Successful SES/IAD/SESA submission

FSG Academy – Main Workshop for FSG 2024
on 21st of October 2023 at Schaeffler in Herzogenaurach

Targets of the SES

The structural design of your vehicle, specifically frame, must be documented:

- The SES is a tool to guide **you** to provide the relevant & important information of your vehicle
- The SES is also a tool for **the competition/us reviewers** to ensure that your vehicle is:
  - rules compliant, but a passed SES does not **guarantee** a rules compliant design!
  - the proposed structural design is safe
- It is **not** your design tool. But, you can access:
  - equations to prove equivalence (to an unalloyed carbon steel tubular space frame, per T3.2)
  - general guidance notes
  - feedback
- The same applies to the IAD

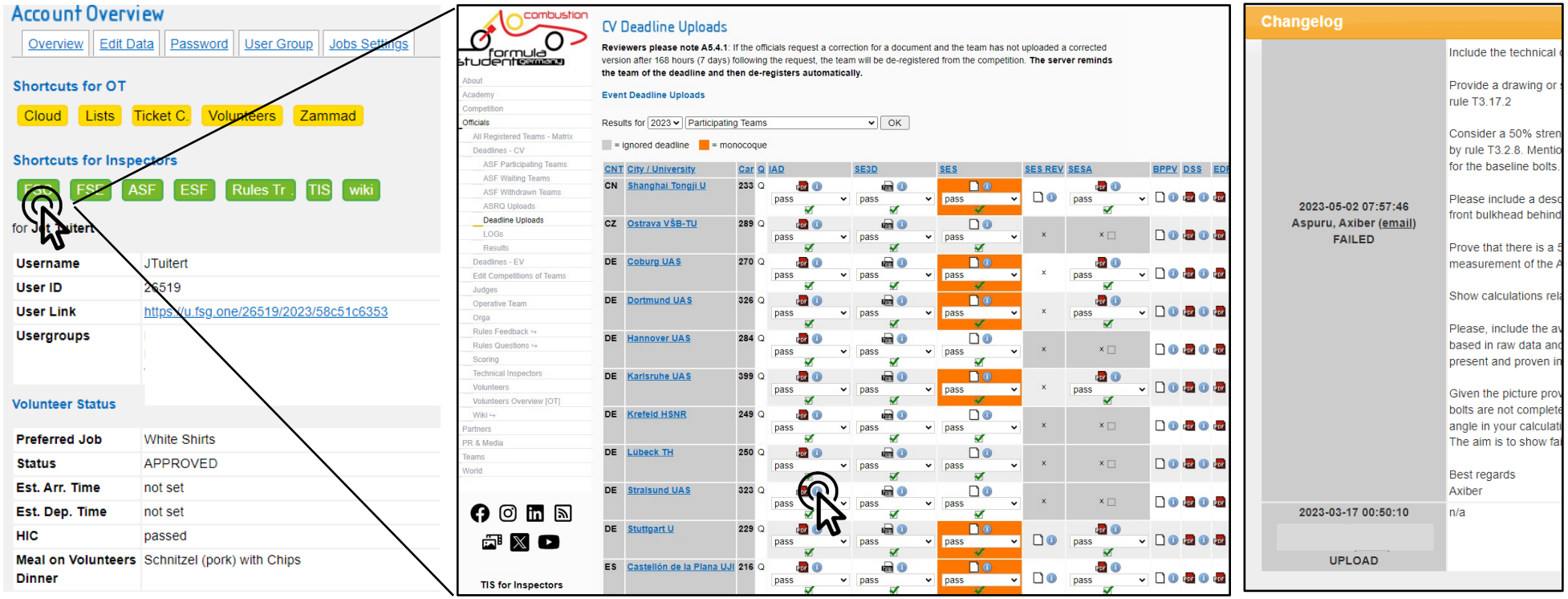
Review order

- SES/IAD checked by multiple events/multiple reviewers.
  - First submit, first reviewed!
- You may upload after moving to the FSG registration, waiting or withdrawn list.
  - Don’t wait until 10 minutes before the deadline
  - **2023: upload 12 hours earlier → first review 3 months earlier compared to last-second upload!**

SES / IAD Reviewers wanted:

Apply: E-Mail to ses@formulatudent.de

- What I see on the FSG website: for all teams registered (!) all uploads – support needed



- Want to become a SES / IAD Reviewer
  - Alumni, not an active team member anymore for at least 1 year+ (meaning, 'skip' a season)
  - Can also be a professional, non-alumni (Ulf)

General rules changes specific for SES/IAD

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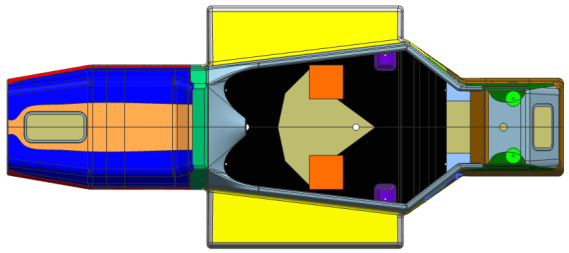
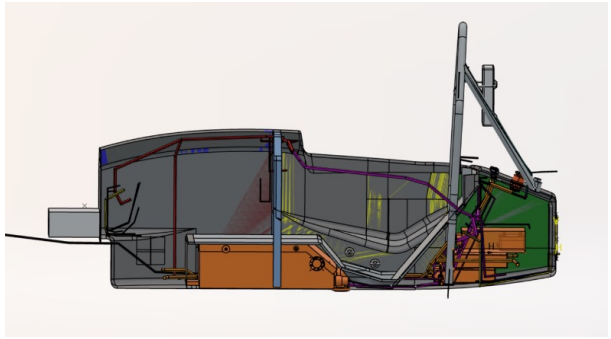
Impact structures (T1.1.12, T3.2.1, T3.15, EV4.4.2, EV5.5.2, CV1.3.2)

T3.15 **Implementation of impact protection**

- Simplified and generalized wording
- Components must now also be protected if exposed from the front
  - Applies (among others) especially to accumulators at the sides



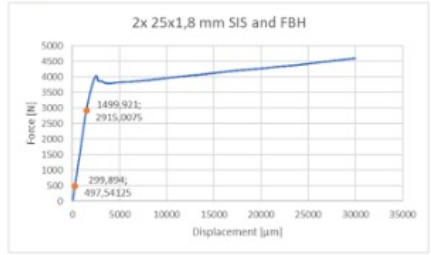


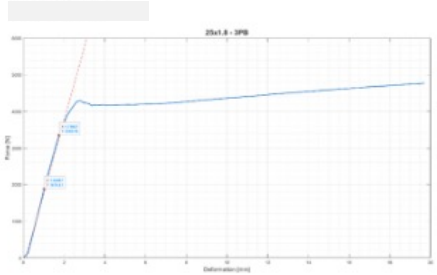
T3.15.3

- Energy absorption needs to exceed 65 J

Formula Student Electric - 2022 - Laminate Testing T3.5 - "Energy Affair"

Car	City / University	Øo, tube	Øi, tube	Support Span	absorbed Energy
		25,4 [mm]	22,2 [mm]	400 [mm]	76,964 [J]
		21,3 [mm]	16,1 [mm]	400 [mm]	64,140 [J]
		25,4 [mm]	22,2 [mm]	400 [mm]	70,293 [J]
		30,0 [mm]	26,0 [mm]	400 [mm]	64,195 [J]
		25,0 [mm]	21,4 [mm]	400 [mm]	49,200 [J]
		25,5 [mm]	22,1 [mm]	400 [mm]	76,660 [J]
		25,0 [mm]	21,0 [mm]	435 [mm]	76,710 [J]
		25,0 [mm]	21,5 [mm]	400 [mm]	75,478 [J]
		30,0 [mm]	27,0 [mm]	404 [mm]	87,541 [J]
		25,0 [mm]	21,4 [mm]	430 [mm]	103,288 [J]
		25,0 [mm]	21,0 [mm]	400 [mm]	130,390 [J]
		25,4 [mm]	22,2 [mm]	455 [mm]	58,282 [J]
		25,0 [mm]	21,4 [mm]	400 [mm]	98,620 [J]
		25,0 [mm]	21,4 [mm]	495 [mm]	82,530 [J]
		25,0 [mm]	21,0 [mm]	400 [mm]	53,200 [J]
		25,4 [mm]	22,2 [mm]	400 [mm]	61,779 [J]
		25,0 [mm]	21,0 [mm]	400 [mm]	73,986 [J]
		25,0 [mm]	21,0 [mm]	460 [mm]	33,400 [J]
		25,0 [mm]	21,0 [mm]	400 [mm]	117,850 [J]
		25,4 [mm]	22,4 [mm]	400 [mm]	117,000 [J]
		20,0 [mm]	15,0 [mm]	400 [mm]	65,950 [J]
		25,0 [mm]	21,0 [mm]	400 [mm]	74,200 [J]
		27,0 [mm]	23,0 [mm]	400 [mm]	82,535 [J]
		25,0 [mm]	21,4 [mm]	430 [mm]	121,974 [J]
		25,0 [mm]	21,0 [mm]	400 [mm]	130,820 [J]
		25,4 [mm]	22,1 [mm]	460 [mm]	69,000 [J]
		28,0 [mm]	25,0 [mm]	450 [mm]	133,612 [J]
		25,0 [mm]	21,4 [mm]	405 [mm]	45,500 [J]
		25,0 [mm]	21,4 [mm]	415 [mm]	116,100 [J]
		25,0 [mm]	21,4 [mm]	400 [mm]	82,755 [J]
		27,0 [mm]	24,0 [mm]	400 [mm]	129,680 [J]
		25,0 [mm]	21,0 [mm]	460 [mm]	77,767 [J]
		25,0 [mm]	21,0 [mm]	460 [mm]	65,348 [J]
		23,0 [mm]	18,0 [mm]	400 [mm]	94,565 [J]
		25,0 [mm]	21,0 [mm]	400 [mm]	99,200 [J]
		25,0 [mm]	21,5 [mm]	400 [mm]	66,280 [J]
		25,4 [mm]	22,2 [mm]	420 [mm]	60,650 [J]
		25,0 [mm]	21,0 [mm]	484 [mm]	50,500 [J]
		25,0 [mm]	21,0 [mm]	450 [mm]	77,300 [J]
		25,0 [mm]	21,3 [mm]	400 [mm]	64,292 [J]
		25,0 [mm]	21,0 [mm]	400 [mm]	84,179 [J]
		25,4 [mm]	22,2 [mm]	400 [mm]	85,390 [J]
		25,0 [mm]	21,0 [mm]	400 [mm]	74,900 [J]
		25,4 [mm]	22,2 [mm]	400 [mm]	78,120 [J]
		25,0 [mm]	20,0 [mm]	400 [mm]	151,584 [J]
		25,0 [mm]	21,0 [mm]	400 [mm]	85,090 [J]
		25,0 [mm]	21,0 [mm]	418 [mm]	69,700 [J]
		25,4 [mm]	22,4 [mm]	400 [mm]	96,216 [J]
		25,0 [mm]	20,0 [mm]	400 [mm]	77,100 [J]
		25,4 [mm]	22,2 [mm]	400 [mm]	139,900 [J]
		25,0 [mm]	21,0 [mm]	400 [mm]	125,000 [J]
		25,4 [mm]	22,2 [mm]	400 [mm]	66,510 [J]
		25,4 [mm]	22,1 [mm]	400 [mm]	71,100 [J]

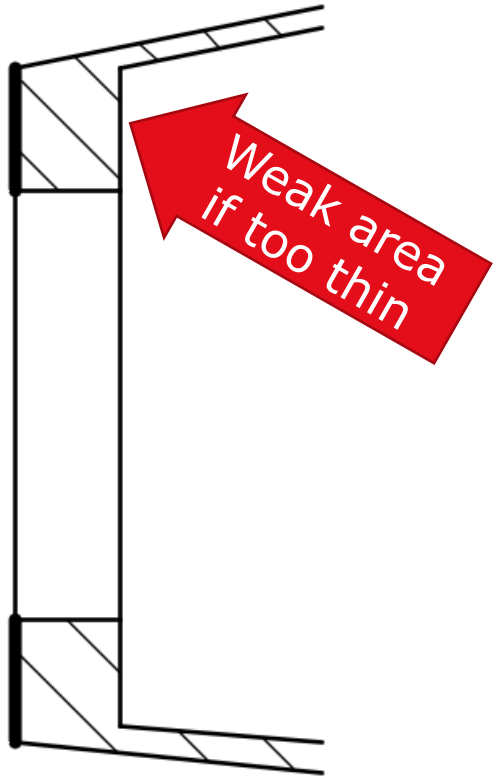




Asymmetrical lay-up

T 3.4.4 **Asymmetrical lay-up restriction**

- If an asymmetrical lay-up is used in the primary structure, the thinner skin must have a thickness of at least 40 % of the thicker skin
- Value of 40% chosen basis wrt. thicker lay-ups of for example 2.5-3.0mm, resulting in 1.0-1.2mm needed o other layer. Prevention of <0.5 mm lay-ups used.



Intent

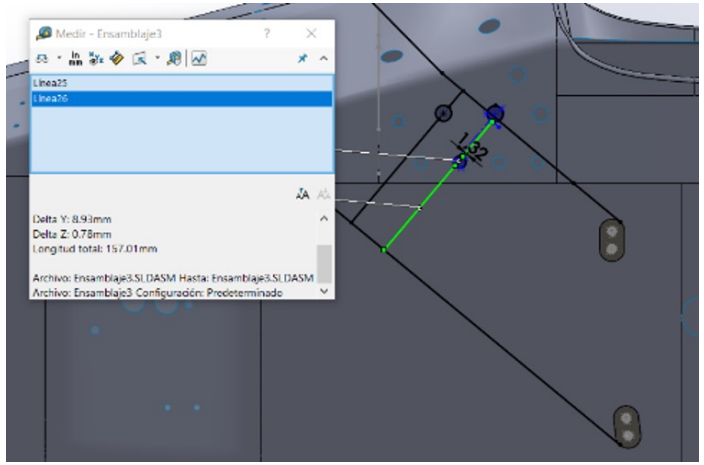
Prevent very thin (=unsafe) layups in critical locations for real application.

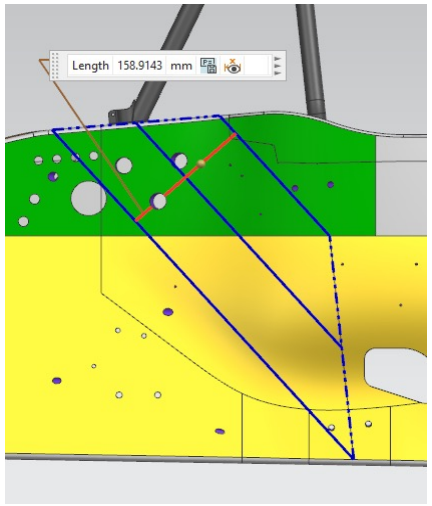
Quasi-isotropic laminates

T 3.5.4 **Non quasi-isotropic laminate definition**

- 'When a laminate is not quasi-isotropic, i.e. has equal strength and stiffness in the 0°, 90° and ±45° direction, the results from the 3 point bending test will be assigned to the 0 ◦ lay-up direction. To show equivalence in the SES, the 0° lay-up direction must be used and oriented accordingly in the chassis.'

Intent
Perform 3-point-bending test for structures representative as used in the car.





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Read Me, Version History and Rules Clarifications

- Read through the revision notes
- Upload new (revised) version and include a description of what has been changed in TAB ' Version History'
- Include relevant rules questions in text form (**no screenshot/image**) in TAB 'Rules Clarifications'
- Feel free to contact ses@formulastudent.de if you have found issues and/or have suggestions

If you have to resubmit your SES then please update the table below, indicating what changes you have made from the previous submission.

Submission Version	Revision Comments

Details of any rules clarifications must be referenced and appended in this tab.

Clarification ID	Details of Clarification Question and Answer

2023 FS Structural Equivalency Spreadsheet Guide

The SES template has been created to simplify the process of proving structural equivalency.

Please enter your values in the yellow cells and paste all the images in the specific tabs which shows your enter

All dimensions and units must follow the European SI System!

The final decision about all designs will be made at technical inspection. Approval of an SES does not guarantee

As downloaded the spreadsheet assumes a baseline steel chassis design. The majority of the cells in the spreadsheet are l
Cells shaded grey are dependant on the data entered in yellow cells, the formulae in these grey cells have been left visible s

The vast majority of the tabs can be accessed using the hyperlinks on the cover sheet. If you enable macros when opening t
There have been a few questions about how to handle bent/two piece tubes in place of a single baseline tube. If properly triar
tube, so please ensure you include images of the tube(s) in the "Chassis Pics" tab for the SES assessor to review. You may
do not need to adjust the number of tubes in the relevant calculation tab.

The SES has been extensively tested, but if you think you have found a mistake in the document or have any questions on h
Please read the guidance notes located at the end of the workbook.

If you find a new problem with the SES template or require a clarification 72 hours or less before the SES submis
proof of equivalency in the "Additional Info" tab as well as filing a Rules question.

Teams are not permitted to rename the name of the TAB or to delete any TAB

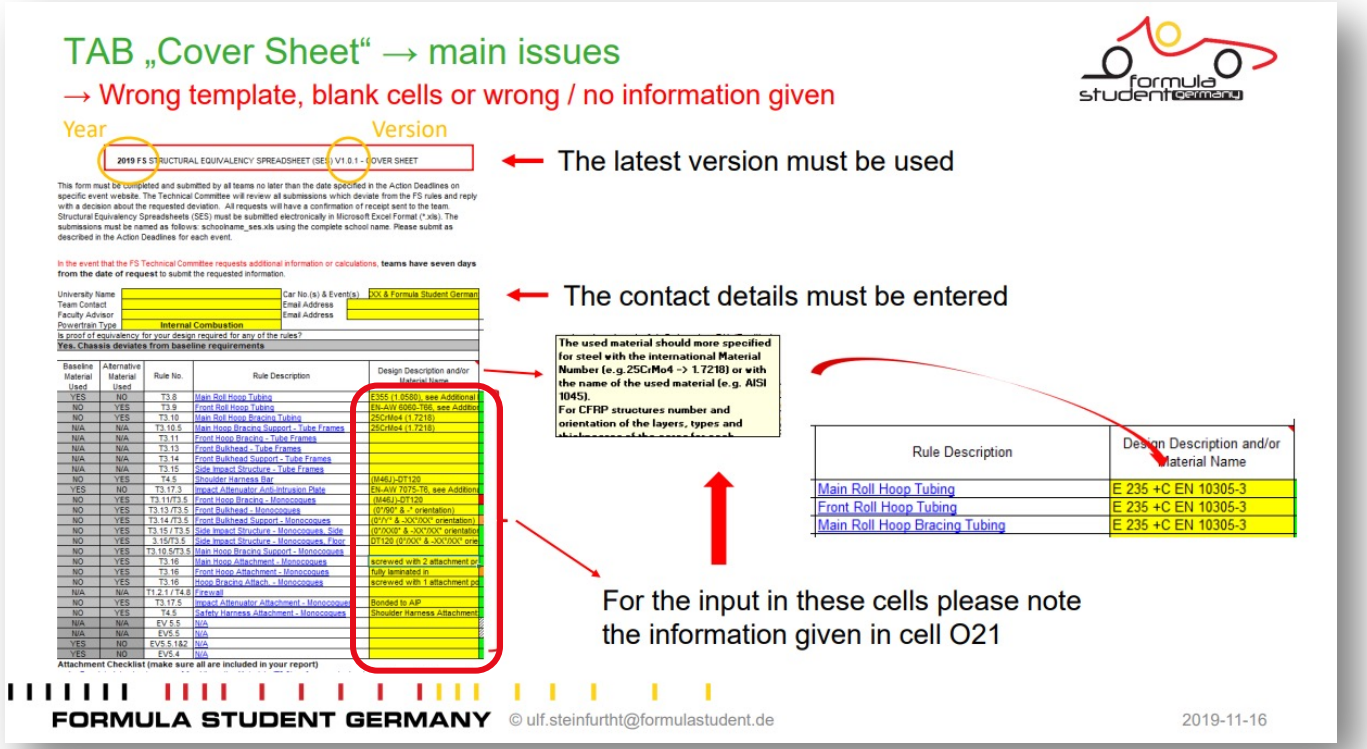
Revisions:

V1.0 First release for 2023 rules
- TAB Cover Sheet: fixed amongst others: TAB links such as in cell A29 to Front Bulkhead reference C/E17, 18,
(reminder for students to check filling out TABs 'Monocoque Lap Joints, Welded Tube Inserts, Steering Rack Col
- TAB Cover Sheet: Note in cell O21 changed to ease review by changed requirement of short description compos
- TAB Chassis Pics: checkboxes added R12:R20 and included 'Compliance to T 7.3.1 - Protection of lubrication s
- TAB T3.10 Main Hoop Bracing: fixed cell format D14
- TAB T3.17.3 IA Al Plate: proof requirement for T3.17.2 added (IA volume max. 350mm from the ground)
- TAB T4.5 Shoulder Harness Bar: link to Guidance Notes added
- TAB EV5.5.1&2 EV4.4 ACPS TSPS side & rear: tabs merged but split for rear and front (previously separate for
- TAB T3.5 Laminate Test - TAB Other 1 Matt'l Shear: format changed to include data for laminate tests
- TAB T3.5 Laminate Test: based on input values, energy calculated in C54, warning messages included in cells
- TAB T3.16 Hoop B'ing Attachments: correction, replaced the 25.4 by 25 mm in cells D14 and F14
- TAB T3.17.5 IA Attachments merged/replaced with general primary structure attachments for plates/panels in c
- TAB T4.5 Harness Attachments: tab's text reworded to represent rules applicable for BOTH frame and monocoq
- TAB T1.2.1 T4.6 T4.8 Firewall: included T4.6 in name tab, heat insulation measures and design/concept specific
- TAB T4.5 Guidance Notes added, linked to TAB T4.5 Harness Attachments and TAB T4.5 Shoulder Harness Ba
- TAB EV5 Accumulator Container: note about lid bending added
- TAB EV4.4 Guidance Notes, added image for tractive system protection structure in guidelines, to clarify the ge
- TAB T3.16 Front Hoop Attachments: renamed to 'T3.16 FH & FH B'ing Attachments' and updated to reflect rule
which was then seperately treated in (old) TAB 'T3.16 Hoop B'ing Attachments'. With more common solution bei
- TAB T3.16 Main Hoop Attachments: renamed to 'T3.16 MH & MH B'ing Attachments', and due to above change

Read_Me | Version History | Rules Clarifications | Cover Sheet | Chassis Pics | MaterialData

Cover Sheet

- Print on large sheet for inspection to enable quicker review
- Cells O24-O49: please read the information given in cell O21
- Do not forget about the attachment checklist:
  - Include your receipts and datasheets etc.
- Reviewers can quickly see, what the overall safety margins are within your chassis and where those margins are lower (needs more attention)



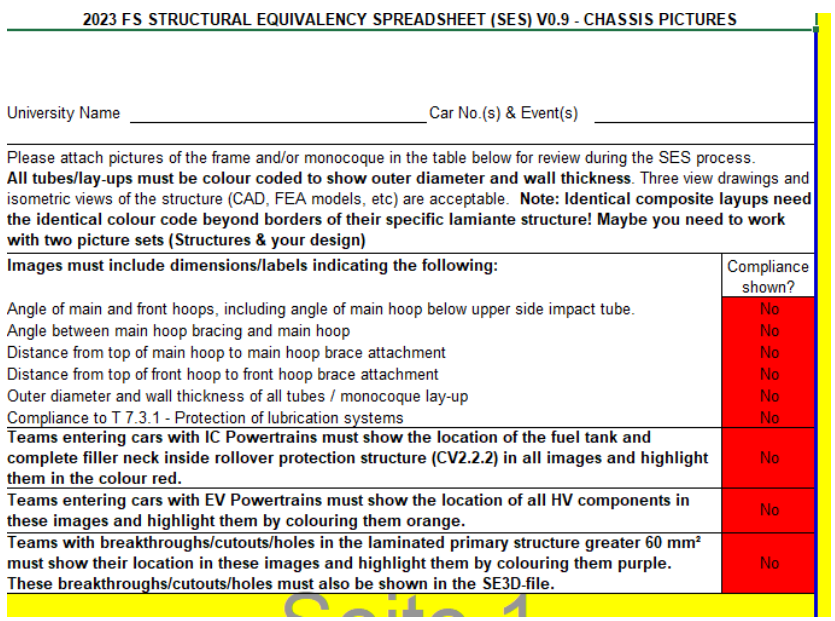
N/A	N/A	T4.5	Safety Harness Attachment		NA								
N/A	N/A	EV5	Accumulator Container										
N/A	N/A	EV5	Accumulator Stack Construction										
N/A	N/A	EV5.5	Accumulator Attachment										
YES	NO	EV4.4/EV5.5	Accumulator&Tractive System Protection Side		NA	NA	NA	NA	NA	NA	NA		
YES	NO	EV4.4/EV5.5	Accumulator&Tractive System Protection Rear		NA	NA	NA	NA	NA	NA	NA		

Attachment Checklist (make sure all are included in your report)	
Receipt, data sheets or proof for Alternative Materials (T3.3) or for non-steel materials (composite, honeycomb, r	No
Properties for all non-steel materials	No
Monocoque Laminate Test data and pictures	No
Holes >4mm drilled in any regulated tubing require proof of equivalency, include area and moment of inertia	No
LAP JOINT TEST for divided monocoque parts	No
Proof for alloyed steel (T3.3.3) as defined by T3.2.2	No

Chassis Pics

- Main issues:
  - Not actually filled out the check boxes, nor the required information provided in the sheet
    - Material dimensions and angles of FH, MH, MHB not actually shown
    - Cut-outs larger than 60 mm² not shown
    - Positioning of TSAC/TS not clearly shown **in all required views (ISO, side, top)**
  - Values of 'YourMaterialX' inner/outer skin and core thickness not in accordance with the value entered in the 3-point-bending test and/or skin shear test

- The colours given in the chart were not applied in the required different views of the chassis (please do not choose your own)
- A different format for showing the laminated structures was used, please keep to the given format (!), **BUT feedback welcome** (see example next slide)



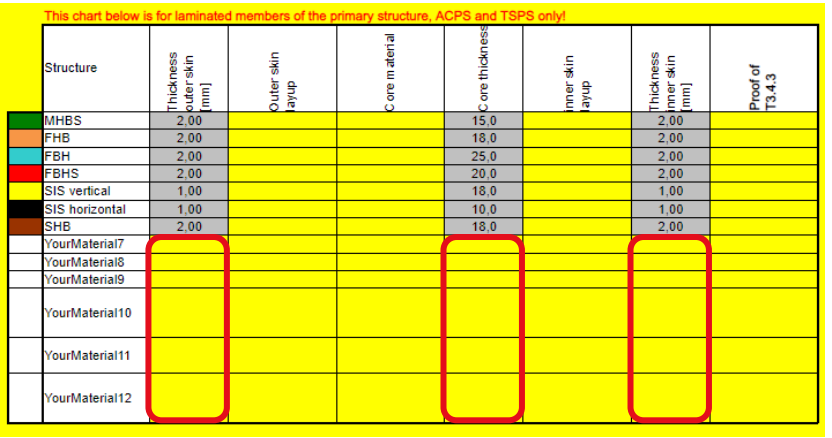
2023 FS STRUCTURAL EQUIVALENCY SPREADSHEET (SES) V0.9 - CHASSIS PICTURES

University Name _____ Car No.(s) & Event(s) _____

Please attach pictures of the frame and/or monocoque in the table below for review during the SES process. **All tubes/lay-ups must be colour coded to show outer diameter and wall thickness**. Three view drawings and isometric views of the structure (CAD, FEA models, etc) are acceptable. **Note: Identical composite layups need the identical colour code beyond borders of their specific lamiante structure! Maybe you need to work with two picture sets (Structures & your design)**

Images must include dimensions/labels indicating the following:	Compliance shown?
Angle of main and front hoops, including angle of main hoop below upper side impact tube.	No
Angle between main hoop bracing and main hoop	No
Distance from top of main hoop to main hoop brace attachment	No
Distance from top of front hoop to front hoop brace attachment	No
Outer diameter and wall thickness of all tubes / monocoque lay-up	No
Compliance to T 7.3.1 - Protection of lubrication systems	No
Teams entering cars with IC Powertrains must show the location of the fuel tank and complete filler neck inside rollover protection structure (CV2.2.2) in all images and highlight them in the colour red.	No
Teams entering cars with EV Powertrains must show the location of all HV components in these images and highlight them by colouring them orange.	No
Teams with breakthroughs/cutouts/holes in the laminated primary structure greater 60 mm² must show their location in these images and highlight them by colouring them purple. These breakthroughs/cutouts/holes must also be shown in the SE3D-file.	No

Seite 1



This chart below is for laminated members of the primary structure, ACPS and TSPS only!

Structure	Thickness outer skin [mm]	Outer skin layup	Core material	Core thickness	Inner skin layup	Thickness inner skin [mm]	Proof of T3.4.3
MHBS	2,00			15,0		2,00	
FHB	2,00			18,0		2,00	
FBH	2,00			25,0		2,00	
FBHS	2,00			20,0		2,00	
SIS vertical	1,00			18,0		1,00	
SIS horizontal	1,00			10,0		1,00	
SHB	2,00			18,0		2,00	
YourMaterial7							
YourMaterial8							
YourMaterial9							
YourMaterial10							
YourMaterial11							
YourMaterial12							

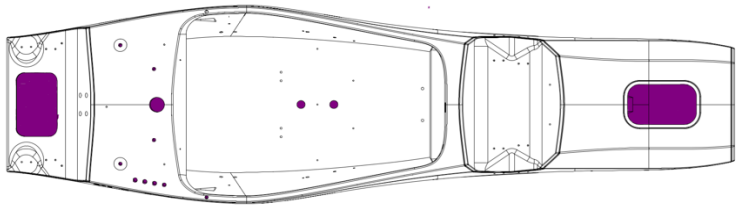
- Printed out version of SES available: if you have suggestions how to format this chart, feel free to comment!

Chassis Pics

- For a reviewer one of the most important TABs:
  - Quick overview
  - If well structured, can make the review much quicker!
  - Other TABs effectively a repetition/detailed info of what is presented here!
  - Skin thickness of >1mm in combination with certain prepregs/fibers gives reviewer assurance. Skin thickness <0.7mm will trigger reviewer to look more closely.

Plybook **Composite 1** (SIS vertical)

Ply Nr.	Material	Direction
1	SIGRAPREG® C W200-TW2/2-E323/45%	45/-45 deg
2	SIGRAPREG® C U255-0/NF-E310/30%	0 deg
3	SIGRAPREG® C U255-0/NF-E310/30%	0 deg
4	SIGRAPREG® C U120-0/NF-E704/35%	90 deg
5	SIGRAPREG® C W200-TW2/2-E323/45%	45/-45 deg
Symmetry	EN AW-5052 Honeycomb	
6	SIGRAPREG® C W200-TW2/2-E323/45%	45/-45 deg
7	SIGRAPREG® C U120-0/NF-E704/35%	90 deg
8	SIGRAPREG® C U255-0/NF-E310/30%	0 deg
9	SIGRAPREG® C U255-0/NF-E310/30%	0 deg
10	SIGRAPREG® C W200-TW2/2-E323/45%	45/-45 deg



Area	FBH	FBHS	FHB	Global	SIS	SIS Floor	TSPS	ACPS rear RI	SHB
	FBH	R_5.3	R_5.3		R_3.2	R_3.2	R_3.2	R_2.2	SHB
Outer									
Thickness	2,78	1,34	1,34	0,69	1,25	1,25	1,25	1,34	1,85
	0/90								
	90°								
	90°								
	±45°								
	0°								
	0°								
	0/90°								0/90°
	0°	0/90°	0/90°					0/90°	0°
	0°	0°	0°					0°	0°
	±45°	0/90°	0/90°		0/90°	0/90°	0/90°	0/90°	±45°
	90°	0°	0°		0°	0°	0°	0°	0°
	90°	0/90°	0/90°		0°	0°	0°	0/90°	0°
	0/90	0°	0°		±45°	±45°	±45°	0°	0/90°
	0°	0°	0°	0/90°	0°	0°	0°	0°	90°
	0°	±45°	±45°	±45°	90°	90°	90°	±45°	±45°
	±45°	±45°	±45°	±45°	±45°	±45°	±45°	±45°	±45°
e	10 mm	15 mm	15 mm	0/10 mm	20 mm	15 mm	20 mm	20 mm	20 mm
er	±45°	±45°	±45°	±45°	±45°	±45°	±45°	±45°	±45°
	0°	±45°	±45°	±45°	0°	0°	0°	±45°	0°
	0°	0°	0°	0/90°	±45°	±45°	±45°	0°	0°
	0/90°	0/90°	0/90°		0°	0°	0°	0/90°	0/90°
	90°	0°	0°		0/90°	0/90°	0/90°	0°	±45°
	90°	0/90°	0/90°					0/90°	0/90°
	±45°								0°
	0°								0°
	0°								0/90°
	0/90								
	0°								
	0°								
	±45°								
Thickness	2,27	0,97	0,97	0,69	0,97	0,97	0,97	0,97	1,75

Material Data

- Make sure the colors in the TAB Chassis Pics matches that with this chart
- Make sure to correctly reference the right material values (custom/'other X') to their respective TAB's Laminate Testing and Perimeter Shear Strength tabs
  - Can be directly cross-referenced, instead of manual value input
- Most front hoops currently use some aluminum, we tend to look more closely to your values here!
  - If FH is made of an alternative material, is welded and/or brackets are welded to the FH, teams must provide the values of the yield and ultimate strength in welded condition

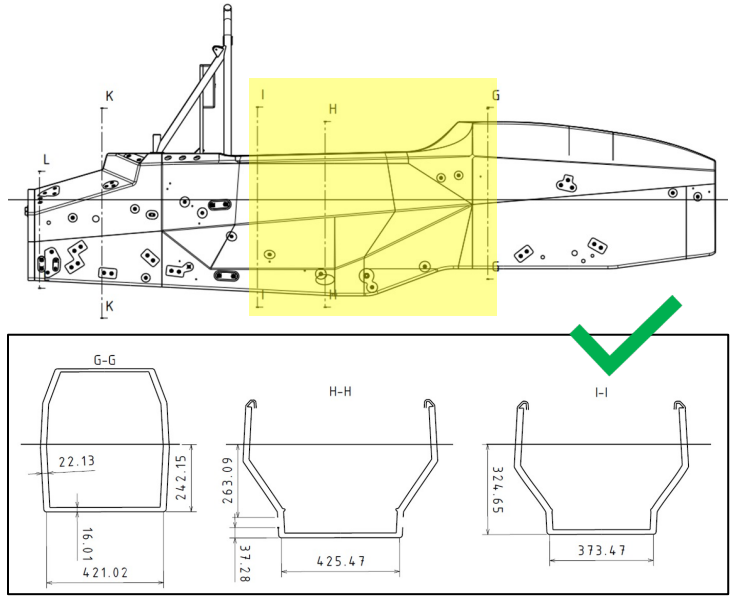
Material Data Sheet

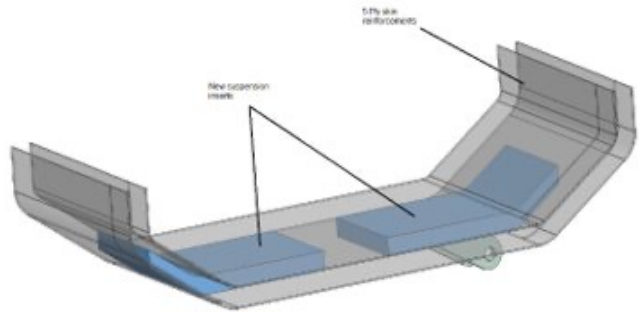
Material Spreadsheet Code	Steel	Aluminium 1	Aluminium 2	Composite 1	Other 1	Other 2	Other 3	Other 4	Other 5	Other 6
Material name	Steel	Aluminium 1	Aluminium 2	T3.5 Laminate	FBHS	FBH	SIS hor	MHBS	SHB	FHB
Colour in Chassis Pics										
Youngs Modulus, E	2.00E+11	7.00E+10	7.00E+10	0.00E+00	0.00E+00	0.00E+00	3.00E+00	4.00E+00	5.00E+00	6.00E+00
Yield strength, Pa	3.05E+08	1.00E+00	2.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E+00	4.00E+00	5.00E+00	6.00E+00
UTS, Pa	3.65E+08	1.00E+00	2.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E+00	4.00E+00	5.00E+00	6.00E+00
Yield strength, welded, Pa	1.80E+08	1.00E+00	2.00E+00	N/A	N/A	N/A	N/A	N/A	N/A	N/A
UTS welded, Pa	3.00E+08	1.00E+00	2.00E+00	N/A	N/A	N/A	N/A	N/A	N/A	N/A
UTS shear, Pa	2.19E+08	1.00E+00	2.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E+00	4.00E+00	5.00E+00	6.00E+00

- Steel properties based on baseline steel and are given in Rule T3.2.4 . All steels are treated equally and are to use the above properties.
- Results from extra physical test required by T3.5 should be entered in the "Other x" materials column as required.
- If you are using TAB "T3.5 Different Layups" to create different/multiple composite layups other than your SIS-Layup from TAB "T3.5 Laminate Test", you must fill out manually the columns at "Other X" in this Material Data Sheet TAB.

Trivial?

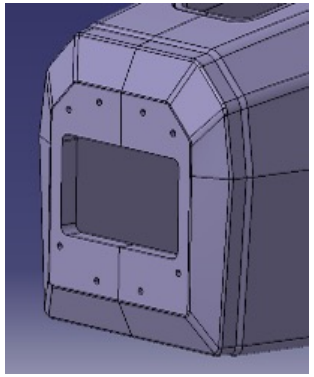
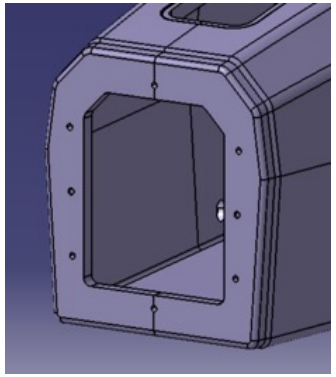
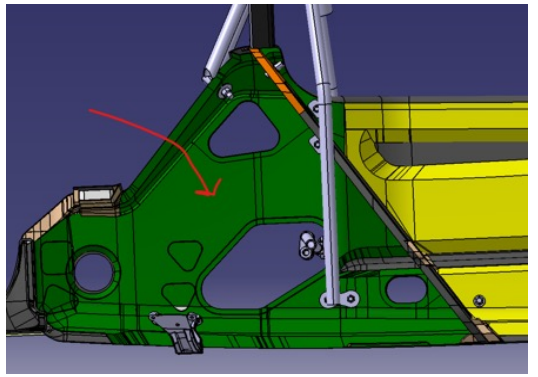
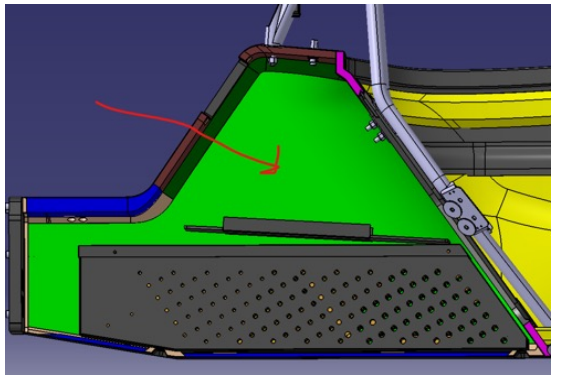
- Everything/every cell that is **YELLOW requires input**
- Everything/every **value** that you actively put in the SES/IAD, **needs a proof of measurement / calculation**
  - Preferably directly (structured) within the available space below and in the same TAB
- Every TAB that requires to report the '**minimal or most critical section**' needs proof that this is indeed the 'minimal or most critical section'
  - Include an image that illustrates this!
- The SES does (currently) not ask about insert design other than MH/MHB/FH/Accumulator/primary structures attachments
  - What about suspension? **Anything that impacts your effective panel height.**





Significant Changes

- A2.2 First year vehicle: significant changes in the chassis structure to its predecessor must be shown
  - Include images highlighting which structures are different, and tables in case of laminate changes
- Significant changes (**multiple!**) are e.g. material type (different lay-up), geometry (dimensions, shape, angles)
- The same mould (previous years) can be used, but new laminate structure (ply/core) is then required
- Changes to the MH and MHB do not fulfil the intent of the rule

T3.8 Main Hoop Tubing, T3.9 Front Hoop Tubing & T3.10 Main Hoop Bracing

- Rather straight forward:
  - Up to you to figure out which tubes are rules compliant and sufficient (T3.2 only provides a **minimum** dimension, irrespective of overall structure geometry)
  - Include image with dimensions of tube

T3.2 Minimum Material Requirements

T3.2.1 Table 4 shows the minimum requirements for the members of the primary structure if made from steel tubing.

Item or application	Minimum wall thickness	Minimum cross sectional area	Minimum area moment of inertia
Main and front hoops, shoulder harness mounting bar	2.0 mm	173 mm^2	11320 mm^4
Impact structures, front bulkhead, roll hoop bracing, driver's restraint harness attachment (except as noted above)	1.2 mm	119 mm^2	8509 mm^4
Front bulkhead support, main hoop bracing supports	1.2 mm	91 mm^2	6695 mm^4

Table 4: Minimum Material Requirements

Main Hoop Structural Equivalency - note, only steel may be used

Material Property	Baseline	Your Tube
Material type	Steel	Steel
Tube shape	Round	Round
Material name /grade	Steel	Steel
Youngs Modulus, E	2.00E+11	2.00E+11
Yield strength, Pa	3.05E+08	3.05E+08
UTS, Pa	3.65E+08	3.65E+08
Yield strength, welded, Pa	1.80E+08	1.80E+08
UTS welded, Pa	3.00E+08	3.00E+08
Tube OD, mm	25.4	25.4
Wall, mm	1.6	1.60

	Baseline	Your Tube	
OD, m	0.0254	0.0254	
Wall, m	0.0016	0.0016	
I, m^4	8.51E-09	8.51E-09	
EI	1.70E+03	1.70E+03	100.0
Area, mm^2	119.6	119.6	100.0
Yield tensile strength, N	3.65E+04	3.65E+04	100.0
UTS, N	4.37E+04	4.37E+04	100.0
Yield tensile strength, N as welded	2.15E+04	2.15E+04	100.0
UTS, N as welded	3.59E+04	3.59E+04	100.0
Max load at mid span to give UTS for 1m long tube, N	9.78E+02	9.78E+02	100.0
Max deflection at baseline load for 1m long tube, m	1.20E-02	1.20E-02	100.0
Energy absorbed up to UTS, J	5.86E+00	5.86E+00	100.0

T3.9 Front Hoop Tubing

- Front hoop: make sure the material data is correct, based on datasheets and/or physical test
- If you weld a FH:
  - you should apply a heat treatment, if it can be done **professionally** (certificate required)
  - If not, **physical testing required**, in 'normal' and 'as welded' condition
  - Explain your design!

Front Hoop Structural Equivalency

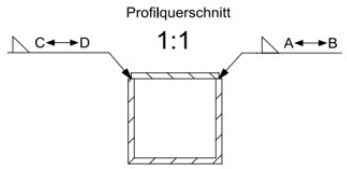
Material Property	Baseline	Your Tube
Material type	Steel	Aluminium 1
Tube shape	Round	Square
Material name /grade	Steel	Aluminium 1
Youngs Modulus, E	2.00E+11	7.00E+10
Yield strength, Pa	3.05E+08	2.40E+08
UTS, Pa	3.65E+08	2.75E+08
Yield strength, welded, Pa	1.80E+08	2.40E+08
UTS welded, Pa	3.00E+08	2.75E+08

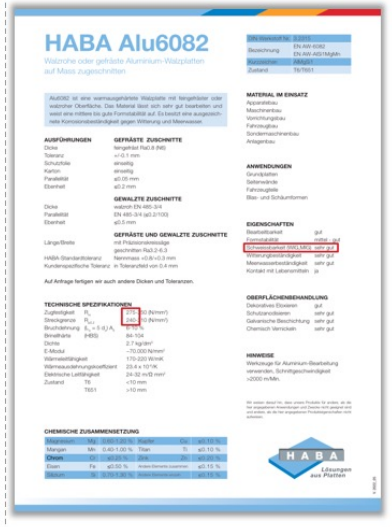
Tube OD, mm	25.4	31.4
Wall, mm	2.4	2

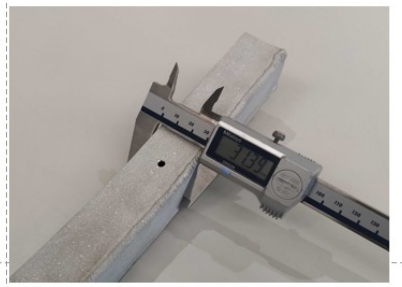
	Baseline	Your Tube	
OD, m	0.0254	0.0314	
Wall, m	0.0024	0.002	
I, m^4	1.1593E-08	3.404E-08	
EI	2.32E+03	2.38E+03	102.8
Area, mm^2	173.4	235.2	NA
Yield tensile strength, N	5.29E+04	5.64E+04	106.7
UTS, N	6.33E+04	6.47E+04	102.2
Yield tensile strength, N as welded	3.12E+04	5.64E+04	180.8
UTS, N as welded	5.20E+04	6.47E+04	124.3
Max load at mid span to give UTS for 1m long tube, N	1.33E+03	2.38E+03	178.9
Max deflection at baseline load for 1m long tube, m	1.20E-02	1.17E-02	97.3
Energy absorbed up to UTS, J	7.98E+00	2.49E+01	311.6

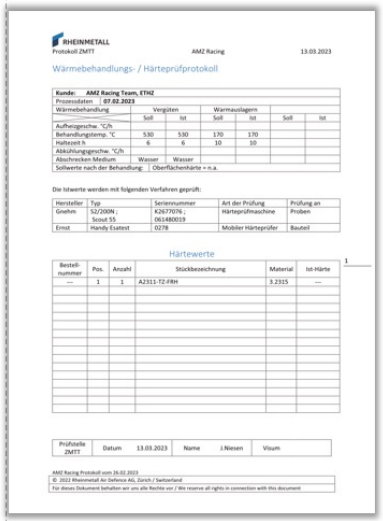
BACK to COVER SHEET

The FRH is made from a machined "U" section and a flat cover as shown on the drawing. The two parts are welded to each other. Material is aluminium EN AW-6082, which has a "very good" weldability according to the provided data sheet.
After welding, the FRH was heat treated (T6) to restore the material properties lost by the welding process. Documentation of the heat treatment is attached.
The welds have not been grinded down or otherwise mechanically altered as specified in T 3.2.7, the surface of the whole FRH has been sand blasted though in order to improve the bonding.



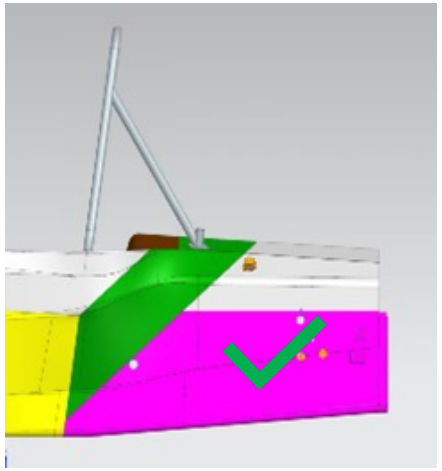


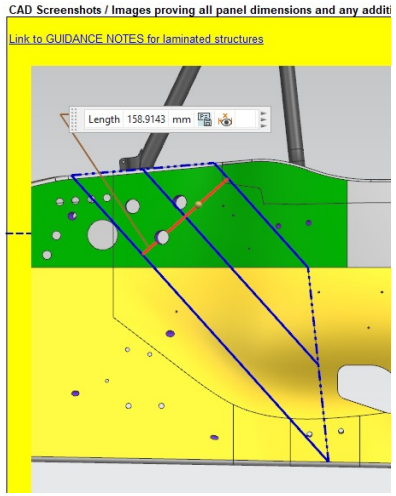




T3.10.5 T3.5 MHoop Brace Spt

- New rule T3.5.4 - not quasi-isotropic laminates, **oriented accordingly**
- We look for: clear measurements, subtracting holes, are larger hole edges laminated, is (in top view) the MHB attached to the laminate on a stiff edge/corner?
- In case of proof of equivalence: is the **structure geometrically stiff**, **load path reasonable**?
- Guidance notes!



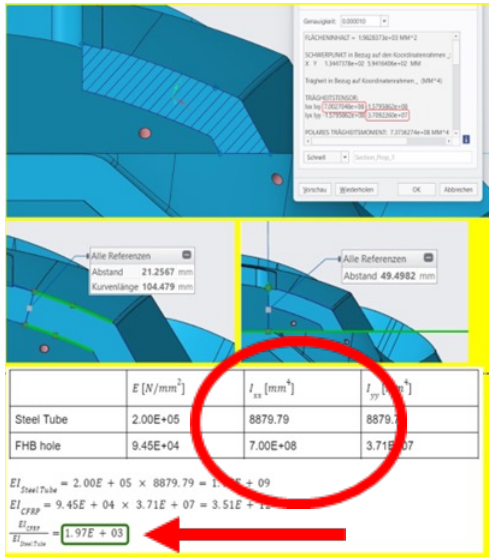


Main Hoop Bracing Supports

		Enter construction type	Composite only	
Material Property	**Baseline**	**Your Tube**	**Your Composite**	**Your Total**	
Material type	Steel	Steel	Other 4		
Tubing Type	Round	Round	NA		
Material name /grade	Steel	Steel	MHBS		
Youngs Modulus, E	2.00E+11	2.00E+11	1.13E+11		
Yield strength, Pa	3.05E+08	3.05E+08	3.03E+08		
UTS, Pa	3.65E+08	3.65E+08	3.03E+08		
Yield strength, welded, Pa	1.80E+08	1.80E+08	N/A		
UTS welded, Pa	3.00E+08	3.00E+08	N/A		
Number of tubes	2	2			
Tube OD, mm	25.4	25.4			
Wall, mm	1.20	1.2			
Thickness of panel, mm			21.41		
Thickness of core, mm			20		
Thickness of inner skin, mm			0.68		
Thickness of outer skin, mm			0.73		
Panel height,mm			158.9		
OD, m	0.0254	No tubes			
Wall, m	0.0012				
I, m^4	6.70E-09		2.40E-08	2.40E-08	
EI	2.68E+03		2.71E+03	2.71E+03	101.1
Area, mm^2	182.5		224.0	224.0	NA
Yield tensile strength, N	5.57E+04		6.79E+04	6.79E+04	122.1
UTS, N	6.66E+04		6.79E+04	6.79E+04	102.0
Yield tensile strength, N as welded	3.28E+04		6.79E+04	6.79E+04	206.9
UTS, N as welded	5.47E+04		6.79E+04	6.79E+04	124.1
Max load at mid span to give UTS for 1m long tube, N	1.54E+03		2.72E+03	2.72E+03	176.6
Max deflection at baseline load for 1m long tube, m	1.20E-02		1.18E-02	1.18E-02	98.9
Energy absorbed up to UTS, J	9.22E+00		2.84E+01	2.84E+01	308.4

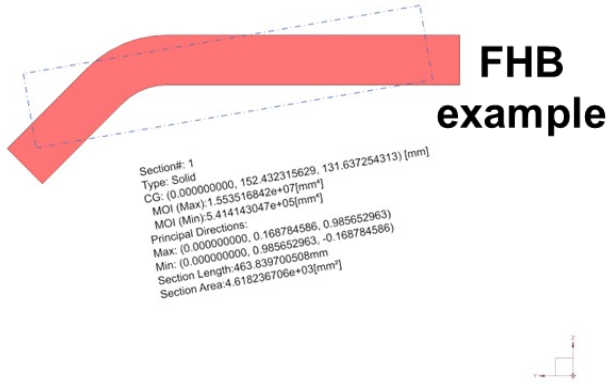
General: How-to EI calculation

- Based on T3.4.1 you may calculate the actual flexural rigidity (EI) of the structure for some areas in the chassis within your SES
- But it is not intended to calculate the EI of the entire cross-sectional area incl. core, but from the skin layers!
- Indication for wrong calculation (besides 10x higher EI, than flat panel calculation) is also the big section area used for your UTS calculation

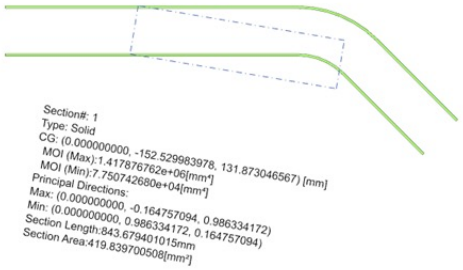


Safety factor EI 1,97 E+3

How **not to** do it



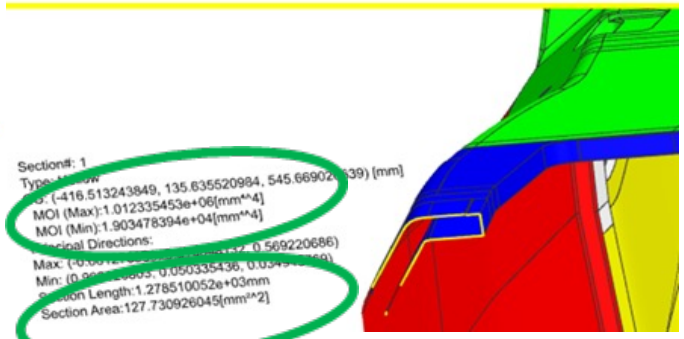
How **to** do it



$I_{CFK} * E_{skin.modulus} \geq I_{Steel} * E_{Steel}$

$19034.8\ mm^4 * 111.0\ GPa \geq 8509\ mm^4 * 20[illegible]\ GPa$

$2112.[illegible]\ kNmm^2 \geq 1701.8\ kNmm^2$

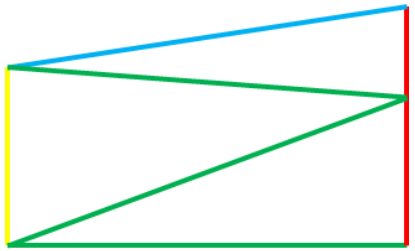


Safety factor EI 1,24

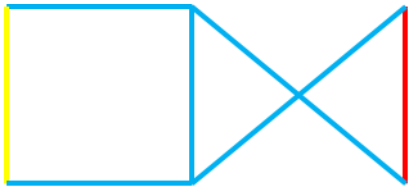
T3.11 T3.5 FHoop Bracing & T3.14 T3.5 FBH Spt. Structure

- We look for:
  - proper loadpath, not only in side view, but also in top view, triangulation
  - FHBS with 'damper cut-out' with depth (z-direction) > 50 mm should have at least an angle of 30 degrees to the connection areas
    - 'Damper cut-out' is always reviewed more closely, prevent another review by already performing additional calculations in advance
  - Alternative calculation allowed!

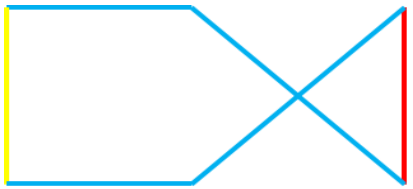
Side view

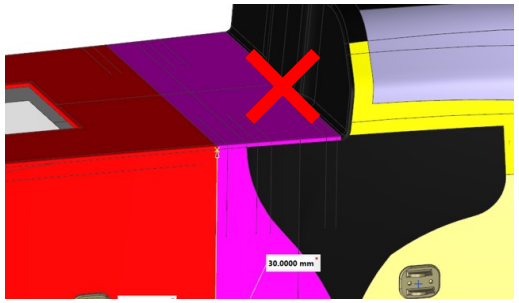


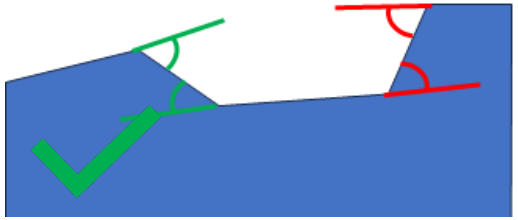
FHB top view OK

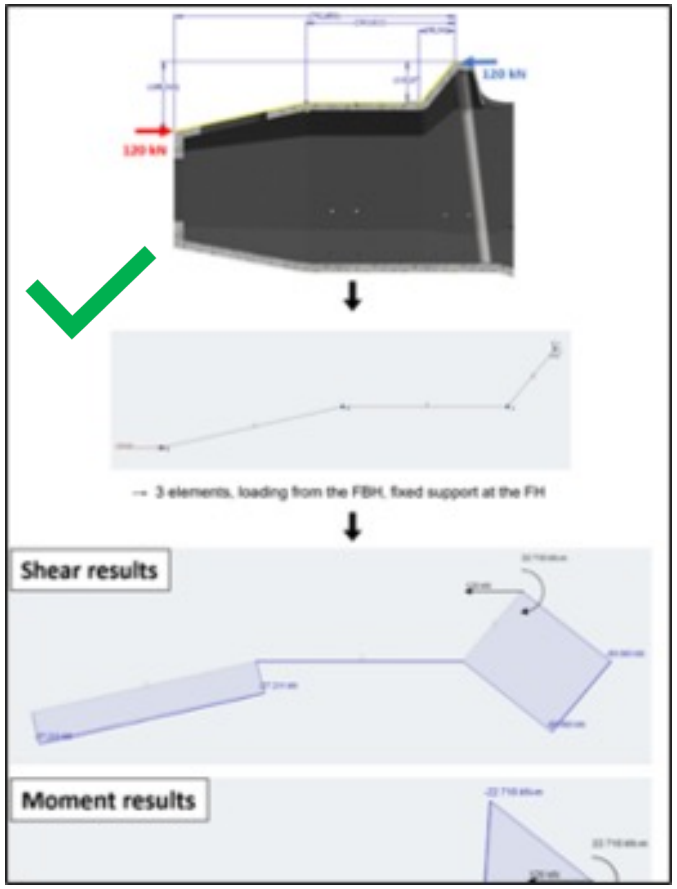


FHB top view NOK







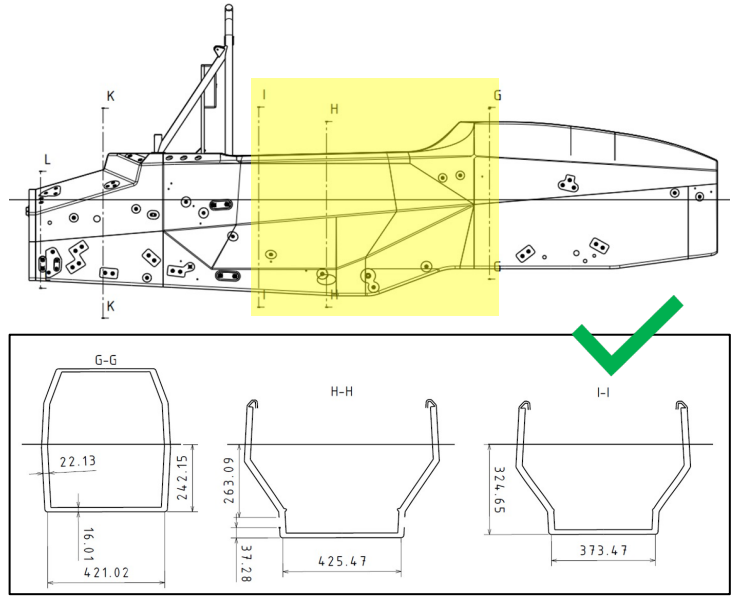


T3.13. T3.5 Ft Bulkhead

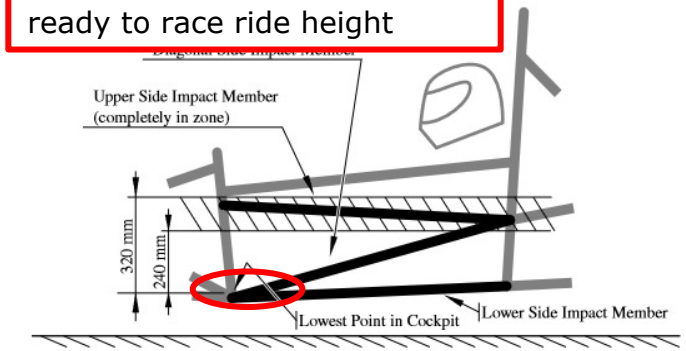
- If the core thickness is reduced towards the cutout edges, the FBH structure has no uniform stiffness
  - Effective 'cut-out' dimensions must meet the area where the actually installed laminate has the same structure as the tested laminate
  - Take into account manufacturing difficulties (e.g. core indentation)
- T1.1.5 - in front view, the front bulkhead (together with the AIP) must cover the driver's feet
- **Problems often only noticed at the event's technical inspection**
- IN 5.1.1: bring the representative bulkhead/test fixture of the IA test
  - Common issue: not the same attachments as reported!

T3.15 T3.5 SIS

- Monocoque
  - Equivalent proof using the Flexural Rigidity **NOT** allowed in the SIS! (T3.4.1)
  - Account for holes (TS, cooling, draining)
  - Consider the whole structure:
    - Chassis is as strong as its weakest point
- Tubular frames:
  - Ensure proper connection to hoops, e.g. T3.14.1
  - Check ride height play in combination with upper member!
    - Common error: upper SIS too high with proper ride height (>30mm)

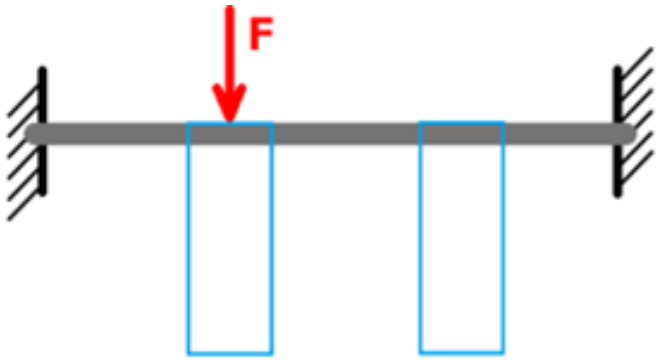


T3.15.2 must be satisfied with ready to race ride height



T4.5 Shoulder Harness Bar

- Last year more detailed calculations required, despite minimum requirements (T3.2):
  - These requirements do not consider overall geometry of the structure itself
  - Problem: **the minimum requirements are not sufficient for a typical shoulder harness span width**
  - Required solutions: larger OD tube, additional supports closer to load application (reduce SHB length)
- Assume: load applications >50 mm away from a node require additional calculations
- For harness attachments, there are additional requirements related to the chassis design (T4.5, T5.5.3)
- Dont 'optimize' by making the car smaller, the driver should still fit!
- Guidance notes!



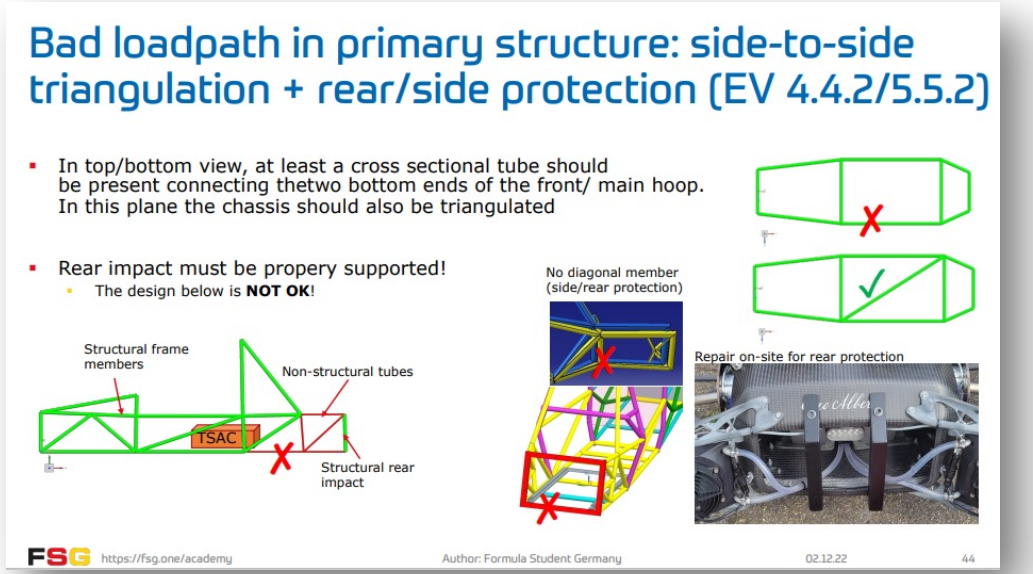
Beam stress scales with the area moment of inertia, increasing OD has more impact on stiffness than increasing wall thickness (decreasing ID)

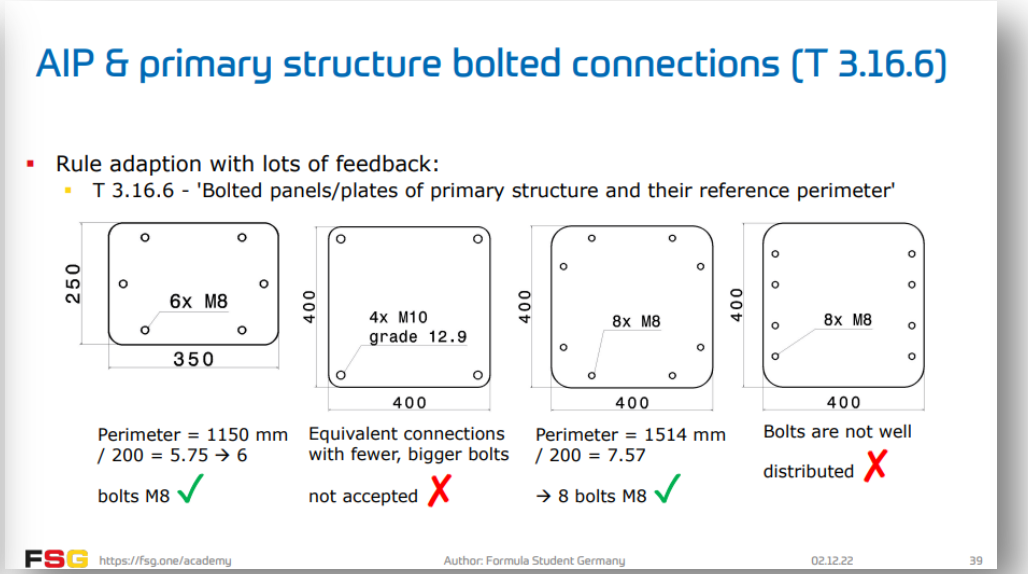
$$I = \frac{\pi(D^4 - d^4)}{64}$$

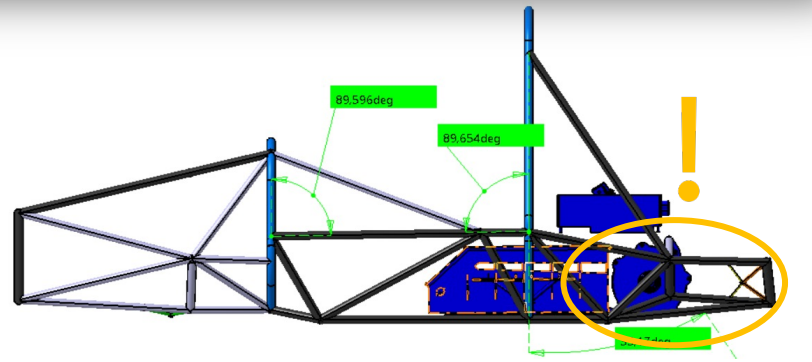
Item or application	Minimum wall thickness	Minimum cross sectional area	Minimum area moment of inertia
Main and front hoops, shoulder harness mounting bar	2.0 mm	173 mm^2	11320 mm^4

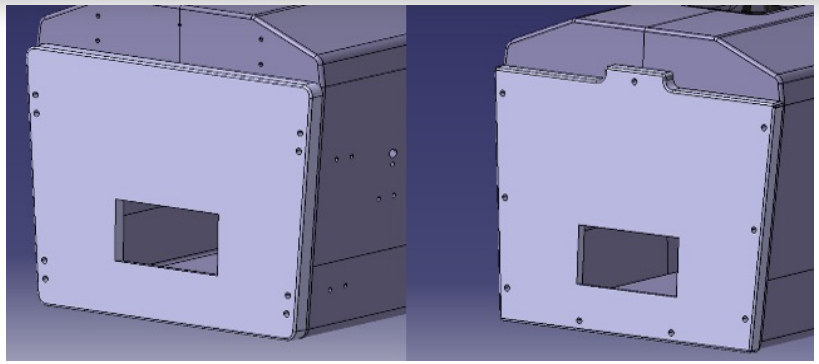
Outer diameter [mm]	Wall thickness [mm]	Inertia [mm^4]
25	2,5	11320
50	2,5	105507 (factor 9)
25	5	16689 (factor 1,5)

EV5.5.1, EV5.5.2, EV4.4 ACPS TSPS Side/Rear



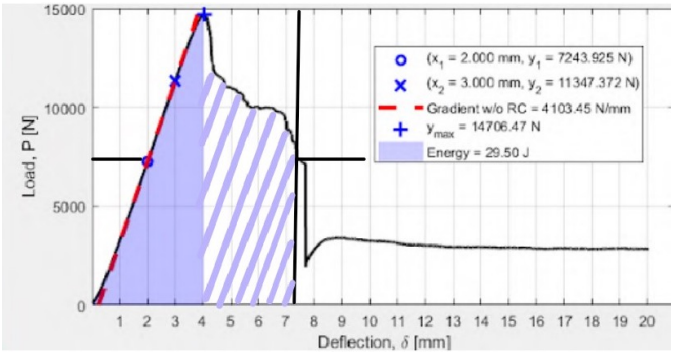


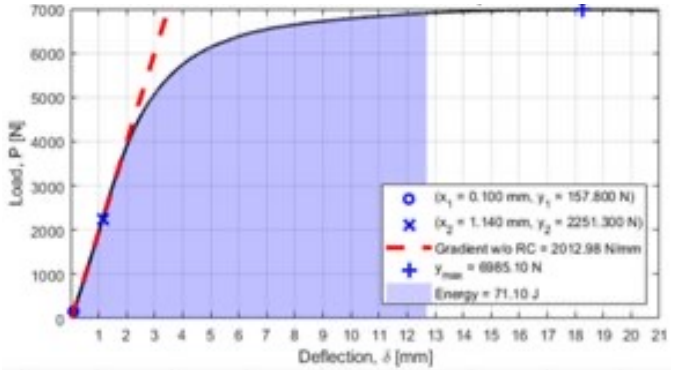


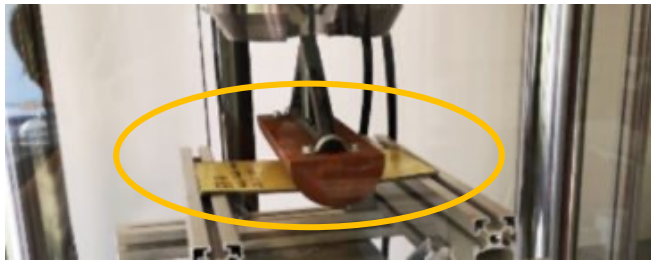


T3.5 Laminate Test – and all following

- Test rig compliance advice:
  - Material should be the baseline material (T3.2.4)
  - Material dimensions should be the same as mentioned in T3.2.1 for the related structure
  - For SIS: two baseline material tubes must be tested
- Energy absorbed for SIS must be at least 65 J
- Only alternative size for laminate panel allowed in TSAC: TABs EV5.5.4 Alt. Matl – 3pt Bending
- Proper documentation
  - Marked on laminate
  - Testing rig
  - All information the graph (which values used etc.)

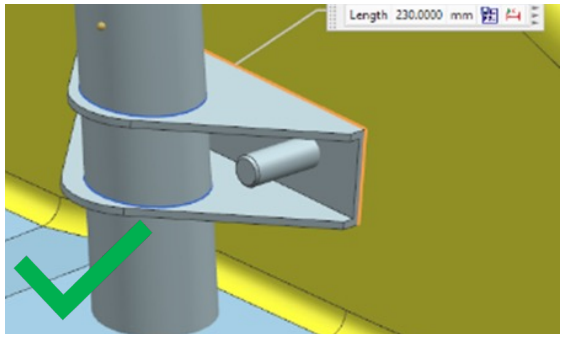


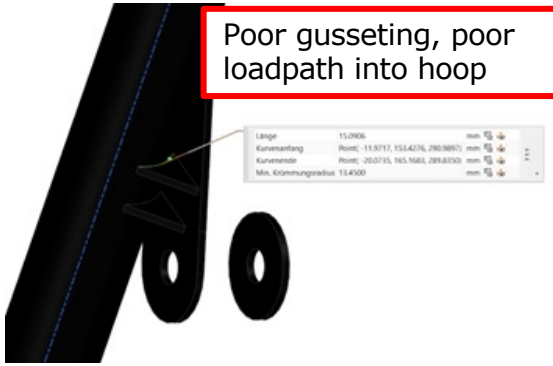




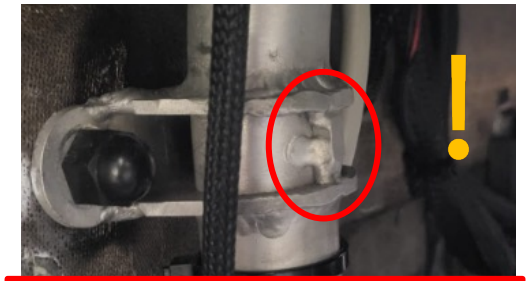
T3.16 MH & MH B'ing, FH & FH B'ing Attachments

- Bad design:
  - Allow local loading/deformation of the tube instead of loading entire tube section
  - Stress concentration on end points of the weld
  - Poor gusseting
- Good design:
  - Good load distribution to hoop, all around
  - Stress concentration captured by surrounding bracket & weld structure
  - Bracket is stiff at monocoque attachment point

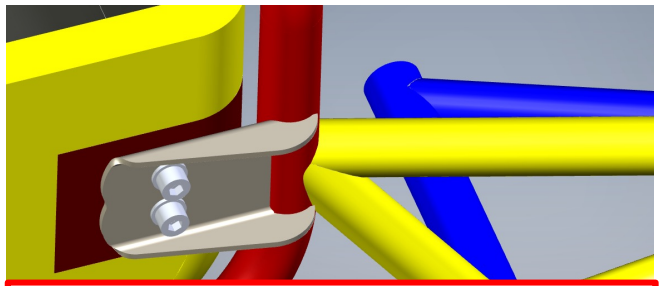




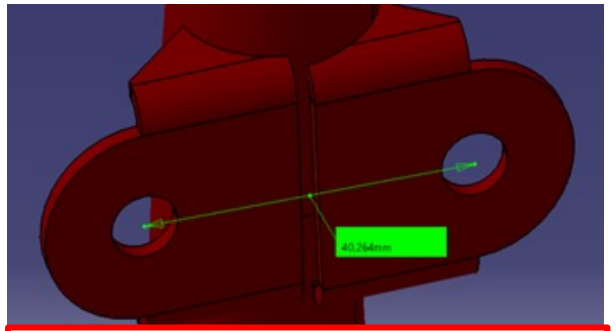
Poor gusseting, poor loadpath into hoop



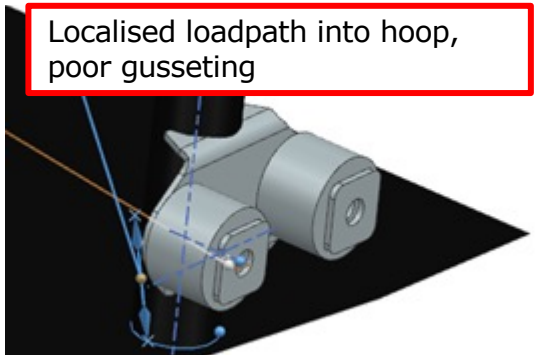
Local reinforcement (creative bookkeeping), last-minute solution. Ensure welding quality



Localised loadpath into hoop, weld attachment not stiff. All welds on single line, poor bending/torque resistance



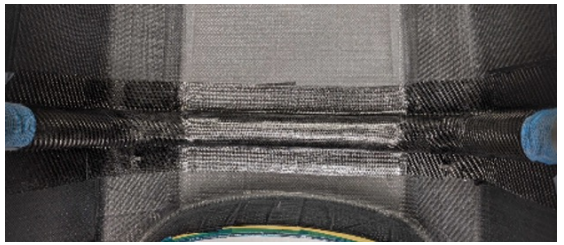
Localised loadpath into hoop, weld attachment not stiff, minimal gusseting



Localised loadpath into hoop, poor gusseting

T3.9.6 Laminated front hoop

- Consider **all three directions** load cases
- Ensure that production matches design
  - Document lamination (will be asked during review / inspection)
  - Are the dimensions matching?
- Ensure proper production
  - If made incorrectly, a laminated front hoop is a weakpoint instead of a strong point!
  - Ensure proper bonding to both monocoque skins
  - Proper finish on core material & tight fit



Not according T3.9.6, insufficient overlap, poor bonding

Outer skin not bonded to front hoop, creating a weakpoint!

T3.16 & T3.17.5 Primary Structure Attachments

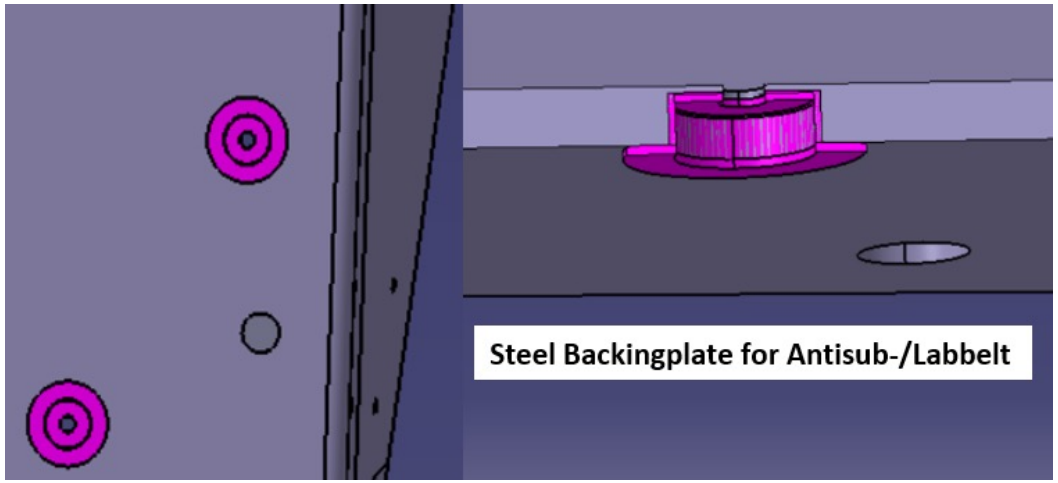
- Formula will be adjusted
- Guidance note will be created

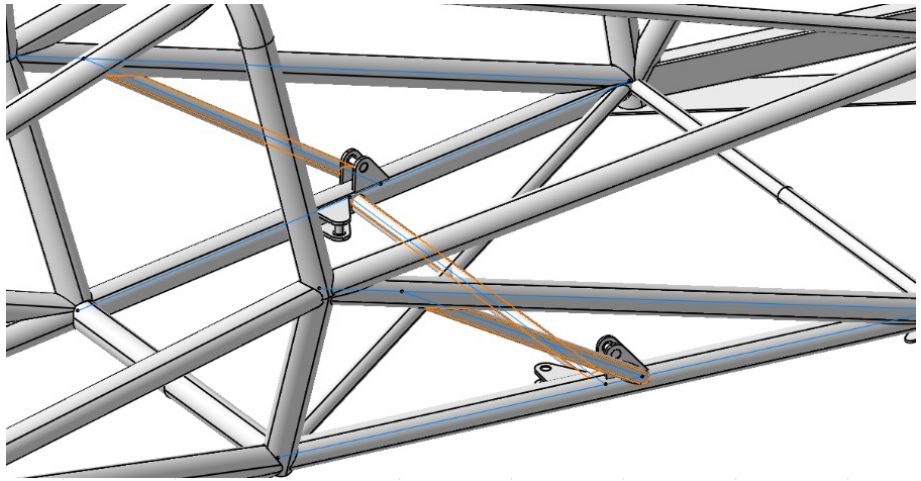
AIP to Bulkhead Attachment	N/A	
Perimeter, mm	1800	
Required No. of fasteners	9	
Fastener dia., mm	5,0	CHECK
No. of fasteners	10	CHECK
Max. Distance between bolt centres	242	FAIL
Check distribution of bolts and elaborate below.		
AIP Thickness, mm	1,5	
Washer/bolt perimeter, mm		
Skin thickness, mm	2	
Insert Perimeter, mm		
Skin thickness, mm	2	
Backing plate thickness, mm		FAIL
Backing plate perimeter, mm		
Edge distance, mm		
Skin shear strength, MPa	0	
Perimeter shear strength, kN	0	FAIL
Perimeter shear strength, kN	0	FAIL
Tearout strength, kN	0	FAIL
Insert images of each attachment point proving the remaining values entered above:		

OTHER Panel/Plate Attachment	FAIL	
Perimeter, mm	1400	
Required No. of fasteners	7	
Fastener dia., mm	8,0	PASS
No. of fasteners	7	PASS
Max. Distance between bolt centres	29	FAIL
Check distribution of bolts and elaborate below.		
Material 1		
Skin / Material type	Composite 1	
Skin / Material name	T3.5_Laminate	
Washer/backing plate perimeter, mm	200	
Washer/backing plate thickness, mm	2	PASS
Insert Perimeter, mm	200	
Edge distance, mm	60	
Skin thickness, mm	2	
Skin thickness, mm	2	
Skin shear strength, MPa	50	
Material 2		
Skin / Material type	Composite 1	
Skin / Material name	T3.5_Laminate	
Washer/backing plate perimeter, mm	200	
Washer/backing plate thickness, mm	2	PASS
Insert Perimeter, mm	200	
Edge distance, mm	60	
Skin thickness, mm	2	
Skin thickness, mm	2	
Skin shear strength, MPa	50	
Perimeter shear strength, kN	40	PASS

T4.5 Harness Attachments

- Common issues:
  - Not at stiff node, no support
  - Lowest chassis member: check for ride height
  - Calculations required for bracket as well (not just the beam to which it is attached, for monocoques physical test required)



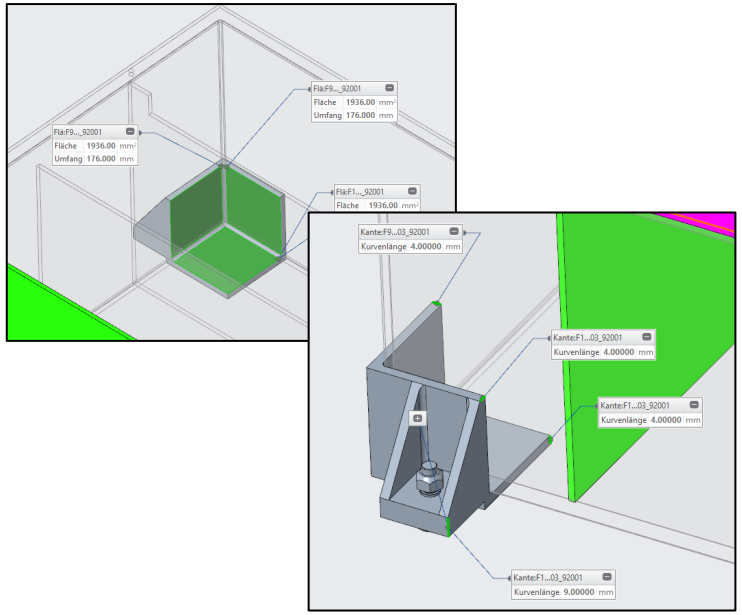


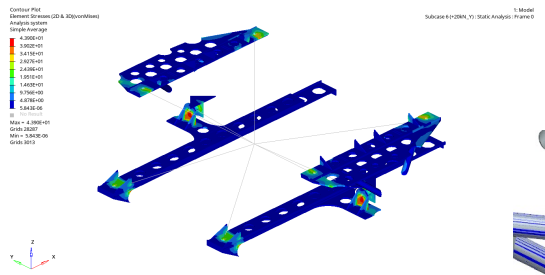
EV5 Accumulator Container, Acc. Stack Construction

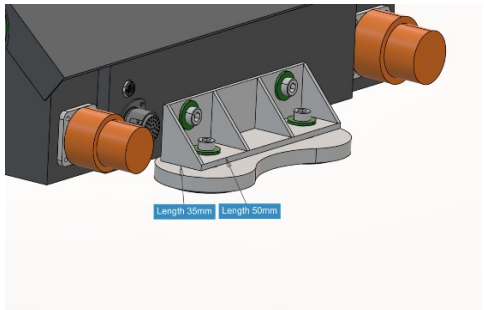
- **See Session Accumulator 16:00-17:00**, after 'Brezel Break'
- EV5.5 Tractive System Energy Storage – Mechanical Configuration
  - Several changes in the rules this year, please read them carefully, as they all are to be documented in the SES!
- Accumulator designs are tricky do document & check in SES
  - Make sure your design is clearly structured
  - Make sure the produced TSAC is the same as what was presented in the SES
  - Improper manufacturing or deviation from the design can be showstoppers! **TSAC's are difficult to adjust on site**

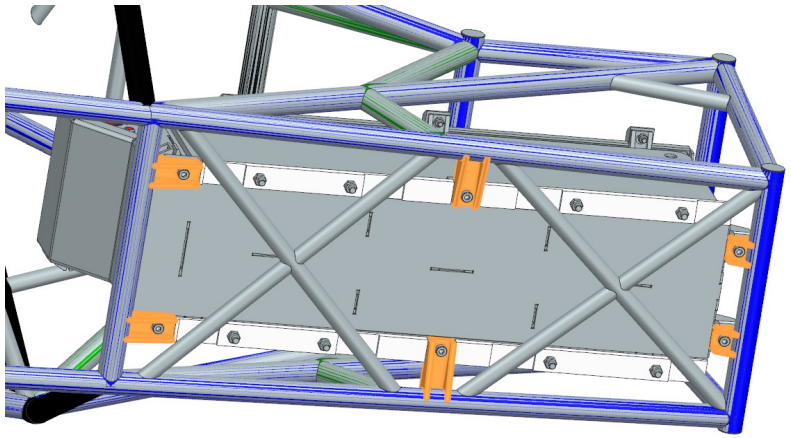
EV5.5. Acc. Attachments

- Complicated designs require complicated equivalency!
  - Keep it simple!
  - Hand calculations are preferred (but can be accompanied by FEM)
  - Make them as designed in SES





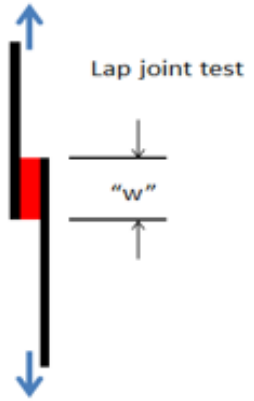




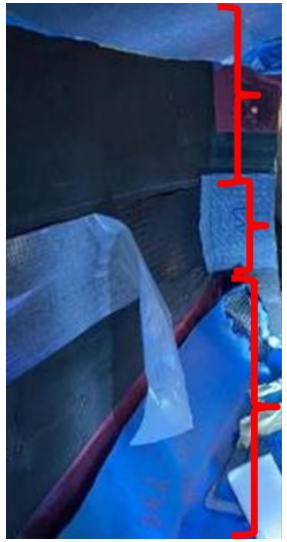
Monocoque Lap Joints

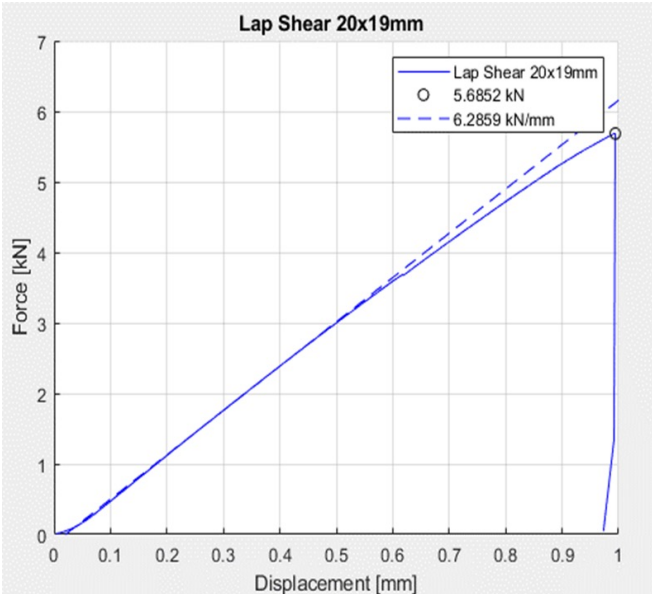
Monocoque Lap Joints

Joint Status	PASS
Single piece monocoque?	**No**
Test sample lap area, mm^2	660.0
Lap joint shear strength, MPa	22.28
Overlap length "w", mm	22
Load/unit length, N/mm	490.2
Skin UTS, MPa (from 3pt bend)	234
Skin thickness, mm	0.6
Load/unit length	133
Safety Factor	3.67



BACK to COVER SHE





- Pictures of all measurements (lap area, width and height)
- Pictures of the lap joint in the monocoque (when available, otherwise a sketch)
- Force-displacement curve

Welded Tube Inserts

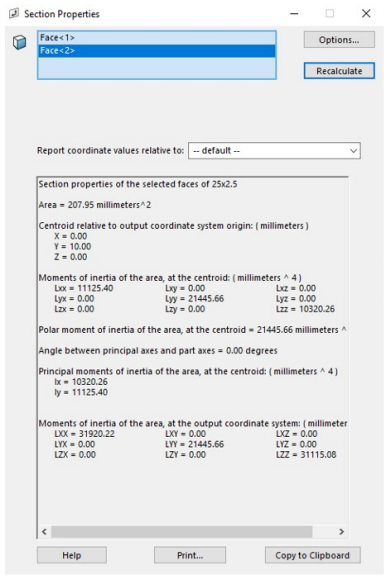
Welded Tube Insert Equivalency - required for all mandated tubes per T3.7.6 with drilled holes > 4mm dia.
If you have more than one type of insert please copy this tab

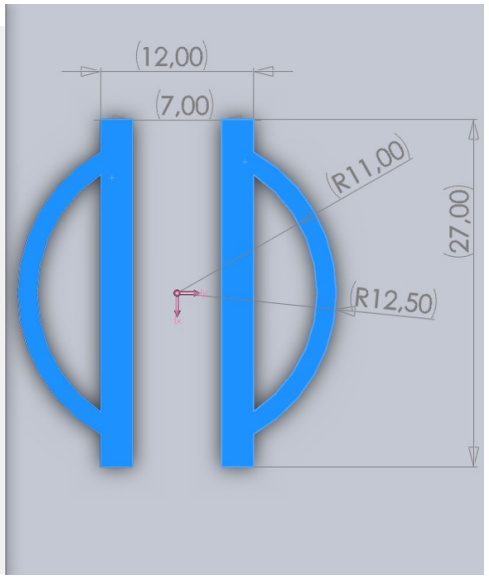
Material Property	Your Tube	Your Tube + Insert
Material type	Steel	Steel
Tube Shape	Round	N/A
Material name /grade	Steel	Steel
Youngs Modulus, E	2.00E+11	2.00E+11
Yield strength, Pa	3.05E+08	3.05E+08
UTS, Pa	3.65E+08	3.65E+08
Yield strength, welded, Pa	N/A	1.80E+08
UTS welded, Pa	N/A	3.00E+08

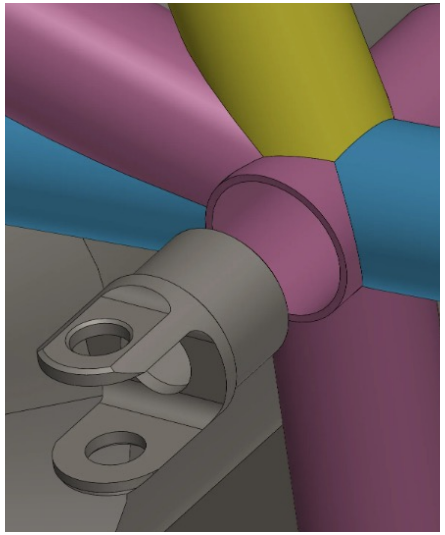
Tube OD, mm	25
Wall, mm	1.5

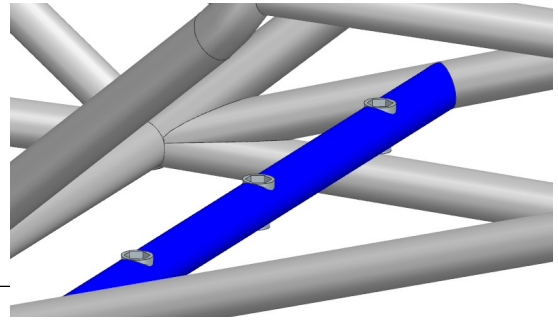
	Your Tube	Your Tube + Insert	
OD, m	0.025		
Wall, m	0.0015		
I, m^4	7.677E-09	1.03E-08	
EI	1.54E+03	2.06E+03	134.4
Tube area, mm^2	110.7	150.0	NA
Insert area, mm^2	NA	58.0	NA
Yield tensile strength, N	3.38E+04	5.62E+04	166.4
UTS, N	4.04E+04	7.22E+04	178.5
Max load at mid span to give UTS for 1m long tube, N	8.97E+02	1.21E+03	134.4
Max deflection at baseline load for 1m long tube, m	1.22E-02	9.05E-03	74.4
Energy absorbed up to UTS, J	5.45E+00	7.33E+00	134.4

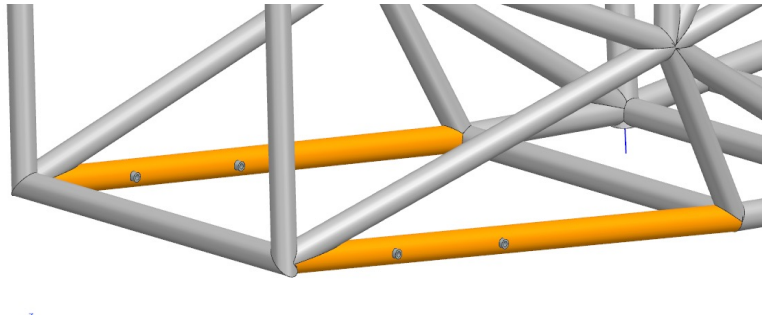
Note - the calculations above take account of the "as welded condition" strength reduction
Insert calculations or CAD screenshot proving tube + insert area and second moment of area below.



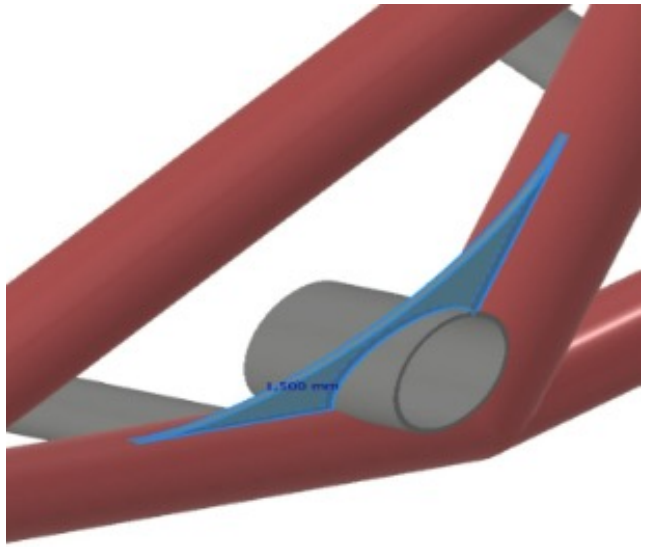


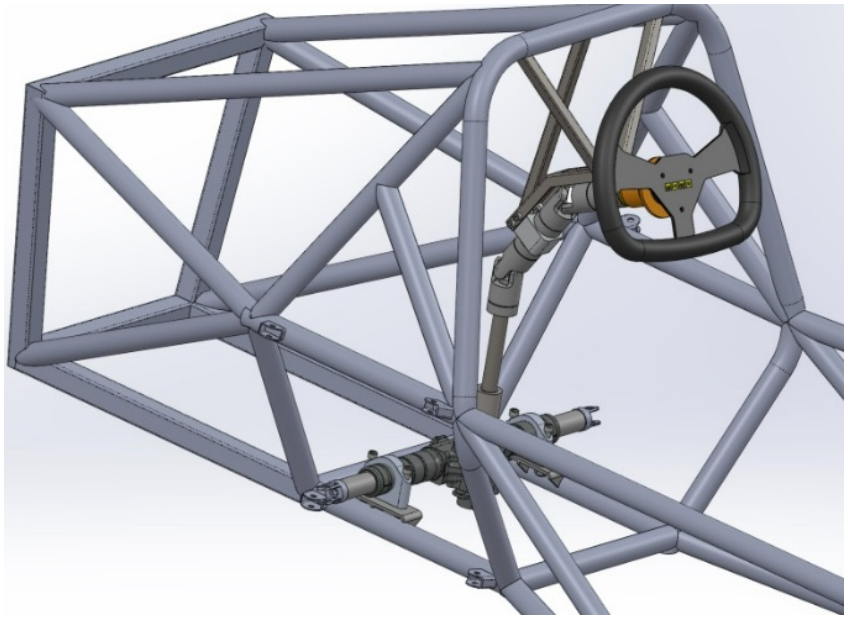


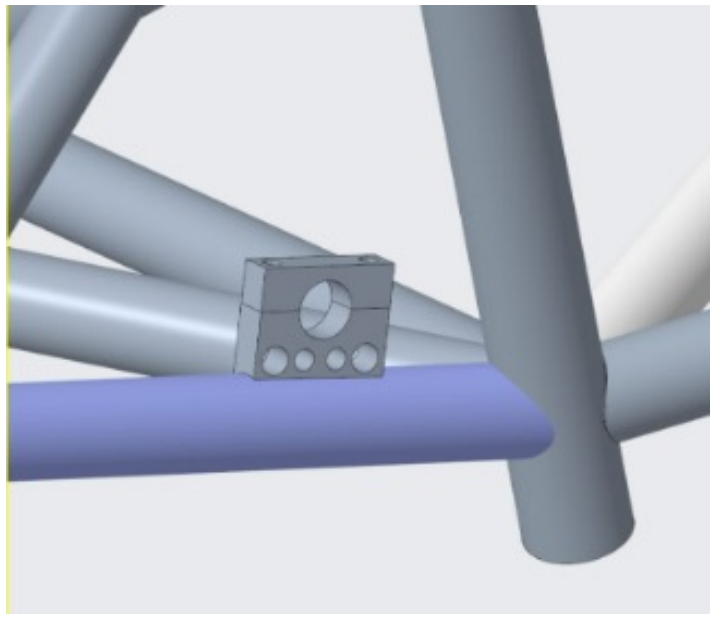




Steering Rack Collars







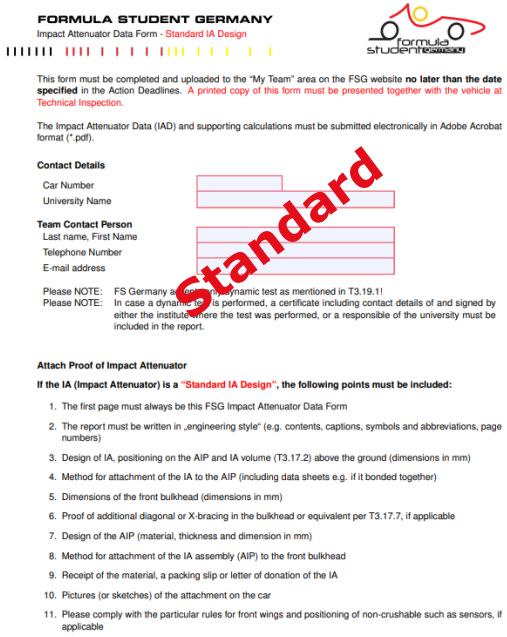
Successful IAD submission

FSG Academy – Main Workshop for FSG 2024
on 21st of October 2023 at Schaeffler in Herzogenaurach

Agenda

From 'front to back':

- IA
  - Standard / 'Own' Design
- IA to AIP Attachment
- AIP
- AIP to Front Bulkhead Attachment
- (Dynamic) Testing



FORMULA STUDENT GERMANY

Impact Attenuator Data Form - Standard IA Design

This form must be completed and uploaded to the "My Team" area on the FSG website **no later than the date specified** in the Action Deadlines. A printed copy of this form must be presented together with the vehicle at Technical Inspection.

The Impact Attenuator Data (IAD) and supporting calculations must be submitted electronically in Adobe Acrobat format (*.pdf).

Contact Details

Car Number
University Name

Team Contact Person

Last name, First Name
Telephone Number
E-mail address

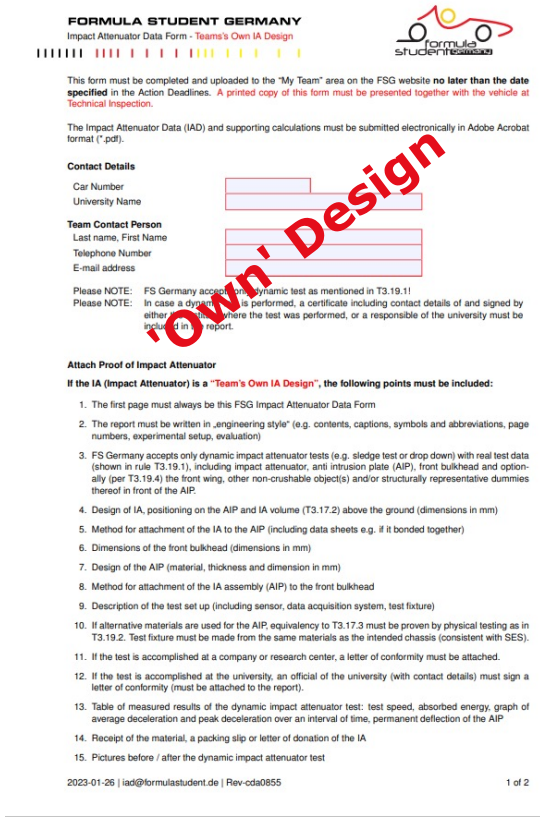
Please NOTE: FS Germany accepts only dynamic test as mentioned in T3.19.1!
Please NOTE: In case a dynamic test is performed, a certificate including contact details of and signed by either the institute where the test was performed, or a responsible of the university must be included in the report.

Attach Proof of Impact Attenuator

If the IA (Impact Attenuator) is a "Standard IA Design", the following points must be included:

1. The first page must always be this FSG Impact Attenuator Data Form
2. The report must be written in „engineering style" (e.g. contents, captions, symbols and abbreviations, page numbers)
3. Design of IA, positioning on the AIP and IA volume (T3.17.2) above the ground (dimensions in mm)
4. Method for attachment of the IA to the AIP (including data sheets e.g. if it bonded together)
5. Dimensions of the front bulkhead (dimensions in mm)
6. Proof of additional diagonal or X-bracing in the bulkhead or equivalent per T3.17.7, if applicable
7. Design of the AIP (material, thickness and dimension in mm)
8. Method for attachment of the IA assembly (AIP) to the front bulkhead
9. Receipt of the material, a packing slip or letter of donation of the IA
10. Pictures (or sketches) of the attachment on the car
11. Please comply with the particular rules for front wings and positioning of non-crushable such as sensors, if applicable

Standard



FORMULA STUDENT GERMANY

Impact Attenuator Data Form - Teams's Own IA Design

This form must be completed and uploaded to the "My Team" area on the FSG website **no later than the date specified** in the Action Deadlines. A printed copy of this form must be presented together with the vehicle at Technical Inspection.

The Impact Attenuator Data (IAD) and supporting calculations must be submitted electronically in Adobe Acrobat format (*.pdf).

Contact Details

Car Number
University Name

Team Contact Person

Last name, First Name
Telephone Number
E-mail address

Please NOTE: FS Germany accepts only dynamic test as mentioned in T3.19.1!
Please NOTE: In case a dynamic test is performed, a certificate including contact details of and signed by either the institute where the test was performed, or a responsible of the university must be included in the report.

Attach Proof of Impact Attenuator

If the IA (Impact Attenuator) is a "Team's Own IA Design", the following points must be included:

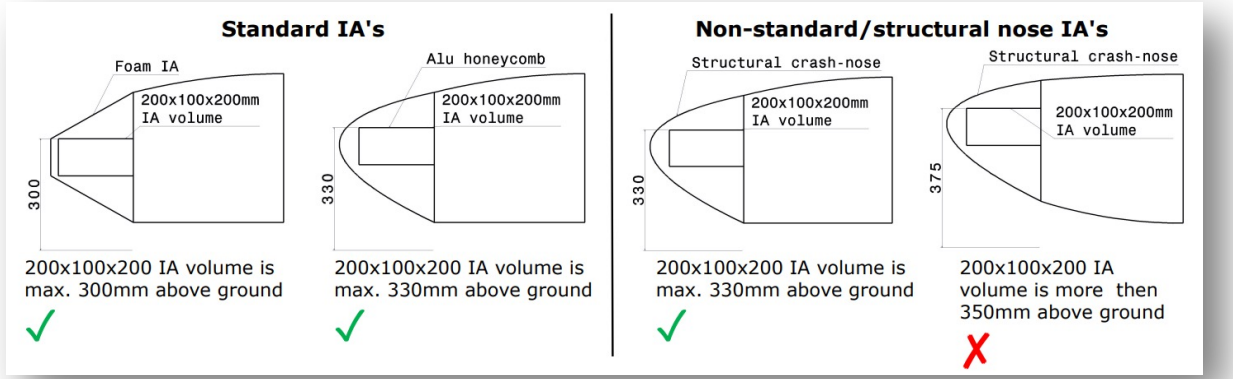
1. The first page must always be this FSG Impact Attenuator Data Form
2. The report must be written in „engineering style" (e.g. contents, captions, symbols and abbreviations, page numbers, experimental setup, evaluation)
3. FS Germany accepts only dynamic impact attenuator tests (e.g. sledge test or drop down) with real test data (shown in rule T3.19.1), including impact attenuator, anti intrusion plate (AIP), front bulkhead and optionally (per T3.19.4) the front wing, other non-crushable object(s) and/or structurally representative dummies thereof in front of the AIP.
4. Design of IA, positioning on the AIP and IA volume (T3.17.2) above the ground (dimensions in mm)
5. Method for attachment of the IA to the AIP (including data sheets e.g. if it bonded together)
6. Dimensions of the front bulkhead (dimensions in mm)
7. Design of the AIP (material, thickness and dimension in mm)
8. Method for attachment of the IA assembly (AIP) to the front bulkhead
9. Description of the test set up (including sensor, data acquisition system, test fixture)
10. If alternative materials are used for the AIP, equivalency to T3.17.3 must be proven by physical testing as in T3.19.2. Test fixture must be made from the same materials as the intended chassis (consistent with SES).
11. If the test is accomplished at a company or research center, a letter of conformity must be attached.
12. If the test is accomplished at the university, an official of the university (with contact details) must sign a letter of conformity (must be attached to the report).
13. Table of measured results of the dynamic impact attenuator test: test speed, absorbed energy, graph of average deceleration and peak deceleration over an interval of time, permanent deflection of the AIP
14. Receipt of the material, a packing slip or letter of donation of the IA
15. Pictures before / after the dynamic impact attenuator test

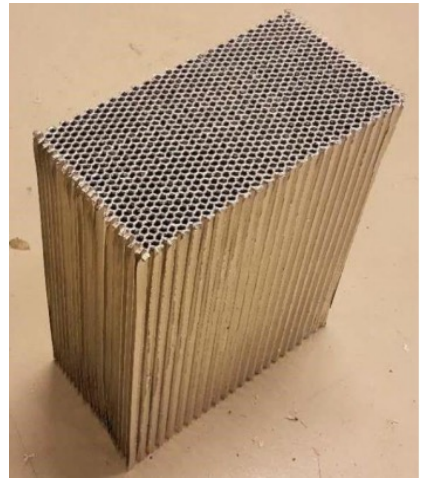
2023-01-26 | iad@formulastudent.de | Rev-cda0855 1 of 2

'Own' Design

Impact Attenuator (1/2)

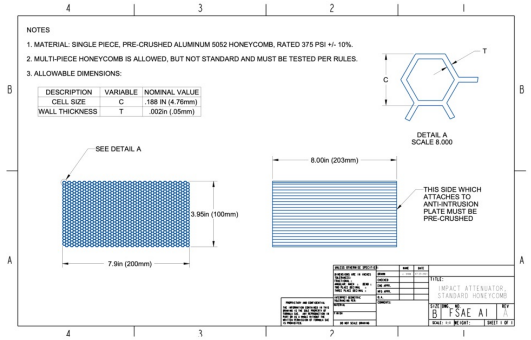
- General
  - recap of positioning of IA: 'for any portion of the required 100×200 ×200 mm³ volume' < 350 mm (T3.17.3)
  - 'in XY-plane'
  - closed front section
  - standard or own design? ➡ effort vs. gain
- Standard Design:
  - 200 x 100 x 200 mm
  - pre-crushed side to AIP
- 'Own' Design:
  - alternative AIP designs must have equivalence to T3.17.3 and be demonstrated by physical testing as in T3.19.2 'crash test'



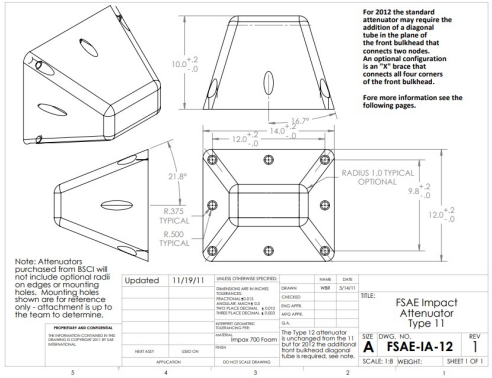


Impact Attenuator (2/2)

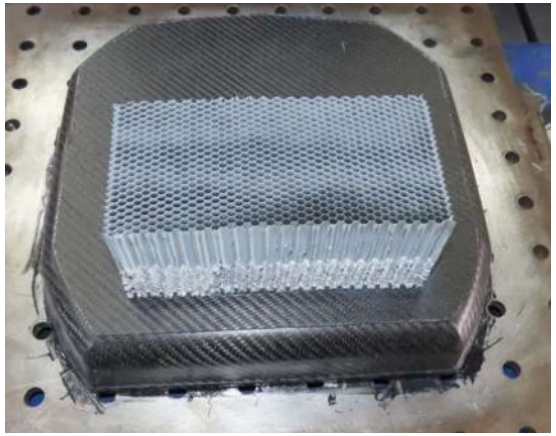
- Standard design:
  - Honeycomb

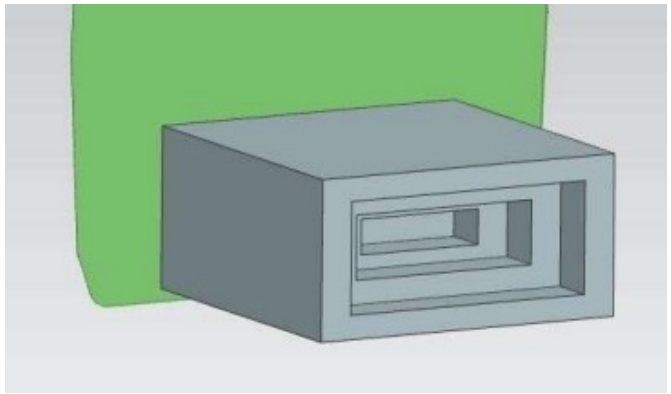


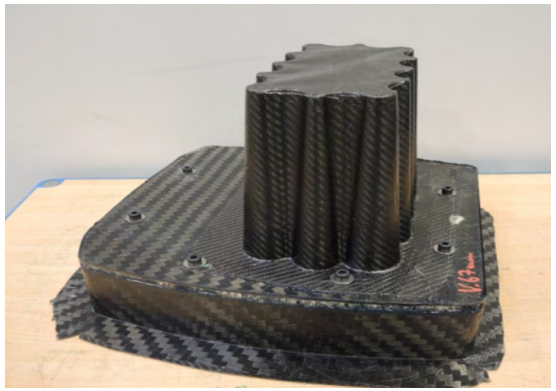
  - Foam



- Own design:

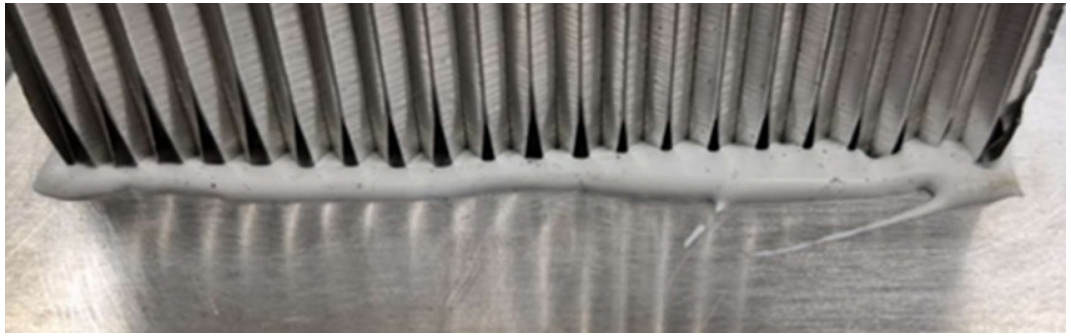






Attachment of IA to AIP (1/2)

- 4x 8mm grade 8.8 bolts **OR** adhesive attachment >60 kN in any direction (T3.17.5)
  - Note: due to T3.2.8, effectively 120 kN!
  - For standard designs: T3.17.7 - adhesive with min. shear strength 24 MPa (**calculation still required**)
    - Examples: Loctite EA9466, Loctite EA E 20HP,
    - 3M Scotch-Weld DP490, 3M Scotch-Weld EC9323 B/A
    - and many more...



Always use engineering judgement, e.g. is this adhesive suitable for CRFP's/aluminium etc.?

Advice: DP490 very good in combination with CFRP's

LOCTITE

Technical Data Sheet

LOCTITE® EA 9466™

Known as LOCTITE® Hysol® 9466™
August 2019

TYPICAL PROPERTIES OF CURED MATERIAL
Cured for 7 days @ 22 °C, 1.2 mm thick film

Physical Properties:

Glass Transition Temperature, ASTM E 1640, °C		62
Shore Hardness, ISO 868, Durometer D		60
Elongation, ISO 527-3, %		3
Tensile StrengthASTM D 882	N/mm²	32
	(psi)	(4,640)
Tensile Modulus, ISO 527-3	N/mm²	1,718
	(psi)	(249,110)

Electrical Properties:

Dielectric Breakdown Strength, IEC 60243-1, kV/mm	30

TYPICAL PERFORMANCE OF CURED MATERIAL

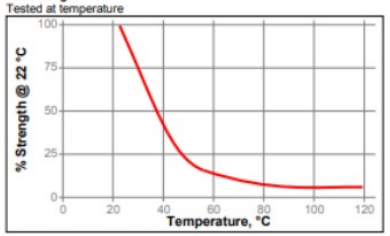
Adhesive Properties

Cured for 5 days @ 22 °C
Lap Shear Strength, ISO 4587:

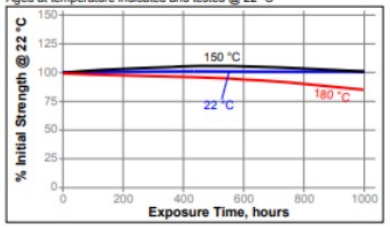
Steel (grit blasted)	N/mm²	37.0
	(psi)	(5,365)
Aluminum (abraded)	N/mm²	26.0
	(psi)	(3,770)
Aluminum (anodised)	N/mm²	17.9
	(psi)	(2,595)
Galvanized Steel (Hot Dipped)	N/mm²	8.5
	(psi)	(1,230)
Stainless steel	N/mm²	23.0
	(psi)	(3,335)
Polycarbonate	N/mm²	5.3
	(psi)	(765)
Nylon	N/mm²	1.6
	(psi)	(230)
Wood (Fir)	N/mm²	11.3
	(psi)	(1,635)

TYPICAL ENVIRONMENTAL RESISTANCE
Cured for 5 days @ 22 °C
Lap Shear Strength, ISO 4587:
Steel (grit blasted)

Hot Strength
Tested at temperature

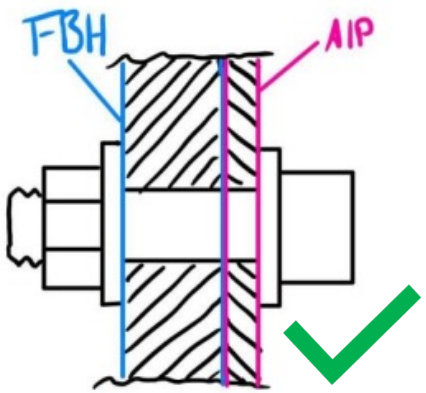


Heat Aging
Aged at temperature indicated and tested @ 22 °C

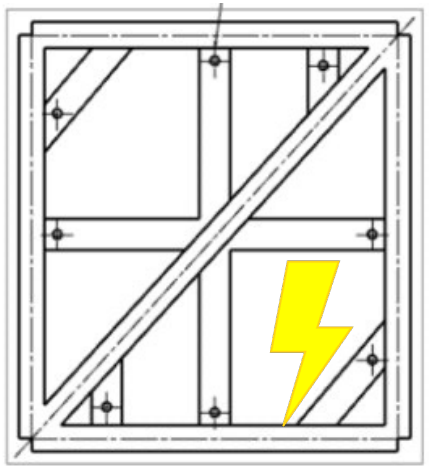


Attachment of IA to AIP (2/2)

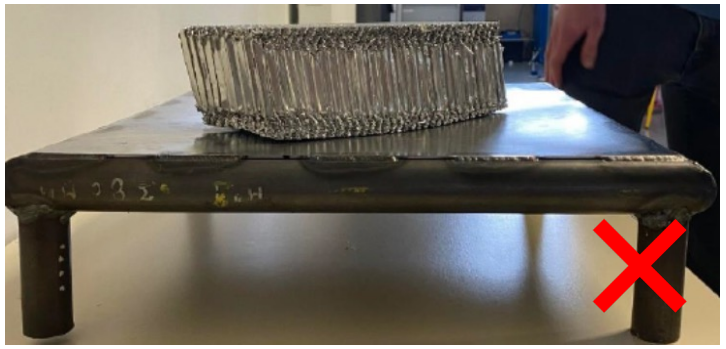
Good welding



Insert in FBH



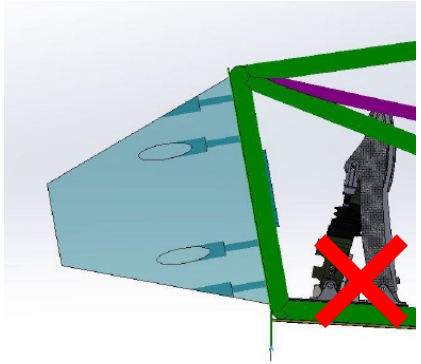
complex design of attachment points



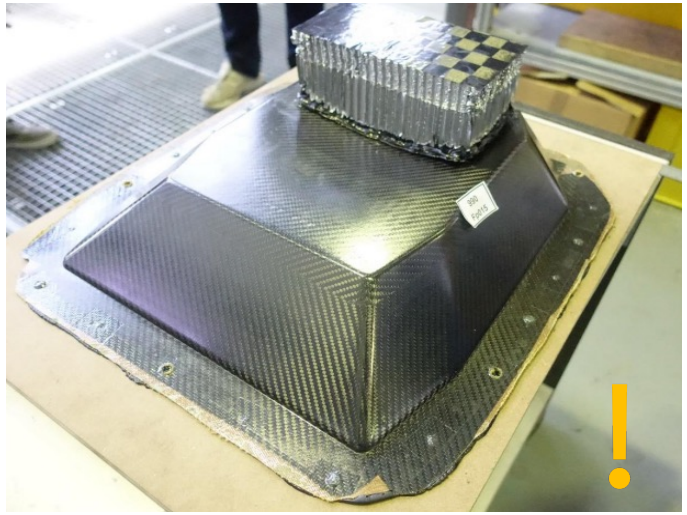
AIP arranged diagonally

Bad welding

Bad welding



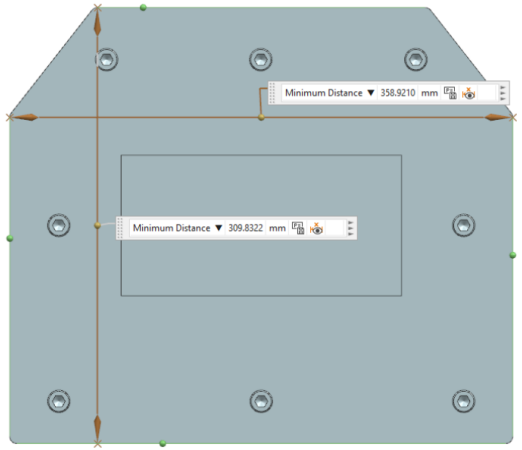
sloping AIP

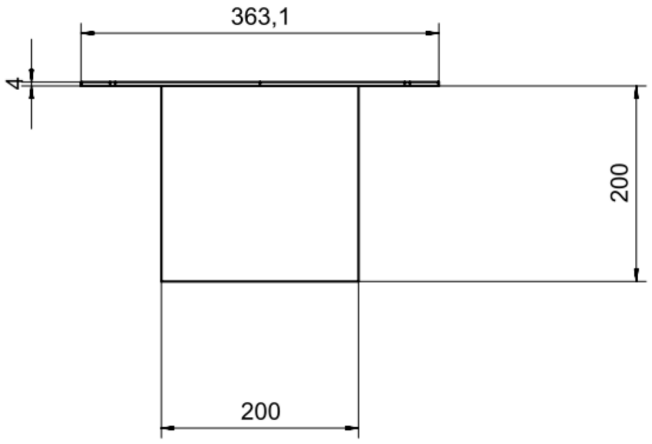


IA glued directly to FBH

AIP

- Standard:
  - 1.5 mm steel/4.0 mm aluminium
  - Show drawing with dimensions, thickness and material and distances of holes for screws





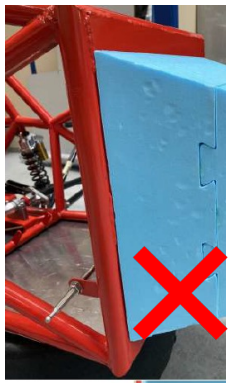
- 'Own' Design:
  - show materials, lay-up, joining methods, manufacturing method
  - present datasheets and receipts

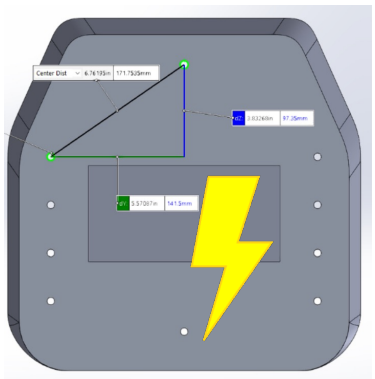
Layer Nr.	Orientation	Material
1	0°	
2	45°	
3	0°	
4	45°	
5	0°	
6	45°	

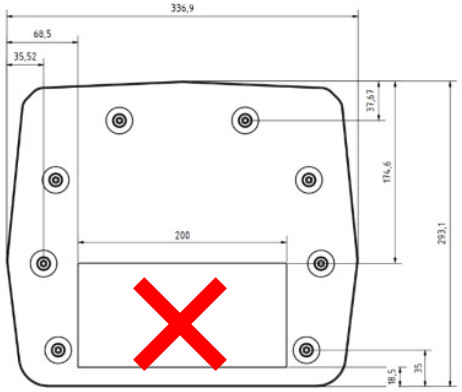
AIP to Front Bulkhead Attachment

- General: see T3.16.6

- Standard:
  - Welded 'in all directions', continuous welding
  - Bolted

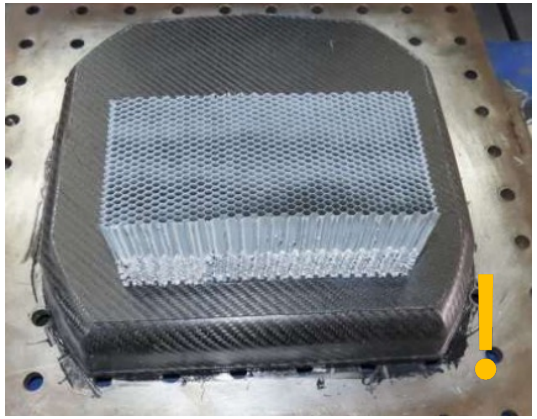


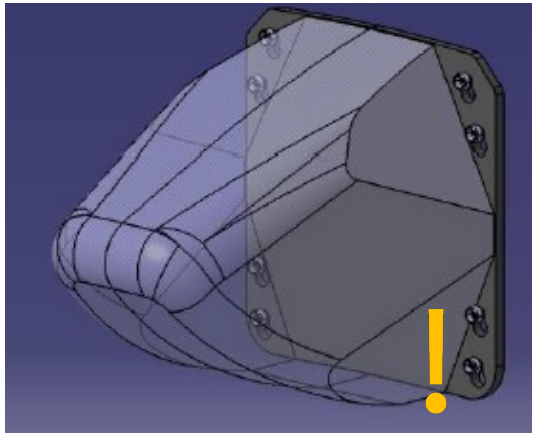




- 'Own' Design: Special designs
  - No holes in FBH
  - IA directly glued to FBH

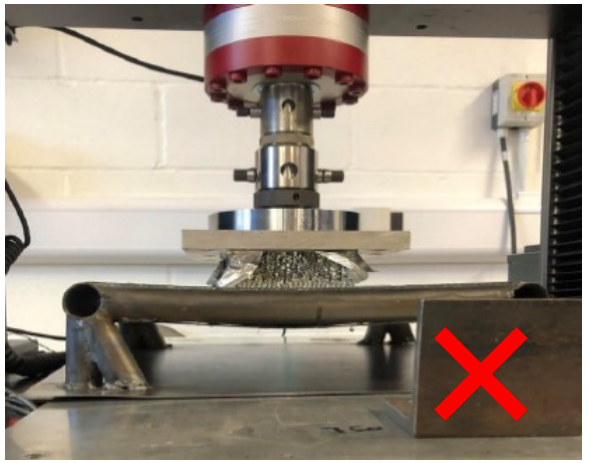
- T3.19.3 Structural nose (only quasi-static test required)





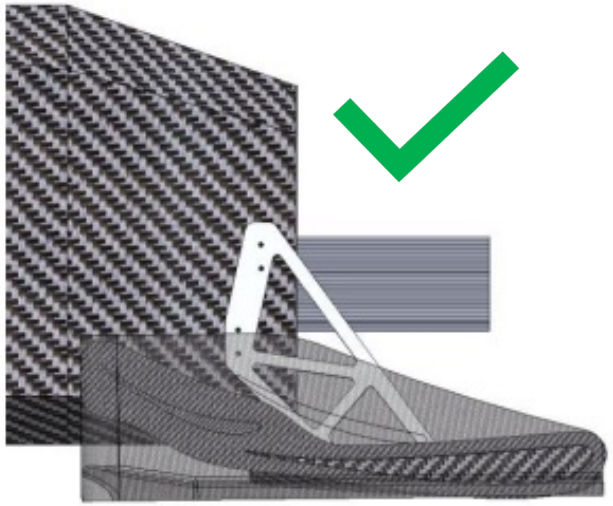
(Dynamic) Testing (1/4)

- T3.19.1 - 'Equivalent (higher) test velocities are only allowed to accommodate for a lower total testing mass, **as long as the energy absorbed is 7350 J or more.**'
  - If these requirements cannot be met, a team must use the standard IA.
  - Higher total testing mass than 300 kg are not allowed.
- T3.19.5 - only dynamic testing

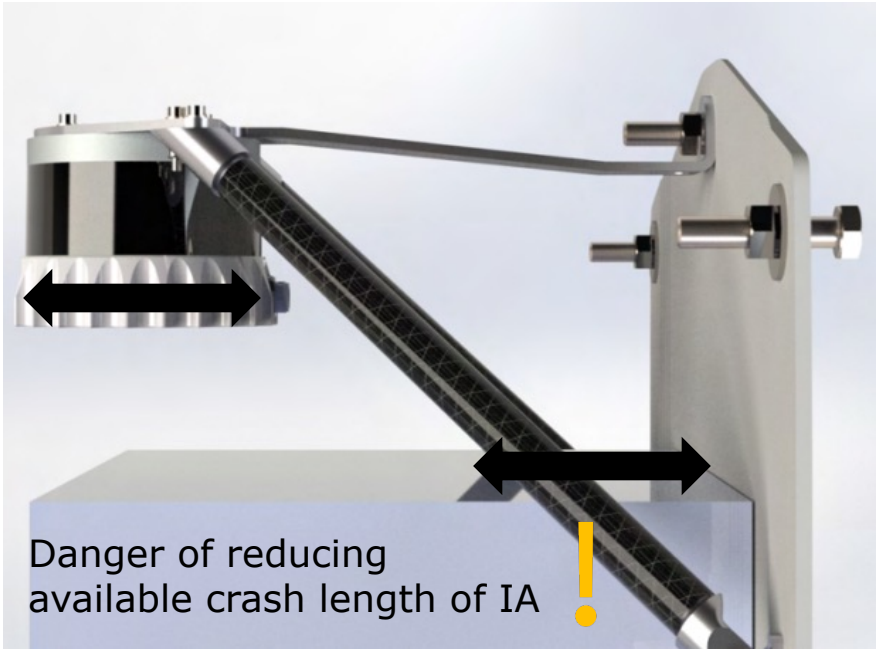


(Dynamic) Testing (2/4)

- T3.19.4 - Crushable objects in front view of AIP require physical testing



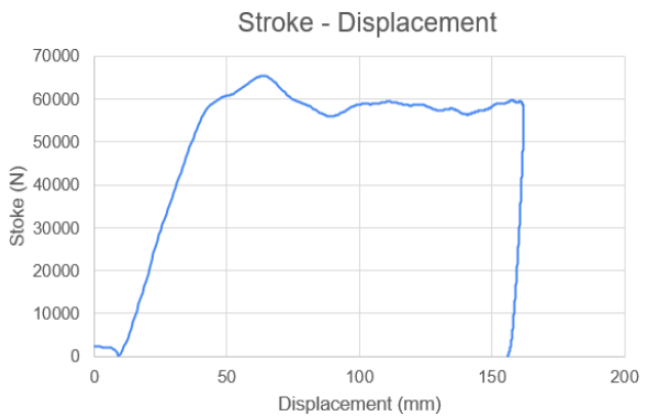
front wing and mountings

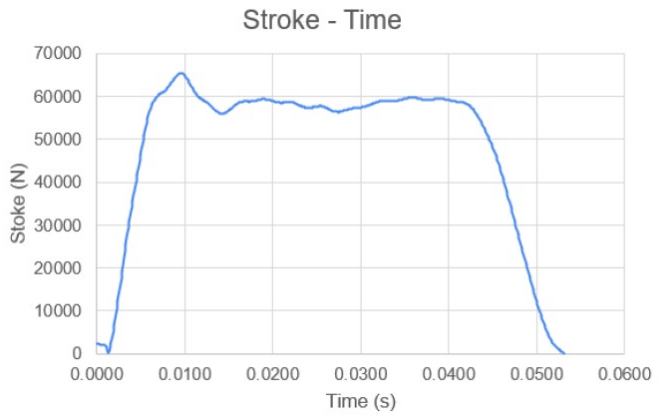


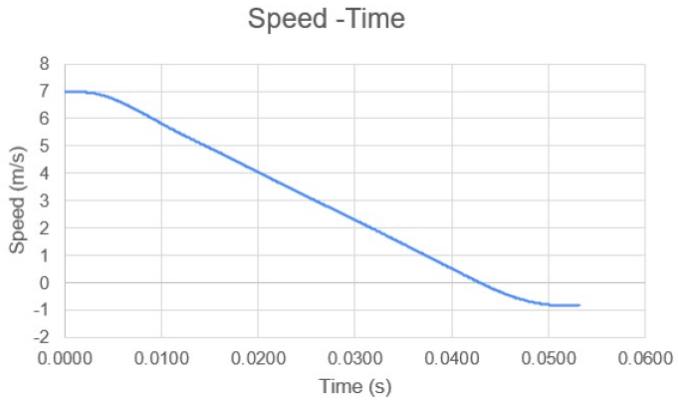
sensors and mountings

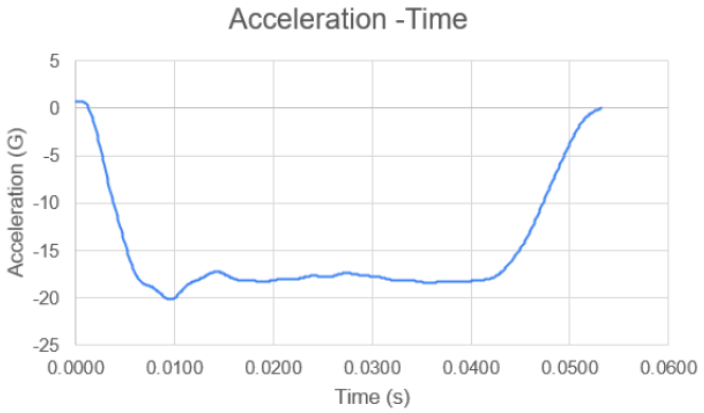
(Dynamic) Testing (3/4)

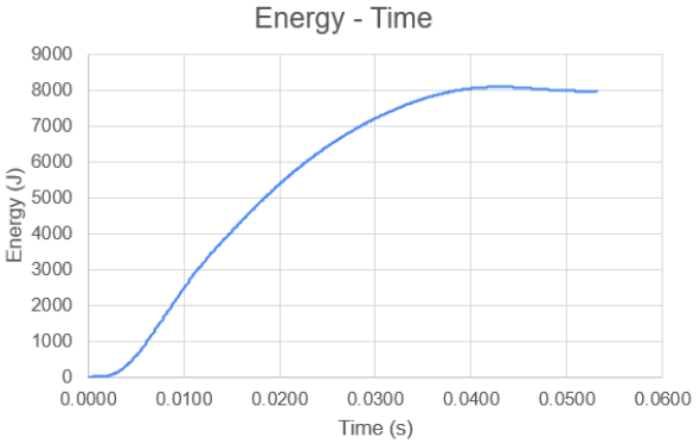
- Please show the following diagrams in the IAD:
  - average deceleration and peak deceleration over time absorbed energy over time (required)
  - absorbed energy over time
  - force over displacement or force over time





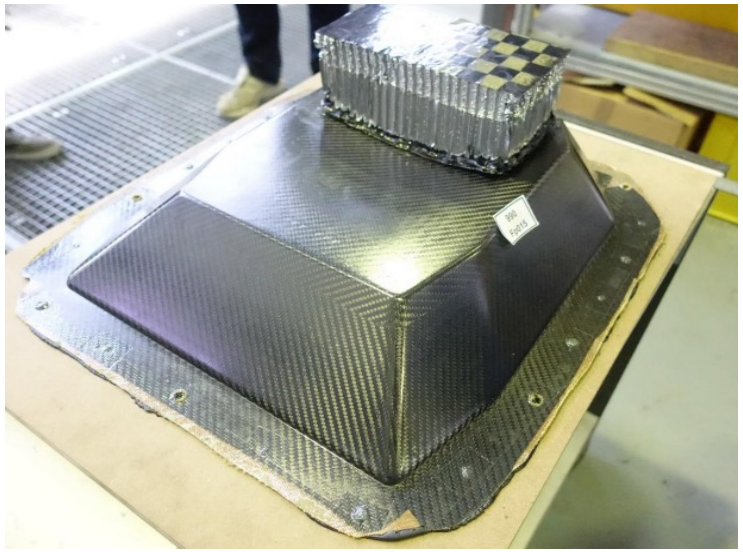


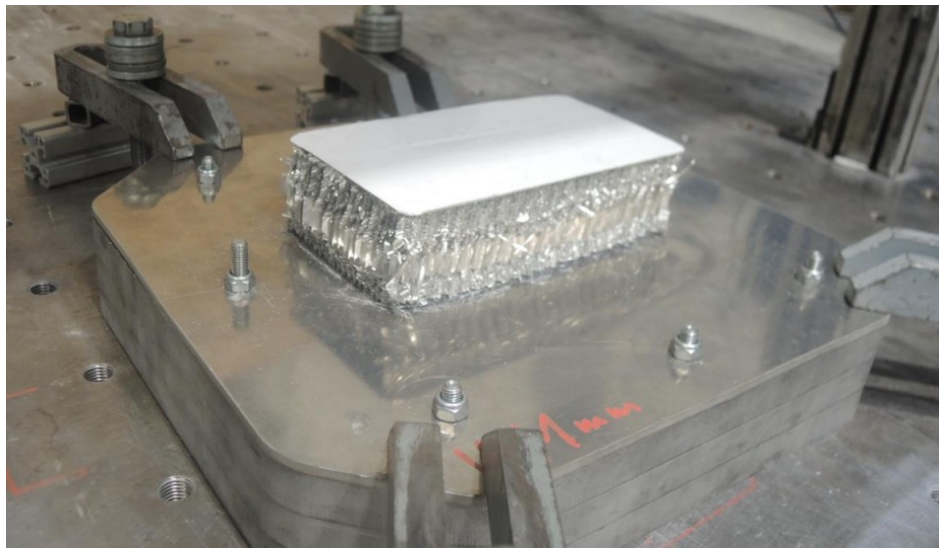




(Dynamic) Testing (4/4)

- IN 5.1.1: 'IA test piece and (representative) test fixture (except for teams with 'standard' IA) must be presented at inspection
  - Possible rules change in future (AIP & FBH must remain intact) analogue to FSAE





General Directions for IA Documentation

- Proper documentation includes:
  - Values backed up with equations, units
  - Pictures displaying different views (ISO, side, top...) before AND after test
  - Pages, tables, figures numbered and referenced
  - Datasheets and relevant values highlighted

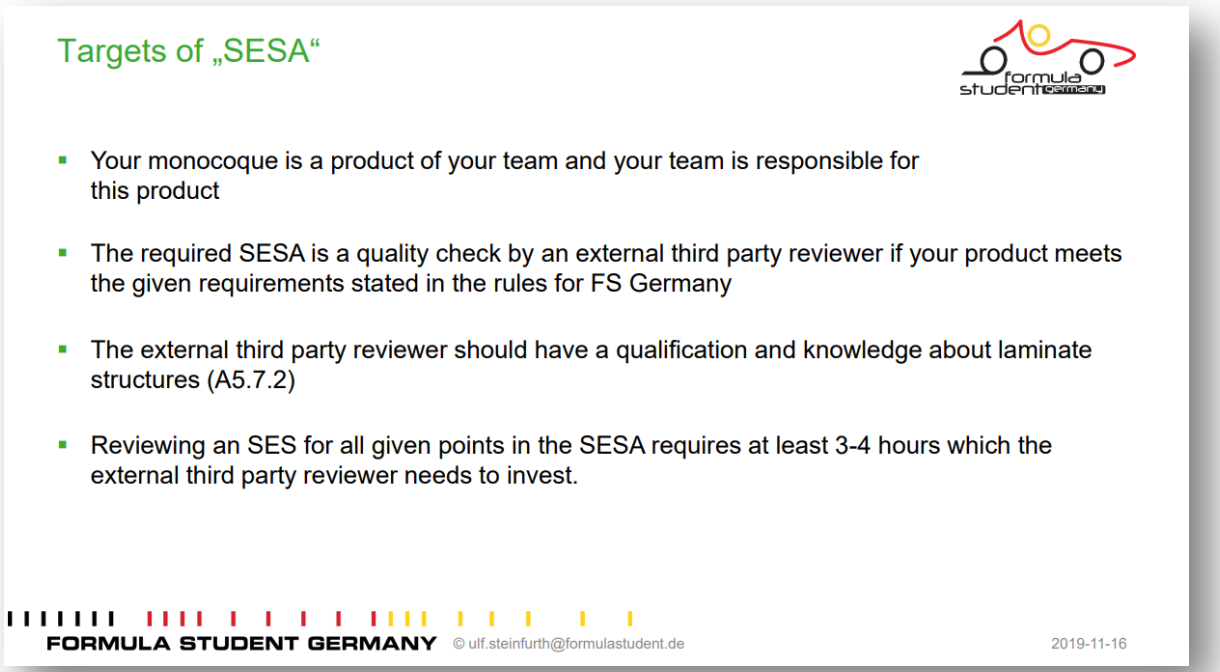
- Review is much quicker if we do not need to 'search'

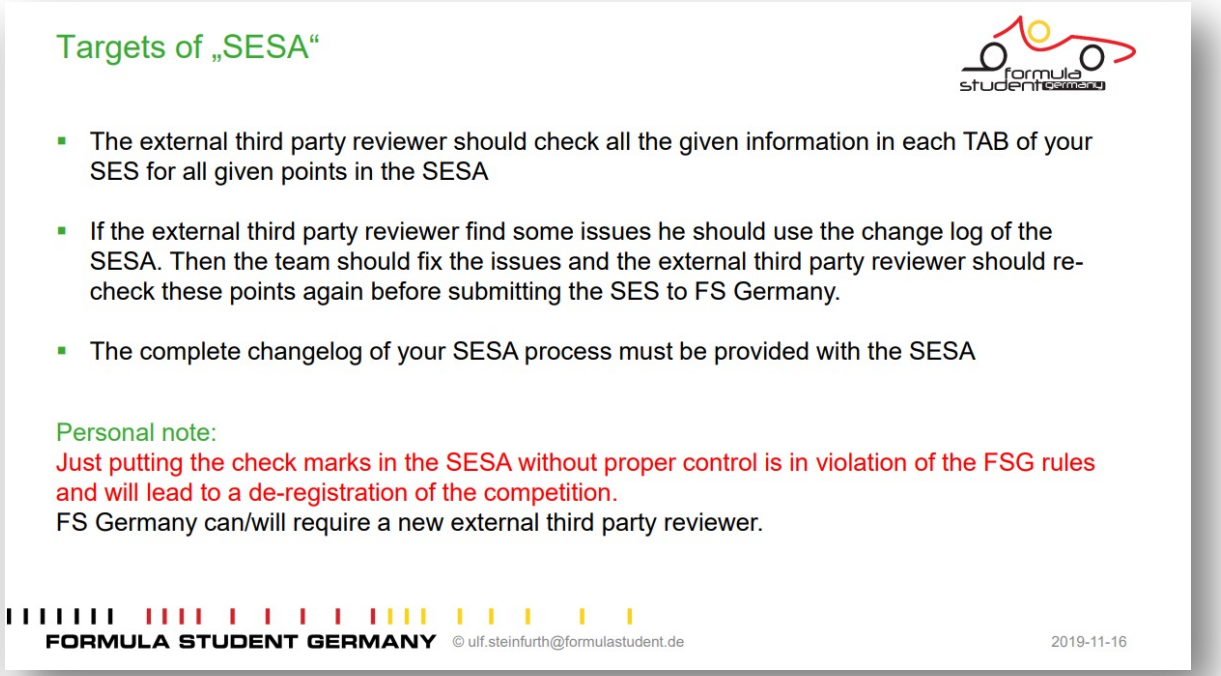
Successful SESA submission

FSG Academy – Main Workshop for FSG 2024
on 21st of October 2023 at Schaeffler in Herzogenaurach

Targets of SESA

- Some repeating required:





- The SESA is also your chance as a team to ask and get valuable feedback from a professional.

Thank you for your attention