New Features in LS-OPT Version 3: Optimization

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4th German LS-DYNA Forum
Bamberg, Germany
September 20, 2005

Overview

- **LS-OPT overview**
- **Overview of features in 3.0**
- **Main features**
  - Improved Visualization
  - Parameter identification
- **Outlook**
  - LS-OPT 3.1
  - LS-PM: Process Manager
- **Conclusion**

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LS-OPT Goals

Design Environment
for LS-DYNA

Tasks

- Identify important variables (variable screening)
- Identify *Sources of Uncertainty* in FE models
- Identify *Material Properties* from physical experiments (system identification)
- Improve *Performance*, satisfy *Design Limits* in an *Uncertain Environment* (RBDO)
- Involve Multiple *Disciplines/Load Cases* (MDO)
- Simultaneous Visualization of results of *multiple* runs
- Manage a *multi-stage process*

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LS-OPT Features

- **Technologies**
  - Experimental Design (DOE)
    - D-Optimal, Latin Hypercube, Space Filling
  - Metamodels (approximations)
    - RSM, Neural Networks
  - Variable screening
  - Probabilistic analysis
    - Reliability, Outlier Analysis
  - Optimization
- **Computing Environment**
  - Multiple Processors
  - Distributed Hardware

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Overview of features
Version 3.0 (4th Quarter 2005)

- **LS-OPT for Windows**
  - Incorporates new Application Program Interface to speed up development/facilitate porting
- **System Identification**
  - Automated use of test curves to calibrate materials/systems
  - Response Surface-based
  - Handles "continuous" test curves
- **Stochastic fields (LS971)**
  - Geometry
  - Shell thickness
- **Improved visualization of stochastic results**
  - Extended LS-PREPOST visualization of design sensitivities and importance of design variables

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Overview of features
Version 3.0

- **Dyna `d3plot` interface**
  - LS-TAURUS interface retired
  - d3plot binary read directly by LSOPT
  - Additional d3plot capabilities
    - extract results for an *element* or a *node*
    - in addition to the maximum/minimum over a part.
  - Improved diagnostics
- **Reliability-based design optimization (RBDO)**
  - Specify probability of failure as design constraints

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Overview of features
Version 3.0

- **Simulation job distribution**
  - Automatic recovery of LS-DYNA databases from remote nodes (d3plot, binout, ...)
  - Recovery of files using wildcard (e.g. "d3*")
  - Interface for User-defined queuing
  - Improved robustness
- **Preprocessing**
  - Improved Hypermorph interface: Variable name, value, bounds automatically imported from template
- **Improvement of neural networks**
  - Committees: Generate multiple neural nets for the same result set. Stabilizes response. Allows point-wise variance computation.

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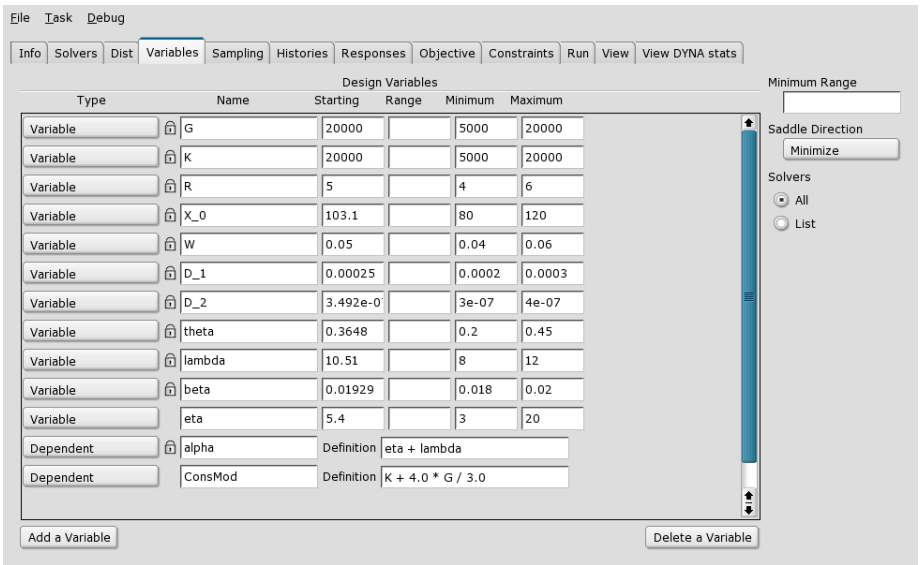
GUI: Variables panel



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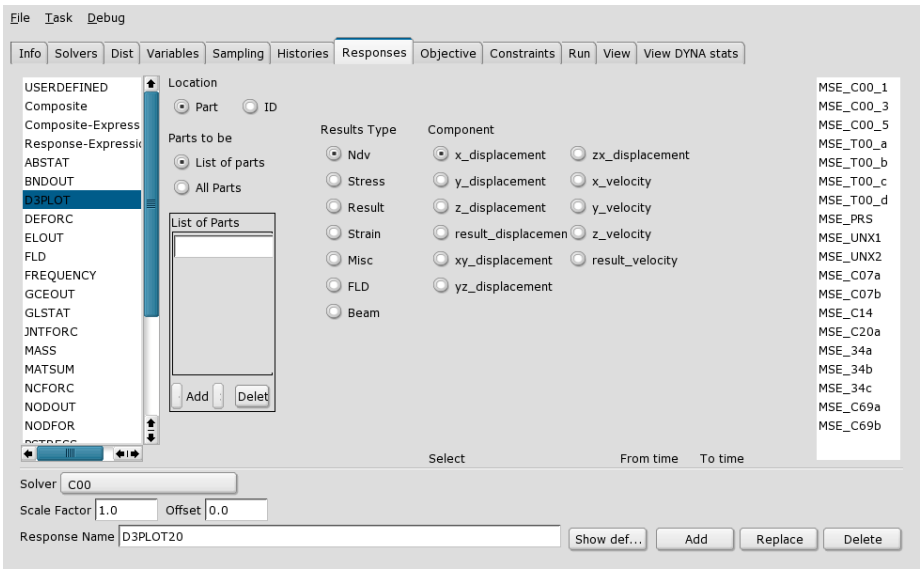
GUI: LS-DYNA interface: d3plot nodal response



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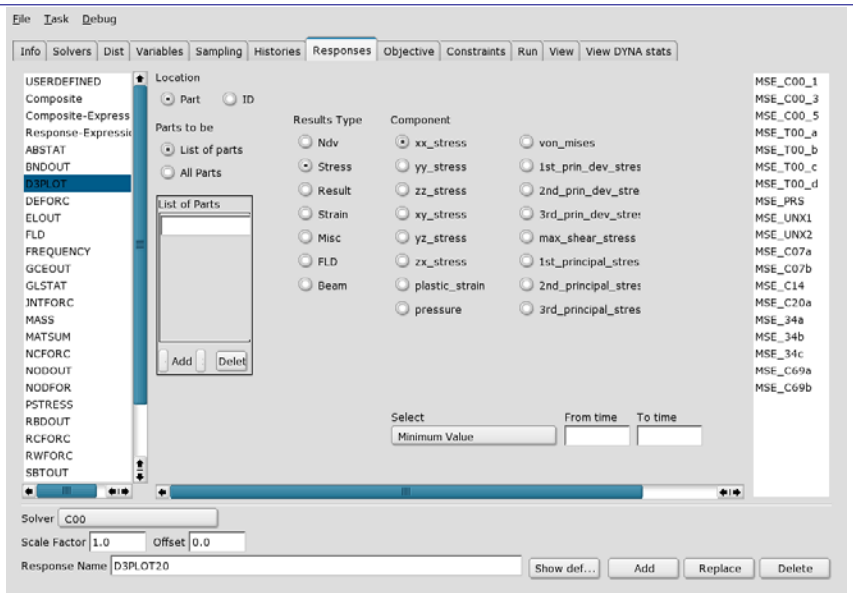
GUI: LS-DYNA interface: d3plot stress response



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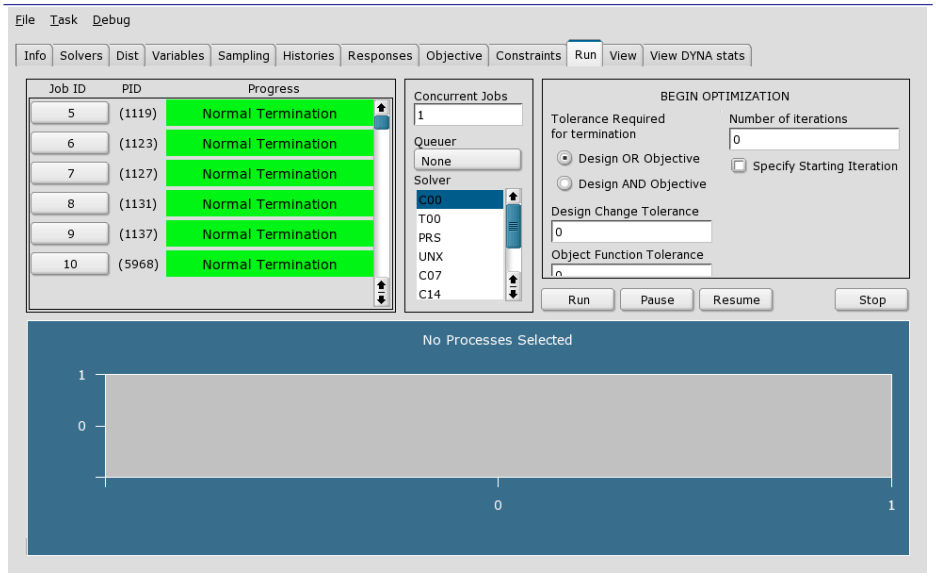
GUI: Run panel



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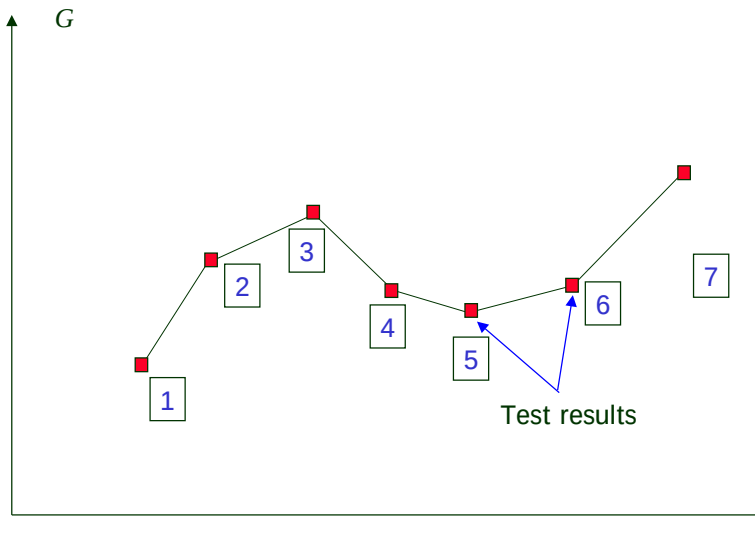
Parameter Identification
Test Points



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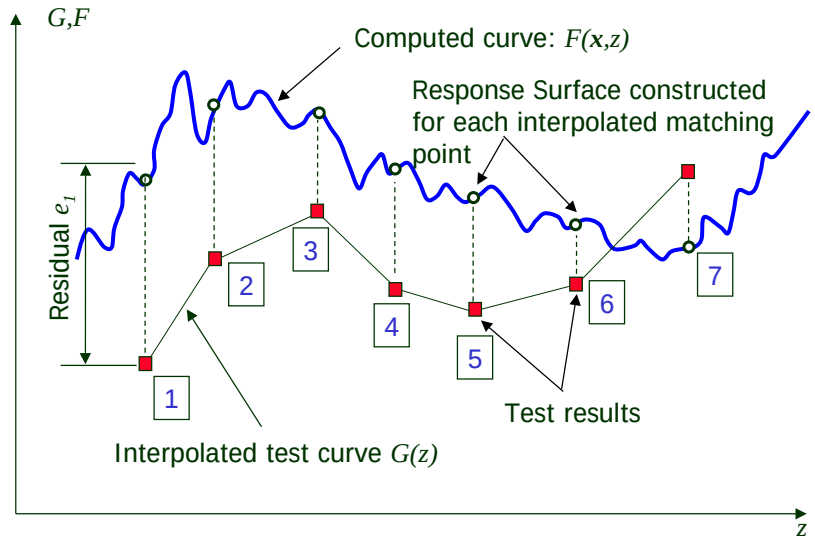
Parameter Identification
Test Points + Computed Curve



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Parameter Identification
Mean Squared Error

Weight (Importance of error)

Response Surface Value

Test Value

Residual

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

Number of points

Residual Scale factor (Normalization of error)

Variables (material or system constants)

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Parameter identification
Relevant commands

- Get test data

```
History 'testcurvename' file "testfilename"
```

- Construct crossplot

```
History 'curvename' {Crossplot (
        history_x_name, history_y_name,
        [numpoints, begin, end] )}
```

Dyna time-histories

- Construct error norm of curve mismatch

```
Composite 'name' {MeanSqErr (
        'testcurvename', 'curvename',
        [numpoints, begin, end,
        weighting_type, scaling_type,
        weighting_value, scaling_value,
        weighting_curve, scaling_curve] )}
```

Curves

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MeanSqErr
Command arguments

Argument name	Description	Symbol	LS-OPT Type	Default
Test_curve	Test Curve name	*G(y)*	*History*	-
Computed_curve	Computed curve name	*F(x,y)*	*History*	-
Num_regression_points	Number of regression points	*P*	*Int*	If < 2 or not specified: number of points in Test curve.
Start_ point	*y*-Position of first regression point	y_L	*Float*	*y*-Position of first test point
End_ point	*y*-Position of last regression point	y_U	*Float*	*y*-Position of last test point
Weight_ type	Weighting type	-	*Reserved option name:* UNITWEIGHT,WEIGHTVALUE PROPWEIGHT,FILEWEIGHT	UNITWEIGHT
Scale_type	Scaling type	-	*Reserved option name:* UNITSCALE, SCALEVALUE, PROPSCALE MAXISCALE, FILESCALE	MAXISCALE
Weight_value	Weight value	*W*	*Float*	1
Scale_value	Scale value	*s*	*Float*	1
Weight_curve	Weights as a function of *y*	*W(y)*	*History*	Weight.*compositename*
Scale_curve	Scale factors as a function of *y*	*S(y)*	*History*	Scale.*compositename*

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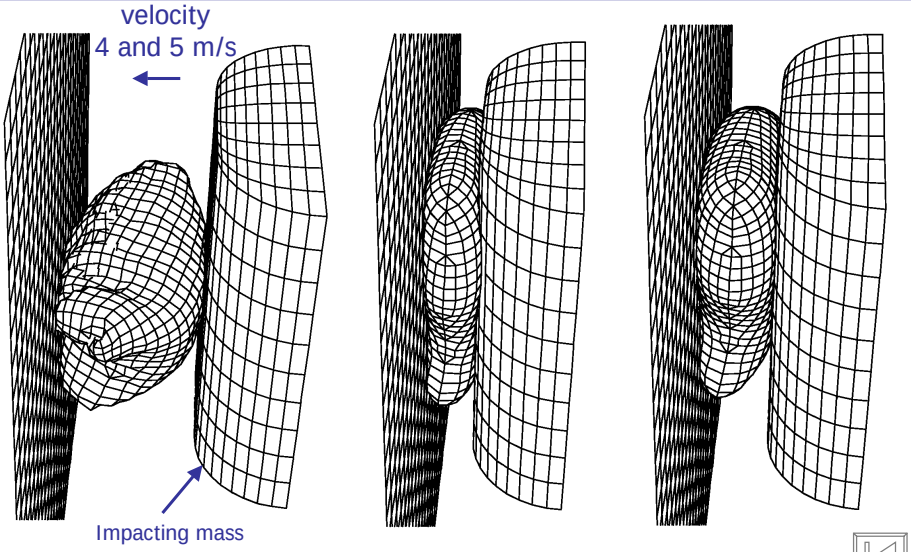
Airbag
System Identification



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Airbag
Problem formulation

- **Goal: Determine Leakage vs. pressure curve for airbag**
- **Given: 2 physical experiments (4m/s & 5m/s impact velocity)**
  - Measure acceleration
  - integrate to find velocity and displacement
  - use scaling to normalize quantities
- **Method: Minimize *Mean Squared Error***
- **Subject to monotonicity constraints**

$$x_{k+1} > x_k, \quad k = 1, 2, \ldots, m$$

- **Choose a flat starting design for leakage coefficient**

[6, 6, 6, ..., 6]*1e-8

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Airbag
Selected Commands

```
composite 'MSE_Acc_4' {MeanSqErr ( Test_acc_4,
 Acc_4mps_sc, 20 ,,,, SCALEVALUE,, 100 )}
composite 'MSE_Acc_5' {MeanSqErr ( Test_acc_5,
 Acc_5mps_sc, 20 ,,,, SCALEVALUE,, 100 )}
composite 'MSE_Vel_4' {MeanSqErr ( Test_vel_4,
 Vel_4mps_sc, 20 ,,,, SCALEVALUE,, 1 )}
composite 'MSE_Vel_5' {MeanSqErr ( Test_vel_5,
 Vel_5mps_sc, 20 ,,,, SCALEVALUE,, 1 )}
composite 'MSE_Dis_4' {MeanSqErr ( Test_dis_4,
 Dis_4mps_sc, 20 ,,,, SCALEVALUE,, 100 )}
composite 'MSE_Dis_5' {MeanSqErr ( Test_dis_5,
 Dis_5mps_sc, 20 ,,,, SCALEVALUE,, 100 )}
composite 'MSE_TOTAL' {MSE_Acc_4 + MSE_Acc_5 +
 MSE_Vel_4 + MSE_Vel_5 + MSE_Dis_4 + MSE_Dis_5}
```


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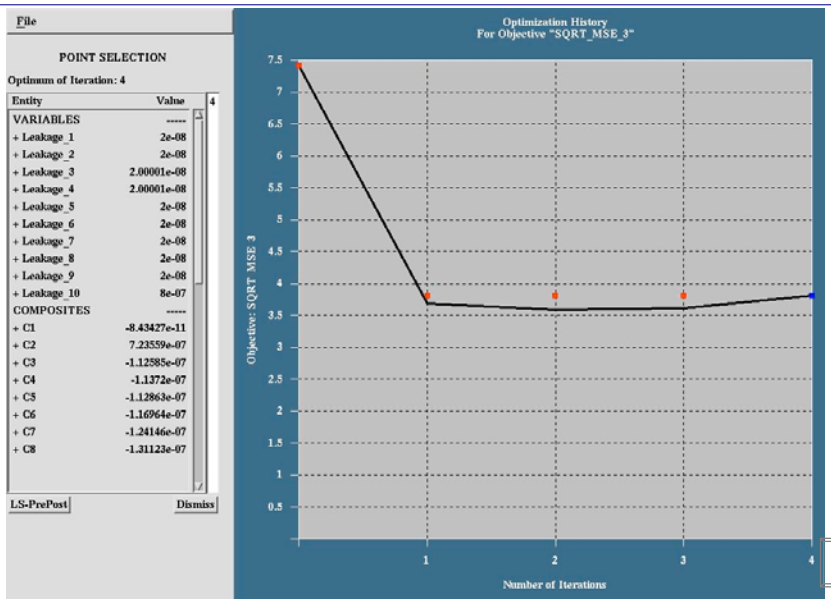
Airbag
Optimization History



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Outlook
Version 3.1

- **Discrete Optimization**
  - Define fixed sets for variables
- **3-D visualization of response surfaces**
  - OpenGL interface
- **GUI input features**
  - Special functions: parameter identification, integration, ...
  - Job distribution features: file recovery, deletion

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Process Manager (LSPM)
Multi-Stage Analysis (2006)

- **Goals**
  - Seamless analysis of a multi-stage process using LSDYNA
  - Emphasis on reliability: file handling, restart, recovery, post-processing
  - Integration with LSPP: Shares LSPP database
  - Extension of the LSOPT queuing features
  - LS-OPT integration: Run as LSOPT job, parameter control, extract data
- **Features**
  - Specify DYNA versions, revisions, options
  - Database handling: recovery, compression, deletion, copying
  - Job scheduling
  - Transmission of files to remote nodes
  - Special job wrapper functions: retrieves data files, monitors progress, recovers database “on call”, emails diagnostics, completion, statistics
- **Post-processing**
  - Seamlessly done through database recovery

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Conclusion

- **Underlying technologies well proven**
  - Optimization, including reliability based (RBDO)
- **Main goal now is to**
  - Continue integration with LS-DYNA and LS-PREPOST. Keep as standalone
  - Improve visualization: visualization of response surfaces
  - Simplify input for special applications, e.g. system identification
  - Add technologies where needed: discrete optimization
  - Refine algorithms where necessary

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