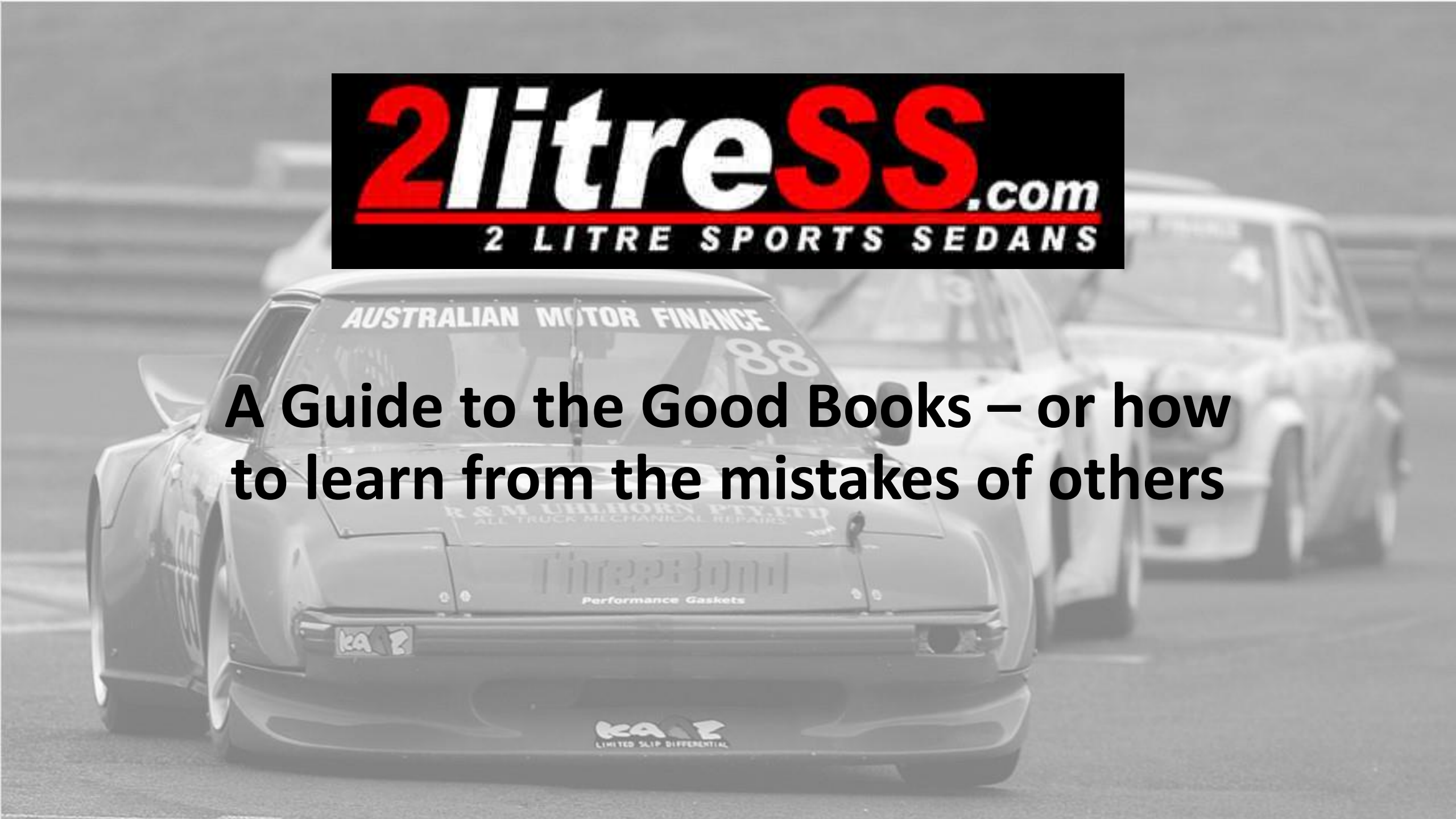

A Guide to the Good Books – or how to learn from the mistakes of others

Race cars are complex critters, with interactions between chassis / aero / driver inputs that make understanding what is happening difficult to measure and understand. Fortunately, there is some help available!

- Books – many have been written, some are exceptional, some are OK, some just want to sell you something.
- SAE Papers – just about every major manufacturer has used motorsport to sell cars to the public, some have written about it via SAE Technical Series papers. While often difficult to understand, it is useful to see how they have “skun the cat” in the search for a competitive car / design.
- Many manufactures' have built cars – a review of what approaches they have taken is always useful.
- Front running cars are often a “closely guarded secret”, however, sometimes the owners are very genuine, and if approached, are more than happy to explain their “why” and “how” in the search for a better performing vehicle. Lee and Bob Ulhorn are a case in point.

The “Good Books”

- Everyone wants to compete at their own highest level – the reality is you are racing the person immediately in front of you, and the person immediately behind you. The real “race” is the one going on in the drivers head, and (imho) is the area where the greatest potential for improvement lies, once the basics are understood.
- It would take a lifetime to learn all about what makes a race car tick, or we can learn from others that have been down the same path.
- No one will be an “expert” in every area, but most will be able to understand the basics, and so be able to prioritise their respective cars.
- Costs – some are in the library, some may have downloads, some can be borrowed, some should be bought, because you will re-read them many times, and I know that I always pick something up when revieweing the good books

The Basics:

- Acceleration – determined by weight and HP (at the wheels), tyre Coeff, and gearing is also a factor
- Deceleration – determined by available brake torque, weight, weight transfer, and the driver.
- Cornering – determined by weight, lateral load transfer, track width, balance (speed dependant), CGH
- Transient response – toe curves, CGH, tyre loads, toe stiffness, weight distribution.

Given weight is a major factor, the minimisation of it should be a priority in every car.

For existing cars, “balance” and driveability are (far far!) more important that ultimate grip. The next page outlines some of the available texts that will:

- Help understand what is going on,
- What needs to be done to achieve primary balance
- What the driver needs to do
- Interactions between systems
- What breaks and why
- Components – what to look for

We do not need to reinvent the wheel to improve our own personal performance. We do not need to spend a lot of $, we simply need to understand the basics, and then apply some simple science.

The “Bible”

the BEST EVERY BOOK written about design of race cars is:

Race Car Vehicle Dynamics – by William F. *Milliken* and Douglas L. *Milliken.*

http://www.millikenresearch.com/rcvdbak.pdf

It covers every aspect, it is also bloody hard to read (math heavy). The authors have 1st hand experience (major manufacturers) and explain how to calculate stuff. They do not give a “why” or which is best.

Outstanding, but hard work.

The Good Reads:

Not everyone wants to be a motorsport chassis engineer, luckily, several authors (with 1st hand experience) have made life easier.

- Prepare to Win – Mr Carroll Smith
- Tune to Win
- Engineer to Win
- Nuts, Bolts & Fasteners

http://books.sae.org/b-706.set/

These are nigh on 40 years old – but are still the best in explaining the “problem” and showing the solutions available. The “If” “Then” in the chassis book is just as relevant today as when 1st published. Outstanding must haves (imho).

Old Books

High Speed, Low Cost - Allan Staniforth. He also did:

Race and rally car source book

Competition car suspension

These are “OK”, I really enjoyed the “string computer” which is a way of visualising roll centre movements, and helps understand camber curves.

Fundamentals of Vehicle Dynamics – Gillespie (very good)

Racing car Design and Development (1973) – Len Terry & Alan Baker

Old, covers the basics reasonably well, shows “evolution” in design.

Racing and Sports Car Chassis Design (1967) – Michael Costin & David Phipps, shows how to do proper load calcs!

How to make your car handle – Fred Phun, very very basic, little explanation of why, little math.

Race Car Engineering and Mechanics – Paul Van Valkenburgh, OK, relatively simplistic.

Aerodynamics

1. Race Car Aerodynamics – Dr Joseph Katz – the best book I have found on the subject, math heavy, but explains “why” and also aero evolution
2. Competition Car Downforce / Competition Car Aerodynamics – Simon Mcbeath – picky heavy, covers the basics, perhaps light on for tech heads.
3. Race Car Design – Derek Seward, OK, bit light in some areas (imho)
4. http://www.racecar-engineering.com/cars/corvette-c6-zr1/
5. https://www.scribd.com/doc/266047391/Aerodynamic-Optimization-of-the-Opel-Calibra-ITC-Racing-Car-Using-Experiments-and-Computational-Fluid-Dynamics
6. Most of the FSAE teams do techo papers on their cars – these are often free to download - if this takes your interest, then a search thru uni libraries will highlight lots of papers.

Engines

1. ACL Engine Manual – the standard text on engine overhaul, explains loads, measurement, design of pistons / rings / bearings – old but very good (imho).
2. Mr Yunick / David Vizard / A Graham Bell – several titles, probably the best is the “A Series Engine” as it helps explain pulse tuning.
3. Tuning for Speed – Phil Irving, old, out of print, but bloody good!
4. Almost all of the major car makers have produced racing engines:
5. GM SPORT COMPACT Performance Build Book — 3rd Edition
6. http://papers.sae.org/983038/
7. http://motary.planet.ee/200SX/science/sr_desin_sae.pdf
8. lots of SAE papers.

Brakes:

1. You absolutely MUST be able to lock up the tires, and without too much effort!!!! If you can not achieve this – you do not have sufficient brake torque.
2. http://stoptech.com/docs/media-center-documents/the-physics-of-braking-systems
3. http://wascb.org/?p=407
4. AP / ALCON / TILTON / PFC / Brembo websites
5. Data on Coeff(f) versus Temp – major pad manufactures
6. Physics of Racing series

Driving

1. A twist of the wrist – Keith Code / Doug Chandler.
2. Going Faster : Mastering the Art of Race Driving – Lopez, used at skip barber school, I havent personally read it.
3. Think Fast – Neil Roberts, ex Swift, Outstanding imho
4. Speed Secrets – ross Bentley – OK imho
5. Lauda / Prost / Senna – all wrote books, all should be read. Lauda's life story is inspirational.
6. There are less SAE papers, but a few on "driver psychology".

Other Useful References:

http://goodridge.com/wp-content/uploads/2015/07/Goodridge-Catalogue-Performance-Parts.pdf?160119

http://aeroquipperformance.com/files/2013-catalog.pdf

Speedflow (Aussie) also do good quality fittings/hoses

https://www.apracing.com/Aboutus.aspx?cid=16 – also Alcon / Brembo / PFC etc. take note of coefficient versus temp for pads.

http://spicerparts.com/ also Dana / Hardyspicer (in Oz)

Other Useful References:

http://www.racecar-engineering.com/ some of the articles are free.

http://www.auto-ware.com/techref/lib_index.htm the Mark Ortiz news letters are exceptional and free

The physics of racing – downloadable .pdf's on the theory

Locost kit car (Ron Champion) plus numerous copies - http://www.cheapsportscar.net/

http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/74417

Other Useful References:

http://www.chaski.org/homemachinist/viewforum.php?f=44

http://www.eng-tips.com/

http://www.efi101.com/forum/index.php?sid=2ccd09bb7c1e0f973c2822b13e71e937

Motec.com.au

Megasquirt – forum is an excellent resource

Aurthur Mallock articles – "trailing arm magic" "TAM" – or how to minimise roll steer with beam axles

Shock Absorber Handbook – Dixon

http://www.varg.unsw.edu.au/Assets/link%20pdfs/thesis_biti.pdf

Claude Rouelle – excellent papers on suspension