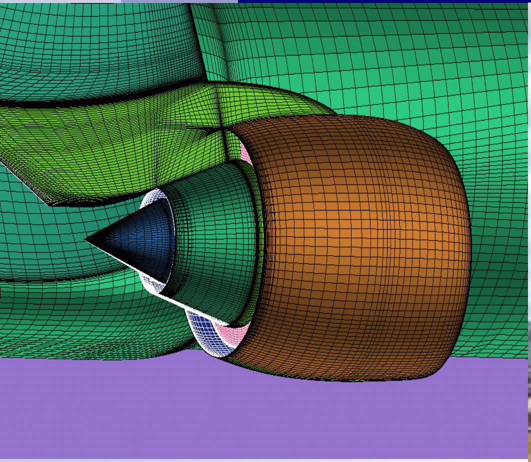
Engineering Solutions Through CAD / CAE / CFD

Automotive Capabilities



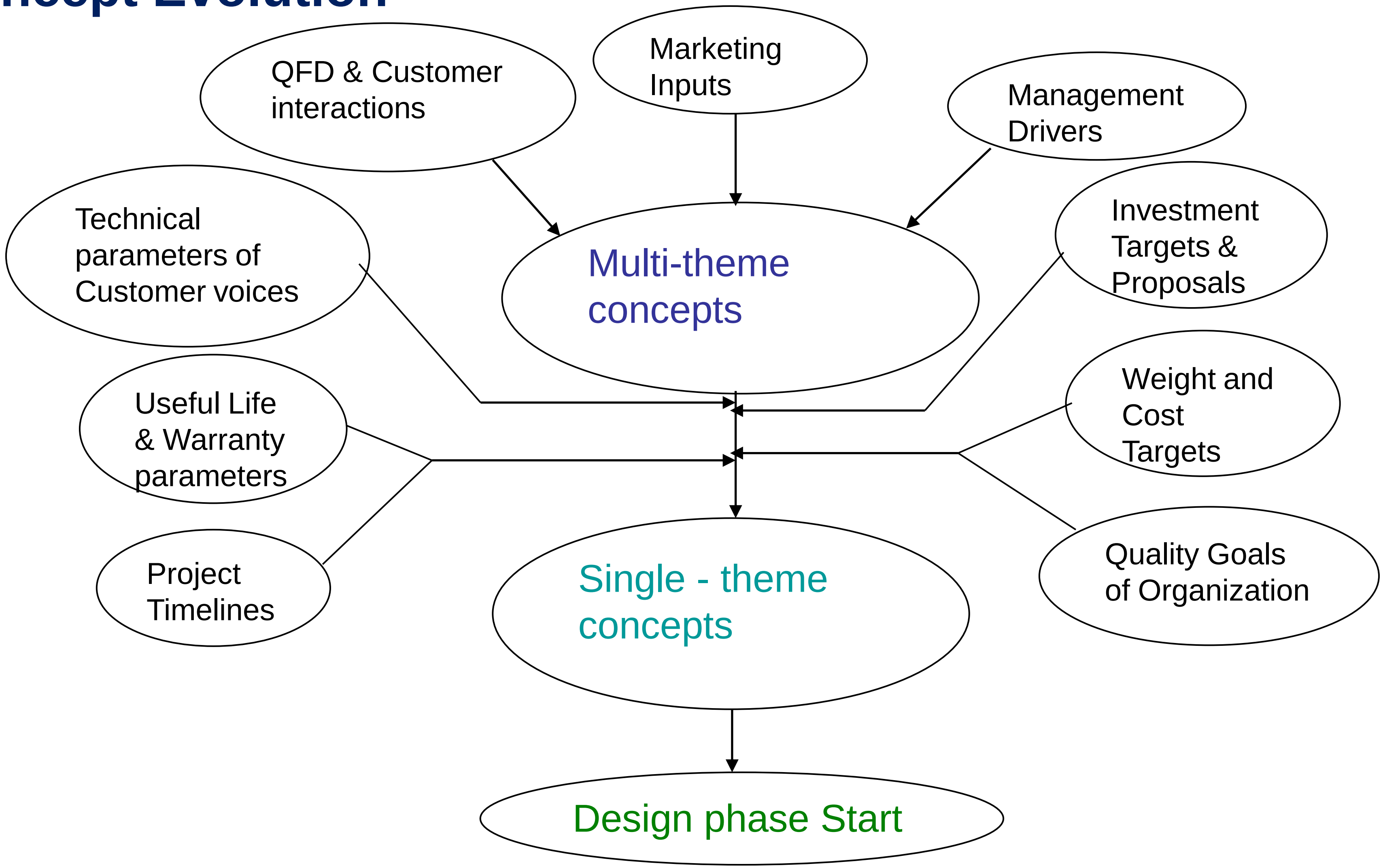
Product Development System

(Automobiles)

Milestones & timeline

- Milestone 1 – QFD & Product Conceptualization ===== 0 – 5 months
- Milestone 2 – Project Go Ahead ===== 5 – 7 months
- Milestone 3 – Engineering Design & Virtual Validation ===== 7 – 14 months
- Milestone 4 – Engineering Proto & Physical Validation ===== 14 – 22 months
- Milestone 5 – Tool try out Proto ===== 22 – 30 months
- Milestone 6 – Tool & Line try out Proto ===== 30 – 35 months
- Milestone 7 – Pre Production ===== 35 – 39 months
- Milestone 8 – FEU & Pre Launch ===== 39 – 41 months
- Milestone 9 – Product Release ===== 41 – 42 months

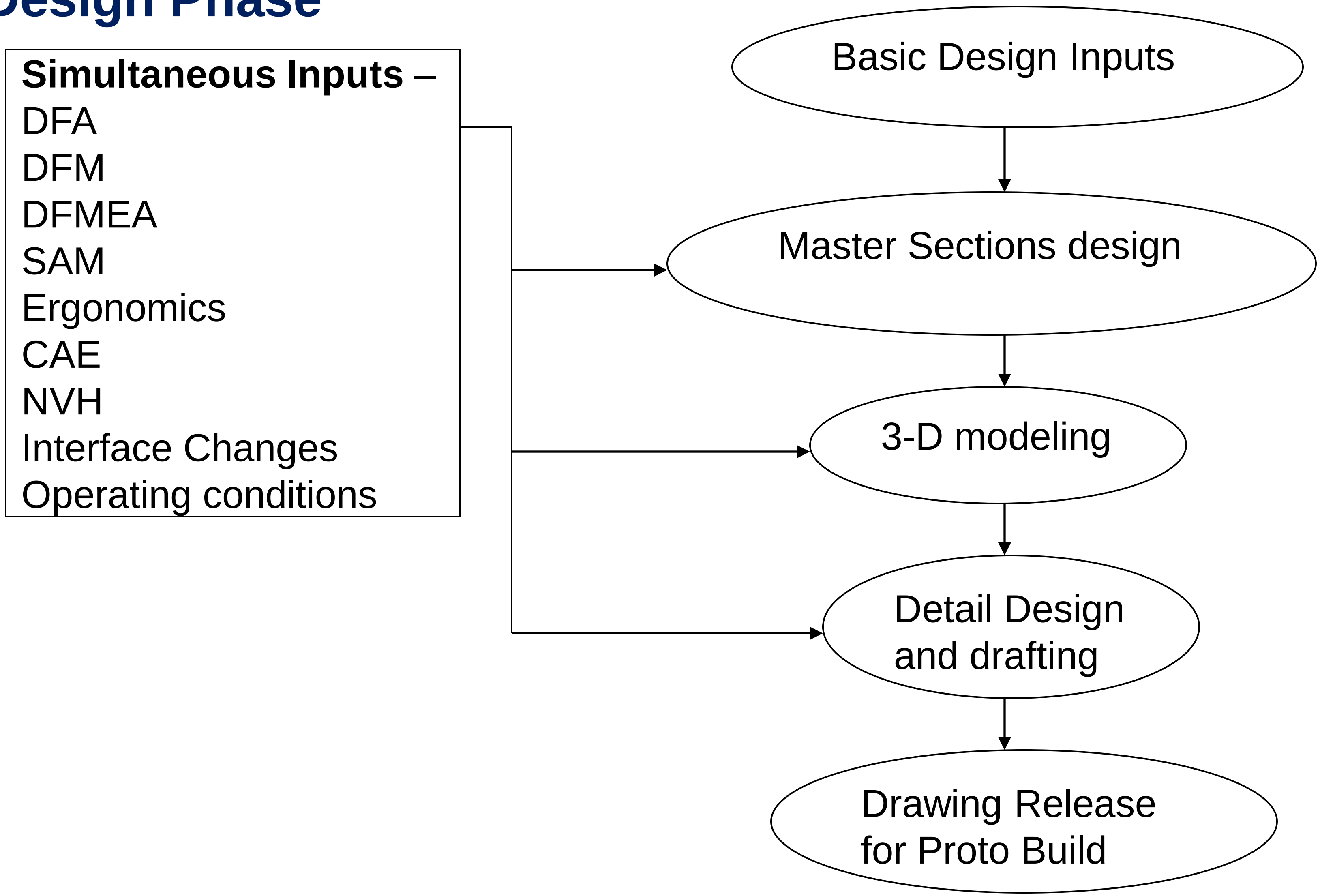
Concept Evolution



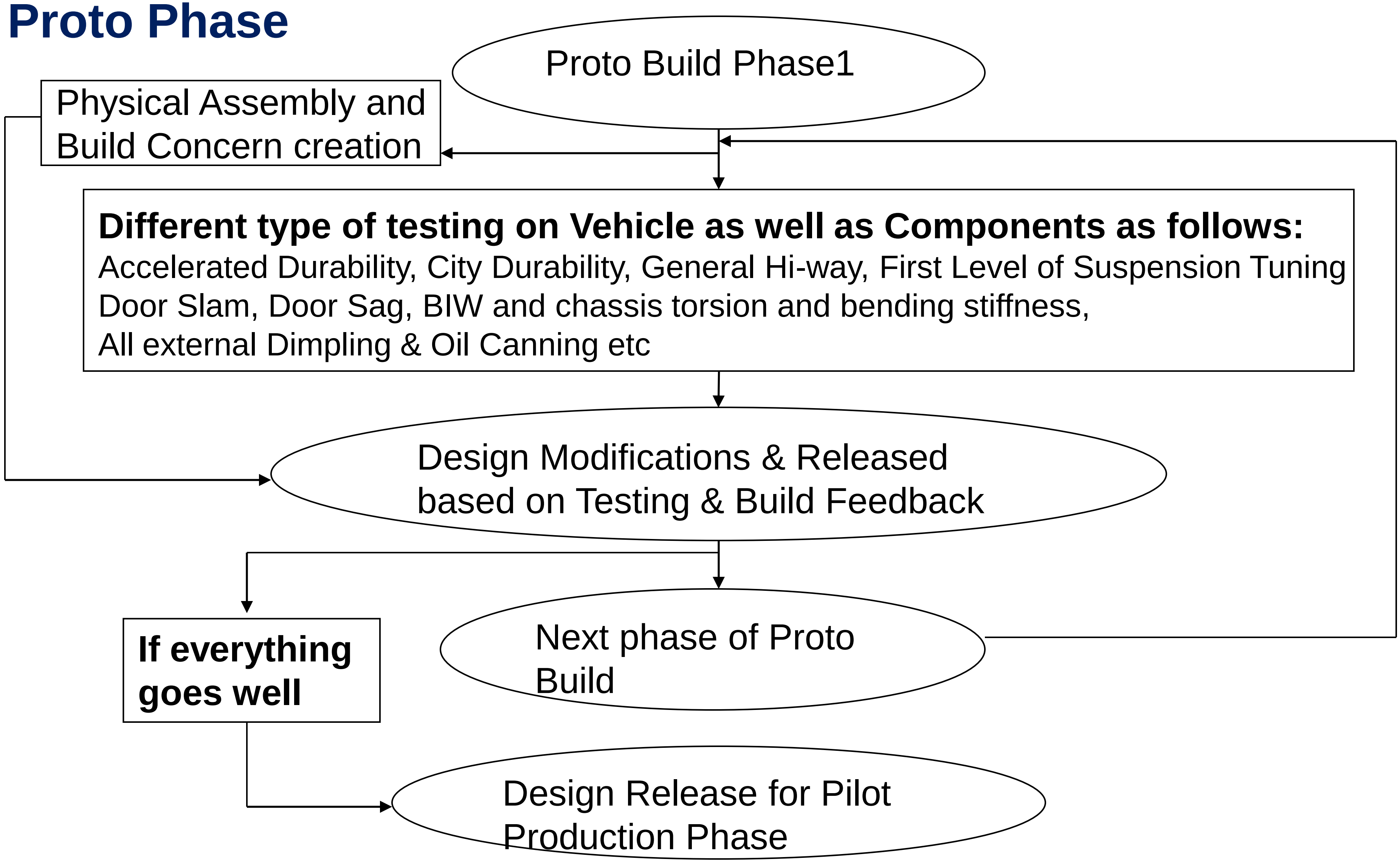
Basic Design Inputs

- Must & Wants – Mfg, TCF, Paint
- Management Drivers – Investment, Cost, Quality, Timeline
- Weight Targets
- Serviceability Targets
- Technical Parameters generated from Customer voice
- RWUP – Useful Life, Reliability, Durability Targets
- Warranty Targets
- Interface information – sections, models, drawings etc.

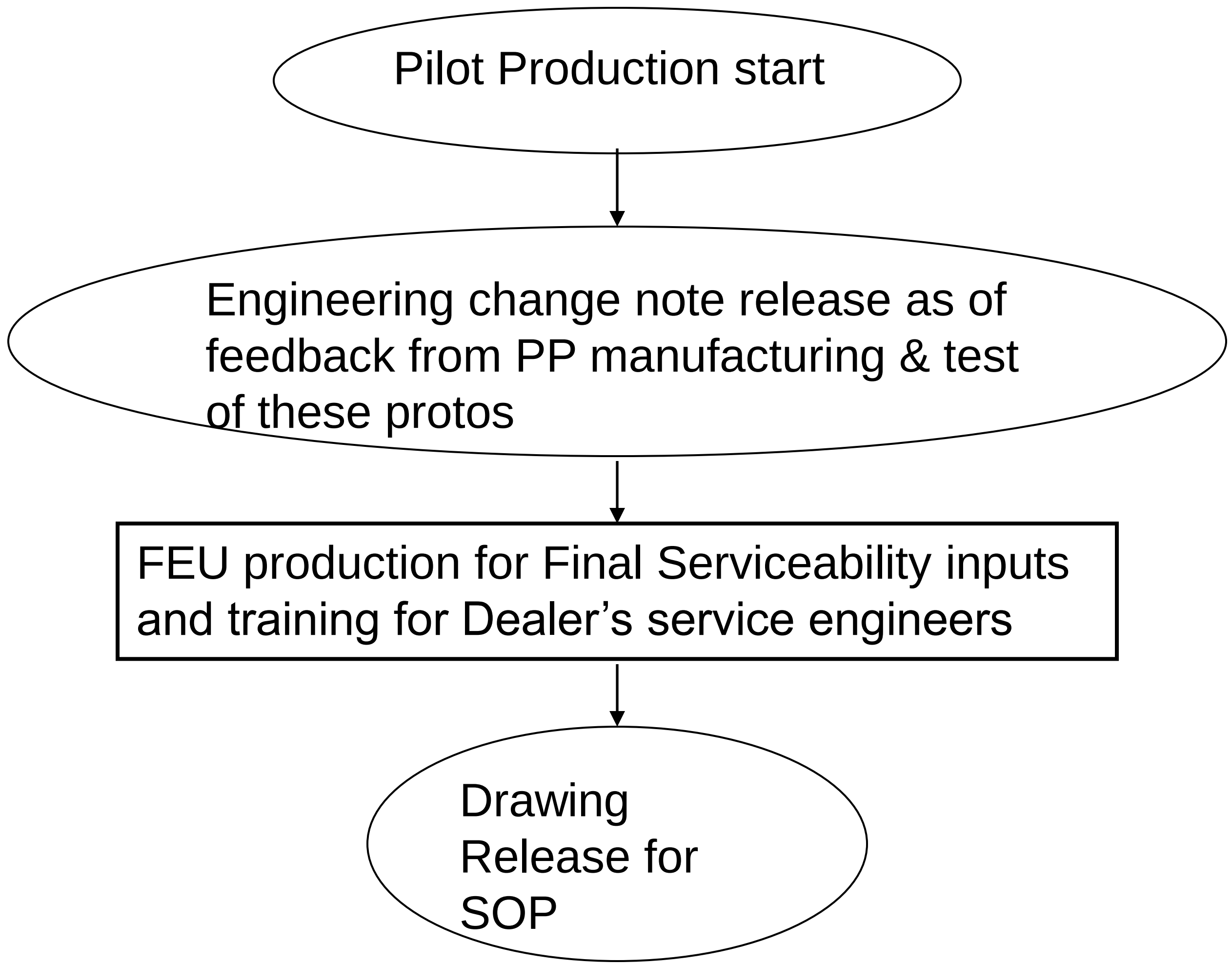
Design Phase



Proto Phase


Proto Build Phase1
Physical Assembly and Build Concern creation
Different type of testing on Vehicle as well as Components as follows:
Accelerated Durability, City Durability, General Hi-way, First Level of Suspension Tuning
Door Slam, Door Sag, BIW and chassis torsion and bending stiffness,
All external Dimpling & Oil Canning etc
Design Modifications & Released based on Testing & Build Feedback
Next phase of Proto Build
If everything goes well
Design Release for Pilot Production Phase

PP, FEU & SOP Phase



Chassis & Suspension

Suspension Design & Development.

a) Complete design of Front & Rear suspension along with complete corner module

b) Sub frame and Chassis.

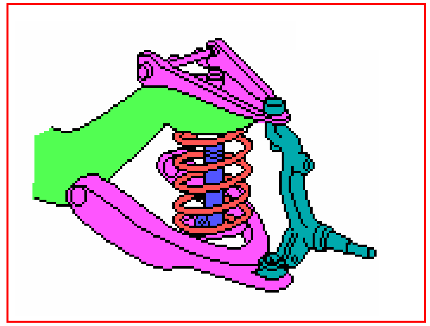
c) Underbody packaging like Brake Bundy tube, Exhaust, fuel tank , spare wheel, Battery etc.

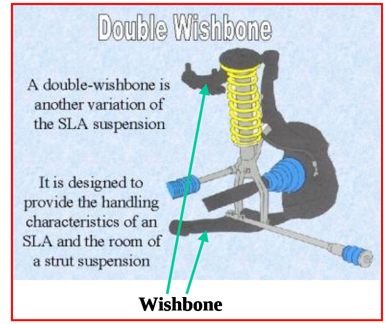
d) Engine compartment packaging and Vehicle Integration.

e) DFMEA, DVP's & Design reviews, conducting FEA analysis and optimization of design.

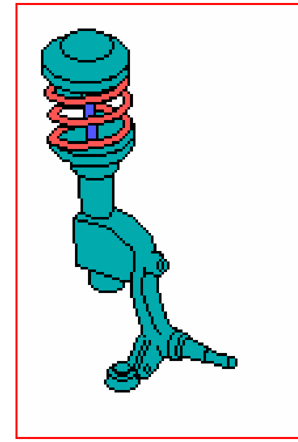
f) Resolving Validation concerns during vehicle development.

Double A-ARM suspension

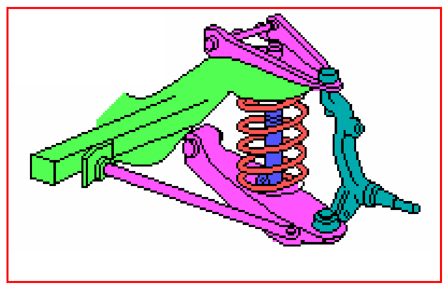




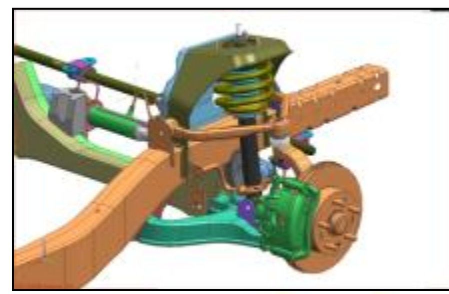
McPherson Strut

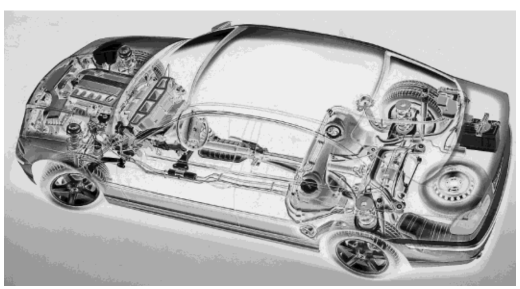


Control Rod Suspension



Torsion Bar





Rear twist Beam suspension

CASE STUDY
Design of Independent suspension

Step1 - Vehicle level inputs

Vehicle specs

- Wheel base :
- Track :
- Drive : Frt/ Rear 2WD/4WD
- CG height :
- Tire Size :
- Tire Type :
- Tire Pr.(F/R) :
- Steering :
- GVW - kg
- Laden FAW - kg
- laden RAW - kg
- Curb wt - kg
- FAW - kg
- RAW - kg
- Payload-kg

Vehicle type

- Car
- SUV
- MUV
- HCV
- LCV
- Mono coque
- Body on chassis

Others

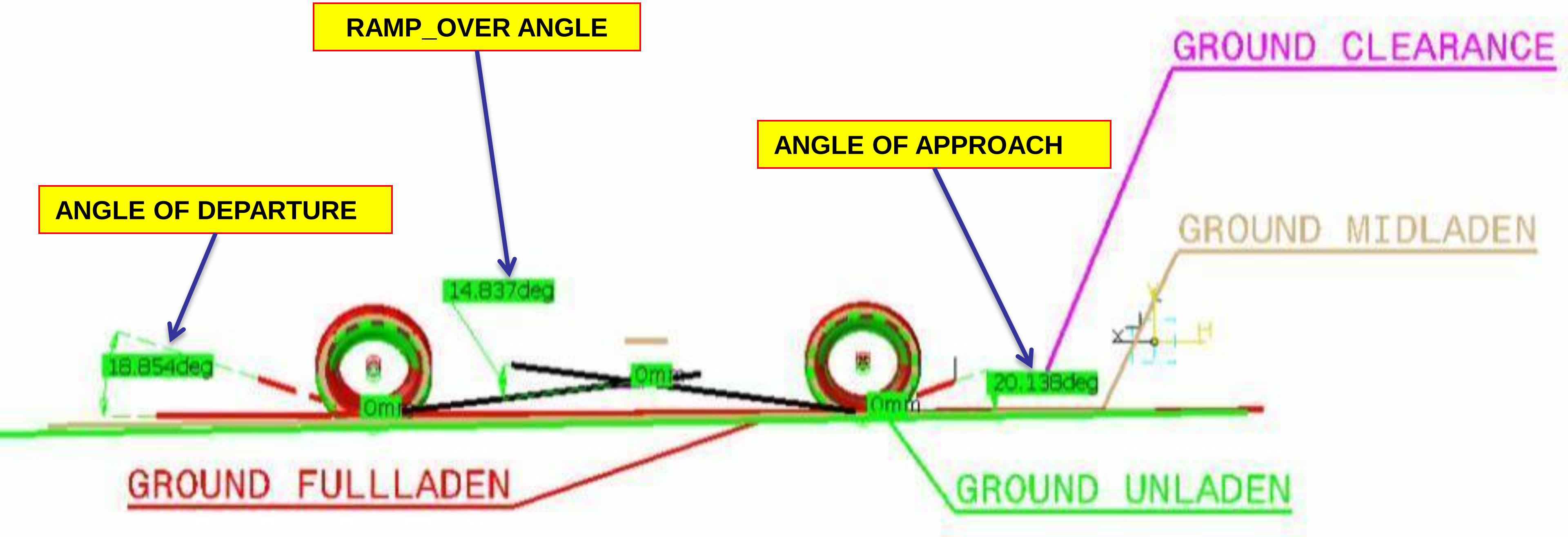
- Ride Height Requirements
- Packaging Hard Points
- Ride and Handling Parameters
- Benchmarking Inputs

Step 2 – Concept Design

- Estimation and setting up targets for Sprung and Unsprung mass
- Deciding on Ride frequencies, Wheel Rate and travel.
- Defining Ground planes and Vehicle attributes in various loading condition.
- Selection of suspension type (Various options needs to be Evaluated in detail)
- Kinematics study of the Layout.
- Optimizing various parameters of front & Rear suspension geometry, camber rate, bump steer, roll centre height etc. in Bump, Roll and steered condition
- Making proposals and carry out feasibility study of packaging for suspension.
- Preparation of wheel envelope for different articulation condition.
- Review with Styling, BIW & Interior team on problem areas and taking necessary steps to resolve the issues after mutual agreement.
- Finalization of layout based on -
  - ✓ Kinematics
  - ✓ Packaging
  - ✓ Styling inputs
  - ✓ Manufacturing feasibility
  - ✓ Serviceability
  - ✓ Reliability etc.

Step 2 – Concept Design

Vehicle Stance



STANCE	ANGLE (deg)
FULLLADEN	0.3
MIDLADEN	0.789
UNLADEN	1.042

Step 2 – Concept Design

Weight Estimation

WHEEL BASE (mm)	2650
FRONT wheel centre X coordinate	1575
VEHICLE TARE CG LOCATION	2740
Front unsprung mass (Kg)	80
Rear unsprung mass (Kg)	70
Front Seats - H Point Longitudinal Position (mm)	3031
Rear Seats - H Point Longitudinal Position (mm)	3715.0

LOAD CONDITION	FAW (Kg)	Front axle sprung wt (Kg)	RAW	Rear axle sprung wt (Kg)	F/R ratio
Tare	650.44	570.44	516.56	446.56	1.27
Curb	697.90	617.90	552.10	482.10	1.26
Mid	741.03	661.03	659.17	589.17	1.13
Full	802.86	722.86	824.14	754.14	0.97

Ride Frequency and Suspension Travel

LOAD CONDITION	REAR FREQUENCY	FRONT FREQUENCY
tare	1.54	1.28
curb	1.48	1.24
mid	1.34	1.20
full	1.37	1.15
TOTAL VARIATION	0.17	0.14

Front Wheel rate (N/mm)	Rear wheel rate (N/mm)
18.84	21
18.84	21
18.84	21
18.84	26.1

VARIATION OF RIDE FREQUENCY BETWEEN TARE AND FULL LADEN IN REAR SUSPENSION IS QUIT COMPARABLE TO FRONT

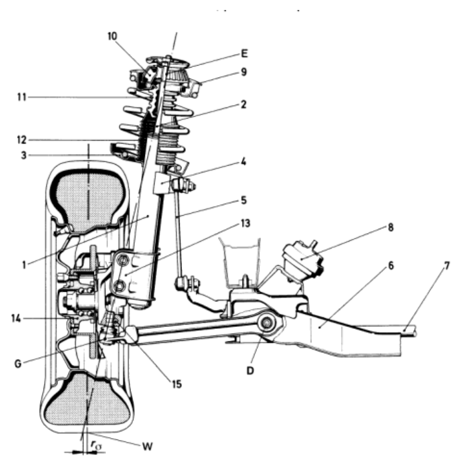
SUSPENSION TRAVEL

SUSPENSION CONDITION	FRONT TRAVEL	REAR TRAVEL
Rebounce to curb	66	59
Curb to Midladen	11.4	25
Midladen to Full laden	15.00	38.5
Full laden to Full bump	67	56
TOTAL TRAVEL	160.28	178.5

Selection of suspension type

Based on the

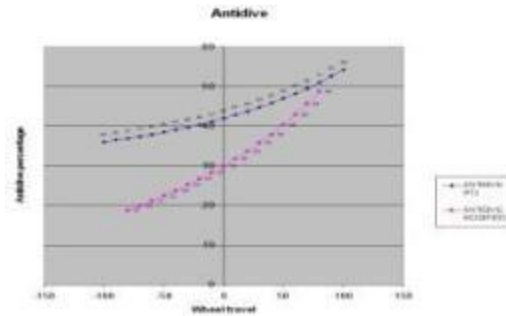
- vehicle type
- Roll Centre height,
- Roll axis,
- Packaging,
- Cost,
- Weight,
- Lead time

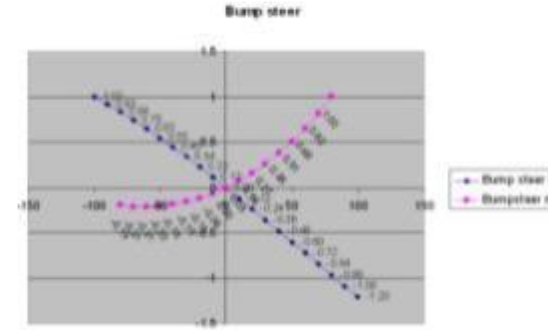


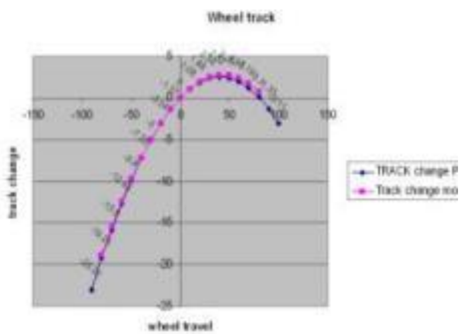
Step 2 – Concept Design

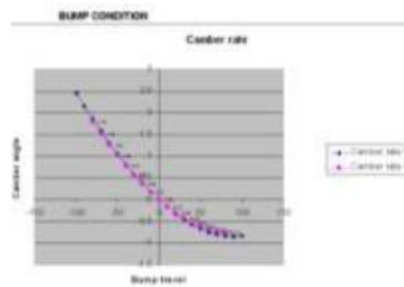
Kinematic Optimization of Front Suspension

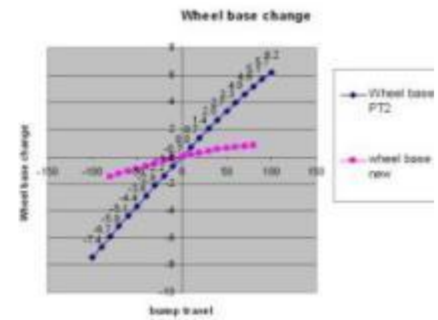
STATIC Values		
Camber Angle	(deg)	0
Toe Angle	(deg)	0
Castor Angle	(deg)	4.54
Castor Trail (hub)	(mm)	2.32
Castor Offset (grnd)	(mm)	21.6
Kingpin Angle	(deg)	12.55
Kingpin Offset (w/c)	(mm)	63.24
Kingpin Offset (grnd)	(mm)	-3.75
Mechanical Trail (grnd)	(mm)	21.54
ROLL CENTRE HEIGHT		100.41

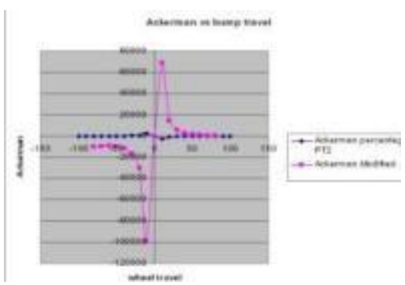


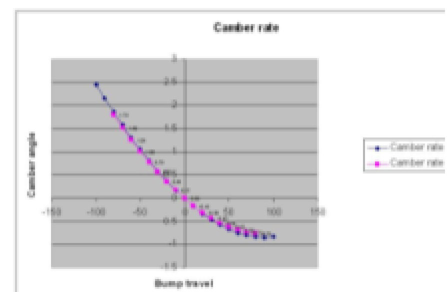






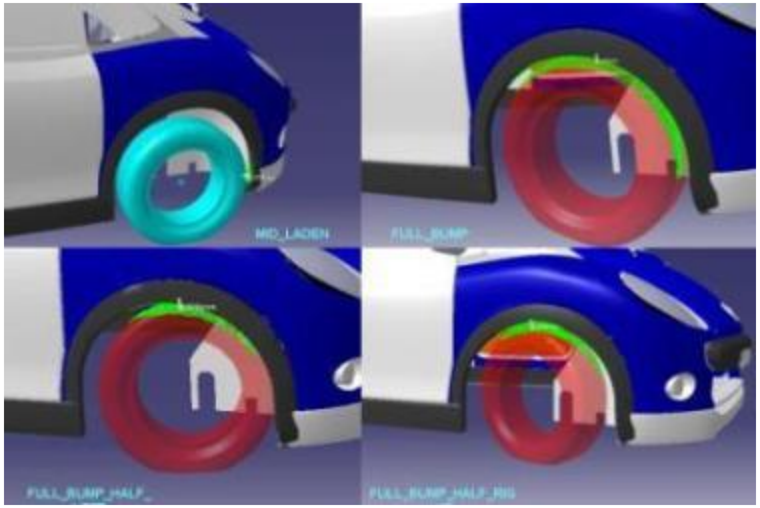


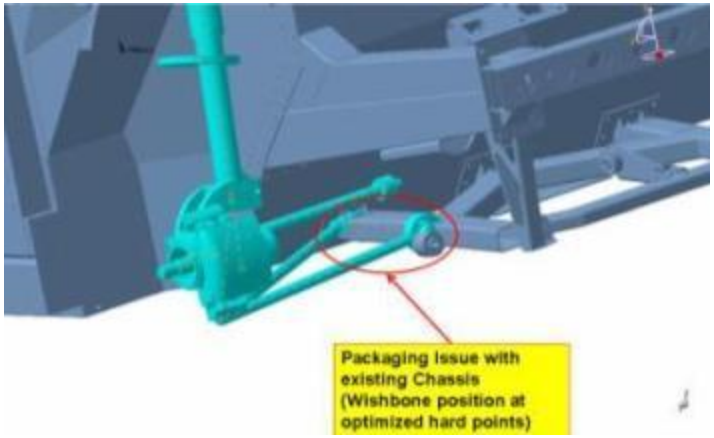


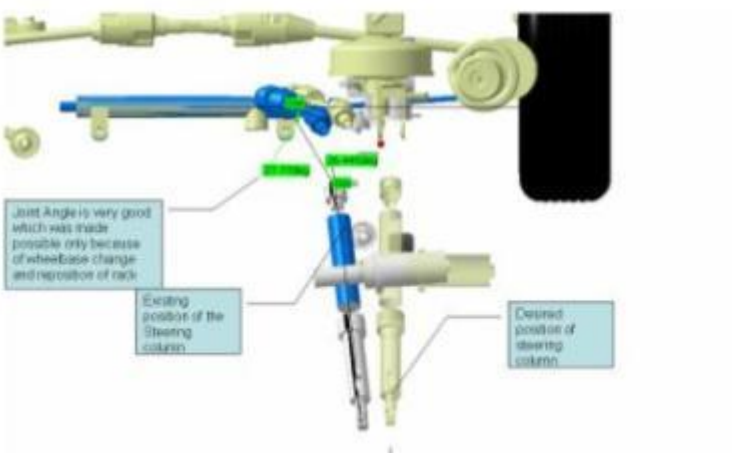


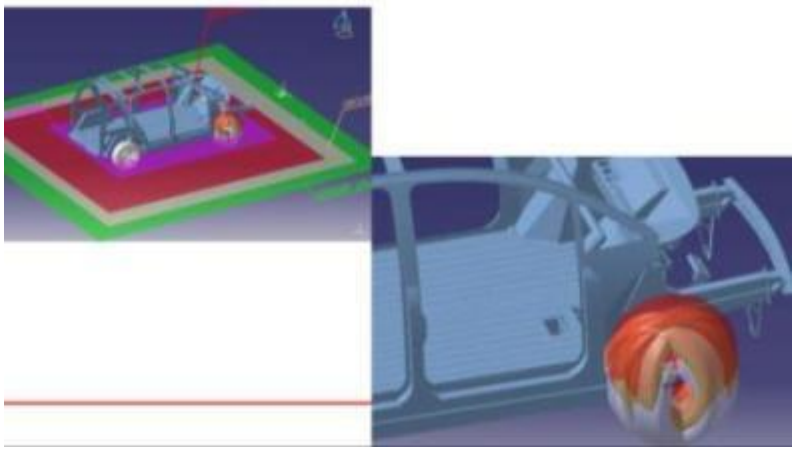
Step 2 – Concept Design

Front wheel envelope and packaging issues



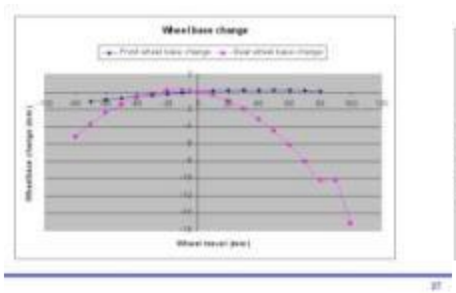


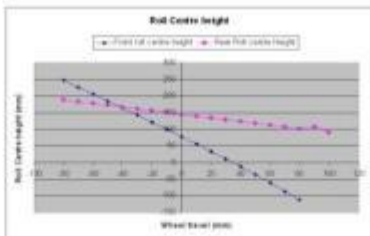


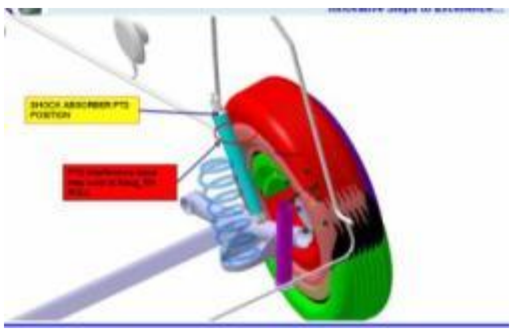


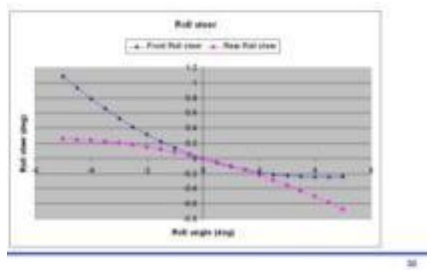
Step 2 – Concept Design

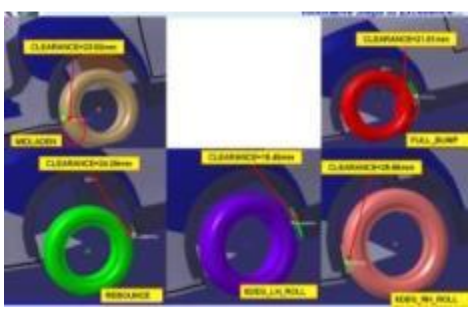
Rear Wheel Kinematics & Packaging

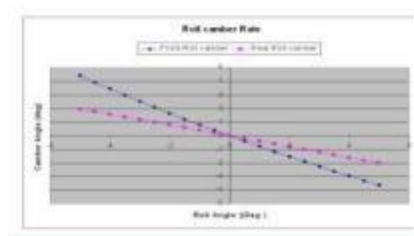




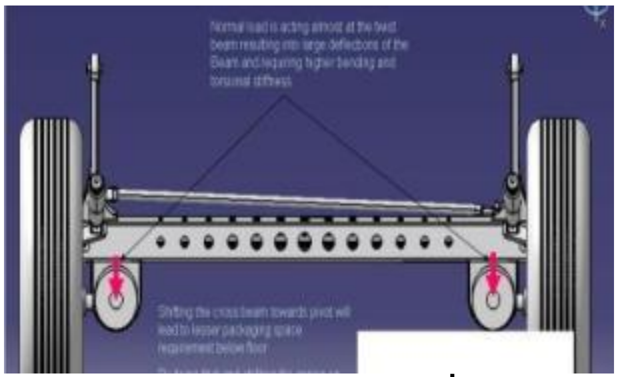




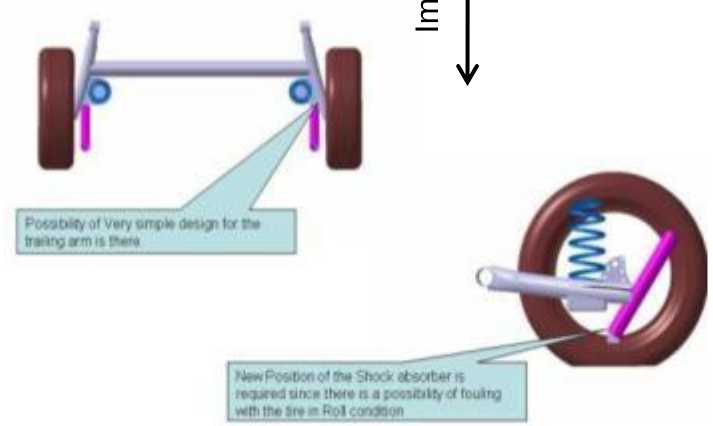




Improved Suspension Design



Improved



Step 3 – Detailed Design

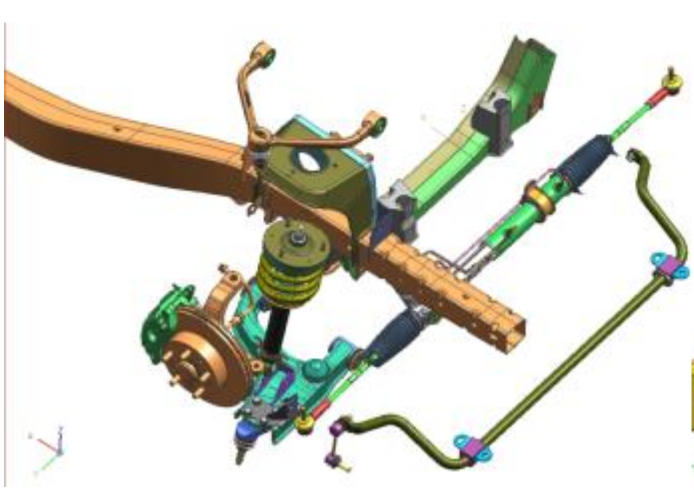
After optimization of kinematics and finalization of basic layout detail design of each component is done.

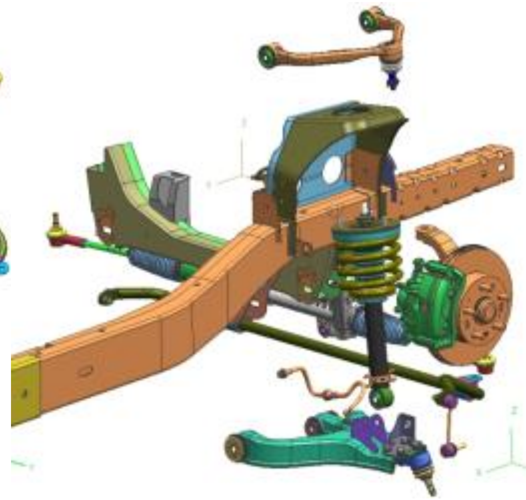
Various load cases are generated for the different Load conditions like pot hole, cornering and curb strike which can occur during driving using simulation tools.

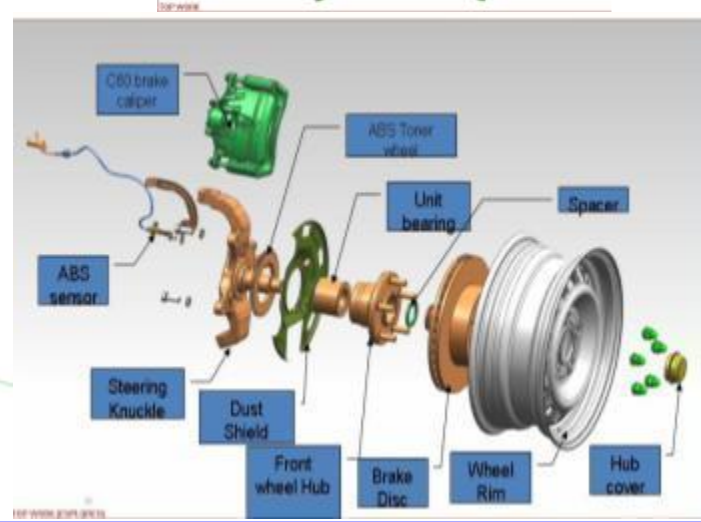
Detail FEA Analysis is done to optimizes the design for Weight using worst case scenario.

Suspension Support

- Apart from the Suspension parts suspension joineries are also very important in deciding the performance of complete suspension in vehicle dynamics.
- Joineries consists of following parts as explained in the Image.
- Attachments of suspension hard points to chassis/ sub-frame
- Attachments of suspension hard points to Wheel.
- Attachments of Steering hard points to Wheel.



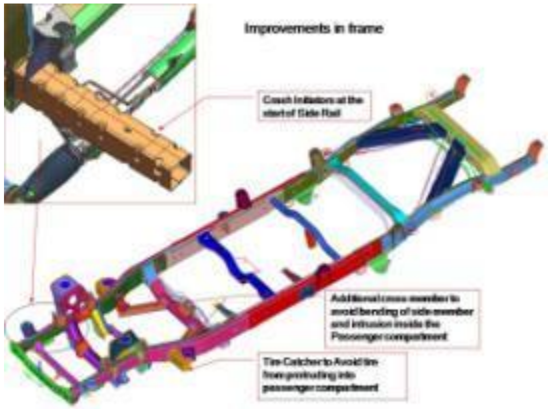




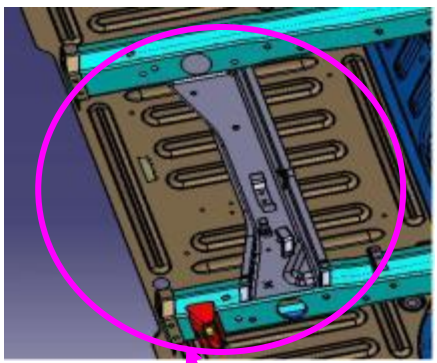
BIW

We can design the following concepts

- Body Mounts over chassis
- Space Frame Body with Plastic Panels
- Steel Unibody



Chassis for Body over chassis concept



Chassis Frame spot welded with Cabin Floor

Basic Joining methodology of Space frame
- more laborious, thus not cost effective for more volumes

In steel Unibody concept full sheet metal body is Welded with sheet metal chassis frame. This helps In reducing step in height, No. of parts, weight.

Benefits of Space Frame Body

- Reductions in No. of Parts.
- Helps in saving weights up to 15%.
- Fewer parts
  - ✓ Simplify the production process
  - ✓ Improving production results
  - ✓ Increases body rigidity & enhancing crashworthiness
  - ✓ Improves passenger comfort
  - ✓ Reduces Cost

Steel Unibody in comparision with Body mounted chassis

- Chassis Frame welded with BIW
- Better Weight management
- Better Crash resistance as Pillars also contributes to Crash.
- Better Ride and Handling of the vehicle
- Better R/1000
- Complex in Assembly

BIW Design Criteria

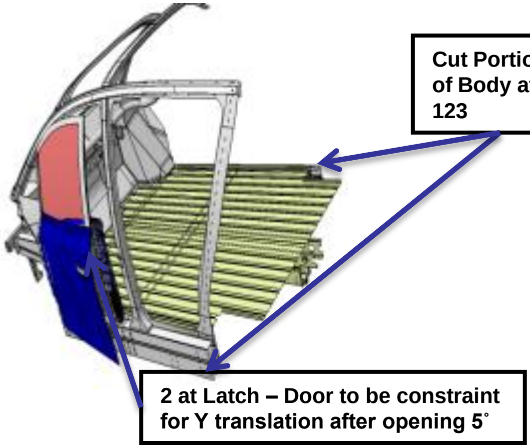
- Door Sag
- Dent resistance
- Crashworthiness – Front, Rear, Side and Roof
- Bending stiffness
- Torsion Rigidity
- Modal
- 3g vertical
- 2g Twist
- 1g Lateral

BIW Design Criteria

Door Sag

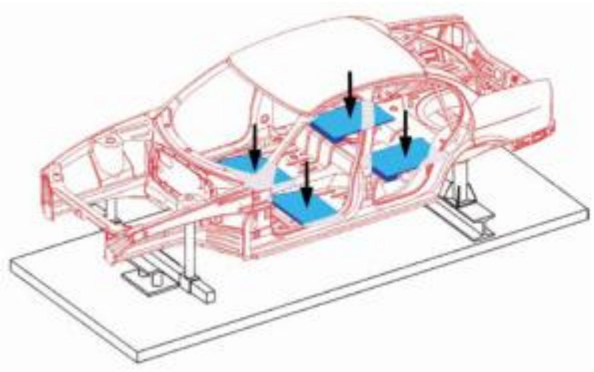
1100 N at Door CG & 430N at Latch – Both Vertical

Boundary Conditions are as:
1,2,3 – Translational DOF in x,y,z
4,5,6 – Rotational DOF in x,y,z



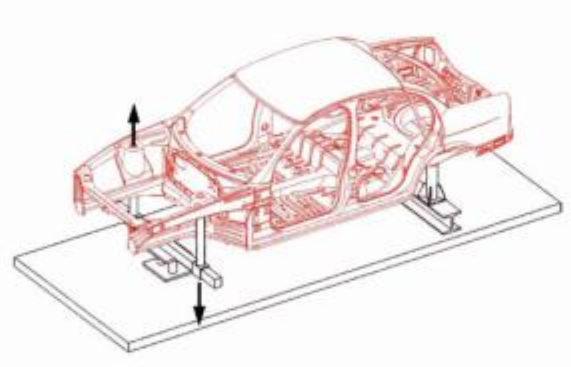
Bending stiffness

Static body rigidity is measured with equal loads applied on each side at the front and rear of the B-pillar as shown. The body is restrained at four ends, and flexing is observed along the body rails.



Torsion stiffness

Static torsion rigidity is measured with only the rear ends restrained and opposing direction loads applied at the front end, and twist angle is observed.



BIW Design Criteria

Crashworthiness

ECE R94 is used as reference.

FMVSS 216 is used as reference.

Dent resistance

- Dimpling Criteria – RWUP
- Oil Canning – RWUP

Modal Analysis

- Natural Frequency of Panels
- Sensitive joint evaluation
- Point Mobility

3g Vertical

- Vertical Load for a RWUP of a very bad Road

2g Twist

- Twist Load when one tyre goes in a pot Hole

1g Lateral

- Cornering forces while turning

Emphasis on weight reduction of Body

- Body typically makes up 45% of the total mass of a vehicle.
- Body-in-white (BIW) typically makes up 28%.

Note:

- A 10% decrease in mass can lead to a 6.25% increase in fuel economy,
- Less fuel burned means fewer pollutants created.
- For every percentage point of overall mass reduction, there is an equal percentage point reduction in power requirements

Choices for Weight Reduction

- High strength materials – IFHS, DP, TRIP, BH etc.
- Low density metals (Al)
- Space Frame Unibody

CLOSURES

Types of Doors

Sash Type Door

- Better Window Frame Lateral rigidity
- Better Yield of Material
- Bigger Window size possible
- Suitable for very high volume
- Complex in design
- Complex joineries
- CO_2 welding - not good for aesthetics

Panel Type Door

- Less Window Frame Lateral Rigidity
- Poor on Yield of Material
- Less Window size.
- Better for mid size volumes
- Simple in design
- Simple joineries
- No CO_2 welding - good for aesthetics

Door Design Criteria

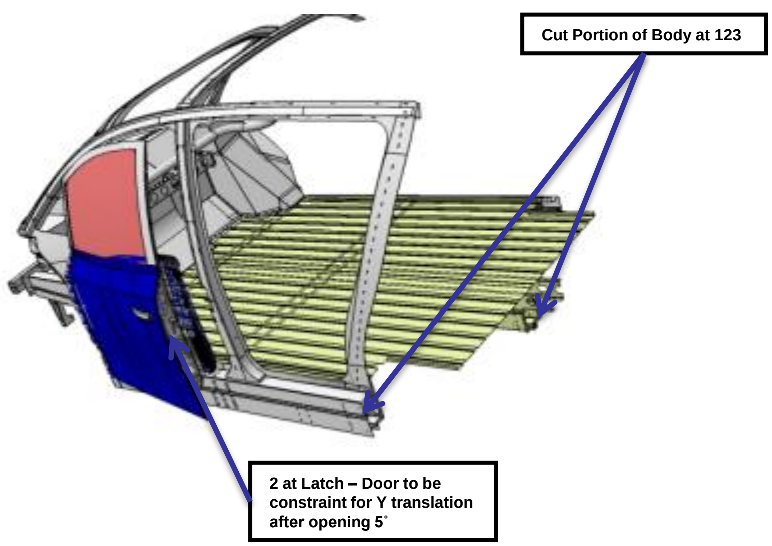
- Door Sag
- Door Dent resistance
- Belt squeeze
- Door Side Strength
- Window Frame Lateral Rigidity
- Door Torsion
- Door Flutter
- Door Over Opening
- Door Slam

Door Design Criteria

Door Sag

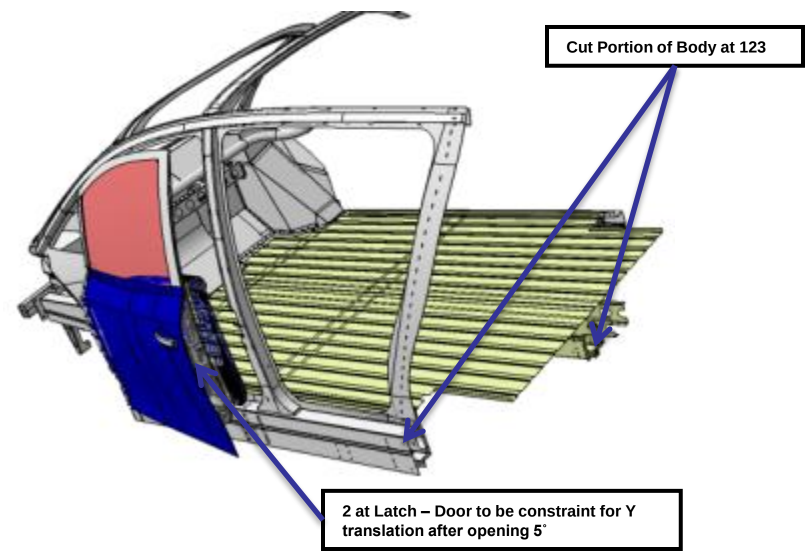
1100 N at Door CG & 430N at Latch – Both Vertical

Boundary Conditions are as:
1,2,3 – Translational DOF in x,y,z
4,5,6 – Rotational DOF in x,y,z



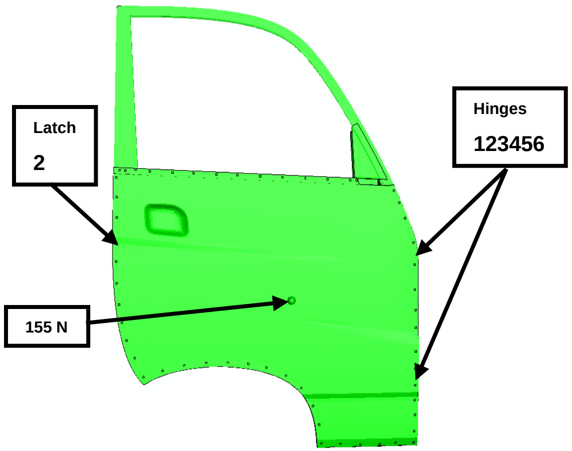
Door Drop Off

Gravity Load of Trimmed Door at Door CG

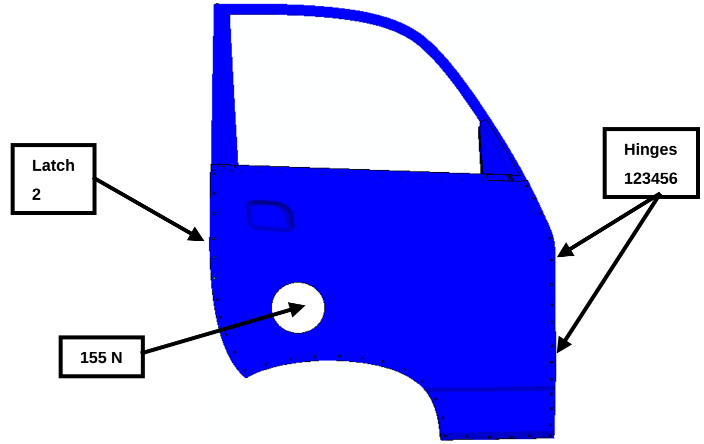


Door Design Criteria

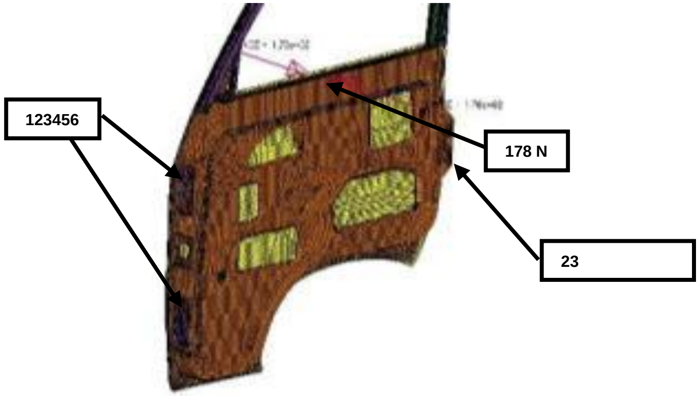
Dent Resistance - Dimpling



Dent Resistance – Oil Canning

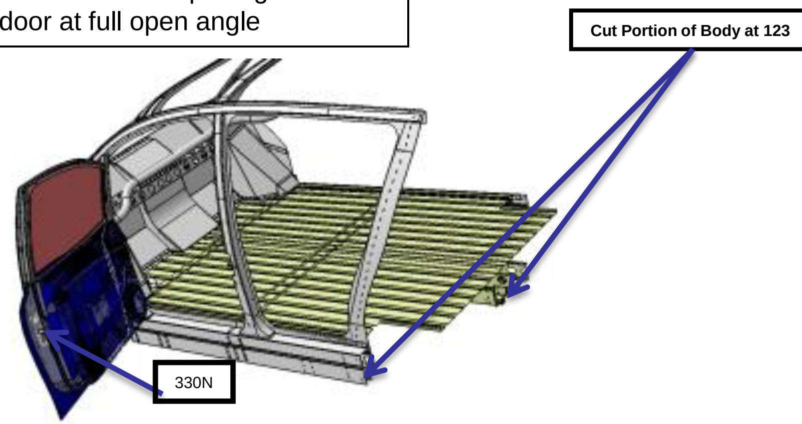


Belt Squeeze



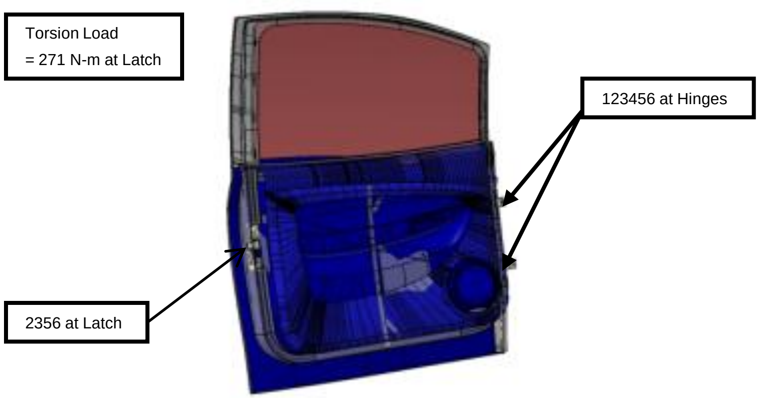
Door Over Open Test

330N at Latch in Door Over Opening direction after keeping door at full open angle

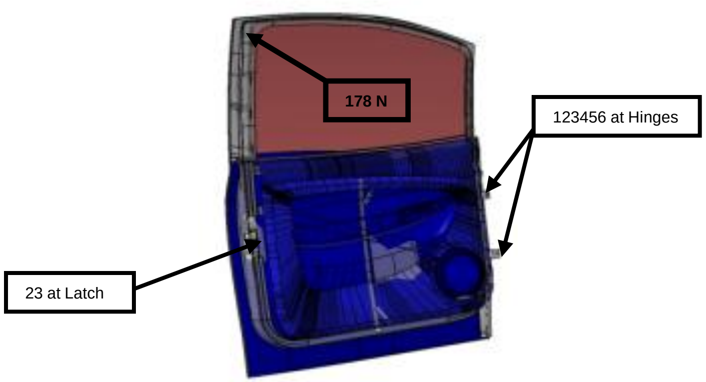


Door Design Criteria

Door Torsion Rigidity



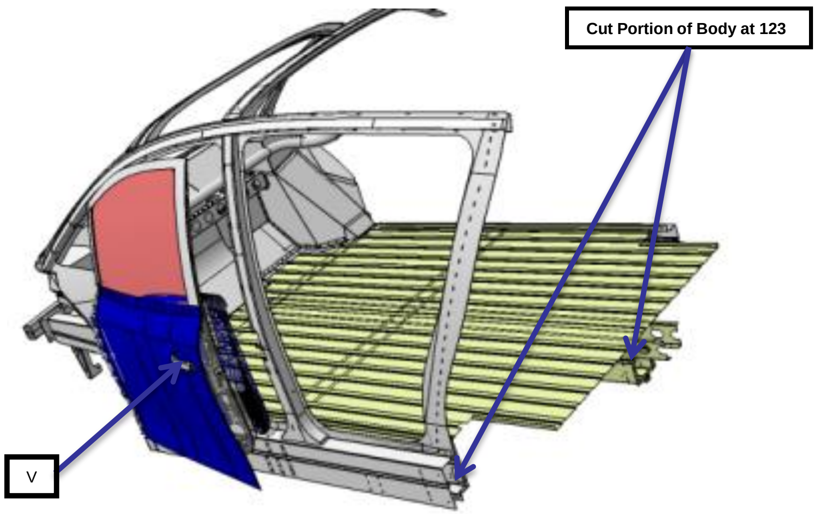
Door Window Frame Lateral Rigidity



Door Slam Test

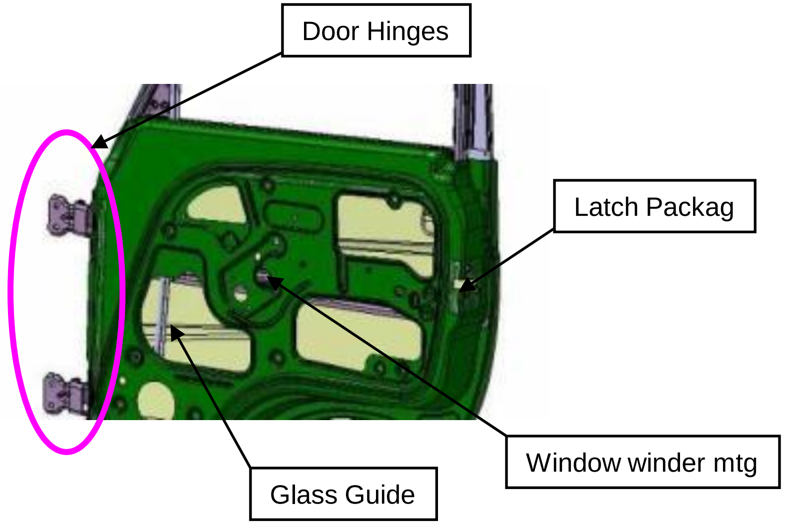
Apply a Door Closing and opening velocity at outer Handle location - Velocity is to be calculate by applying 165 Nm torque at Outer Handle.

See that everything works without failure for 100000 cycles of opening and closing



Major Interfaces considered

- Door Latch
- Door Hinges
- Window Regulator
- Window Glass
- Glass Run Seals
- Waist Level weather strips
- Door Primary Seal
- Body Sides to maintain Gaps and Flush
- Door Outer Handle mechanisms
- Door Inner Handle mechanisms
- Door Trims
- Pop-up knob



Types of Intrusion Bar Design for Side Impact

Design criteria's

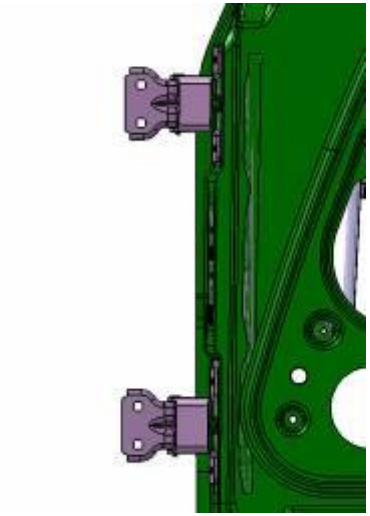
1. Polar moment of Inertia and
2. Section Modulus

Bar Type

Beam Type

Types of Hinges

- Concealed Hinges
- Open face mtg type (to be covered later)
- Guise Neck type
- Lap type



Open face mtg type

Concealed type

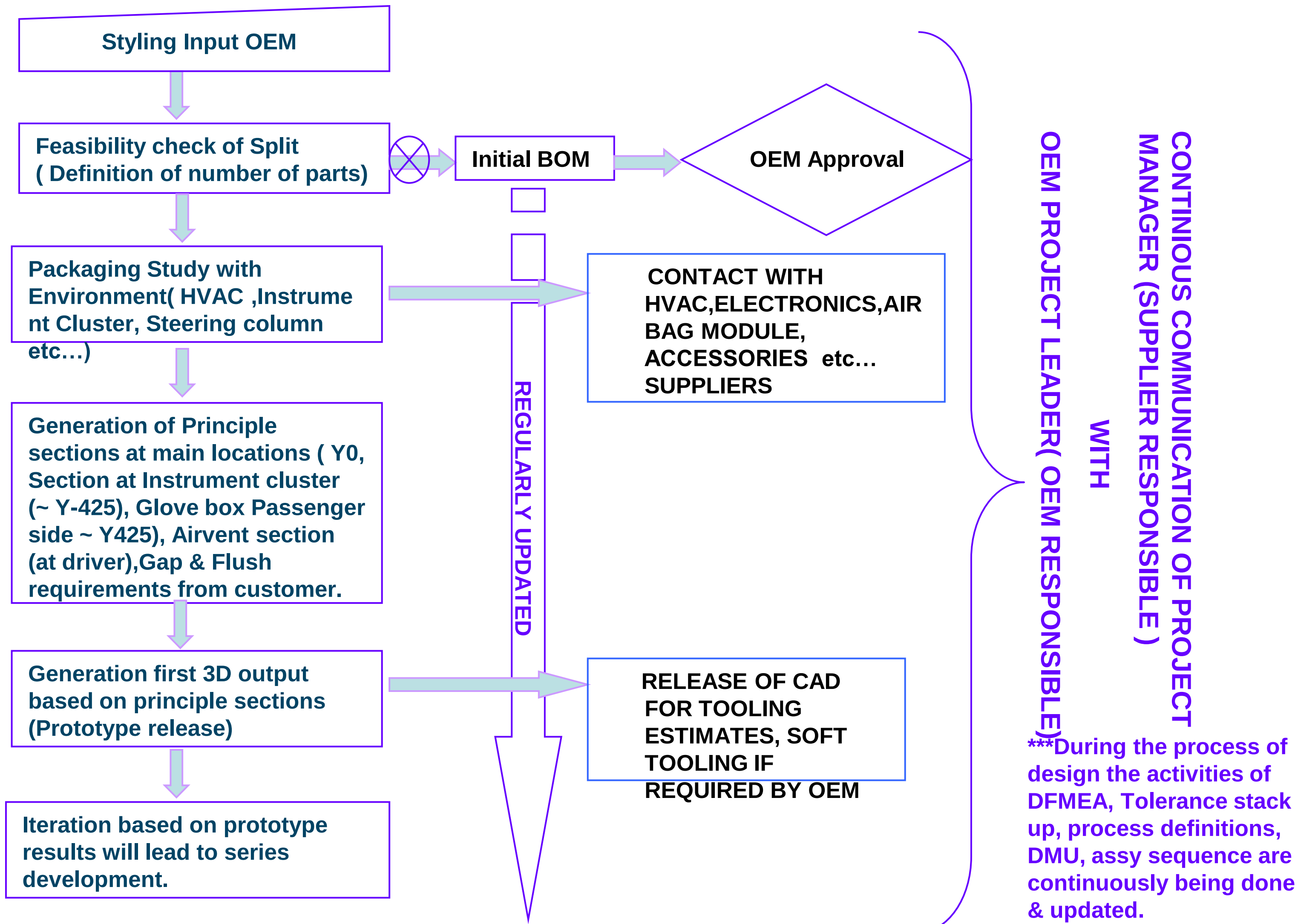
Guise neck type

Interiors

We Designs -

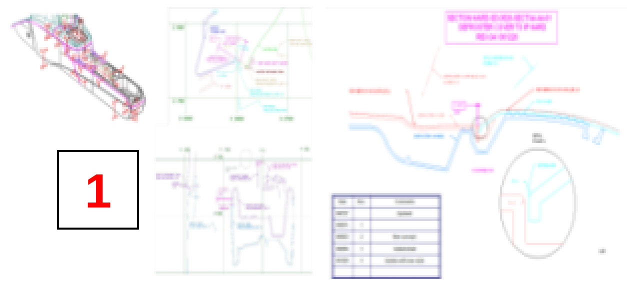
- INSTRUMENT PANEL DESIGN
- CENTER CONSOLE DESIGN
- DOOR PANEL & DOOR MODULE DESIGN
- SIDE TRIMS

Design Flow


Styling Input OEM
Feasibility check of Split (Definition of number of parts)
Initial BOM
OEM Approval
Packaging Study with Environment(HVAC ,Instrument Cluster, Steering column etc…)
CONTACT WITH HVAC,ELECTRONICS,AIR BAG MODULE, ACCESSORIES etc… SUPPLIERS
Generation of Principle sections at main locations (Y0, Section at Instrument cluster (~ Y-425), Glove box Passenger side ~ Y425), Airvent section (at driver),Gap & Flush requirements from customer.
REGULARLY UPDATED
Generation first 3D output based on principle sections (Prototype release)
RELEASE OF CAD FOR TOOLING ESTIMATES, SOFT TOOLING IF REQUIRED BY OEM
Iteration based on prototype results will lead to series development.
CONTINIOUS COMMUNICATION OF PROJECT MANAGER (SUPPLIER RESPONSIBLE)
WITH
OEM PROJECT LEADER(OEM RESPONSIBLE)
***During the process of design the activities of DFMEA, Tolerance stack up, process definitions, DMU, assy sequence are continuously being done & updated.

Phase 1 - Proposal

- **Concept Generation Using Master Sections**
- **Packaging & Ergonomics study**
- **Tolerance Analysis**
- **Reverse Engineering**
- **Technical surface changes for style**
- **Layouts & Packaging**



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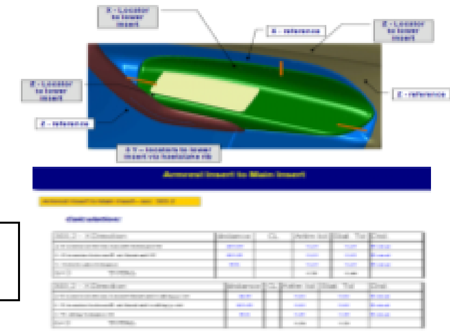

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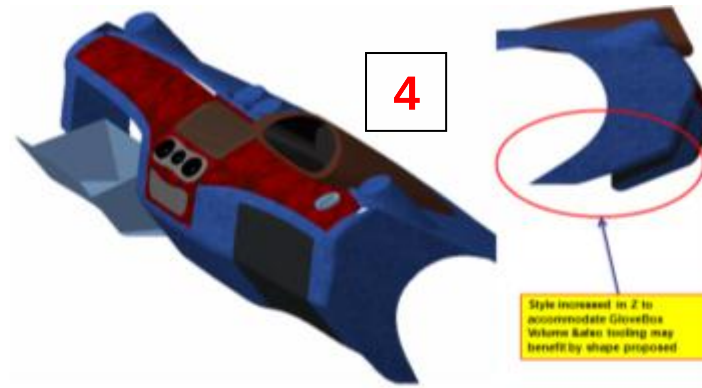

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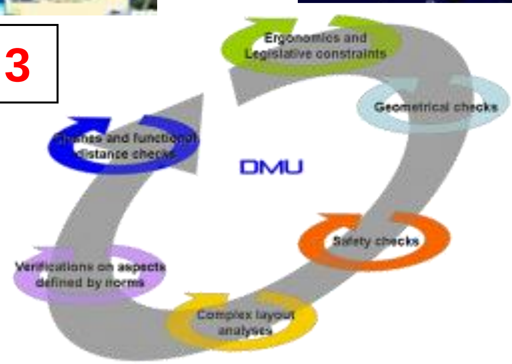
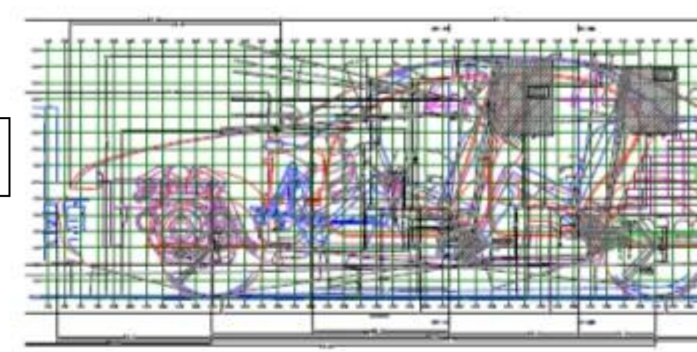
3





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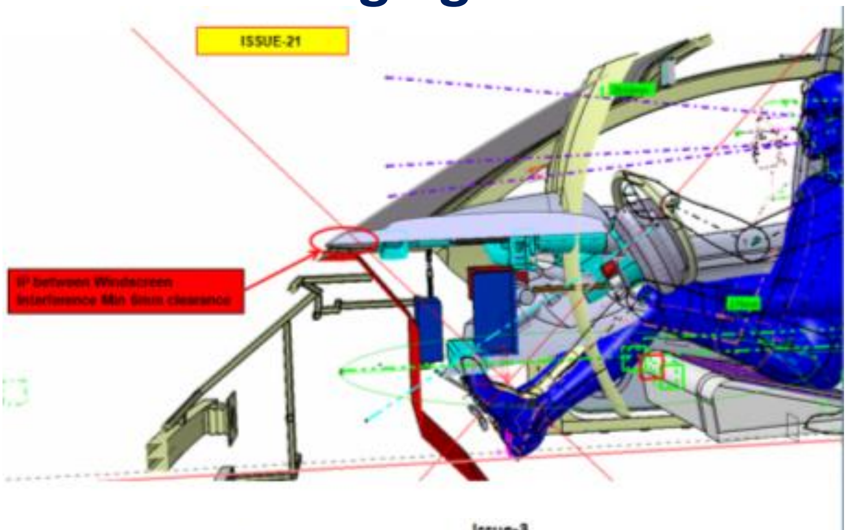
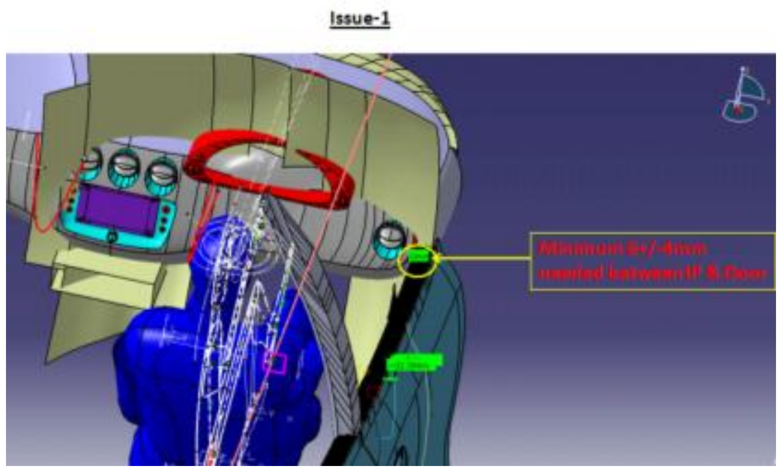
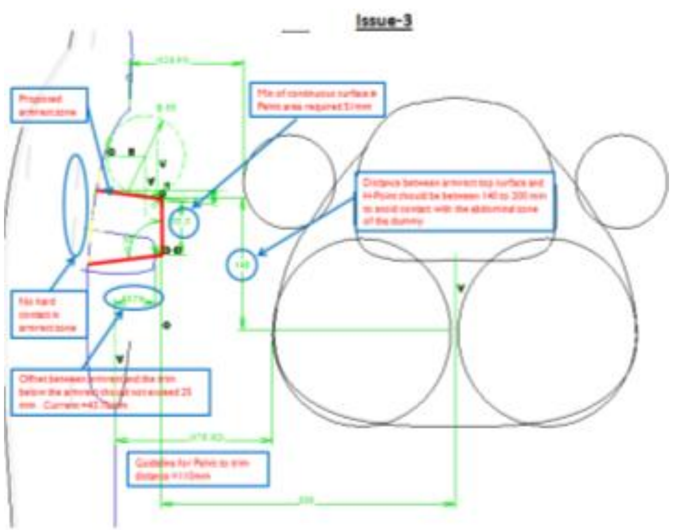
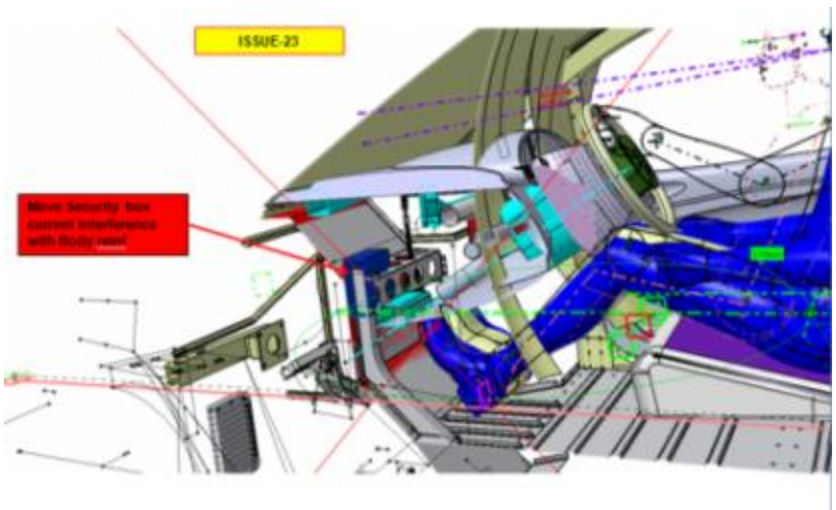
Phase 1 – Packaging Checks





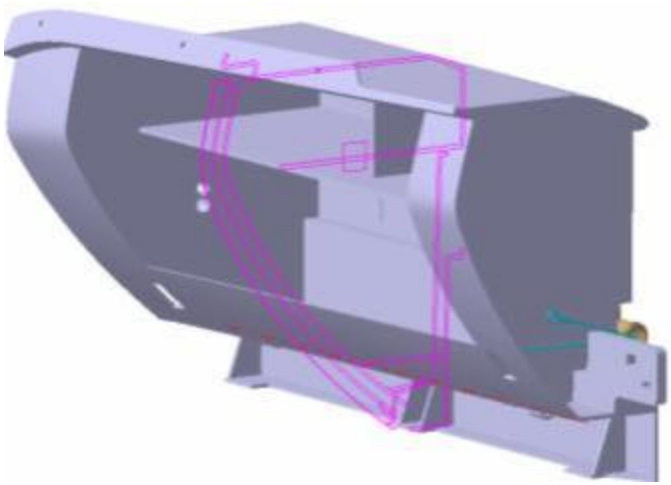


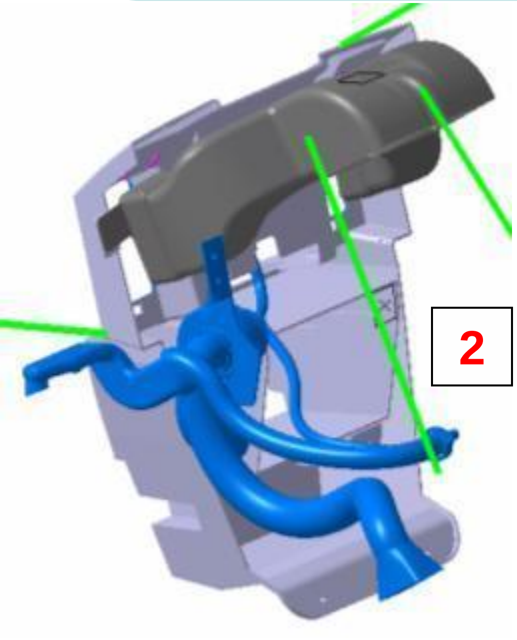


Phase 2 – Product Feasibility

- Product Feasibility checks
- Design Automation
- Data Conversion
- Geometric Modeling & Drafting

1





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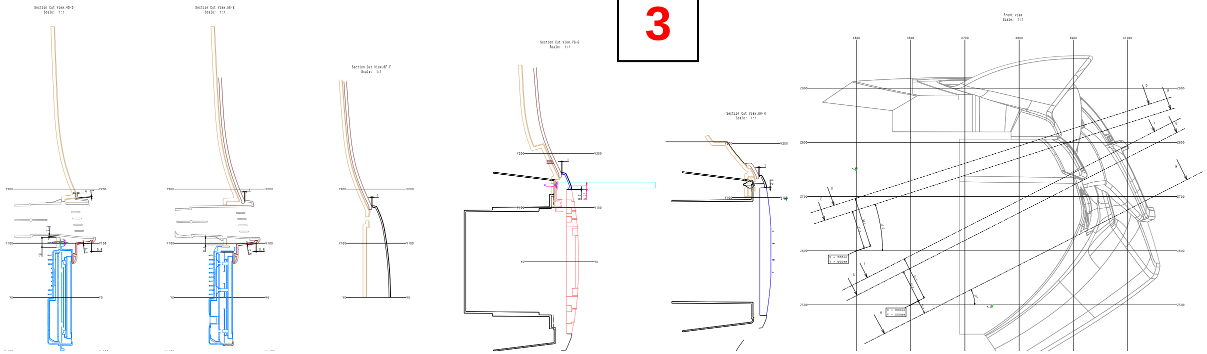
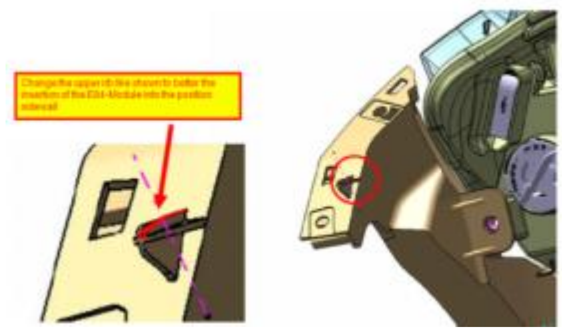
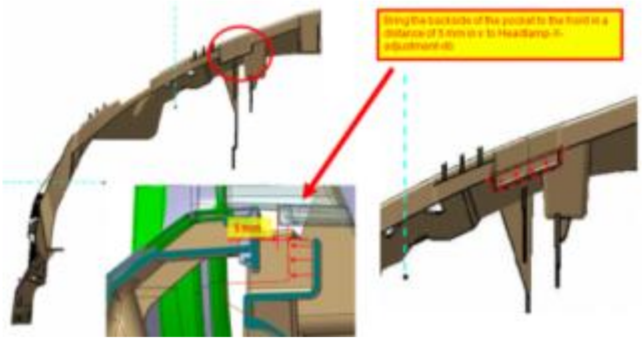


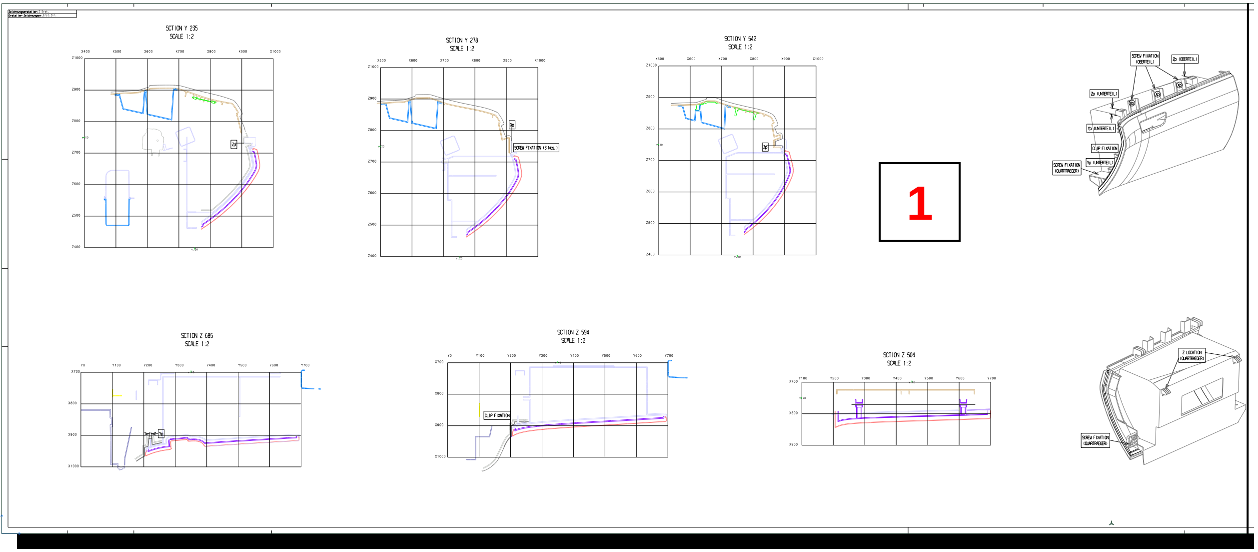
Phase 3 – Production Validation

- Design Optimization
- DMU
- Change Management

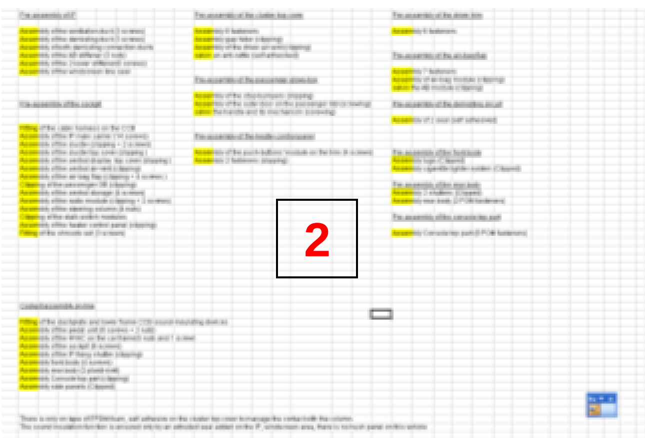




Phase 4 – Design and tooling

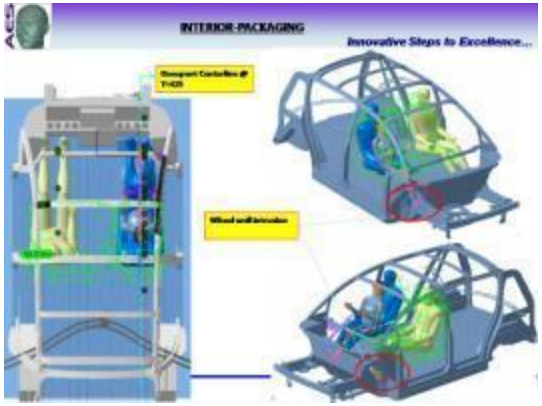


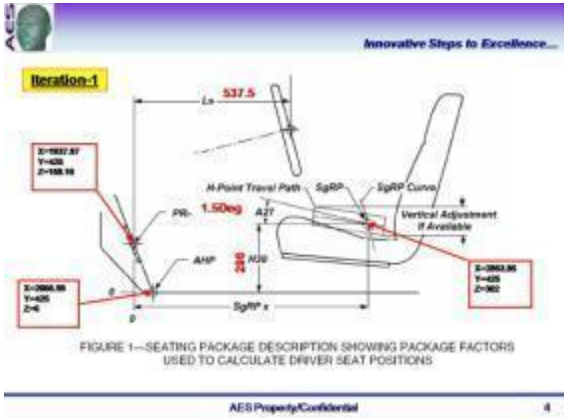
Assembly process

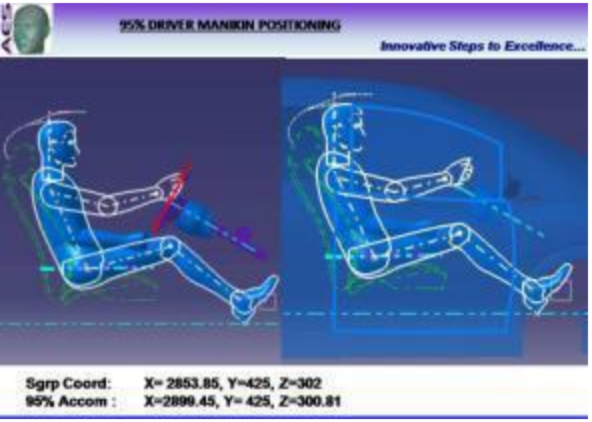


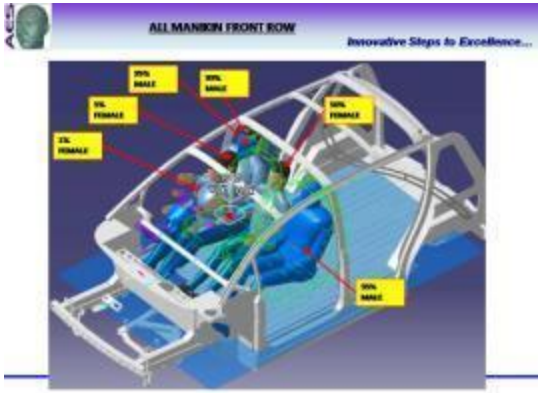
INTERIOR CASE STUDY
SCOPE : OCCUPANT PACKAGING STUDY

Manikin Positioning as per SAE

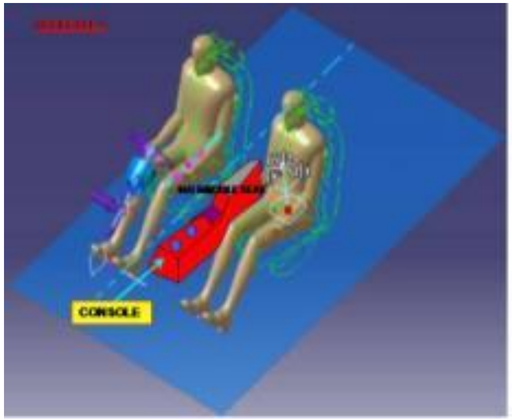






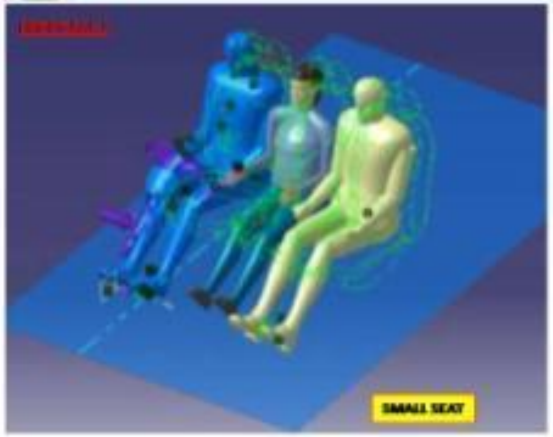


Seat Layout Proposal



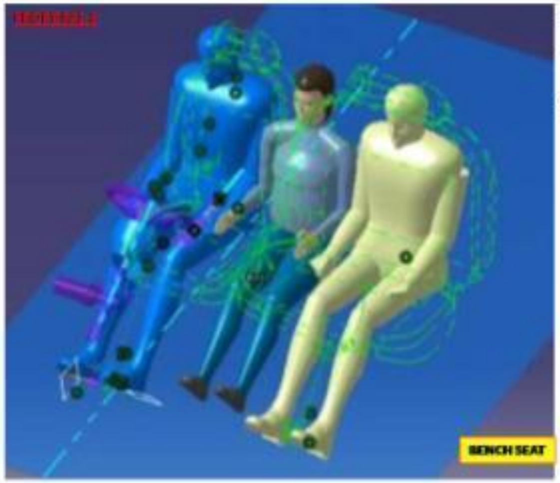
Advantages:

1. Center Console can be added with features like cup holders, 12volt, Armrest, handbrake etc.
2. Comfortable maneuvering for the driver & passenger.



Comments:

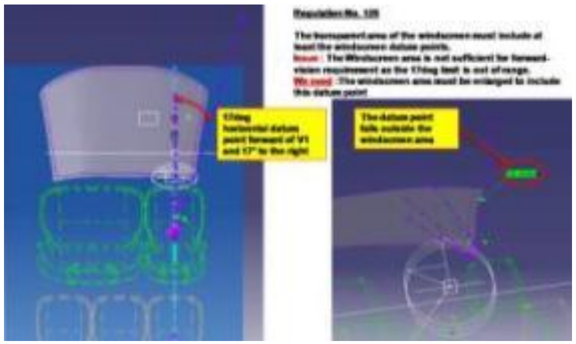
1. We will need a customized seat for the middle passenger.
2. 50% Female can be accommodated with a bit of uncomforting for the adjacent manikins.

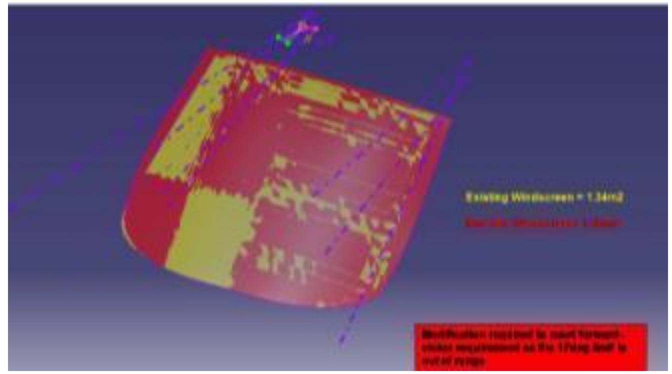


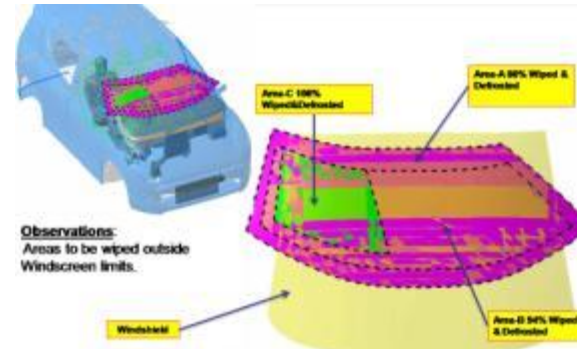
Comments:

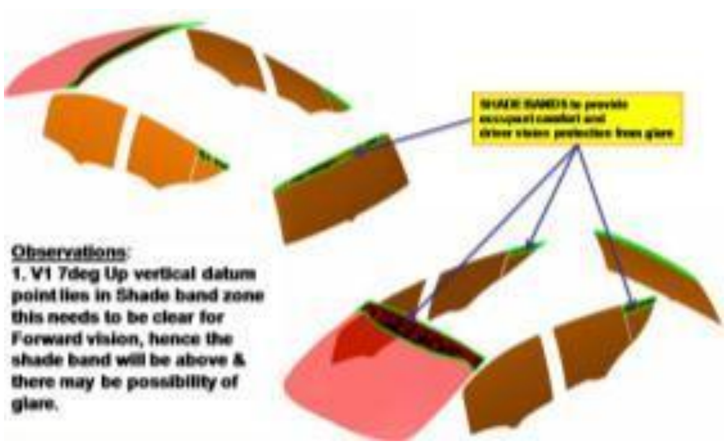
1. We will need a customized bench seat for both front passengers 60-40 split.
2. 50% Female can be accommodated with much better comfort.

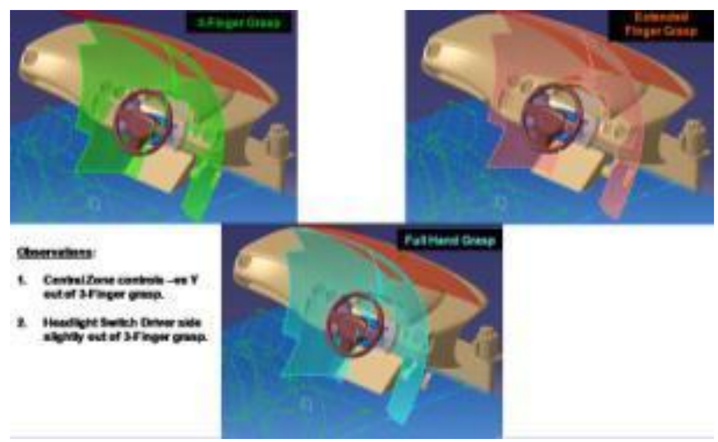
Regulation Study



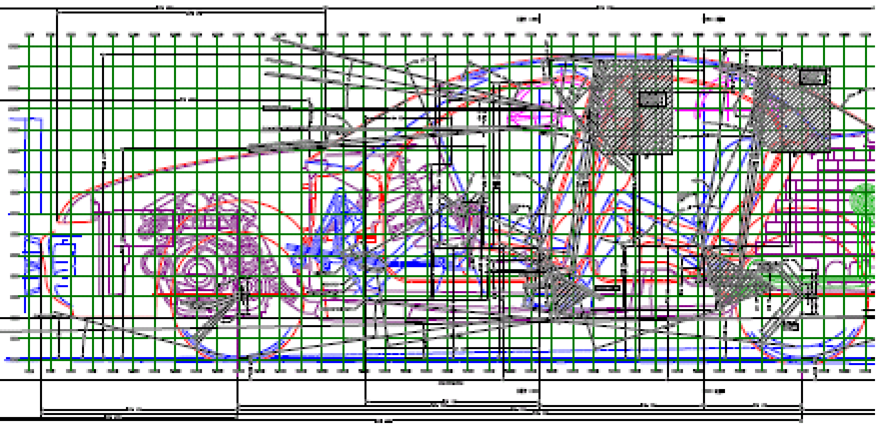


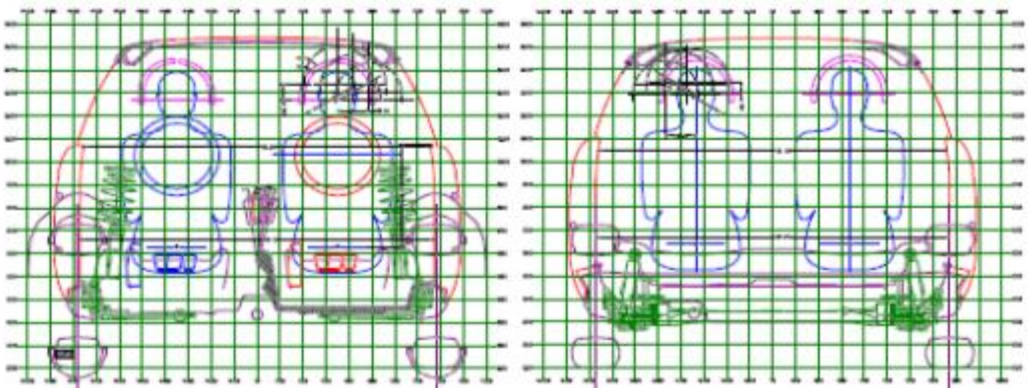






Packaging Drawings





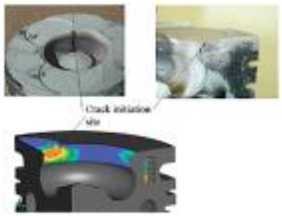
FEA Capabilities of AES in Automotive

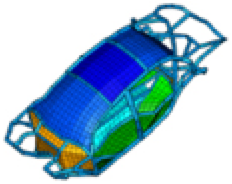
FEA Services

Durability

- Suspension and Chassis components stiffness evaluation and Life prediction
- Powertrain Components – Thermo-mechanical simulations
- BIW Stiffness Evaluation

ANSYS/ABAQUS/FE-Safe

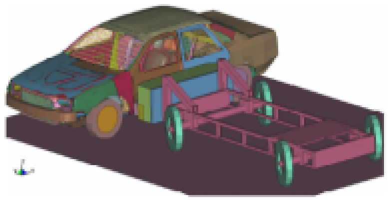




Crash Simulation

- Full-Frontal Collision as per FMVSS, IIHS, NCAP
- Side Impact Simulation with injury level to the passenger using dummy
- Occupant Safety including Airbag deployment and Seat belt safety test

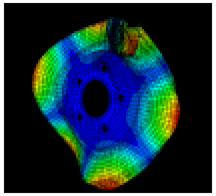
LS-DYNA/RADIOSS

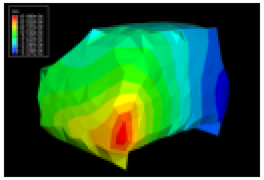


Noise, Vibration and Harshness

- Brake Squeal Simulations
- Acoustic simulations for sound pressure level inside cabin
- Powertrain NVH

ABAQUS/NASTRAN

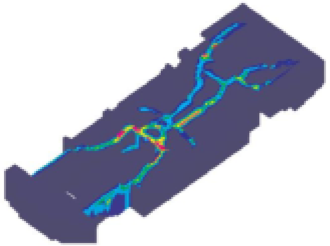




Design Optimization Studies

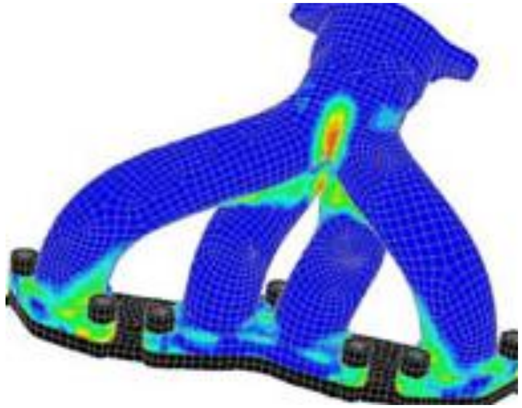
- BIW & Chassis Topology Optimization
- Size and Shape Optimization of Suspension and Chassis components
- Optimization studies using Design Sensitivity analysis and Pareto curves for trade-off studies

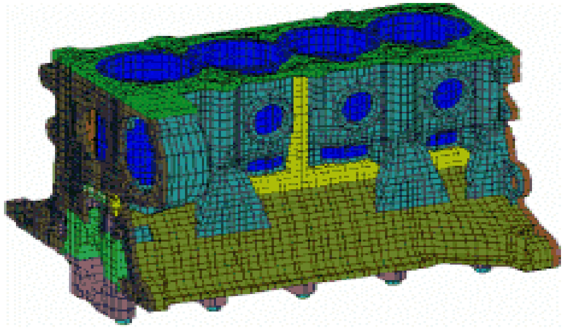
OptiStruct/Genesis/VisualDoc



FEA Services

- Finite Element Analysis for Static & Dynamic
- Linear and Non-linear problems in Steady state/ Transient
- Stress Analysis, Structural and Thermal analysis
- Crash and Impact analysis
- Fatigue and Durability analysis
- Plastic Deformation
- Creep Analysis
- Rotor Dynamics
- NVH
- Harmonic, Spectrum & Random analysis
- Transient Dynamic analysis
- Sub-model analysis
- Coupled field analyses
- Design Optimization studies

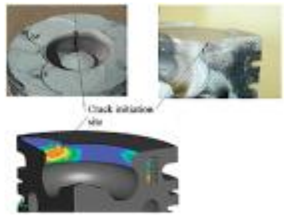




- ANSYS for FE analysis
- ABAQUS for Non-linear Structural FEA
- Nastran
- LS-DYNA for Impact analysis
- HYPERMESH & ICEM CFD for meshing
- PRO/E, AUTOCAD, CATIA and UNIGRAPHICS for CAD modeling

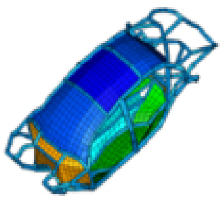
FEA Capabilities- Domain Level

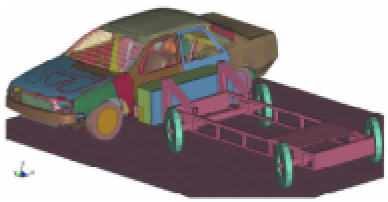
Example : Automotive Domain



Durability

- Suspension and Chassis components stiffness evaluation and Life prediction
- Powertrain Components – Thermo-mechanical simulations
- BIW Stiffness Evaluation





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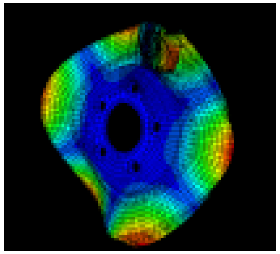
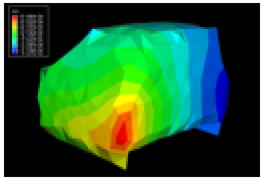
- Acoustic simulations for sound pressure level inside cabin
- Chassis and Powertrain NVH





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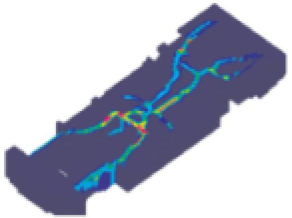
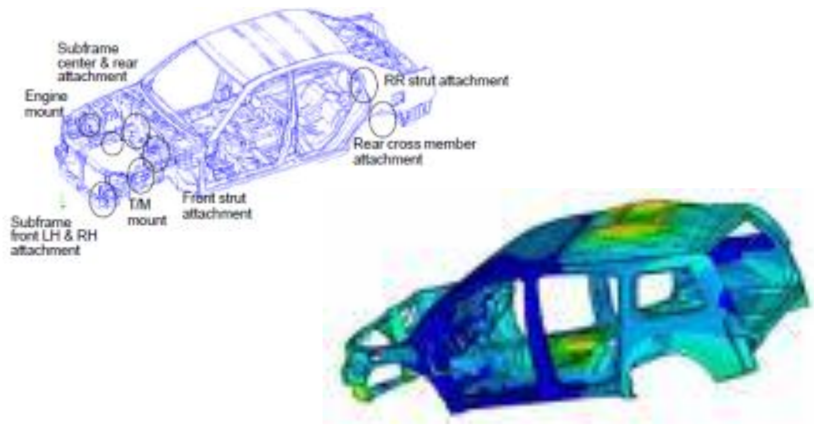


FEA Capabilities – Component Level

Example : Different Analyses in Automotive Components

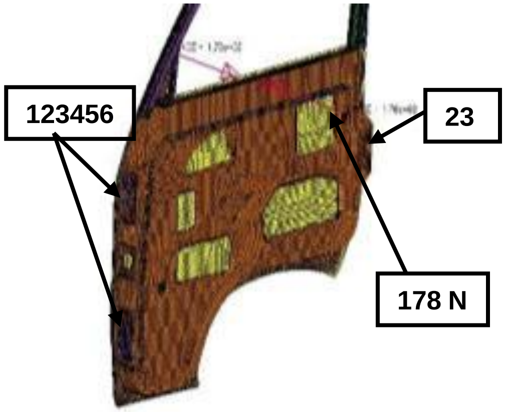
- Complete finite element modeling and analysis solution for simulating the real-world behavior of materials, processes, and products
- FE modeling & meshing for **NVH, durability and crash.**
- Stress, vibration, thermal and heat transfer analysis.
- Interior/exterior **acoustic** analysis
- Frequency, point mobility NVH analysis
- Durability & damage tolerance analysis
- BIW normal modes analysis
- Crashworthiness (offset/side/front/rear)
- Optimization – size, shape, topology.
- Chassis and Powertrain NVH
- **Brake caliper** – disc brake system
- **Exhaust system** thermo-structural and acoustic analysis
- Transmission loss studies on enclosures
- Durability analysis of components like **crankshaft, connecting rod, piston, intake and exhaust system, steering wheel, carrier plate, rotor assembly, plastic components, Elastomers** etc.
- Fatigue analysis of **control arm and steering knuckle.**
- **Spot weld failure**



Door Belt Squeeze Analysis

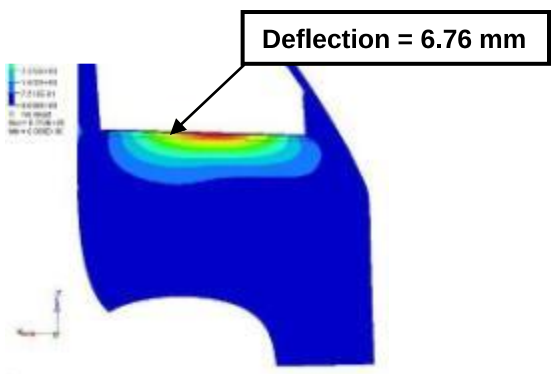
1. Input parameters (Design Spec) –

- Design must meet the acceptance criteria of Belt squeeze.
- Load cases are –
  - Direction – Normal to Door belt line
  - Load value – 178N
- Acceptance criteria
  - Deflection ≤ 3 mm
  - Stress < Yield value of Panel materials

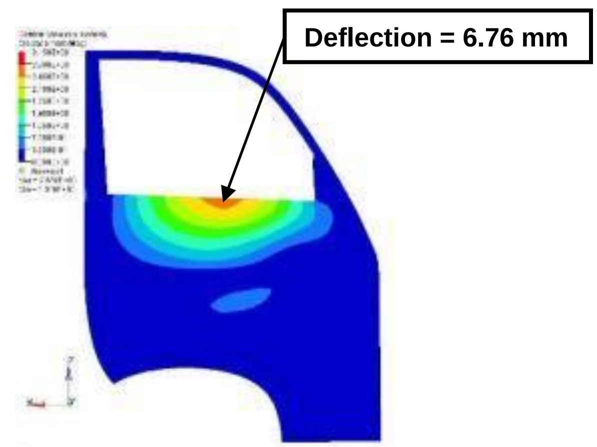


2. Design Spec -

- 3-D model of Door shell Assy
- Material definition of all panels and reinforcement
- Thickness of all panels and reinforcements.



Reinforcement (0.8 mm) was incorporated at door outer panel.

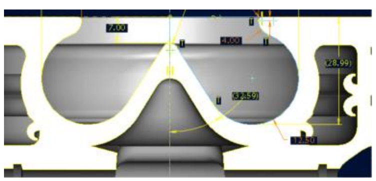


Durability Analysis of HD Piston

Objectives :

- ➢To predict fatigue life of piston subjected to Thermal, Structural and Inertia loads.
- ➢Life Prediction for 10 million cycles.

Geometry Modeling & Meshing



Analysis Steps

- **Fully featured, 3-dimensional quarter model assembly**
- **1 Steady-state temperature analysis**
- **2 Structural analyse**
- Thermal Load Analysis at 300 kW @ 2200rpm
- Thermal + Rated Gas Load Analysis,

  Peak Pressure [20 MPa]
- Thermal + Peak Inertia Load [3500 m/s2]
- **1 Goodman Fatigue Analysis**

Boundary conditions

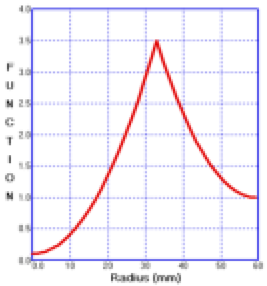
- Axi-symmetric BC on piston assembly
- Displacement BC to prevent axial movement
- Weak springs to prevent rigid body rotation
- Material Used : SAE 4140

Loads

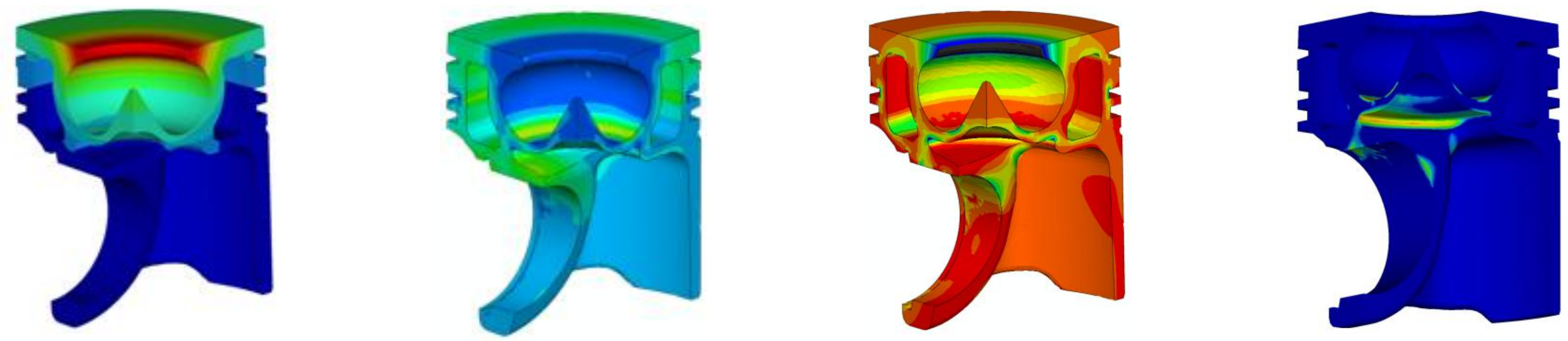
- Analysis 1: Steady-State heat transfer (ABAQUS)
- Analysis 2: Step 1 – Thermal load from Analysis 1 (ABAQUS)

  Step 2 – Thermal + Gas Load for Peak Cylinder Pressure

  Step 3 – Thermal + Peak Inertia
- Analysis 3: Goodman Fatigue Analysis (FE-Safe)



Result & Discussions for DH Durability Analysis



Temperature profile **Max & Min Principal Stresses** **Fatigue Safety Factor**

Typical contour plots

Final Results :

From the Simulations, temperature profile, various stress plots and Fatigue safety factor results were plotted. Based on the analysis, performance of the part under various load cases were determined.

Conclusion :

1. Stresses were little above yielding under compressive conditions.
2. Fatigue Safety factor was well above the safety limits.

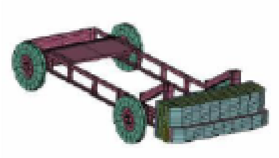
Side Impact Crashworthiness Simulation

Objectives :

➢Crash analysis to predict capability of energy absorption of Side door.
➢To validate thoracic trauma index and pelvic acceleration on dummy are within safety guidlines (FMVSS 214).

Geometry Modeling & Meshing

Vehicle model



MDB model

Dummy model

Side door model

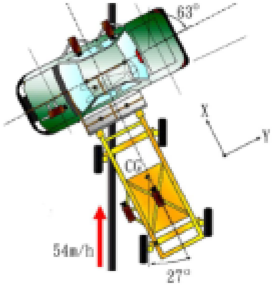
Analysis Methodology

Model:

CAD model from CATIA V5 was meshed with shell and brick elements for vehicle and MDB and dummy is a Hybrid III 50% dummy model.

Set-up

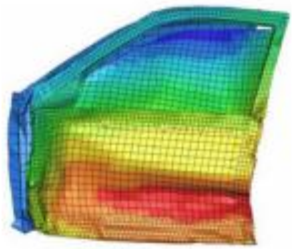
-As per FMVSS 214 regulations
-Intersection Crash involving two moving vehicles
-MDB moving velocity 33.5mph
-Vehicle Stationary
-MDB wheel crabbed at 27 deg



Result & Discussion for Side Impact

Task Executed:

Meshing was carried out in HyperCrash. Analysis is carried out in RADIOSS. Different plots are provided in the technical report using HyperView Post-processing.



Typical contour plots

Final Results :

From the Analysis, the intrusion of side door in the cabin were detected and energy absorption was calculated. Further with the dummy TTI (Thoracic Trauma Index) and Pelvic acceleration were calculated.

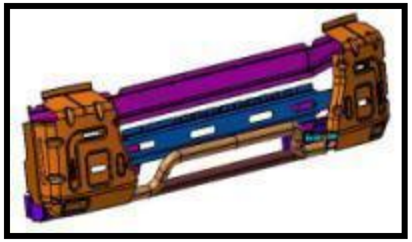
Conclusion :

- Impacting force causes severe injury to Pelvic area of the dummy.
- Acceleration of thoracic is well within 90G and Pelvis is slightly below 130G of FMVSS limit.

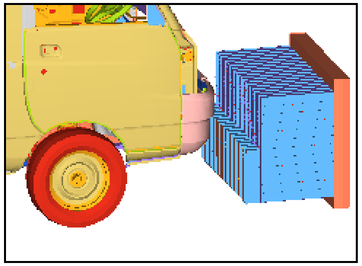
Frontal Crash

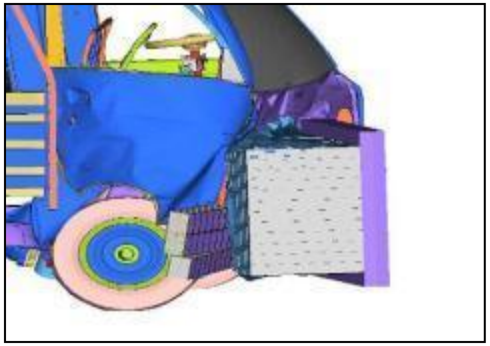
Input parameters (Design Spec) –

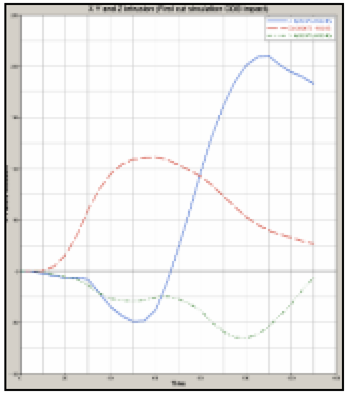
- Design must meet the acceptance criteria of ECE R94 for Frontal offset crash for occupant safety.
- Load cases are –
  - Barrier for hitting – Stationary (As per std)
  - Speed of Impact - 56 Kmph
- One of the acceptance criteria
  - Steering penetration in X ≤ 100mm, Z ≤ 80mm



Structure Layout







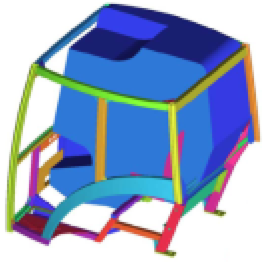
Iteration#1:
X intrusion 200 mm
Z intrusion 85 mm

Acoustic Simulation of Tractor Cabin

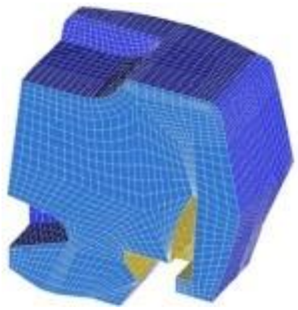
Objectives :

➢NVH Simulation to predict Sound Pressure level near driver's head.

Geometry Modelling & Meshing



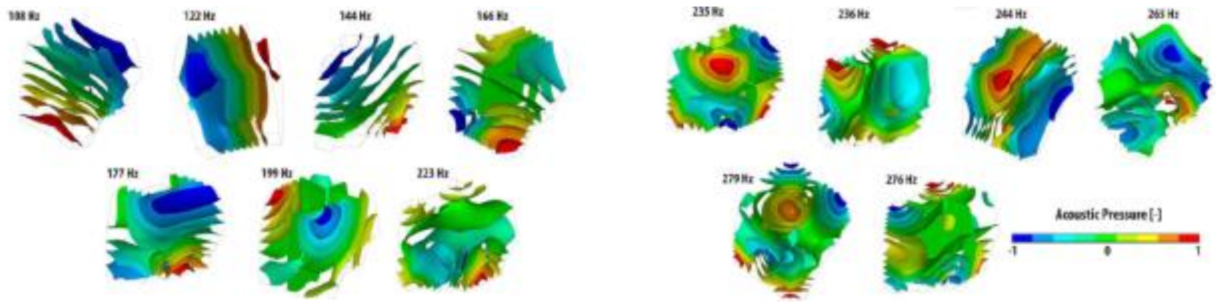
Customer Model



Base model for Test Case

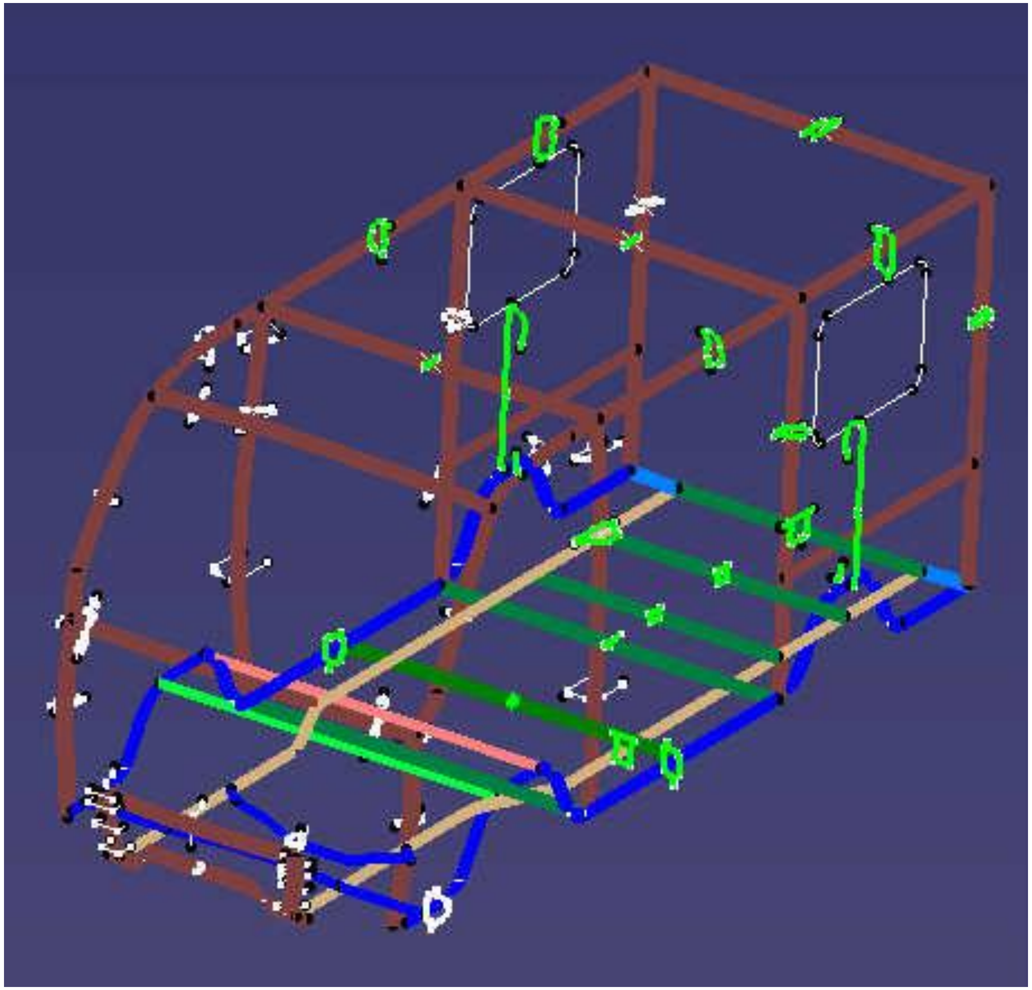
Set-up

- Air density : 1.2 kg/cu.m
- Air bulk Modulus : 1.39E5 Mpa
- Sound Speed : 340 m/s
- Fixed BC at Connection points of cabin to chassis



Typical contour plots

Beam Model – Initial CAE & NVH of Unibody Construction



Thank you !!
Questions?