Potomac, MD 20854. (301) 299-4893

Dealer: Alfa, used equipment, sending units

Owner Peter Stevens distributes various models of new and used rally equipment.

Ricker Rally Products, 1156 S. W. 4th Avenue, Pompano Beach, FL 33060. (305) 782-2829

Dealer: small, portable wheel-mounted sending units

SBR Rallye and Race Products, 3716 Marigold Drive, Fort Wayne, IA 46815. (219) 483-4034

Dealer: WesTek, Hella, Corbeau (competition seats), Leo rally computers

Owner Steve Zoller is the primary distributor of WesTek equipment.

Subē Sports, 17161 Palmdale Street, Huntington Beach, CA, 92647. (714) 847-1501

Dealer/importer: Terratrip, Coralba computers, Rally supplies - primarily Pro Rally.

T & D Rally Performance, 7604 Errol Drive, El Cerrito, CA, 94530. (510) 527-8787

Distributor: Alfa, RJ External Sending Units, auxiliary light bars, other rally equipment.

Suppliers

This section lists companies that manufacture or sell components, equipment, and supplies which are useful to rallyists. Many of these items are not rally-specific.

Belden Wire and Cable, Richmond, IA. (317) 983-5200

Manufacturer: 8735 3-conductor shielded cable suitable for sending unit connections.

Cinch Connector Division, 1501 Morse Avenue, Elk Grove Village, IL 60007. (312) 981-6000

Supplier: connectors – Jones, modular, etc.

Datel, Inc, 11 Cabot Boulevard, Mansfield, MA 02048. (800) 233-2765 or (508) 339-3000

Manufacturer: Digital meters

Digi-Key, 701 Brooks Avenue South, P. O. Box 677, Thief River Falls, MN 56701-0677. (800) 344-4539

Dealer: electronic supplies

This company distributes a huge array of small electronic parts from various manufacturers. They sell connectors, cable material, tools for building cables, batteries, displays, and most things you might need to install rally equipment. Their free catalog is worth having, and you can order a single item!

E&B Marine Supply, 201 Meadow Road,
Edison, NJ 08818. (800) 634-6382

Dealer: AcuBand motion-sickness
acupressure bands

Edmund Scientific, 101 East Gloucester
Pike, Barrington, NJ 08807-1380. (609)
547-8880

Dealer: scientific supplies

This supply house publishes a catalog of
items useful for small projects. Of special
interest to rallyists are their list of
magnets. They also carry the two
Westbend timers that are useful as
interval timers.

Electro-Transfer Systems, Inc., 1916 South
Main Street, South Bend, IA 46613. (219)
234-0600

Manufacturer: Molded waterproof
connectors

Hamlin, Inc., 612 East Lake Street, Lake
Mills, WI 53551. (414) 648-3000

Manufacturer: position sensors and reed
switches

Hoosier Racing Tire, 65465 US 31,
Lakeville, IA 46536. (219) 784-3152

Supplier: Specialized track racing tires,
groover kits.

Jones Instrument Corp., 432 Fairfield
Avenue, Stamford, CT 06902. (203) 327-
6440

Manufacturer: mechanical speedometers,
tachometers, and other instruments, as

well as speedometer cables and fittings.
Their units are used by many
competitors in the Great American Race
because they are less sensitive to
temperature variations.

Lynn Electronics, 915 Pennsylvania Blvd,
Feasterville, PA 19047. (215) 677-6700

Supplier: Pre-assembled cables with
modular plugs

Meylan Corporation, 543 Valley Road,
Upper Montclair, NJ 07043-1844. (201)
744-6400

Manufacturer: clocks, stopwatches.

The Meylan catalog lists both their own
products and items from other
manufacturers. Many unusual timepieces
are carried, including a printing
stopwatch.

Micro Switch, 11 West Spring Street,
Freeport, IL 61032-9945. (815) 235-6600

Manufacturer: position sensors and Hall
Effect transducers

Molex, Inc., 2222-T Wellington Court, Lisle,
IL 60532. (708) 969-4550

Manufacturer: Connectors

National Marine Products, #4 The
Fenway, Westport, CT 06880. (203) 226-
6216

Distributor: AcuBand motion-sickness
acupressure bands

Newark Electronics, 4801 North Ravenswood Avenue, Chicago, IL 60640-4496. (312) 784-5100

Distributor: Electronic components from a wide range of manufacturers

ORA Electronics, P. O. Box 4029, Chatsworth, CA 91313-9931. (800) 423-5336 or (818) 772-2700

Supplier: Connectors, cables, switches, noise suppressors

Permag, Corporate headquarters: 1150 Kifer Road, Suite 201, Sunnyvale, CA 94086. (408) 730-0611

New York area: 400 Karin Lane, Hicksville, NY 11801. (516) 822-3311

Boston area: 10 Fortune Drive, Billerica, MA 01865. (508) 663-7500

Chicago area: 1050 Morse Avenue, Elk Grove Village, IL 60007. (708) 956-1140

Dallas area: 1111 Commerce Drive, Richardson, TX 75081. (214) 699-1121

San Francisco area: 1159 Sonora Court, Sunnyvale, CA 94086. (408) 738-1080

Supplier: magnets

This company distributes permanent magnets in every conceivable configuration. Their catalog lists magnets from many manufacturers, and they can “hone them, dice them, slice them, cut them, grind them, magnetize them, calibrate them, and demagnetize them” to suit any application.

Radio Shack, U. S. Headquarters: 500 One Tandy Center, Fort Worth, TX 76102. (817) 390-3011

Supplier: cables, connectors, switches, and other components in general

Stuart-Warner Instrument Corp., 580 Slawin Court, Mount Prospect, IL 60056. (708) 803-0200

Manufacturer: speedometers, tachometers, and a full line of automotive gauges. They also manufacture speedometer cables and fittings.

Switchcraft, Inc., 5555-T North Elston Avenue, Chicago, IL 60630. (312) 792-2700

Manufacturer: Connectors

Virginia Plastics Co, 3423 Aerial Way Drive, Roanoke, VA 24018. (703) 344-0957

Supplier: Pre-assembled cables with modular plugs

Wheel Mate Products, (800) 821-6025 or (213) 946-8881

Supplier: lug nuts, wheel nuts

J. C. Whitney & Co., 1917-19 Archer Avenue, Chicago, IL 60680. (312) 431-6102

Dealer: General parts and accessories

This company carries some hard-to-find stuff, not particularly rally-related, but useful under special circumstances (e.g. cold-weather rallying).

Book Dealers

Albion Scott – Motobooks, 48 East 50th Street, New York, NY 10022. (212) 980-1928

Bookstore.

This shop has an incredible collection of books on every motorsport topic, including current and back issues of every periodical, especially the European magazines.

Automotive Books, T. E. Warth, Esq., Lumberyard Shops, Marine on St. Croix, MN 55047. (612) 433-5744 (M-F 8:30-4:00 Central Time) Fax (612) 433-5012

Dealer: rare, out-of-print, and obscure motoring books.

This outfit specializes in rare, out-of-print, and obscure motoring books. They maintain a large inventory of such books. If they don't have the title in stock, they will initiate a search. You only pay the fee for the search (\$10) if they are successful in locating it and you choose to purchase the book.

The Candid View, 6730 Desco Drive, Dallas, TX 75225-2703. (214) 368-5538

Importer/dealer of rally and motorsport-related calendars. Their yearly Pro Rally calendars feature the superb photographs of the top cars and drivers in World Rally Championship competition.

Classic Motorbooks, P. O. Box 1/RT090, Osceola, WI 54020. (800) 826-6600

Mail-order Bookstore

This outfit publishes an expansive catalogue of automotive books and video tapes at generally reasonable prices.

EWA, 369 Springfield Avenue, P. O. Box 188, Berkeley Heights, NJ 07922-0188. (908) 665-7811

Mail-order Bookstore

EWA markets a books, magazines, and videos along with a line of miniature cars.

The Motorsport Collector, 5120 Belmont Road, Suite L, Sowners Grove, IL 60515. (800) 722-8630, (708)515-1440

Mail order source for videos, art, books, and memorabilia for the racing enthusiast.

RMI Distributors, 15 East Washington Street, Rutland, VT 06701. (802) 773-4030

Mail order source for Pro rally-oriented videos.

Organizations

This section lists some of the clubs and organizations in the U. S. and Canada which put on road rallies. Of course, not every club or organization is listed. We provide this list as a starting point for those trying to locate events in their area. We don't list every SCCA-affiliated club, since a call to the SCCA national headquarters will get you the name of the rally contact in your region's affiliate. Also, many of these clubs publish

newsletters periodically. Phone numbers with a ☎ notation indicate hotlines that maintain a recorded message.

Associated Rallyists Limited, c/o Bob Paauwe, 3100 F. Cambridge Road, Cameron Park, CA 95682. (916) 672-0601

Blue Ridge Mountain Sports Car Club, c/o Dave Sekella, 700 Maple Street, Fleetwood, PA 19522. (215) 944-0755

Branded Rally Club, c/o Marc Ressler, 4811 Indian Lane, College Park, MD 20740. (301) 474-7393

Brandywine Motorsport Club, c/o Dutch Dryden, 423 Marcus Road, Middletown, DE 19709

Buckingham Sports Car Club, c/o Jerry Pirrung, 525 Rabb Street, Willow Grove, PA 19090-2138. (215) 659-8350

Canadian Association of Rallysport, att: Terry Epp, Director, 595 Elm Road, Stouffville, ONT L4A 1W9, Canada. (416) 640-6444

Cannonball Enterprises, Box 241, Wyoming, NY 14591

Brock Yates organizes the yearly One Lap of America.

La Carrera USA, Loyal Truesdale, US Coordinator, 3049 Laurel Canyon Boulevard, Studio City, CA 91604-4214. (213) 464-5720

Loyal is the coordinator for US entries to La Carrara Panamericana and several other race/rallies run yearly in Mexico.

C.A.R.S RallySport Ontario, att: Dennis Wharton, Director, RR #2, Petersburg, ONT N0B 1H0, Canada. (519) 576-7463

Cascade Sports Car Club, P. O. Box 4304, Portland, OR 97208

Chuckanut Sports Car Club, c/o Ken and Sue Lingbloom, 926 South Samish Way, Bellingham, WA 98226. (206) 733-8897

COCR Rally Club, c/o Debbi Segall, 189 Weldon Street, Rochester, NY 14611. (716) 235-5032

Commonwealth Rally Club, c/o Steve Novatne, 63 Puggy Lane, Bethlehem, PA 18015-4444. (215) 867-1608

Cumberland Motor Club, c/o Bill Owen, 13 Riverview Drive, Brunswick, ME 04011. (207) 729-3611

Dallas Sports Car Club, c/o Bob Benson, 7529 Madeira, Fort Worth, TX 76112-4404. (817) 457-8833

Emerald Empire Sports Car Club, c/o Kelvin Dietz, P. O. Box 1204, Eugene, OR 97440. (503) 686-1375

Empire Sports Car Club, P. O. Box 2207, Empire Station, Albany, NY 12220

Fairfield County Sports Car Club, 129 Mount Pleasant Street, Derby, CT 06418. (203) 732-2677

Gre TRACE, Limited, 12790 Merit Drive,
Suite 100, Park Central IX, Dallas, TX
75251-1126. (214) 788-2323

This is the group which organizes The
Great American Race, a cross-country
TSD event for antique cars.

Kitchener-Waterloo Rally Club, P. O. Box
60, Heidelberg, ONT N0B1Y0, Canada

Land Park Rally Team, Sacramento, CA,
☎ (916) 488-SVSCC

Long Island Sports Car Association, c/o
Gary Urhan, Box 130, East Northport, NY
11731. (516) 681-6140

Maple Leaf Rally Club, c/o Ross Wood,
557 Hayward Cres., Milton, ONT L9T 4T8,
Canada. (416) 876-1492

Massacre, P. O. Box 53, La Cañada, CA
91012

Creators of the St. Valentine's Massacre
and other armchair rallies and
adventures.

Metro Rally Conference, ☎ (201) 633-
0575

The Metro Rally Conference is a group of
clubs which put on a series of events in
the Greater New York area. Their Dial-A-
Rally phone number gives upcoming
events.

MG Car Club of Long Island, c/o Jim Vice,
P. O. Box 2382, Setauket, NY. (516) 421-
3744

Motorsport Club of New Jersey, c/o Ed
Harris, 14 Cambridge Road, Glen Ridge, NJ
07028. (201) 744-4088

**National Sports Car Club (NSC) of
Dayton, OH**, Mark Fox, P. O. Box 9053,
Dayton, OH 45409. ☎ (513) 293-9522

Olympic Rally Competition Association,
c/o Greg Hightower, 12803 195th Place SE,
Issaquah, WA 98027. (206) 226-4936

Orlando Sports Car Club, c/o Don
Robertson, Box 276, Windermere, FL 34786.
(407) 876-2336

Peterborough Motor Sports Club, c/o
Peter Watt, 523 Bolivar Street,
Peterborough, ONT K9J 4R5, Canada. (705)
749-0563

Quequechan Sports Car Club, c/o Ric
Golen, P. O. Box 1974, Fall River, MA
02722. (508) 990-0907

Rainier AutoSports Club, c/o Jerry Hines,
15 Central Way, #300, Kirkland, WA 98033.
(206) 823-6343

RALLY-L, contact: Mark Evangelista,
Internet:
EVANGEL@GUV.M.CCF.Georgetown.EDU,
US mail: 19759 Framingham Drive,
Gaithersburg, MD 20879. contact: Bill
Caloccia, Internet: caloccia@stratus.com.
(301) 977-6554

This "organization" is a group of people
across the world who communicate
using an electronic mail (e-mail) service
called Internet. RALLY-L allows you to
post "messages" which are distributed to

the entire group. Many of the messages deal with TSD rallying on the national level and some of the best rallyists in the country participate. If you don't have direct access to Internet or Bitnet, one of the easiest ways to get access to RALLY-L is to join Compuserve. You can then contact Mark to get information on joining RALLY-L.

Raritan Valley Sports Car Club, c/o Marc Lees, 500 Auten Road 4A, Somerville, NJ 08876-5056. (908) 281-7846

Santa Barbara Sports Car Club, Mike Pariseau. (805) 966-5962

Santa Monica Sports Car Club, 2627 Midvale Avenue, Los Angeles, CA 90064

Southeast Sports Car Association (SESCA), c/o Robert Hoke, 6304 Kaybro Street, Laurel, MD 20707. (301) 725-5877

South Jersey Corvair Club, c/o Steve Chmielewski, 348 Lakeshore Drive, Brick, NJ 08723

Sports Car Club of America (SCCA), 9033 E. Easter Place, Englewood CO 80112. (800) 255-5550 or (303) 779-6622

A nationwide sanctioning body for Rallying as well as most other motorsports. Their monthly publication, Sports Car, generally has an article or two dedicated to Rallying, mostly at the national level. Call for your area's local affiliated club.

Sports Car Club of New Hampshire, c/o Josh Hill, 24 Messenger Street, Lebanon, NH 03766

Sports Car Club of Vermont, c/o Dan Way, 68 North Street, Bristol, VT 05443. (802) 453-4792

TarHeel Sports Car Club, c/o Bowie Gray, Box 3122, Wilson, NC 27893. (919) 243-2397

The Rally Club, P. O. Box 1582, Cupertino, CA 95015. (408) 739-4635

Toronto Autosport Club, c/o Rich Sullivan, 96 Springdale Drive, Barrie, ONT L4M 5B4, Canada. (705) 728-1577

Touring Club of New England, c/o M. Rhodes, 181 Littleton Road #302, Chelmsford, MA 01824

Tropical Sports Car Club, c/o Gary Skantar, 11000 N. W. 24th Street, Coral Springs, FL 33065. (305) 344-1938

Tuscarawas Valley Touring Club, Inc., P. O. Box 20853, Canton, OH 44701

UBC Sports Car Club, P. O. Box 84-6138 SUB Boulevard, Vancouver, BC Canada V6T 2A5. (604) 682-3296

Valley Sports Car Club, c/o Pego Mack, 1010 Goodale Hill Road, Glastonbury, CT 06033. (203) 633-8663

Wing & Bonnett, c/o Tom Smith, 611 Homestead Road, Brielle, NJ 08730. (908) 223-0326

WRC – Washington Rally Club, c/o Doug Sheatsley, 2292 Cartbridge Road, Falls Church, VA 22043. (703) 204-0026

Worcester Area Sports Car Club, P. O. Box 1110, Worcester, MA 01613

Driving Schools

This section lists U. S. and Canadian driving schools which have at least some programs oriented toward improving street driving and/or rally driving skills. Notes are given for schools which specialize in one particular area or discipline. A separate section is given for European Pro Rally Schools.

Bob Bondurant School of High Performance Driving, Firebird Raceway, P. O. Box 60968, Phoenix, AZ 85082-0968. (800) 842-7223 or (602) 961-1111

Buck Baker Racing School, 5000 Currituck Drive, Charlotte, NC 28210. (704) 527-2763 or (704) 596-8930

While specializing in Stock Car racing, this school also offers a 2-day high-performance driving weekend.

Ford-Michelin Ice Driving School, P. O. Box 774167, Steamboat Springs, CO 80477. (303) 879-6104

As the name suggests, this school specializes in driving on ice. They offer ½ day through 1½ day courses using their cars on an ice track.

Rally Right School, contact: Kerry Voll, 706 Roxbury Road, Southbury, CT 06488. (203) 264-9690

Yearly Pro Rally weekends are staged by this group, with an emphasis on instruction for first-time and novice competitors.

Pitaressi Motor Sports, 1940 North Victory Boulevard, Portland, OR 97217. (503) 285-4449

Porsche Precision Driving School, P. O. Box 11912, Fort Lauderdale, FL 33339. (305) 561-2881

Powell Motorsport Advanced Driving School, RR 1, Blackstock, ONT, Canada, L0B 1B0. (416) 985-9741

Road Atlanta Driver Training Center, Route 1, Braselton, GA 30517. (404) 881-8233

Bertil Roos Driving School, P. O. Box 221, Blakeslee, PA 18610. (800) 722-3669 or (717) 646-7227

Jim Rusell Racing Driver's School – West, 1023 Monterey-Salinas Highway, Salinas, CA 93908. (800) 821-8755 or (408) 372-7223

Jim Rusell Racing Driver's School – Canada, P. O. Box 119, Mount Tremblant, QUE, Canada J0T 1Z0. (819) 425-2739

Skip Barber Racing School – East, Route 7, Canaan, CT 06018. (203) 824-0771

Skip Barber Racing School – West, Sears
Point Raceway, 29355 Arnold Drive,
Sonoma, CA 95476. (707) 939-8000

***Stevens Advanced Driver Training
School***, Box 1122, Merrimack, NH 03054.
(603) 424-2227

***Willow Springs International Driving
School***, The Driver's Connection, Willow
Springs International Raceway, P. O. Box X,
Rosamond, CA 93560. (805) 256-2471

European Pro Rally Schools

Bill Gwynne Rally School International,
17 Thorpe Place, Overthorpe Road,
Banbury, Oxfordshire OX16 8XM, England.
011-44-295-259-201

Carsport UK Rally School, 17 Wyedean
Rise, Belmont, Hereford and Worcester, HR2
7XZ, England. 011-44-432-270-976

Silverstone Rally School, Silverstone Park,
Silverstone, Northamptonshire, NN12 8TL,
England. 011-44-327-857-413

Welsh Forest Rally School, Cambrian
House, Carmo, Caersws, Montgomery,
Powys, SY17 5W, England. 011-44-686-420-
207

B. Bibliography

There are, sadly, very few (other) books on TSD Rallying. Many of the books which have been written are out of print or out of date. This is a compilation of every book I know on the subject. The list is broken into three sections and the books in each section are listed in reverse chronological order. I have included books on Pro Rallying simply because it is often unclear from the title or a description whether a book deals with TSD or Pro Rallies. If you are interested in obtaining an out-of-print book, you might try a (very) well stocked library or Automotive Books/T. E. Warth, Esq. (see Appendix A).

TSD Rallying

Rally to Win, James Neihouse, Shot in the Dark Productions, 3802 Sentry Drive, Cocoa, FL 32926, 12.56 minutes, 1991.

This video is an introduction to the sport for first-time rallyists. It gives an overview of an event without going into the specifics of course following or timekeeping. A good sideshow, for the price (\$15.00 plus shipping and handling). However, it may show some conventions and customs not used in your area.

How to Rally and Win, Russell Brown, Lynda Polk, Curt Rich, and Randy Waibel, Second Edition, Houston Region SCCA, P. O. Box 1894, Houston, TX, 77401, 59 pages, softbound, 1990.

This small-format, type written, privately published manual is intended as a companion to the Houston Region SCCA Road Rally School. It covers the basics of competing in a TSD Rally and explains some simple calculating methods. A sample rally is given, as well as short articles on equipment and trap rallies. The introduction contains the boldly amusing statement “*If you are totally familiar with the material and execute each rally instruction properly, you will win*”. Available from the publisher (\$10.95) or Competition Limited.

Road Rally Regulations, Sports Car Club of America, Englewood, CO, 101 pages, softbound, yearly.

This handbook gives all the competition rules for SCCA National and Divisional TSD Rallies, both Course (trapped) and Touring (straightforward). This is a must-have item for competitors in these events as well as for teams competing in

regions or clubs which use the 'National Regs' as their standard. This book is published yearly and is available from the SCCA (\$7.50).

Rallying, Richard L. Knudson, Lerner Publications Company, 48 pages, hardbound, 1981.

This short book is part of the Superwheels & Thrill Sports series designed for young readers. The book gives a good overview of the sport, looking at both TSD and Pro Rallying.

The Complete Rally Book, David Hebb, Stein and Day, Briarcliff Manor, NY, 197 pages, softbound, 1979.

A completely revised and updated version of *The Rally Book*. Out of print.

Rallying to Win, Jean Calvin, Bond/Parkhurst Books, Newport Beach, CA, 174 pages, hardbound, 1974.

An introductory how-to book for TSD competitors. Calvin covers basic Rally concepts, types of events, and basic equipment in fair detail. Although her descriptions of 'modern' computational tools and some of her terminology are now dated, many suggestions and tactics are still valid. Out of print, but often available at T.E. Warth.

Regional Road Rally Handbook, Stan & Shirley Wantland and Jim Meyers, Second Edition, SCCA, Englewood, CO, 205 pages, softbound.

This loose-bound manual contains all the information necessary to stage a Regional-level road rally. It covers the myriad types of rallies and has straightforward how-to explanations on everything from developing a Rally program down to the minute details of putting on an event. The handbook is rounded out with several example rallies that are dissected in great detail. The book can currently be obtained directly from the SCCA (\$15.95).

The Rally Book, David Hebb, Hawthorne Books, New York, NY, 176 pages, softbound, 1973.

A basic text suitable for novice competitors that still reads surprisingly well despite its age. The fundamentals of TSD rallies are examined, with a heavy emphasis on course following and a comparative light treatment of formulas and equipment. Good to read (if you can find it) as a first text, but not ideal if you are ready to graduate from Novice Class. Out of print.

Rallying On Time, Lou Magyar, privately published, 66 pages, looseleaf, 1970.

This manual describes The System – a navigation strategy for running Limited-Stock Class. It is based on giving readings every minute using rate tables (minutes-per-mile factors).

A New Guide to Rallying, Larry Reid, Sports Car Press, distributed by Crown Publishers, New York, NY, 127 pages, softbound, 1969.

Larry Reid provides a wealth of information in this book, making it a very good text for intermediate-level competitors. The sections of the book which deal with equipment are dated, but the clear explanations of navigation methods and depth of information make up for this shortcoming. Out of print.

The Sports Car Rally Handbook, Gene Hammond, Sterling Publishing Co., New York, NY, 144 pages, softbound, First Edition: 1958, Revised 1962.

An early book with many interesting bits of information. An analysis of expanding versus the “new” non-expandable tires is presented, as well as many ideas on navigation. Out of print.

A Guide to Rallying, Larry Reid, Sports Car Press, Ltd., New York, NY, 127 pages, softbound, 1957.

A basic text that is now quite dated, but does contain many interesting hints. Those interested in learning the sport would do better with the updated version (above) or a later text, while rallyists interested in the history of the sport or the beginnings of the Touring Club of New England will find this book interesting and amusing. Out of print.

Sports Car Rallies, Trials, and Gymkhanas, David Hebb and Arthur Peck, Channel Press, Great Neck, NY, 160 pages, hardbound, 1956.

This book covers an incredible variety of rally-related topics without going too

heavily into any of the 'serious' aspects of navigation, formulas, etc. Common types of rallies including gimmick rallies, regularity runs, and hillclimbs are discussed as well as chapters on 'Rally Comfort' and 'Concours D'Elegance' (wax offs). Out of print.

Rallies and Trials, S. C. H. Davis, Iliffe & Sons, Ltd., London, 184 pages, 1951.

This gem consists of narratives of the author's exploits as rally driver on many great and small events of the 1930s and 1940s. He tells of the colossal Monte Carlo Rallies, the French Rallye Gastronomique, and other major European events. While the rallies and locations are unfamiliar and some of the many photos are almost a century old, Davis's writing brings out the essence of competition and adventure which is central to our sport. Out of print.

TSD Tables

TSD Road Rally Pocket Reference, Clint Goss, Rally America!, 20 pages, softbound, 1991.

This shirt-pocket-sized reference contains all sorts of useful as well as esoteric information. Many of the tables and formulas from this book appear in the Pocket Reference.

Lotus Spreadsheet Tables, Ric Golen, 8 Pearl Street, South Dartmouth, MA 02748

Ric developed and distributes a “starter set” of navigation tables. They are based

on Lotus 1-2-3 running on IBM PC compatible computers.

Rally Basics – Tables, Fables, Factors & Formulas, Gene Henderson, Competition Limited, 262 pages, softbound, 1988.

This stack of tables begins with a 16 page introduction to the sport and a walkthrough of a 'first' rally (probably too much math for a real first-timer). The tables include a two page conversion from miles of error to correction factors, minutes/miles tables (uncorrected) for 10 mph to 68 mph by 0.1 mph giving results in thousandths of a minute (28 pages), and a 203 page table similar to Norman Cone's (below) for 10.0 to 59.9 mph by 0.1 mph for each odometer correction factor from 0.900 to 1.100 by 0.001 increments. This volume could be useful if you adapt your navigation method to the format of the information provided and don't have a handy computer to generate custom tables. Be sure to get the correction sheets or a corrected copy. Available from the publisher (\$24.95).

Corrected Minutes Per Mile Factors, Norman Cone, published by MPM Enterprise, P.O. Box 897, Ben Franklin Station, Washington, DC, 20044, 1967.

The first table published which eliminated the need to calculate corrected speeds/mileages on-the-run. Each page of this book gives minutes/mile numbers for speeds from 2.0 to 60.9 mph by 0.1 mph for a given

correction factor. Once you calibrated the odometer/speedometer, you could use a single page of this book for all minutes/mile values. Out of print.

Larry Reid's Rally Tables, Larry Reid, Sports Car Press, distributed by Crown Publishers, New York, NY, 130 pages, softbound, 1959.

These tables are rather limited for running precision events today for several reasons. First, they give results only to the tenth of a mile and, second, the result is given in minutes and seconds, with the resulting loss of precision and probable conversion to hundredths. However, novice teams might find these tables useful if they are running with a stock odo and have not yet obtained a hundredths-reading clock. Out of print.

Stimson's Rally Factors, Stimson, Sports Car Press, distributed by Crown Publishers, New York, NY, 128 pages, softbound, 1970.

A set of corrected time table for speeds from 10 to 59 mph and factors from 0.900 to 1.100. Out of print.

Floyd's Factors, Floyd C. Stone, Auto Gear Unlimited, 1134 Bald Hill Road (Route 2) Warwick, RI 02886.

A table giving a single minutes/mile value for every speed from 5.00 to 64.99 mph by 0.01 mph. The value is given to the thousandth of a minute. Out of print.

Driving, Car Setup, and Handling

Bob Bondurant on High Performance

Driving, Bob Bondurant with John Blakemore, 144 pages, softbound.

This is the text associated with the Bondurant course on performance driving. It discusses racing techniques that are useful for car control on the road. Available from Classic Motorbooks.

Behind the Wheel with Jackie Stewart, VHS Video, 55 minutes.

This video illustrates driving techniques using race and street cars. Available from Classic Motorbooks.

In Control, Sandy Stevens, P. O. Box 1122 Merrimack, NH 03054-9983. 1991.

This video teaches car control techniques to “average” drivers. It is an extension of the Sandy Stevens style of instruction used in his advanced driving courses, demonstrated by sports analyst Sam Posey.

All Wheel Drive High Performance

Handbook, Jay Lamm Doo, Motorbooks International, Osceola, WI, 144 pages, softbound, 1990.

This book concentrates on the specifics of four-wheel drive cars. Aside from the full chapter on Pro Rallying, much of the book has information and suggestions that relate to all-wheel drive performance driving.

Zen Driving, K. T. Berger, Ballantine Books, New York, NY, 165 pages, softbound, 1988.

A book on the psychology of street driving, from the point of view of Zen philosophy. Interesting reading.

The Front Wheel Drive Performance

Advantage, Jack Doo, Motorbooks International, Osceola, WI, 128 pages, softbound, 1988.

This book explains the dynamics of suspension and performance of front-wheel drive cars in basic terms. Chapters include setup for racing, autocross, ice racing, and rally. The 23 page rally discussion is specific to Pro Rally.

How to Make Your Car Handle, Fred Puhn, HP Books, Tucson, AZ, 200 pages, softbound, 1981.

This book is an excellent primer on the fundamentals of car suspension design and modification. Although it is primarily oriented towards autocross and road racing applications, the basic concepts are developed in such a way that the reader should be able to apply the principles to rally suspensions at all levels of the sport.

Pro Rallying

Rally Racing, Sallie Stephenson, Crestwood House, New York, NY, 46 pages, hardcover, 1991.

A look at Pro Rallying designed for the juvenile reader.

Against Gravity, Ed McCabe, Warner Books New York, NY, 290 pages, softbound, 1990.

A narrative account of the author's escapades competing in the Paris-Dakar Rallye, the world's most grueling motor sports event.

How to Start Rallying, Russell Bulgin (editor), Brands Hatch Publications, Ltd., Kent, England, 62 pages, softbound, 1988.

A primer on the sport of Pro Rallying, from a British viewpoint, designed for the potential competitor. With eight different authors and many color photos for support, this book covers car setup, driving technique, Pro Rally schools, co-driving, as well as rallycross and other related topics. Excellent photos augment this text. Available from Classic Motorbooks.

Rallying, Stuart Turner and Tony Mason, Fourth Edition, Haynes Publishing Group, Somerset, England, 128 pages, hardbound, 1987.

A very general book touching on all aspects of European Stage (Pro) Rallying. About half the book deals with the 'top end' of the sport and is of interest to Rally fans. The other half touches on the details of how to begin rallying and even talks about how to organize a rally. Older editions of this book go under the name Drive It – The Complete Book of Rallying. There seem to be many copies of the 1983 second edition floating around, but it is surprisingly dated compared to the

fourth edition. Available from Classic Motorbooks.

Rallying – The 4 Wheel Drive Revolution, Graham Robson, Haynes Publishing Group, Somerset, England, 192 pages, hardbound, 1986.

An in-depth analysis of the motivation for and development of four-wheel drive Pro Rally cars. An excellent book for enthusiasts of European Pro Rallying and four-wheel drive cars in general. Outstanding photography and diagrams. Available from Classic Motorbooks.

Rally Navigation, Martin Holmes, Haynes Publishing, Somerset, England, 187 pages, hardbound, 1983.

A how-to book for navigating European-style Pro Rallies. There is a heavy emphasis on map-reading, dealing with pace notes, and organizing a team. Out of print.

Periodicals

AutoSport EXPRESS, 213 Kingsland Avenue, Lyndhurst, NJ 07071.

(201) 804-8730

A monthly which highlights events in the Greater New York area.

Grassroots Motorsports, P. O. Box 5907, Daytona Beach, FL 32118.

Covers autocross, road rallies, time trials, ice racing, and road racing at the local level.

Rally Magazine, 706 Roxbury Road,
Southbury, CT 06488.

A monthly magazine concentrating on all aspects of rallying; from trap events to international stage rallies; plus hillclimbs, profiles, technical articles, and other news.

SportsCar, Sports Car Club of America,
9033 East Easter Place, Englewood, CO
80112.

This monthly magazine covers all the SCCA events, with primary concentration on racing. However, there are sections each month on Pro Rally and TSD rally, mostly covering events or topics of interest at the national level. Subscriptions to this magazine are part of your membership in SCCA.



Do You Enjoy Driving?

Would you like to spend a day driving the most interesting roads in a scenic area? How about adding a bit of competition - a test of precision driving without the risks and high costs of racing?

Here's everything you need to get started in the sport of Road Rallying. You will discover how to use your own car, without modifying it, to get into a sport which involves driving skill, precision, teamwork, and (most important) **FUN!**

"All Road Rallyists MUST buy this book; it's a veritable gold mine of information. I wish we had one for PRO Rallying."

- John Buffum, National PRO Rally Steward

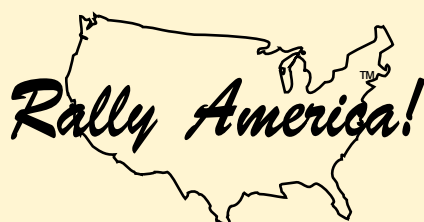
"Everything you'd ever want to know is in The Road Rally Handbook. It's a 'must have'!"

- Kerry Voll, Editor, Rally Magazine

"This is the best book on TSD Rallying available, new or used. Clint Goss offers every level of competitors, from beginner through advanced, a method to improve their scores and enjoy the sport. It's all easy to follow. Highly recommended."

- Gene Henderson, Owner, Competition Limited

Clint Goss has run and organized hundreds of Road Rallies, as well as competed in Pro Rally and Solo II. He runs the Rally program of the Fairfield County Sports Car Club. He and his wife, Vera, have won at the local, regional, divisional, and national levels, as well as the New England Region Rally of the Year.



6 Fieldcrest Road
Westport, CT 06880

This book is your constant reference, from getting started to winning at the National level. Whether you are just out for fun or heavily involved in Rallying, you will refer to this book again and again.

ISBN 0-9632401-0-2

