

Simulation Automation

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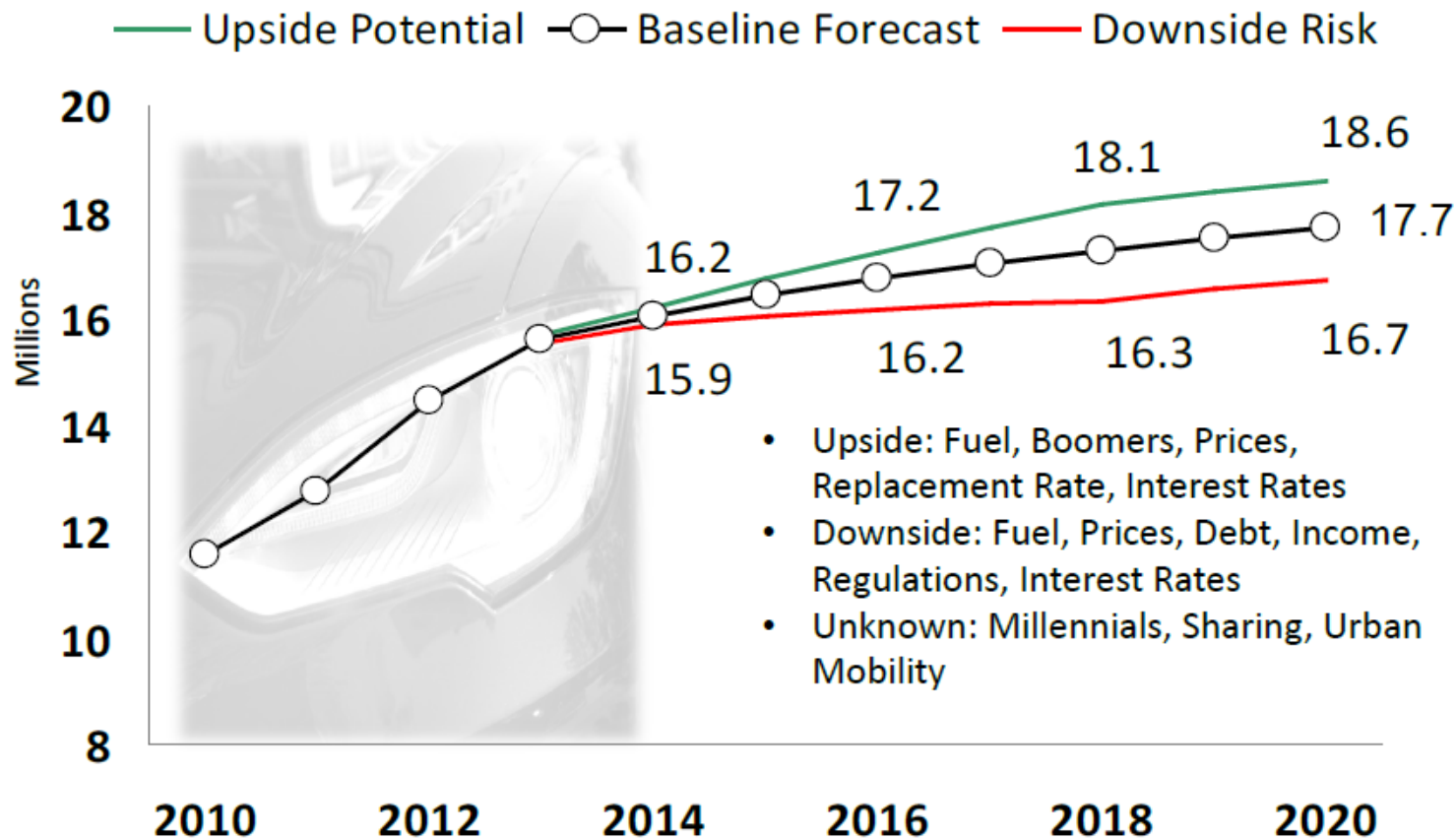


Agenda

- Driveline Business
- AAM Introduction
- Automation Choices & Objectives
- Simulation process
 - System Integration
 - Manufacturing Process Integration
- Simulation Automation at AAM
- Investment & Benefits
- Summary

North America Driveline Trends

US LV Sales - Upside Potential/Downside Risk



Source: LMC Automotive

AAM 2013 Profile

AAM's Vision : To be world's best driveline integrator and metal formed products manufacturer

Sales

\$3.21 Billion

Products

Driveline, Drivetrain
& Chassis Systems
Metal-Formed Products

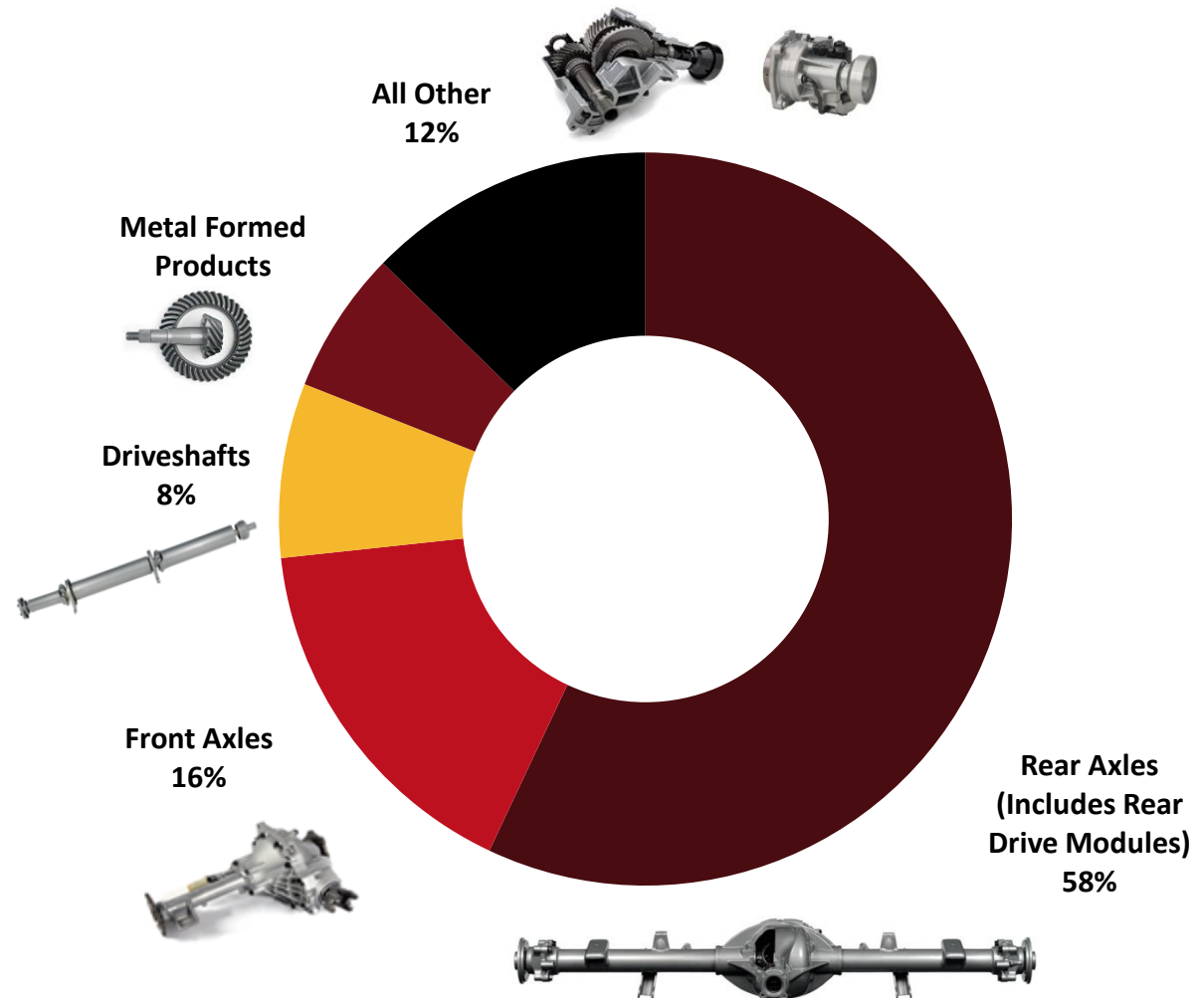
R&D Spending

\$103.4 million

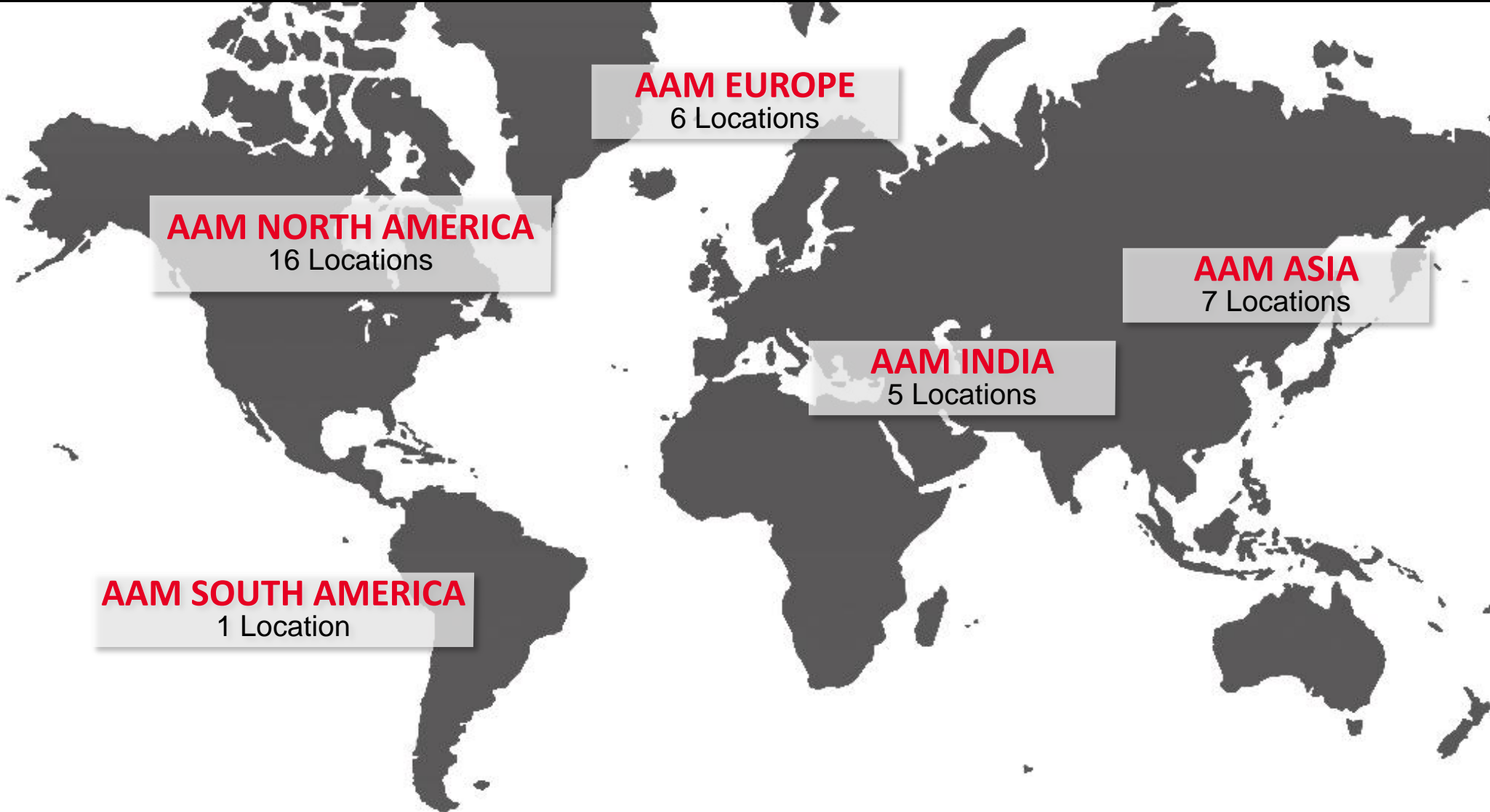
Associates

Nearly 13,000 associates

Sales Percentage by Product



Global Support



OVER 30 FACILITIES | 13 COUNTRIES | MORE THAN 100 CUSTOMERS

GLOBAL SUPPORT TEAMS | GLOBAL DESIGN CORE COMPETENCY CENTERS | CUSTOMER REGIONAL SUPPORT

Corporate North America

- ESTABLISHED: **1994**
- WORLD HEADQUARTERS: **DETROIT, MI**
- MANUFACTURING FACILITIES: **FOUR Major**
- ENGINEERING CENTERS: **FOUR**
- AUBURN HILLS PROTOTYPE BUILD CENTER
- ROCHESTER HILLS TECHNICAL CENTER
 - OPERATIONS: **24/7, 361**
 - DYNAMOMETER SYSTEMS: **20**
 - CAPABILITIES: **PRODUCT TEST LAB**

N.V.H. LAB

E.C.S. LAB

CORP. MATERIALS LAB

FASTNERS LAB

CORP. GEAR LAB



- Design automation
- Simulation automation
- Process automation – Can happen in any part of the organization with processes (HR, Purchasing, CAE, etc.)
- Others?

Simulation automation and optimization solutions enable engineering teams to:

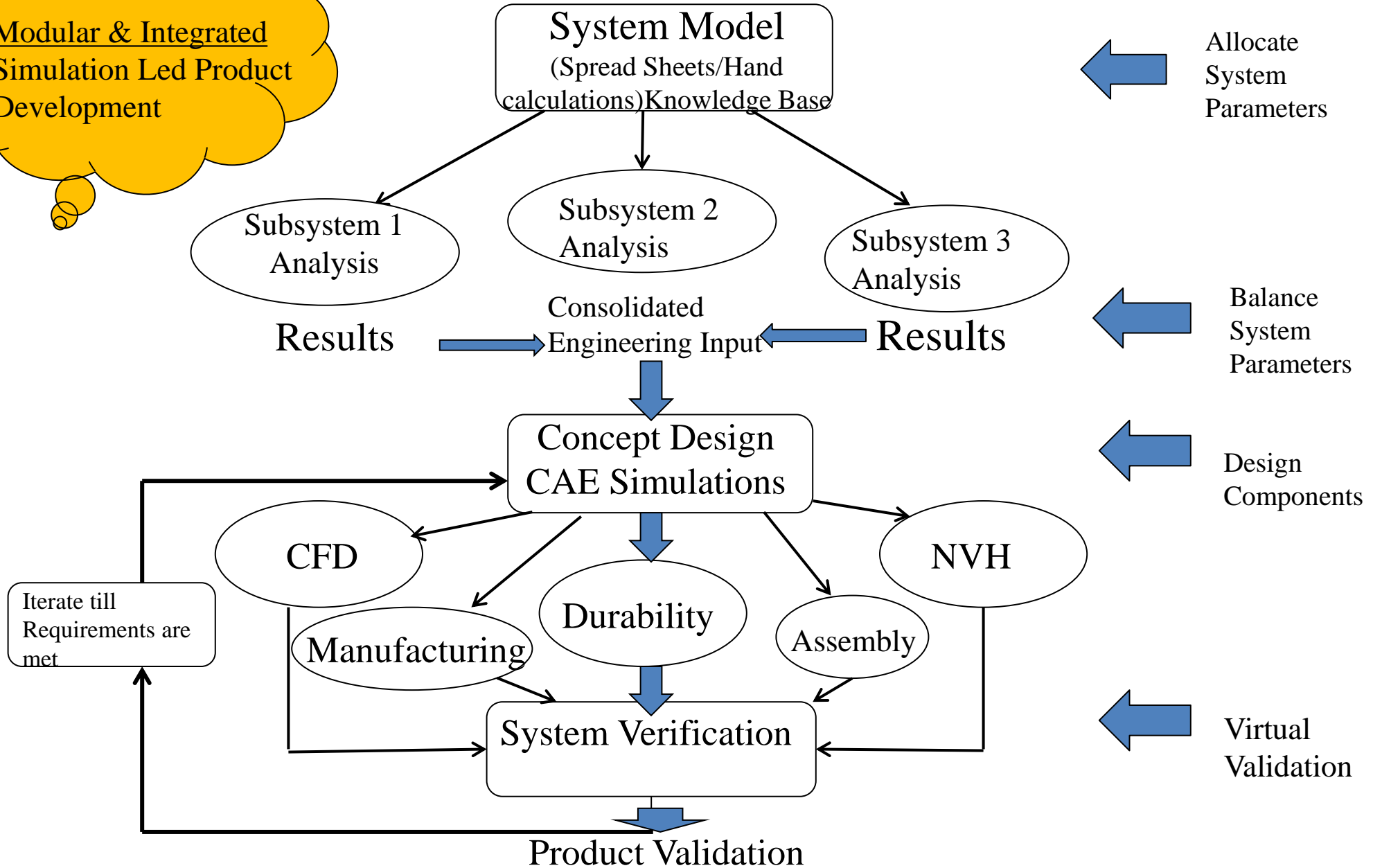
- Drastically reduce design cycle time through integrating workflow processes in an automated environment
- Link data from multiple CAE, Test and CAD systems in a seamless “desktop”
- Deliver more reliable, better-quality products through accelerated evaluation of design alternatives
- Lower hardware investments through effective use of legacy systems and more efficient job distribution
- Eliminate the bottlenecks of ineffective communication by enabling secure design collaboration among partners

- CAD geometry automation (Drawing templates, KBE, Design Best Practices, Guidelines . . .)
- Databases (Components, Bearings, Gears etc.)
- Well defined closed form formulas (Engineering Calculations . .)
- Clear data interfaces (Inputs/Outputs)
- Results (Reports, charts etc. – Customer Requirements)
- Archival & Retrieval Strategy

- Formula automation
 - Matlab, Mathematica, Excel etc.
- Data exchange automation between various functions
- Procedure automation – including DOEs
-
-
-
- **Vision: Entire part design process automation**

Analytical Tools: System Integration

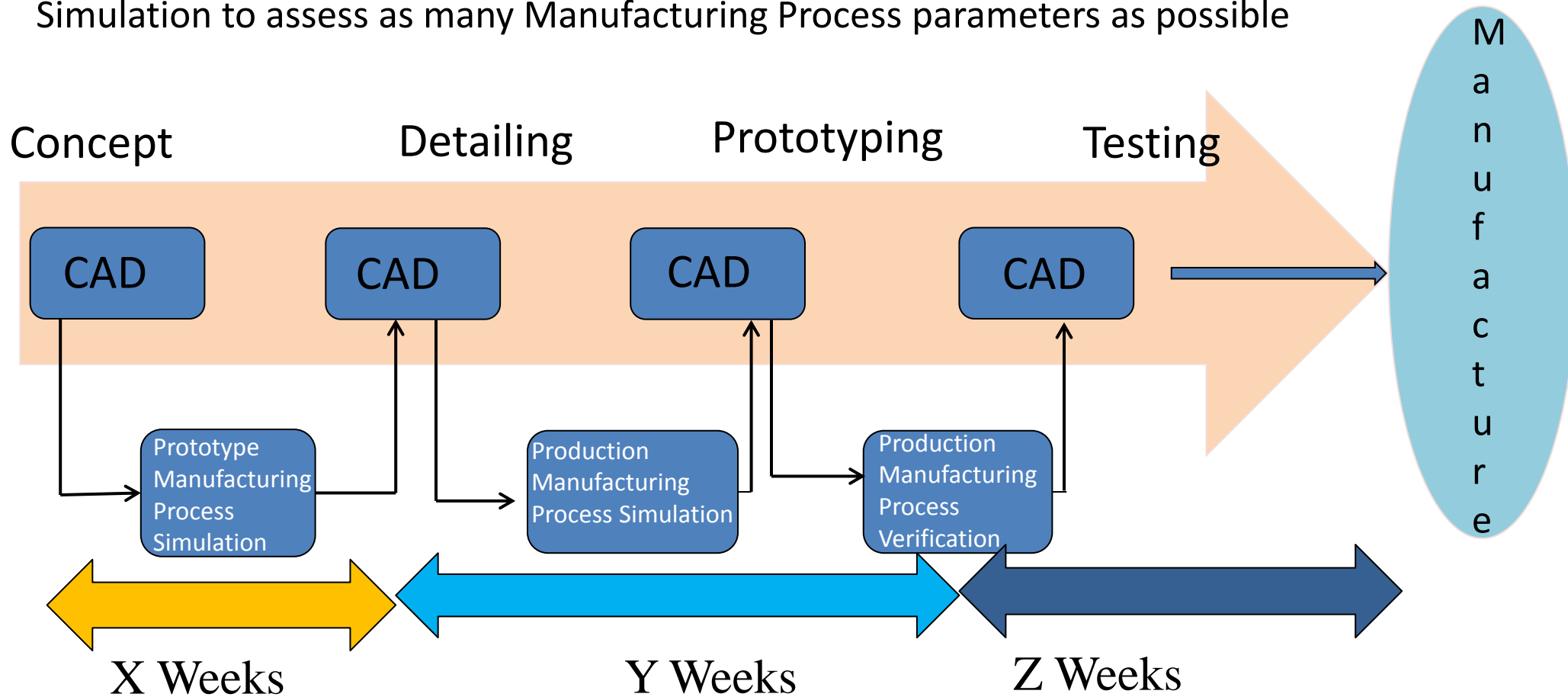
Modular & Integrated
Simulation Led Product
Development



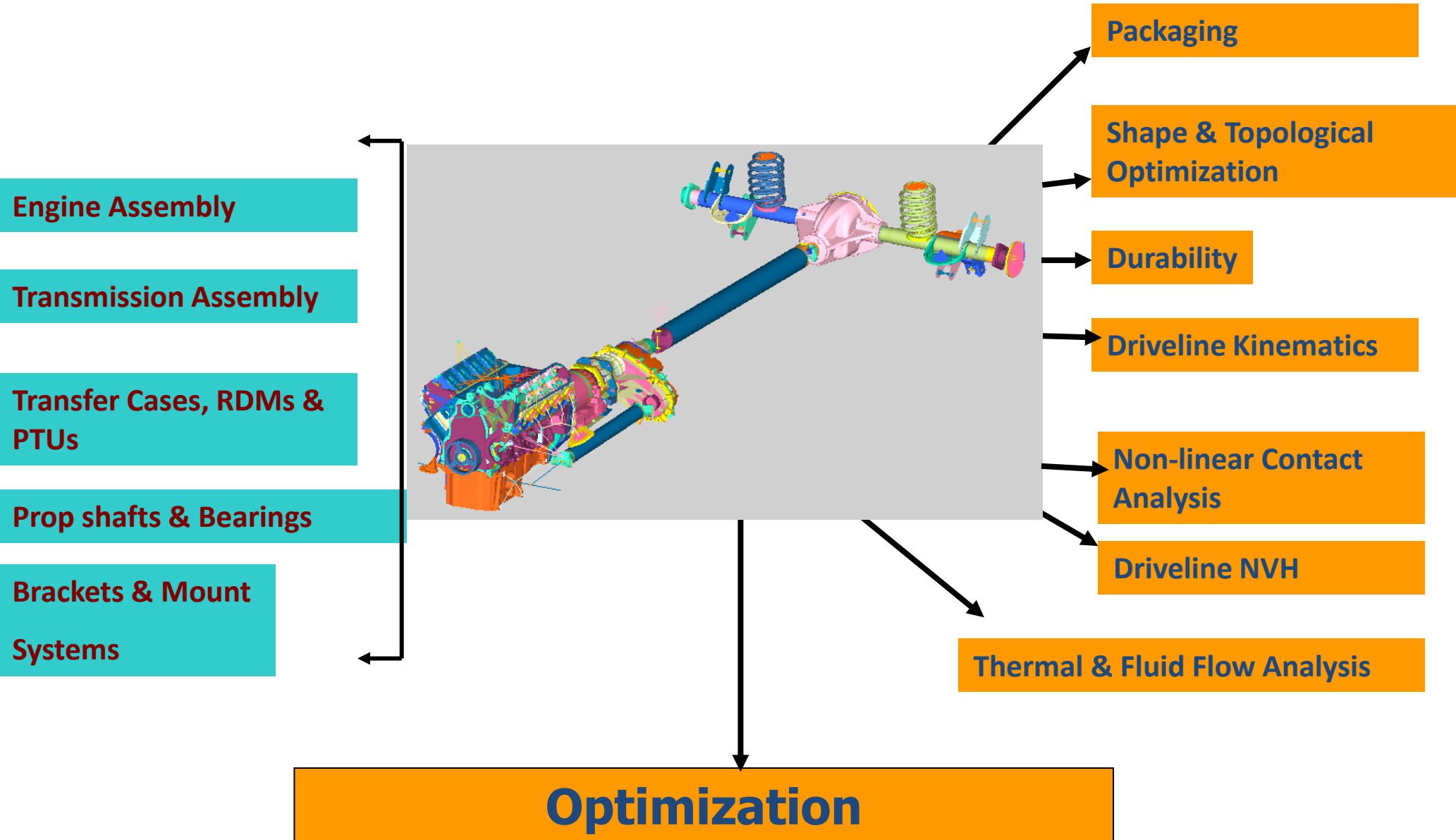
Manufacturing Analysis Integration

Objective: Design for Manufacturing

Simulation to assess as many Manufacturing Process parameters as possible



Automation of Multi-Disciplinary Optimization Process

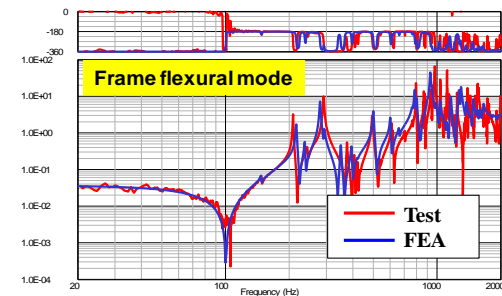
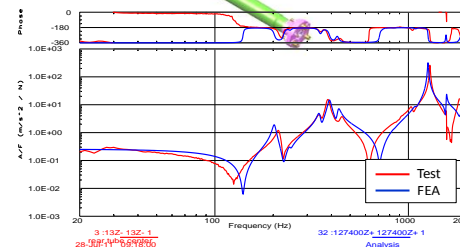
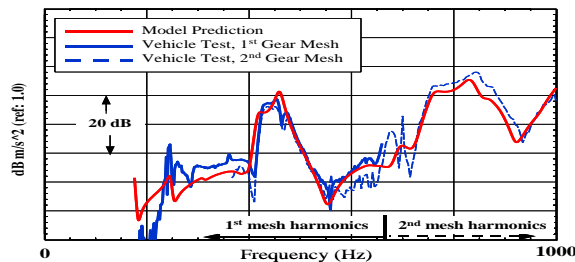
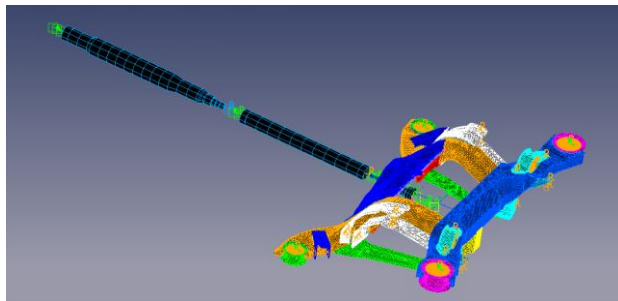
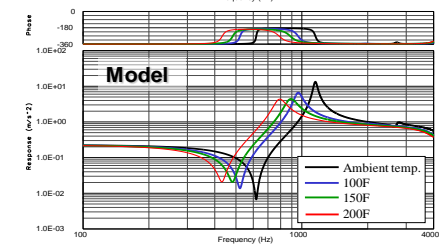
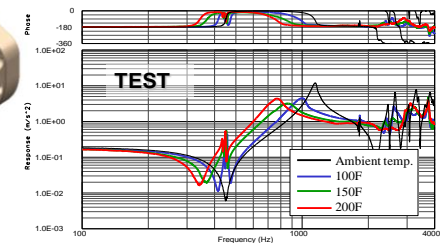
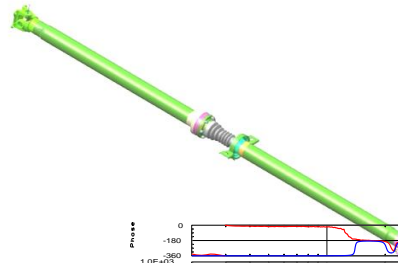
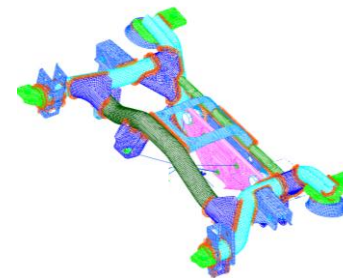
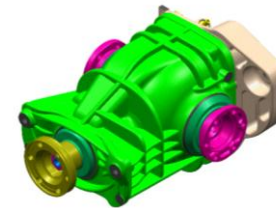
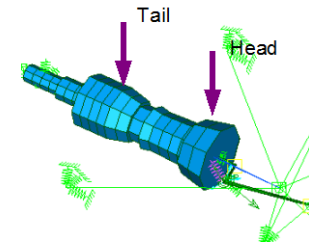


AAM Driveline NVH FEA Process

Driveline NVH FEA Modeling Approach

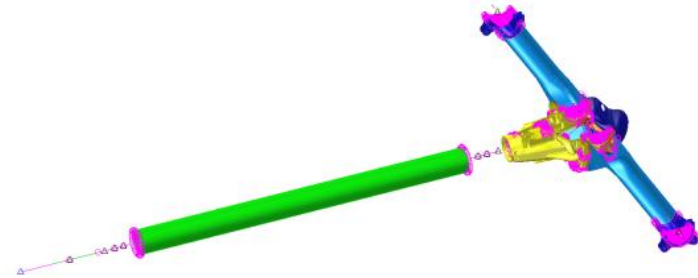
the building block method

- ❑ Treats the system as assembly of various components
- ❑ Component models validated and tuned first
- ❑ System model assembled afterwards with tuning of connection compliances
- ❑ FEA model as simple as possible
- ❑ Run-Many-Cases for Correlation and Design Study



NVH FEA Process Improvement and Automation at AAM

- Needed CAE tools to quickly assemble driveline NVH FEA models from database and high level dimension descriptions – critical for early phase architectural optimization and study
- The CAE tools should be capable of driving parametric and optimization studies
- A platform for process improvement, control and common database across different departments in the organization.
- Other benefits:
 - Minimize repetitive work for analysts – efficiency
 - Eliminate human errors and improve model consistency and accuracy

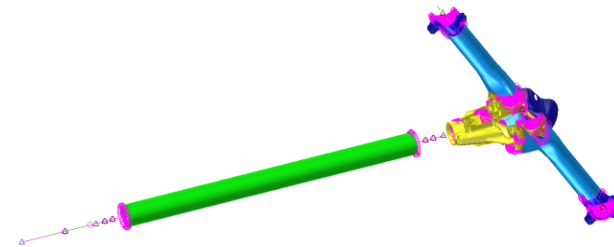
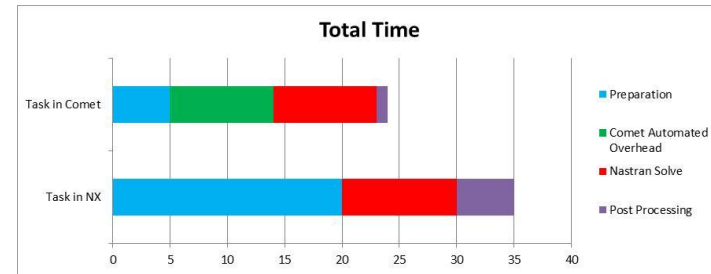


Interface between Gear Calculations & NVH

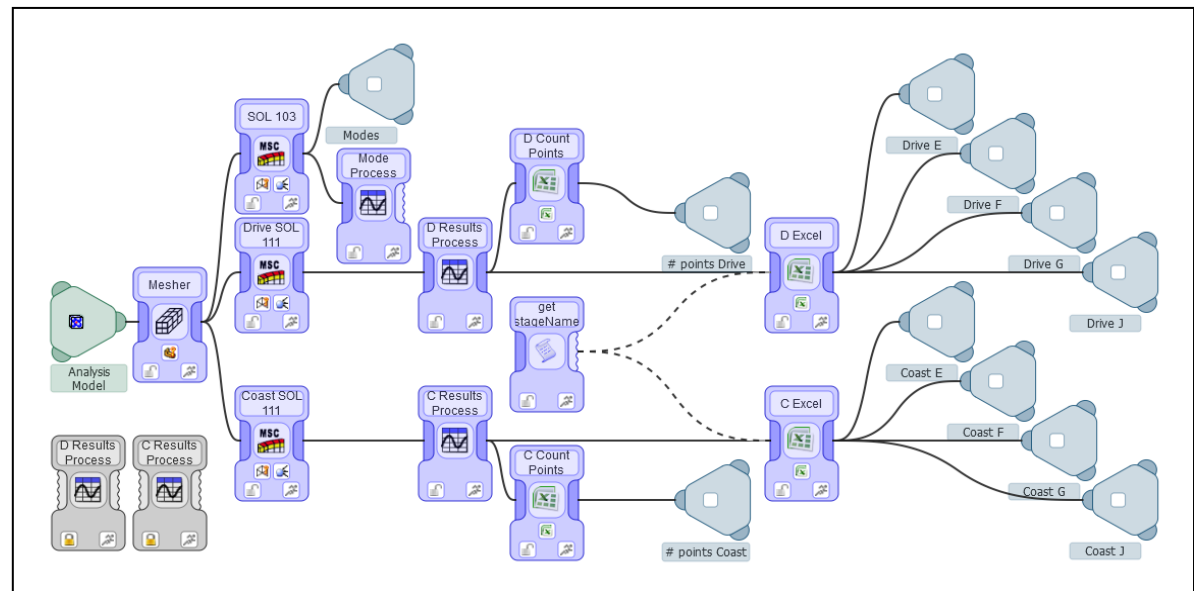
AAM selected and partnered Comet Solutions to further develop their SimApps products to meet the challenges.

Forward Deployment of Analysis

- Abstract modeling software in which the manual construction tasks are automated freeing the engineer to focus on design iterations
 - Data basing of commonly used parts
 - Fast and easy connection and replacement of parts
 - Fast and easy modification of parameters
 - Automatic report generation and plotting tools
- Time saving over large tasks can be greater than 50%
 - Total Comet Time Saving on typical NVH CAE Construction task: **61% time savings**



- Smaller scale tasks also have a large time saving due to manual tasks being handled by Comet (automated)
 - Total time is reduced
 - User interface time is greatly reduced
 - **76% time savings**



Automated Reporting

- Reports are also automatically generated by Comet in HTML format
 - Data is organized per pre-determined process
 - All parameters used in model are documented and managed in database
 - Response curves are automatically plotted and overlaid

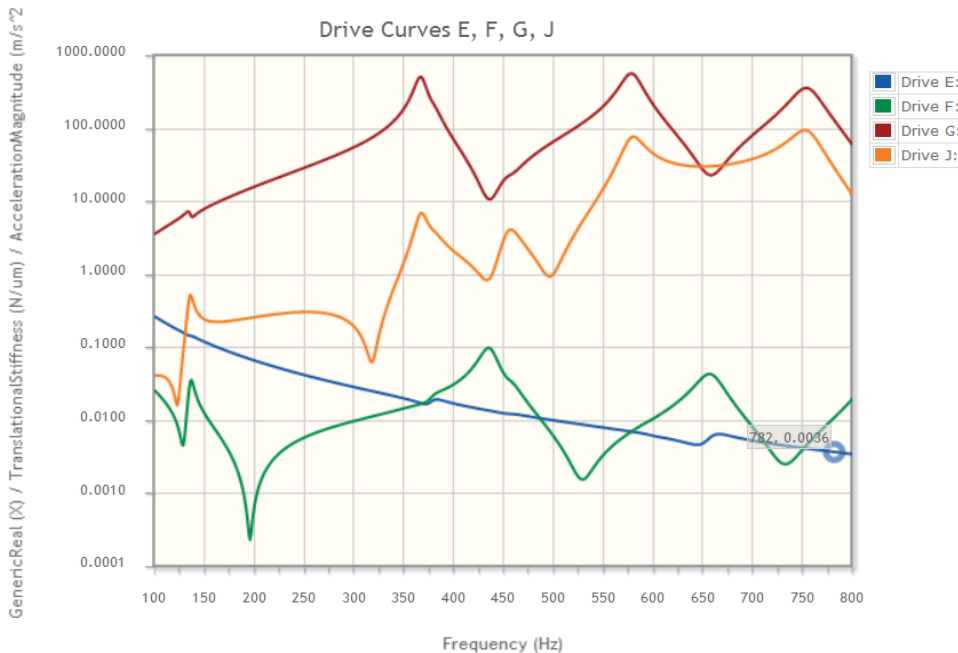
Example of Parameters in HTML Report

Dashboard Report

Summary	
Project Title	: AAM s2 TEMP
Stage	: Root/NVH CAE Starter/New Housing/Add Internals/Add Prop/Linear 101/Sol 111 starting at 0/Curve Comparison/Tail Bearing
Generated Time	: Wed Jun 11 10:47:11 2014

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Variables			
Name	Value	Unit	
Coast Pitch Point Xp	-89.74	mm	
Coast Pitch Point Yp	-27.62	mm	
Coast Pitch Point Zp	-13.61	mm	
Coast dir cosine exl	-0.4882	mm	
Coast dir cosine eyl	-0.4875	mm	
Coast dir cosine ezl	0.7238	mm	
Diff Assy Ixx	38911	kg*mm^2	
Diff Assy Iyy	56326	kg*mm^2	
Diff Assy Izz	40604	kg*mm^2	
Diff Assy Mass	12.11	kg	
Diff Bearing Stiffness Kx	1000000	N/mm	
Diff Bearing Stiffness Ky	1000000	N/mm	
Diff Bearing Stiffness Kz	1000000	N/mm	
Diff Bearing Stiffness Rx	100000000	N*mm/rad	
Diff Bearing Stiffness Ry	0	N*mm/rad	
Diff Bearing Stiffness Rz	100000000	N*mm/rad	
Drive Pitch Point Xp	-91.75	mm	
Drive Pitch Point Yp	-27.62	mm	
Drive Pitch Point Zp	-13.64	mm	
Drive dir cosine exl	0.7016	mm	
Drive dir cosine eyl	-0.1262	mm	



Example of Curve Overlays in HTML Report

Investments & Benefits



- Engineers providing input, data and information
 - 10% of expert engineers time for 4 weeks
- Data & information
 - Weeks of Organizing various data flows and interfaces
- Programmer resources & time needed
 - Few months of programming
- Testing & Validation
 - One to two months of testing
- Implementation
 - IT deployment within weeks
- Return on Investments are 10x dollars
- Added benefits of new ideas and improved processes
- **You will only realize the full benefit if deployed enterprise wide – ensure users have no other option!**

- Ever increasing multi-disciplinary optimization simulations drive complexity and hence the need for automation
- First time capable designs require “error-free” simulations
- Automation is a huge enabler for
 - Standardization
 - Global 24/7
 - Reuse
 - Consistency
 - Reliability of results
- ROIs make business case sense!

Thank You!