MeshWork's Parameterization & Optimization

**Aerospace**
- Blade Containment
- Bird Strike
- Failure Analysis
- Emergency airplane landings

**Automotive**
- Crash/Safety
- Airbag modeling (FSI)
- Occupant safety
- Pedestrian safety
- CFD

**Material Optimization**
- Composites

**Consumer Products**
- Electronic Component Design
- Drop Tests of Consumer Products
- Sports Equipments

**Defense**
- Under Water Detonation
- Explosion Analysis (Fluid/Structure Coupling)
- Shield Simulation

**Energy Sector**
- Failure Analysis
- CFD Analysis
- Turbine Blade Analysis

**Production**
- Metal Cutting
- Metal forming
  - Metal Stamping
  - Forging
  - Hydroforming
  - Casting
  - Springback
  - Glass Forming

**Bio-Medical**
- Blood Pump
- Knee Cap Design
- Heart Valves
- Surgical Instruments Design

**DEP – ONE STOP SHOP FOR ALL THE DESIGN, CAE, ENGINEERING, OPTIMIZATION NEED**
• BIW
• Closures
• Suspensions
• Subframe
• Interiors
• Seats
• Bumper systems
• Crush Cans
• Brakes
• Tires
• Power-Train
• Axles
• Fuel Tanks
• Exhaust
• Batteries

FULL VEHICLE TRIMMED MODELING
DEP LEVELS OF ENGAGEMENT - AUTOMOTIVE

- Styling
- Product Design
- Product Engineering
- Tool Design Development
- Prototyping
- Manufacturing
- Marketing, Sales, Distribution & Service

Our Core Competence
New Styling Theme Powered by MeshWorks
**DEP–FULL VEHICLE CAE EXPERTISE**

*Cut, Stitch and Weld method in Morpher*

*Match to the styling theme*

*Weld line creation, weld repitch.*
DEP–FULL VEHICLE CAE EXPERTISE

Inputs

Morphing

Outputs
**Schematic Diagram of MDO**

**BIW/Frame Stiffness**
- 1st Freq, 2nd Freq
- Static Bending/Torsion
- A/B/C Joint Stiffness
- Sub/Frame Stiffness
  - Shape:
  - Frt side MBR, Reinf Frt side MBR, CTR Side MBR, Side Sill,
  - Back/Beam, Frt sub/Frame,
  - Dash/MBR, A-pillar, B-pillar,
  - Floor CRS MBR, Frame Section
  - Thickness of Main Part (20)

**Durability**
- Stress values
- Shape:
  - Front & Rear shock absorber area,
  - Joint area, Reinforcements
  - Frame Section
  - Thickness of main parts (20)

**Vehicle Dynamics**
- Handling Flexibility
  - Front & Rear suspension hard points
  - Stiffness & Damping

**Drive-Line & Eng Mount**
- Vibration Response at Drive-line
  - Engine & T/M MTG Position,
  - Axle MTG Postion,
  - Section of Sub/Frame
  - Thickness of Sub/Frame

**NVH**
- FRF Analysis Results
- Engine Excitation Response
- Road Excitation Response
- Cavity Mode
  - Shape:
  - Frt side MBR, Reinf Frt side MBR, CTR Side MBR, Side Sill,
  - Back/Beam, Frt sub/Frame,
  - Dash/MBR, A-pillar, B-pillar,
  - Floor CRS MBR, Frame Section
  - Thickness of Main Part (20)

**Crash/Safety**
- Offset/Frontal/Low leg form
- Side Impact/Roof Crush
- R-CAR/HeadImpact
  - Shape:
  - Frt side MBR, Reinf Frt side MBR, CTR Side MBR, Side Sill,
  - Back/Beam, Frt sub/Frame,
  - Dash/MBR, A-pillar, B-pillar,
  - Floor CRS MBR, Frame Section
  - Thickness of Main Part (20)

**CFD**
- Effective Cooling Area
  - Wheel tread, Back beam height,
  - distance (back beam & radiator)
  - Hood angle,
  - wind shield angle, Truck height

**DEP–FULL VEHICLE CAE EXPERTISE**
DEP–FULL VEHICLE CAE EXPERTISE

DESIGN PARAMETERS

SHAPE PARAMETERS
Cross-section of A/B/C/D Pillars (NVH/Roof crush)
FH/RF/RH/Rocker sections (NVH/Roof crush)
Front/Rear rail section (Crash/Safety) (Crash/Safety)
Bumper sections (Crash/Safety)
Front overhang (Crash/Safety)
Windshield (CFD)

FEATURE PARAMETERS
No. of Beads (Crash/Safety)
Number of crush features (NVH/Crash/Safety)
Number of Ribs (NVH/Crash/Safety)

TOPOLOGY PARAMETERS
Addition/removal of members (NVH/Crash/Safety)
Relocation of members (NVH/Crash/Safety)

COMPOSITE
Material selection
Number of layer
Fiber Orientation
Fiber Locations in co molded parts
NVH/Crash/Safety

STRUCTURAL PARAMETERS
Thickness of shell structures (NVH/Crash/Safety)
Cross-sectional properties of beam members (NVH/Crash/Safety)

WELD PARAMETERS
Spot weld pitch (NVH/Crash/Safety)
Continuous weld length (NVH/Crash/Safety)

Early Stage Design Changes

Later Stage Design Changes
DESIGN PARAMETER - SHAPE PARAMETER
DESIGN PARAMETER - FEATURE PARAMETER
DESIGN PARAMETER - FEATURE PARAMETER
Design Parameter - Topology optimization

NON-DESIGN SPACE

PACKAGE SPACE

‘CARVED OUT’ TOPOLOGY SATISFYING PACKAGING, STYLING & NON-DESIGN SPACE

NEW EFFICIENT ARCHITECTURE DEVELOPMENT
Design Parameter - Composite Material optimization

Fiber Orientation optimization

UD tape vs LFTD layout optimization

Ply thickness optimization

Ply stack up optimization
DESIGN PARAMETER :- PART MOVEMENT
DESIGN PARAMETER :- WELD PITCH

15 mm
30 mm
45 mm
60 mm
15 mm
30 mm
45 mm
60 mm
DEP–FULL VEHICLE CAE EXPERTISE

DEP-Crash Expertise (Exteriors)

- Offset Impact
- Side Impact (EU)
- Frontal Impact
- Side Impact [US]
- Rear Impact
- Pedestrian Protection
- IIHS Side Impact
DEP-Crash Expertise (Exteriors)

FULL FRONTAL BARRIER

OFFSET DEFORMABLE BARRIER
DEP–FULL VEHICLE CAE EXPERTISE

DEP-Crash Expertise (Exteriors)

SIDE IIHS

SIDE POLE

REAR OFFSET BARRIER
DEP-Crash Expertise (Interiors)

Knee impact :-Driver side

Knee impact :-Passenger side

Interior-IP Pendulum impact

Interior-Garnish Trim Head impact
DEP-Seating Analysis Expertise

Child Restraint Systems
ECE R44 / R16

Luggage Retention
ECE R17

Seat & Seat Belt Anchorage
ECE R14 / R17 / R80

Seat & Seat Belt Anchorage
FMVSS 207 / 210

FMVSS 201 Head Impact

Seat Head restraint & attachment assemblies FMVSS 202
Seat Back Tube
FMVSS 202A, FMVSS201, Modal, Rear Impact (High and low speed), FMVSS225 (w/tether).

Headrest Bracket and HR Rod
FMVSS 202A, FMVSS 201

Seat Back Pivot Bracket
FMVSS 202A, FMVSS201, Modal, Rear Impact (High and low speed), FMVSS225 (w/tether).

Tower
FMVSS 208, FMVSS 207/210, Modal, FMVSS 201, FMVSS202A, Rear Impact

Recliner cross tube/seatback lower c/s member
Recliner Strength, Rear Impact, Modal, FMVSS 225

Recliner Brackets
FMVSS 208, FMVSS 207/210, Modal, FMVSS 201, FMVSS202A, Rear Impact

Front c/s tube, Pivot Brackets
FMVSS 208, FMVSS 207/210, Modal

Pivot Bracket (LH/RH)
FMVSS 207/210, FMVSS 208, Cargo

Cushion side support bracket (LH/RH)
FMVSS 207/210, FMVSS 208, Cargo Rear Impact (Energy Management), Modal
Parameters being changed to improve performance

The Cross member was parameterized to 47 mm from 57mm

The Head Rest rod diameter was parameterized to 7 mm from 11.5 mm
NOISE & VIBRATIONS ANALYSIS

- BIW Normal modes
- Trim Body modes
- Acoustic Cavity modes
- Point Mobility
- NTF/VTF analysis
Power train Noise & Vibrations
Power train bending dynamics

• Normal Modes Analysis of entire powertrain and driveline
  – Evaluation of natural frequencies of the sub-system and the associated powertrain bending mode shapes
  – Identification of critical speeds by mapping natural frequencies with operational dynamic loads

• Forced response Analysis for dynamic loads
  – Prop. Shaft imbalance loads
  – Engine torque pulsation - harmonics
DEP CFD-Expertise

Aerodynamics, Front end flow, Under hood flow, HVAC
Complex Transmission and Transfer case housing FE models can be morphed rapidly to fit the profile of new internals.
Parametric Engine & Transmission FE models can be generated for quick synthesis of FE models using the MeshWorks/MORPHER.

Shown here are the following parameters:
• Inlet port dia
• Outlet port dia
• Combustion chamber height
• Bolt dia
• Runner wall thickness

PLEASE SELECT SLIDE SHOW MODE TO SEE ANIMATION
Approximate time for animation = 1 minute
Shown here are the following parameters:

- Length of inlet nozzle
- Diameter of inlet nozzle

Parametric FLUENT CFD MODEL

PLEASE SELECT SLIDE SHOW MODE TO SEE ANIMATION
Approximate time for animation = 1 minute
Design Variable 2- Vent Window Size

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td>Vent Window Size</td>
<td>-3.00</td>
<td>3.00</td>
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</tbody>
</table>
Design Variable 3 – Water Jacket Height

<table>
<thead>
<tr>
<th>WaterJacket Height</th>
<th>Min</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>-3.00</td>
<td>2.00</td>
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</tbody>
</table>
Design Variable 6 - Bolt Length

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td>Bolt Length</td>
<td>-10.00</td>
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</tbody>
</table>
Design Variable 7 – Water Jacket Wall Thickness

<table>
<thead>
<tr>
<th>WJ_wallThickness</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-4.00</td>
<td>4.00</td>
</tr>
</tbody>
</table>
DV1: Bolt Length - Animation
DV2: Main Bolt Position - Animation
DV4: Insert Hole Shape - Animation
DV5: Insert Height - Animation
The fillet areas will be smoothened in each design to have nice blend with surrounding surfaces.
DV7: Vent Window Size - Animation
**Purpose:**
This tool will create a tria or tetra rib in a given tet-mesh component by sketching the profile of the rib.

**Application areas:**
Inserting ribs in chassis and power train tet components.
Purpose:
This tool will create new tetra mesh by 'unioning' or 'intersecting' two different tet mesh components.

Application areas:
1) Cutting holes in a tet mesh component
2) Joining different tet mesh components
3) Design space model creation
**MESHWORKS** (Common Control Blocks to parameterize models from different disciplines)

**UNIFICATION USING MESHWORKS**

**OPTIMIZER** (Isight, ModeFrontier etc.)

- Design Variables & Limits
- Objectives
- Constraints

**DOE**

**CFD Solver**

**NVH Solver**

**Results Extraction scripts**

**Input-Output matrix**

**Optimized design**

**AB AQUS**

- Durability Design1
- Design2
- Design3
- Design ‘n’

- Sealability
  - Design1
  - Design2
  - Design3
  - Design ‘n’

- Baseline-durability
- Baseline - NVH
- Baseline - CFD
- Baseline - sealability

**DEP MDO EXPERTISE**
Finite Element Analysis of Stent

Finite Element Approach of Stent

Stress distribution during expansion

Stent Expansion
Structural Analysis and optimization of Balloon Expandable Stent

FE Model of a STENT

Stress Contour
Structural & CFD Analysis – Mechanical Heart Valve

FE Model

CFD Analysis
DEP Bio-Medical EXPERTISE

**Parametrization of Stent**

- **Full Offset**
- **Thickness**
- **Angle Offset**
- **Horizontal Strut width offset**
- **Curved Strut width offset**
Structural Analysis of Knee Joint Replacement

Strain

Max Principal
- 0.00701
- 0.00601
- 0.00501
- 0.00401
- 0.003
- 0.002
- 0.001
- 1.7e-06

Y Displacement

Displacement
- 5.9e-05
- 5e-04
- 4e-04
- 3e-04
- 2e-04
- 1e-04
- 0.0017
- 0.002

Fy = (5/5)
Stress Contour at different Flexion Angles

- Zero Degree Flexion
- 90 Degree Flexion
- 120 Degree Flexion
Structural Analysis of Hip Joint Replacement

FE Model

FE Stress Analysis
 Structural Analysis of Total Disc Replacement

Spinal Implant

Stress Contour for compressive loading of the artificial spinal disc
DEP Defense EXPERTISE

Blast Performance Study

Baseline Model Animation
Von Mises Stresses

Baseline Model Animation
Displacements