Advanced Capability & Application of Genesis Software Topology

Advanced Vehicle Development and CAE
General Motors

Acknowledgment
GM Vehicle Optimization and CAE Teams (AVD-CAE)

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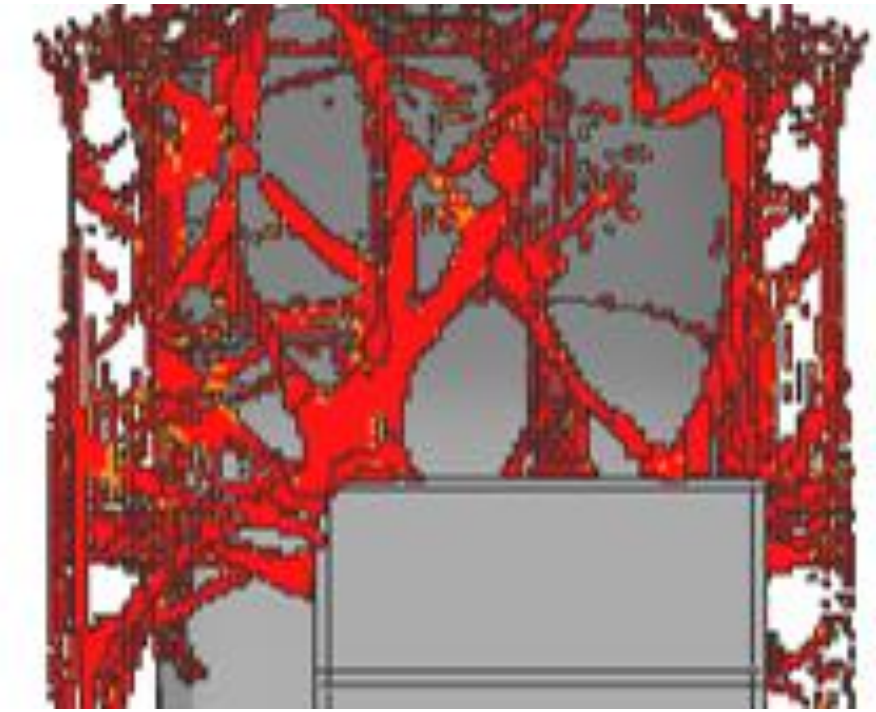
Overview

- Example 1T: Load Path Improvement with Lua Scripts
- Example 2T: Multi-model Competency to find common and unique loadpaths for architecture bandwidth optimization

Example 1T – Load Path Improvement with Lua Scripts

Challenge: Load Paths from Topology Optimization to be more ‘clear and interpretable’



Current
Under Body Topology

Model Details

Full Body Topology

DOF = 5 million
No of Topo Design Variables = 1 million
No of Load Cases = 120
No of Constraints = 100

Mass is Allocated
Objective Function is to Minimize SE

Lua Script

```
SCRIPT=LUA
-- GENESIS Lua script
--
-- progressively reduce the mass fraction constraint (by changing
-- a DTABLE constant) and increase the power according to a set schedule
--
-- KEEP THE MF VALUE TO BE THE SAME FOR ALL THE CYCLESa
-- THERE WILL BE NO VERIFY IN THIS SETUP
-- mf is actually a DUMMY. It is NOT used at all
-- This only changes the POWER
-- Design Space - can have many design spaces
--                each dsg space can have its own MF constraint
--                each dsg space can have a manf constraint
--                There can be a global mf constraint too
--
-- All that this script does is : ;change the power based on cycle number
--
----------------------------------------
--
schedule = {
             { mf = 0.10, power = 1.25, maxCycles = 10 },
             { mf = 0.10, power = 2.00, maxCycles = 10 },
             { mf = 0.10, power = 2.75, maxCycles = 10 },
             { mf = 0.10, power = 3.50, maxCycles = 10 },
             { mf = 0.10, power = 4.25, maxCycles = 10 },
             { mf = 0.10, power = 5.00, maxCycles = 10 },
           }
--
-- optionally do a final verification analysis at the end with all
-- densities >= verify set to 1.0 and densities < verify set to 0.0
--verify = 0.7 -- set to the level you want or comment out to skip
--
omf = 1.0  -- this should match the initial density set on TPROP
mfname = "MF"  -- name of mass fraction DTABLE constant
--
----------------------------------------
```

Genesis Capability

Support Lua Scripts

The customized scripts allows to change both

a) The mass fraction allocation
b) The the power setting

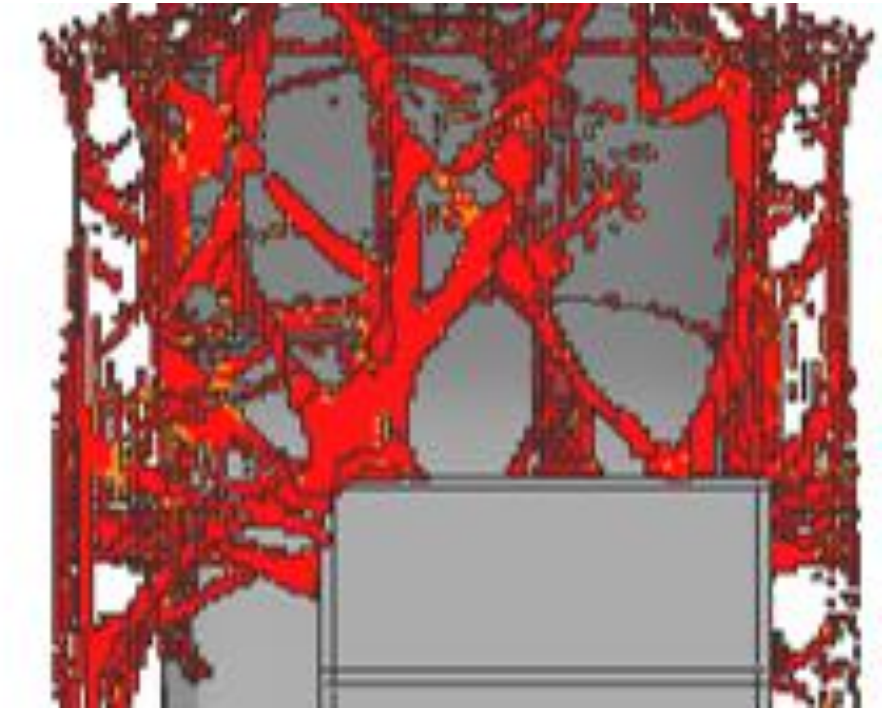
AND

c) Does final verification run with 0-1 polarization

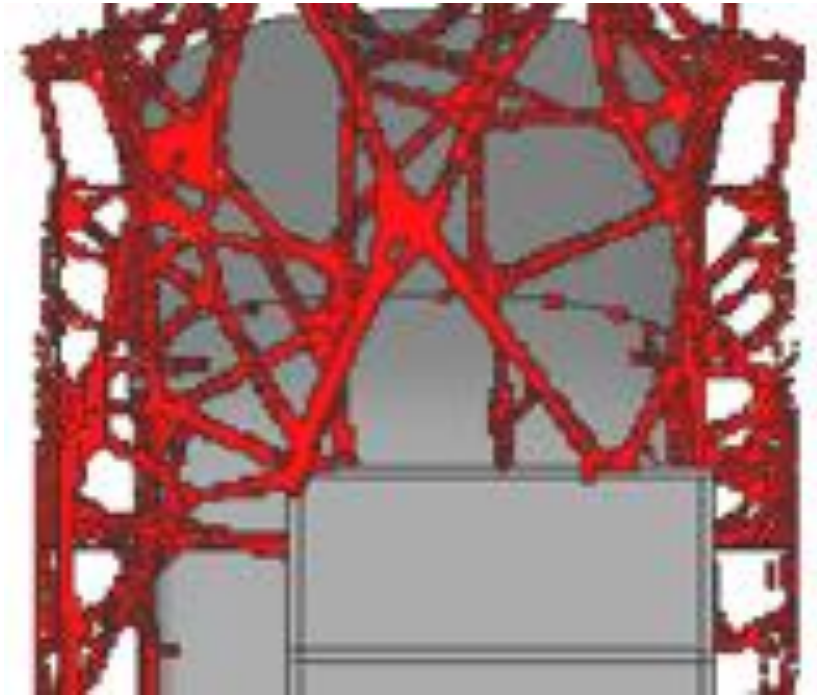
*Appreciate Brian Watson for the specialized Lua Script

*Acknowledge that Lua Scripts is a very powerful way to customize and control various options in Genesis. It has Allowed us to explore many options.

Results – Clarity of Loadpaths



Current (NO LUA)
Under Body Topology



New (WITH LUA)
Under Body Topology

Results Data

Min SE MF 5%		Initial Mass (kg)	Final Mass (kg)	Topology Quality Index (Density above 90%)	Time (hr)
Model	Current NO Lua	77.62	77.62	69.8%	14
	New WITH Lua	77.62	77.61	93.4%	61

- TQI is good
- Longer Run Times

*Appreciate J.P. Leiva and Phani Adduri for implementing and Validating the TQI index. This is an easy way to check quality Of result, without graphical post-processing

Example 2T

Challenge: To assess the Multi-Model Capability in Genesis

Definition of MMO:

To find common topologies, across derivative vehicles or multiple configurations of a vehicle and meets performances.

MMO - Explained

GM Current Product

Common (C)

Sedan (S)

Hatch Back (H)

Min(mass)
Meet Vehicle Performance

C,S,H are designable

C+S = Perf. 1
C+H = Perf. 2

Methods

PRIOR SCIENCE:

Method : All models need to merged as 1 deck
Sets of MPC and SPC will have to be generated
This will allow to turn models on or off for specific subcase
Optimization will be performed with this setup

NEW SCIENCE:

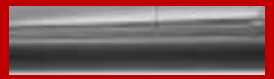
Method : Each Model will be a stand alone functional opt model
A master file will call out each of the models for optimization
Optimization will be performed with this setup

Appreciate J.P, Leiva and Brian Watson for this amazing capability.
This capability provides new opportunities in optimization

MMO - Example

Upper Body Design Space (All above Floor)

Under Body Design Space (Floor)



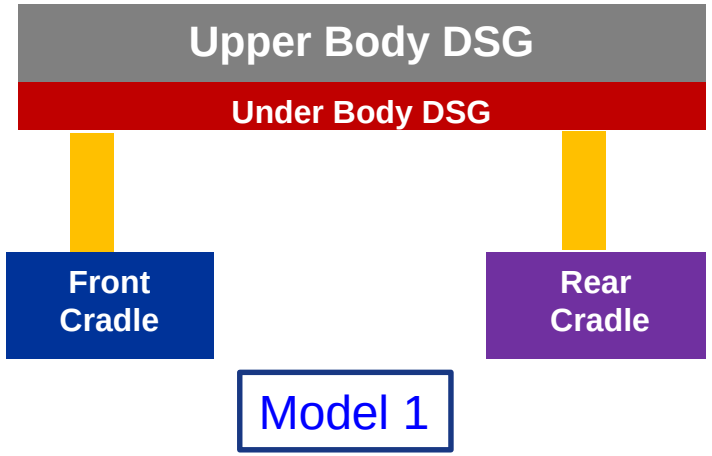
With/ Without

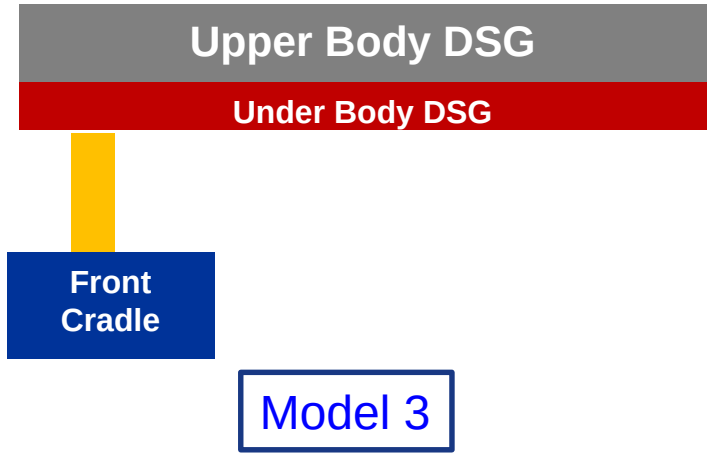
With/Without

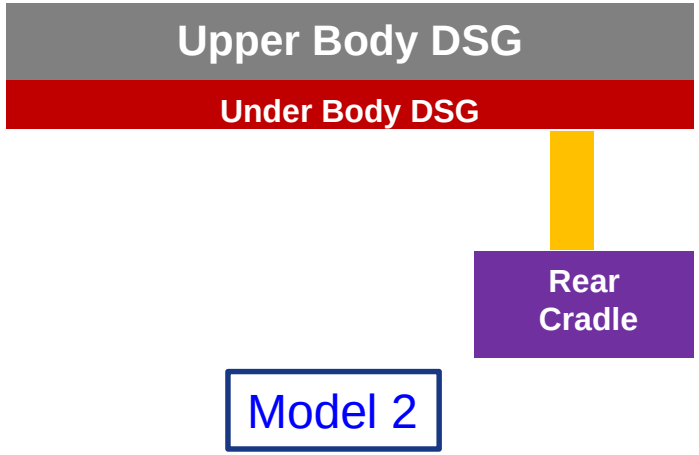
Front Cradle

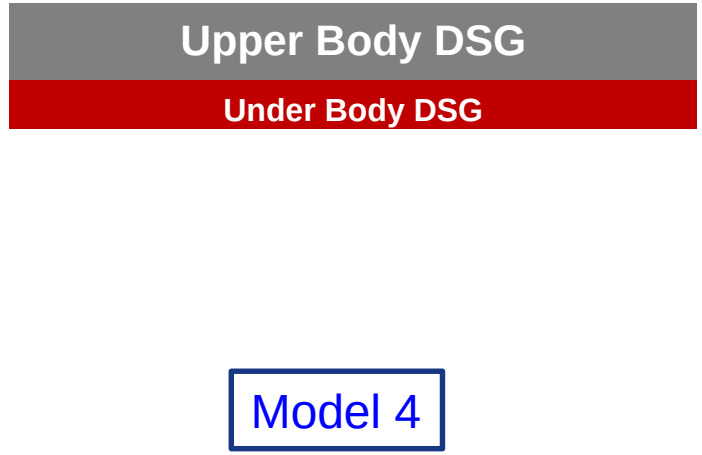
Rear Cradle

MMO – 4 Configurations









MMO Model Details

Topology Optimization

Min(SE) with Mass Fraction budget

4 different configurations of a vehicle with a common design space

DOF = ~4 million

Number of load cases (FFKs and GST)

Description	Genesis Version	Number of load cases
MMO (Prior Science)	Version 15	One model: 124
MMO (New Science)	Version 16	Model_1: 16 Model_2: 34 Model_3: 28 Model_4: 46 sum: 124

Results

	Resource	No. of cycles	Clock time (hrs)	Objective (Final)	Note
MMO **Prior Science**	1 Machine 8 CPU	12	5.5	34	- Labor Intensive to Set Up (5 days) All decks need to be merged as 1 deck - Needs large Memory - Compute time will be high
MMO **New Science**	4 Machines 4 CPU/Machine	13	3.0	33	- Easy to set up (1 day) Modular set up - Low on resource requirement, but needs more machines. - Compute time will be low All models run concurrently

Acknowledgements

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Joung Choi

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