Webinar

New Features in LS-OPT® 7.0

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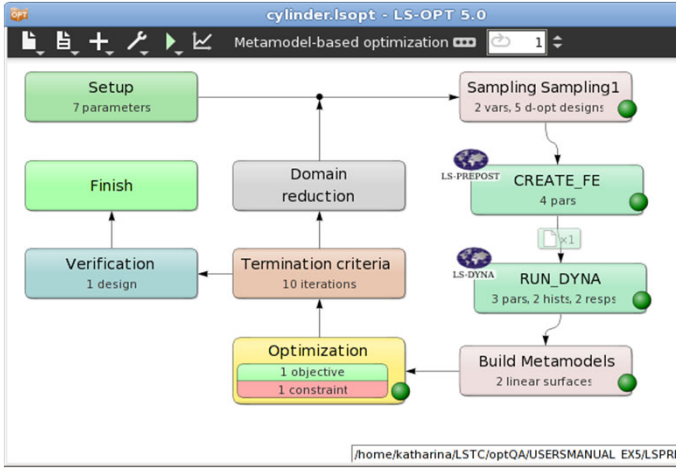
Outline

- Overview on LS-OPT
- New Features in LS-OPT 7.0

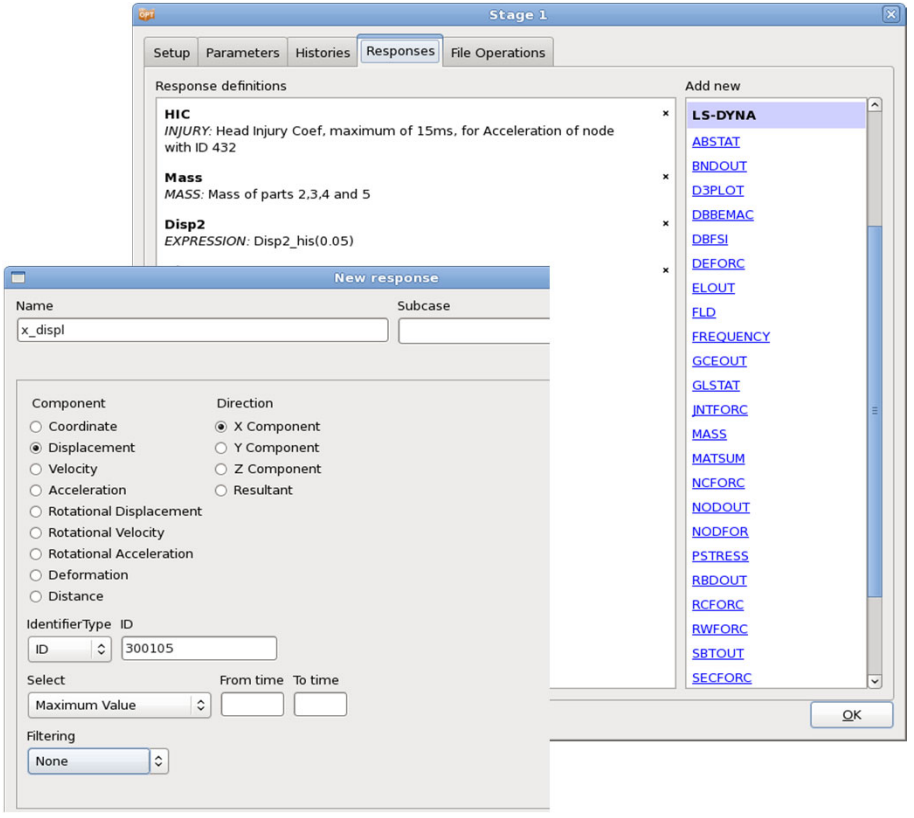
About LS-OPT

- LS-OPT is a stand alone optimization software
  - → can be linked to any (simulation) code –
    - Interface to LS-DYNA, Excel, Matlab
    - Interface to LS-PrePost, PRIMER, ANSA, Hypermorph, …
      → **shape optimization**
    - Interface to META Post
      → **result extraction**
    - Interface to LS-OPT, LS-TaSC
      → **nested optimization**
    - User-defined interface
    - Interface to Queuing Systems
      - PBS, LSF, SLURM, AQS, User-defined, …
  - → **LS-OPT as process manager**



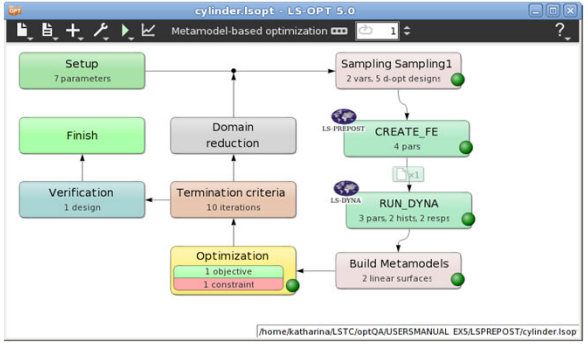
About LS-OPT

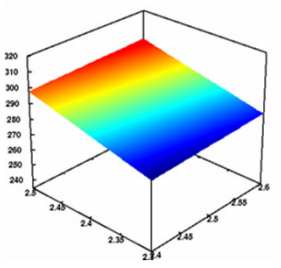
- LS-DYNA integration
  - Importation of design parameters from LS-DYNA keyword files (*PARAMETER)
  - Support of include files (*INCLUDE)
  - Result extraction of most LS-DYNA response types
  - Checking of LS-DYNA keyword files (*DATABASE_)
  - Monitoring of LS-DYNA progress

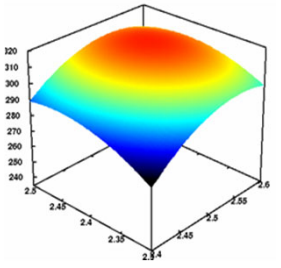


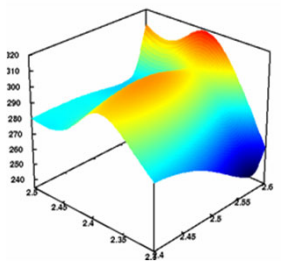
Methodologies

- (Sequential) Response Surface Method ((S)RSM)
  - → Metamodels
    - Polynomials
    - Radial Basis Functions (RBF)
    - Feedforward Neural Networks (FFNN)
- Genetic Algorithm (MOGA->NSGA-II)
  - → Multi-objective Optimization
    - Direct and metamodel-based
- Monte Carlo Analysis
  - → Robustness Analysis
    - Direct and metamodel-based



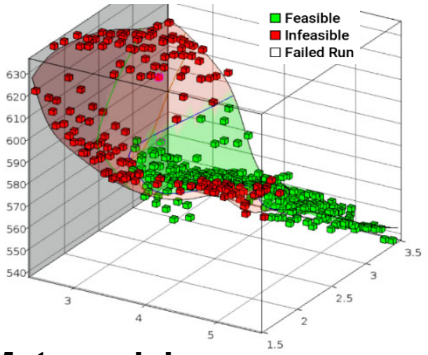




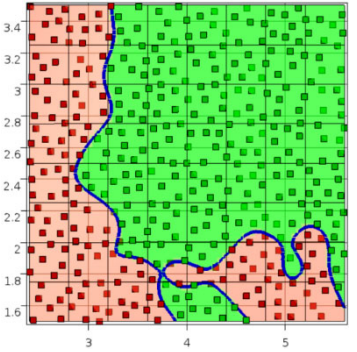


Methodologies

- Classifiers (Support Vector Classification)

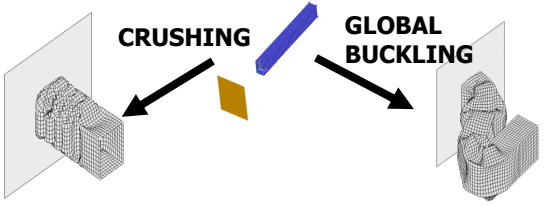


Metamodel
Approximation of response



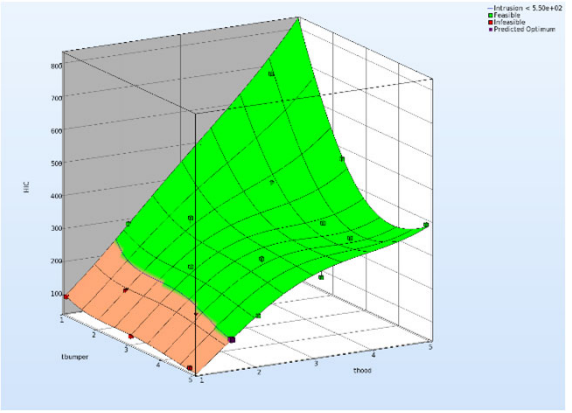
Classifier
Approximation of constraint boundary
- Design point (variable values)
- Feasibility of each design

- Discontinuous responses
- Binary responses
- → Constraints for optimization or reliability analysis



Applications of LS-OPT

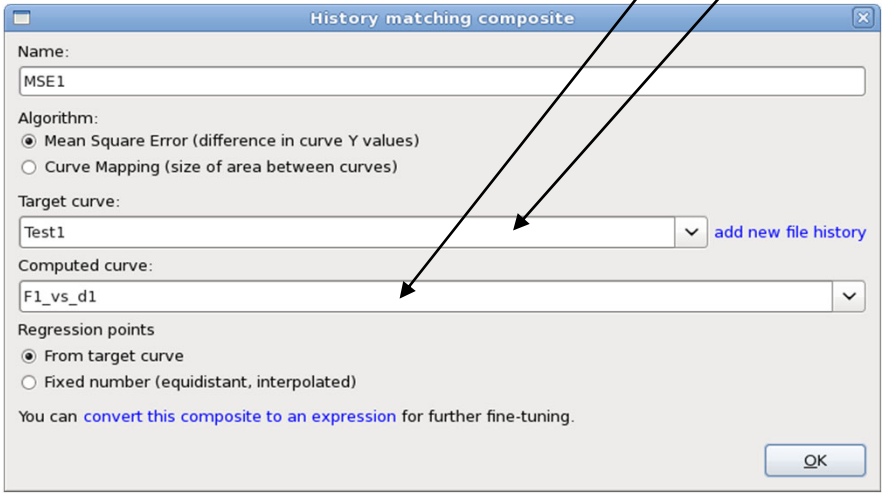
- Optimization
  - Size-/Shape optimization
  - Mixed continuous/discrete variables
    - Specify sets of discrete variables (e.g. sheet thicknesses)
  - Parameter/System Identification
  - Multiple load cases
    - Multi-disciplinary Optimization (MDO)
  - Multi-objective optimization (Pareto Frontier)
  - Multi-level optimization
  - Reliability based design optimization
  - Robust parameter design



Applications of LS-OPT

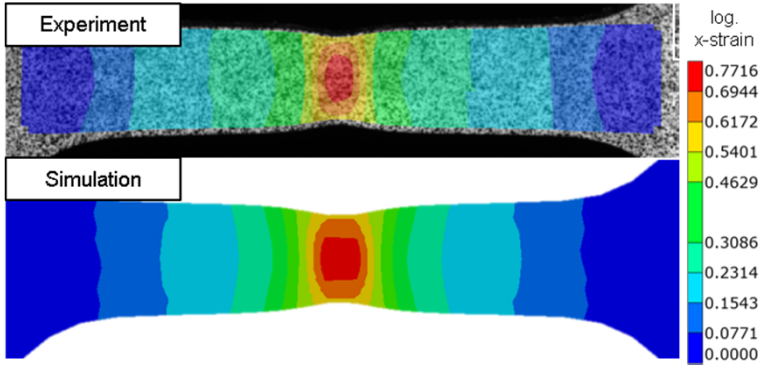
- Optimization
  - Parameter/System Identification Module: Calibration of test and simulation curves or scalar values

$$\frac{1}{P}\sum_{p=1}^{P} W_i \left(\frac{F_i(\boldsymbol{x}) - G_i}{s_i} \right)^2$$

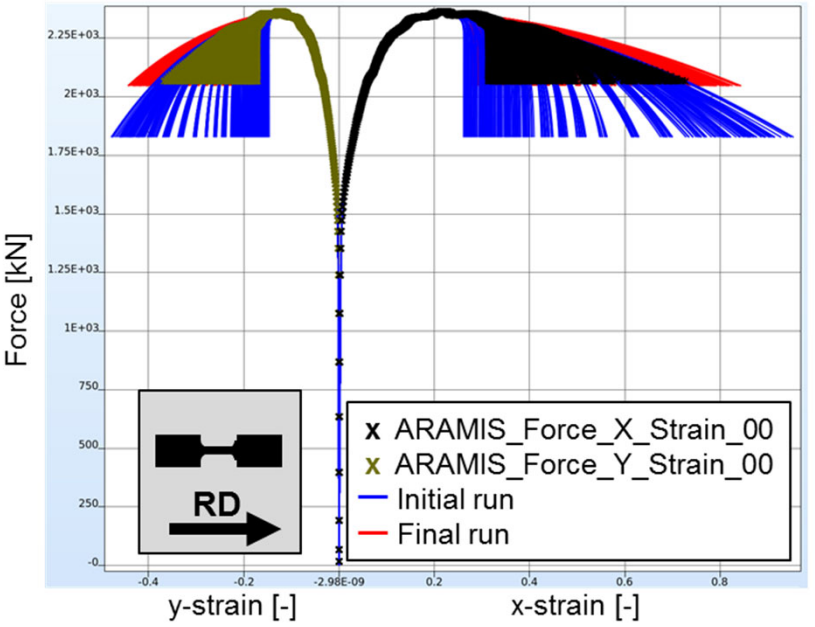


Applications of LS-OPT

- Optimization
  - Full-field calibration
    - parameter identification using DIC data
    - Matching in time and space

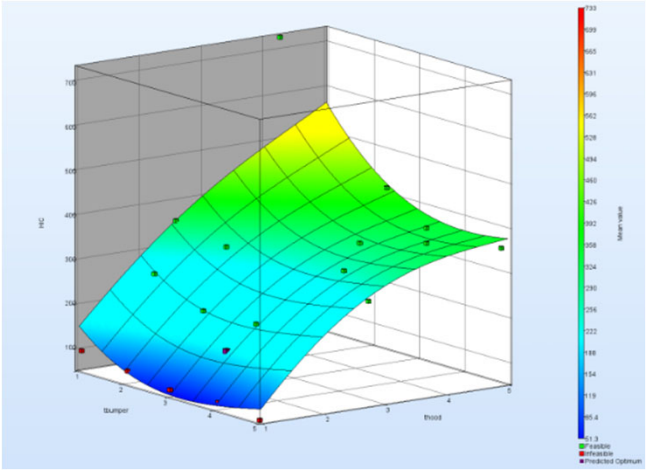


Deformation field of tensile test

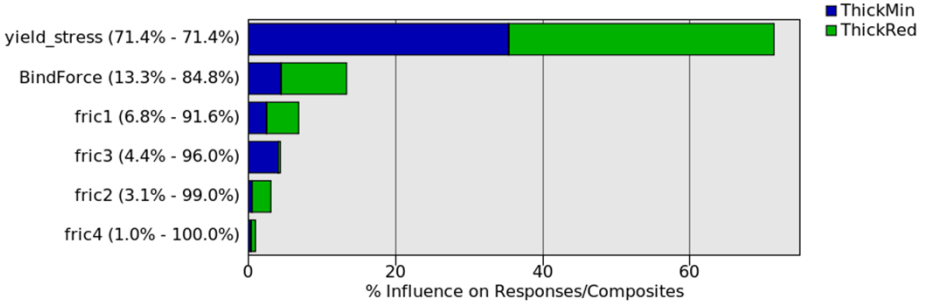


Applications of LS-OPT

- Sensitivity Analysis
  - Design Exploration
  - DOE Studies for Variable Screening (ANOVA, Sobol)
    - *Contribution of variables to system performance*
    - *Identification of significant and insignificant variables*
    - *Ranking of importance*
  - *Principal Component Analysis (PCA)*

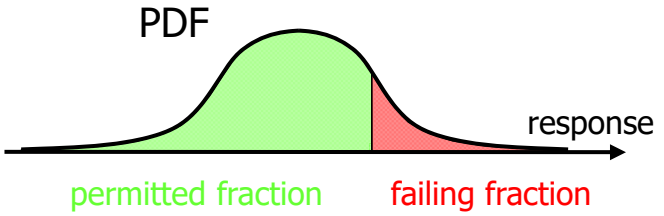


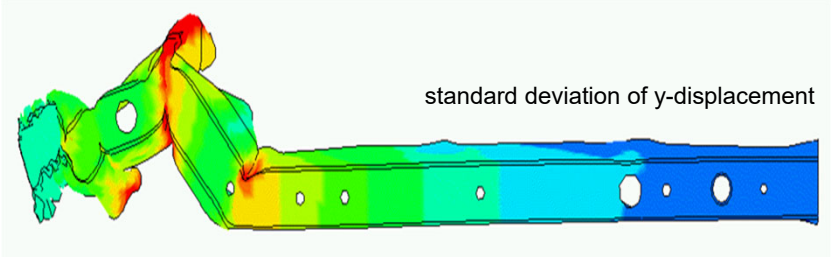
Global Sensitivities Plot

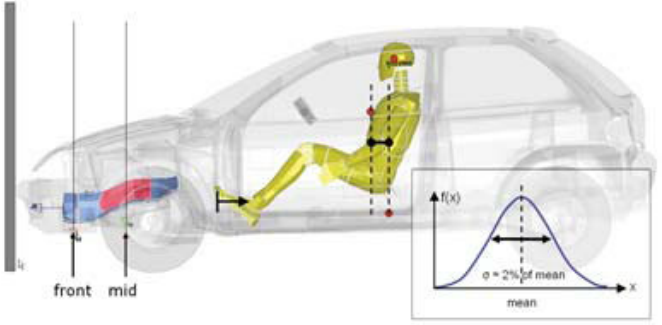


Applications of LS-OPT

- Stochastic/Probabilistic Analysis: Consideration of uncertainties
  - Test of Model Robustness
    - Statistics (mean, standard deviation)
    - Correlation Analysis
  - Reliability (Probability of Failure)
  - Outlier Detection
  - Fringe statistical results on FE model



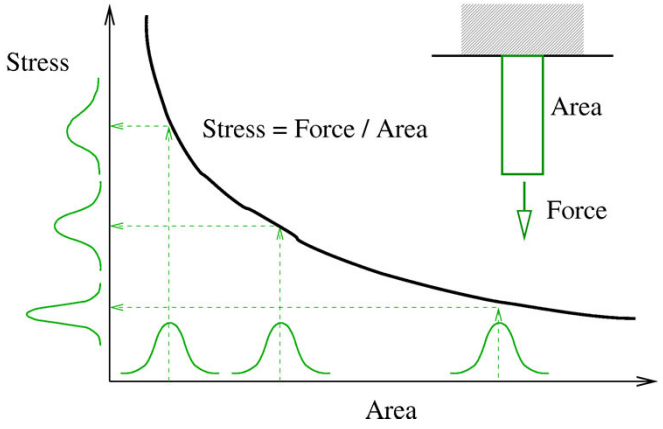




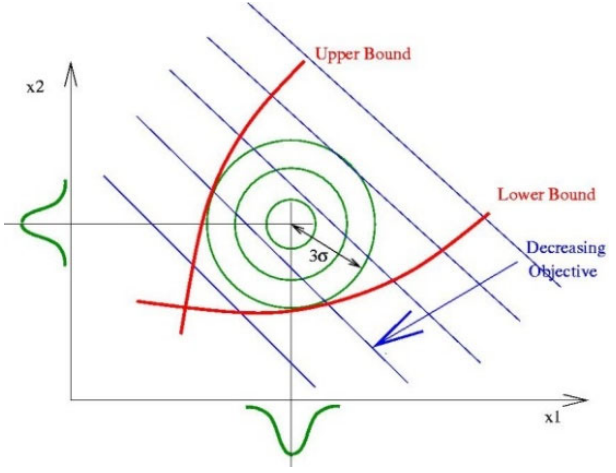
Applications of LS-OPT

Optimization incorporating uncertainties

- Robust Parameter Design (RDO)
  - Improve/Maximize the robustness of the optimum

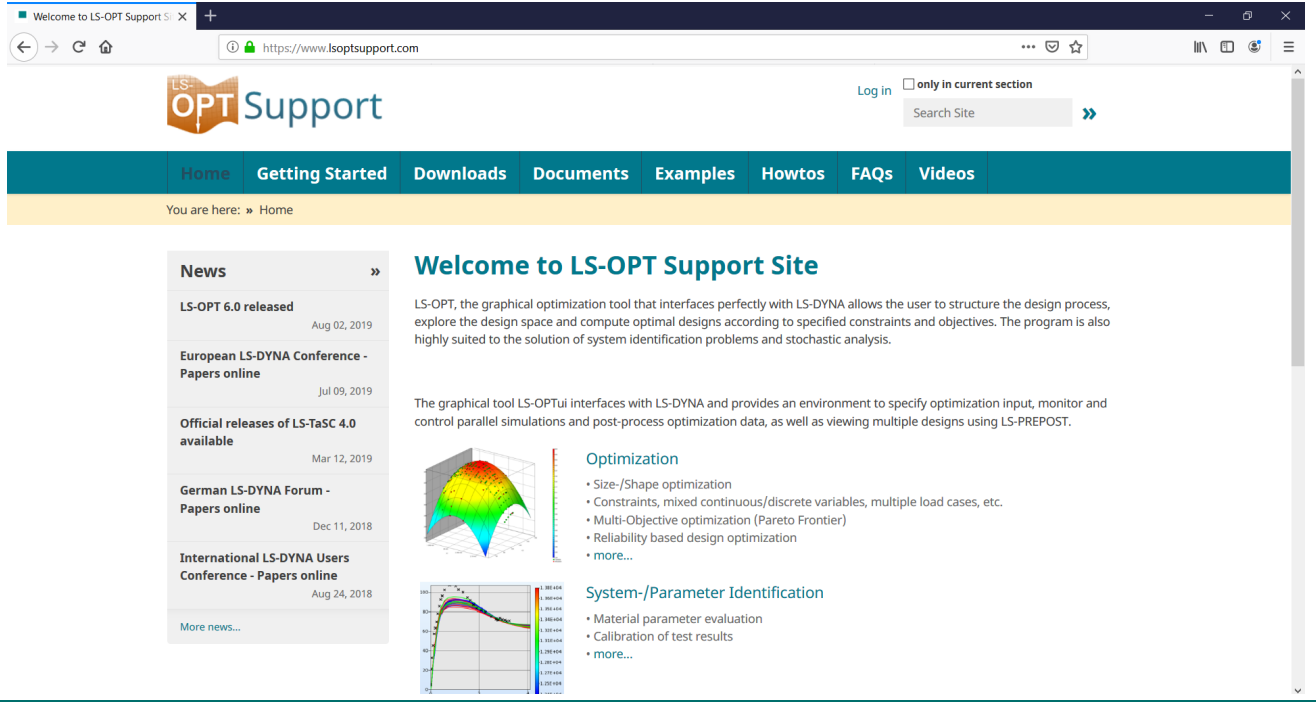


- Reliability Based Design Optimization (RBDO)
  - Improve failure probability of optimum



LS-OPT Support webpage

- www.lsoptsupport.com
  - Many examples, tutorials, FAQs, HowTos…

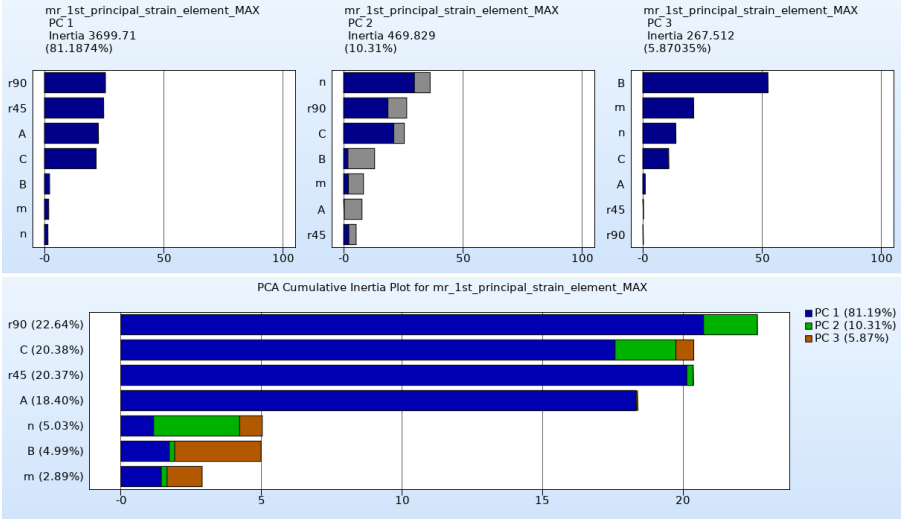


New Features in LS-OPT 7.0

Principal Component Analysis (PCA)

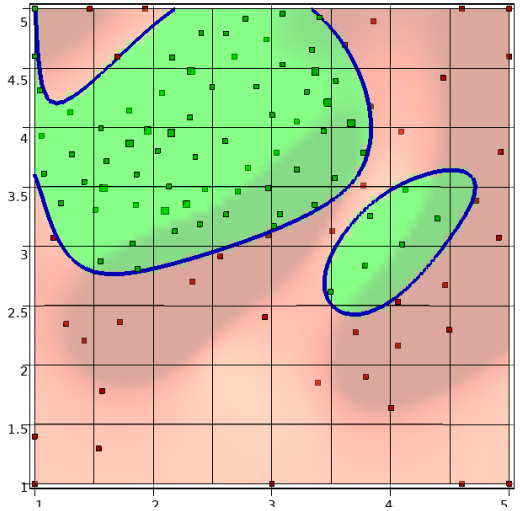
→ Influence of variables on histories or multipoint responses

- Multivariate statistical technique
  - Reduction of correlated observations (time values/spatial points) without loosing information
    - → Principal components
- Uses Proper Orthogonal Decomposition (POD) of correlation matrix
- Sensitivities:
  Contribution of each principal component and cumulative history/multiresponse sensitivity measure

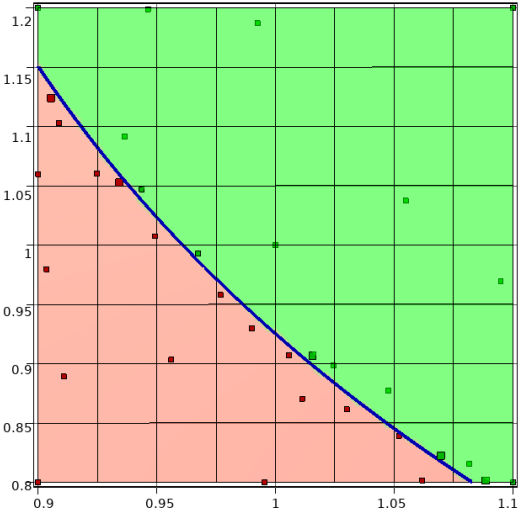


Adaptive Sampling

- EDSD Sampling Constraints (Explicit Design Space Decomposition)
  → sampling based on classifier predictions
- Optimization
  - Sampling in feasible region

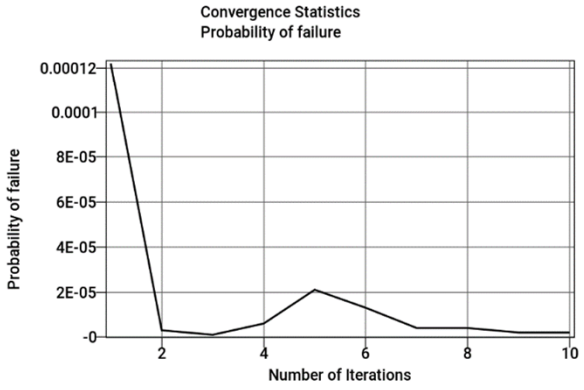


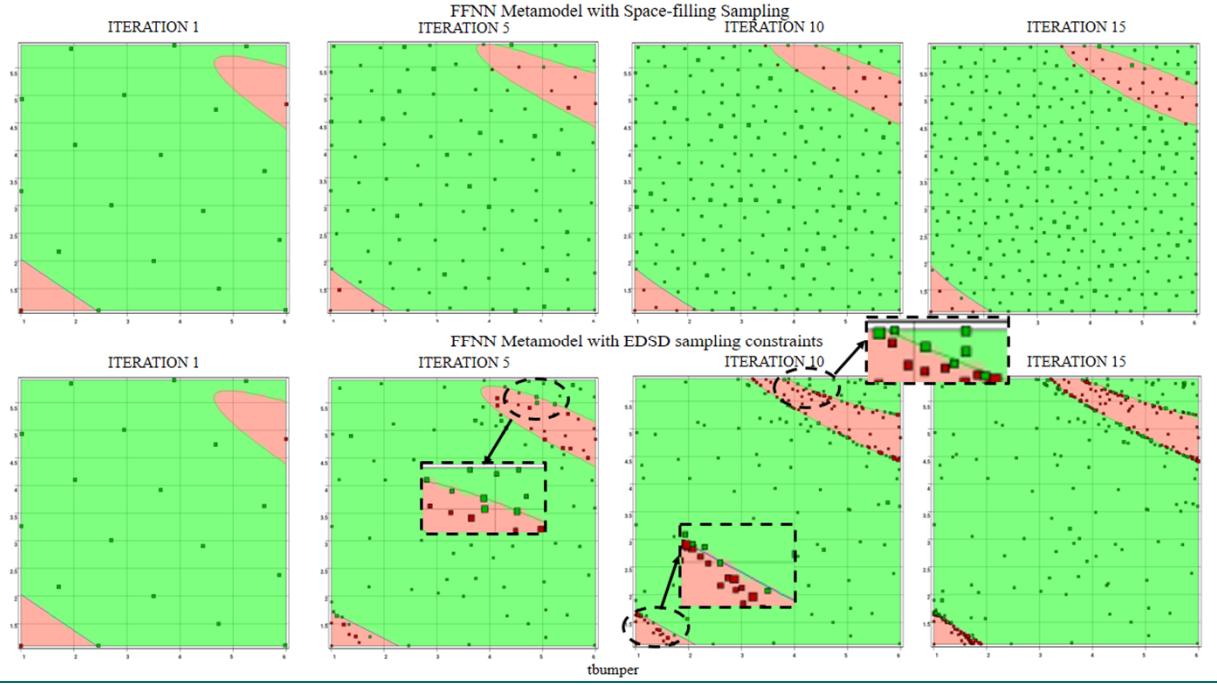
- Reliability
  - Sampling near the boundary



Sequential Monte Carlo Analysis

- Iteratively add space-filling or adaptively selected samples
- Convergence
  - metamodel accuracy
  - probability of failure





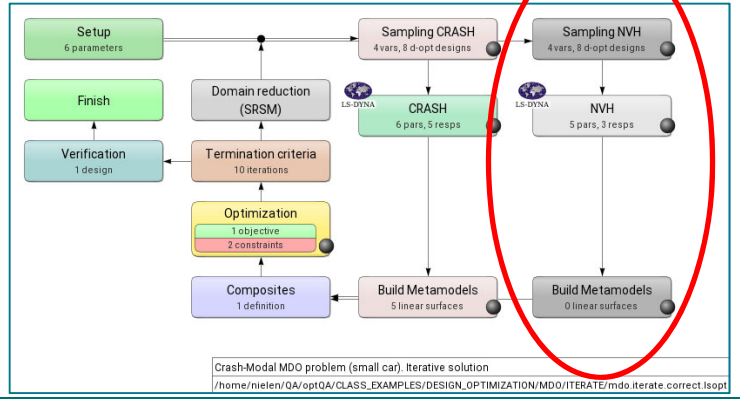
Job scheduler

- SSH Support
  - *SSH is the default access into UNIX systems*
  - Well understood by IT staff Maintained and secure
    - Run job directly on remote machine
    - Submit job to cluster via proxy machine
    - Supports OpenSSH or PuTTY binaries (common)
  - SSH host configuration saved in user settings as opposed to project file
  - GUI settings in lieu of environment variables
- Simplified BLACKBOX queuing system
  - No need to implement LsoptJobCheck script
  - User-defined termination criteria from GUI
    - Job executable return code
    - Line in stdout (e.g. `N o r m a l`)
    - File existence
    - Line in file
- User-defined port range for runqueuer
- Parallel limit
  - Increase number of simultaneous runs - 300 parallel limit no longer valid

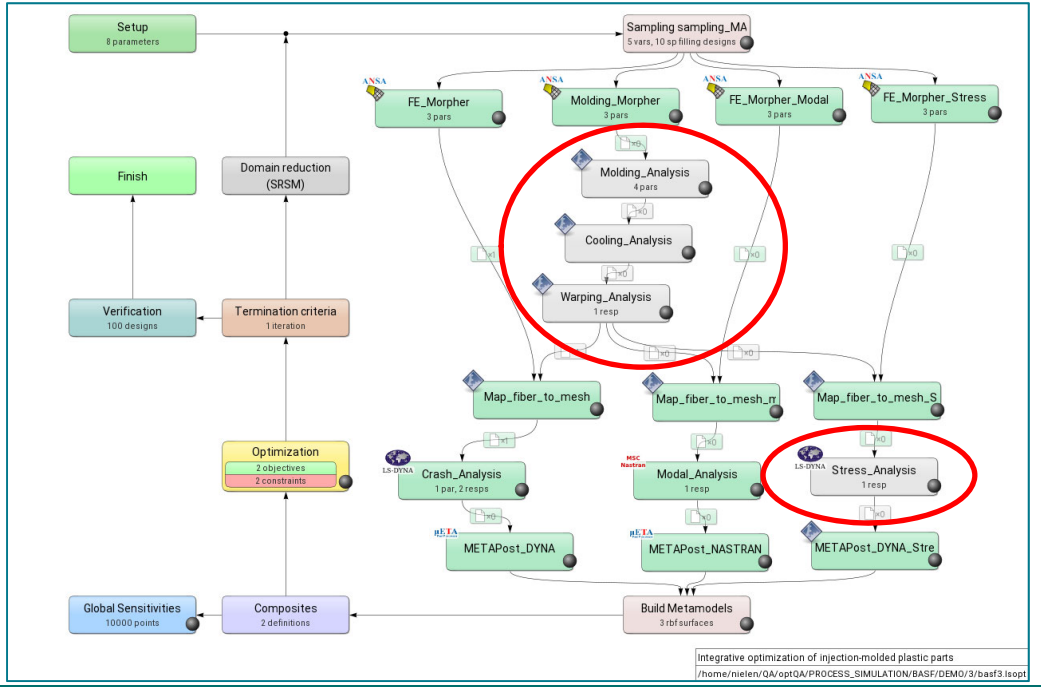
Process Management: Case and Stage (de)activation

- Deactivate selected MDO samplings or stages
- Automatic (de)activation of dependent composite expressions, classifiers, objectives, constraints, …

Case deactivation



Stage deactivation

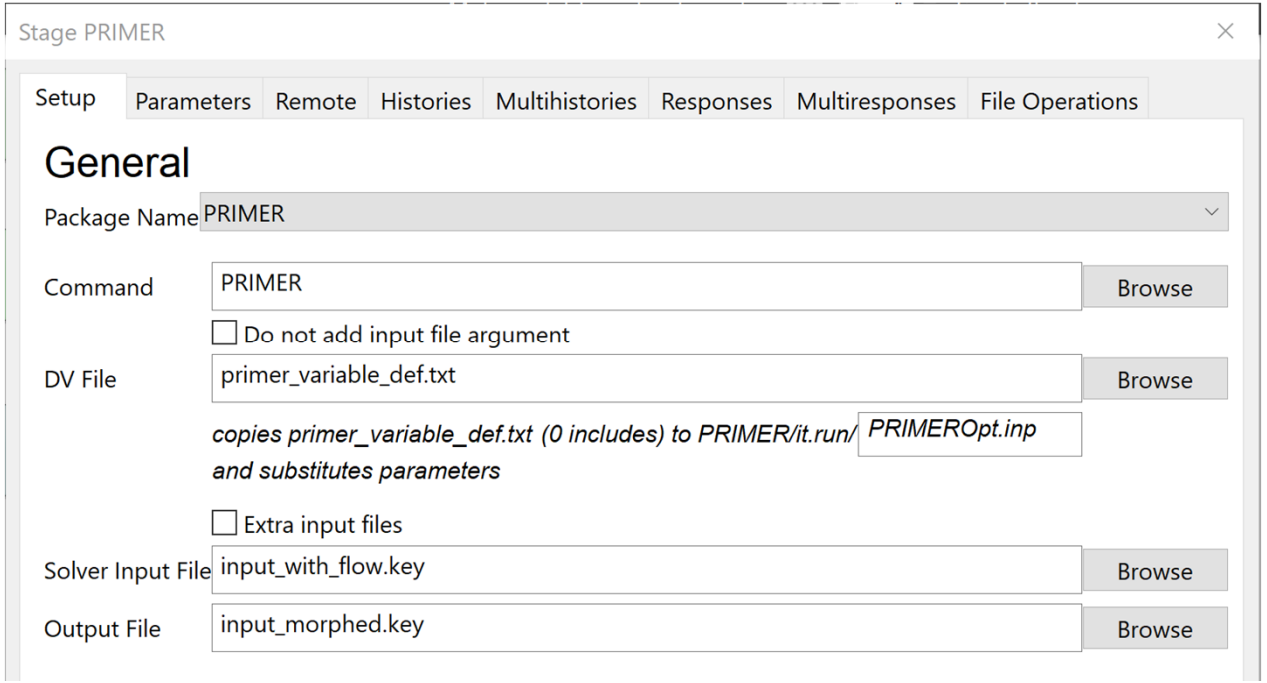


Command line options

- Run LS-OPT in batch mode with command line options
- LS-OPT command line options
  - Archiving
  - Repair
  - Baseline Run
  - Clean

Interface to Oasys PRIMER

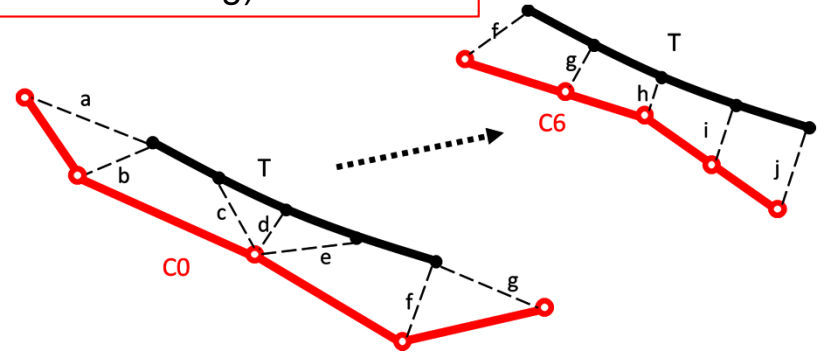
- Shape optimization using PRIMER morphing tool



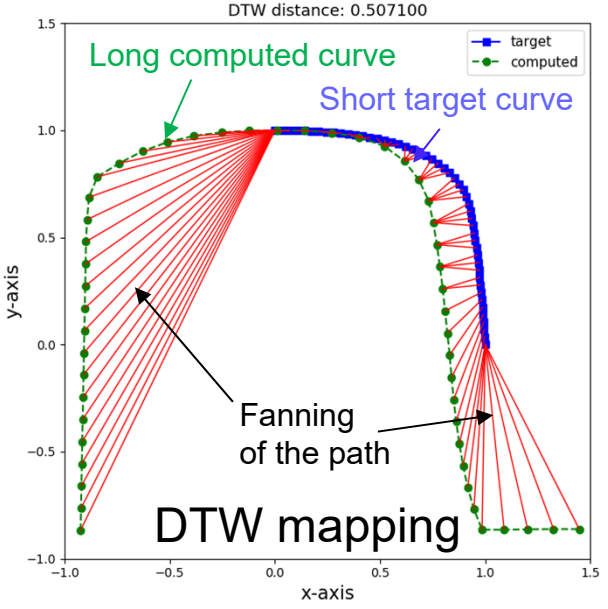
Material Calibration Using Partial Curves

- Modified Dynamic Time Warping
  - Partial curves confound the error source (shape vs length mismatch)
  - Trimming improves curve compatibility and can reduce optimization complexity

Partial Dynamic Time Warping (DTW with iterative remeshing).



- Suitable for noisy curves
- Suitable for partial mapping



Comparison of Curve Distance Measures

Distance Metric	Principle	Advantage	Disadvantage
Euclidean Distance (MSE)	**Mean Squared Error** of the difference in curve ordinates	• noise • partial curves	• hysteresis: the curves must be functions
Partial Curve Mapping (PCM)	**Area between curves.** Preserves the arc length.	• curves of unequal geometric length • hysteresis	• noise (due to arc length preservation)
Discrete Fréchet (DF)	**Minimum of the maximum** of all possible edge lengths along a path which connects all given data points, taking into account the location and ordering of the points.	• noise • hysteresis	• curves of unequal geometric length
Dynamic Time Warping (DTW)	Minimizes the sum of path connectors between the curves in a **one-to-many mapping** end to end.	• noise • hysteresis	• curves of unequal geometric length • more expensive to compute
Modified Dynamic Time Warping (DTW-p)	Recursively **trims coincident end connectors** of DTW. Simple extension of DTW.	• noise • hysteresis • curves of unequal geometric length	• more expensive to compute

More Information on the Ansys/LST Product Suite

- Ansys/Livermore Software Technology (Ansys/LST)
  www.lstc.com
- LS-DYNA
  - Support / Tutorials / Examples / FAQ
    www.dynasupport.com
  - More Examples
    www.dynaexamples.com
  - Conference Papers
    www.dynalook.com
  - European Master Distributor
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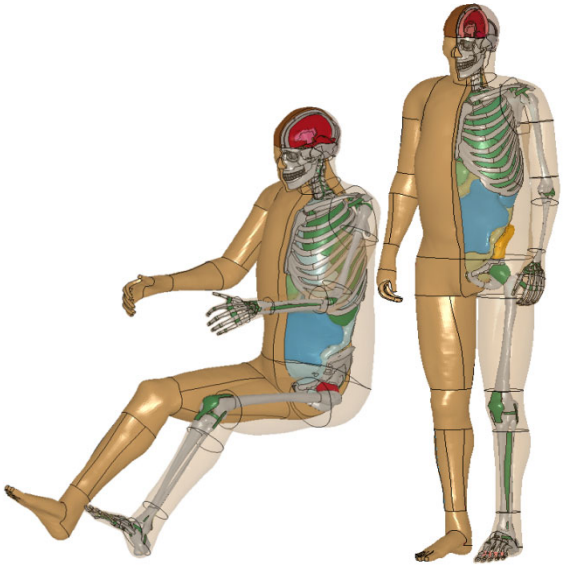

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