simulating REALITY™

MSC Software

Simulation-Supported Decision Making

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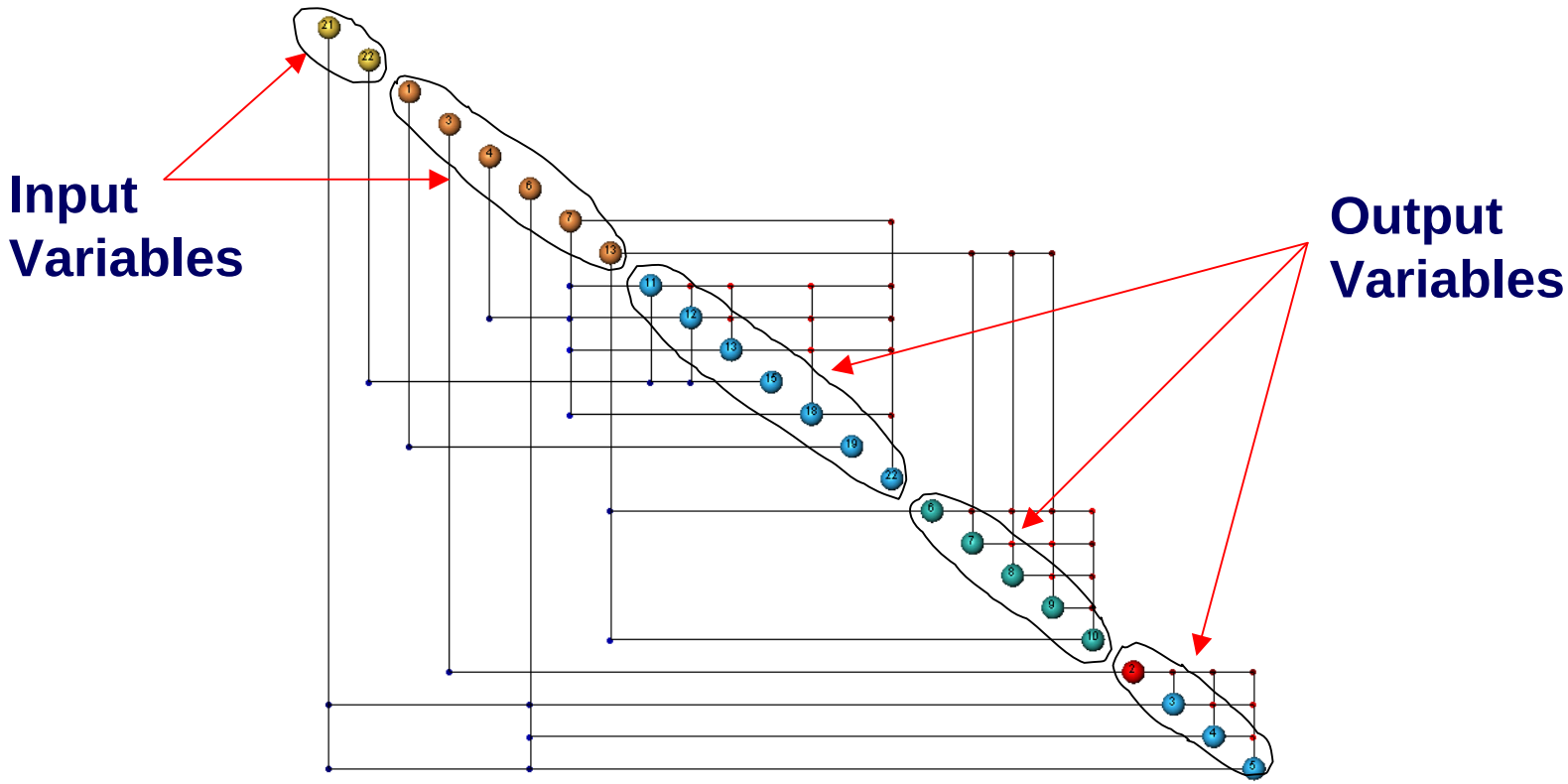
Tool for Decision Making

- Quickly Identify and Understand How a Product Functions:
  - What are the major variables driving functionality?
  - What are the combinations of variables that lead to problems in complex systems?
- Ability Exists Today

Correlation Maps

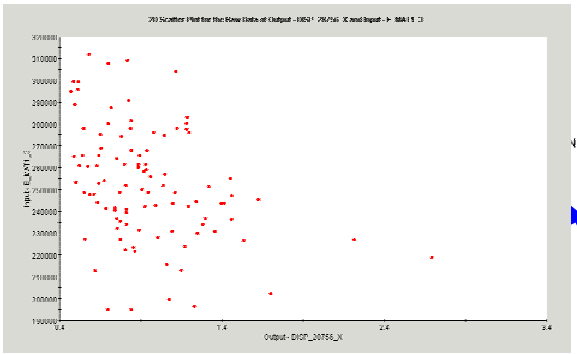
Correlation Maps to Understand Cause & Effect

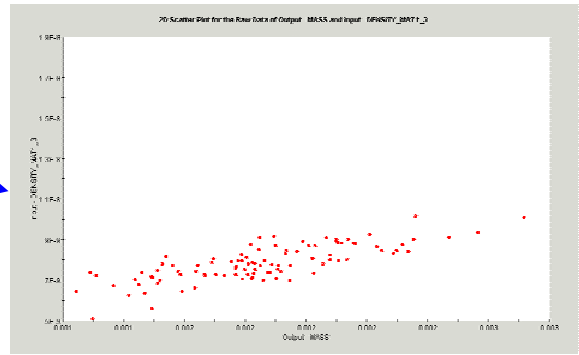


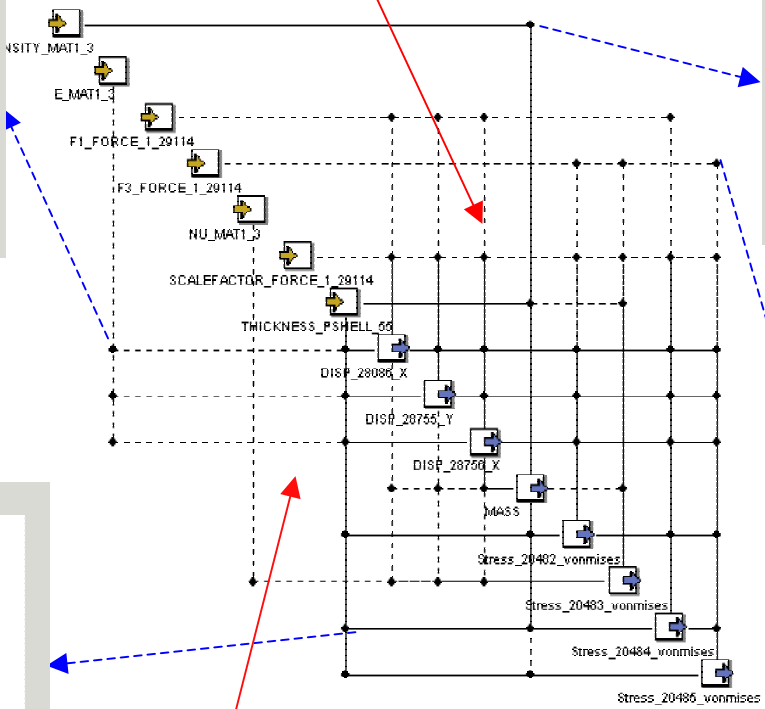
- Ranks input variables and output responses by correlation level
- Follows MIT-developed Design Structure Matrix model format

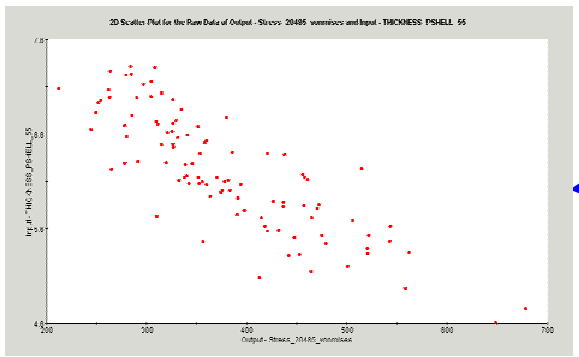
A Correlation Map

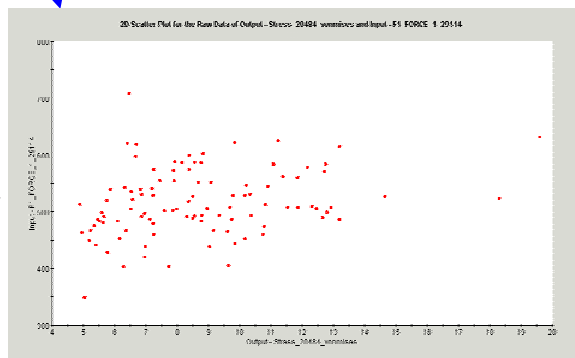
Upper right –
positive correlation







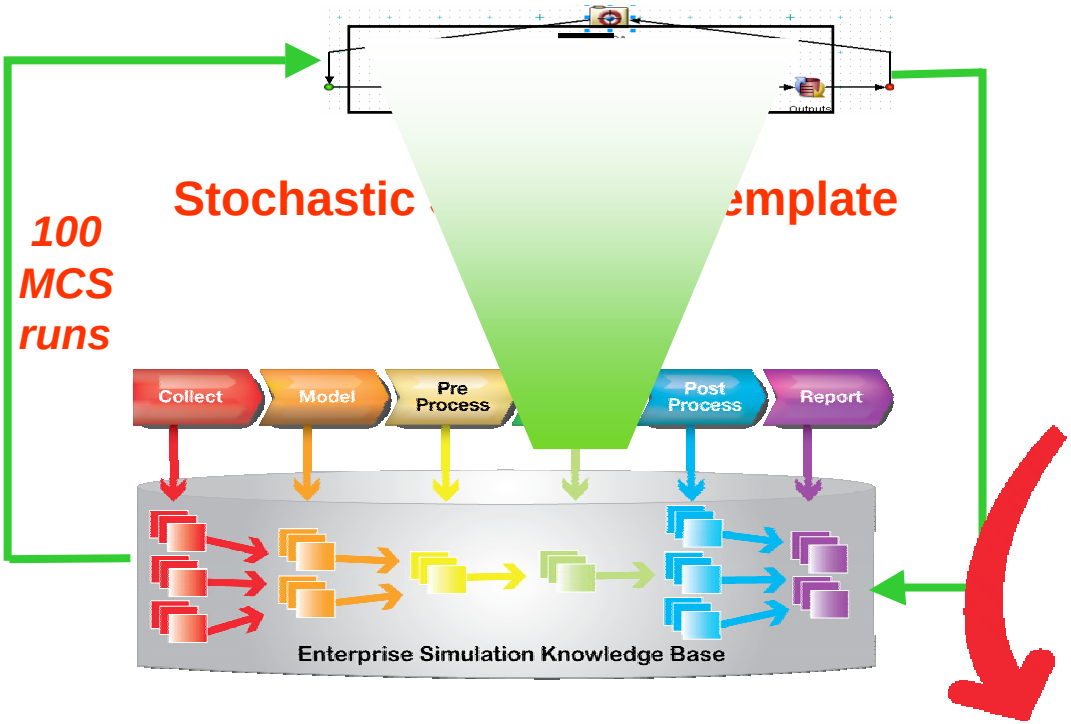


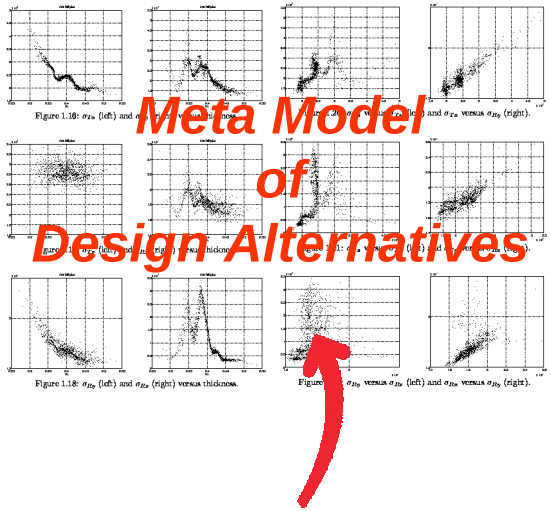


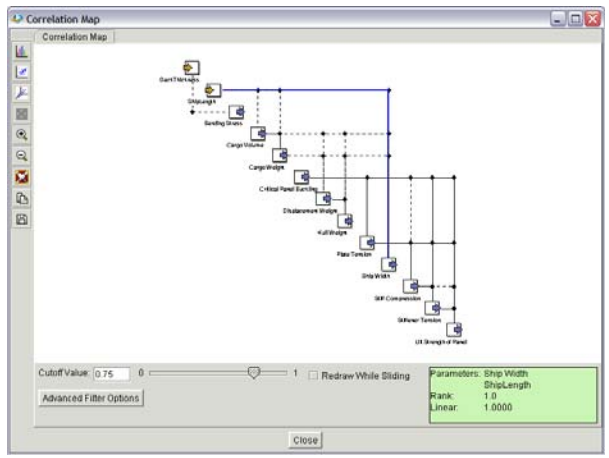
Lower left –
negative correlation

Filters Variables Based on Correlation Level

Generation of Correlation Maps







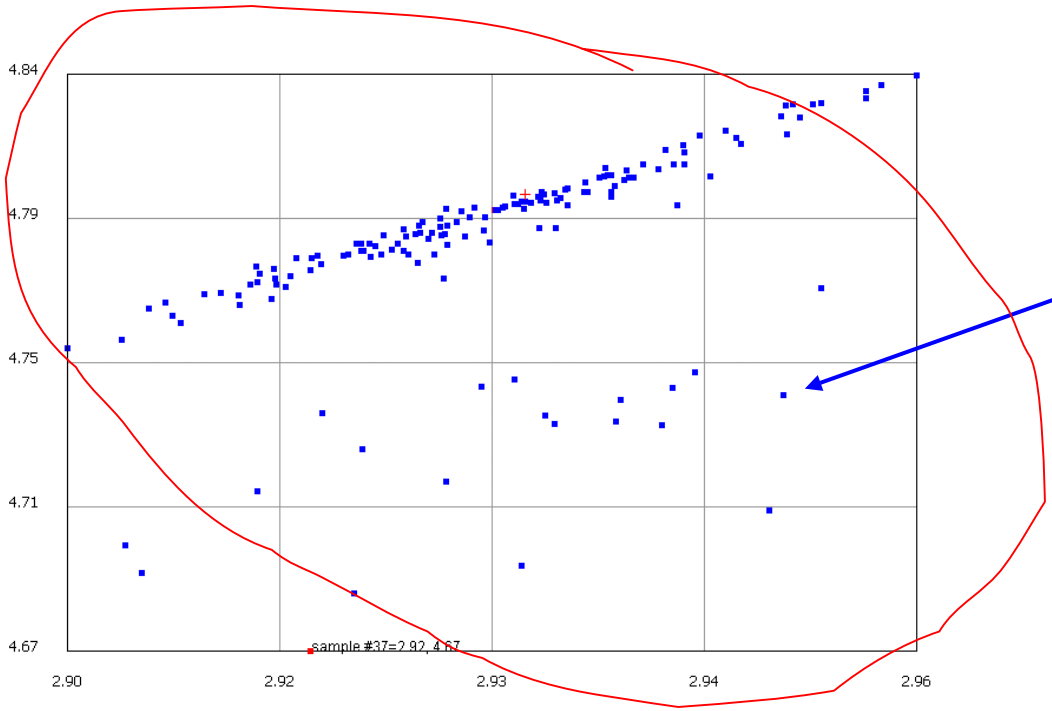
Correlation Map:

- Includes All Results

- Highlights Key Variables

Monte Carlo Results show Reality

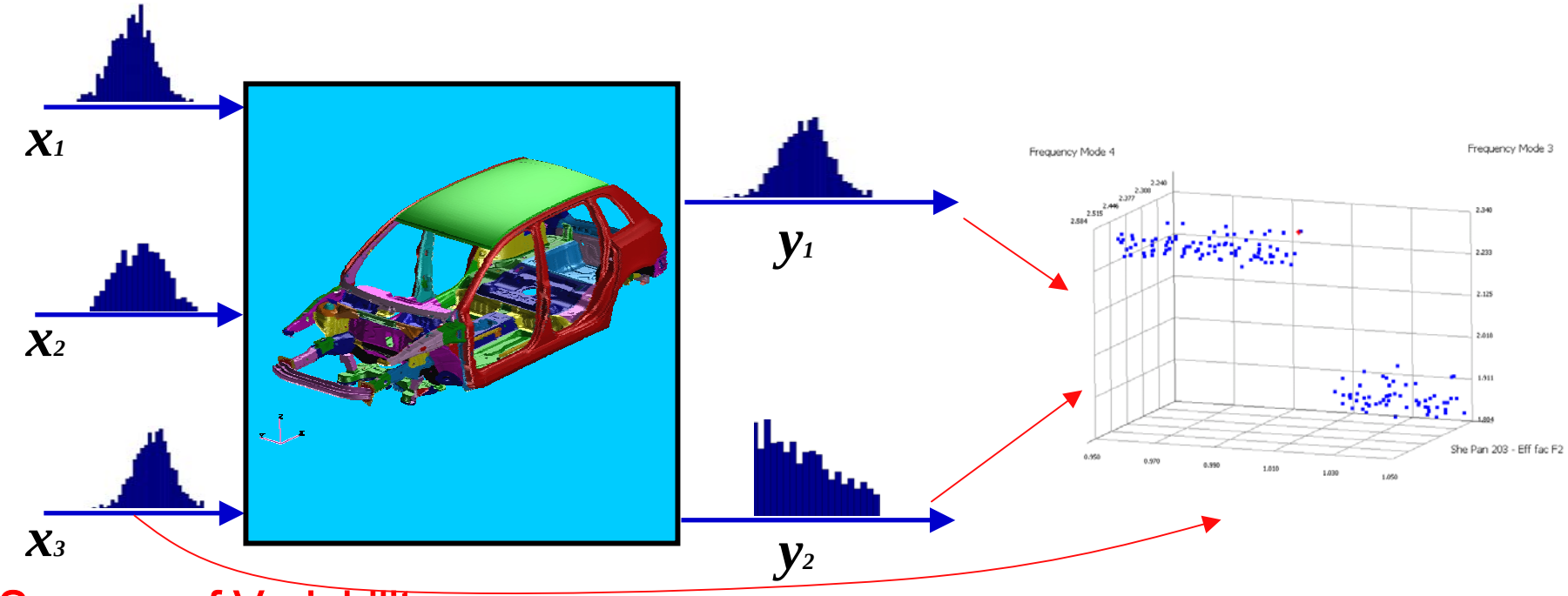
Collection of computer runs = Simulation



Single computer run = Analysis

Understanding the physics of a phenomenon is equivalent to the understanding of the topology and structure of these clouds.

MONTE CARLO METHOD



Sources of Variability

- Material Properties
- Loads
- Boundary and initial conditions
- Geometry imperfections
- Assembly imperfections
- Solver
- Computer (round-off, truncation, etc.)
- Engineer (choice of element type, algorithm, mesh band-width, etc.)

Solution:

Establish tolerances for the input and design variables.

Measure the system's response in statistical terms.

Monte Carlo Simulation Results

Number of 2D Views of Results = Sum of all integers from 1 to (Number of Variables -1)

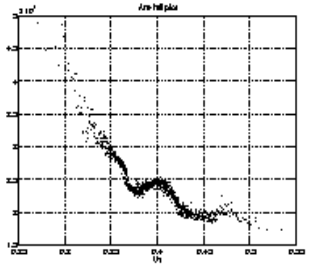
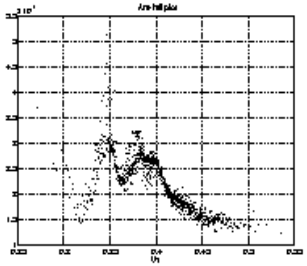



Figure 1.16: σ_{Tx} (left) and σ_{Ty} (right) versus thickness.

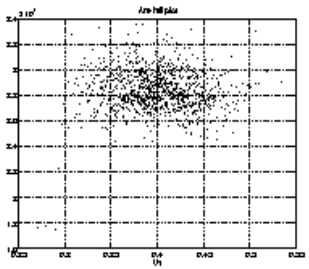
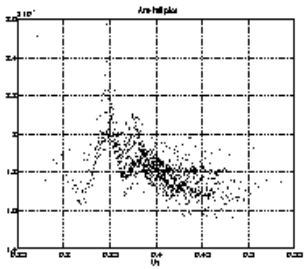



Figure 1.17: σ_{Tx} (left) and σ_{Rx} (right) versus thickness.

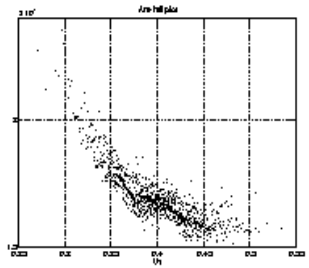
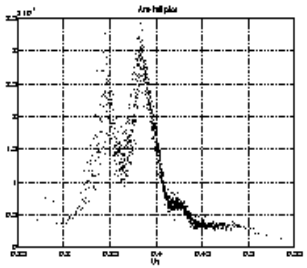



Figure 1.18: σ_{Ry} (left) and σ_{Rx} (right) versus thickness.

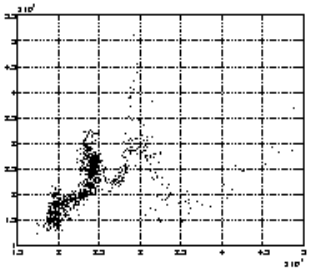
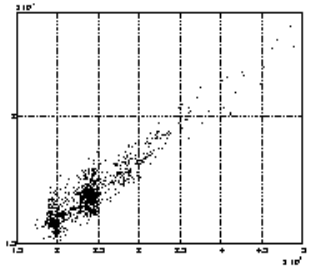



Figure 1.20: σ_{Tx} versus σ_{Ty} (left) and σ_{Tx} versus σ_{Ry} (right).

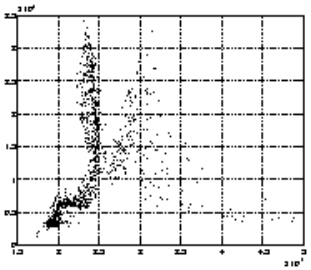
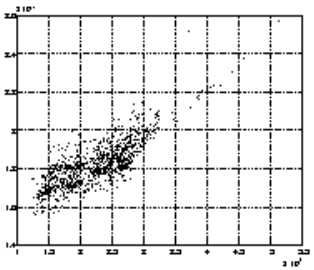



Figure 1.21: σ_{Tx} versus σ_{Rx} (left) and σ_{Ty} versus σ_{Rx} (right).

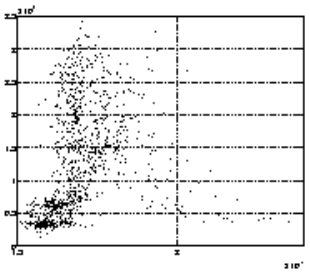
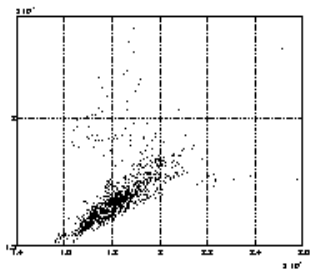
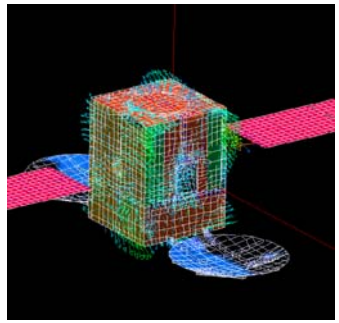



Figure 1.22: σ_{Ry} versus σ_{Rx} (left) and σ_{Rx} versus σ_{Ry} (right).



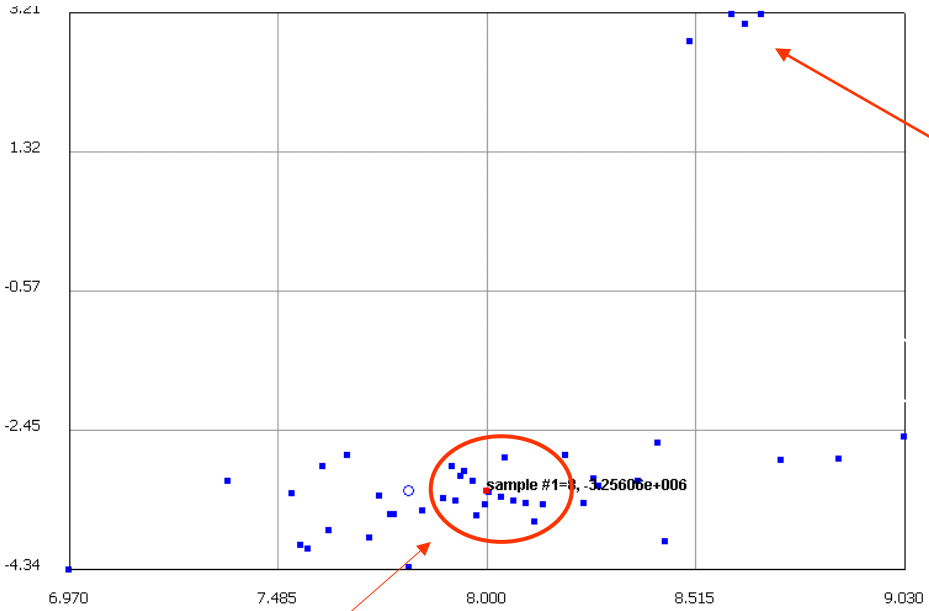
12 of the 78 2D views that resulted from a simulation with 6 outputs from a scan of 7 inputs with uniform distributions.

Generation of Correlation Maps

Correlation Map – a 2-D view of a Results Data generated from Monte Carlo Analysis

- **Incorporates Variability and Uncertainty**
- **Updated Latin Hypercube sampling**
- **Independent of the Number of Variables**
- **Results with 100 runs**
- **Does Not Violate Physics**
    - **No assumptions of continuity**
- **“Not elegant, only gives the right answers.”**

Outlier Identification



Outliers: may be dangerous:
- Lawsuit
- Warranty
- Recall

Most likely behavior

Process for Decision Support

- Model a multi-disciplinary design-analysis process
- Randomize the process model
- Run Monte Carlo simulation of the model
- Process Results
  - Correlation Maps showing Cause and Effect
  - Outlier identification showing anomalies
  - Direction for Design Improvement

Correlation Maps Filter Complexity while Modeling Reality

- Identify what influences functionality
- Address Uncertainty and Variation
  - Provides credibility in modeling & simulation
  - Results clouds represent what is possible
- Easy to use
  - No methods or algorithms to learn
- Reduces risk through better engineering
  - Takes all inputs into account vice using initial assumptions
- Changing the general engineering process