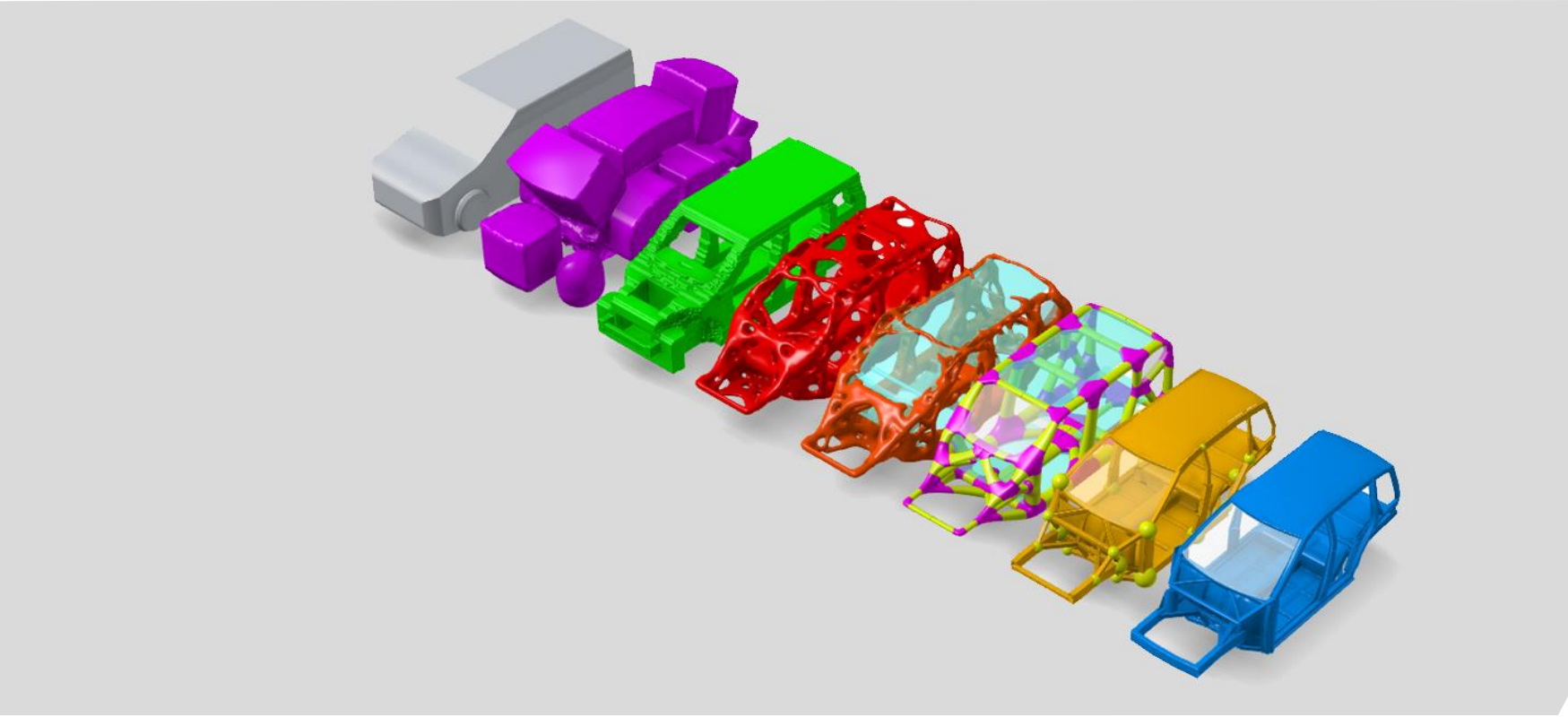

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ALTAIR CONCEPT C^{123} BRIEF OVERVIEW

Jan, 2024

CONCEPT DEVELOPMENT

Altair Concept[123] Concept Process
Developed Over a Decade (approx. 2010) - Live Process
Great Example of MODVIZ, Solver, AI Integration
Rapid Design Exploration - Package Play – Innovation Generator - Disruptive
Optimization Driven & Inherent Robustness, System Assessment
Target Setting / Quality / Trade-offs / Cascading
Speed Promotes Concurrent Working Removing Attribute Siloes

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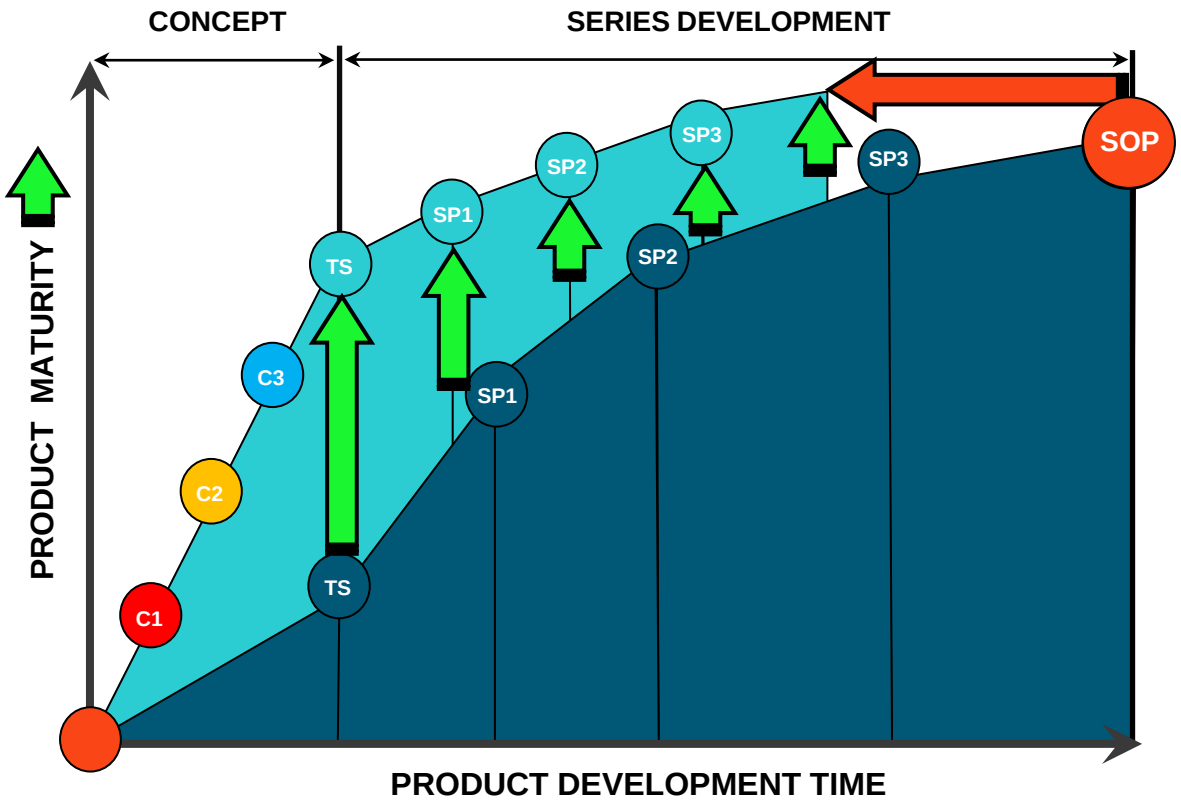
Schematic BIW Design Process

Delivers Key Business Benefit – Significant Development Time Reduction with Increased Maturity



Example :
Industry Step Change
‘24 Month Car’

Standard Development

Simulation Driven Design

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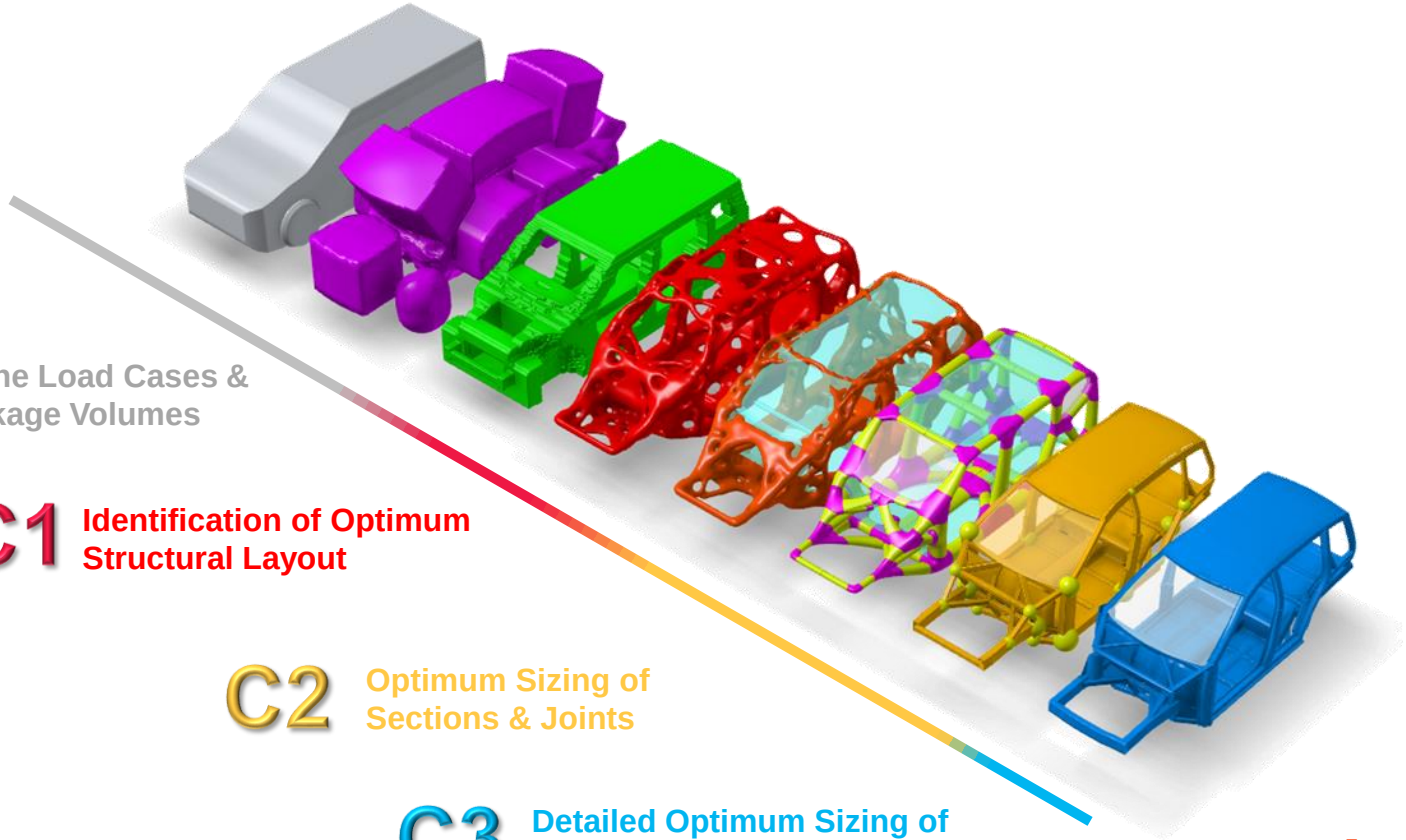
C^{123} Vehicle Concept Development Process



C0 Define Load Cases & Package Volumes

C1 Identification of Optimum Structural Layout

C2 Optimum Sizing of Sections & Joints

C3 Detailed Optimum Sizing of Manufacturable Sections & Joints

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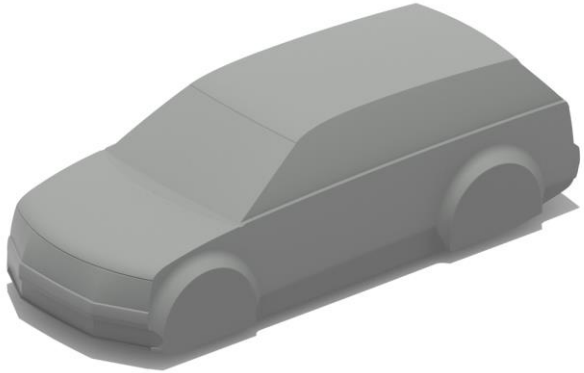
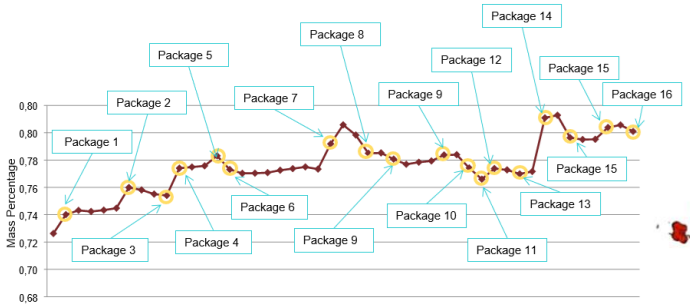
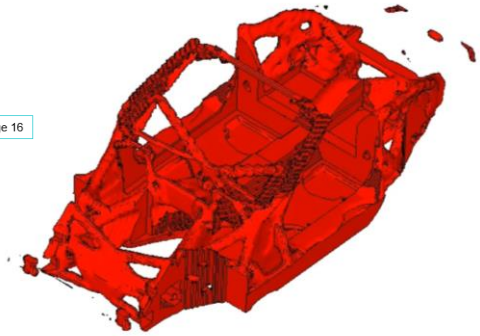
C1 Identification of Optimum Structural Layout

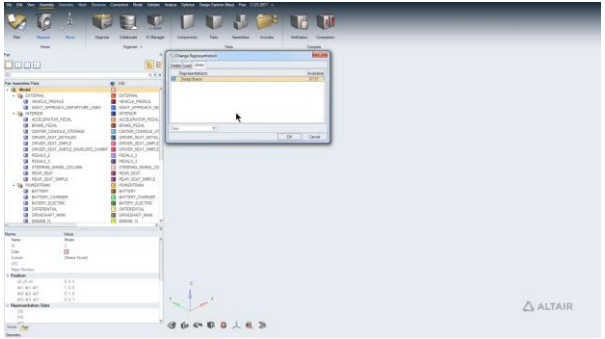


Package Space Exploration

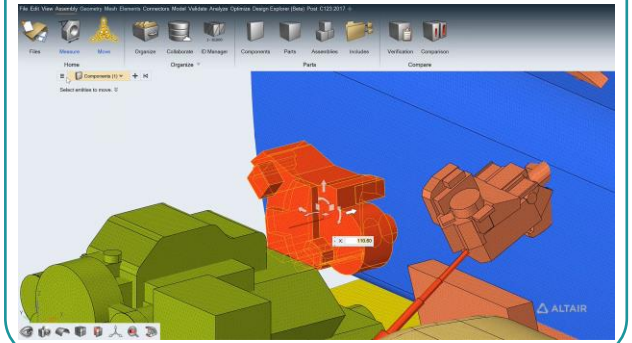




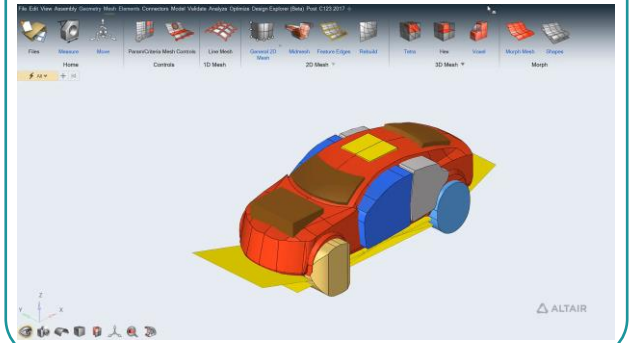
Design Space Library



Package Space Manipulation



Fast Design Space Generation/Edit



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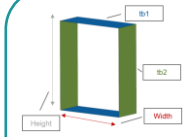
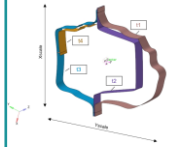
C2 Optimum Sizing of Sections & Joints

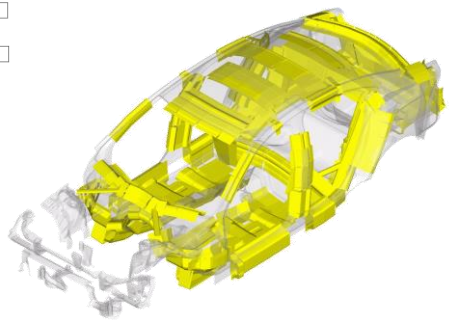
Section Sizing



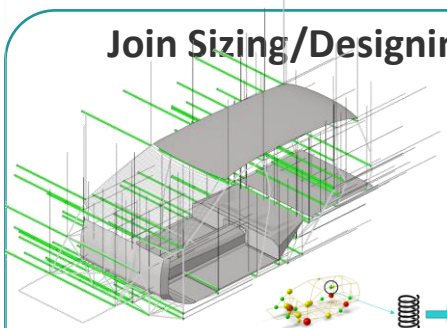
Idealised Box Sections

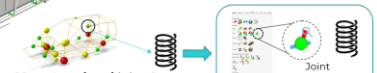


Real World (RW) Sections

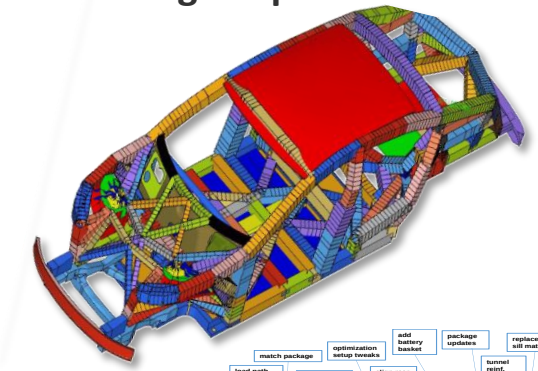


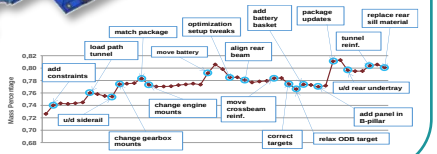
Join Sizing/Designing



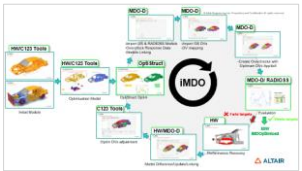


Fast Design Exploration

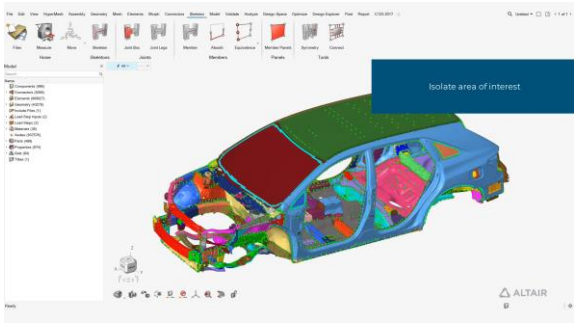




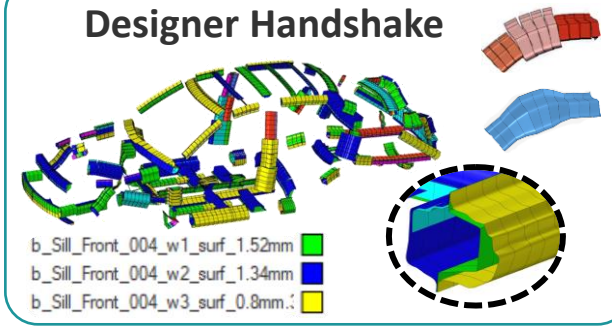
Rapid Crash Overchecks



Fast & Easy Model Build



Designer Handshake



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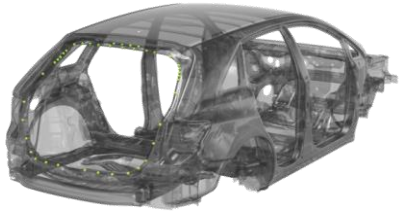
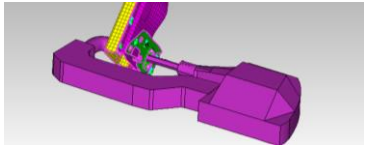
C3 Detailed Optimum Sizing of Manufacturable Sections & Joints

Industrialisation refinement

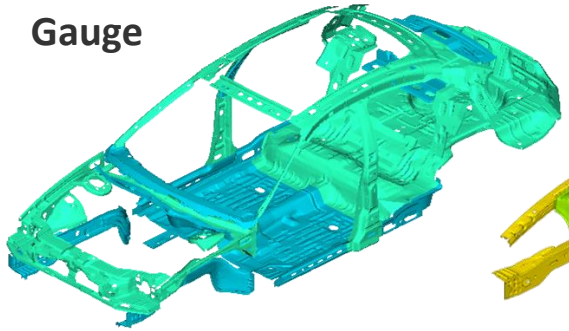
Joining technology, Connection placement optimisation, Gun accessibility checks…

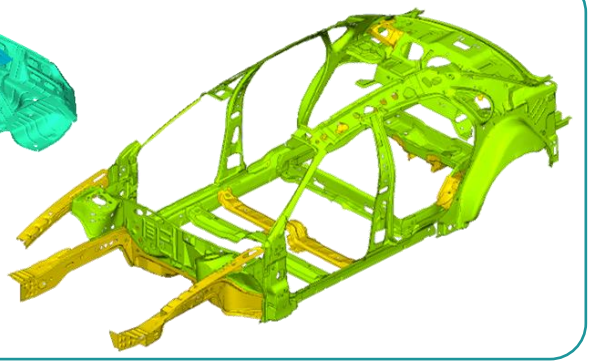
- **Bill of Process** — Tool makes joining decisions in line with manufacturing process chronology
- **Bill of Materials** — BoM used to aid joining selection & pitch decisions
- **Geometric Checks** — Detailed assessment of proposed joint location suitability conducted
- **Manufacturing Rules** — Key manufacturing constraints regarding joinability of certain materials considered.
- **Gun Clash Detection** — Tool checks that a rivet/RSW gun can reach the proposed site.
- **Meshed Model** — Geometry extracted from meshed model





Gauge

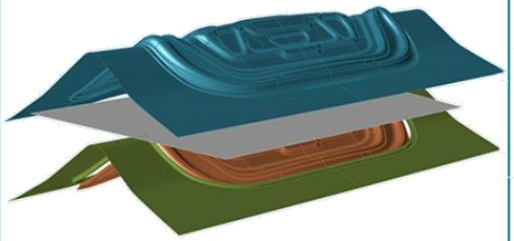




Value Engineering

€

Manufacturability



Ply stackup

1. If the outer layers have different thicknesses, check that:

$$\frac{maximum\ outer\ layer\ thickness}{minimum\ outer\ layer\ thickness} < maximum\ allowed\ ratio$$

2. If the outer layers have the same thickness, check that:

$$\frac{max(inner\ layer\ thickness, outer\ layer\ thickness)}{min(inner\ layer\ thickness, outer\ layer\ thickness)} < maximum\ allowed\ ratio$$

Gauge loadcase sensitivity

DESVAR	LABEL	DESCRIPTION	30kmh Barrier	BOF10 Roof	BOF10 Front	BOF10 Rear	ECER29 Roll Over 90	ECER29 Roll Over180
1	PSHELL_37	CROSS MEMBER	YES					
3	PSHELL_40	VERTICAL MEMBERS FRT						
6	PSHELL_81	MEMBER				YES		
10	PSHELL_168	SIDE PANEL LFT		YES	YES	YES	YES	YES
11	PSHELL_172	A-PILLAR LFT	YES		YES		YES	YES
13	PSHELL_181	REINFORCING PLATE LFT	YES					
14	PSHELL_197	B-PILLAR LFT	YES		YES		YES	YES
15	PSHELL_200	C-PILLAR LFT INR		YES		YES		YES
16	PSHELL_206	SIDE REINFORCEMENT UPR LFT					YES	YES
17	PSHELL_210	DOOR FRAME LFT	YES		YES		YES	YES
18	PSHELL_211	C-PILLAR LFT OTR				YES		YES
19	PSHELL_225	REINFORCING PLATE RGT	YES					
21	PSHELL_272	SIDE PANEL RGT		YES		YES	YES	
22	PSHELL_279	A-PILLAR RGT	YES				YES	
23	PSHELL_280	C-PILLAR RGT INR		YES		YES		
25	PSHELL_283	B-PILLAR RGT	YES				YES	
26	PSHELL_314	SIDE REINFORCEMENT UPR RGT					YES	
27	PSHELL_317	C-PILLAR RGT OTR				YES		
28	PSHELL_318	DOOR FRAME RGT	YES				YES	
30	PSHELL_369	REINFORCEMENT A-PLR RGT	YES				YES	
31	PSHELL_380	REINFORCEMENT A-PLR LFT	YES				YES	
35	PSHELL_5739	PLATE	YES					

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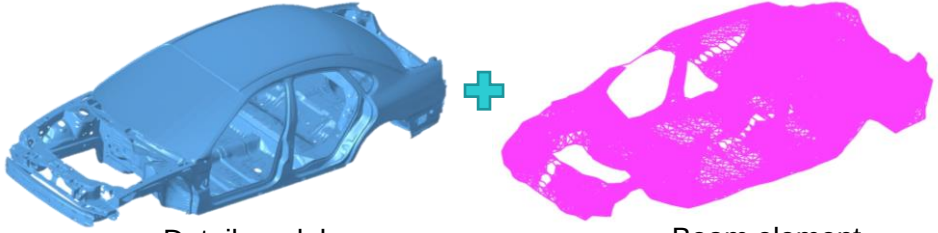
Exoskeleton – Concept generation & Improvement



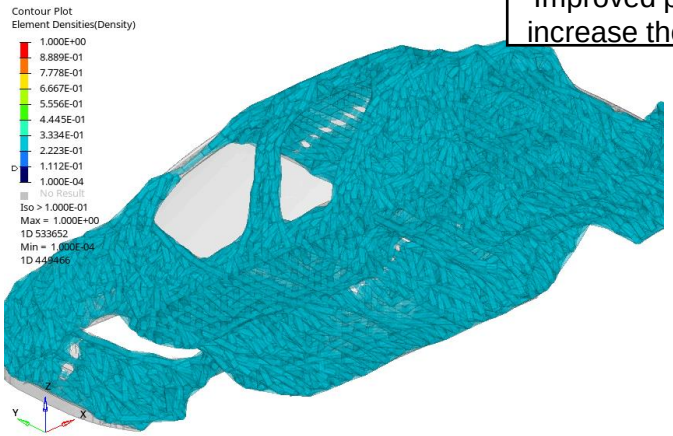
Detail model

Beam element

Exoskeleton model

- Ability to create little extra potential loadpaths
- Can be used on an existing mesh (tie contact)
- Helps with non-intuitive problem e.g. global mode
- Quickly identify where the user should focus attention for solving a problem

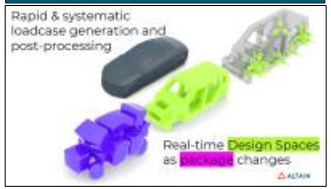
Improved performance by increase the potential area



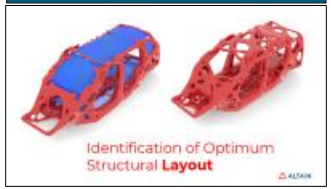
Exoskeleton result

Altair Concept C[123]

C0: Design Space

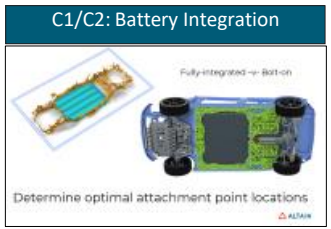


C1: Layout



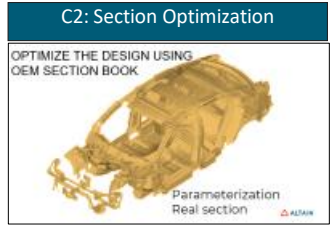
C1: Collaboration

C1/C2: Battery Integration

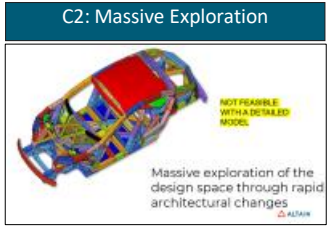


C2: Design Direction

C2: Section Optimization



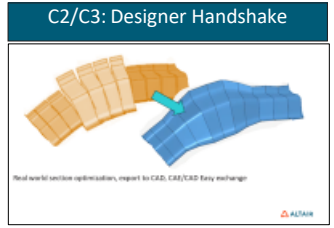
C2: Massive Exploration



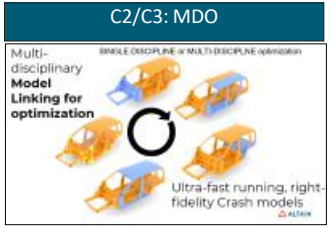
C2: Targets

C2: Joints

C2/C3: Designer Handshake

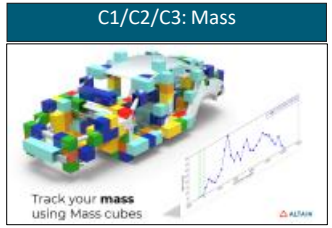


C2/C3: MDO



C3: Detailed

C1/C2/C3: Mass



C2/C3: Diagnostics

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RECENT EXECUTIONS
DIFFERENT SUPPORT MODELS

Knowledge Transfer, Training Software & Methods

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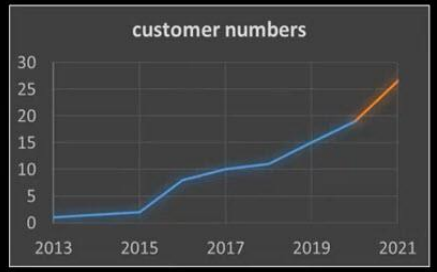
Customers

C1

C2

C3



Hyundai

Zoox

NEVS

Daimler

FCA

Aston Martin

Ford

Ferrari

Dyson

JAGUAR

LAND ROVER

JLR

CEVT

BMW

NIO

北汽集团 BAIC Group

Beijing Auto

Renault

PSA

Benteler

CSR sifang

Changan Auto

Guangzhou Auto

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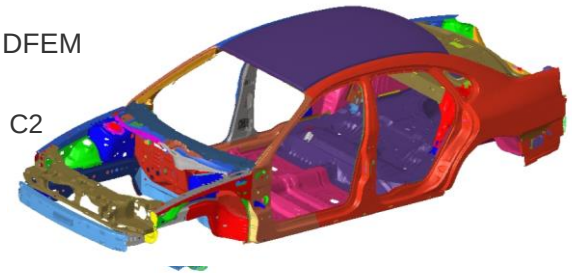
Detailed model vs. C2 model – Accuracy and CPU time

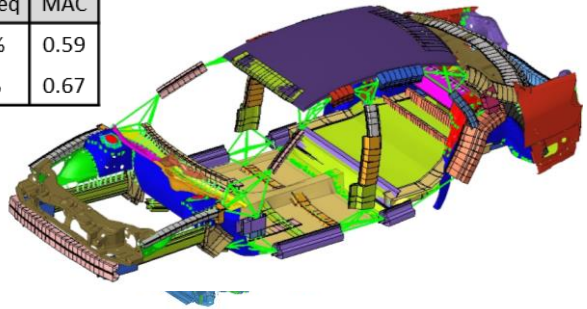
DFEM

C2

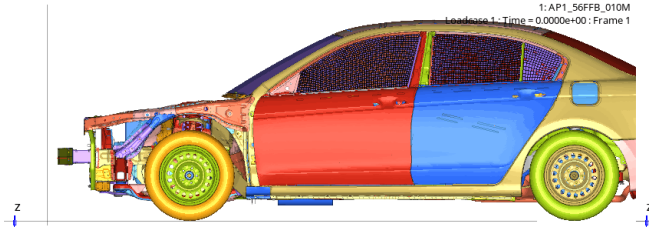


DFEM

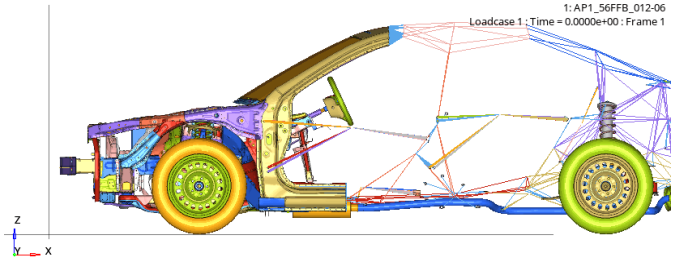
#	Delta Freq	MAC
Torsion	-2.60%	0.59
Bending	0.90%	0.67



C2



Detailed Models



'Right-Fidelity' Models

	High Fidelity (DFEM)	Low Fidelity (C2)
Modal Analysis	30min	1min
56kph FFB crash	7hrs (32CPU)	30mins (32CPU)

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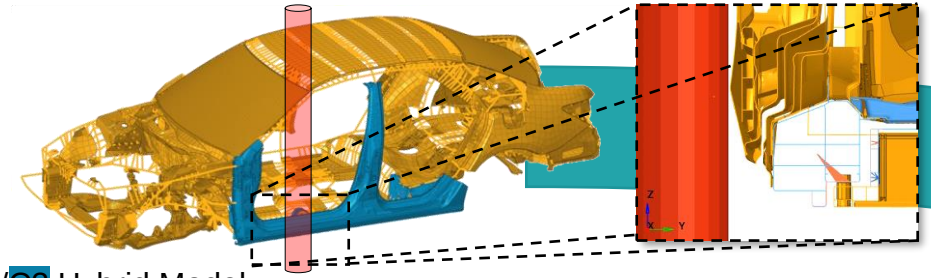
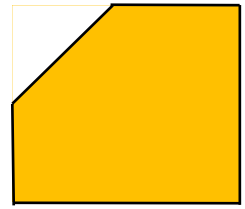
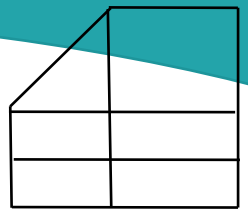
Rocker application – C2 + Radopt + AI

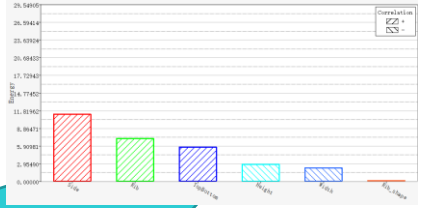


C2/C3 Hybrid Model
Exported Sill Concepts
Side Pole Impact

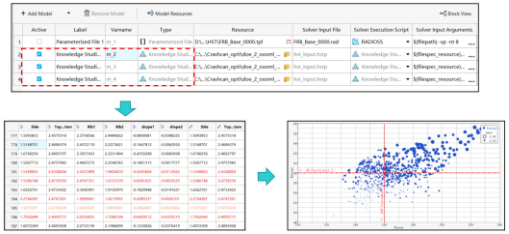




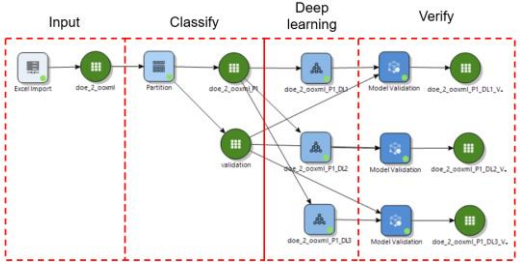
Radopt



C2 + DOE



HST + Knowledge studio
Rocker reduce 19% of mass



Knowledge studio – Deep learning

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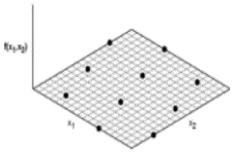
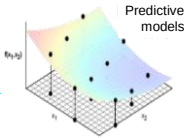
Machine Learning

Automatic Identification of Crash Behaviour Clusters

Traditional Response surface-based optimization

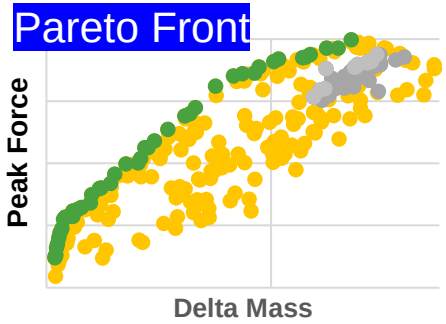


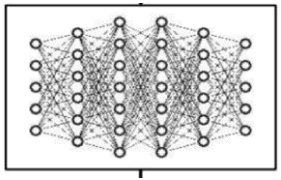
DoE



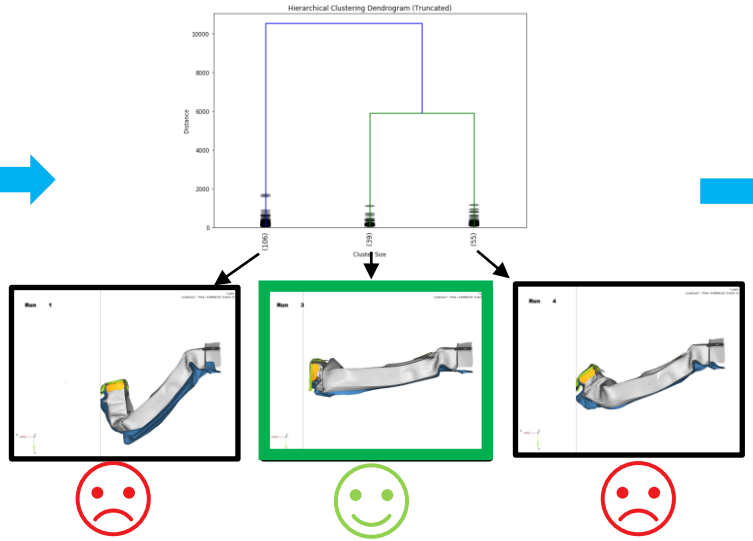
e.g. Peak Force
Prediction

Multi-objective optimization
Peak force vs. Mass





Machine Learning
Behaviour clusters

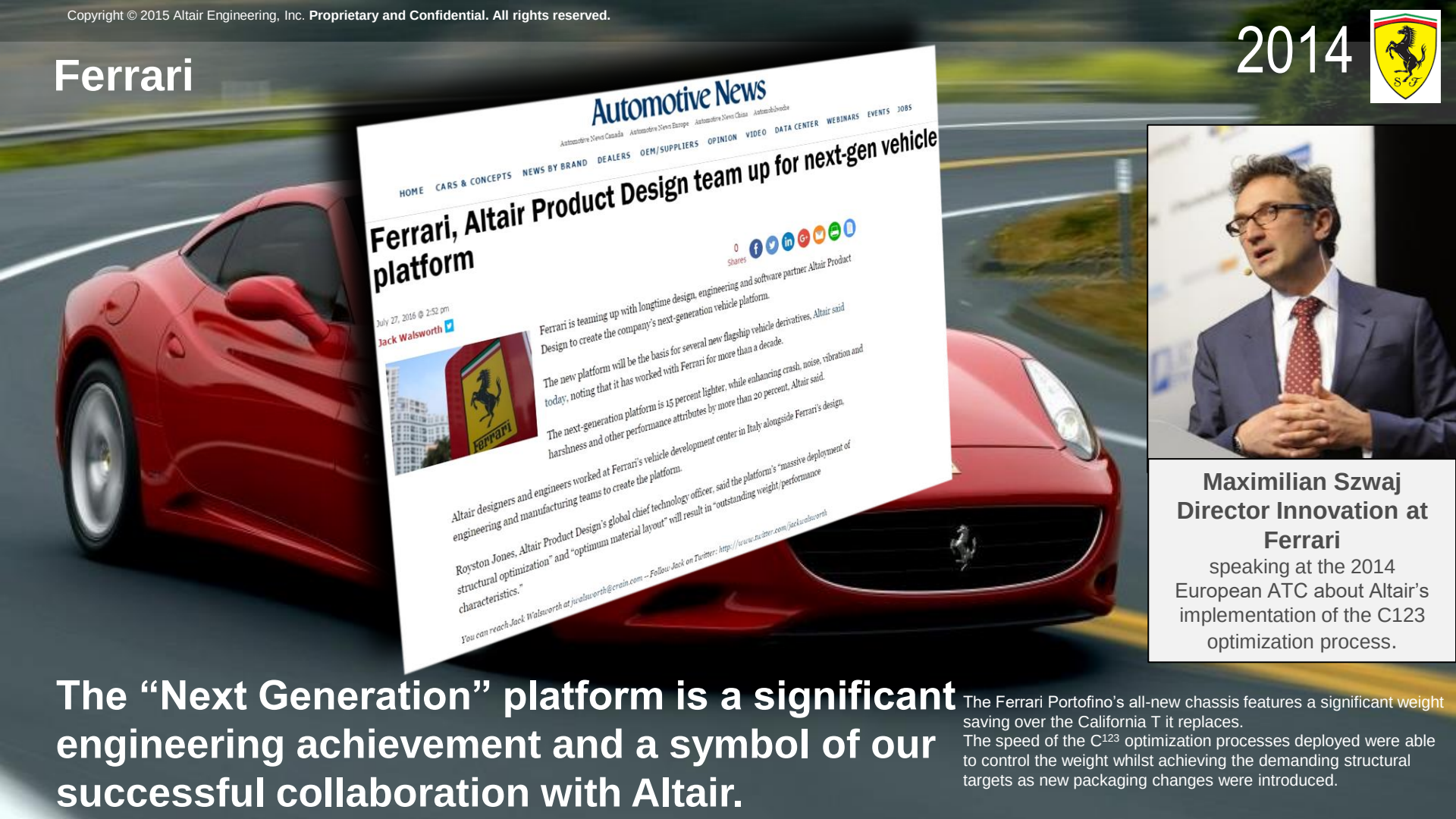


Optimization with ML constraints

Multi-objective optimization
Peak force vs. Mass
Add constraint of desired deformation shape (ML)

Ferrari

2014



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Ferrari, Altair Product Design team up for next-gen vehicle platform

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July 27, 2016 @ 2:52 pm

Jack Walsworth

Ferrari is teaming up with longtime design, engineering and software partner Altair Product Design to create the company's next-generation vehicle platform.

The new platform will be the basis for several new flagship vehicle derivatives, Altair said today, noting that it has worked with Ferrari for more than a decade.

The next-generation platform is 15 percent lighter, while enhancing crash, noise, vibration and harshness and other performance attributes by more than 20 percent, Altair said.

Altair designers and engineers worked at Ferrari's vehicle development center in Italy alongside Ferrari's design, engineering and manufacturing teams to create the platform.

Royston Jones, Altair Product Design's global chief technology officer, said the platform's "massive deployment of structural optimization" and "optimum material layout" will result in "outstanding weight/performance characteristics."

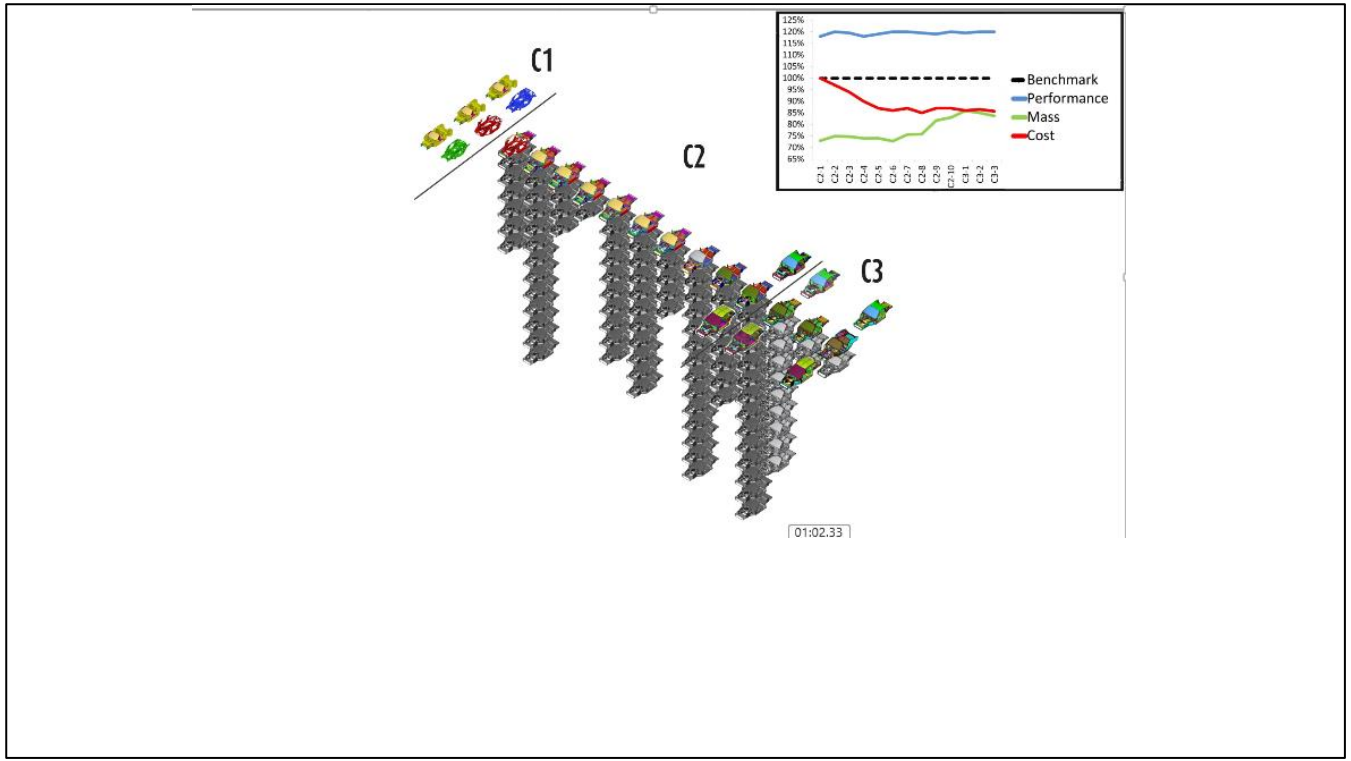
You can reach Jack Walsworth at jwalsworth@crain.com -- Follow Jack on Twitter: http://www.twitter.com/jackwalsworth

Maximilian Szwaj
Director Innovation at Ferrari
speaking at the 2014 European ATC about Altair's implementation of the C123 optimization process.

The "Next Generation" platform is a significant engineering achievement and a symbol of our successful collaboration with Altair.

The Ferrari Portofino's all-new chassis features a significant weight saving over the California T it replaces.
The speed of the C^{123} optimization processes deployed were able to control the weight whilst achieving the demanding structural targets as new packaging changes were introduced.

C123 – VIRTUAL DEVELOPMENT GARAGE – EXAMPLE (FERRARI)



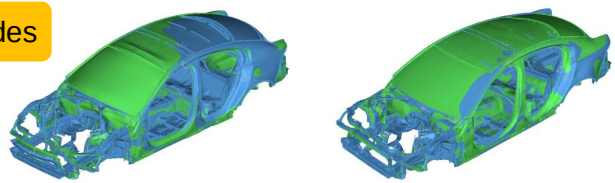
Ferrari

ALTAIR

JLR C2 PoC 2019

NVH

Modes

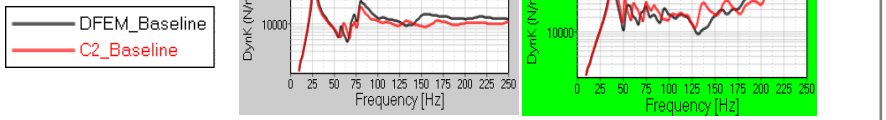


DFEM

C2

#	Delta Freq	MAC
Torsion	-2.60%	0.59
Bending	0.90%	0.67

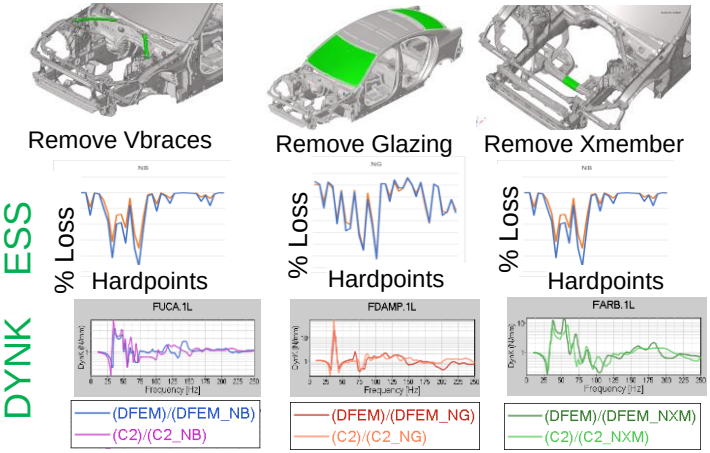
Dynamic Stiffness



ESS

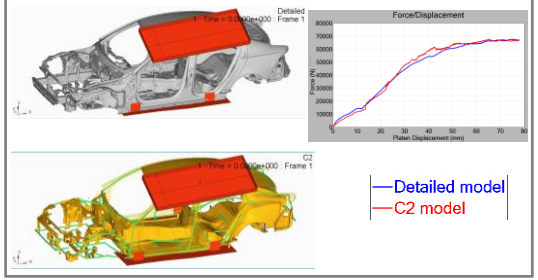
HP		Delta
FLCA.1L	x	6.7%
FLCA.1L	y	-8.6%
FLCA.1L	z	-3.6%
FUCA.1L	x	-7.8%
FUCA.1L	y	-3.2%
FUCA.1L	z	-10.5%
FDAMP.1L	x	5.3%
FDAMP.1L	y	-4.2%
FDAMP.1L	z	-13.6%
FARB.1L	x	-13.5%
FARB.1L	y	-12.6%
FARB.1L	z	-5.3%
RSUB.1L	x	18.8%
RSUB.1L	y	1.4%
RSUB.1L	z	-8.5%
ENG.1L	x	10.1%
ENG.1L	y	-7.8%
ENG.1L	z	-1.1%
RDAMP.1L	x	3.8%
RDAMP.1L	y	-7.9%
RDAMP.1L	z	-10.9%

Design Direction Check – Performance Loss

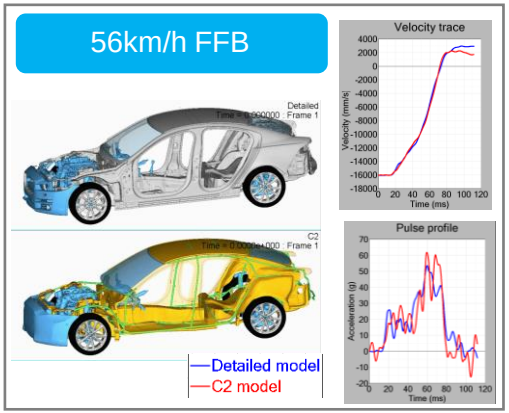


CRASH

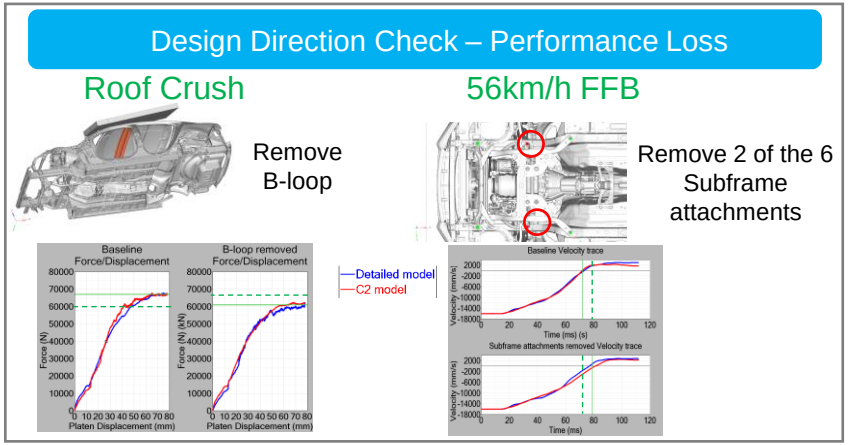
Roof Crush



56km/h FFB



Design Direction Check – Performance Loss



Summary

- C1 could generate BIW loadpath according to specific loadcase
- C2 model could speed up optimization process for linear and crush model (30mins -> 1mins for linear, 7hrs -> 0.5 hrs for crash)
- C2 model in DOE could save massive CPU time, especially for AI application – Need a lot of data !!
- C2 model are easier to parameterize the section and optimize it
- C2 model is a good boundary condition for global loadcase for component optimization, such as twistbox, shocktower…etc
- C2 Linear model is using Optistruct, and Crash model is using Radioss as solver
- Exoskeleton is a smart way to quick identify the area which need to be reinforce

THANK YOU

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#ONLYFORWARD

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