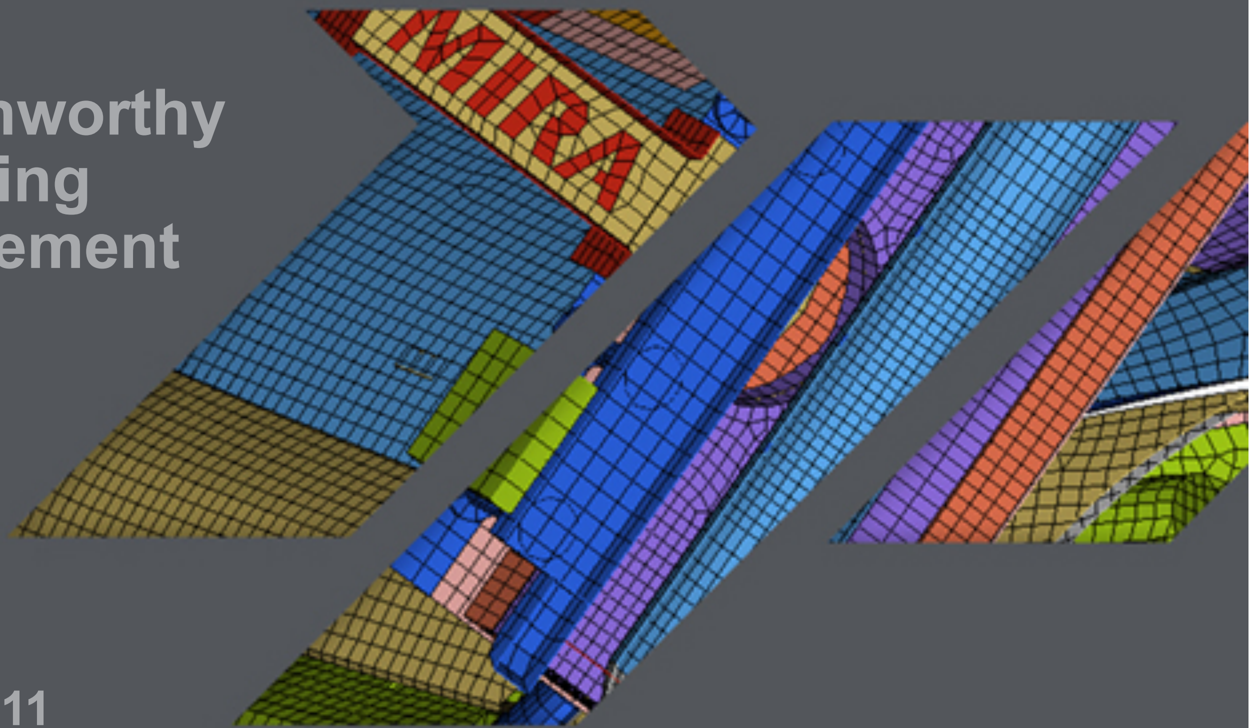
Railway Interiors expo

MIRA

Developing a Crashworthy Seating System Using Advanced Finite Element Analysis



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Railway Interiors Expo 2011

Cologne

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Smarter Thinking.

Developing a Crashworthy Seating System Using Advanced Finite Element Analysis

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    - Compin S65 Lightweight Seat Concept
- Finite Element Modelling
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Introduction

- This project was carried out for Compin Seats, Evreux, France.
- Proof of concept of Compin's S65 lightweight seating system through a simulation and test programme.
- Dynamic testing in MIRAs Hyge reverse accelerator facility to evaluate injury potential and structural integrity to AV/ST9001 standard.
- Finite Element (FE) simulation was used to predict performance prior to testing.
- The FE model was modified to improve results and liaison between engineering teams enabled a viable solution to be developed.
- First phase testing to validate simulation results.
- Design optimised to improve performance and reduce weight and cost.
- Second phase testing to achieve full compliance.

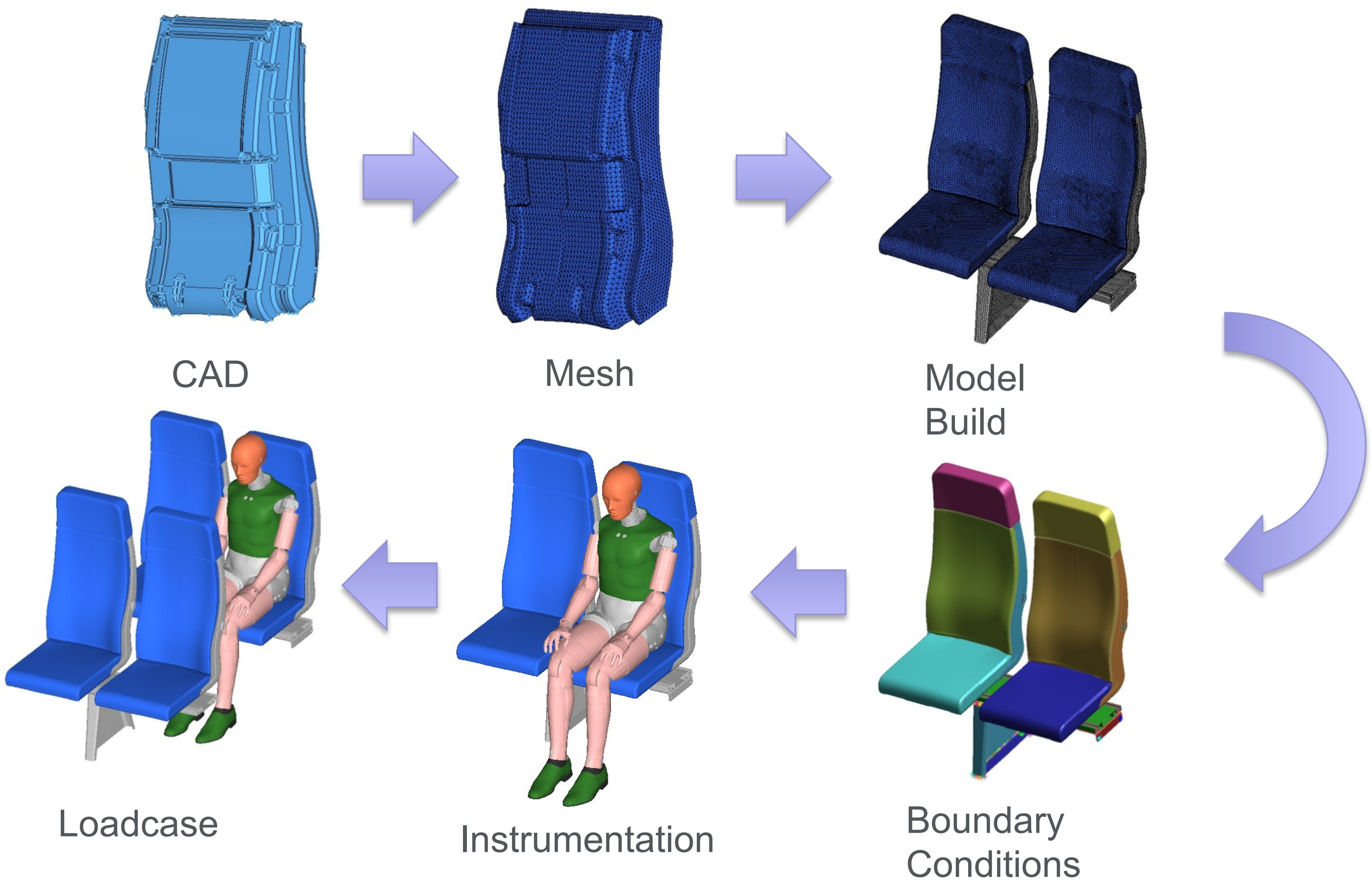
Crashworthiness Standards

- As of March 2011 rail seats in Europe are designed to meet GM/RT2100 issue 4 (RSSB/TSI).
- GM/RT2100 iss 4 superseded AV/ST9001 (RSSB) with updated injury criteria and tolerance levels.
- Defines survival space for maximum seat and table deformation.
- Clarifies definition of structural failures and component detachment.
- GM/RT2100 iss 4 also incorporates:
  - EN15227 Structural Crashworthiness
  - EN12663 Static Loadcases

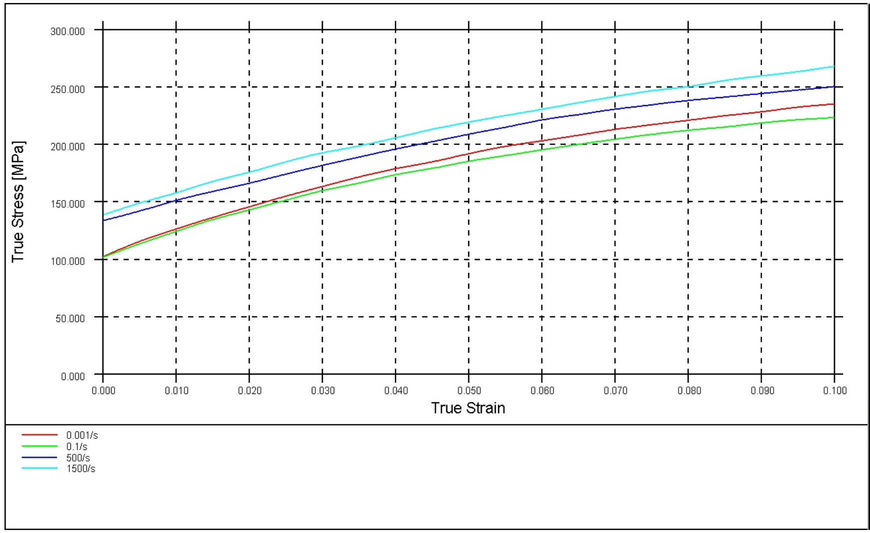
Injury Criteria	Head Resultant Acceleration	Head Injury criteria	Neck Bending moment Flexion	Neck Bending Moment Extension	Neck Injury Criteria (NIJ)	Chest Acceleration	Chest deflection	Chest V*C	Abdomen Deflection	Abdomen V*C	Femur Peak Force LH	Femur Peak Force RH	Knee Displacement LH	Knee Displacement RH	Tibia Index Up/Low LH	Tibia Index Up/Low RH	Tibia Axial Load LH
AV/ST9001	80g (3ms)	500	**190 Nm**	**-57 Nm**	Not required	Not required	**30mm**		40mm (frangible Abdomen)	Not required	4.0 kN	4.0 kN	**12 mm**	**12 mm**	**0.75**	**0.75**	Not required
GM/RT2100 issue4	80g (3ms)	500 (HIC15)	**310Nm**	**-135Nm**	1	60g (3ms)	**63mm**	1.0 ms^{-1}	40mm (HIII RS)	1.98 ms^{-1} (HIII RS)	4.0KN *	4.0kN *	**16mm**	**16mm**	**1.0 ***	**1.0 ***	8.0kN

- The S65 seat is Com
development for the
inter regional segme
- The S65 seat feature
environmentally frien
strength and high rec
- Dimensionally flexibl
widths, backrest ang
options.
- Wide range of option
function, meal tray, n
armrest and footrest.
- Designed to conform
proposed European

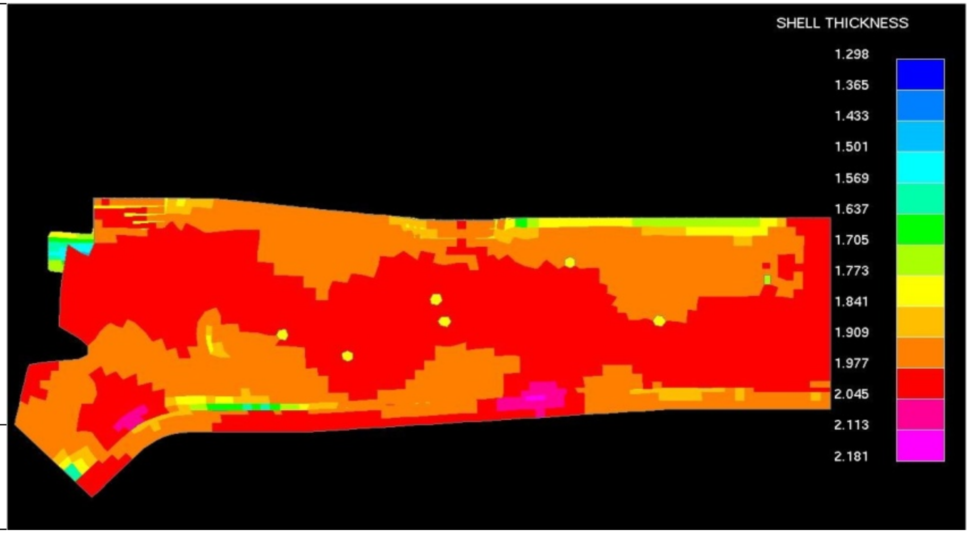
Finite Element Analysis



Material Models



Strain Rate Effects

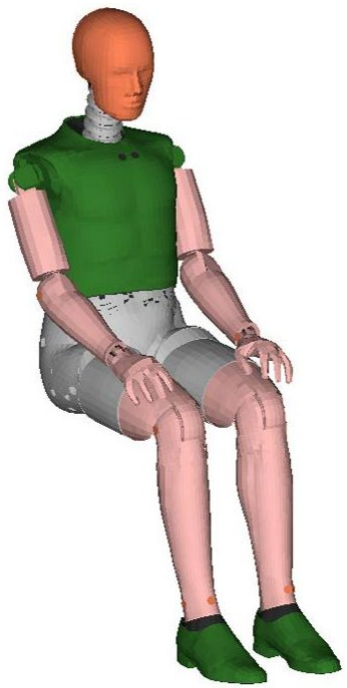


Forming Effects

- Most material properties are characterised by quasi-static tensile testing, no dynamic effects.
- Many metallic materials exhibit strain rate sensitivity where stiffness increases with the rate of deformation – important in high speed impacts.
- Manufacture method important e.g. metal forming creates initial stresses and material thinning/ thickening in complex geometry
- Work hardening and heat treatment effects also alter mechanical properties.

Dummy Models

Fully Instrumented HIII 50%ile Dummy Model

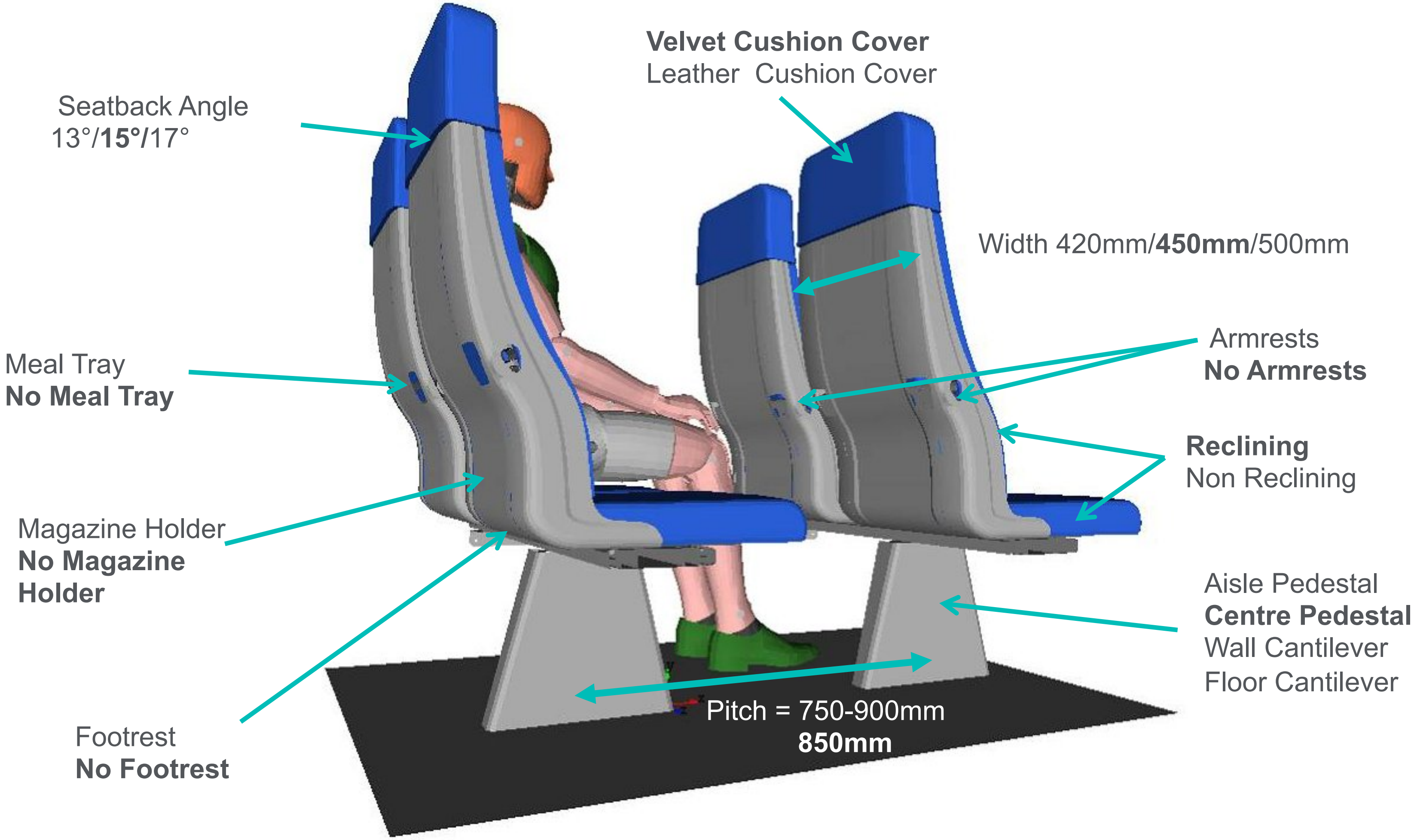


Detailed model with 130,000 elements for extracting injury criteria.

Rigid HIII 95%ile Dummy Model

Coarser model with 5000 elements for correct mass and inertia

Seat Configuration

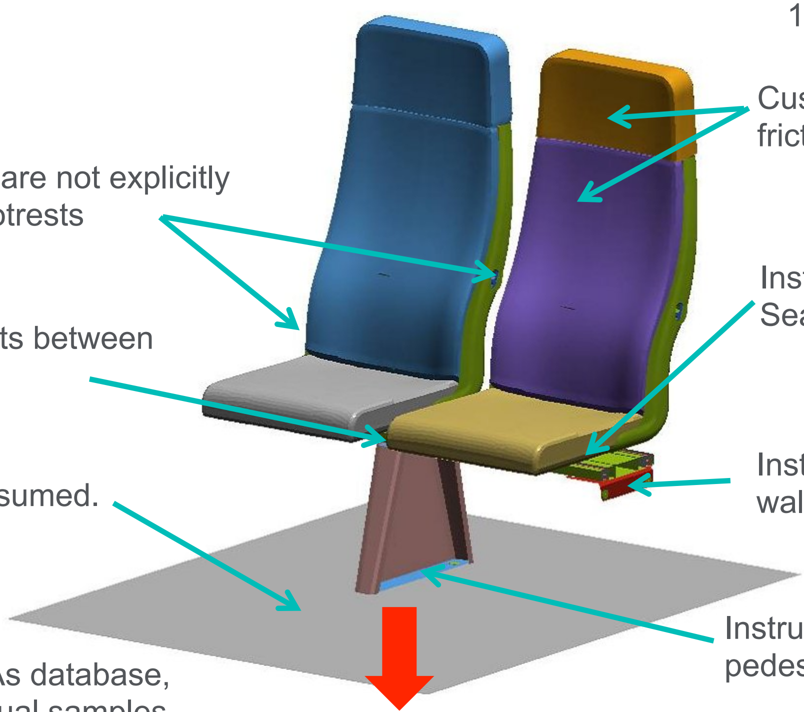


Model Details

Model run with LS-DYNA 971
explicit solver on Linux cpu cluster

Trim components (plastic) omitted

Runtime optimised:
26.7hrs on 4cpu
19.0hrs on 8cpu
11.0 hrs on 16cpu



Cushion cover coefficient of friction assumed.

Non-structural components are not explicitly modelled e.g.. Armrests, footrests

Instrumented beam elements between Seat and crossmember

Instrumented beam elements between pedestal and crossmember.

Instrumented beam elements between wall mount and side (rigid sled).

Floor coefficient of friction assumed.

Instrumented beam elements between pedestal and floor (rigid sled).

Materials are best fit from MIRAs database, higher strain rate tests from actual samples are always recommended.

Gravity defined by a constant load.

HyGe Reverse Accelerator Facility

- UKAS accredited.
- Up to 100g reverse acceleration.
- Dedicated and highly experienced test engineers and technicians
- Sled can accommodate a rail vehicle body-side and floor sections.
- Multiple seat and table configurations.
- Multiple scenarios in a single test.

Test/Simulation Loadcases

Forward

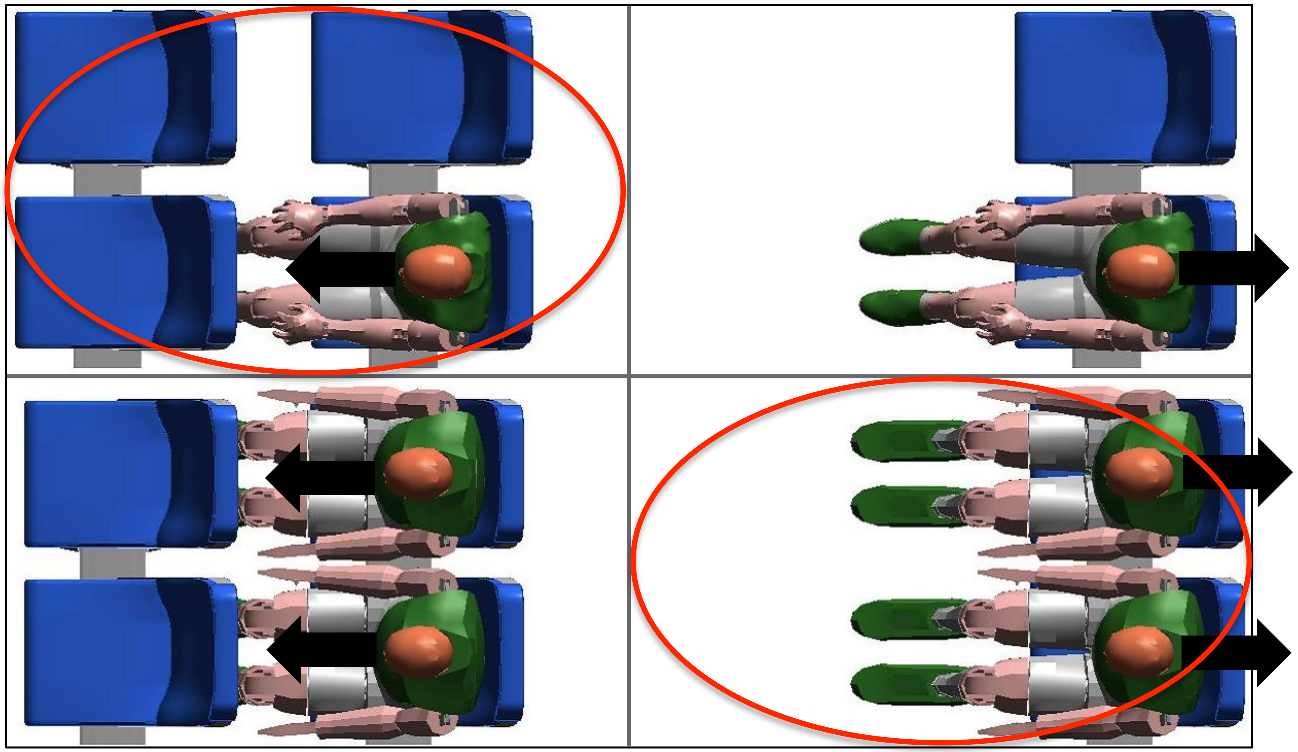
Sled Direction

Rearward

Sled Direction

Injury Potential
1x50% HIII Instrumented

Structural Integrity
2x95% HIII Ballast

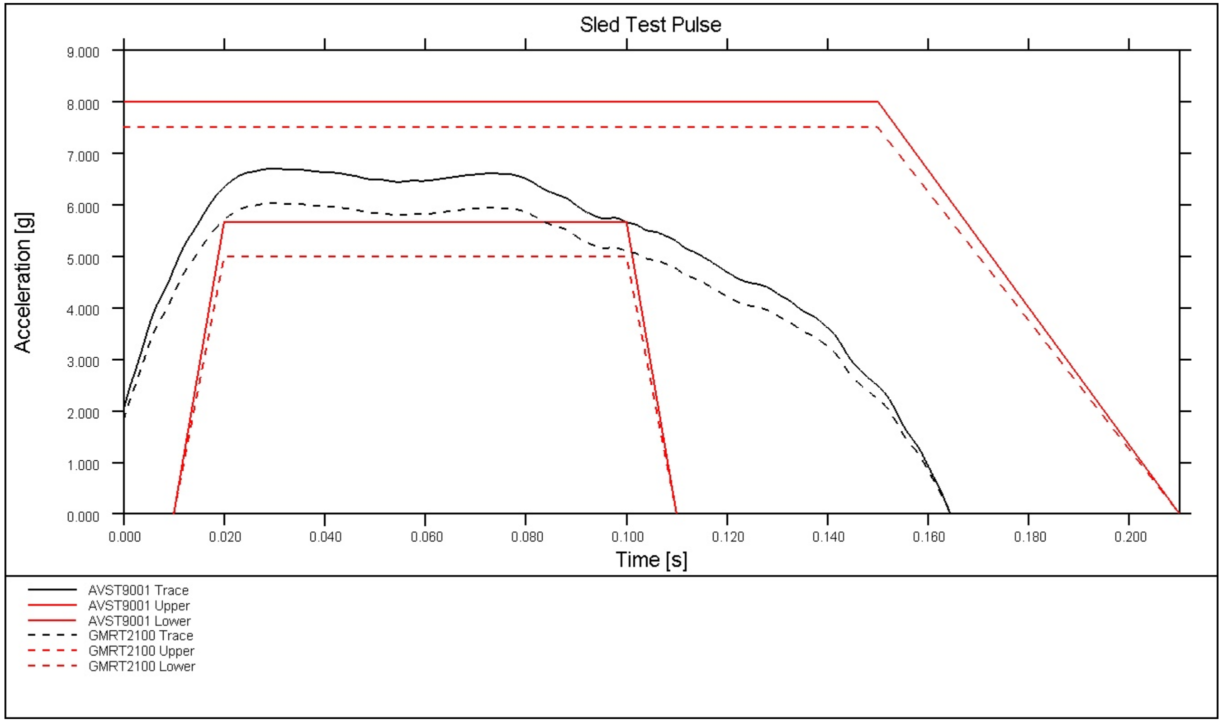


Test Seat Row

Launch Seat Row

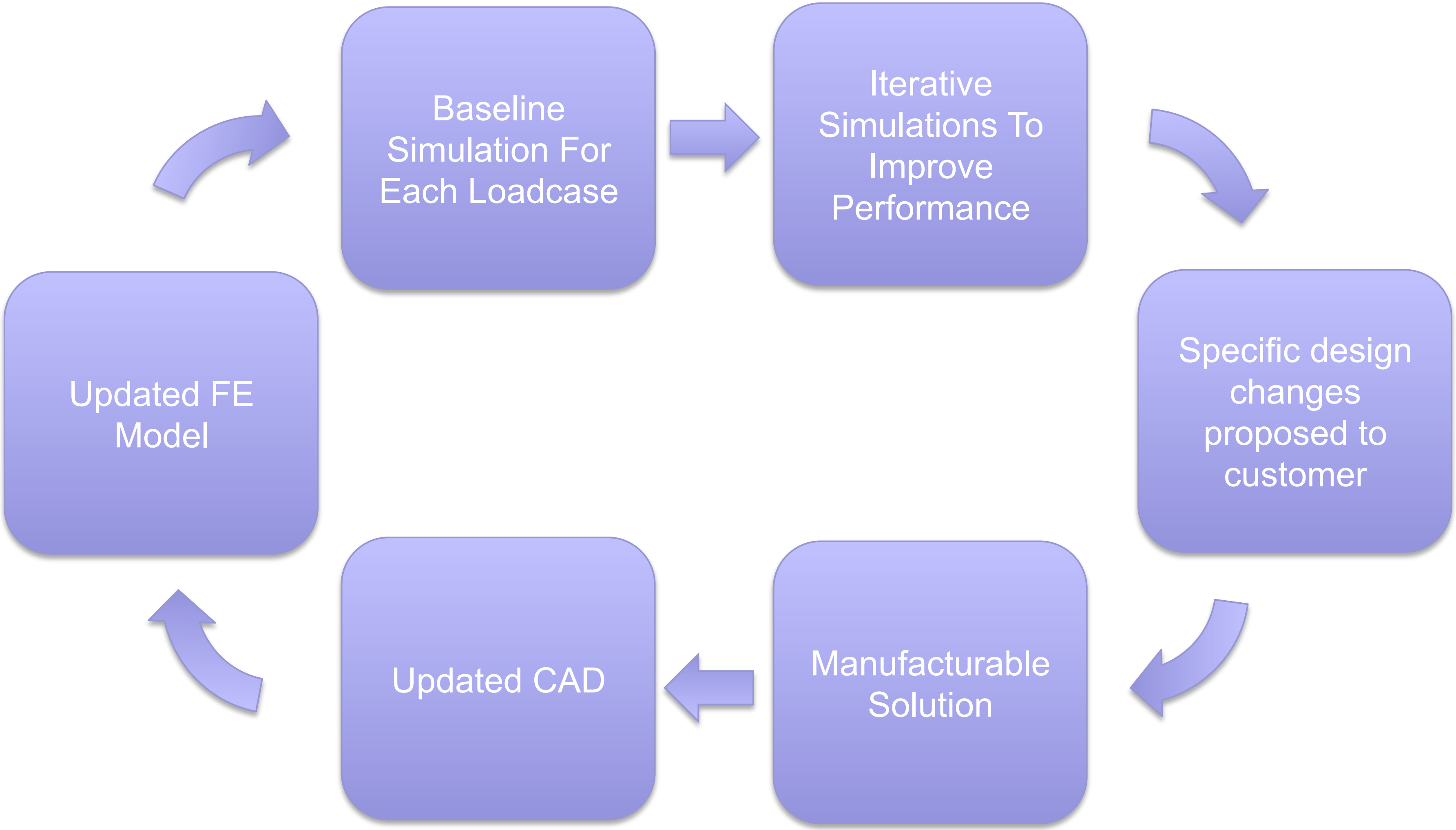
Test Seat Row

Sled Pulse

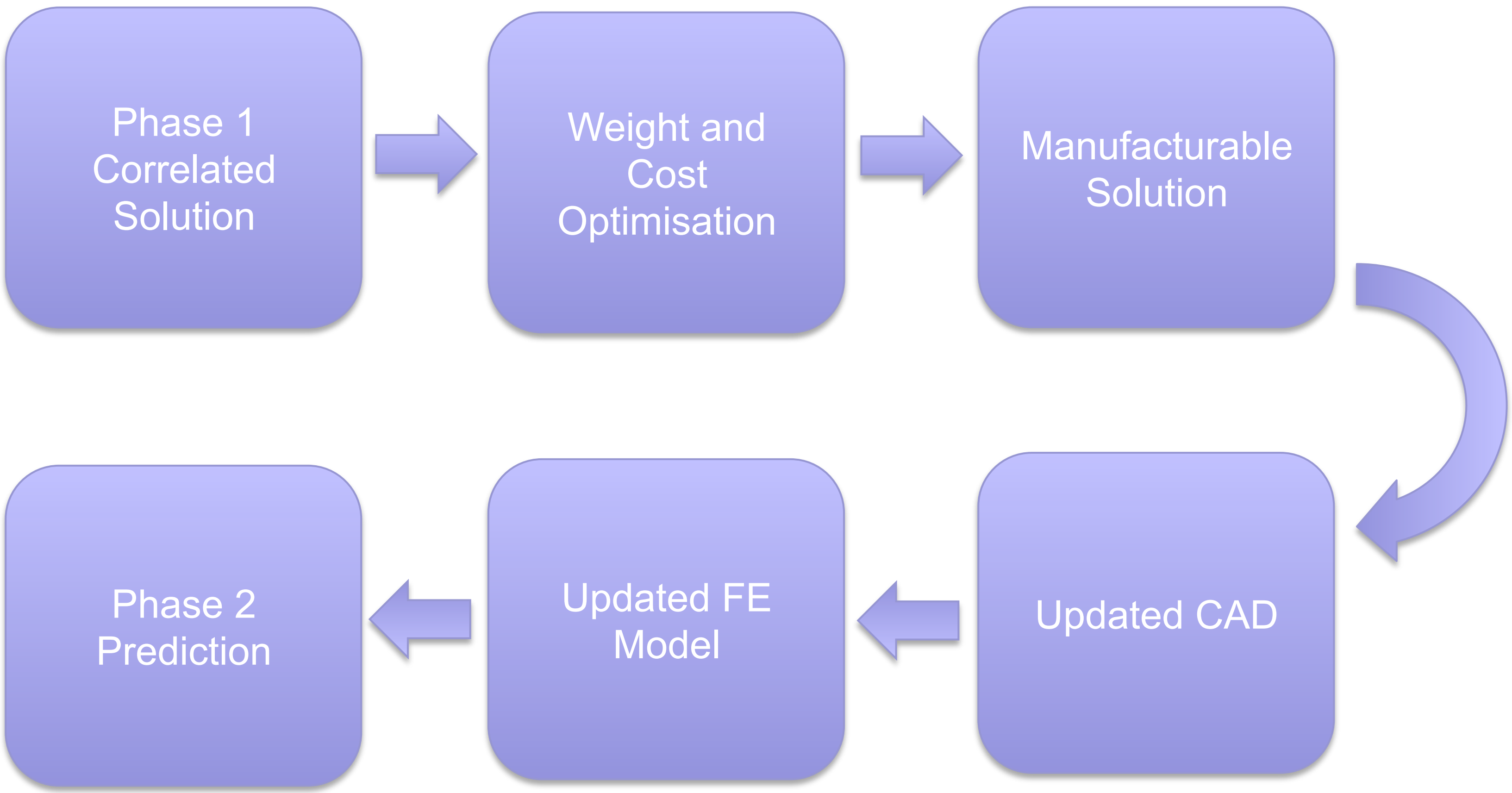


- The test pulse must remain within the limits defined in the standard, this was approx 10% higher in AV/ST9001 compared with GM/RT2100.
- The test pulse is generated through careful design of the HYGE metering pin.
- In the simulation, the pulse is applied as a prescribed motion on the sled.

Phase 1 Concept Design

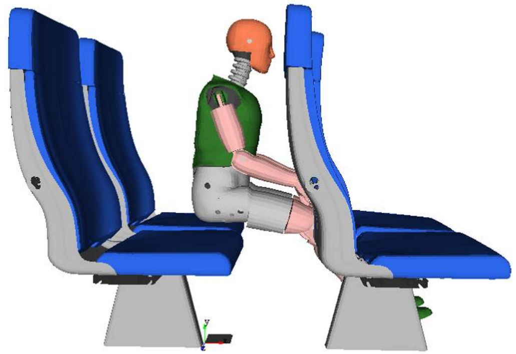


Phase 2 Design Optimisation

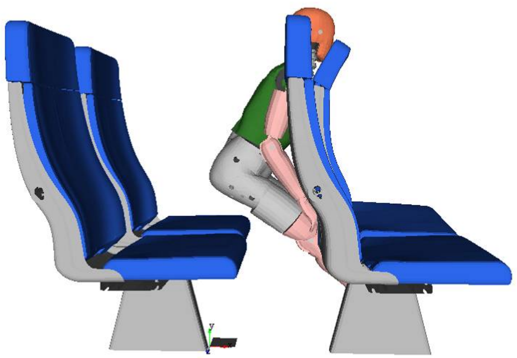


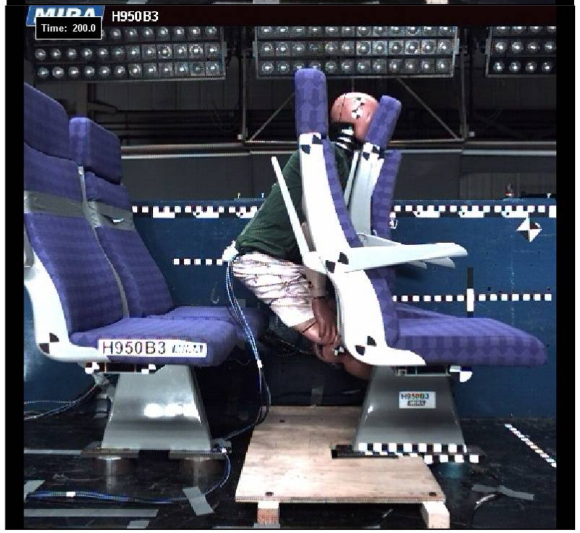
Correlation - Injury Potential Forward

120ms
Lower Leg Impacts Seat Back



200ms
Head Impacts Headrest





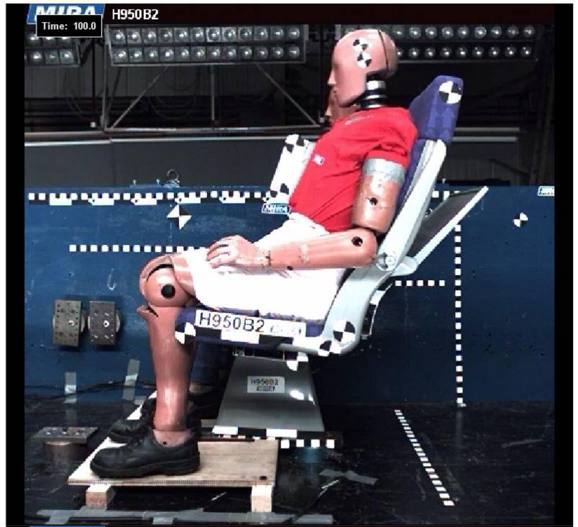
Correlation - Injury Potential Forward

Injury Criteria AV/ST9001		Max	Target	D3041	D3096	943E1	I3120	950B3
6.6.1 Injury Criteria				Orig Pred	Ph1 Pred	Ph1 Test	Ph2 Pred	Ph2 Test
(a)	HIC (18ms)	500	400	929	255	251	177	178
(b)	Max Head Acceleration (3ms)	80g	64g	95.1g	66.9g	52.8g	32.7g	49.4g
(d)	Neck Bending Moment Extension	57Nm	45.6Nm	39.3Nm	28.4Nm	23.0Nm	17.7Nm	21Nm
(e)	Femur Peak Compressive Load	4000N	3200N	6430N (LH)	5440N (LH)	5746N (RH)	4412N (RH)	4404N (LH)
(f)	Sliding Knee Displacement	12mm	9.6mm	16.5mm	8.4mm	4.9mm	7.7mm	6.1mm
(g)	Tibial Index	0.75	0.6	1.35	0.63	0.67	0.65	0.74

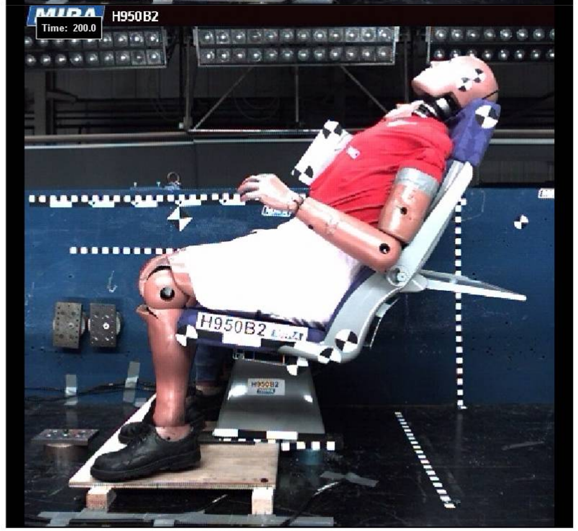
- Very good correlation for HIC, femur loads and Tibial index
- The improvements made from the original concept through phase 1 and phase 2 optimisation processes were validated by the physical testing.

Correlation - Structural Integrity Rearward

100ms
Initial Seat Rotation

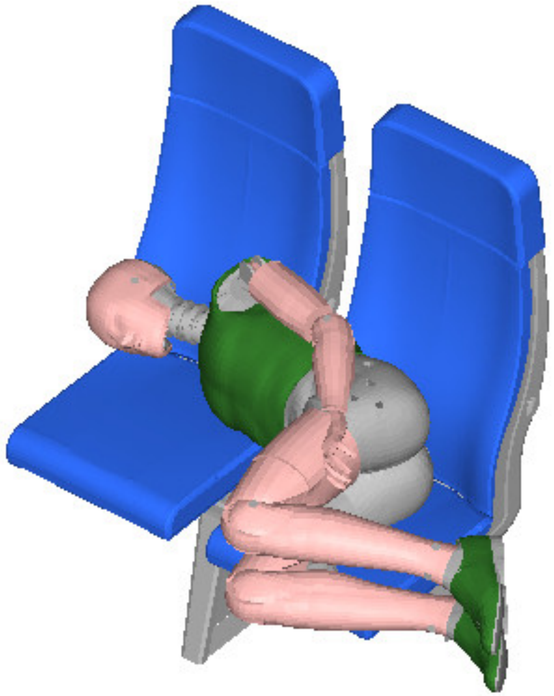


200ms
Peak Loading Into
Seat Structure



Conclusions

- The initial predictions revealed that with some design changes, the crashworthiness requirements could be met.
- Phase 1 testing with the design changes in place gave comparable results against the predictions.
- Further simulation iterations allowed the performance, weight and cost to be optimised.
- Phase 2 testing validated the optimisation process and compliance was achieved.
- Simulation offers a cost effective alternative to physical testing.
- Future legislation is likely to offer simulation as an option providing it can be validated against physical testing at component or full scale level.



Thank You For Your Attention!

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