



# Dimensional Engineering challenges to digitalization



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# GM's vision to digitalization

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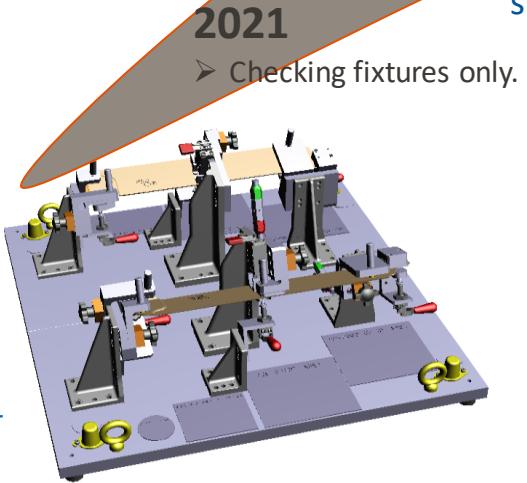
- **Faster to Market by reducing vehicle and component physical validation.**
- **First vehicle to be build is good for customer use.**
- **Increase and optimize use of CAE software tools for virtual validation with dimensional data/build variation input from manufacturing process.**

# 2021- 2025 Progressive Dimensional Engineering Standard Work Glide Path from Hardware to Virtual



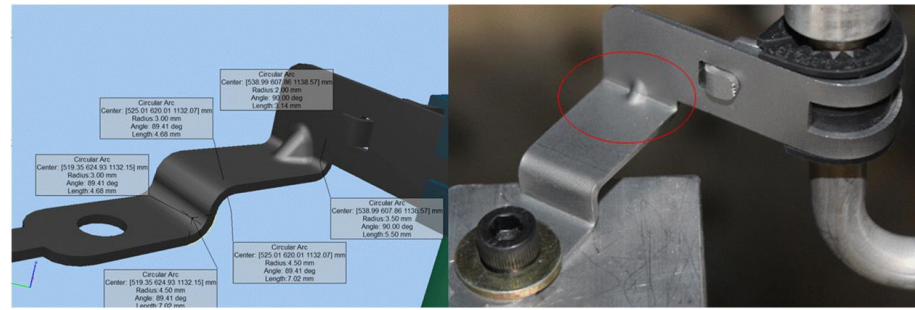
ZERO HARDWARE  
GOING FORWARD

- Virtual
- Hardware



**2021**  
➤ Checking fixtures only.

**2022**  
➤ Start Automation of available tools in spread sheets.



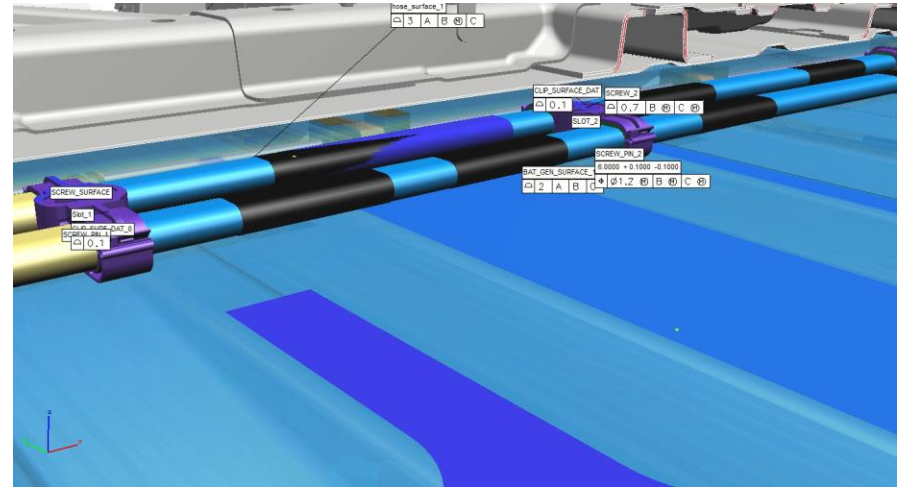
**2023**  
➤ Support CAE Virtual Validation with critical dimensions/ tolerances for for key product features/geometries.

**2024**

- Machine Learning to develop GD&T strategy.
- Run 3D variation analysis in CAD Software.

**2025**

- Full CAE Virtual Validation with dimensional data from manufacturing processes.



# Traditional Validation Process

## Old Strategy (component structural durability)

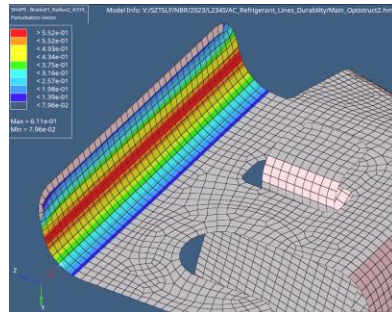


Input

Output



Nominal 3D model design

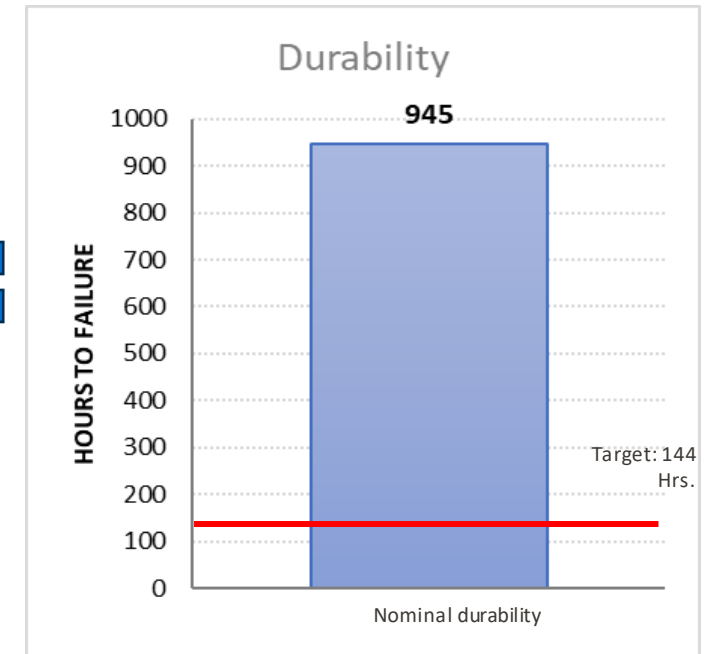


Design CAE Analysis:  
Formability, Max Stress,  
Strain, etc.



Physical  
Testing

Parts from Production





# Virtual Validation Process

## New strategy 2025

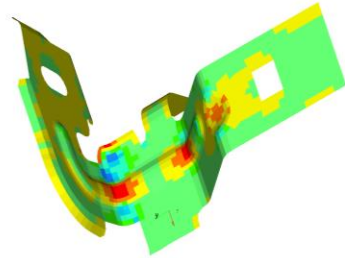


Run CAE analysis with variation and manufacturing processes

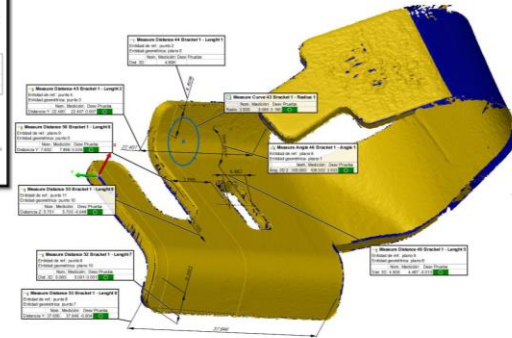
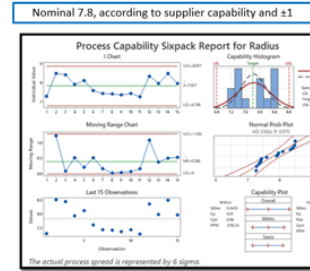
### Inputs



Nominal 3d math model



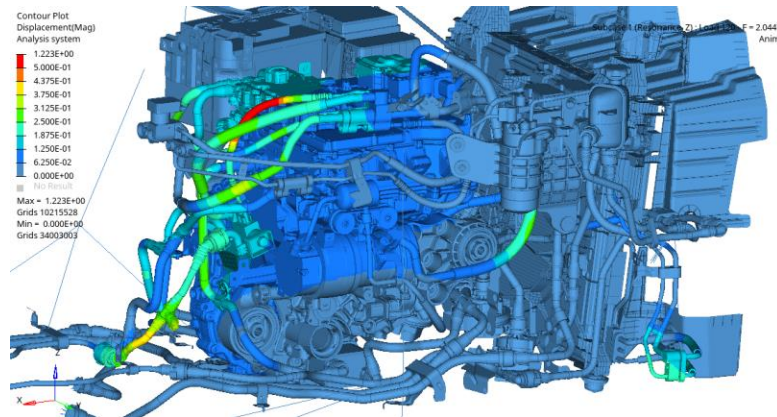
CAE Stamping thinning



Manufacturing Process Variation



### Output



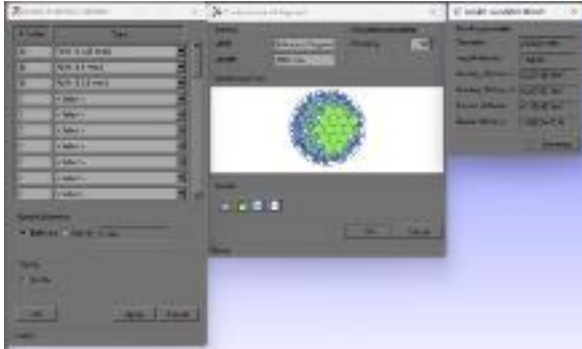
Vehicle level Plumbing Durability

# Virtual by 2025: Wire Harness simulation

IPS Cable simulation

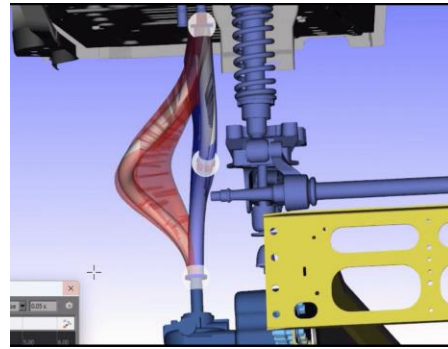


# IPS Cable Simulation: What it can do for wiring harnesses.



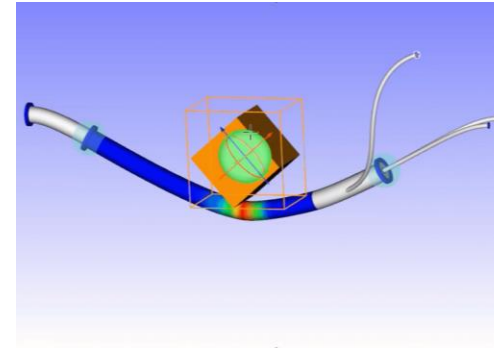
## Bundle behavior estimation

- Bundle physical properties can be estimated.



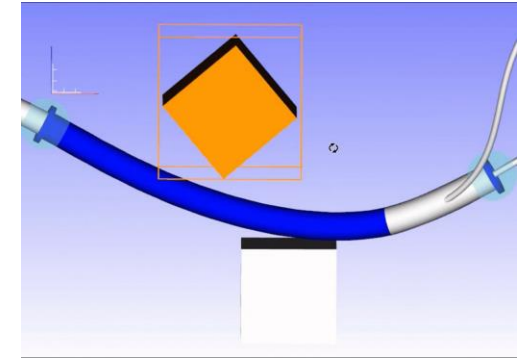
## Tolerance Envelopes

- Envelopes including length tolerances can be created
- Tolerance envelopes can include motion.



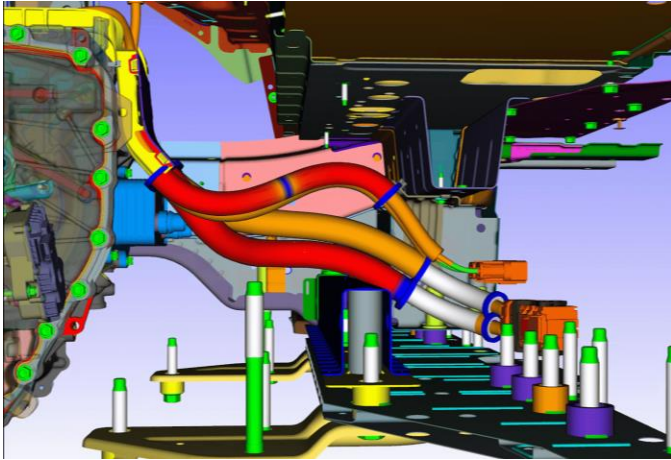
## Harness Deformation

- Harness can be deformed in collision applying Forces/Contact with solid components



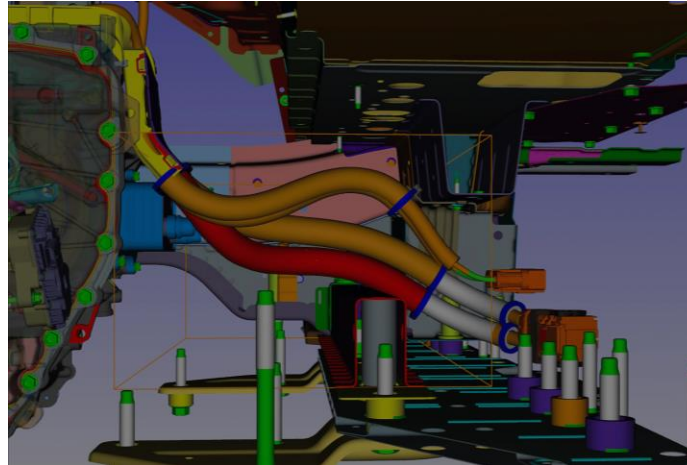


# IPS Cable Simulation: What it can do for Wiring Harnesses



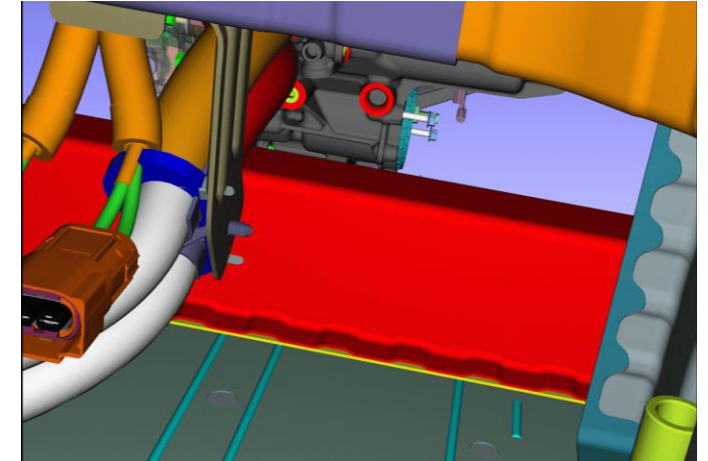
Flexible Cables simulation

- Length optimization.
- Physical phenomena cable applied (force, bend radius.. etc).



Collision detection

- Cable deformation during collisions



Roll simulation

- Dynamic/static simulation (roll, jounce/rebound).



# Virtual Validation Example

## CAE Model input variables:

- Harness outside diameter= manufacturing variation (+%) + Future growth (+%).
- Bundle package tool created on IPS (green)= Length Tolerance + X.X mm.



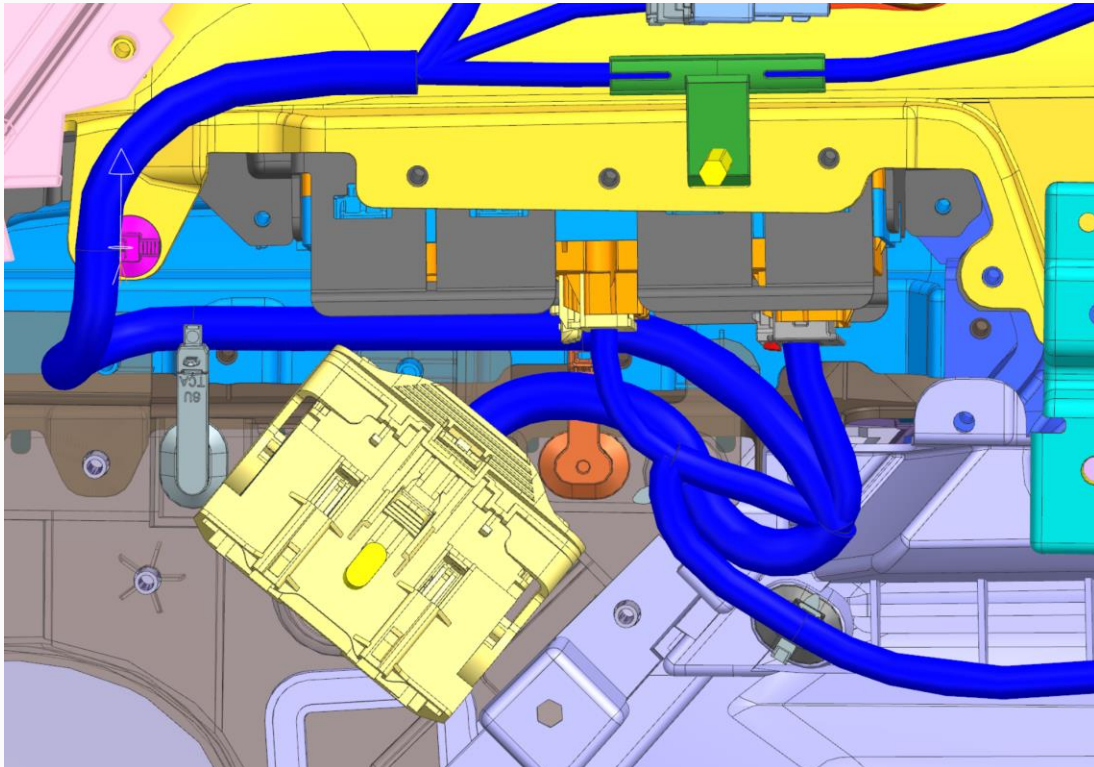
## Component:

### Door wiring harness design

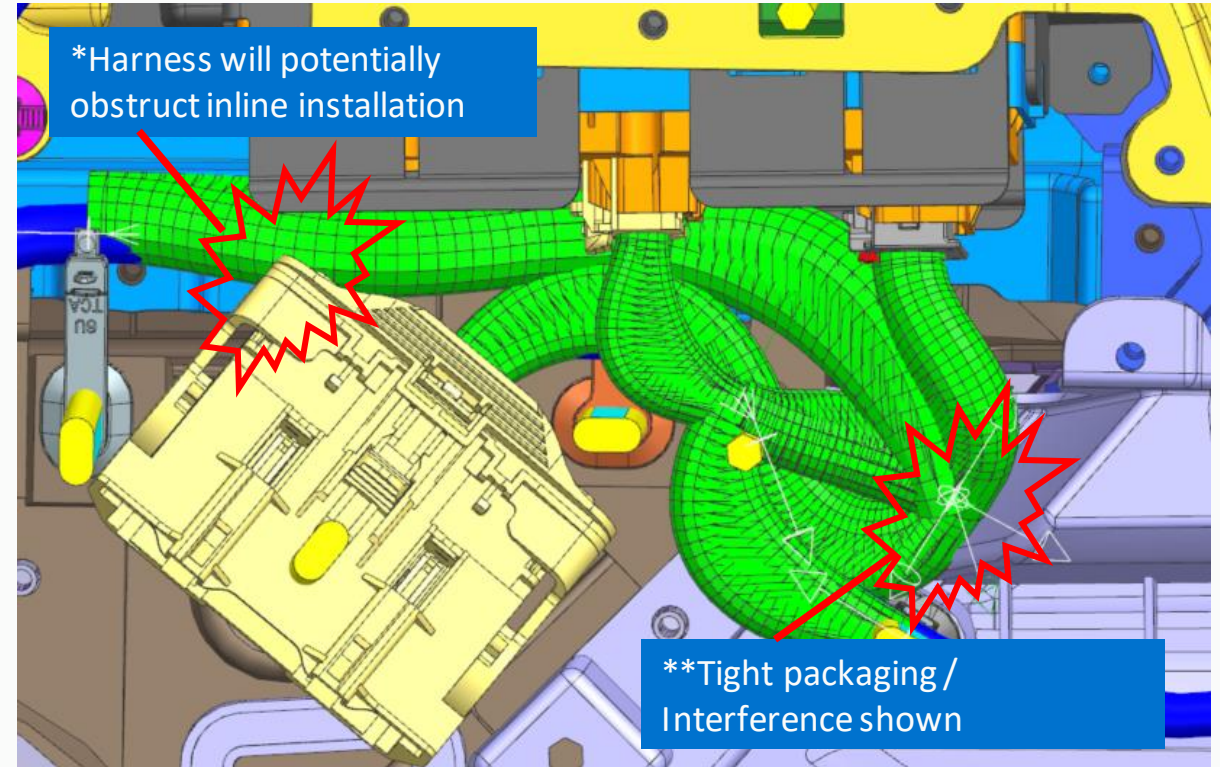
## Model results:

- Harness variations \*
- Harness clearance criteria between harness breakout and map pocket panel (below switches)\*\*

3D math data design (Nominal)



IPS model run



# Moving from 2D Dimensional Boards to 3D Gages

## Electrical Harness Dimensional Checking Evolution



### From Traditional Wiring Harness built onto a 2D Board



#### Issues with the component:

- ✗ Late design changes due to dimensional variation from manufacturing process.
- ✗ Low part repeatability.
- ✗ High disconnection between math data vs physical part.

# Moving from 2D Dimensional Boards to 3D Boards

## Electrical Harness Dimensional Checking Evolution (CONDUMEX EXAMPLE)



To 3D boards representing harness installation on vehicle



### Benefits:

- ✓ Increase dimensional fidelity to 3D math.
- ✓ Reduce assembly/ warranty issues.
- ✓ Part repeatability.