Beyond “Form & Fit”, the Management of “Function”

PIM… The VISION

- Manage *All Information* that has *Any Bearing* on the Product Description from the Inception of Product Design through Retirement/Disposal of the Product, (i.e., not just Cradle to Grave, but *Lust to Dust*).
  - This would include:
    - The Form of the Product
    - The Fit of the Product
    - The ***Function, or Behavior*** of the Product
    - (and a whole host of other stuff… eh?)

What Application Could Do That?

Hint… the answer is a close relative of the Mathematical Concept of the

Null Set

Real PIM is not an Application

At least, not if we Buy into

The VISION

Manage *All Information* that has *Any Bearing* on the Product Description from the Inception of Product Design through Retirement/Disposal of the Product, (i.e., not just Cradle to Grave, but *Lust to Dust*).

We Don’t Need No Stinkin’ PIM

‘Cause We Don’t Know What that is…

…Unless We Spell It Out — *(the Semantics are…)*

- PdmResponsibility
- PdmFoundation
- PdmFramework
  - **Entities**
  - **Relationships**
- PdmBaseline
- PdmViews
- PdmDocumentManagement
- PdmSTEP
- PdmProductStructureDefinition
  - **Part Description**
  - **Structure Relationships**
- PdmEffectivity
- PdmChangeManagement
- PdmManufacturingImplementation
- PdmConfigurationManagement
  - **ProductClass to Specification**
  - **ProductClass to Part**
- Etc.…

Enterprise PIM Systems: Focus on Form

- Geometry of Piece Parts
- Configuration Management
- Assembly Relationships (aka BOM, “Bill of Material”)
  - As-Designed
  - As-Planned
  - (As-Built)
  - ((As-Maintained))

CAD PIM Systems: Focus on Fit

- Assembly Relationships
  - As Designed
- Piece Part Geometry
- Assembly Envelopes
- Mating Surfaces

We Need More Specific Information Tracked, Related & Stored

- **PIM Implementations do Specific Things**
- **Any Given Implementation leaves LOTS of things out!**
- **Any Combination of PIM Applications leaves LOTS of things out!!**
- **There are holes in the fabric of:**

The VISION

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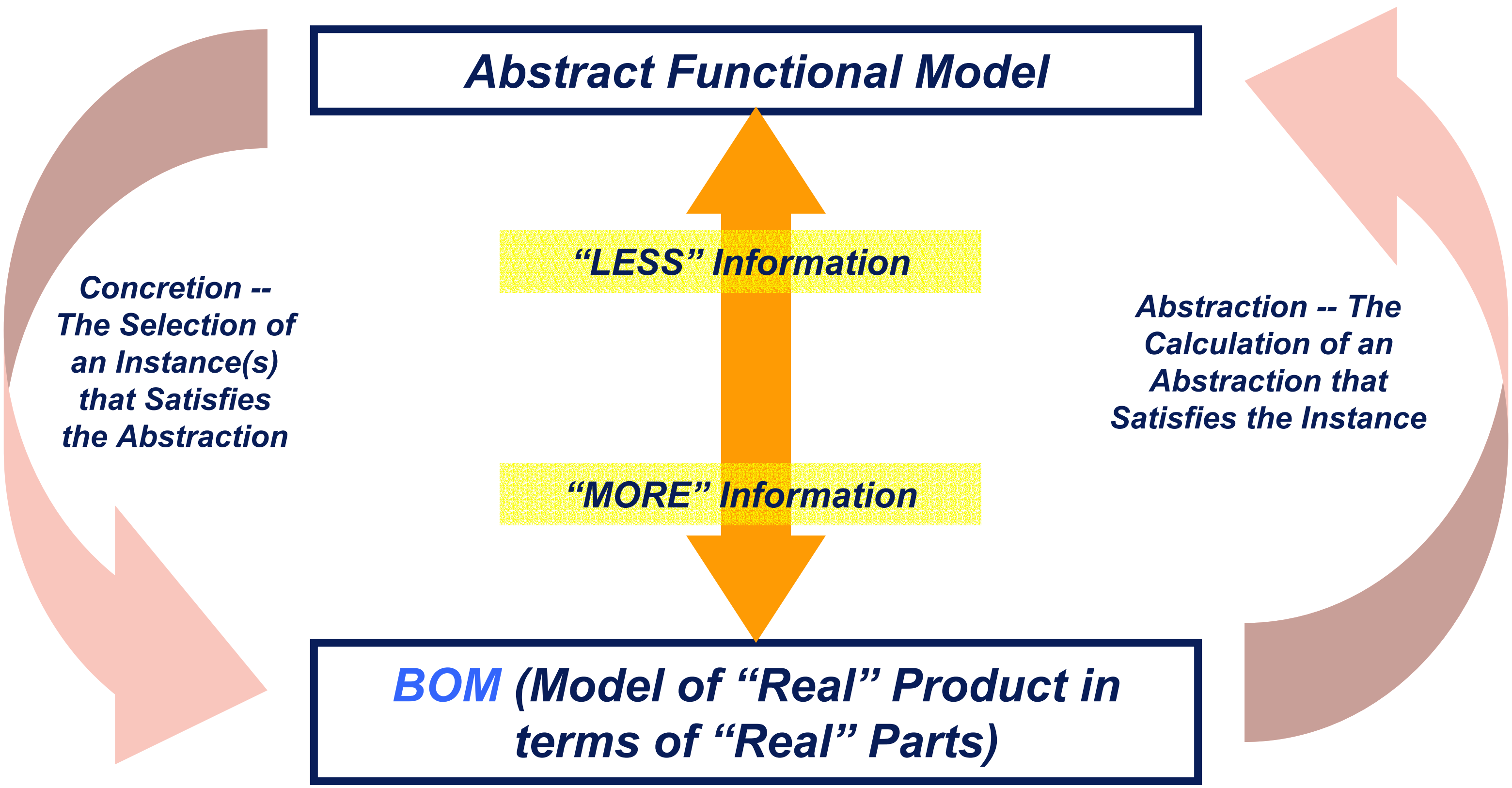
Functional Models

- Functional Models focus on the Behavior of
  - Systems, Subsystems (Abstract)…
  - Assemblies, Parts (Concrete).
- Functional Models are Used to:
  - Establish Target Product Behavior to Guide and Constrain Design
  - Validate the Product Behavior During & After Design
- Functional Models Are based on Abstractions

Functional Models and Their Data

- Functional Models can Consume and Generate VAST Amounts of Data
- Functional Models must be Validated through Test Data (yet more VAST amounts of Data)
- Functional Models often based on Abstractions built on Abstractions.
- These Abstractions Must Eventually be Relateable to that which can or has been Built. (Specific Systems, Parts, or Classifications of These.)

Functional Models ⇔ BOM
(Abstract ⇔ Concrete)



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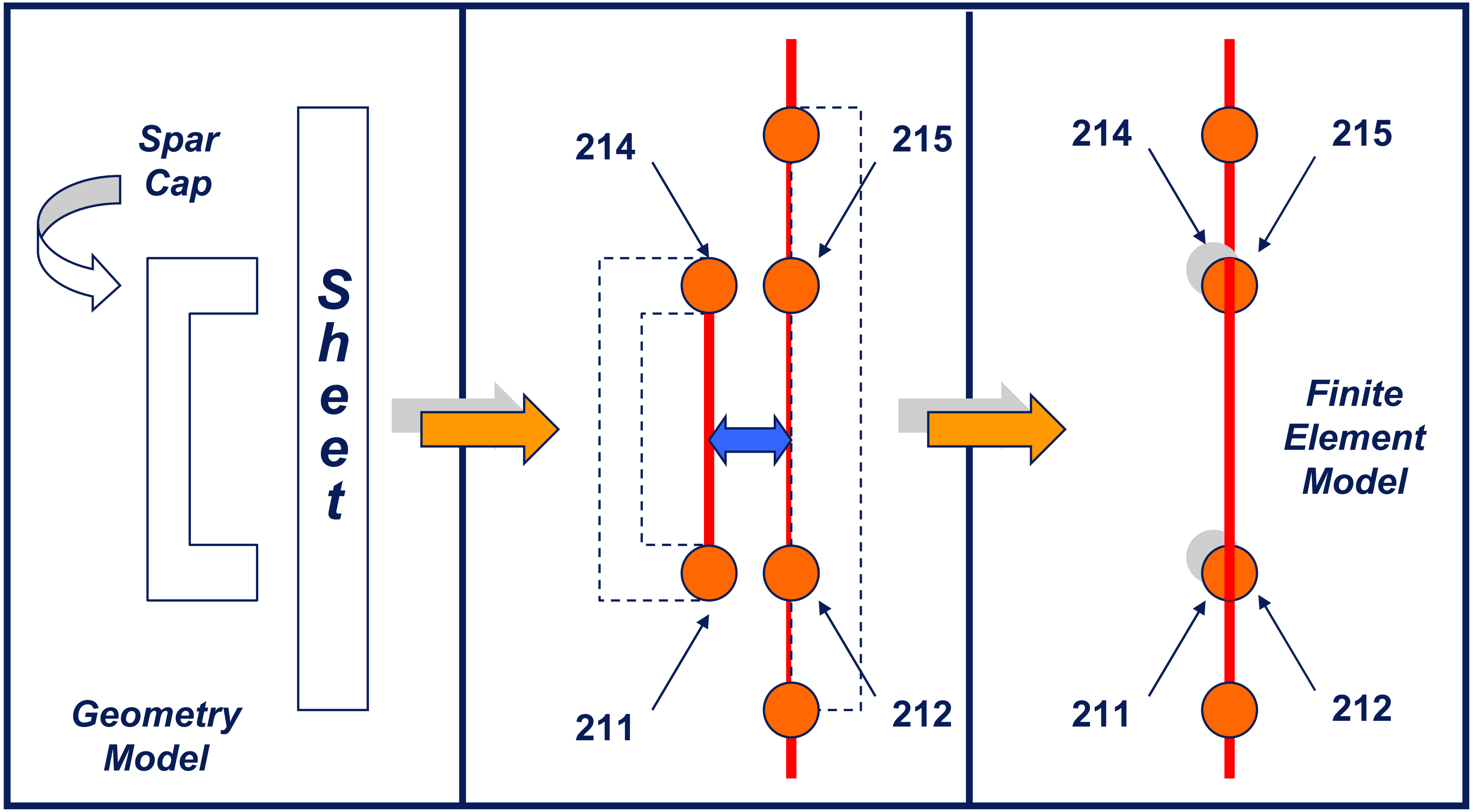
Who Needs "Less" Information?

- If the Abstract Model has "LESS" Information… *What GOOD is it*?
  - Technically it does have Less Information (it's an Information Theory thing)…
  - … But it makes Information accessible to the person (and programs) that would be difficult to deduce from the "Real" (physical) Model.
  - It unveils Information to the Practitioner.
- Bottom Line: Many "real" models can satisfy one "abstract" model

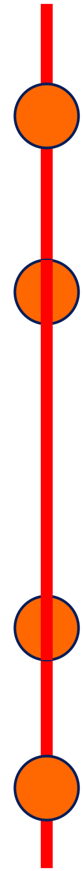
Example of Transforming a "Real" Model to "Abstract" Model



The Finite Element Model

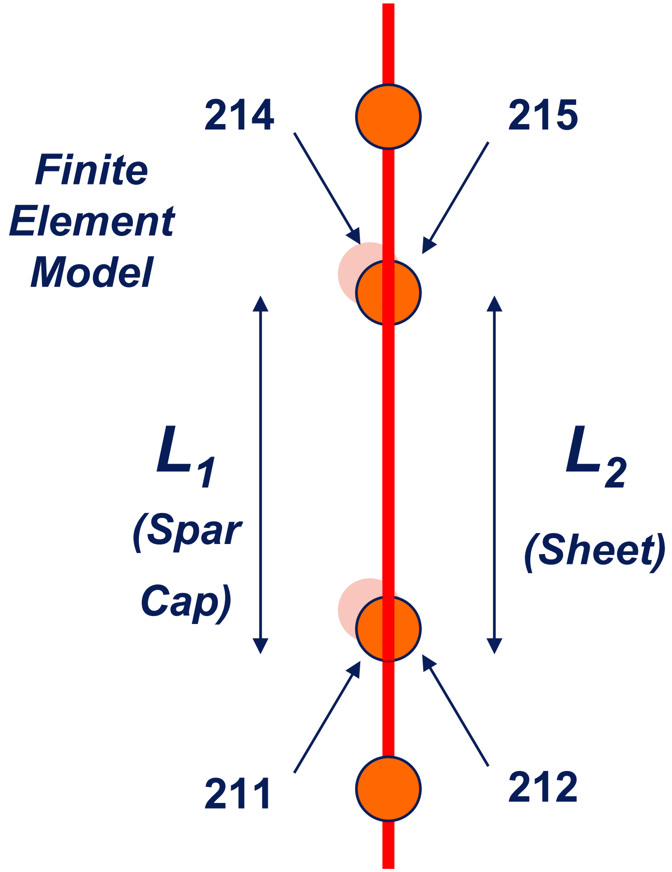
of a Spar Cap welded to a Sheet

Surely you recognize it?



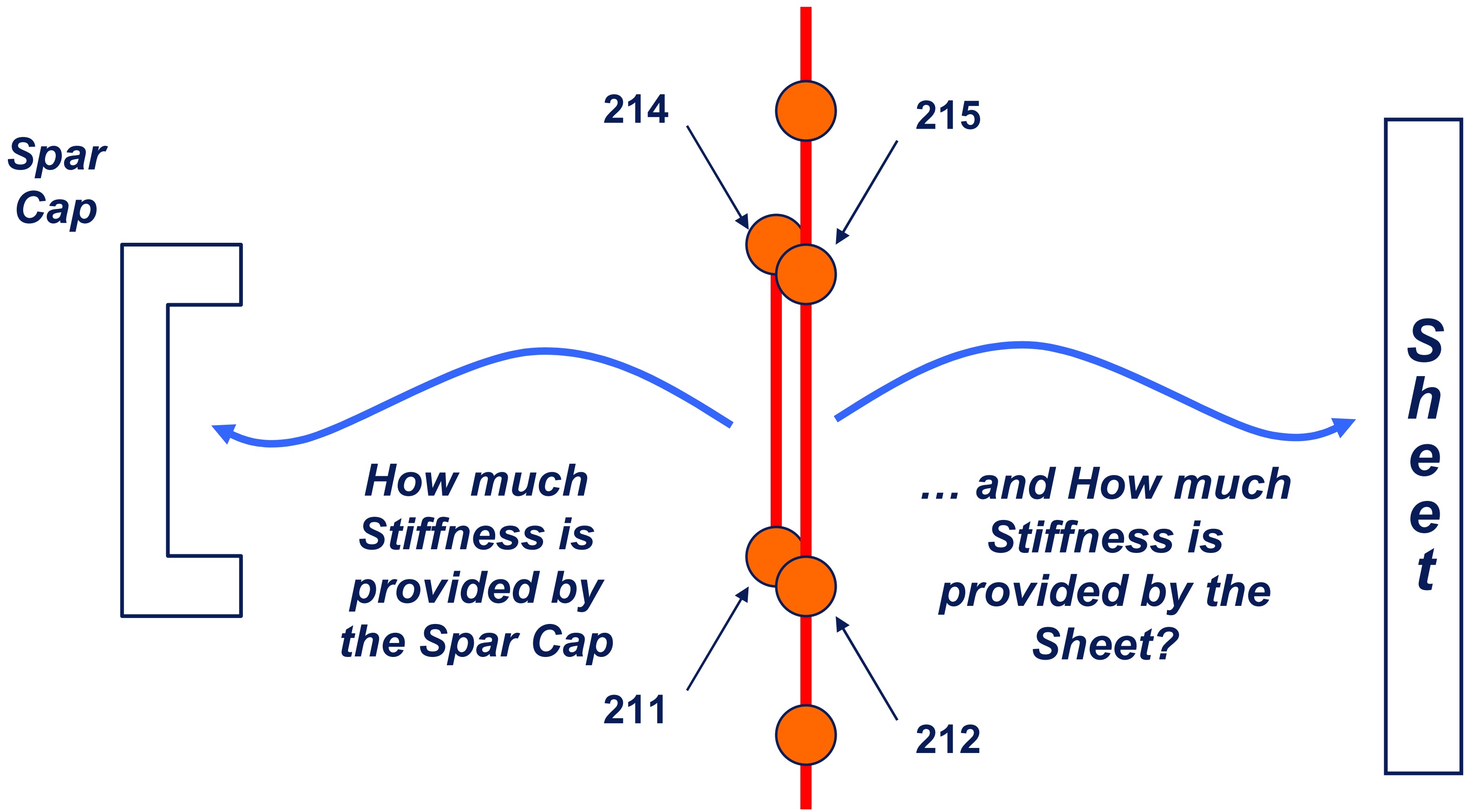
(just kidding)

Ambiguities in the Abstract Model by Itself

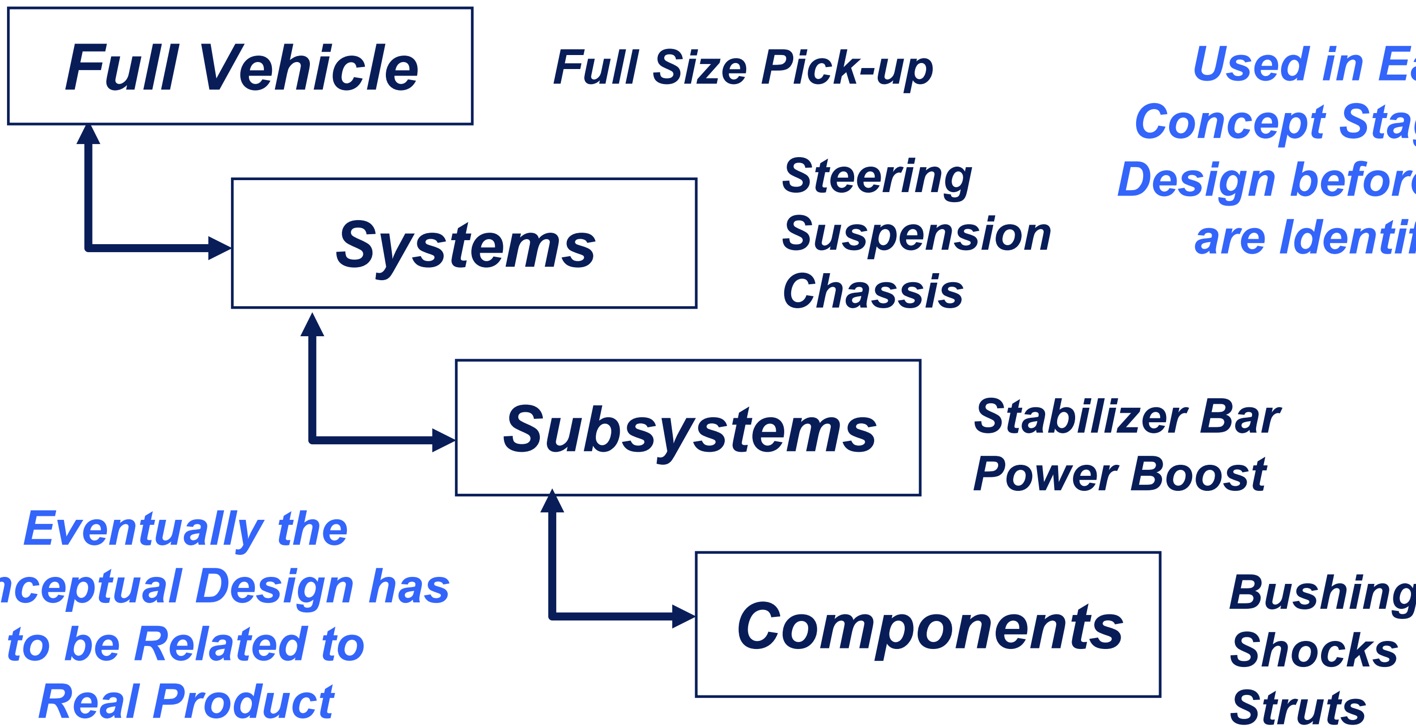


- We need to size the spar & sheet thicknesses and adjust the span of the spar cap.
- $L_1 \not\equiv L_2$, but they occupy the same spatial coordinates.
- Which is the spar cap (L_1)? Points (214,211), (214,212), or (215,212)?
- We will need to make sure we can map back to the Geometry model for the answer.

Need to Map the Abstract Model to the Real Model



Many Models are of Abstract Products Composed of Abstract Parts
(an Abstract Vehicle, for Instance)



Used in Early Concept Stages of Design before Parts are Identified

Eventually the Conceptual Design has to be Related to Real Product & Real Parts

Parametric Models

Abstract Functional Model

Handling: (H_1, H_2, … H_n)

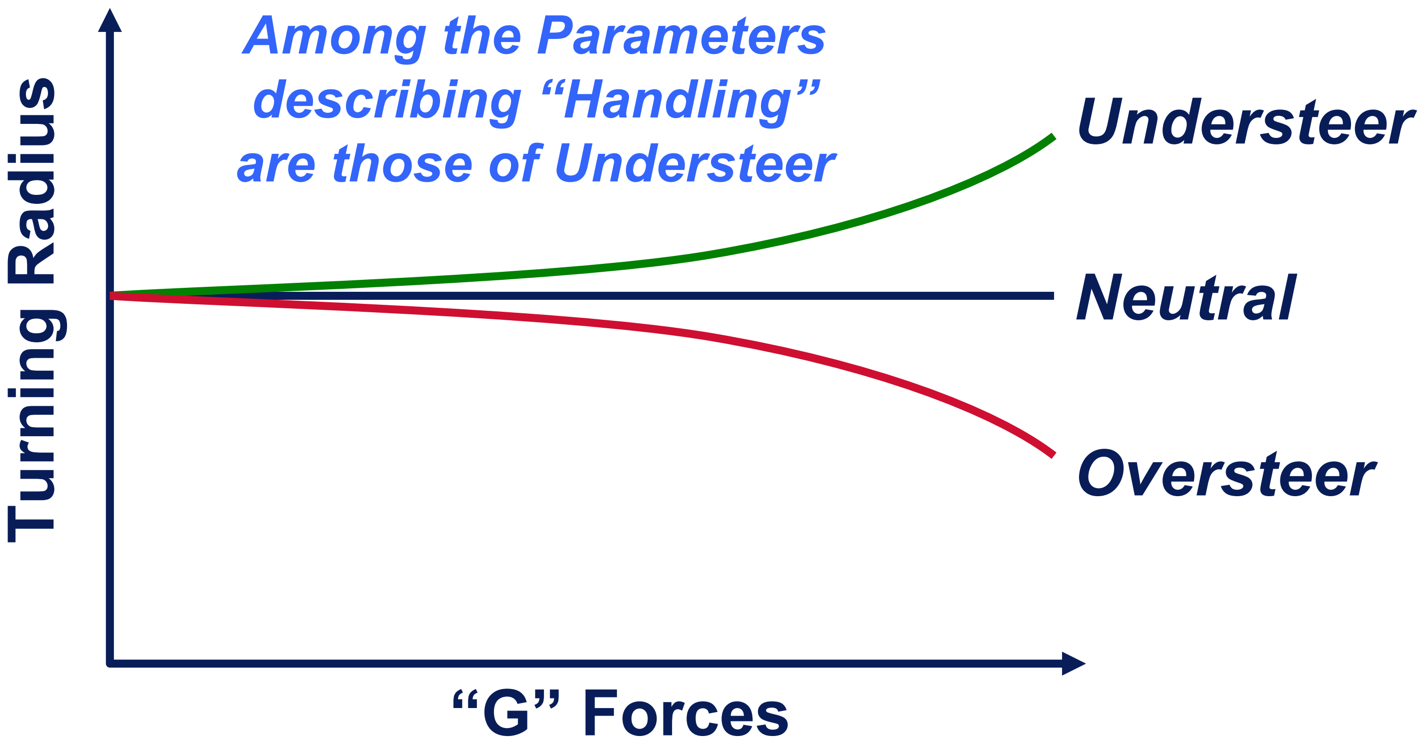
Given Handling as a Target, it takes some Intelligence to "guess" at which Components or Systems will result in it

Given specific Chassis, Suspension, Steering Systems, etc; We can Calculate the Handling

BOMish System Model

Chassis (C_1, C_2, … C_n), Suspension (S_1, S_2, … S_n) etc.

Example from Automotive Modeling
Handling



Handling: Abstract Function of Abstract Objects

- Abstract Subsystems are Assigned Measureable (or Calculable) Parameters need by the Functional Model of Handling
  - Chassis (C_1, C_2, … C_n)
  - Steering (S_1, S_2, … S_n)
  - Suspension (…)
- Handling Parameters (such as Understeer) are Calculated for the Abstract Vehicle
- Handling is just one of Many Abstract Models of "Vehicle"

Mapping to BOM

- Functional Models must be mappable to "Real" Systems & Parts

  (… or what would be the point?)
- Mappings can be simple & direct:
  - This functional component maps to that part.
- Mappings can be much more Complex.
  - Point to the "Part" which is the "Cylinder"
  - Can't… It is the void left in the assembly of the block, gasket, head & piston.
  - It is that which is not!

Automotive Functional Models

Noise, Vibration & Harshness

Safety

Durability

Many Functional Models Each with Its Own Architecture & Structure

Crash

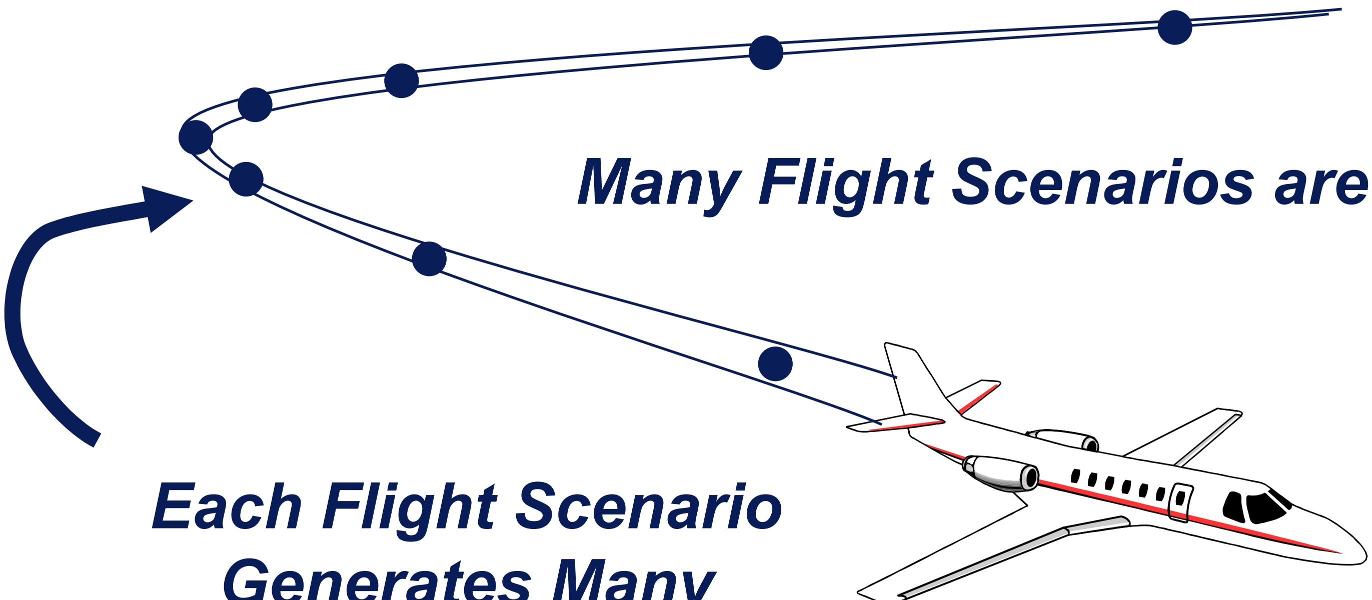
Each Functional Model has Its Own Relationships to Other Models and/or Parts

Ride

Load & Stress Analysis

Handling

Flight Scenarios



Many Flight Scenarios are Analyzed

Each Flight Scenario Generates Many External Load Cases

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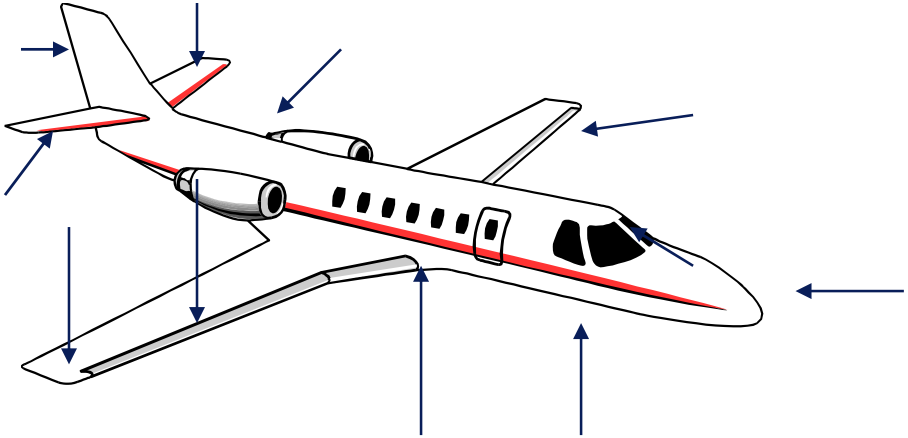
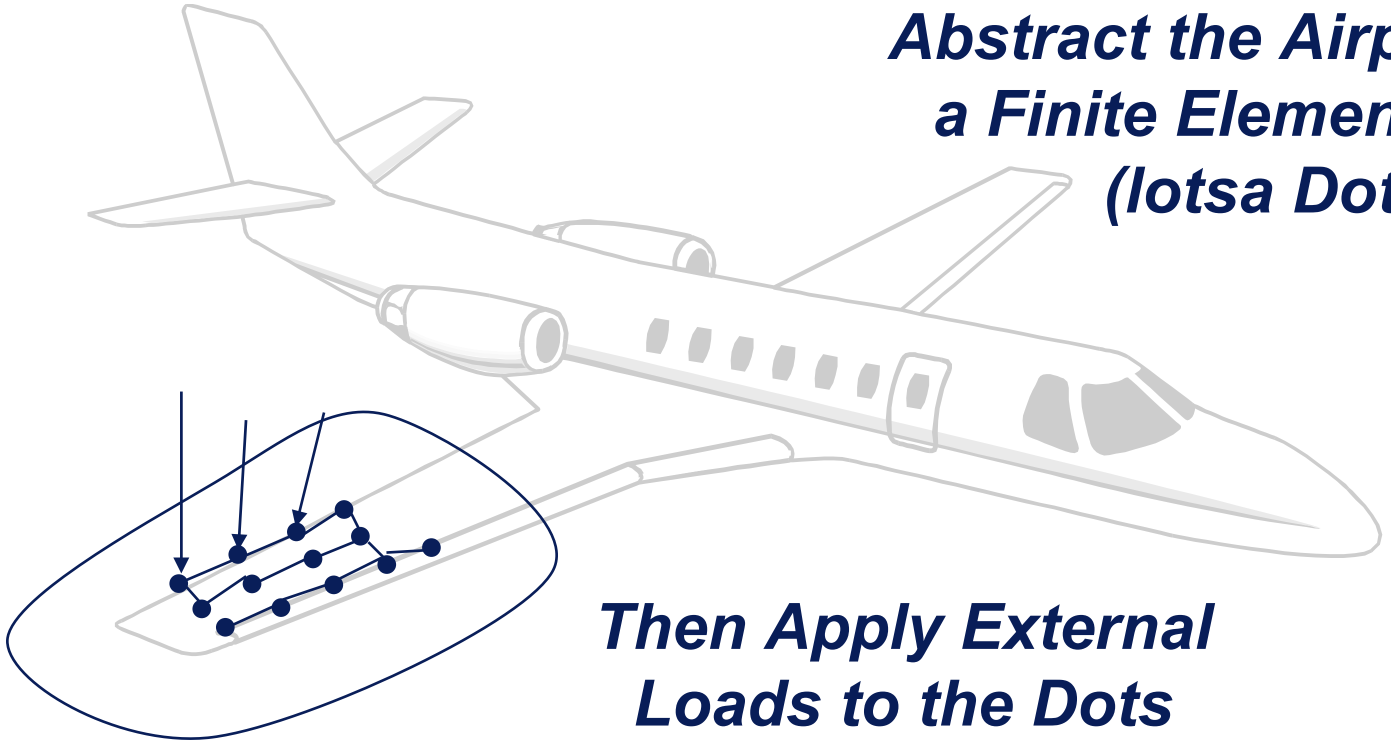
Each External Load Case Is Complex

Each load case details MANY specific loads on various parts of the airplane.



Parts to Dots

The Art of Finite Element Modeling



Abstract the Airplane into a Finite Element Model (lotsa Dots)

Then Apply External Loads to the Dots (Load Case)

Finite Element Solvers

- Given a finite element model and a Load Case…
- … The solver calculates the Internal Loads.
  - The Internal Loads take into account the effect of force on one part, on the forces exerted on all the other parts.
- There are a lot of external loads applied.
- There are a WHOLE lot of internal loads calculated.
  - Many dots to describe a part &
  - Many parts to build an airplane

The Human Element

- 10^1 People working External load cases
- 10^2 People worry about the Dots and Generating Analysis Results.
- Results used for Detailed stress analysis, to do sizing & gauging of parts & Other “stuff”.
- 10^4 People need the Results… like Designers

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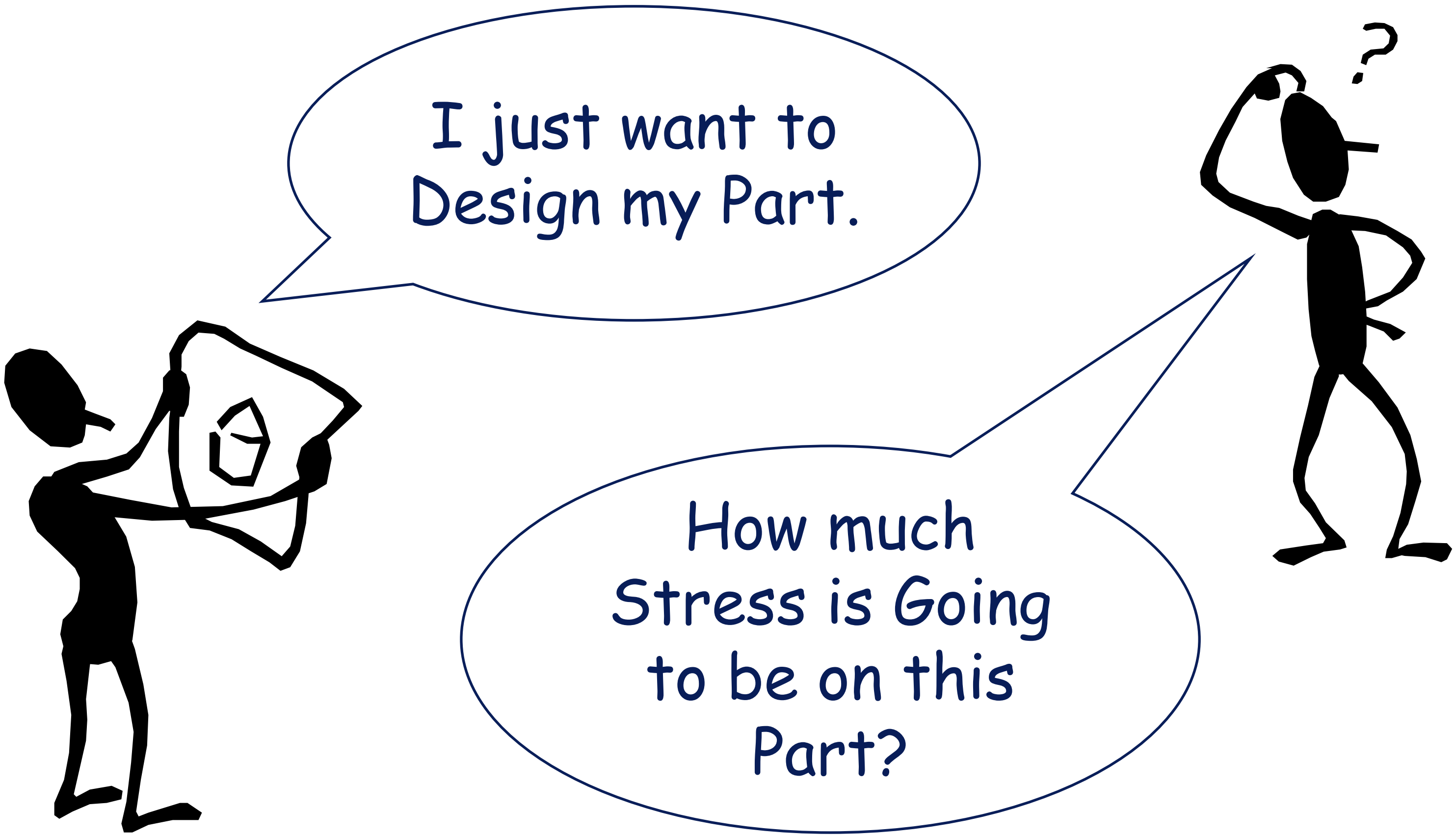
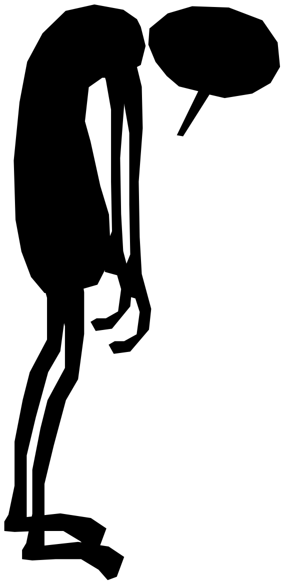
Meanwhile… The Poor Designer



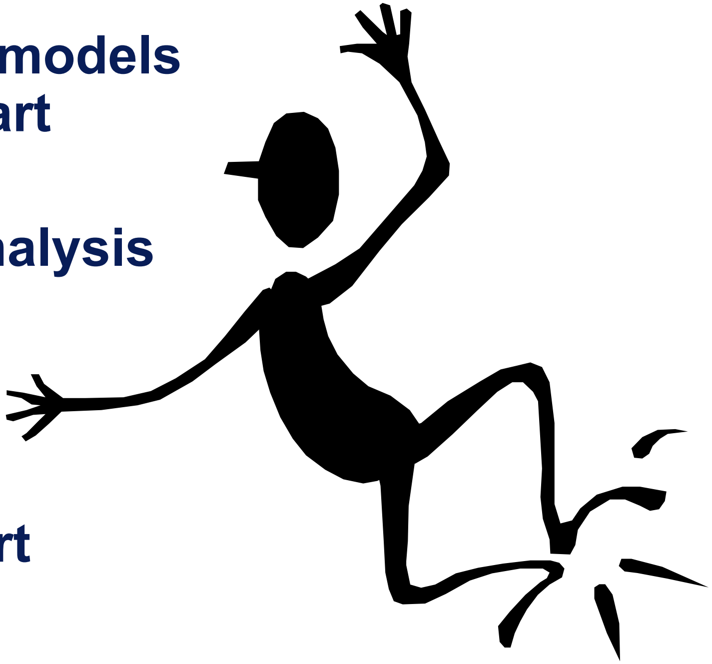
"What's the Stress on my Part?"
A Daunting Task

- There is great quantity of Data to sift:
  - Take the Large Number of Flight Scenarios
    Times the Number of Load Cases.
    Times the Number of Point Loads
    Times the Stress at each point
    (3 in the X-Y-Z Directions,
    3 Rotational Stress)
  - Positively Boggling
- (The Stress is Actually
  on the Designer)



Specific Functional Product Data Required

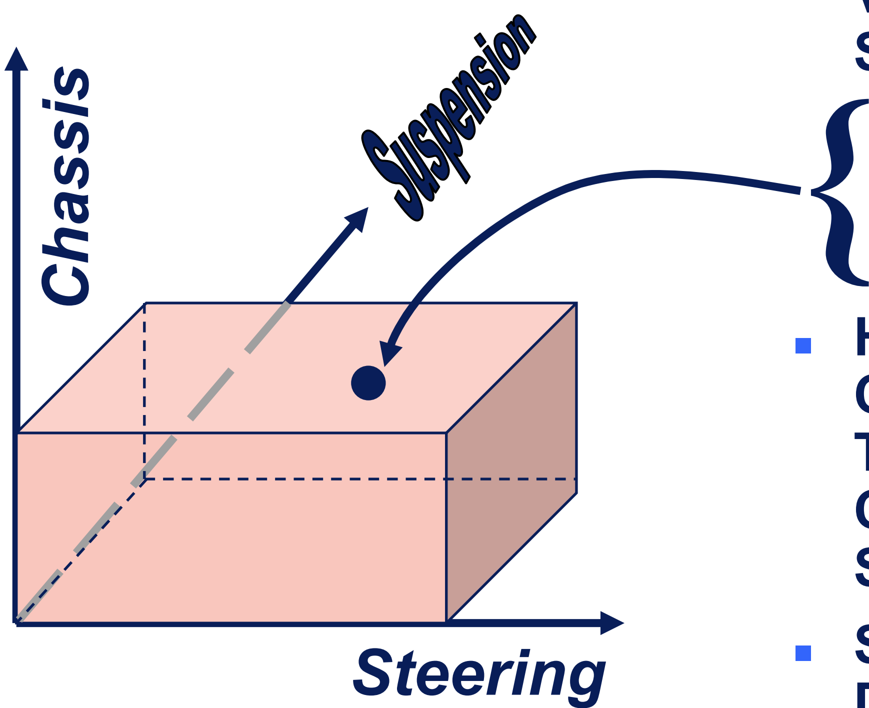
- **Provide Functional Product Data**
  - **Semantics of Functional models & their Relationship to Part Structure**
  - **Semantics of Loads & Analysis Results.**
- **Provide Access by**
  - **Load Case**
  - **Maximum Stress on a Part across All Load Cases**
  - **Combinations of Stress by Different Axes.**



Given the Handling as a Target

- Moving Analysis/Simulation in Front of Design
- Remember our Model of Handling based On Abstract Vehicle Components?
  - Chassis, Suspensions, etc, characterized NOT be specific systems & parts, put parameterized representations of them
- We want to calculate a solution space for our target Handling based on those parameters.

Solution Space



- Values of Parameters are Varied to Form Point in Space
  - Chassis (C1, C2, … Cn)
  - Steering (S1, S2, … Sn)
  - Suspension (…)
- Handling Parameters are Calculated and Compared to Target to Decide if Configuration is in the Solution Space.
- Sensitivity of Parameters is Determined

Summary
In Order to Serve the Manufacturing Industry:

- **We Must:**
  - ***Provide Functional Models and Data*** **Representing a Products Behavior. Both to:**
    - ***Validate Design***
    - ***And most importantly, to Guide Design & Design Re-Use***
  - ***Continue Expanding the Semantics of Product Information*** **and capturing the information based on those semantics.**
  - ***Pursue Federating Technologies*** **to Bring Together Systems that allow applications that capture various aspects of Product Information to Work Together.**

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