FRAME DESIGN 101

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Albion Associates LLC
Outline

• Basic Requirements
• Main & Front Hoop – General Requirements
• Helmet Clearance
• “Percy”
• Main Hoop Bracing
• Front Hoop Bracing
• Front Bulkhead Support
• Foot & Toe Protection
• Side Impact System
• Cockpit Templates
• Seat
• Safety Harness Mounting
• Frame Design Process (if we have time)
• SES Review (If we have time)
Basics

- ALL teams need to submit an SES (or an SCRF)!!
- Recommendations for young teams:
  - Stay with a tube frame (not a monocoque)
  - Stay with the Baseline tube sizes (T3.4.1)
  - Stay away from the Alternative Frame Rules (part AF).
  - Stay away from the thinner tubes allowed for 2015 (T3.6)
## Basic Tubing Sizes, T3.4
### Steel

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<tr>
<th>Tube</th>
<th>Min. Size, Inch</th>
<th>Min. Size, Metric</th>
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<tbody>
<tr>
<td>• Main Hoop, Front Hoop, Shoulder Harness Bar</td>
<td>1.00” x 0.095”</td>
<td>25.0 mm x 2.50 mm</td>
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<tr>
<td>• Main Hoop Bracing, Front Hoop Bracing, Front Bulkhead, SIS Accumulator Protection Structure</td>
<td>1.00” x 0.065”</td>
<td>25.0 mm x 1.75 mm</td>
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<tr>
<td>• Front Bulkhead Supports, Main Hoop Bracing Supports,</td>
<td>1.00” x 0.049”</td>
<td>25.0 mm x 1.50 mm</td>
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<td>26.0 mm x 1.20 mm</td>
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Basic Rules for Frame Approval

To get a frame approved either via SES or at Technical Inspection

1. Minimum tube size, 1.00inch OD x 0.047/0.049 inch wall (25.0 mm x 1.2 mm metric)
2. Triangulation
3. No bent tubes (other than Main Hoop and Front Hoop) (Require additional tubes to meet T3.5.5)
4. Loads from Mandated Tubes go to Structural Nodes
T.3.10.3 Main & Front Hoops - General Requirements

Helmet Line

T3.10.3 When seated normally and restrained by the Driver’s Restraint System, the helmet of a 95th percentile male (anthropometrical data) and all of the team’s drivers must:

a. Be a minimum of 50.8 mm (2 inches) from the straight line drawn from the top of the main hoop to the top of the front hoop. (Figure 1a)

b. Be a minimum of 50.8 mm (2 inches) from the straight line drawn from the top of the main hoop to the lower end of the main hoop bracing if the bracing extends rearwards. (Figure 1b)

c. Be no further rearwards than the rear surface of the main hoop if the main hoop bracing extends forwards. (Figure 1c)
T.3.10.3 Main & Front Hoops - General Requirements

Helmet Line

T.3.10.3 When seated normally and restrained by the Driver’s Restraint System, the helmet of a 95th percentile male (anthropometrical data) and all of the team’s drivers must:

a. Be a minimum of 50.8 mm (2 inches) from the straight line drawn from the top of the main hoop to the top of the front hoop. (Figure 1a)
When seated normally and restrained by the Driver’s Restraint System, the helmet of a 95th percentile male (anthropometrical data) and all of the team’s drivers must:

b. Be a minimum of 50.8 mm (2 inches) from the straight line drawn from the top of the main hoop to the lower end of the main hoop bracing if the bracing extends rearwards. (Figure 1b)
Helmet Line

T3.10.3 When seated normally and restrained by the Driver’s Restraint System, the helmet of a 95th percentile male (anthropometrical data) and all of the team’s drivers must:

c. Be no further rearwards than the rear surface of the main hoop if the main hoop bracing extends forwards. (Figure 1c)
T.3.10.4 The 95th percentile male template will be positioned as follows: (See Figure 2.)

- The seat will be adjusted to the rearmost position.
- The pedals will be placed in the most forward position.
- The bottom 200 mm circle will be placed on the seat bottom such that the distance between the center of this circle and the rearmost face of the pedals is no less than 915 mm (36 ins).
- The middle 200 mm circle, representing the shoulders, will be positioned on the seat back.
- The upper 300 mm circle will be positioned no more than 25.4 mm (1 inch) away from the head restraint (i.e. where the driver’s helmet would normally be located while driving).
Percy’s Placement

The bottom 200 mm circle will be placed on the seat bottom with the center of the circle (”Percy’s” hips and buttocks) no less than 91.5 cms (36 inches) from the rear face of the pedals in their most forward position.
T.3.13.6 - Main Hoop Bracing

- T.3.13.6 The Main Hoop braces must securely integrated into the Frame and be capable of transmitting all loads from the Main Hoop into the Major Structure of the Frame without failing.

- T3.13.7 The lower end of the Main Hoop Braces must be supported back to the Main Hoop by a minimum of two Frame Members on each side of the vehicle; an upper member and a lower member in a properly triangulated configuration.
  
  a. The upper support member must attach to the node where the upper Side Impact Member attaches to the Main Hoop.

  b. The lower support member must attach to the node where the lower Side Impact Member attaches to the Main Hoop.

NOTE: Each of the above members can be multiple or bent tubes provided the requirements of T3.5.5 are met.
### FSAE Main Roll Hoop Support Configuration Examples

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T.3.14 Front Hoop Bracing

- Two braces extending forward on both the left and right sides, 1.00” OD x 0.065” wall steel tubing or approved equivalent.
- Constructed such that they protect the driver’s legs and **should** extend to the structure in front of the driver’s feet. (Note: Not “must extend”)
- Attached no more than 50.8 mm (2 in) below the top-most surface of the Front Hoop.
- If the front hoop leans rearwards by more than 10 degrees from the vertical, it must be supported by additional bracing to the rear. This bracing must be constructed of material per Section T3.4.1.
T.3.20 Front Bulkhead Support

A minimum of three (3) tubes supporting the Front Bulkhead on each side.

- One tube per side must be within 50.8 mm (2 inches) of the top of the Front Bulkhead.
- One tube per side must be at the bottom of the Front Bulkhead.
- The third tube is the diagonal brace.
- All three tubes must meet be 1.00” OD x 0.049” wall or approved equivalent.
- The triangulation must be node-to-node, with triangles being formed by the Front Bulkhead, the diagonal and one of the other two required Front Bulkhead Support Members.
- A Front Roll Hoop Brace that goes all the way forward to the Front Bulkhead can be used as one of the three (3) tubes, EXCEPT that it cannot be used as the diagonal brace.
## Front Bulkhead Support

### FSAE Front Bulkhead Support Configuration Examples

These designs do not necessarily include members required by rules T3.14 and T3.18.1.

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Front Bulkhead Support – cont’d

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T.3.18.1 Foot & Toe Protection

T.3.18.1 Front Impact Structure

The driver’s feet must be completely contained within the Major Structure of the Frame. While the driver’s feet are touching the pedals, in side and front views no part of the driver’s feet can extend above or outside of the Major Structure of the Frame.
Side Impact Requirements

T.3.25 Tube Frames

The Side Impact Structure must be comprised of at least three (3) tubular members located on each side of the driver while seated in the normal driving position, as shown in Figure 7. The three (3) required tubular members must be constructed of material per Section T3.4. The locations for the three (3) required tubular members are as follows:
T.3.25 Side Impact Protection - Tube Frames

Minimum of three (3) 1.00” OD x 0.065” wall steel tubes or approved equivalent:

- **Upper**, connecting the Main Hoop and the Front Hoop at between 300 mm (11.8 inch) and 350 mm (13.8 inch) above the ground. *All of the member must be at a height between 300 mm (11.8 inches) and 350 mm (13.8 inches) above the ground.*
- **Lower**, connecting the bottom of the Main Hoop and the bottom of the Front Hoop.
- A diagonal.
- With proper gusseting and/or triangulation, it is permissible to fabricate the Side Impact Structural members from more than one piece of tubing.
T.4.1 Cockpit Opening

• T.4.1.1 In order to ensure that the opening giving access to the cockpit is of adequate size, a template shown in Figure 8 will be inserted into the cockpit opening. It will be held horizontally and inserted vertically until it has passed below the top bar of the Side Impact Structure (or until it is 350 mm above the ground for monocoque cars). *Fore and aft translation of the template will be permitted during insertion.*

• T.4.1.2 During this test, the steering wheel, steering column, seat and all padding may be removed. The firewall may not be moved or removed.

*Presenter’s note: Only those things mentioned above may be removed, nothing else, including the shifter.*
T.4.2 Cockpit Internal Cross Section

- T.4.2.1 A free vertical cross section, which allows the template shown in Figure 9 to be passed horizontally through the cockpit to a point 100 mm (4 inches) rearwards of the face of the rearmost pedal when in the inoperative position, must be maintained over its entire length. If the pedals are adjustable, they will be put in their most forward position.

- T.4.2.2 The template, with maximum thickness of 7mm (0.275 inch), will be held vertically and inserted into the cockpit opening rearward of the Front Roll Hoop, as close to the Front Roll Hoop as the car’s design will allow.

- T.4.2.3 The only items that may be removed for this test are the steering wheel, and any padding required by Rule T.5.8 Driver’s Leg Protection that can be easily removed without the use of tools with the driver in the seat. The seat may NOT be removed.

Note: Cables, wires, hoses, tubes, etc. must not impede the passage of the templates required by T.4.1 and T.4.2.
T.4.2 Cockpit Internal Cross Section - Cont’d
T.4.3.1 Seat - Not OK

**T.4.3.1 Seat**

The lowest point of the driver’s seat must be **no lower than the bottom surface of the lower frame rails or by having a longitudinal tube (or tubes) that meets the requirements for Side Impact tubing, passing underneath the lowest point of the seat.**

Note: The smallest tube would be 1.00” OD X 0.049” wall)
T.3.3.1 & T.5.4
Shoulder Harness Mounting Bar

T.3.4.1 - Minimum size must be 1.00” OD x 0.095” wall thickness steel, or approved equivalent. (Was 1.00” OD x 0.065” wall thickness in 2007)

T.5.4.1 - The shoulder harness must be mounted behind the driver to structure that meets the requirements of T.3.4.1. However, it cannot be mounted to the Main Hoop Bracing or attendant structure without additional bracing to prevent loads being transferred into the Main Hoop Bracing.

T5.4.2 - If the harness is mounted to a tube that is not straight, the joints between this tube and the structure to which it is mounted must be reinforced in side view by triangulation tubes to prevent torsional rotation of the harness mounting tube. *Supporting calculations are required.*
Questions?
Frame Design Process

Where do you start?

What is YOUR process?
Frame Design Process

- Examine current design
- Start with “Percy” with legs (and tallest driver if over 6’ 1 1/2”)
- Add engine/transmission
- Add cockpit template envelopes
- Add suspension pick-up points and rocker mounts
- Rough out tubing configuration
- SUBMIT YOUR SES!!
- Add safety harness mounts
- Add engine/transmission mounts
- Check SES submission still valid
- Perform FEA for torsional rigidity
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