Powering Innovation That Drives Human Advancement

Enhancing Engineering Solutions with LS-OPT, Twin Builder & LS-DYNA

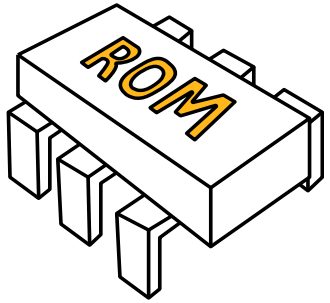
Siddharth Shah

May 2025

Elevating your Simulation Process

True productivity emerges from seamlessly integrated workflows, and intuitive, well-defined interfaces can accelerate and streamline your entire simulation process

– Nielen Stander (Sr. Principal R&D Engineer)



ROM technologies empower engineers to turn complexity into clarity—capturing the full power of high-fidelity simulations in real time, and opening the door to faster innovation and smarter decisions

– Sameer Kher (Sr. Director R&D)

Faster, portable models can open possibilities to new levels

High-fidelity simulations provide deep knowledge of the quantities, **but**:

! Require high computing power

! Are not suitable for real-time

! Considerable memory to store

! Time consuming for optimization

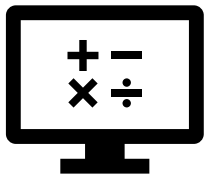
Reduced Order Models can enable new solutions requiring:

✓ Low computing power

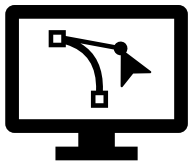
✓ Faster than real-time

✓ Portable (smaller models)

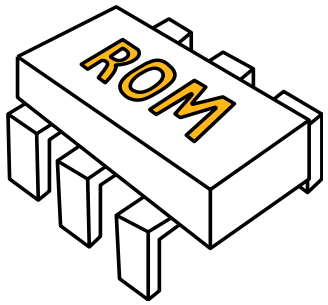
✓ Fast optimization



Through math and AI/ML based technologies



Reduced Order Model (ROM)



Simplification of a high-fidelity engineering simulation while preserving essential behavior and dominant effects using data driven algorithms.

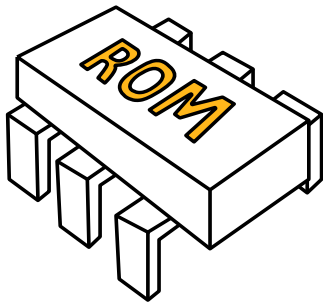
Simplify high-fidelity complex models

Reduce computational resources

Speed-up development cycles

Accuracy preservation

ROM Technology A Key Enabler



Fast Design Optimization

Accelerate 3D Simulations

Simulation Democratization

Systems Modeling

Embedded Controls

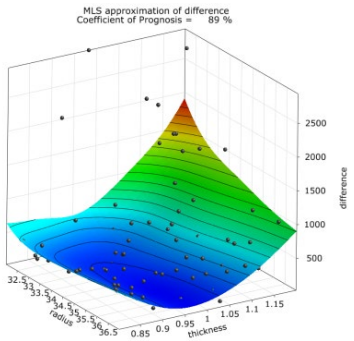
IP Protection

Digital Twin

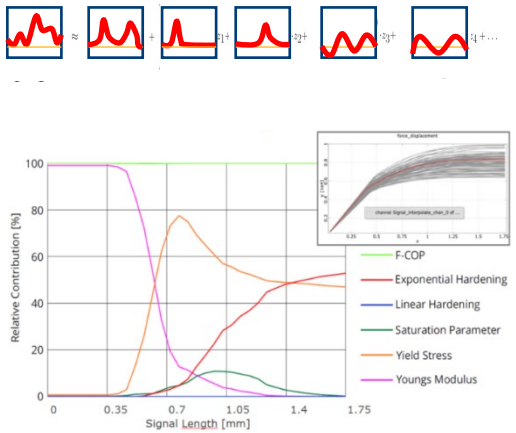
MBSE

Supports Wide Spectrum Of Data

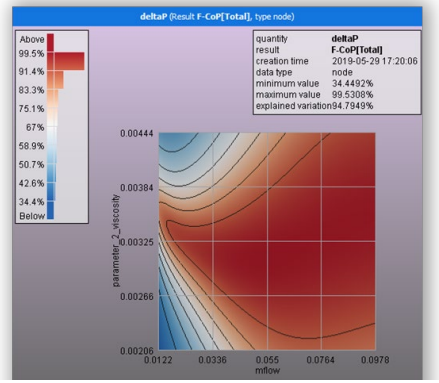
0D ROM for scalars



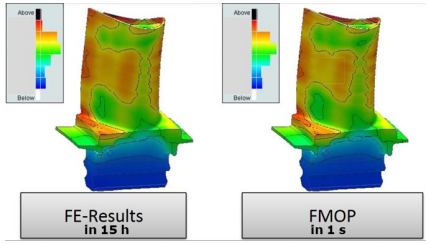
1D ROM for signals & curves



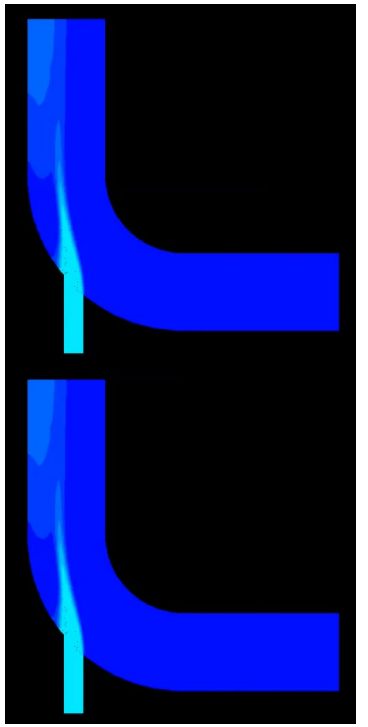
2D ROM for Wavefronts & Performance Maps



3D ROM for Fields



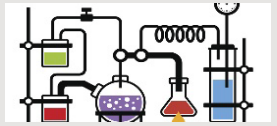
4D ROM for Transient Fields

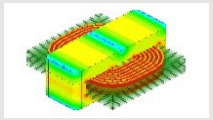


From Scalar to Field Data

ROM Generation Workflow

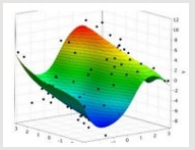
TRAINING DATA GENERATE





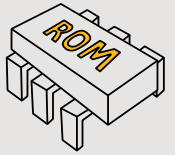
Hours/Days
~Tera/Giga Bytes

ROM GENERATION



Minutes
~Mega/Kilo Bytes

ROM CONSUMPTION



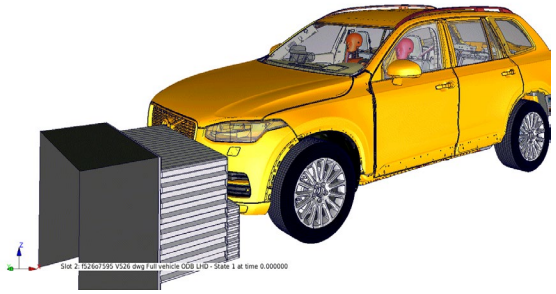
FMU

Twin

Seconds

- ROMs built using a combination of statistical and physics-based machine learning techniques
- ROMs based on smaller datasets for engineering simulations

Synergy : **LS-DYNA**, **LS-OPT** and **Twin Builder**

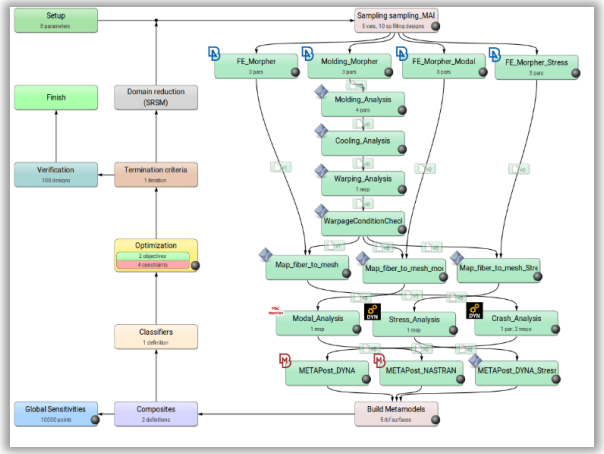


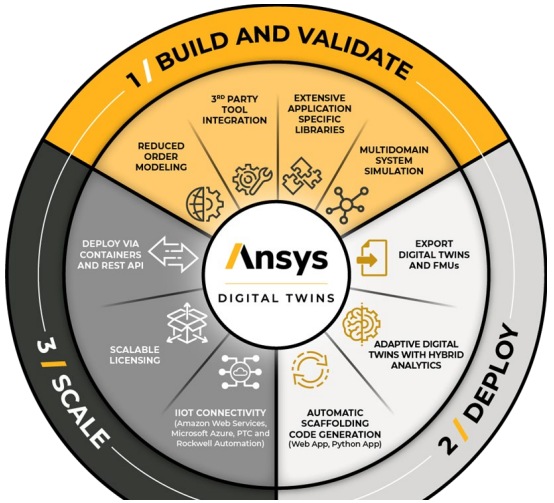
LS-DYNA

- General purpose Highly Non-linear Mechanics software
- Tightly coupled, scalable Multi-physics solver
- Versatile set of tools to solve real-world applications

LS-OPT

- Multi-case, Multi-stage, Multi-level Process
- Optimization (Direct, Metamodel-based)
- Reliability and Robustness
- Material calibration



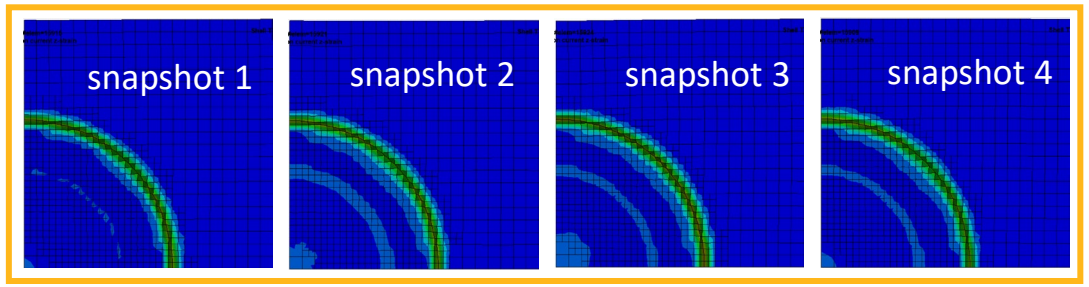


Twin Builder

- Black Box agnostic ROM generator/builder
- Multidomain Systems Modeling
- Embedded Software Integration
- IIoT Connectivity

How **Twin Builder** Works: SVD → Modal Coefficients → Interpolation

Snapshots/ Observations /Samples

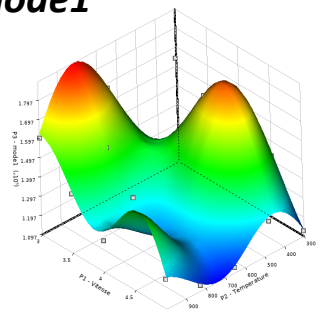


Correlation Matrix

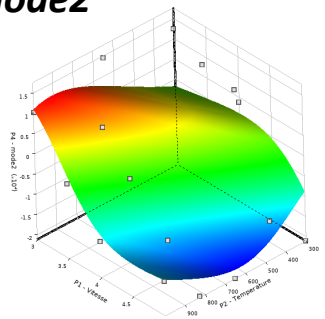
SVD

Modes & Coefficients

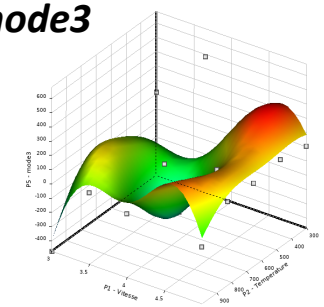
mode1



mode2

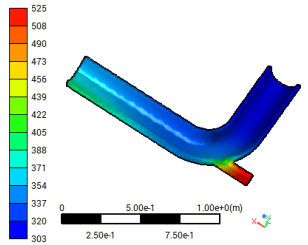


mode3

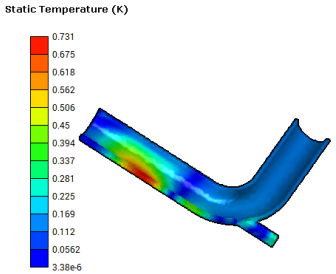


A Static ROM is thus a combination of an SVD (Singular Value Decomposition) compression and mode coefficient interpolations

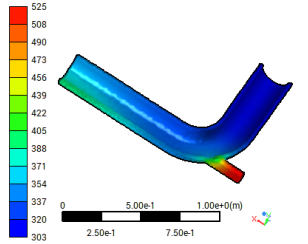
Reference



Difference



ROM

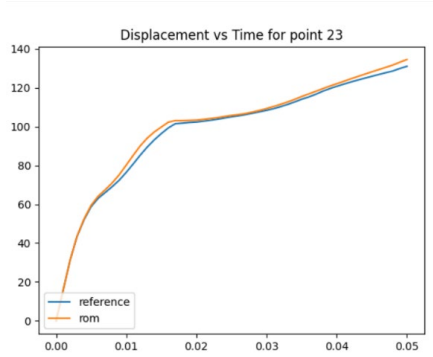


Modal coefficients interpolated using metamodels

Validation at Verification points

Ansys

Overview of Tool Chain



LS-OPT Pro

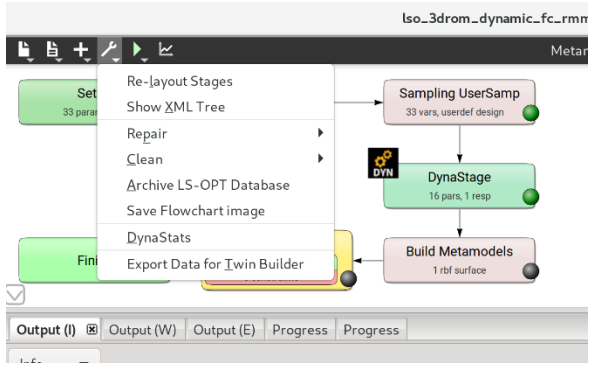
Design sampling, Job distribution

LS-DYNA

Input Files, D3Plot Results

Response, Field History, Field Extraction

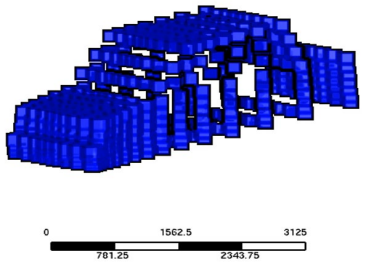
LS-OPT Pro

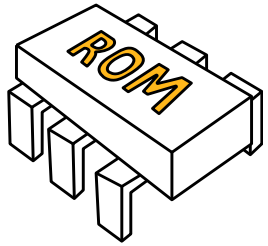


Export *Twin Builder* Archive

Twin Builder

ROM can be used as a surrogate solver in an LS-OPT workflow

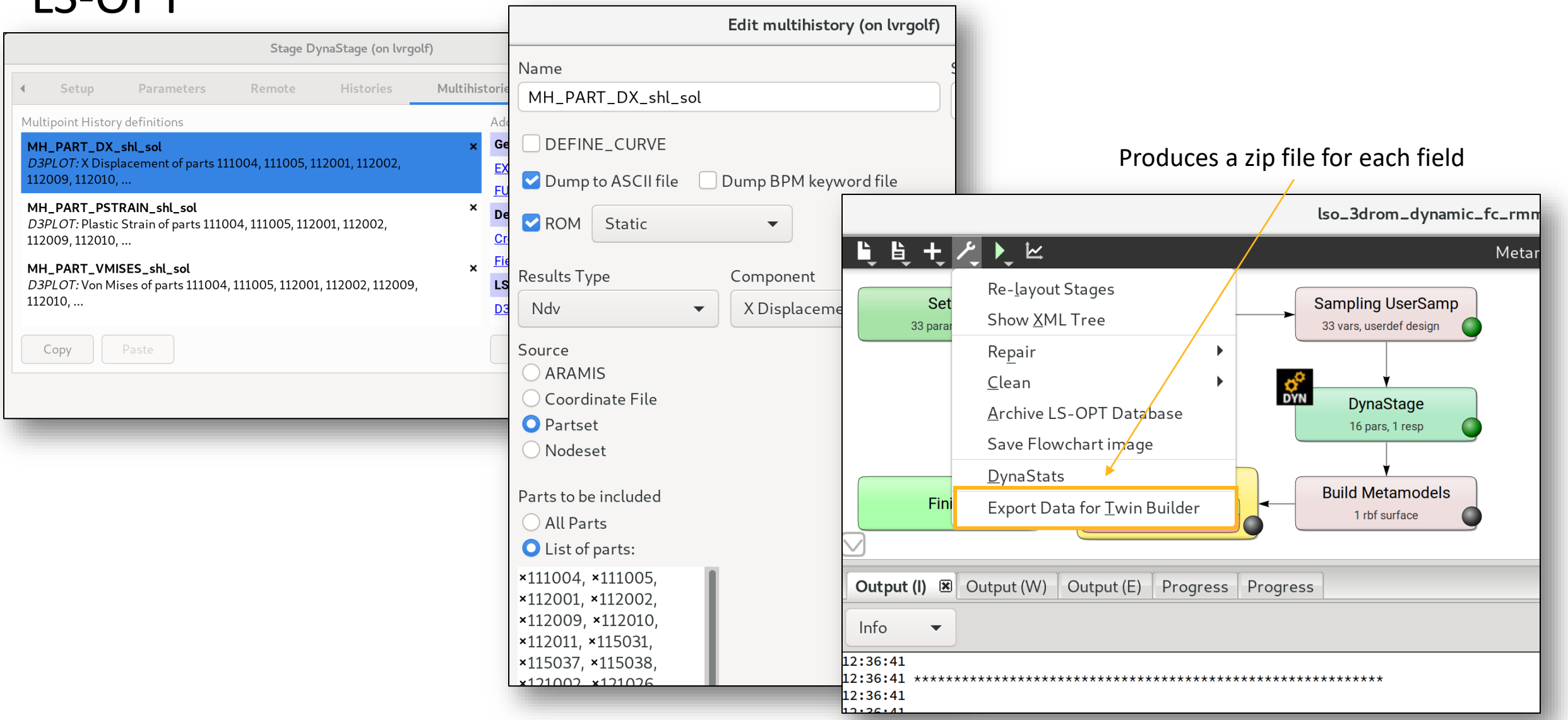




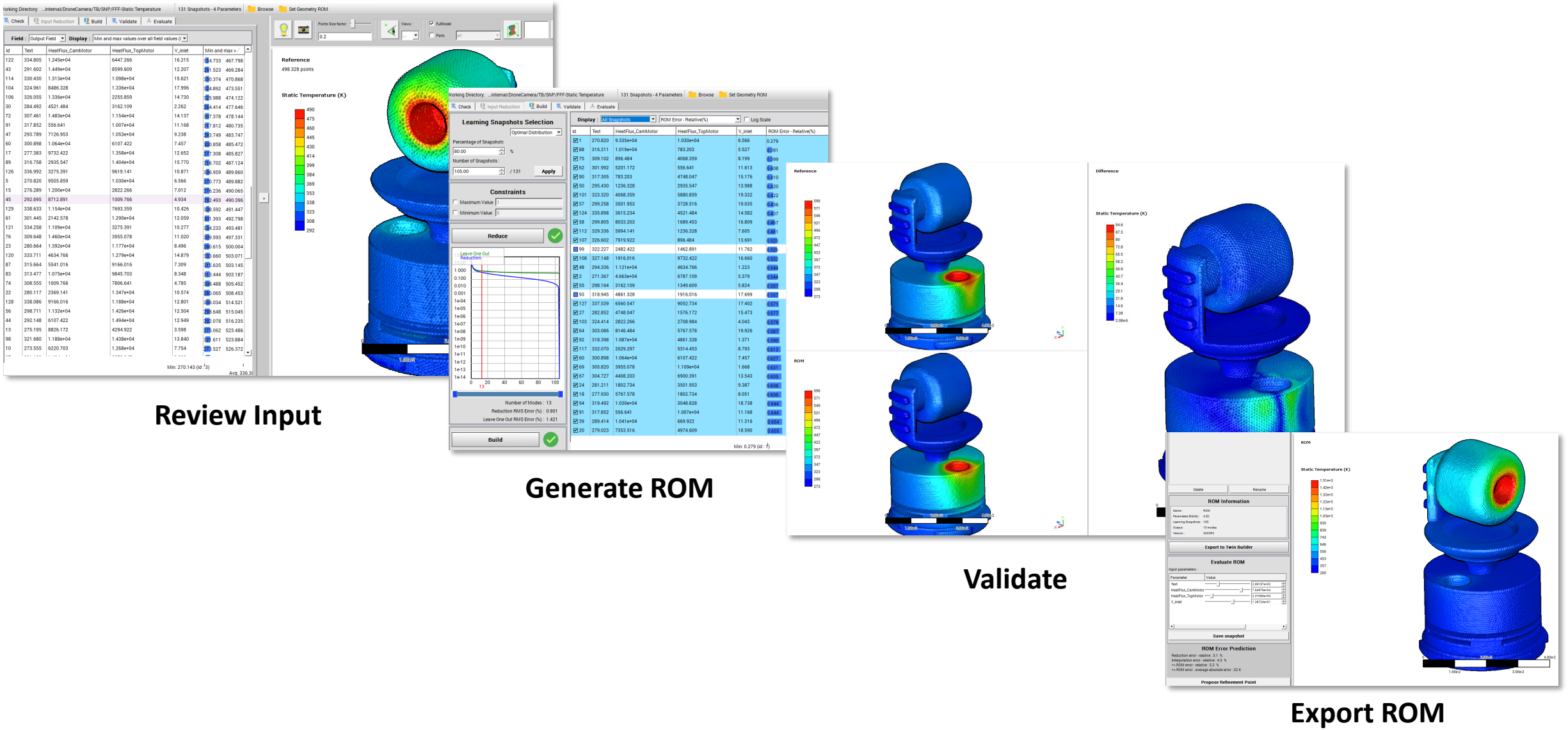
Parametric Field History ROM

Input Type	Scalar
Output Type	**Signal/Field**

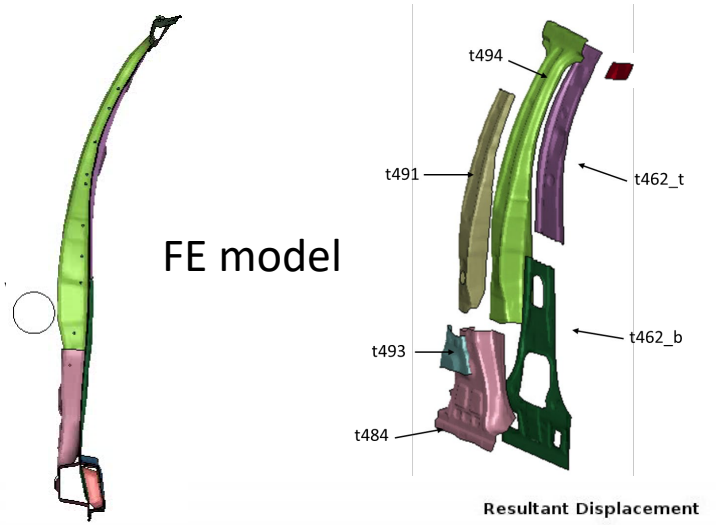
LS-OPT

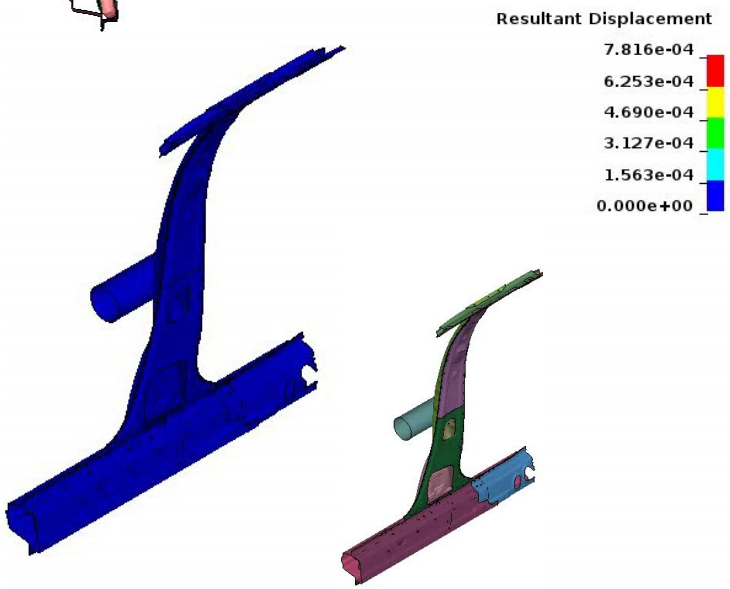


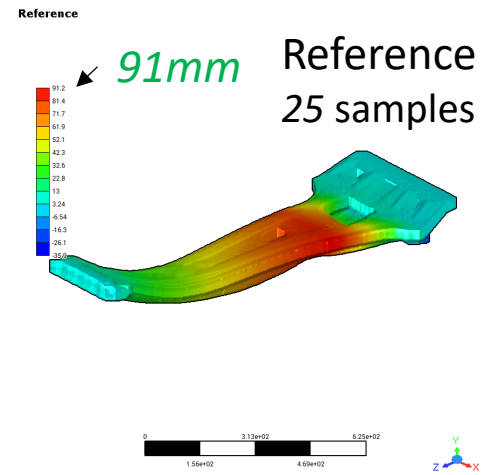
Twin Builder

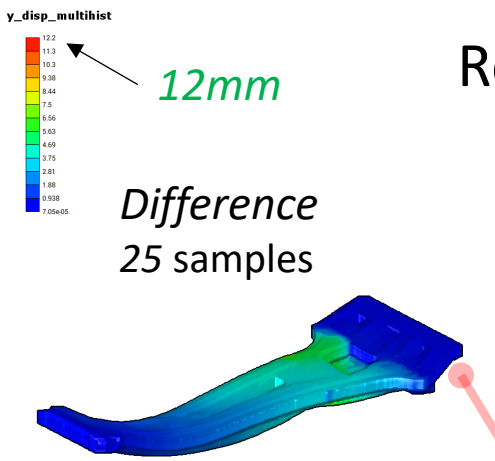


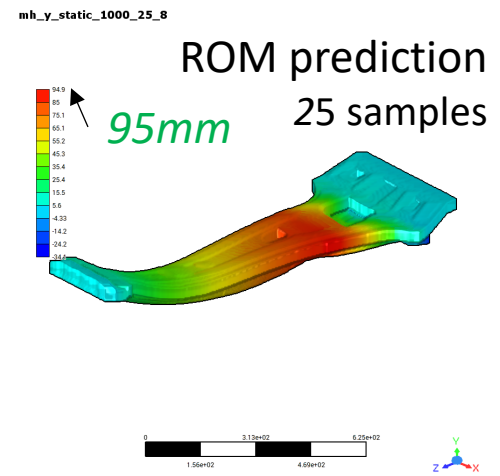
Example: Side impact B-Pillar Displacement (7 parameters)

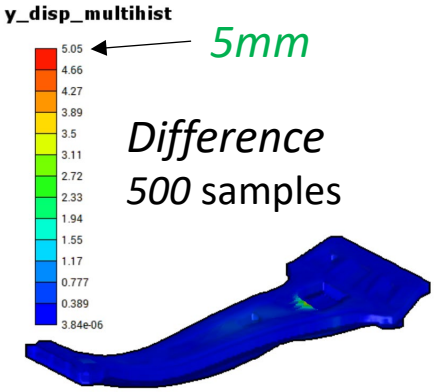




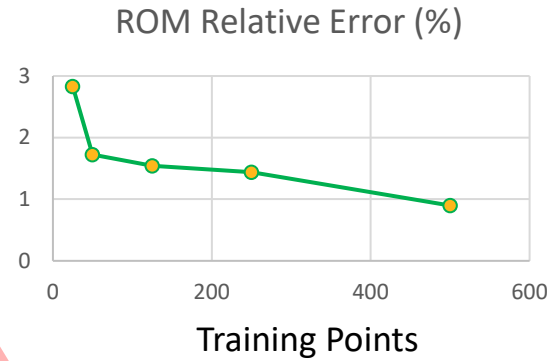


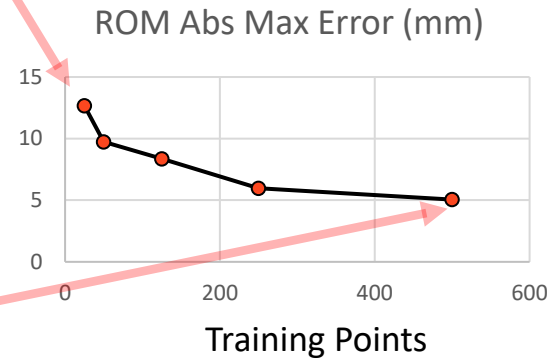






Reduced Order Models



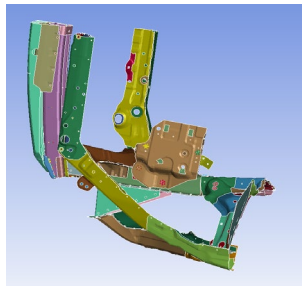


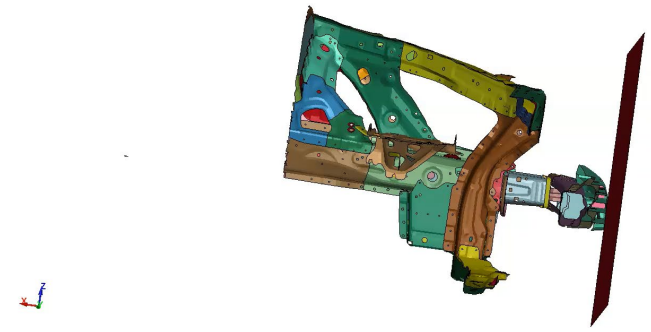
Example: Bumper model (7 Parameters)

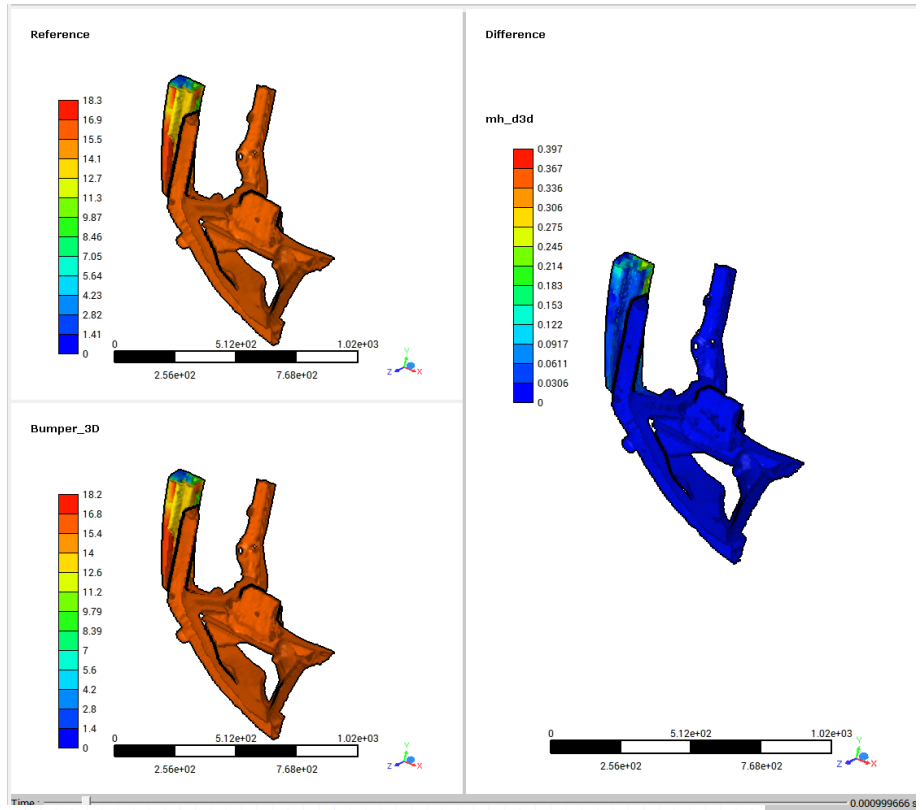
- Simulate the impact of thickness variations in 7 different regions of the bumper structure on overall body deformation
- Designpace : 7 parameters, distributed over 100 points
- ROM employed to reduce computational effort and improve design efficiency

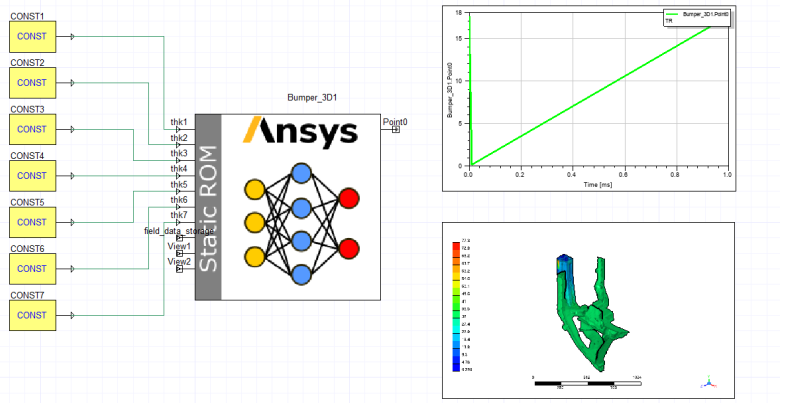
Design space

Variable	*Min*	*Max*
$thk1$	*1.4*	*1.8*
$thk2$	*1.3*	*1.5*
$thk3$	*1.8*	*2.2*
$thk4$	*1.6*	*1.8*
$thk5$	*1.8*	*2.2*
$thk6$	*1.7*	*1.9*
$thk7$	*6*	*8*

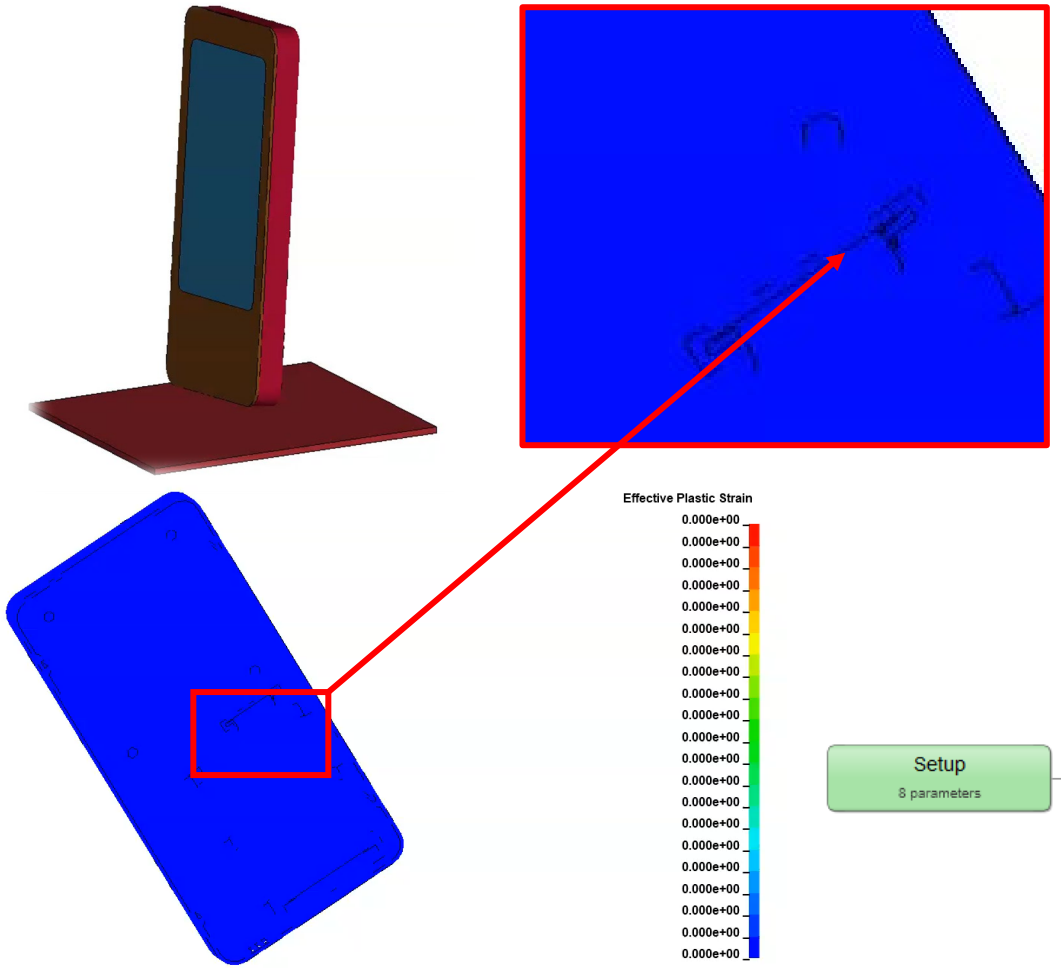








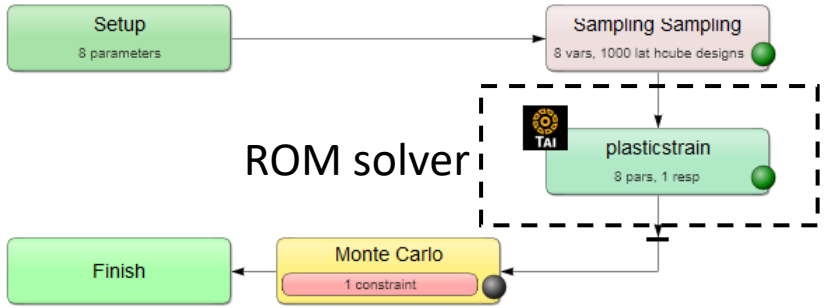
Example: Cell Phone Drop (8 variables)

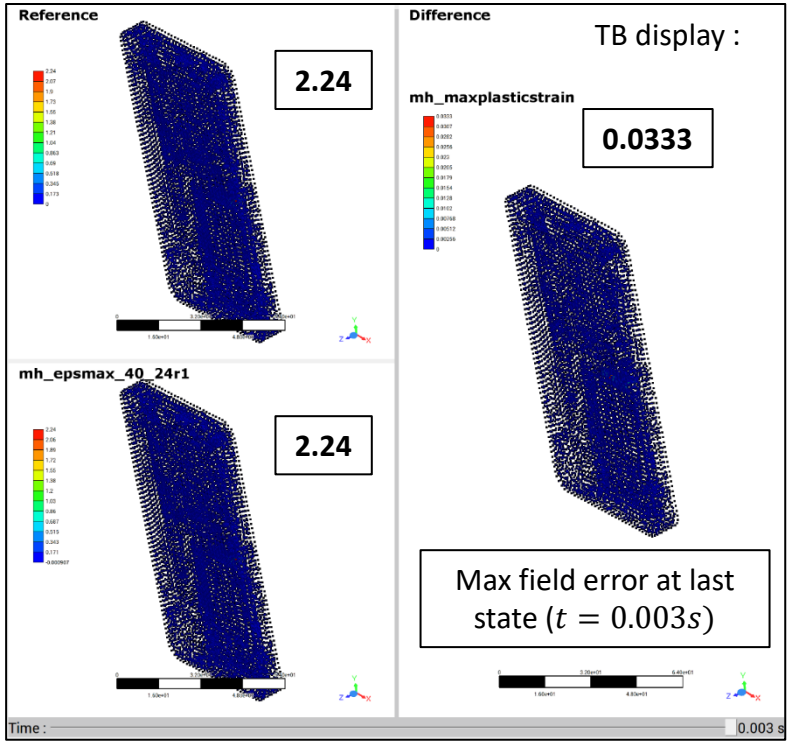


Design space

Variable	*Min*	*Max*
$dropvel$	-5000	-4000
E_g	2700	3300
Sy_g	60	80
E_pcb	3600	4400
Sy_pcb	55	65
E_h	3600	4400
Sy_h	55	65
t_pole	0.8	1.2

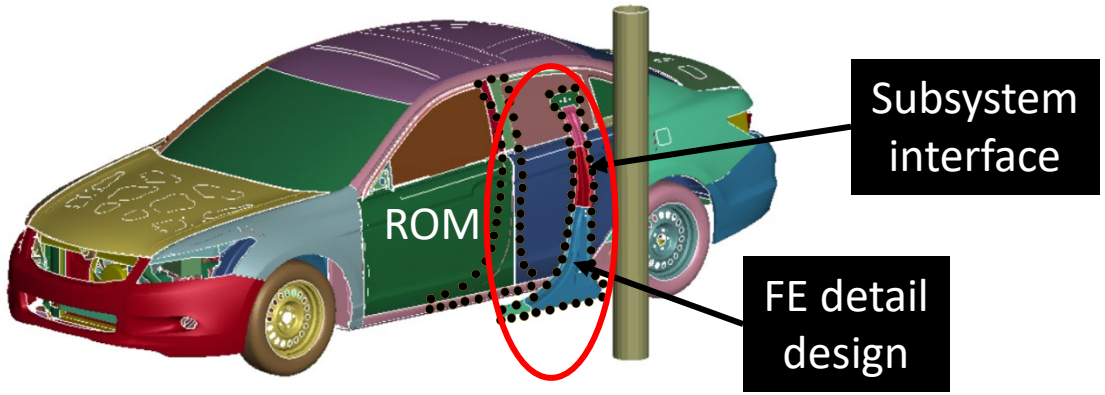
- Full-field Effective Plastic Strain ε^{pl}
  - Highly localized
- 8 Noise variables including velocity
- ROM built using **40** training samples





LS-OPT Monte Carlo Process with TB Solver

Future Outlook



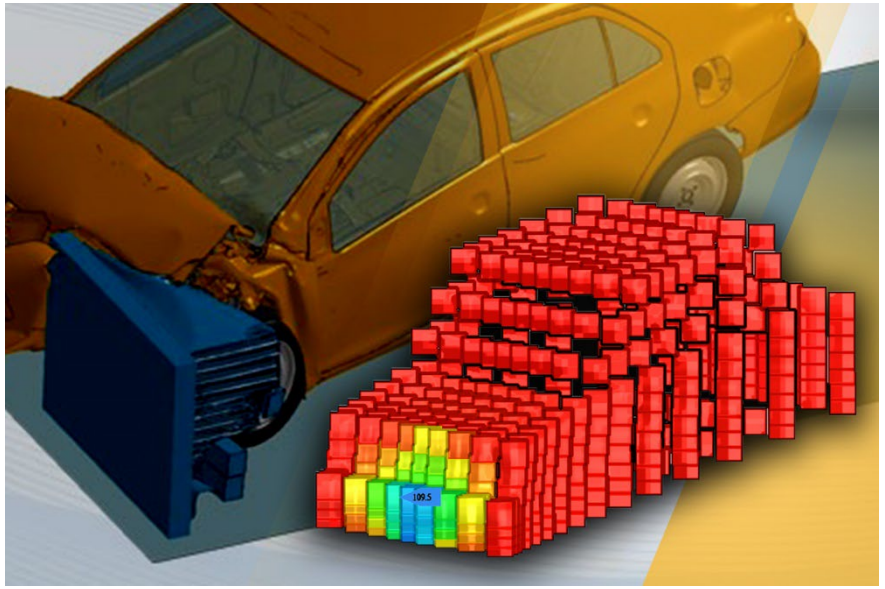
Use Case: Auto Frontal Crash

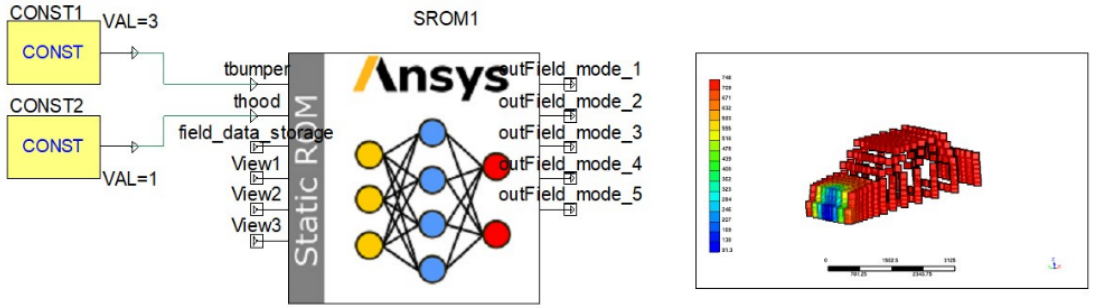
- Simulate the impact of hood and bumper thickness on body deformation
- Design space has 2 parameters, distributed over 20 points
- 80% of available data used to train the ROM

Design space

Variable	***Min***	***Max***
$tbumper$	*1*	*5*
$thood$	*1*	*5*

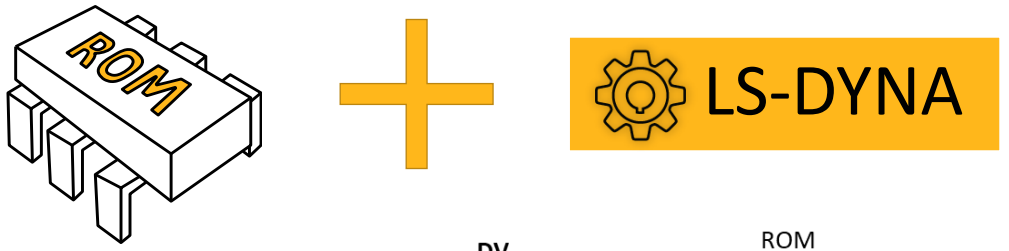
- By just using 80% of the training data to build the ROM, we reach Max error is less than 3%





ROM + LS-DYNA Coupling

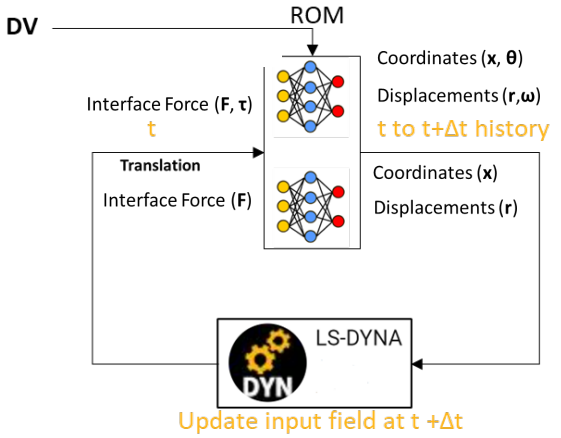
[FUTURE RELEASE]

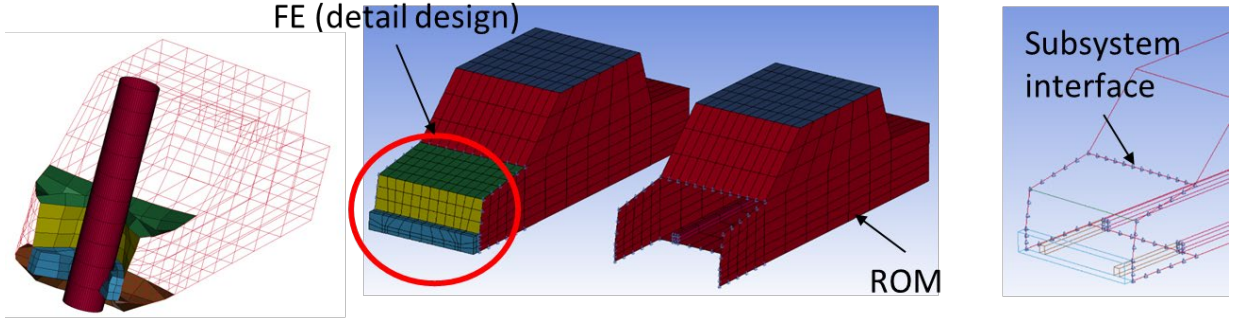


- Replace Assemblies with ROM
- Multiple Interfaces Supported
- Construct ROMs Offline

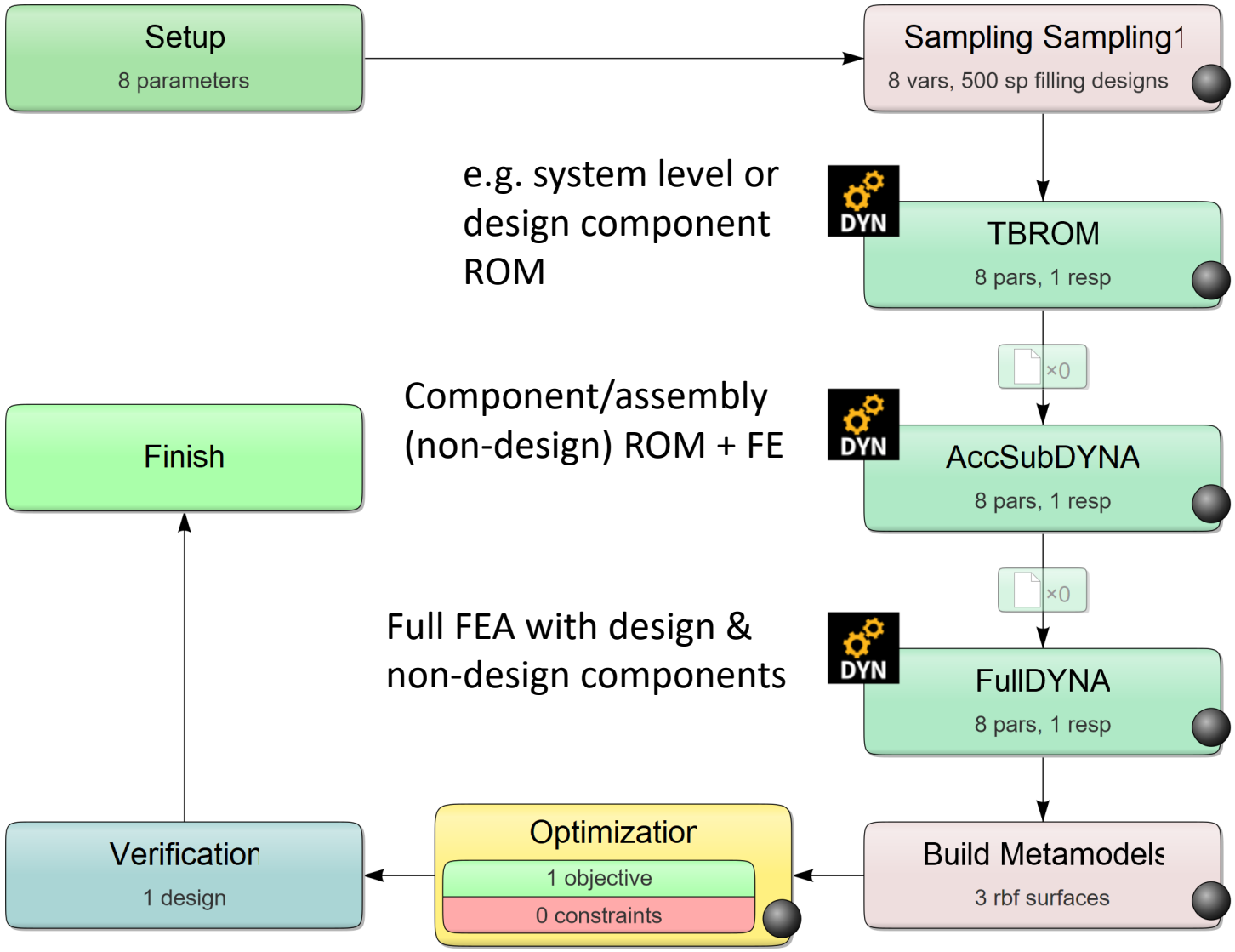
Coupling Mechanism

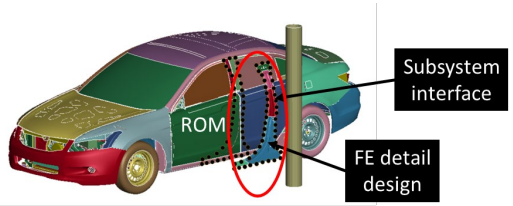
- Exchange displacement-force coupled at interfaces
- Co-simulate FEA and ROM domains over time with communication at selected frequency
- Moments and rotations can also be use





Multi-fidelity Optimization Concept



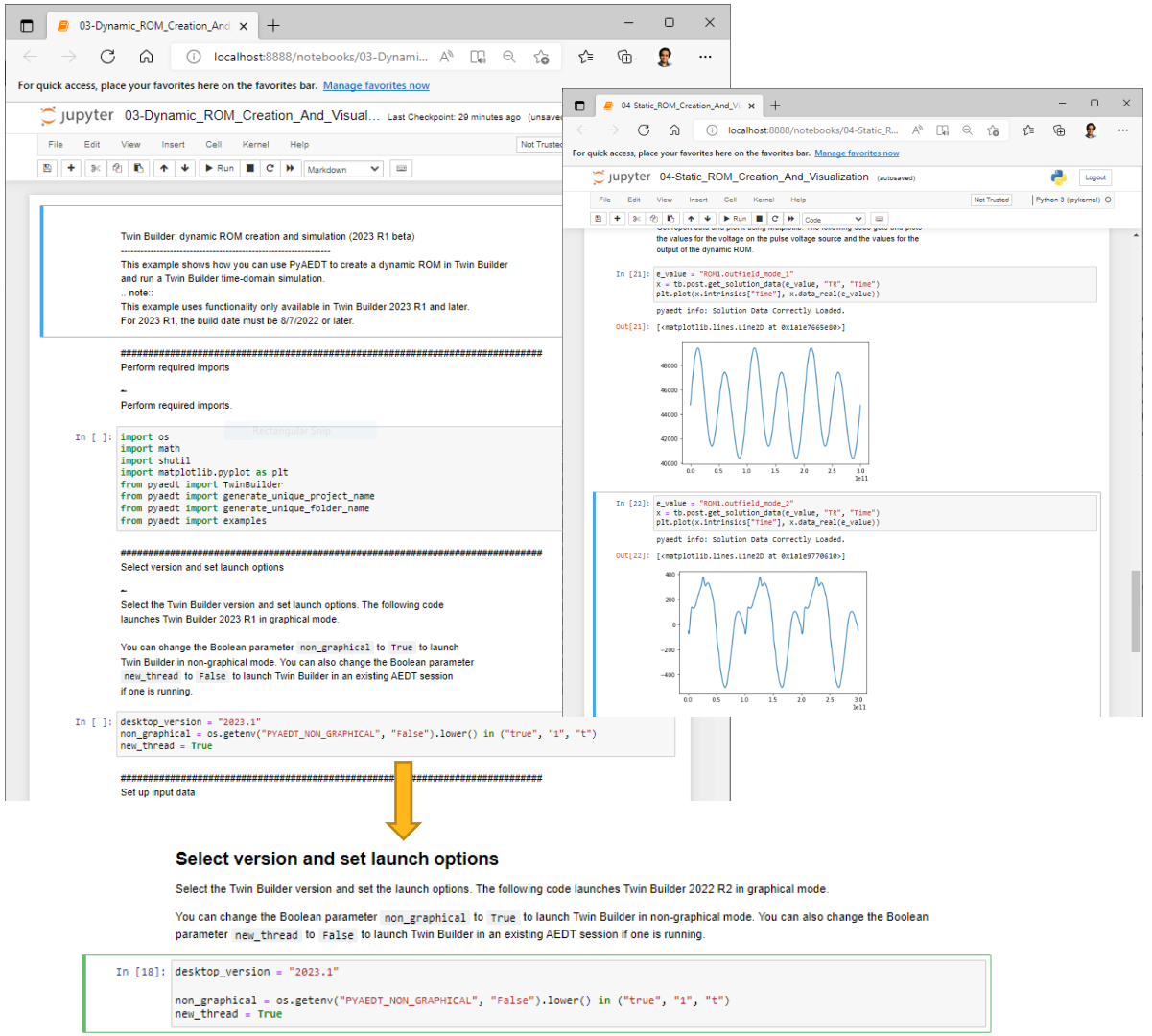


Currently user-defined stage needed between the LS-DYNA stages for conditional evaluation

Automation with PyAnsys

PyAnsys **Python + Ansys**

- Examples for creating Static ROM and Dynamic ROM
- Scripting examples on github/pyAnsys
  - Exposed in opensource pyaedt package
  - Requirements: licensed copy of Twin Builder, Python
  - Documentation: https://aedtdocs.pyansys.com/
  - Run on command line or in a jupyter notebook
  - Can run Twin Builder in batch mode



Summary

ROMs are our clear enablers in the system level simulation paving way for future innovations

Combining ROMs with Hybrid Analytics unlocks new possibilities for Digital Twins

Streamlining Workflows and automating are key to removing sources of error, and reduces complexity


Ansys