Formula Student Germany

FSG Workshop on 8th November 2008 at BMW

Schedule

07:30 – 08:30	60‘	Registration		
08:30 – 08:45	15‘	Welcome		
08:45 – 09:45	60‘	New Rules		
10:00 – 11:00	60‘	SEF & IAD	Business Plan Presentation	
11:15 – 12:15	60‘	Testing and Setup	New Cost Rules 2009	
12:15 – 13:30	75‘	Lunch		
13:30 – 14:30	60‘	Highlight Speech		
14:45 – 16:15	90‘	New Chassis Design	Formula for Success	Round Table FSG Board meets Team Captains One person/team only.
16:15 – 17:00	45‘	Coffee Break		
17:00 – 18:00	60‘	Fuel Efficient Dynamics	Preparation for Engineering Design	
18:15 – 18:30	15‘	Summary		

⬜ , 🟦 in “Studio Projekthaus” 🟨 in “FIZ Forum” 🟩 in “Panorama Projekthaus”

Speaker

Highlight Speech (German)	Wolfgang Mattes – BMW Group Department Head Research & Development
Welcome	Johannes Trauth – BMW Group Vice President HR Direct Munich Tim Hannig – Kion Group GmbH & FSG Board / Steering Committee
Summary	Dr. Ludwig Vollrath – Verein Deutscher Ingenieure e.V. & FSG Board / Steering Committee
Rules *	Frank Röske – Porsche Leipzig GmbH & FSG Board / Steering Committee
SEF & IAD	Ulf Steinfurth – UAS Stralsund & FSG Steering Committee
Testing and Setup	Michael Zottler – TU Graz & FSG Operative Team
New Chassis Design	Ronald Müller – Rennteam Uni Stuttgart Jürgen Seidler – TU Graz
Fuel Efficient Dynamics	Cas Droogendijk – TU Delft
Business Plan Presentation	Barbara Schlögl – Carbo Tech Composites GmbH & FSG Steering Committee
New Cost Rules 2009 *	Jan Helbig – Europcar Autovermietung GmbH & FSG Steering Committee
Formula for Success	Henk Wapstra – TU Delft Cas Droogendijk – TU Delft
Preparation for Engineering Design *	Daniel Nowicki – BMW Group Research & Development, FSG Judge Paul Daman – BMW Group Research & Development, FSG Judge

* No handout provided

IA / IAD & SEF

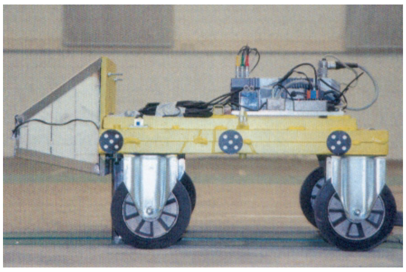
Die Reglementierungen für den Impact Attenuator (IA) und Structural Equivalency Form (SEF) werden stetig überarbeitet, um die Sicherheit der Fahrzeugführer und anderer Eventteilnehmer zu erhöhen.

Impact Attenuator (IA) / Impact Attenuator Data (IAD)

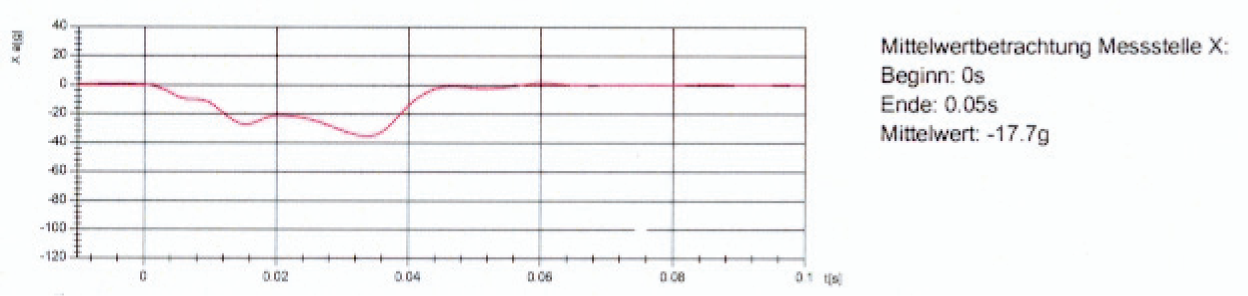
Für 2009 ergeben sich gemäß Punkt 3.20 in den Abmaßen und der Art der Befestigung für den IA keine Änderungen gegenüber 2008.
Dagegen wurden die Anforderungen für den Impact Attenuator Data Requirement (IAD) erhöht.

Es muss ein Impact Attenuator Data Requirement (IAD) eingereicht werden, der den Nachweis erbringt, dass der IA die geforderten Beschleunigungen im Mittelwert von 20g und ein einmaliges Maximum von max. 40g erreicht.

Ab 2009 sind bei der FSG Kalkulationen und / oder Simulationen als Nachweis für den IAD nicht zulässig.



Es müssen reale Tests durchgeführt werden und die Auswertung der Tests muss einem ingenieurmäßigen Stil aufweisen (Inhaltsverzeichnis, Versuchsaufbau, Messwerte, Auswertung etc.).
Der Aufbau der Crashbox ist zu beschreiben und die Crashbox ist vor und nach dem Crash zu fotografieren.
Dazu sind Messschriebe in der Form $\ddot{x} = f(t)$ einzureichen und die o.g. Beschleunigungen gemäß Rule 3.21.2 zu berechnen.



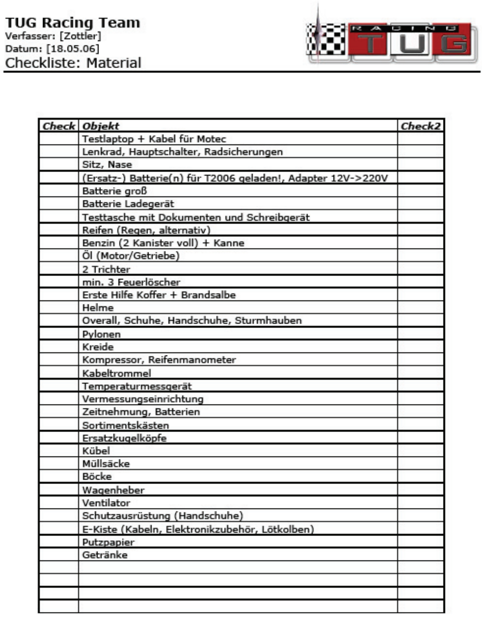
Mittelwertbetrachtung Messstelle X:
Beginn: 0s
Ende: 0.05s
Mittelwert: -17.7g

Zum Scrutineering beim Event in Hockenheim 2009 ist die gecrashte Box als Nachweis vorzuzeigen.

Structural Equivalency Form (SEF)

- Jedes Team muss einen SEF einreichen unabhängig davon, ob die Materialvorgaben eingehalten werden oder nicht. Dazu wird das entsprechende Formblatt demnächst zum Download bereitgestellt.
- In 2009 keine Materialvorgabenänderung gegenüber 2008.
- Wenn 3.3.1 – NOTE 2 angewandt wird, muss für diese Anwendung kein SEF eingereicht werden. Es muss lediglich auf dem Formblatt vermerkt werden.
- Bei Materialauswahl gemäß 3.5 (Alternative Steel Tubing) unbedingt NOTE 1 bis NOTE 3 beachten.
- Vergleichswerkstoff für FSG 2009 ist bei allen Berechnungen S 235 (St 37-2).
- Für FSG 2009 bei Verwendung alternativen Materialien muss der SEF einen ingenieurmäßigen Stil aufweisen (Inhaltsverzeichnis, Formelzeichen, Abkürzungen, Materialnormen, Berechnungen mit Zwischenschritten, Auswertungen)
- Für FSG 2009 bei alternativen Materialien zusätzlich Erläuterung der Ergebnisse.

Check, Check and Double-Check



TUG Racing Team
Verfasser: [Zottler]
Datum: [18.05.06]
Checkliste: Material

Check	*Objekt*	*Check2*
	Testlaptop + Kabel für Motec	
	Lenkrad, Hauptschalter, Radsicherungen	
	Sitz, Nase	
	(Ersatz-) Batterie(n) für T2006 geladen!, Adapter 12V->220V	
	Batterie groß	
	Batterie Ladegerät	
	Testtasche mit Dokumenten und Schreibgerät	
	Reifen (Regen, alternativ)	
	Benzin (2 Kanister voll) + Kanne	
	Öl (Motor/Getriebe)	
	2 Trichter	
	min. 3 Feuerlöscher	
	Erste Hilfe Koffer + Brandsalbe	
	Helme	
	Overall, Schuhe, Handschuhe, Sturmhauben	
	Pylonen	
	Kreide	
	Kompressor, Reifenmanometer	
	Kabeltrommel	
	Temperaturmessgerät	
	Vermessungseinrichtung	
	Zeitnehmung, Batterien	
	Sortimentskästen	
	Ersatzkugelköpfe	
	Kübel	
	Müllsäcke	
	Böcke	
	Wagenheber	
	Ventilator	
	Schutzausrüstung (Handschuhe)	
	E-Kiste (Kabeln, Elektronikzubehör, Lötkolben)	
	Putzpapier	
	Getränke	

TUG Racing Team
Verfasser: [Zottler]
Datum: [18.05.06]
T2006 Checklist

- Öl
- Wasser
- Radmuttern 180Nm + Sicherungen
- Reparaturüberprüfung
- Warnleuchten
- Volltanken
- Setup Überprüfung
- Errors
- MoTec Download
- Sichtkontrolle

Trouble-Shooting

- Understand your car
- Improve reliability
- Monitoring the operating reliability

Basic Setup

- Setup Change: Was it good or bad?
- Driver Training
  - Feedback via lap time
  - Help from an experienced driver

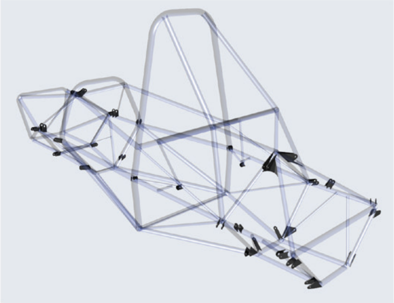
  Basically: No locking or spinning wheels, smooth motions
- Fix rough parameter
  - E.g.: final drive, ground clearance, break balance, …
  - Change only one parameter

Special Setup

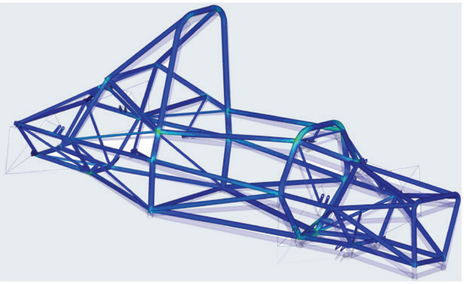
- Acceleration
  - Reduce driving resistance
  - CG should be at the back
  - TC / LC Setup (very good with tire data)
  - 2nd run direct after 1st run (tire temp.)
- Skip pad
  - Test the complete Skid Pad
  - Good for basic car setup
  - 2nd after 1st
- Autocross
  - Different setup (tire temp.)
  - No cones
  - 2nd after 1st
- Endurance
  - Before competition test a hole endurance
    - Restart
    - Temp. oil / water
    - Driver phys. / menth.
  - Tactic (safe fuel, treat car with care / push hard)

Formula Student Germany

Workshop BMW Munich | 2008-11-08 | New Chassis Design



- What is the frame?
  - Connects all parts of the car
  - Accommodates the driver
- What are the requirements?
  - Needs to be lightweight and stiff
  - Easy to manufacture
  - Low in cost



Concept

- **First CAD-Model**
  - CAD-Model considering rules and available space
  - Make yourself placeholders to clarify the design envelope
- **Mockup: Aim: define the major dimensions of the frame**
  - Build the first mockup as soon as possible
  - Make yourself hardcopies of the templates and Percy
  - Put the improvements back in CAD
  - Interfaces with the suspension team
- **Load cases & Simple FEA**
  - Breaking, Acceleration, Cornering
  - Beam/Truss Model

    → Best way to optimize weight & stiffness

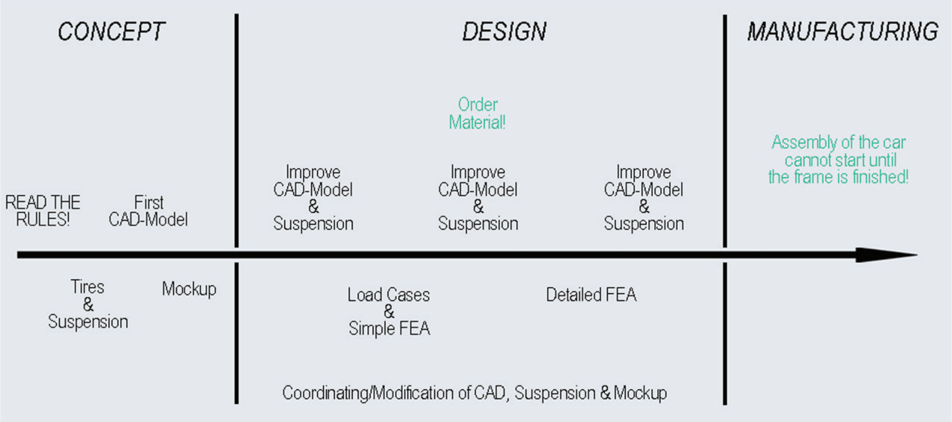
Design

- **Load cases & Simple FEA**
  - Breaking, Acceleration, Cornering
  - Beam/Truss Model

    → Best way to optimize weight & stiffness
- **Use triangulations to avoid squares**
- **Load initiation in nodes to prevent bending**
- **Try to use big outer diameters and thin wall thickness (min. for welding 0.8mm)**
- **Try to get as close to the minimum requirements as possible (→ Imperial Tube Sizes)**
- **Try to lay the dampers parallel to tubes**

Material

- Stiffness cannot be improved by using alloyed steel!
  - However it is sensible to use alloyed steel (e.g. 25CrMo4) for security relevant structures (cockpit, suspension)
- Heat treatment:
  - It is definitively better to do it (Design)
  - Do it node to node to prevent huge distortion
- Welding
  - TIG!
- Bending
  - Use heat treated tubes for bending



CONCEPT

DESIGN

MANUFACTURING

Order Material!

Assembly of the car cannot start until the frame is finished!

READ THE RULES!

First CAD-Model

Improve CAD-Model & Suspension

Improve CAD-Model & Suspension

Improve CAD-Model & Suspension

Tires & Suspension

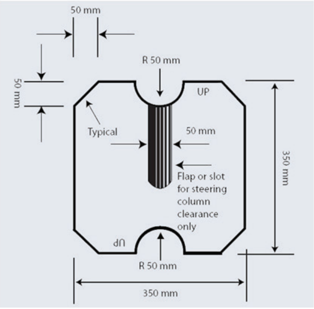
Mockup

Load Cases & Simple FEA

Detailed FEA

Coordinating/Modification of CAD, Suspension & Mockup

- 4.2 Cockpit Internal Cross Section:
  - 4.2.1 A free vertical cross section, which allows the template shown in Figure 9 to be passed horizontally through the cockpit to a point 100 mm (4 inches) rearwards of the face of the rearmost pedal when in the inoperative position, must be maintained over its entire length.
  - 4.2.2 The only things that may encroach on this area are the steering wheel, steering column and any padding that is required by Rule 5.7 "Driver's Leg Protection".
  - 4.2.3 For 2009, teams whose cars do not comply with 4.1 or 4.2 will have 35 points deducted from their Design Event score.



- 4.1 Cockpit Opening
  - 4.1.1 In order to ensure that the opening giving access to the cockpit is of adequate size, a template shown in Figure 8 will be inserted into the cockpit opening. It will be held horizontally and inserted vertically until it has passed below the top bar of the Side Impact Structure (or until it is 350 mm above the ground for monocoque cars).
  - 4.1.2 During this test, the steering wheel, steering column, seat and all padding may be removed.

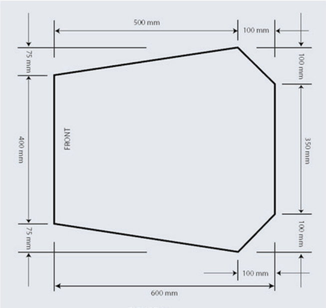


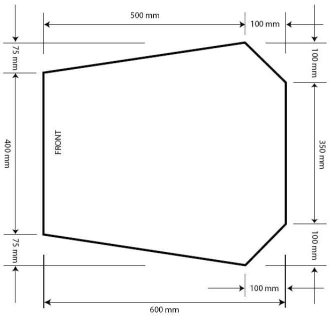
FIGURE 8

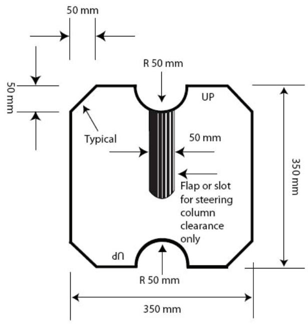
Referent: Ronald Müller

Email: r.mueller@rennteam-stuttgart.de

Making a monocoque in three steps

- Design
  - The three ways you can design a monocoque
    - Depending on the resources you have, it has to be your first decision before you start
  - What you need to know before starting the design.
    - Keep in mind. The monocoque has to be the connection of all components and modules your car consists of. The driver has to find a comfortable place to do his work. Its last function is to look fine
  - The rule change concerning the patterns those have to fit into the car





- Analysis
  - How you can simplify Sandwich composites
    - Something about the distances between the outer plys (Example I-Beam)
    - What kind of falsification do you have to deal with?
  - How to set up ply stacking on example of torsion
    - How to use a simple FE-analysis of an isotropic material for setting up a ply stacking
  - What you can gather form failure criteria analysis
    - What failure criteria should you use? Why? And what can learn form?

- Building
  - The most common ways to manufacture a mold and a monocoque. Something about their advantages and disadvantages.
    - Resin infusion
    - Hand lay-up
    - Prepregs
  - Some examples for threaded inserts you can use.
    - No final design is faultless. So what can you do if you have to screw something to your monocoque after all inserts have been set.

How to build a fast car?

- Handling (2 sides: good driver training and an easy to drive/predictable car with good ergonomics)
- Fuel economy (you can gain up to 100 points and lose even more)
- Large GG diagram (good car set up, good tyres, braking power, accelerating power)

If you have an unlimited financial budget and unlimited resources, there is still a trade off to make between: Handling, power and fuel economy: you can't get them all, but one of them could be less important than you would guess at first sight, see following paragraph.

Looking at the power: actually we mean: accelerating power. So with $a = F/m$ you can either gain F or lose m. By losing m, we gain more a than by increasing F. This is why: the lateral force capability of a tyre increases generally by a lower factor than the normal load (tyre load sensitivity). This loss in m also increases the handling response of the car.

To increase fuel efficiency, you can limit power (and thereby also reduce car mass because of a possible lighter engine, driveline and auxiliary systems) and after that, make the engine as fuel efficient as possible. So how many power is needed?

Does more power always make you faster?

- About 85% of the time the car has > 0.2g lateral.
- Only 15% of the time the car has full throttle.

Compared to other formula classes, at FS power is relatively less important, or to put it differently, other factors (like fuel eco, suspension set up, cost analysis, etc.) are more important. A simplified calculation indicates that having a 30% power/weight ratio advantage, makes you probably only a few percent faster around the track, but gaining extra fuel economy points.

How to distribute the power?

Question yourself if you want an engine delivering a flat torque curve with less shifting around the track, or do you tune the engine to a power peak, making more shifting necessary. Analyse the typical corner exit speeds experienced at FS and make sure you are in a drivable range of your engine.

Engine choice

There are many factors to take into account choosing an engine, but here are some efficiency related differences between one cylinder engines and four cylinder engines:

- Less mechanical losses in one cylinders (less rotating parts)
- One cylinders have a better surface/volume ratio, and therefore a better thermodynamic efficiency
- 4 cyl engine parts are designed for delivering more power (restrictor does limits 4 cyl. Not 1 cyl 450 cc)
- Lower mass (450 cc weighs 29 kg) and less parts

How can we design the engine fuel efficient?

The following efficiencies determine the chemical to mechanical energy conversion:

- Thermodynamic efficiency (fuel choice, AFR, combustion chamber design, ignition, compression ratio)
- Volumetric efficiency (intake and exhaust design, camshaft design/choice, forced induction)
- Mechanical efficiency (engine oil, piston rings)
- Pumping efficiency (compressor, cooling water, alternator)

Conclusion

In the trade off: handling/fuel economy/power, you have to question how much power you need. First of all make you car handle, than you make your car deliver the desired power, and after that, make your car fuel efficient. Look at your resources and decide which modifications are really needed. After all only about 50% of the cars finish endurance, and only good management makes all effort of designing a fuel efficient car worth it.

Referent: Cas Droogendijk, DUT Racing

Business Plan Presentation Event (75 points)

Convince the executive board (your judges) to invest in your concept

Adapted scoring sheet:

Executive Summary	5
Content	20
Deep Dive Topic	10
Organisation	10
Visual Aids	10
Delivery	10
Questions	10
Max. points from judge	**75**

- Executive Summary:

  Deadline: June 12, 2009 12:00 CET

- NEW - Deep Dive Topic:

  Every team has to present this special deep dive topic in a detailed way as a part of the team's business plan presentation to the judges.

Scoring:

1st Place:	75 points
2nd Place:	74 points
3rd Place:	73 points
4th Place:	72 points
5th Place:	71 points

Formula for non-finalists:

PRESENTATION SCORE = 70 x (P_{your}/P_{max})

P_{max} is the highest score awarded to any team not participating in the finals

P_{your} is the score awarded to your team

What is the formula for success?

Because of the different interests and resources of the different FS teams, there is no real formula for success, other than good project management.

Product management

The product management is used to manage the construction and operation of the car. We converted the System Engineering approach to a methodology more useful for a FS car, containing the following main phases:

- The top level phase
    - The process input / assignment by the competition (next year there will change a lot here), the university and the team
    - The top level requirements
    - The design philosophy, which states priorities in your top level requirements
- The concept phase
    - Market analysis, where do you get your information
    - Trade offs using the requirements
- The design phase
    - Work break down structure, to make sure no part will be left out
    - Load cases
    - Design synthesis, creating a physical structure
    - Documentation
    - Design loop
- The production/assembly phase, verification is important
- The operation phase, also important to verify, and especially to identify the source of the error

There are some tools to guide this process, eg.:

- Data, Part, Risk, Performance/quality, Financial management and Time management.

Special attention needs to be paid to the integration between the different departments within the team.

Team management

As said before, the team structure will differ significantly withing Formula Student, depending on the different resources and interests. However, one factor will be important within every successful team: motivation.

This is accomplished by:

- Fist: assessing the members. Get to know the different qualities (eg. By making excersises) and give them tasks matching their qualities. This is a continuous process, and will take a lot of the manager’s time.
- Second: educate and challenge your members.
- And last but not least: take care of a good communication.