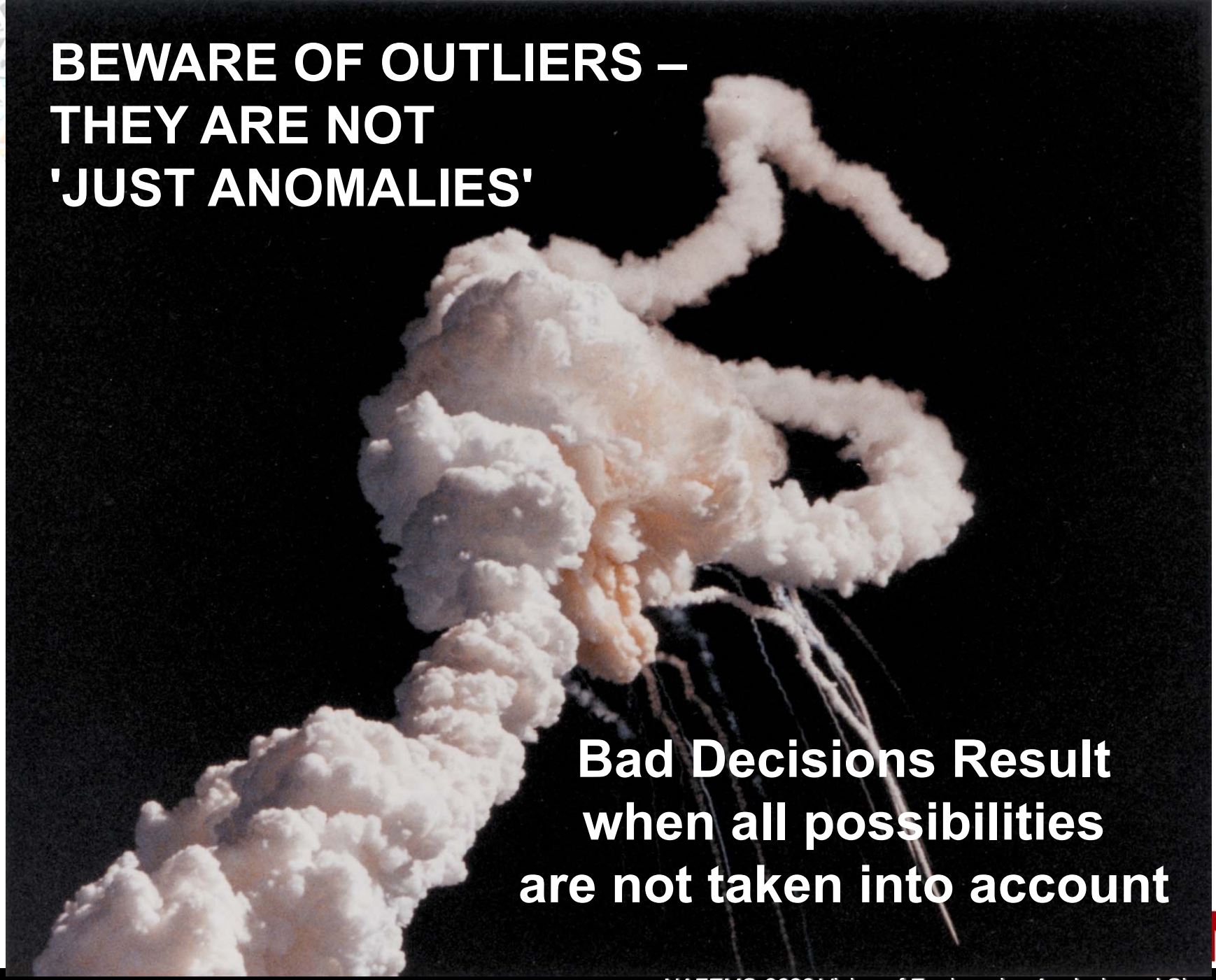
NA Regional Summit 2008 NAFEMS
2020 Vision of Engineering Analysis and Simulation
October 29 - 31, 2008 | Hampton, Virginia

Simulation Supported Decision Making

Gene Allen
President
Decision Incite

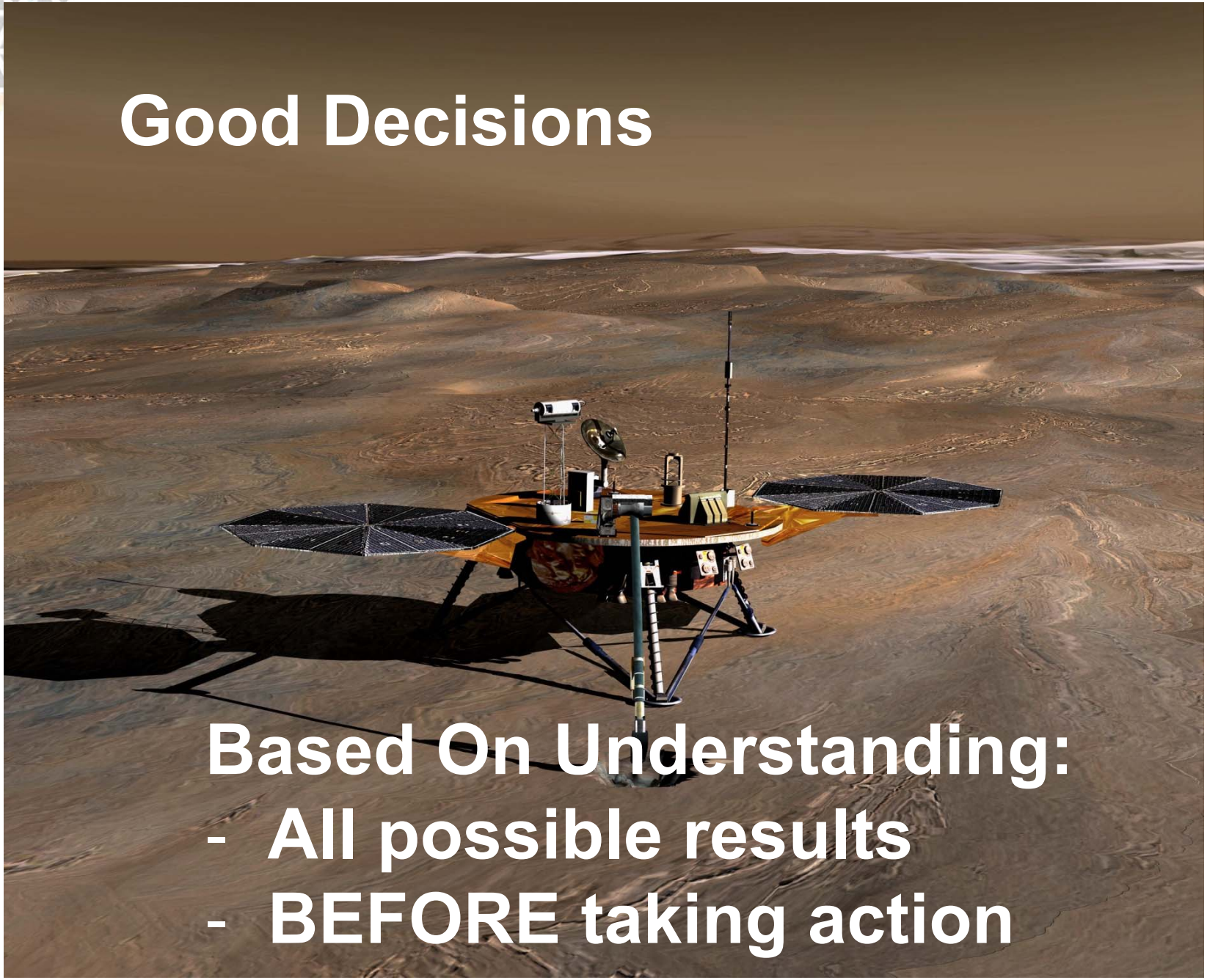
Decisions Result in Actions

BEWARE OF OUTLIERS – THEY ARE NOT 'JUST ANOMALIES'



Bad Decisions Result when all possibilities are not taken into account

Good Decisions



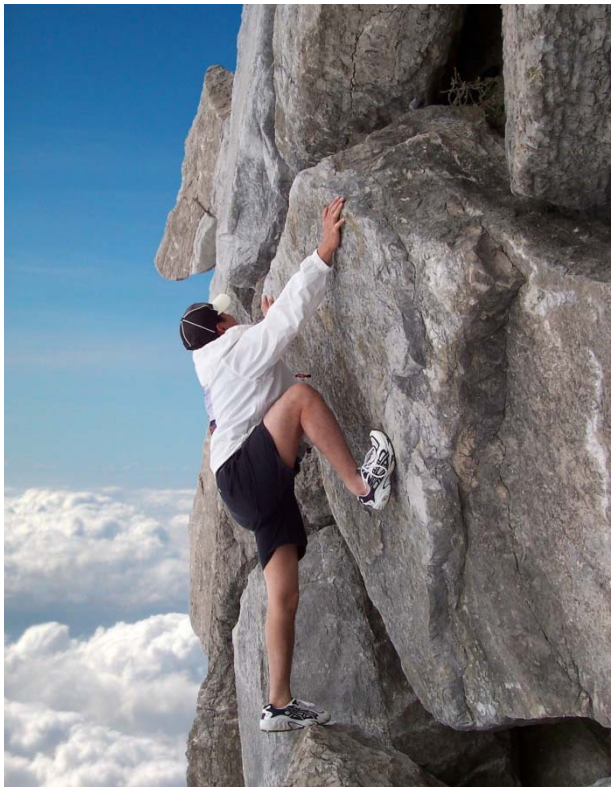
Based On Understanding:

- **All possible results**
- **BEFORE taking action**

Understanding from Knowledge

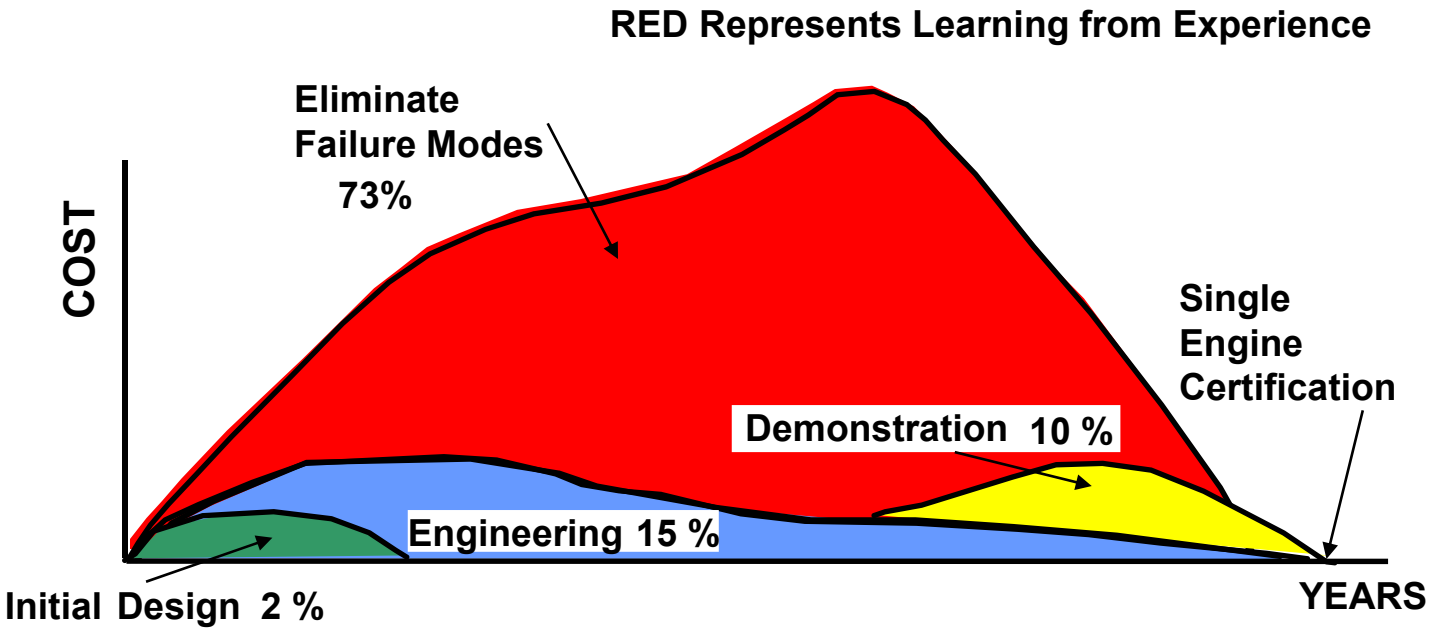
Knowledge is based on

Education & Experience



Experience

- **Takes Time and Money**
  - Von Braun had hundreds of V2 failures before the Saturn V



  - Graph for Saturn V rocket engines: $2.2 Billion, 9 years

Source: Rocketdyne

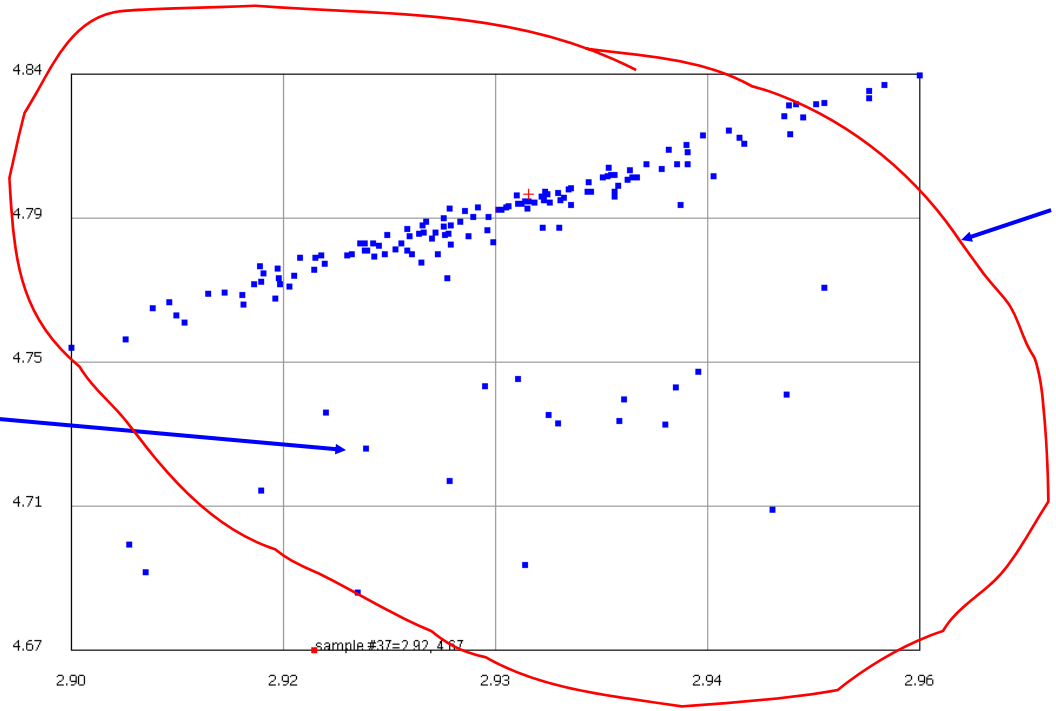
Simulation *Accelerates* Experience

- Understand How a Product Functions
- Identify:
  - Major factors driving functionality.
  - Combinations of factors that lead to problems (outliers).
- This Ability Exists Today!
  - Due to advances in compute capability

Analysis vs. Simulation

One run vs. Many runs

Single computer run = Analysis



Multiple computer runs = Simulation

Understanding the physics = Understanding the topology and structure of the data cloud.

It is NOT Simulation without Variation

- **Material Variation Examples**

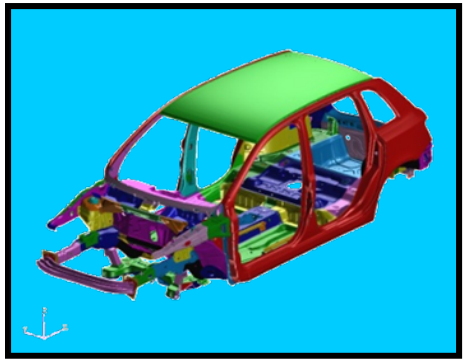
MATERIAL	CHARACTERISTIC	VARIATION
Metallic	Rupture	8-15%
	Buckling	14%
Carbon Fiber	Rupture	10-17%
Screw, Rivet, Welding	Rupture	8%
Bonding	Adhesive strength	12-16%
	Metal/metal	8-13%
Honeycomb	Tension	16%
	Shear, compression	10%
	Face wrinkling	8%
Inserts	Axial loading	12%
Thermal protection (AQ60)	In-plane tension	12-24%

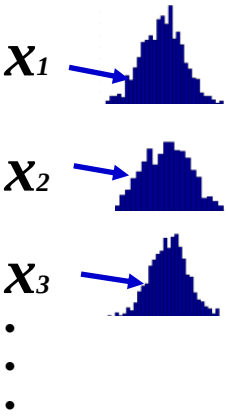
- **Similar Variation with Geometry**
- **More Variation with Forces**

It's the Way the World Is

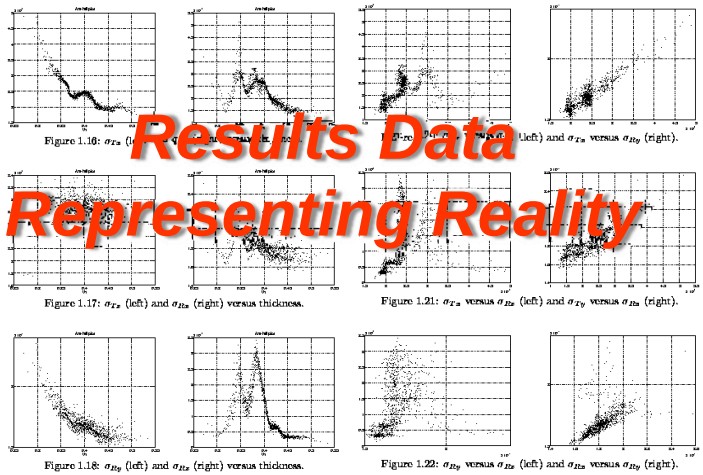
Source: Klein, M., Schueller, G.I., et.al.,Probabilistic Approach to Structural Factors of Safety in Aerospace, Proceedings of the CNES Spacecraft Structures and Mechanical Testing Conference, Paris, June 1994, Cepadues Edition, Toulouse, 1994.

Simulation from an Analysis Model





100 + runs

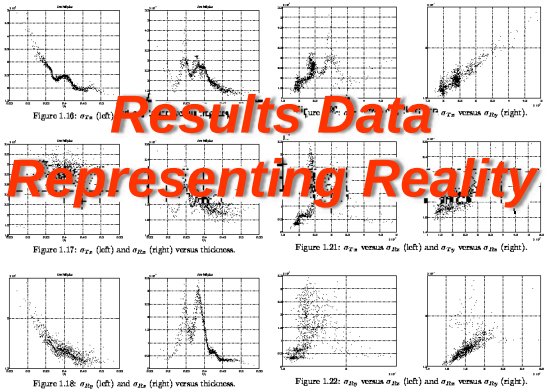


1. 2. 3. 4.

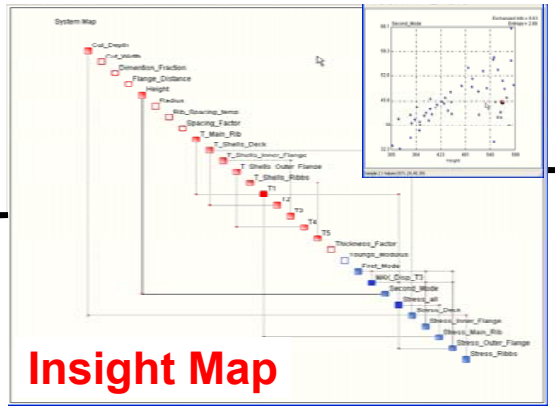
PROCESS STEPS

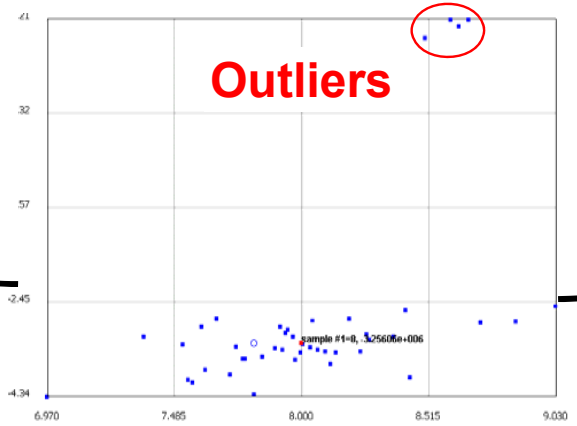
1. Start with a product or process computer analysis model
2. Replace all discreet inputs with ranges and distributions
3. Run model ≈ 100 + times randomly changing all variables
4. Result is a Multi-dimensional data cloud that represents reality

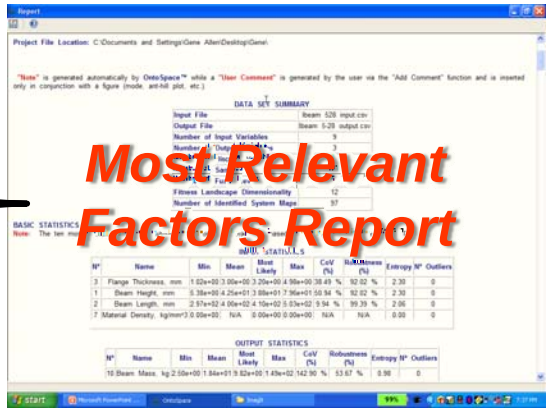
Simulation Results to Information



Results Data Representing Reality







Most Relevant Factors Report

Simulation Input to Knowledge

Can compliment education and experience

Can be validated by all members of a team

A good team will beat a superstar

We NEED Simulation

To complement
Education and Experience

To Meet our Challenges