Design DeBrief Notes Silverstone July 2008

There are winners in any competition and therefore there are also non-winners! Anyone who took part will have **learned** something; either from themselves or from others. Even the Judges learn something new every year.

The purpose of the event as a whole is **education**. All of the scoring and feedback is really meant to "fast track" that learning curve and start to bridge the gap between theory and practice; between classroom and industrial commercial reality. If at times it seems unfair then fortunately that is the first lesson learnt: life is rarely fair and the playing field is often not level.

A greater **emphasis** this year was placed on the student's **understanding** as well as on the car and also on looking into the "**design for manufacture**" understanding. The competition brief requires consideration of production of 1000 units per year and naturally part of the consideration of design for manufacture will be cost. Consequently the design judges will have to be thinking (a little) of cost and particularly value when scoring the teams. The formal costing is of course a separate static event itself.

Submitting a technical brief to management on time and in the defined format and length is a key life skill. That's why we get so petty about the **penalties**.

This is the easy bit, there are no excuses for losing ANY points at all. Reports were much better in format, layout and legality with only one or two excessively long.

There were quite a few **late** submissions, most seemed to arrive in the last few hours, and this after 12 months preparation. Some lost 10 points for the sake of one or two minutes, WHY? A slight delay at your end, the ISP or at the IMechE end will lose you a guaranteed 1/15th of the available marks. This is a senseless throw away that with the current level of competitiveness can never be won back.

Over **80%** of you had some form of penalty, either for the car not being fully compliant with the technical regulations or for the pre-event submissions not being correctly in line with the rules. Those who reverted back to us with genuine reasons for **appealing** these penalties were heard and many proved their case: we had made a mistake. Another useful life skill; how to stand up for yourself in the face of officialdom (keep copies of your correspondence as proof)!

In the **Report** for FS do not integrate graphics with text, do not use landscape for the text pages, do not use columns, its all spelled out for you and I know it is slightly different to other events, but that's life. The Specification Sheet is also unique to FS and you need to use the correct one without modification.

Well done to someone who observed that the fitting of 2500 words onto the 4 pages at 12 point font size is very difficult and crowded, we will check this out for next year!

The Report must **explain** your chosen solution to the challenges presented by the FS rules, not just the FSAE rules although they are very similar. It should explain why the eventual chosen compromise was considered the best, not just state what was done and how it was done. Ideally look at all options, pros and cons and briefly outline the choice process in each major area.

Example Engine choice: single, twin or 4 cylinder. Weight and cost and complexity of packaging ancillaries, limitations of ancillaries, e.g. water pumps, alternator, clutch etc. Lubrication and cooling. Structural factors. Gear ratios. Fuelling system. Cost.

Your Report should also be **proportional**: by this I mean that whilst all major areas should be outlined the key areas should be prioritised.

A few common points are discussed below:

Smaller capacity than allowed, need validated good reason for choosing 450cc when rules allow 610cc.

Starting, the dynamic events provide the most points. The car must pass Scrutineering, brake and noise before you can attempt the dynamic events. You cannot do this unless the car will start. Later the car needs to fire up reliably on its own battery when stinking hot, with heat soak affecting the fuel system, the electrics and the starter motor itself. Getting the 4 cylinder going can be awkward, let alone the twins or single cylinders. Think carefully as to what is happening inside the cylinder at the low cranking speeds and look in detail at ignition events etc. Hot start testing/mapping is quite easy as you can try it as many times as you like. Cold start mapping requires much greater patience!

Cooling and lubrications systems are tricky to predict theoretically. The bike engine is in a different environment and requires different things in a car.

Planning to finish means starting in good time and keeping on time and on budget. Costs and masses should be budgeted and accounted for.

Knowledge transfer is vital if your university is to learn year on year. This is part of the **team management** and is a must for bigger teams.

Rules, car must meet the rules. Noise, crash structure and driver sizes are all major challenges without which the car will not be allowed to run. The first thing to look at must be rules changes that will affect you.

Pointless to try to cover other formula areas or road car within the FS brief, car will not be competitive.

3 basic stages to getting a running car, the design and the manufacture and the assembly. The last two take far longer than you think and you need to consider both of these at the design stage.

Design for manufacture is a key skill, if it is simple to draw, model and dimension then it will likely be simple to make accurately to tolerances etc. If made properly it will then fit properly and reduce assembly costs and warranty bills.

Testing is vital and serves to eradicate problems and to improve the basic car set up for driver's needs or shortcomings. To do this the car must be **finished**. Having the wheels pointing the right way with a stationary car is vital, even if design flaws may not maintain that alignment once loaded.

Stiffness is what keeps that alignment. Good load paths and detailed attachment design, e.g. toe link stiffness, creates stiffness, not simply material choice. All forces come from the tyres, the engine or the driver and the design that considers these basic parameters from the beginning will end up with better and more elegant load paths than designs that start with a structure and then add bits to accommodate the suspension and engine later. It is all an iterative loop and needs consideration of the manufacturing process as well as material choice from the outset. Costs will fall out of this process quite naturally and often dictate starting again in some areas.

Driver is important, for design this means fitting him in, giving him controls with fluid and finesse and feedback and installed stiffness. Adjustability for different sizes needs accommodating. Steering geometry is important for a twisty course, for driver fatigue as well as lap times.

Transient event, great priority on nimbleness and driver feel. No real priority on top speed or downforce if they detract from the nimbleness. Dampers affect transient manoeuvres more than you will believe. With a light car with relatively high unsprung mass then any friction in route from tyre to damper will screw things up. Friction under load may be massively higher than without.

Installed stiffness of pivots, brackets and bellcranks will help. Quality bearings and construction will help. Quality dampers will help. Simple design of geometry of linkages will help.

Vehicle size, appropriate for the course, suspension geometry for tight corners. A kart would probably murder a FS car around here but the 8" wheel rule prohibits this.

Tyres are the starting point for suspension design choices. Consider all options and justify fully choices made, even if solely on cost or sponsor grounds. Suspension adjustability needs to be based on what the tyre needs, or is estimated to need. Look carefully at your tyres after running and then look at other who are quicker or slower than you.

Safety, this is relative, nothing is 100% safe. This is a relatively low speed event, with no wheel to wheel racing and plenty of run off space. It is not to be ignored but the nature of the track and the rules means that things can go wrong in reasonable safety and you can learn from your mistakes and others (cheaper method). **Fire risk** is perhaps the biggest area to pay attention to. Nobody ever enjoyed being in the BBQ rather than beside it, no-one ever. This is why rules insist on exit time and cockpit size. **Losing brakes** is next, this is why rules require a test and over-travel switch. **Losing steering** is next, this is why rules require front crash structure and plenty of space. A huge **side impact** penetration is very unlikely but the rules do also consider this. A **light** car ultimately has less energy to get rid of!

Wheel design, if you are looking to design your own wheels think carefully about all of the aspects, e.g. tyre fitment, attachment, spigoting, stiffness including in torsion, temperature effects, tolerances, costs and of course air tightness.

No single correct "answer" to any of the areas really, other than those required by the rules. Up to you to have reasoning based on sound principles, or extensive test data if not, to explain your chosen route. See the **big picture** if possible. Think of **manufacture** at all times.

Technology. Do not use things just for the sake of it: any innovation should be proven to be viable or it risks being merely a gimmick. Even the best technology falls down occasionally; this may be why some of your Reports etc. arrived late even though you thought they were sent in plenty of time!

The Design part is separate from the **track times**: it should be as they are different mainly in that the design part does not assess the biggest variable of all, the driver.

In **summary**: the team and the car are both assessed; both need some practice prior to the event. The car will not be running unless it meets the **rules**. The car cannot be **reliable** unless it has been **tested**: it cannot be tested unless it is **ready**: it will not be ready unless you **plan** and organise it to happen to a **schedule** with some inclusion of contingency for when things do not fit, do not arrive or cannot be paid for. It cannot be organised to be **manufactured** or assembled in time if it is not designed and drawn and filed logically for future reference on time. Few components can be designed in **isolation**: therefore components can only be designed in detail if it is known how they fit into the overall coherent **big picture design plan**. Detail design therefore requires some knowledge or estimation of the major load cases or major masses and distribution and basic vehicle concept. You cannot plan the basic vehicle concept, on time or otherwise unless you **read the rules and any updates and understand them**. You need to start on this now.

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