The GENESIS of Corvette Racing, Seat Construction: Designing out of the Box… You've Cornered Yourself Into

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October 2, 2018 | Plymouth, MI

Outline

- Background
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- PME's General Process for Implementing Optimization
- Using GENESIS as a Tool to Gain Insight
- PME's Background in Seat Design and Safety
- 2016 seat rules update
  - Geometric
  - Lateral Loading
  - Rear Loading
  - Crush
- Impact of the Rules on Our Existing Program
- Timeline
- Design
  - Addressing Egress
  - Ergonomic Driven Geometry
  - Structural Development and Optimization
  - Reevaluating the Problem
  - Implementation of Topography
  - Final Design/Shape
- Manufacturing
- Rules Update
- Testing
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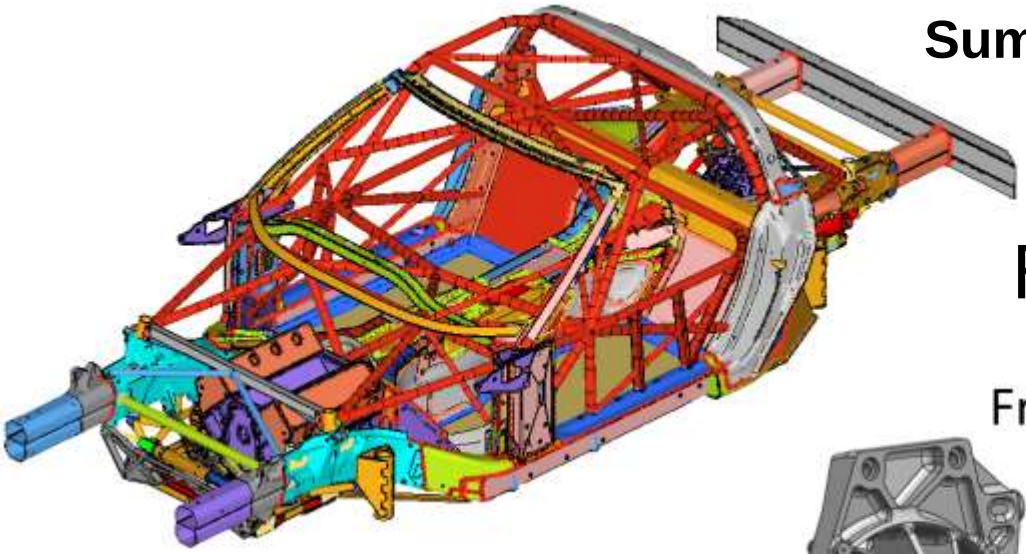
A Background of Pratt & Miller and Corvette Racing

- Headquartered in New Hudson Michigan.
- Product development company that solves its customers most technical problems.
- The company's core capabilities include Research & Innovation, Engineering & Design, Prototype Manufacturing, Test & Development, and Production.

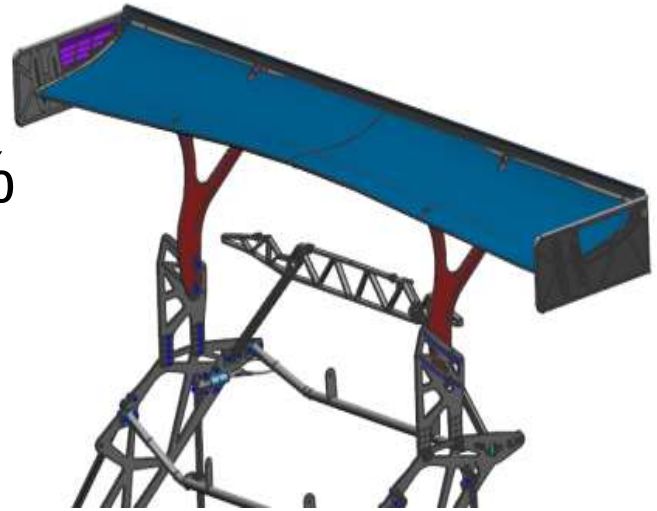
GENESIS and Pratt & Miller



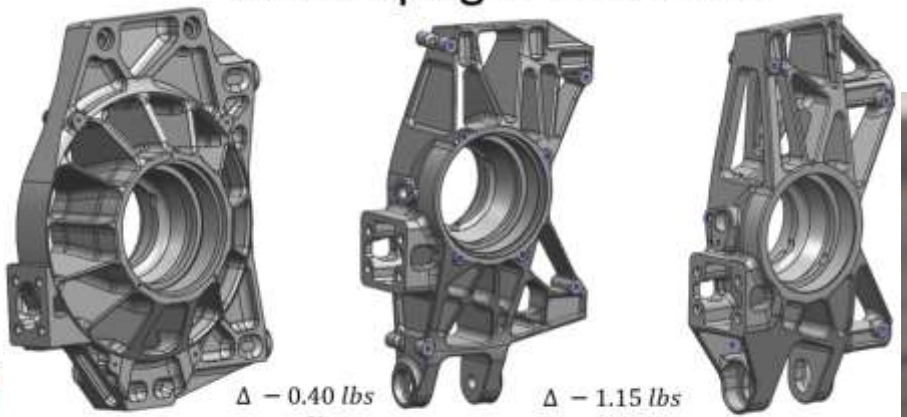
Summary of C7.R Structural Gains

Torsional Rigidity = +50%

Full Car Weight ≈ -65 lbs



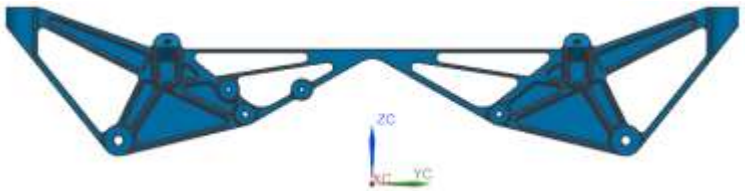
Front Upright Evolution



C6.R GT1
6.80 lbs
Intuitively Designed
FEA Checked

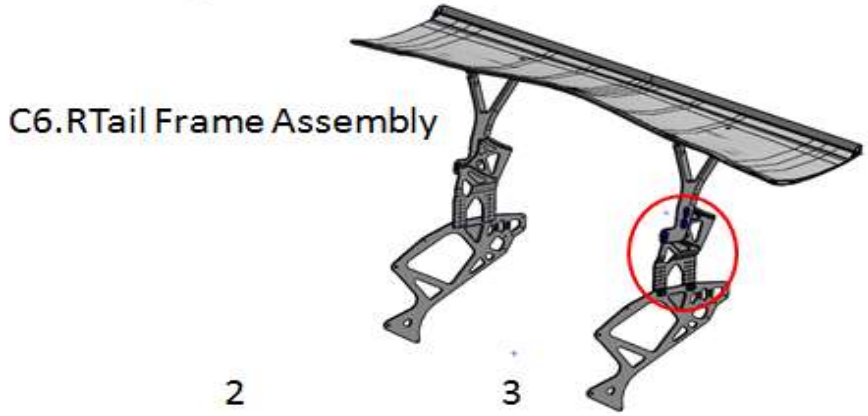
C6.R GT2
6.40 lbs
FEA Iteratively
Designed and Checked

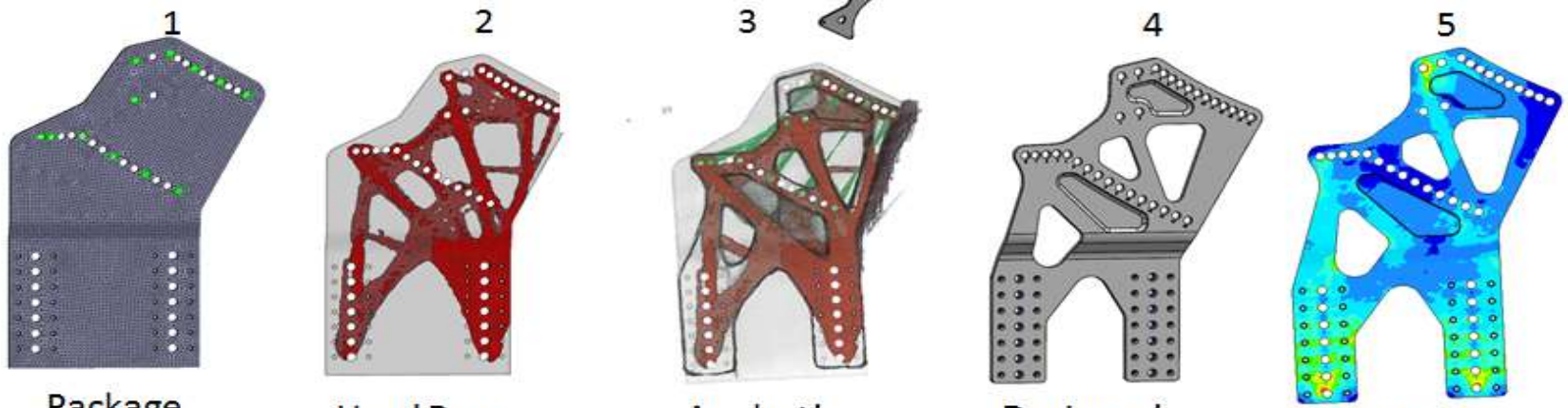
C7.R GT2
5.25 lbs
GENESIS Optimized
FEA Iteratively
Designed and Checked



PME's Process for Implementing GESESIS

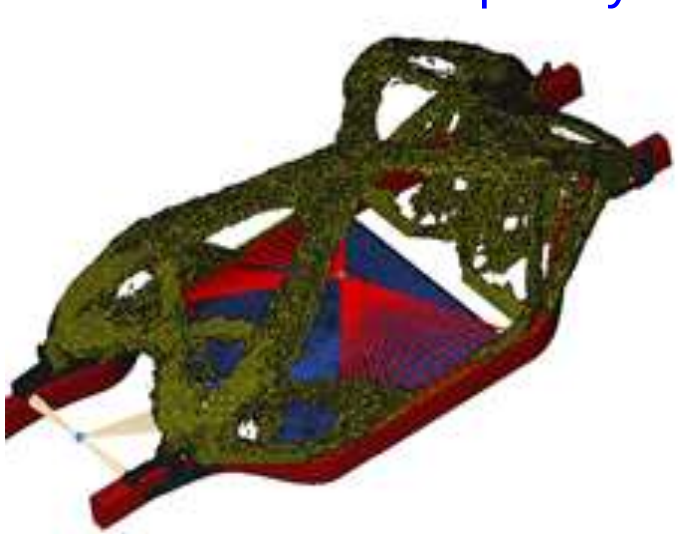
PME's Integrated Optimization Design Process





GESESIS as Tool to Gain Insight

- **Optimization very susceptible to focused load cases.**
- **Being aware of these sensitivities is critical in avoiding oversight.**
- **Additionally, when understood, these sensitivities can be utilized.**
  - We frequently use focused load cases as a metric for evaluation.



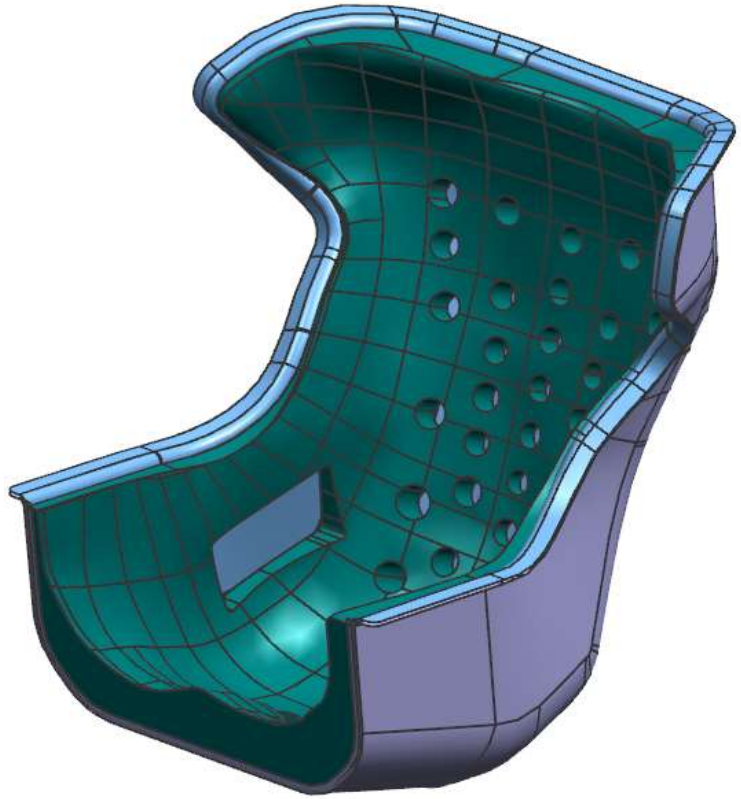
TORSION

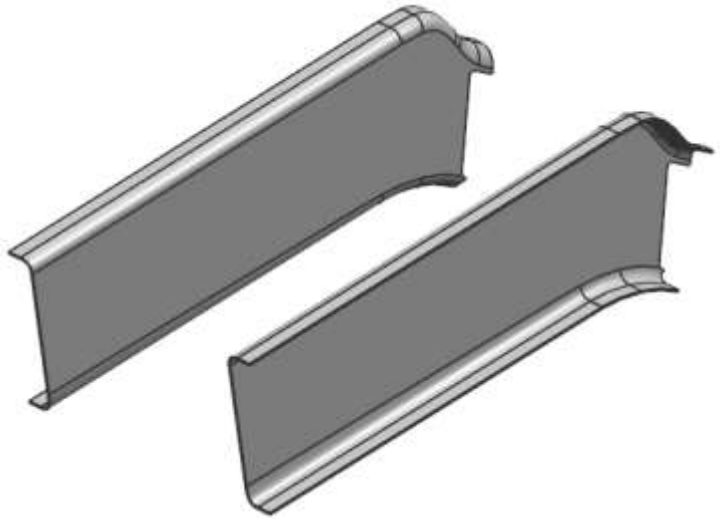
VERTICAL BENDING

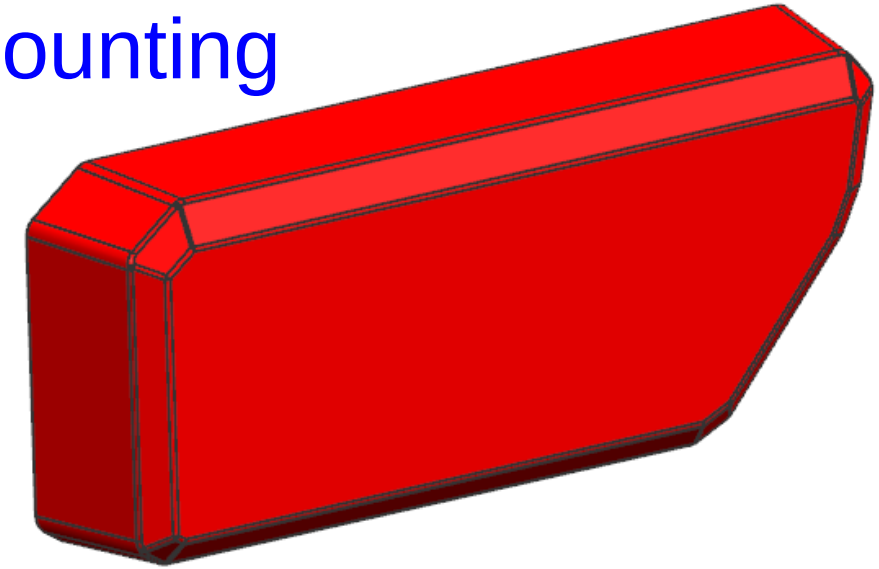
SIDE IMPACT

PME Background in Seat Design and Safety

- Very high expectations when pertaining to safety.
  - Side crush box
  - Leg boards
  - Non adjustable seat.
    - w/ added back mounting







Preliminary Seat Regulations Change – Geometric

STANDARD FIA 8862-2009

- 2016 GTLM rules - Geometric Concerns
  - Side Head Support
  - Maximum insert foam thickness

Added Side Head Support

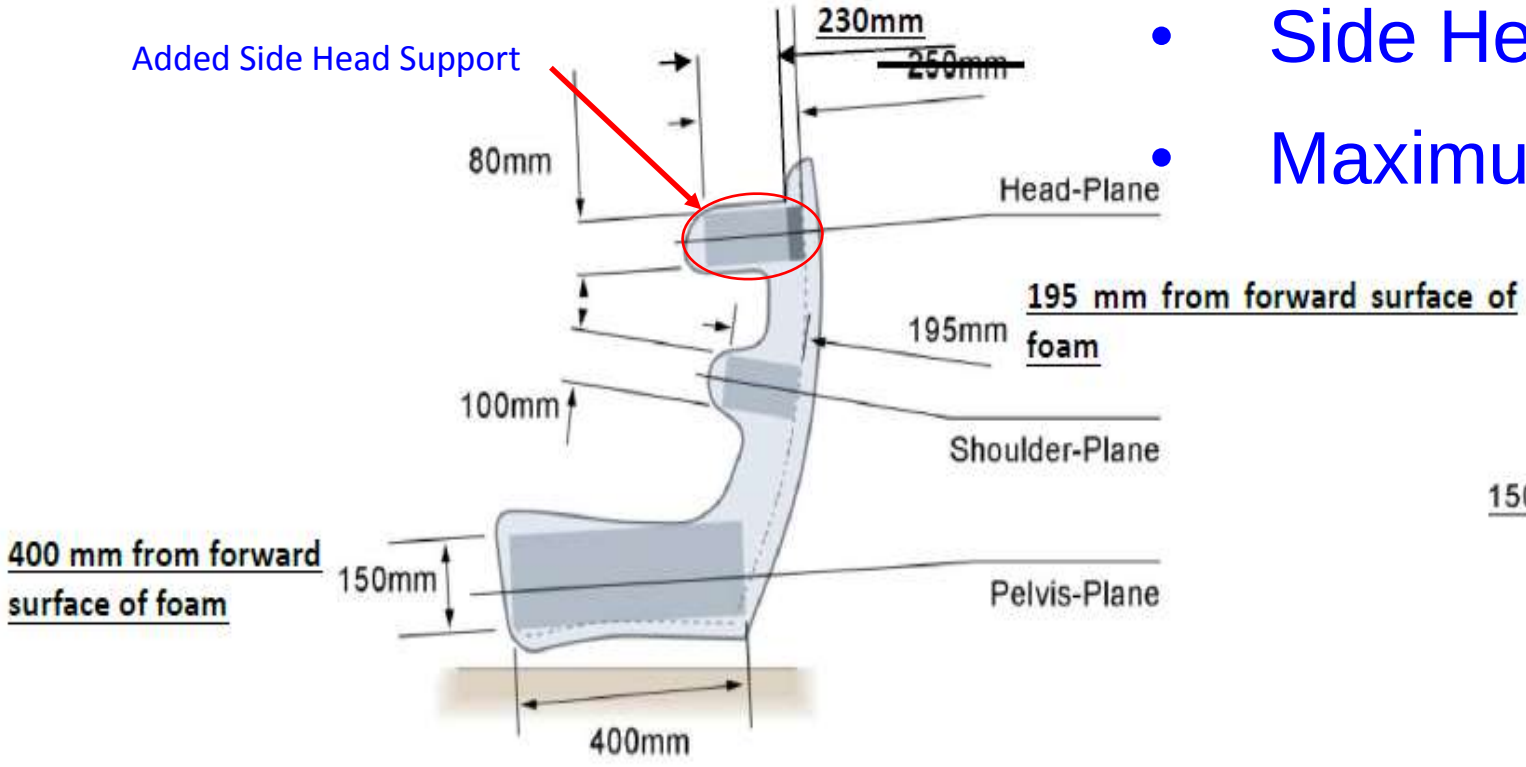


Figure A2. Plans de référence (pour la tête, les épaules et le bassin) et dimensions MINIMALES
Figure A2. Reference Planes (for Head, Shoulder and Pelvis) and MINIMUM Dimensions

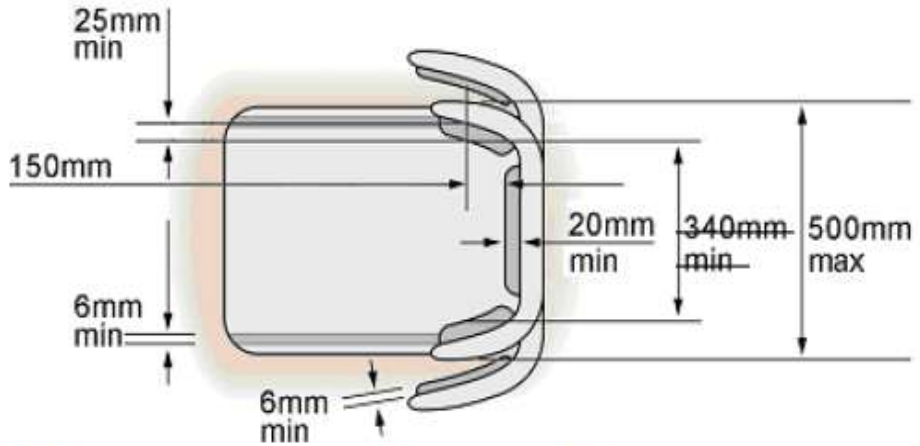
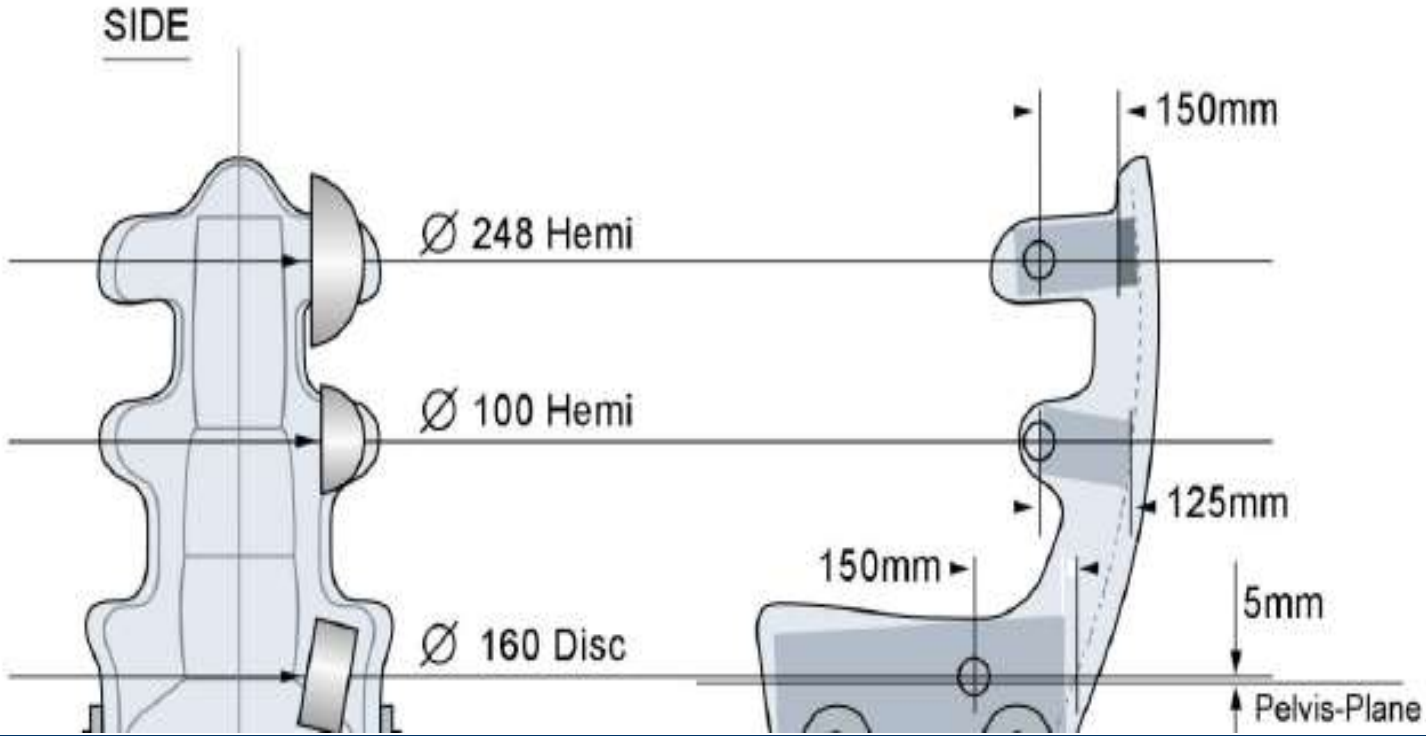


Figure A3. Dimensions pour le Côté du siège-tête et les matériaux absorbant l'énergie
Figure A3. Dimensions for Seat-Side-Head and Energy Absorbing Materials

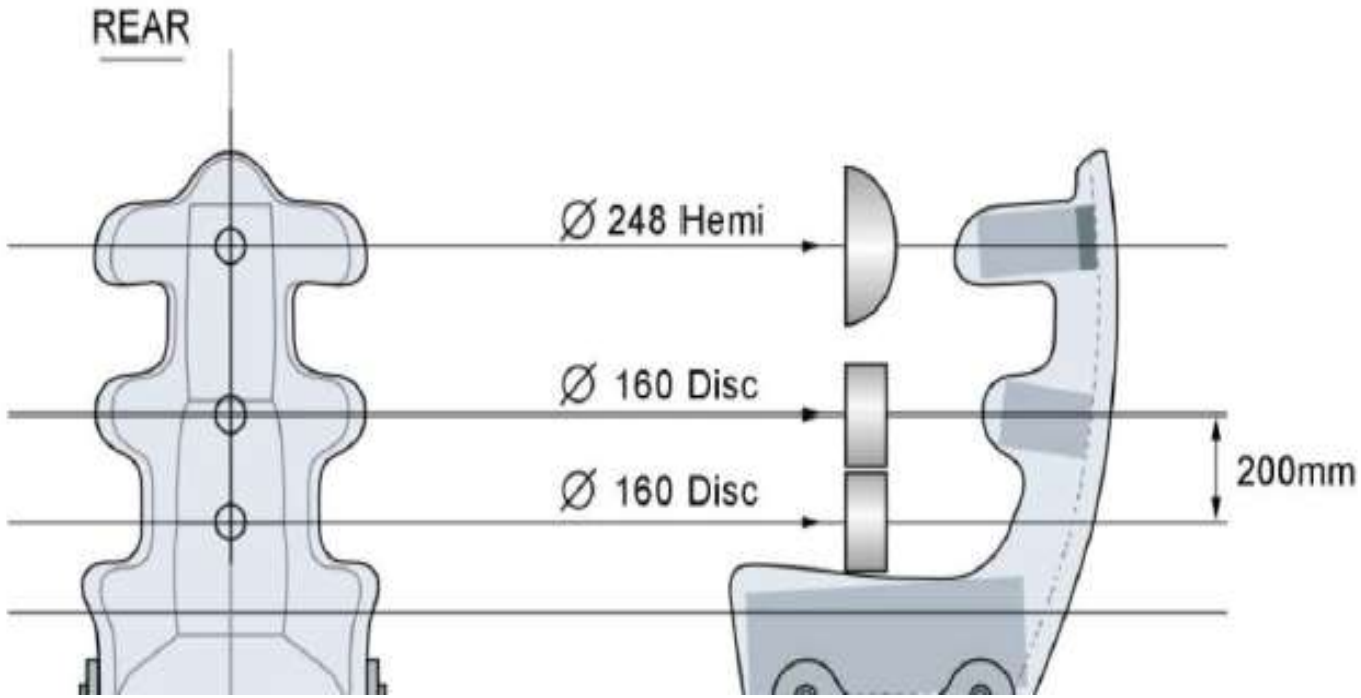
Change in Seat Regulations– Lateral Loading Requirements

Load Case	Loading Location	Direction	Input Load (kN)	Max Deflection (mm)
1 - Side Loading	Seat Side - Head	Side (Y)	7	80
	Seat Side - Shoulder	Side (Y)	11	60
	Seat Side - Pelvis	Side (Y)	14	40

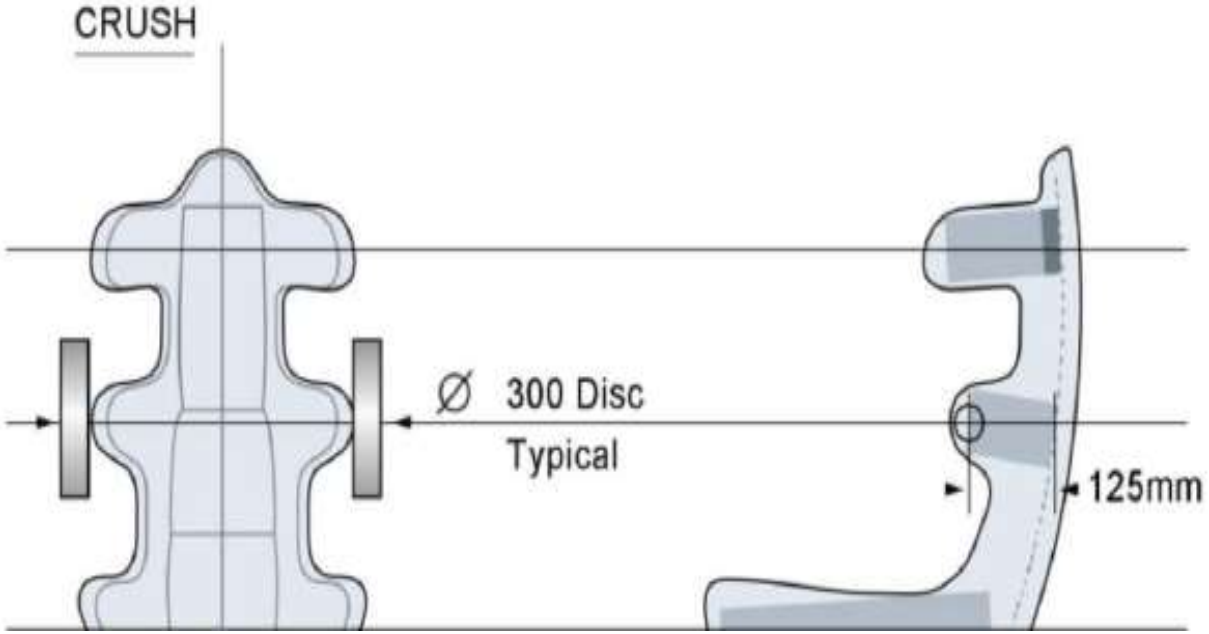


Change in Seat Regulations– Rear Loading Requirements

Load Case	Loading Location	Direction	Input Load (kN)	Max Deflection (mm)
2 - Rear Loading	Seat Back - Head	Rear (X)	7	120
	Seat Back - Shoulder	Rear (X)	14	100
	Seat Back - Middle	Rear (X)	14	80

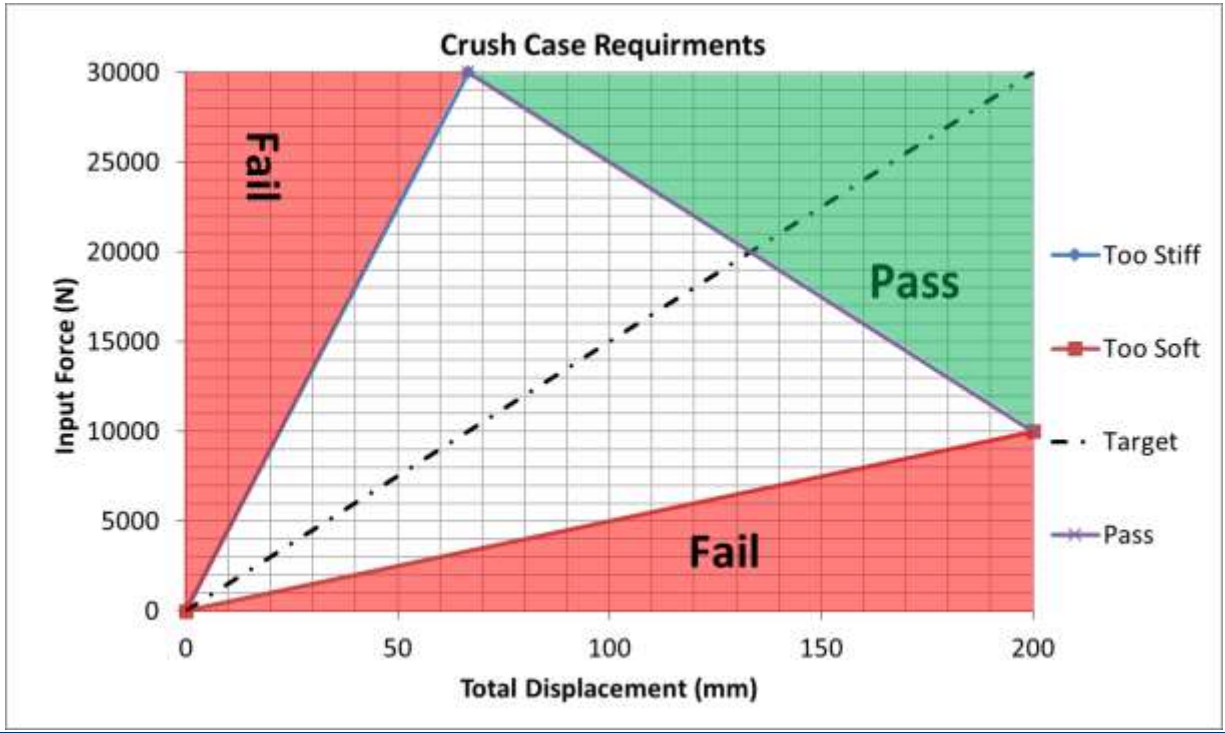


Change in Seat Regulations– Structural Energy Requirements

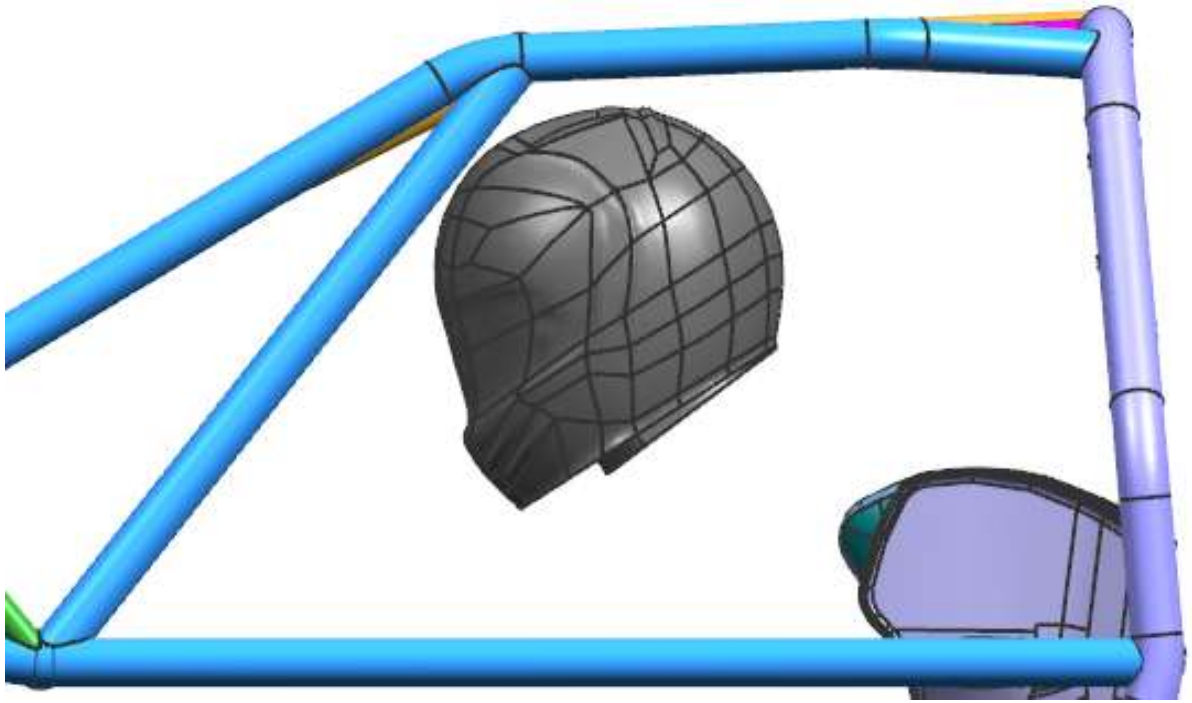


- Seat loaded from either side at shoulder points.
- Energy storage requirement of 1kJ must be met.
- Cant exceed 200mm total deflection
- Cant exceed 30kN of load applied

- Force Deflection Plot
  - Operating Slope Range – white
  - Slope Must Extend to Green (no failure)

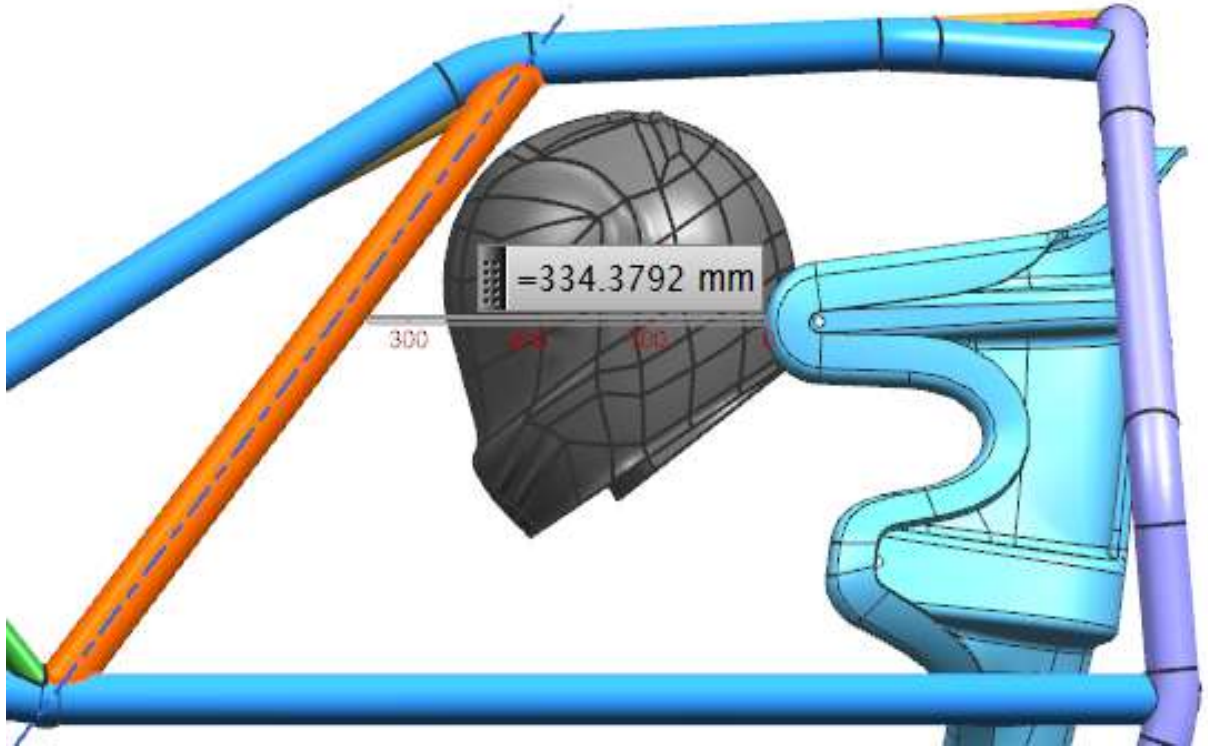


Seat Design – Impact of New Requirements



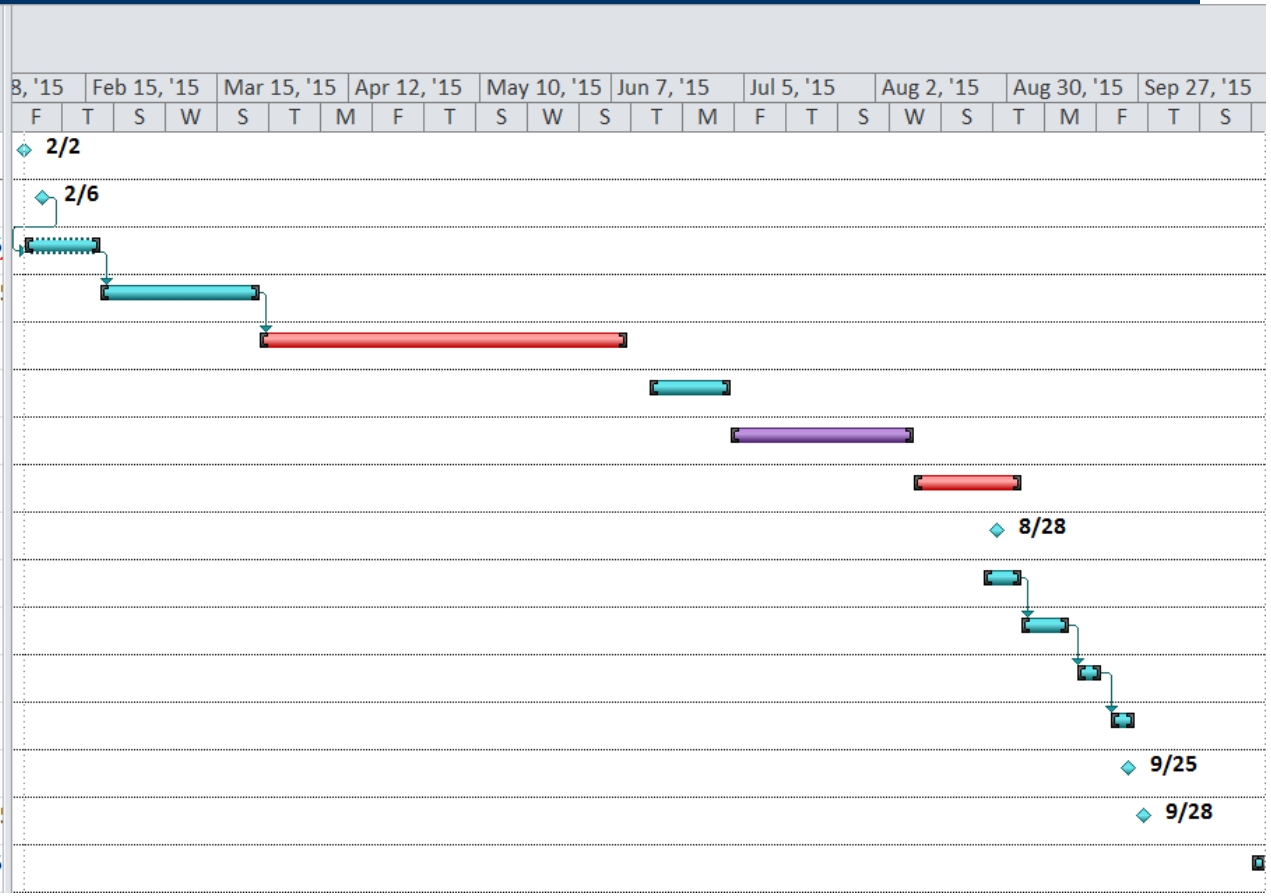
C7.R Pre 2016 Egress Area

C7.R 2016 Rules Update Egress Area



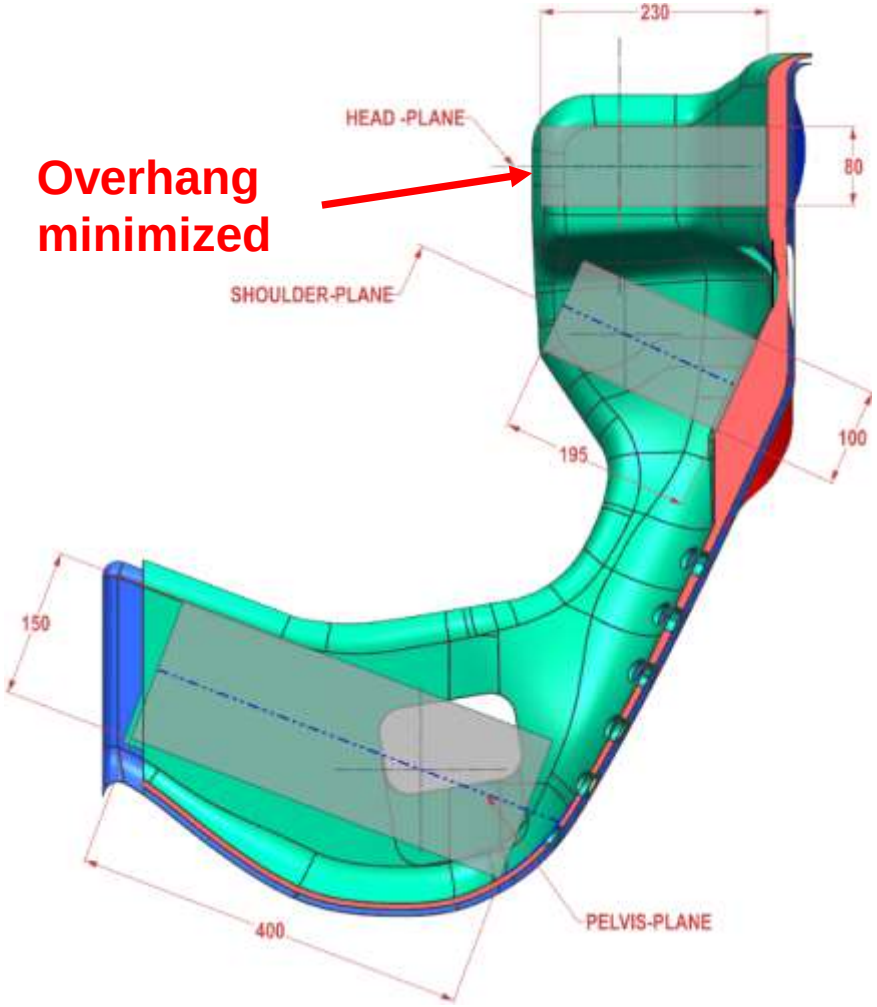
Seat Design – Strategy/Timeline

Task Name	Duration	Start	Finish
Rules Received	0 days	Mon 2/2/15	Mon 2/2/15
Rules Eval	0 days	Fri 2/6/15	Fri 2/6/15
Design Evaluation of Rules and Off the Shelf Seats	12 days	Mon 2/2/15	Tue 2/17/15
Brainstorming for Design Direction	24 days	Wed 2/18/15	Mon 3/23/1
Eronomic Driven Surface	56 days	Tue 3/24/15	Tue 6/9/15
Baseline FEA Eval	13 days	Mon 6/15/15	Wed 7/1/15
Wasted Time (Lack of Resources)	28 days	Thu 7/2/15	Sun 8/9/15
Structural Development/Optimization	17 days	Mon 8/10/15	Tue 9/1/15
Molds Released	0 days	Fri 8/28/15	Fri 8/28/15
Topography Development	6 days	Tue 8/25/15	Tue 9/1/15
Topography Interpretation/Usable Design	8 days	Wed 9/2/15	Fri 9/11/15
Final Layup Development	5 days	Mon 9/14/15	Fri 9/18/15
Seat Manufacturing	5 days	Mon 9/21/15	Fri 9/25/15
Inhouse Test	0 days	Fri 9/25/15	Fri 9/25/15
Seat Ships	0 days	Mon 9/28/15	Mon 9/28/1
Lab Testing	3 days	Wed 10/21/1	Fri 10/23/15

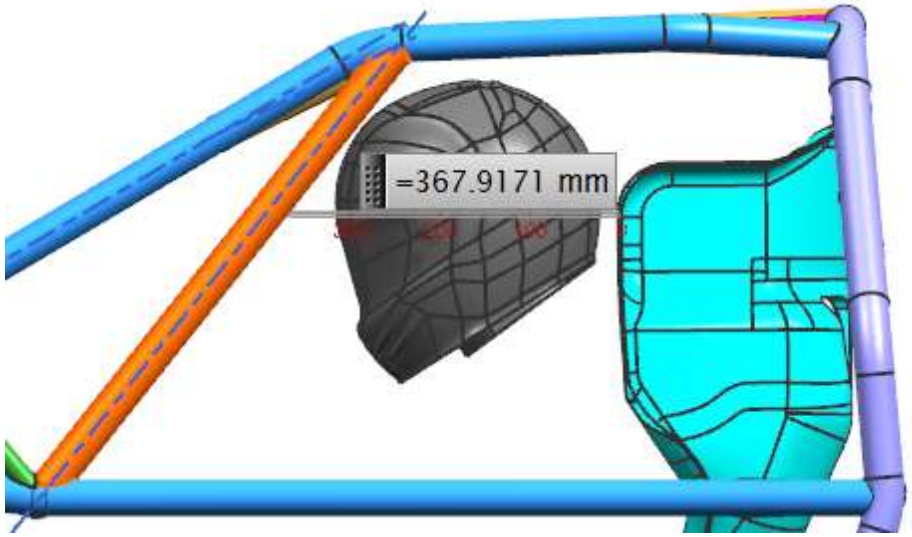


- Strategy was to let ergonomics to drive geometry and meet all structural requirements with layup.
- We left no time to circle back and modify geometry if it was required.

Seat Design – Addressing Egress

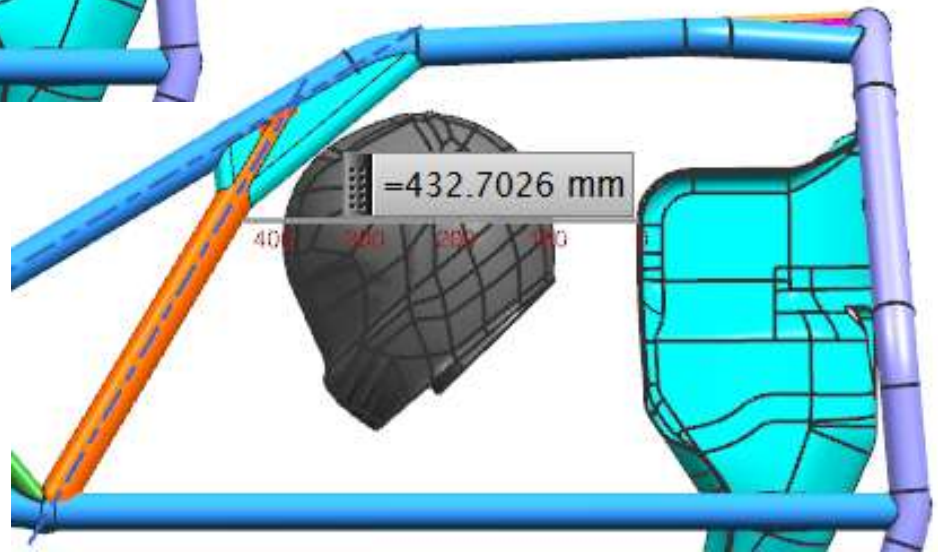


Overhang minimized

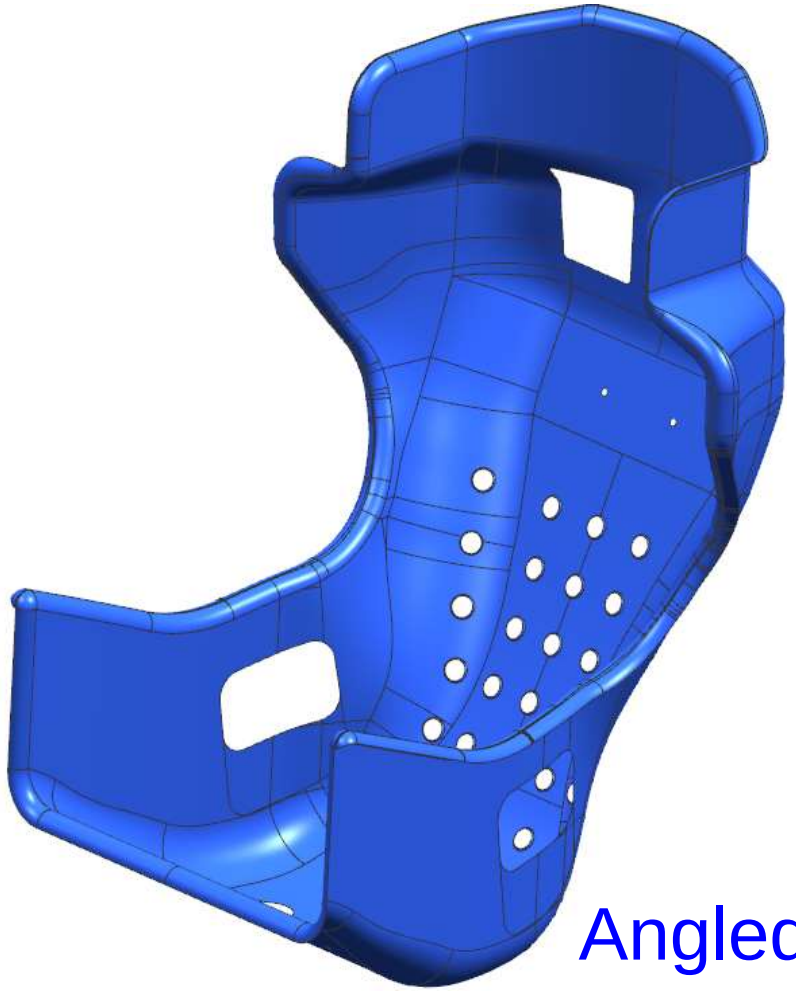


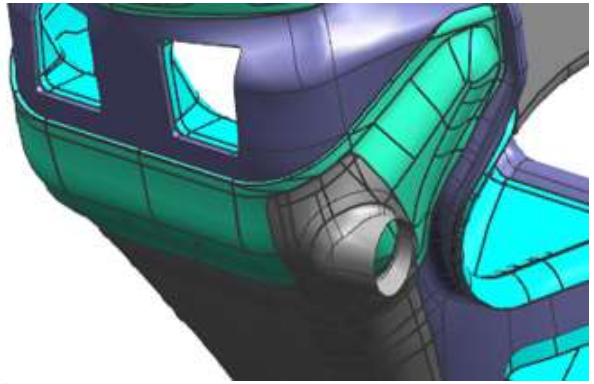
Egress with PME Seat

Egress with PME Seat and Chassis Modifications



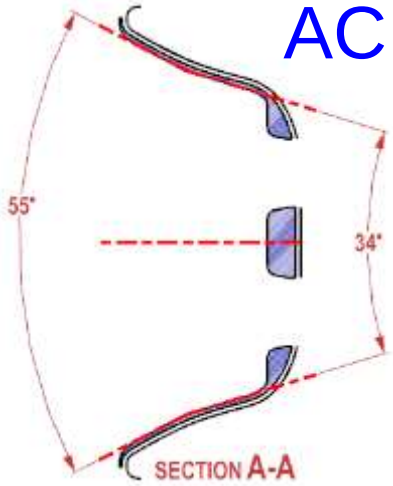
Seat Design – Ergonomic Driven Geometry





AC Plenum

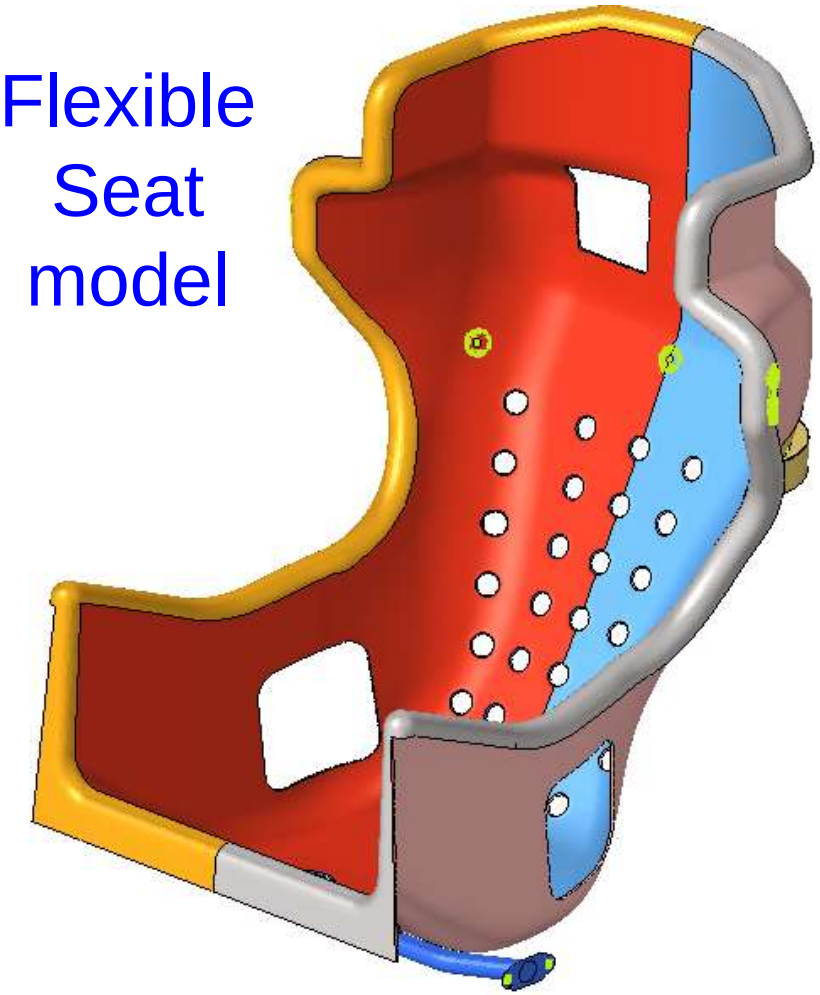
Belt Location Adjustment with Large Hole

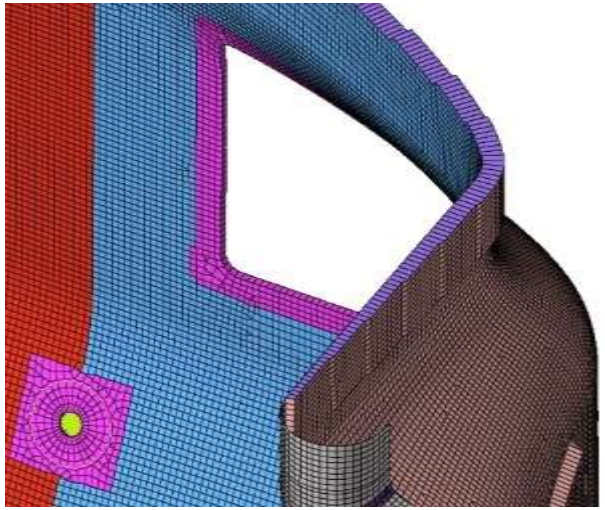


Angled Shoulder Support

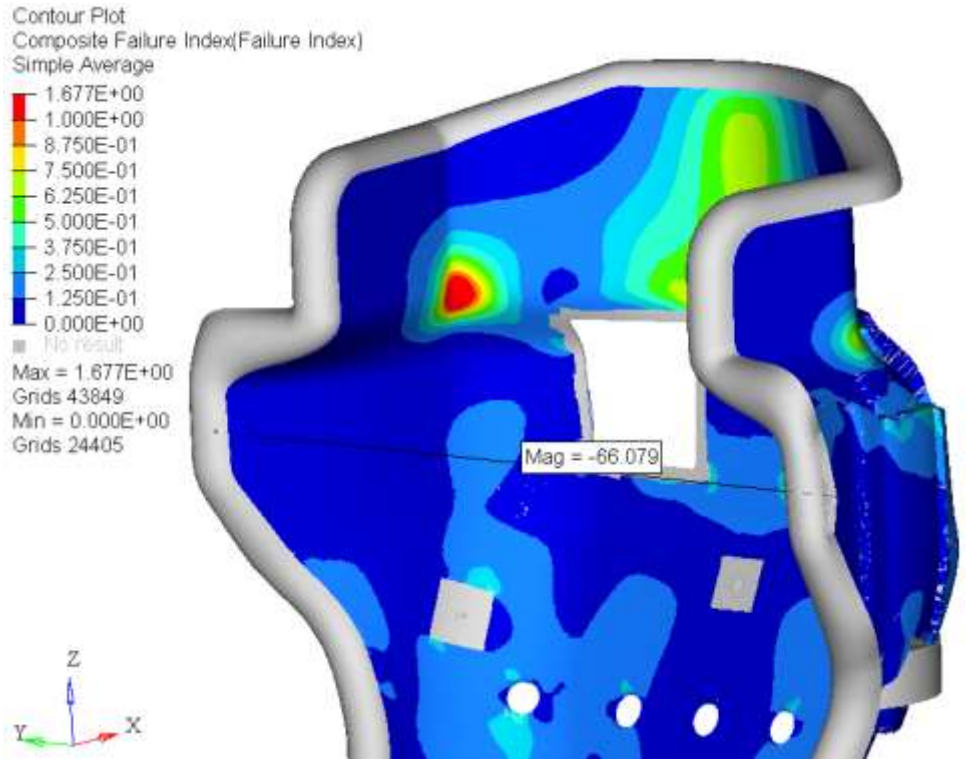
Seat Design – Structural Development and Optimization

Flexible Seat model





Cross-Section of Adjusted Solid Core Thickness in Model

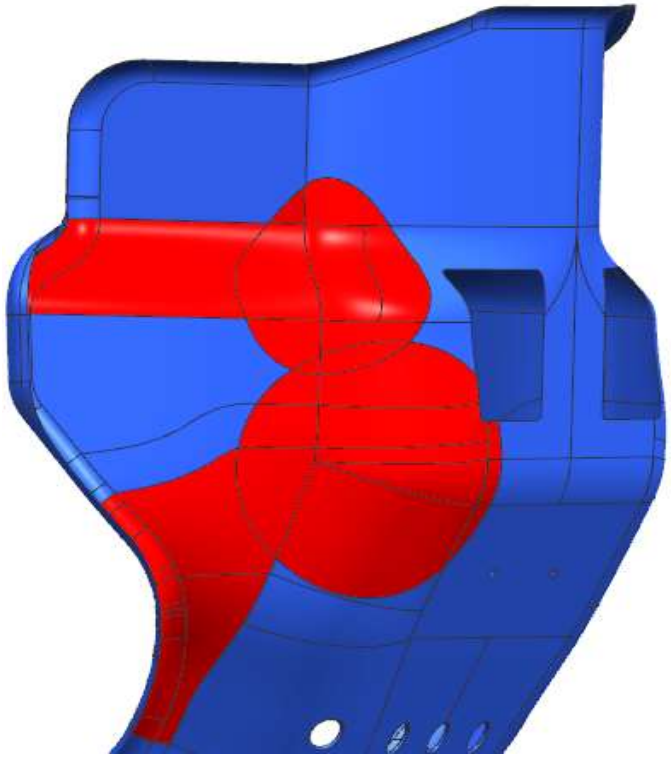


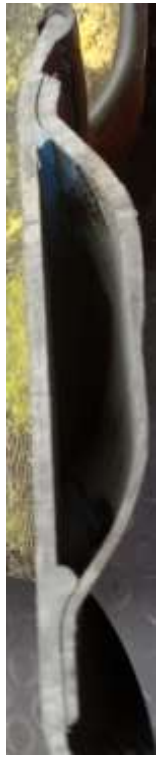
Common Stress and Deflection Results at Another Dead End

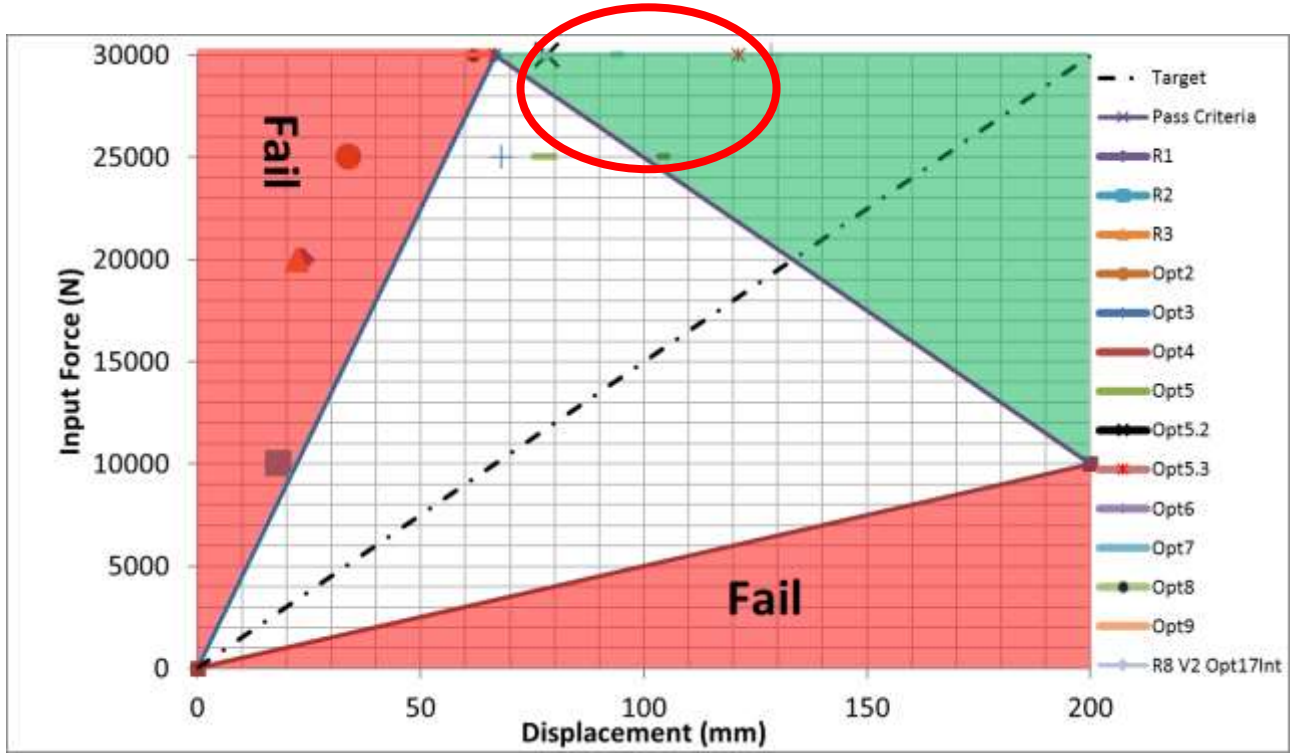
Seat Design – Reevaluating the Problem

We felt that the 3 major contributors to this were the following

1. the out of plane surface connecting the head support to the shoulder support.
2. The relatively wide under shoulder bolster return.
3. The 3D curvatures in the transition from the shoulder bolster to the back support.

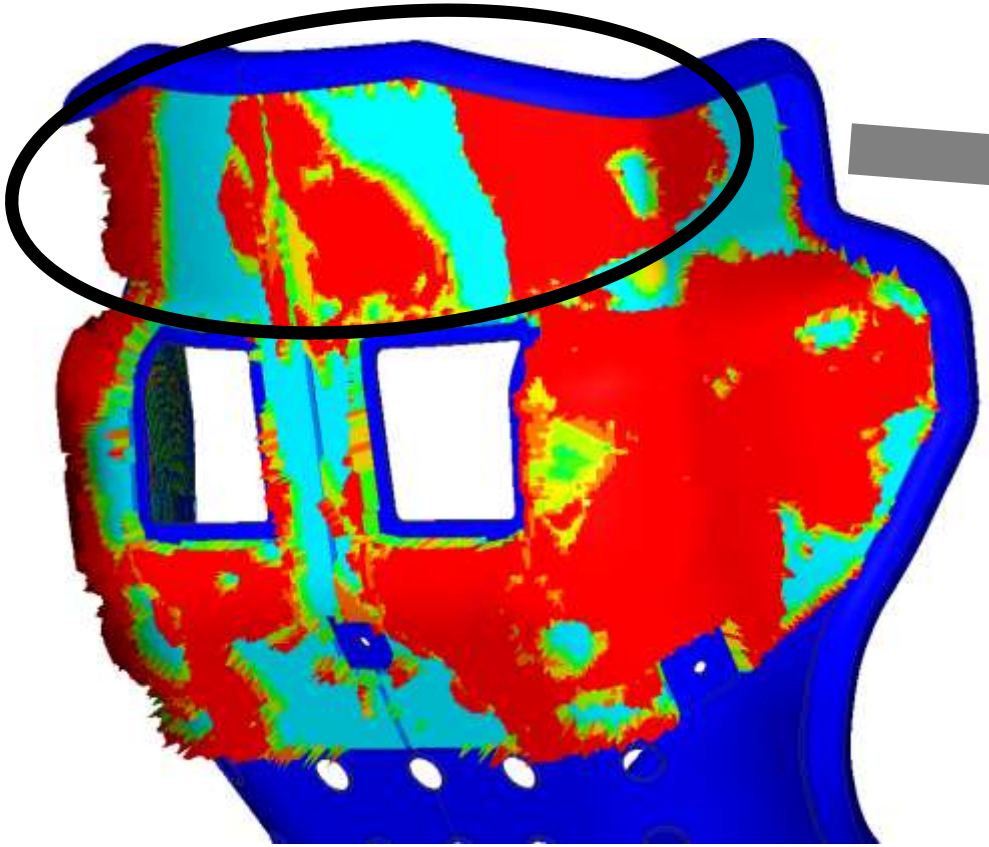




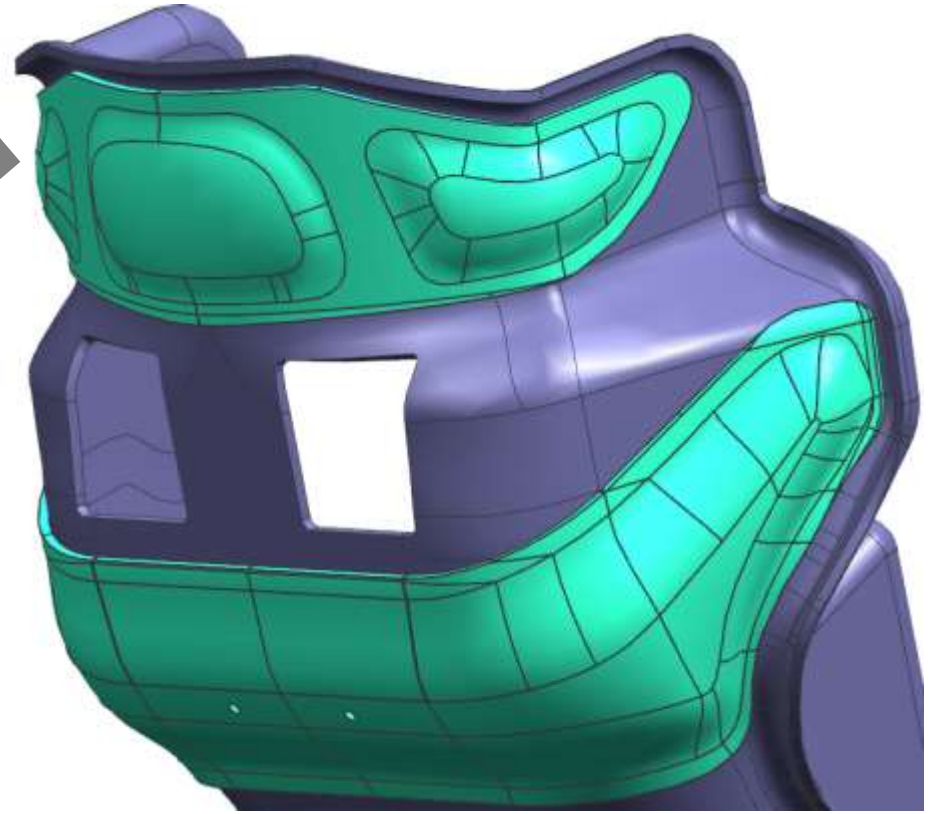


Seat Design – Implementation of Topography

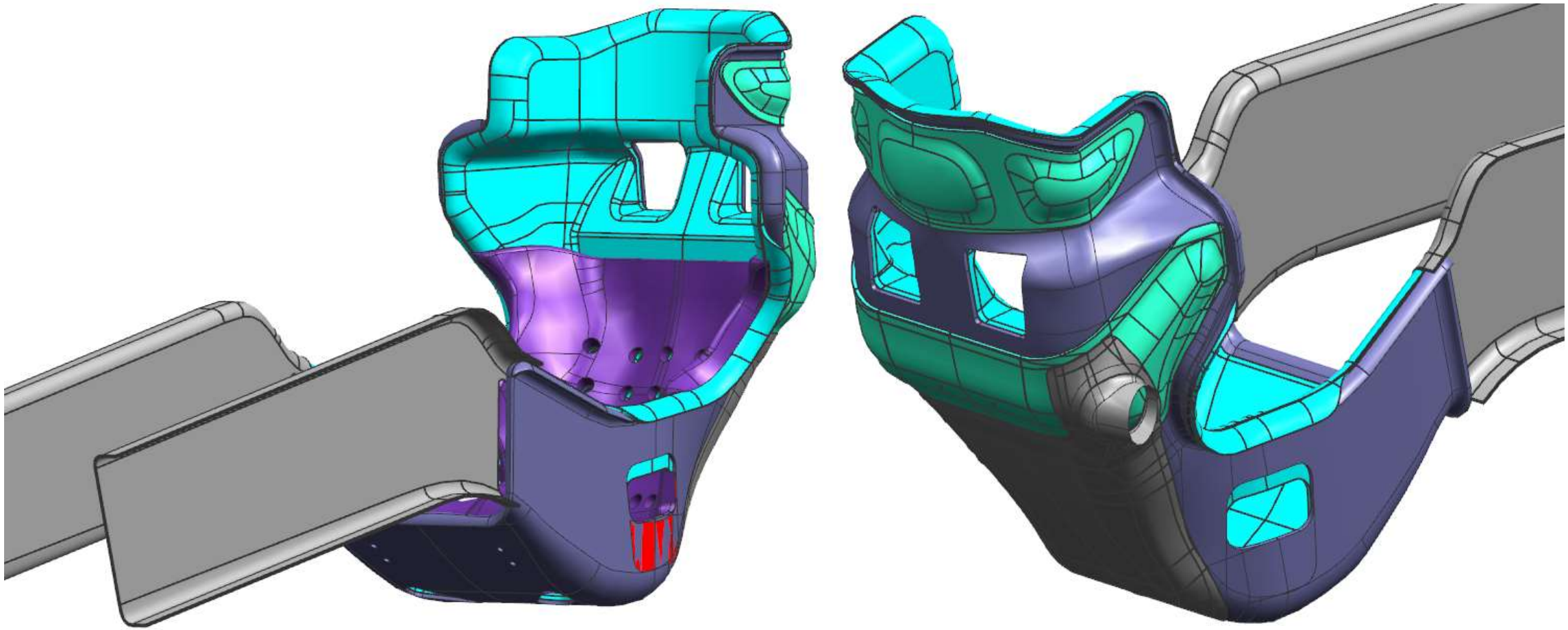
Important Takeaway from Topography Optimization



Manufacturable Interpretation of topography Optimized Hat Section



Seat Design – Final Design



Seat Manufacturing

Update on Rules Development

- 2 weeks till testing in Italy
- Crush test no longer a requirement
  - This had actually be decided months earlier

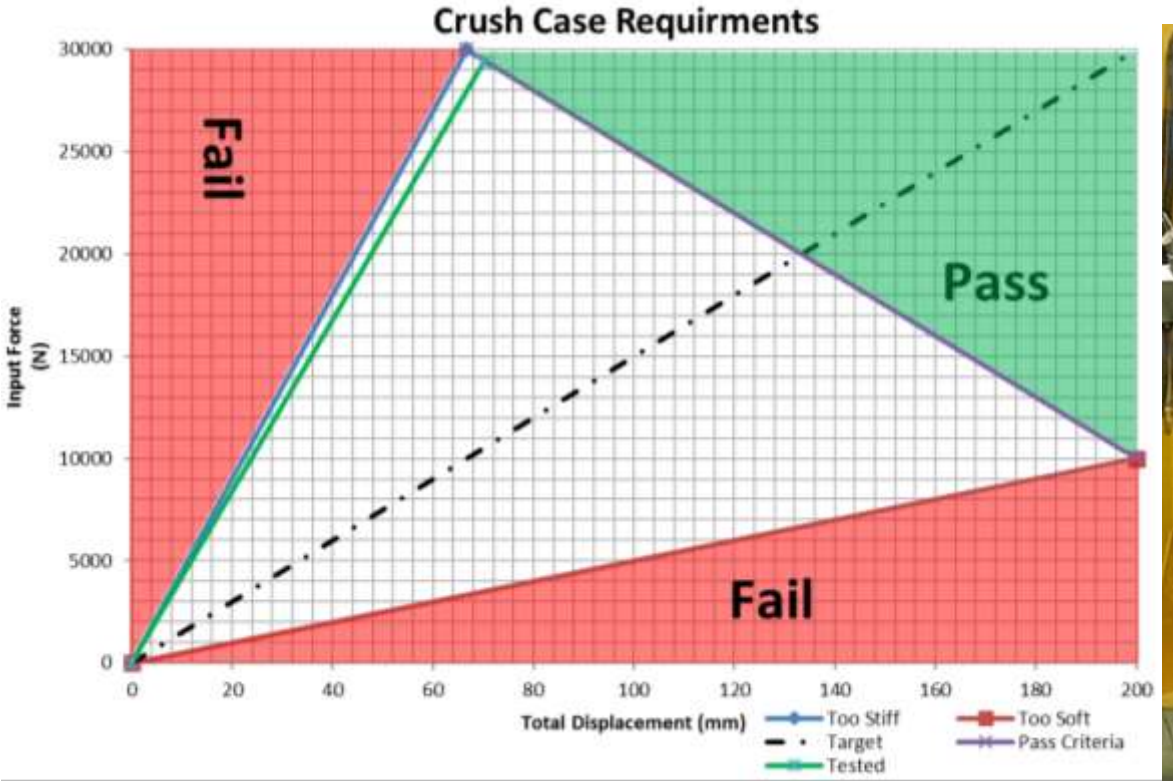
2.1 Circuit-Specific Seat

The circuit-specific seat must meet all the criteria defined in this standard, with the following two exceptions:

i) crush test, as defined in Article 7 "Performance Assessment During Crush Test 3" is not required for circuit-specific seat

ii) the seat-side-head width of 500mm, as defined on Figure A3 is not required for circuit-specific seat.

Seat Testing in Italy



Position	Time [s]	Applied Load [kN]	Deflection [mm]	Total Max. deflection [mm]
Energy side left	46.5	29.6	35.9	70.3
Energy side right	46.5	29.1	34.4	

The Results

- 3rd year racing with seat
- Drivers like the comfort
  - Complain anytime we try them in something else.
- Egress Time - No Reduction
- Performs well in wrecks
- Project seen as a success
  - We see our last ditch effort to run GENESIS topography optimization as a major contributor to that success.