

Best Practices for Mechanical Design & Scrutineering



Context

- This presentation is ADDITIONAL to the FSG Academy
 - [FSG Academy 2023: Rules and Statics](#)
 - [FSG Academy 2023: Tech Inspection](#)
 - [FSG Academy 2023: SES](#)(you need to be logged in to the FSG website for access)
- We want to „substitute“ FSG Academy with regards to CV & Hybrid
- We want to present a more practical and „bottom-up“ approach

Best Practices - Overall

- In order to win the race, you first have to finish!
 - Focus on key areas to improve
 - Do not change *everything*, especially if it worked well
 - Get the car running at least 2 months before the competition
- Vehicle Status Video deadline (June 21st 2024)
 - Strict deadline! Your car has to drive!
 - As soon as your car drives, make a rules compliant VSV!
You never know what might happen in testing
- TESTING, TESTING, TESTING!



Best Practices – Chassis Design

- Use the SES template as soon as possible
(last year's template works fine for the design phase)
- FSG Rules Question tool is not intended for general design questions
 - Instead you can write our FSA Specialists: [contact the FSA team](#)
- Alloyed steel has additional requirements! (T3.3.3)
- Welding aluminium (front hoop) has additional requirements!
- Be careful with asymmetric and non-isotropic laminates!

Best Practices – Bodywork & Radii

T1.1.2 Bodywork – the outermost surface of the chassis or any fairing parts and covers

Changelog Version 1.0: Added definition of bodywork

Changelog Version 1.1: Clarified rule

T2.3.2 In any side view in front of the cockpit opening and outside the area defined in T8.2 all parts of the bodywork must have no external concave radii of curvatures. Any gaps between bodywork and other parts must be reduced to a minimum.

Changelog Version 1.0: Added rule about the shape of the bodywork

Changelog Version 1.1: Clarified rule

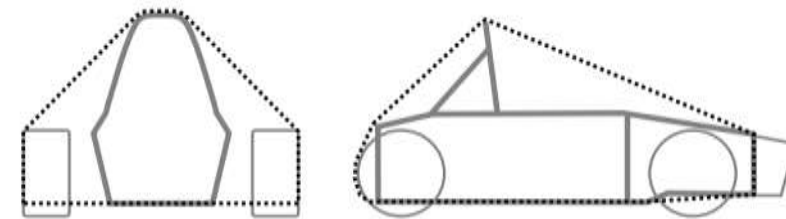
T2.4.1 For all edges that could come into contact with any standing pedestrian without reaching to the vehicle, the minimum radius of the bodywork and aerodynamic devices is, 3 mm for all forward facing edges and 1 mm for all other edges .

Changelog Version 1.0: Unified minimum radius for aerodynamic devices and bodywork

Changelog Version 1.1: Clarified rule

Best Practices – Envelopes (T1.1.16 & 18)

- The definitions have changed, the intent stays the same!
- Rollover protection envelope:
 - Critical components (and driver) need to be protected by a suitable structure
 - The figure tries to give a good example
- Surface envelope:
 - Components should not “stick out” too far
 - Lower boundary = projection in side view of rollover protection!
 - Intent: Protection also in case of suspension failure
- If in doubt, please submit an FSG Rules Question!



Changelog Version 1.1: Clarified definition of surface envelope

Best Practices – Suspension & Steering

- You may use alternative fasteners in the suspension and steering!
- (not for the brakes!)
- Equivalency means:
 - Yield strength
 - Ultimate strength
 - Loadpath in bolt head
 - Good engineering practise (material choice,...)
- **stationary parts** of the steering rack must be within rollover envelope

Changelog Version 1.0: Prescribed positioning of steering rack

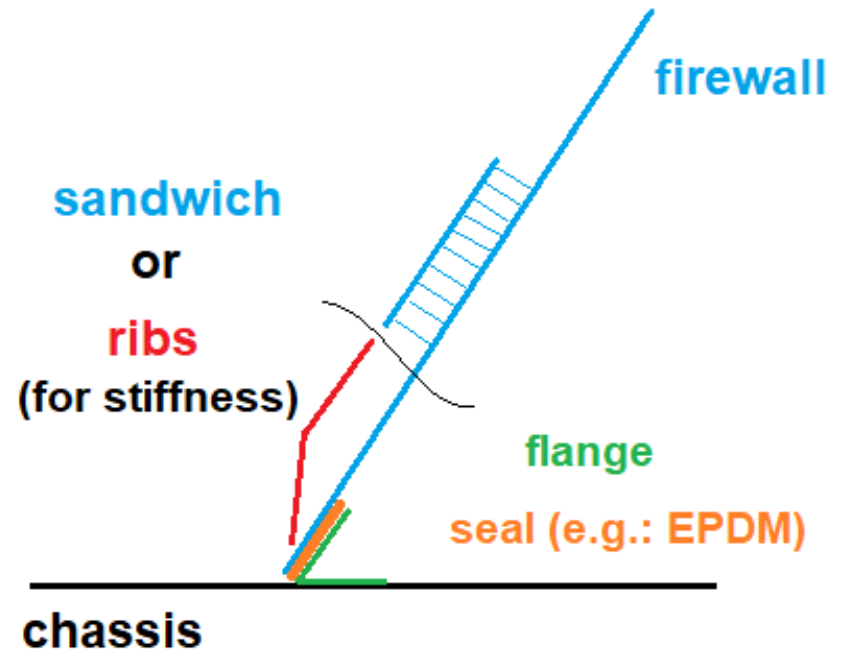
Changelog Version 1.1: Clarified rule

Best Practices – Brakes & Wheels

- Please keep it conservative!
- A flying wheel or disintegrating brake is no recipe for winning!
- Consider fatigue strength because every rotation is a load cycle!
- Brake disc “floaters” with snap-rings only okay if OEM!
- Brake pedal face (area that touches sole) must be metal
- It is called “brake pedal” not “break pedal” ;)
 - The brake pedal will be tested by Scrutineers!
 - Beware of “stramme Wadln!”

Best Practices – Firewall

- Requirements
 - Fire resistant
→ you can test UL 94-V0 yourself!
 - Rigid
→ use sandwich plate or ribs
 - must seal against the passage of fluids
→ use flanges & seals



Best Practices – Cooling System

- All components must be rated for at least 120°C
- plain water requirement only for combustion engine
- Keep it cool! Climate change is real ;) Radiator and fans better one size larger



Tips for Mechanical Inspection

- Our goal:
 - Guarantee adequate safety
 - Get as many cars on track as possible
 - Keeping it fair for everybody
- How we do it:
 - Inspection Sheet (see homepage)
 - Checking Rules if necessary
- You might not get points in Scrutineering, but without stickers you don't get any dynamic points!



Tips for Mechanical Inspection

- How you can prepare:
 - If you are not sure – ask a Rules Question
 - If in doubt, keep it conservative
 - Ask yourself: does it look right?
 - Do a “dry run” with your alumni
 - Participate in pre-events if possible
- Bring everything to the event:
 - Documents, date sheets, Rules Questions
 - Test samples
 - Spare parts and equipment
 - Material and tool for fixing things





Q&A

Session 2 Mechanical Design & Scrutineering

Q&A for Mechanical Design | 1

Question	Answer
We use common lithium-iron batteries from motorcycles in our CV car. Should we transition to using customized battery packs similar to those in EV cars?	If you believe that this brings you a benefit: sure! It might also be the first step along your path to CV-Hybrid or even full EV. But don't underestimate the challenge and the risks associated with it!
How to start your first Monocoque: Basics principles, basic equipment, mold making, test samples, SES ? Are Aluminium/ Kevlar Honeycomb easier compared to wood?	This can impossibly be answered here, but I started out with "Konstruieren mit Faserverbundwerkstoffen" and then got in touch with Alumni from my team. In your case you should get in touch with other teams that have already manufactured monocoques. Of course, sponsors can help as well, but keep in mind that their daily business might be very different from your project. Maybe I should write a book on that ;)
For aero development, what are the most important points to emphasize?	1.) Don't blindly trust your CFD! 2.) Start small, build it, test it, understand it. Only then make it more complex. 3.) One day of testing with some flaps, gurneys, sheet metal, tape and pieces of string as "flow-vis" will go a lot further than weeks in CFD
Any ideas to increase stiffness of aerodynamic components?	Internal ribs and bulkheads - take inspiration from aircraft!
What materials are best to use to construct a firewall for a car? Especially with regard to adequate stiffness?	Will be covered in the presentation
My question is about rule T.2.3.2. What parts of the bodywork must be subject to this rule? Just the frame and aerodynamics or also nose and monocoque?	See slides: this has been clarified in the version 1.1 of the rules which are going to be published in the upcoming days. New definition: Bodywork = Bodywork – the outermost surface of the chassis (frame or monocoque) or any fairing parts and covers

Q&A for Mechanical Design | 2

Question	Answer
The best practices seen with respect to firewalls and something that teams can use effectively?	will definitely make a slide dedicated to that topic :)
Question about Firewall in electric car with space frame chassis: How to pass firewall requirements?	see he live stream and sketch that I made on the whiteboard
What are the biggest differences between your scrutineering and scrutineering in the United States?	I have never been at a US competition - but FS Austria Scrutineering is widely regarded to be "very strict - but not unreasonable". We have a very experienced pool of scrutineers, so they know what to look for. But when looking at the rules we will not only judge the written words, but also keep in mind the intent of the rule and judge accordingly. We also try to help you out with ideas for solutions if something is not okay - rather than just leave you to yourself with the remark that it is simply not rules compliant.
For aerodynamic devices, how to design with CFRP / GFRP to withstand the deflection imposed by the regulations, without adding too much weight?	Similar to general question about monocoques: start with lecture like "Konstruieren mit Faserverbundwerkstoffen" and try to get in touch with people who already did it. Wings and flaps are also much easier to try and test something - after all, that is what FS is meant for!
T10.1.5: In which mechanical properties do we have to show equivalence in comparison to critical fasteners.	Yield strength, ultimate strength and generally suitable design and material. For example: Aluminium has very poor fatigue strength and is prone to cracking, even more so if there is a starting point like the bottom of the thread. Example 2: there needs to be enough material left at the bolt head in order to transfer the forces, so very flat bolt head designs might not be suitable.
If the ride height is checked with 4 corners at their lowest setting, a car with active can still get under the limit during driving by adjusting roll or tilt	That is correct, but we believe the intent is being fulfilled: We want to make sure that active suspension cannot be used to alter the ground clearance once on track in order to generate a "sliding skirt" seal for ground effect.

Q&A for Mechanical Design | 3

Question	Answer
Is there a specific list of things that scrutineers revise at the competition? Can we as a Team have Access to that list in Order to simulate beforehand?	You are very much encouraged to simulate a tech inspection, preferably with one of your alumni as the "scrutineer" who has been at the competition before.
Are we allowed to have accumulator cooling holes in the SIS and is there a rule specifying the diameter or area of these holes ?	Holes in the SIS need to be documented in the SES and will be checked in detail through the document review process. The effective panel height is being reduced by the diameter of the holes. Good engineering practice must be followed with regard to loadpath and connection between inner and outer skin. Adequate shear strength (protection against intrusion) is necessary.
During scruti it is often mentioned that team xy has a nice solution for a problem. Would be quite nice if interesting solutions get published.	We cannot publish sensitive information without consent, but we try to give "Best practices" advice in this Academy
Question about Firewall in frame space chassis. This is very difficult to make a correct firewall in this type of chassis. Do you have any good tip for that?	see he live stream and sketch that I made on the whiteboard
We have rivet nuts in firewall to mount second part of firewall. Is rivet nut with bolt in it considered as open hole in firewall?	For EV car you have to include another insulation layer + ground the bolt / rivet nut. But apart from that: opening refers to holes that remain open. Be aware that there are rivet nuts which are closed at the end, so they seal completely against fluids.
Will the new stricter requirments for HSC and attachments be in the new SES? Will it have different equivalencies from the one already present for the TSAC?	The required calculations are not very complicated, we will provide guidance in the HSF template and check it there.
T482 We need firewall between drivers head and HV. Is carbon monocoque covered in fireproof fabric considered as firewall or do we need to add alluminium plate?	In the SES you only have to show the HSC in thr chassis pictures like the fuel tank and document the firewall.
	You need to include the aluminium layer if this part is considered to be the TS firewall

Q&A for Mechanical Design | 4

Question	Answer
How strongly do you recommend to students to build and include a build-in wireless telemetry system into the car that could transmit data to a laptop?	This is part of the design competition: you have to determine what systems bring you the most advantage. For most applications, it is good enough to have a data logger with cable connection, so without real-time wireless data transfer.
Is there a possibility to be approved or checked by the scrutineers in the process of production (pre season)?	We do not offer this as a formal service, but if you get in contact with officials that live near you, there is a good chance that they are willing to informally check your car before the competition.
Rule: T3.16 Can two attachment points with 15kN in any direction, instead of using 1 attachment point with 30kN in any direction, be used to fasten the TSAC?	"one attachment point" is considered to be two M8 bolts, and if they use the same bracket this will be considered as a single attachment point.
What if we just cover the concave Radii with a champfer?	Looking at the fastest car in the competition and trying to copy that is not a good starting point, instead you should start with a very simple concept, get that running and then improve from there. The biggest mistake you can make is making the challenge to hard for yourselves and then fail at delivering a working vehicle - a FS team will only stay together, when there is a working output which allows you to actually participate in competitions.
As your car painting of the monocoque. You have painted a concave radii in the bottom part. Is that allowed?	Yes, the lower part which is covered within the aerodynamic device boxes allows any shape
Our Front Suspension extends beyond the top of the chassis, but we also use a cutout, how are we supposed to cover this section?	You may still have components above / outside the bodywork. You just have to make sure that the bodywork fulfills the requirements and has minimal openings for the suspension components. If in doubt, please send a Rules Question incl. Drawings
T 2.3.2 - When talking about the rule before, you did on the board a sketch of a chassis with a concave radius in its bottom part. Is it ok to have that?	Up to a height of 500 mm, you are allowed any kind of shape of the bodywork because it is within the areas allowed for aerodynamic devices, see T8
Are screws inside gearbox connecting carrier and with wheel hub considered as critical fastener?	If they are part of the suspension, so responsible for keeping the wheel attached to the car, then they are critical fasteners yes.

Q&A for Mechanical Design | 5

Question	Answer
Could you clarify different coolants than plain water for ev cars?	You can use oil as coolant, typical would be transformer cooling oil, it has the advantage of being completely non-conductive.
For the cooling system, to what extent can the cooling tubes run outside the chassis?	As far as I am concerned, the only limitation is that the driver must not be able to come in contact with hot cooling system parts when entering or exiting the car.
UL94-V0 testing - If we do the test by ourself following the normative procedure, is the documentation of the test results a valid supporting material at event?	If you have third party documentation, the document is enough. If you test yourself, please film the whole test, use some still frame pictures from that as documentation and bring the video + test samples to the event.
We have a carbon fibre footrest, which has a layer of carbon between the pedal and the foot. It has no structural purpose in the pressing direction, allowed?	For the purpose of making your own life easier, I would suggest changing the design in such a way that the part that is visible during tech inspection is clearly not carbon fiber. It really does not pay off to get into a discussion here in my opinion.
Do the stiffening components of the firewall also need to fulfill UL-94 V0?	Yes, the 3 requirements "rigid, fire resistant and sealing against liquids" have to be fulfilled at the same time. If the stiffening components are necessary, they are considered integral to the firewall and thus have to be fire resistant. But you can always perform your own UL 94-V0 test with your unique combination of materials.
T4.6.2 If heat resistant material is in the firewall with proof that temp is always below 60 degrees, why is the convection part (25mm air gap) of the rule?	From my understanding of the rule, the 25mm requirement is only necessary if there are hot parts like exhaust manifold. But if you are not sure, please post a FSG Rules question with more information about your design.
Where can I find some material online (YouTube channels, websites) about best practices and how to design parts of a car for FS?	With regards to literature I would search for racecar engineering topics. With regards to mechanical manufacturing advice, the custom car scene has lots of material on video streaming platforms. For composite manufacturing, I would search for boat builders and maybe model aircraft builders, I could imagine that there is content about that online.

Q&A for Mechanical Design | 6

Question	Answer
What is the rationale of having cooling components rated for 120°C on systems that are not going to go beyond 60°C?	Because the 60°C is only the design temperature and in prototype racing it often happens, that the actual temperatures are very far away from the design values. Also, we believe that any part which is properly suited for (any) cooling system should have this temperature rating, so this rule aims to make sure that only parts that are actually intended for cooling systems are being used.
For rule T.2.8.9 about steering rack positioning would a steering sensor or other part directly mounted to the rack be considered as "static parts" of the rack?	Please make a FSG Rules Question with more information about your specific design. The intent is that in case of one side of the front suspension failing, the steering system will still work for the other side (as in: the steering rack is not being damaged and blocked because it came in contact with the ground)
About the brake pedal: in between the foot and the brake pedal face we use griptape. It is not metall, but it doesn't affect the forceflow. Is this allowed?	Yes, but you should make sure that at least on some areas, the metal is still visible, so that is is just easier to check for the scrutineers.
Sometimes stuff just goes wrong. In what ways is repairing a broken monocoque OK? Are tests required?	see sketches I drew on the whiteboard in livestream. short answer: yes definitely possible to properly repair a monocoque.
How should we test the force on MH supporting points, like: hand calculations, FEA or physical testing?	Physical testing is the best for us to check. Next best thing is hand calculations. FEA is only the last resort, because it takes a lot of time on our side to make sure that the result is indeed meaningful and correct.
If i make some individual seat parts (not the hard seat, but additive, soft made from foam) can i put them into car? and how to change them after Scrutineering?	In the rules this is called "padding" and yes it can be changed after Scrutineering, no problem. You can use velcro as attachment, although standard practise is making the seat from rather hard foam which gives proper support and is stable enough to just be but into the car and stay in place without any attachment.
Must every Attachment for the rear akkumulator Crashplate withstand 30 kN?	A laminated plate that is attached to the chassis using bolts has to use the number of bolts specified by T3.16.6 - each M8 bolt is considered to have 15 kN of strength in any direction. There is no "dedicated" attachment points for that application, but rather a flange with a total number of bolts as required.

Q&A for Mechanical Design | 7

Question	Answer
If we have a CFRP monocoque and an electric 4WD, how do we insulate the HV wiring for the front tires?	With additional firewall parts
Could you make a scheme to illustrate T7.3.3 rule on chain scatter shield please? (start and end parallel to the lowest point of the driven sprocket)	There is a drawing in the FSAE Rules, T.5.2.2
Its just okay to start manufacturing time before the new rules, or it is too early? (For next year)	<p>We have made the commitment to publish large rule changes before the actual rules - like for example the changes to the driverless format at FSG. However, we might have to react to unsafe developments, which will result in major rules changes, and this of course cannot be published in advance.</p> <p>The general timeline is that in September the new season starts with design phase and manufacturing really gets going in december / january - so at that point of course the Rules have been published and there has been enough time to answer any remaining questions. If you want to start manufacturing earlier than that, there is some risk remaining for you.</p>
T12.4.1 All vehicles will get timing equipment provided by the competition organizers. - Can this rule be more clarified? (purpose and meaning of the rule)	This refers to the RFID Tags that we put onto the car, for more information, please check the FSA and FSG competition handbook with dedicated sections about that.
If i combine seat and firewall, how can i put in some side parts? should i make a through bracket to the space frame tube? can i attach them to firewall?	<p>Be aware: the seat may be removed for checking the templates, however the firewall has to remain in the car. So if you combine them, you have to keep it in the car for the templates.</p> <p>Apart from that: attaching things to the firewall is possible, but you have to cover bolts + ground for EV application. Might be easier to just bond it to the firewall and not have any bolts sticking through. Maybe blind rivets into just one skin of a (laminated sandwich) firewall work for you as well.</p>

Q&A for Mechanical Design | 8

Question	Answer
Is it possible to solve the problem of overweight by using some "empty" parts rather than solid parts; also what about using "partially empty" parts?	You seem to refer to the very core elements of designing lightweight parts. One of the most effective way to design lightweight constructions is optimising the geometry! So for example: a beam in bending will be very light and strong, if it is a high profile with thin wall thickness. Then from that optimised overall geometry you can go into details and maybe you can make cutouts and holes. And only then in the third step you should check if you have a different material available to make the part even lighter - because there was a reason that you wanted to use a particular material in the first place.
UL94-V0 testing - If we do the test by ourself following the normative procedure, is the documentation of the test results a valid supporting material at event?	If you have third party documentation, the document is enough. If you test yourself, please film the whole test, use some still frame pictures from that as documentation and bring the video + test samples to the event.
Will a fully laminated in main hoop ever be allowed, as it is for the front hoop. We do not believe the 8 screws are necessary.	The main hoop has a significantly higher importance compared to a monocoque front hoop. The requirement to have bolted attachments is not about technical necessity but about being able to check it in tech inspection. The brackets, bolts and backing plates can be checked, while it is really difficult for the laminated hoop - we have to rely on pictures mostly. So short answer: no this rule will most likely stay the way it is.
My team have EV engine EMRAX 208, Is that requires covers around all sides of engine?	Please submit a Rules Question to the FSG website including drawings, it is impossible to answer this without additional information.
How can we show that a 3D printed part meets UL94 V0 standard?	You have to show documentation that the part was printed with the correct fill grade. Unless stated otherwise in the datasheet, we consider the rated fill grade to be 100%

Miscellaneous Q&A

Question	Answer
What are the best habits to keep track and a register of the parts that are designed, produced, bought... And how to documentate it	Standard practise is having a system for part /drawing numbers and then putting that number on the part itself for proper identification. But just organising stuff into boxes with labels might be good enough for your application.
Is traceability (in the supply chain) important for a formula student team?	From my point of view only to the extend that you need to be sure what specifications your part actually has. And for the purpose of crossing Schengen area borders you might need a lot of documentation.
Are there plans for doing embedded software scrutineering and if so how would this be approached?	No, there is no plan for any code review. This would need special hardware and because we are an engineering design competition this would be a too big drawback
What is the consensus on using open source software packages in embedded software solutions, specifically regarding to safety of open source code?	Looking at the fastest car in the competition and trying to copy that is not a good starting point, instead you should start with a very simple concept, get that running and then improve from there. The biggest mistake you can make is making the challenge to hard for yourselves and then fail at delivering a working vehicle - a FS team will only stay together, when there is a working output which allows you to actually participate in competitions.
Will there be a recording of the Academy so we can re-watch it afterwards?	We are hoping to get that running, yes, but at this point I can only promise that the slides + Q&A Session will be made available afterwards
We placed top 3 at the 2023 event and are now changing class from CV to EV due to FSG no longer supporting CV. Will we be pre-registered for the 2024 EV class?	Please write an E-Mail to info@fsaustria.at
We placed top 3 last year. Due to FSG no longer allowing CV teams we are switching to EV. Are we still pre-registered for the 2024 FSA Event?	please sent a mail to info@fsaustria.at
Does the DV Steering motor have to be inside the surface envelope?	please ask the questions with regard to Driverless questions in the FSG Rules Questions Tool, FSA does not offer any Driverless events