Playing Nice Across Time & Space

Tools, Methods and Tech for
Multi-Location Multi-Decadal Teams

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Emerging Disruptive Technologies Assessment Symposium 2015

A Little History

- I have been around the Modeling, Simulation, Visualization and Information Technologies space for over 25 years
  - They are grand, challenging, disruptive, ever changing and incredibly powerful. They grow more so every day.
  - And, like any sharp tool, they have sharp edges.

- I would like to share some “Observations” from those years
  - As in Lessons Observed vs. Lessons Learned
  - And, I would appreciate your thoughts on any that I may have missed

How To Play Nice

- The Game is:
  - Multi-Decade, Massive, Complex System Conception, Design, Development and Operations
  - Targeted towards a hostile and unforgiving environment
  - With a gifted, diverse and distributed group of friends
  - With the goal of getting as far off the planet as possible

- The Rules Come From:
  - Physics / Teams / Process / Science / Story
  - Time / Distance / Culture / Goals / Generations

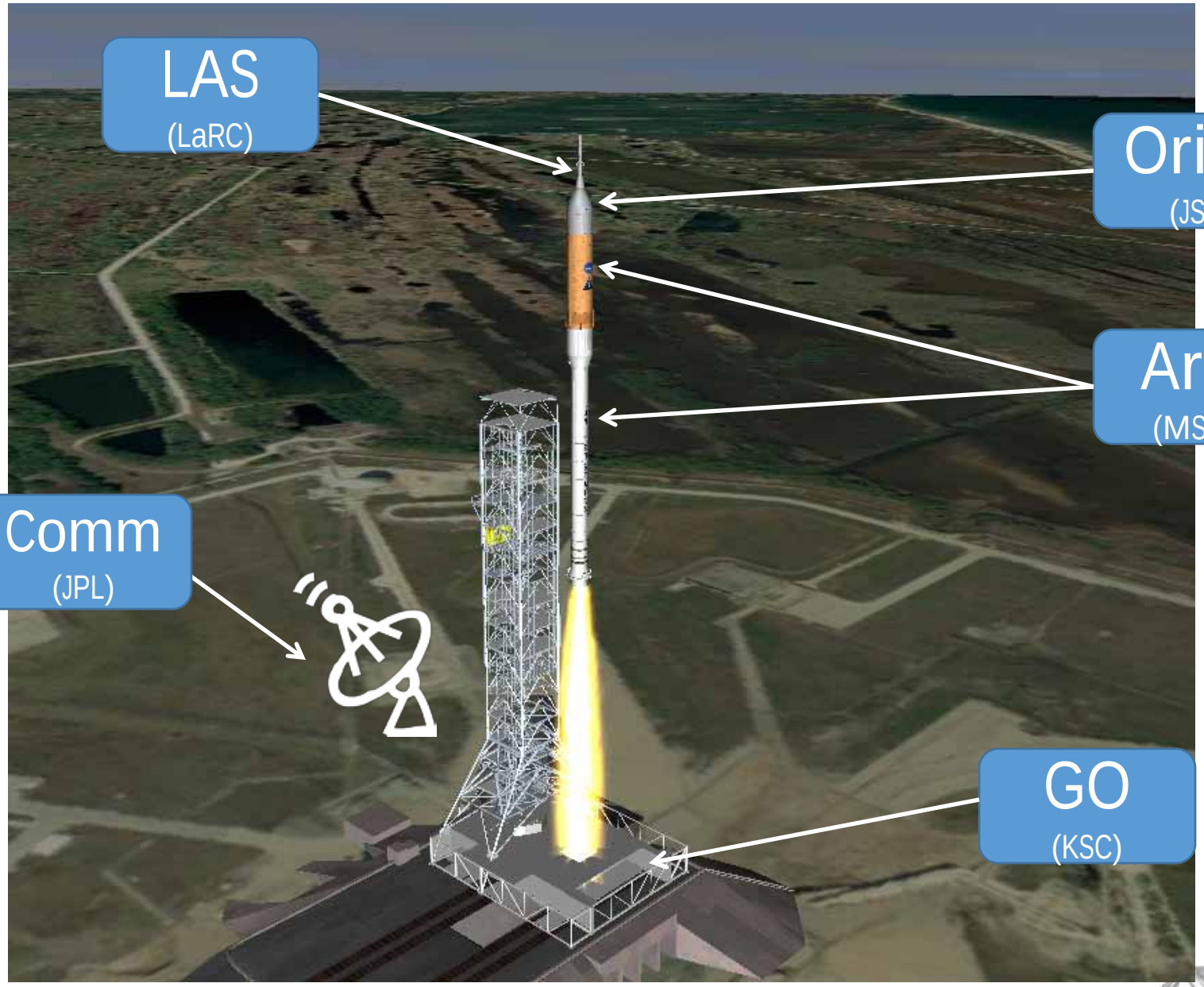
Some Definitions (circa 2001)

- We Model
  - We represent the **thing** we want to study
  - With as much detail as is necessary for that study
- We Simulate
  - We represent **behavior** of the thing(s) we want to study
  - With as much detail as is necessary for that study
- We Decide
  - We look at the thing(s), their behavior(s), **determine** the next step(s) and **communicate** the results of the study
  - With enough detail for that study to be used or re-used

Communications Observation

Very Large Bolts

Ares 1 Launch Sim (HLA, Trick, 5 sites)



Simulation Speeds Communication

- It is non-threating (‘ish).
- Leadership is not wrong, I just need their help to get the simulation right.
- Or, everyone is wrong, and we need to know now.
- Imagine 3 people vigorously discussing what turns out to be 3 different concepts
  - **The worst thing that can happen is that they come to an agreement and leave happy**
  - Simulation can help ensure everyone is at least in the same argument, and it leaves a record

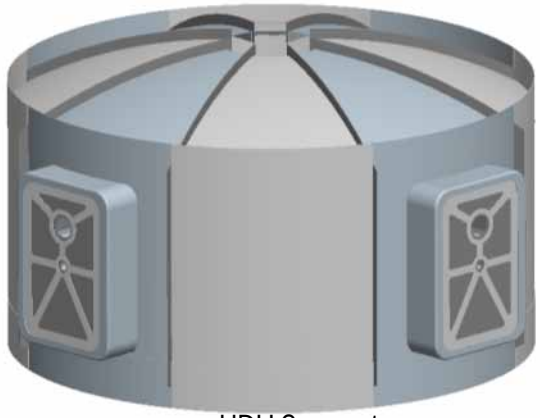
Concurrent Design Observation

Habitat Demonstration Unit

HDU Overview

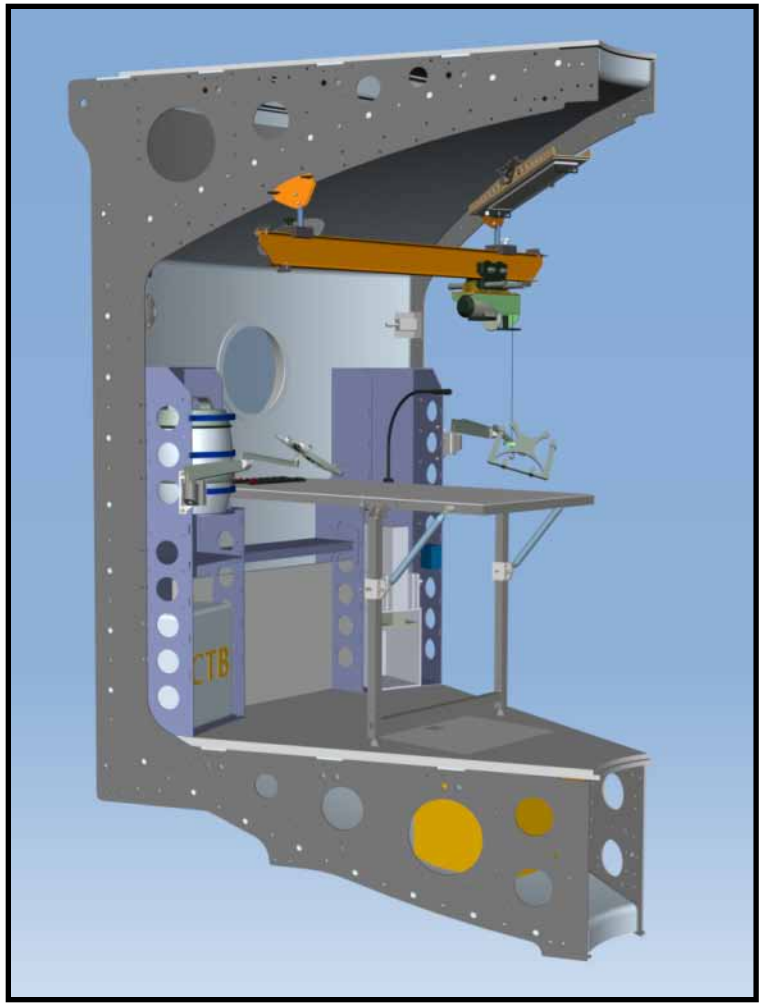
- Vision
  - Develop, integrate, test, and evaluate a Habitation prototype to better understand mission architectures, requirements and operational concepts
- Timeline
  - Project Kick-off: **June 2009**
  - Shell: October 2009 – April 2010
  - Systems Integration: **April – August 2010**
    - 10 Month Build, 4 Month Integration
  - Field Test at Desert RATS September 2010
- Participation
  - Jointly managed and built across 3 Time Zones with subsystems from 7 Centers

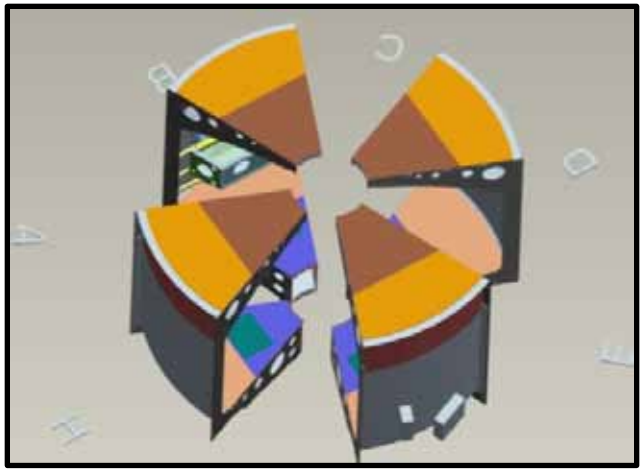
Lunar Reference Concept (PEM)

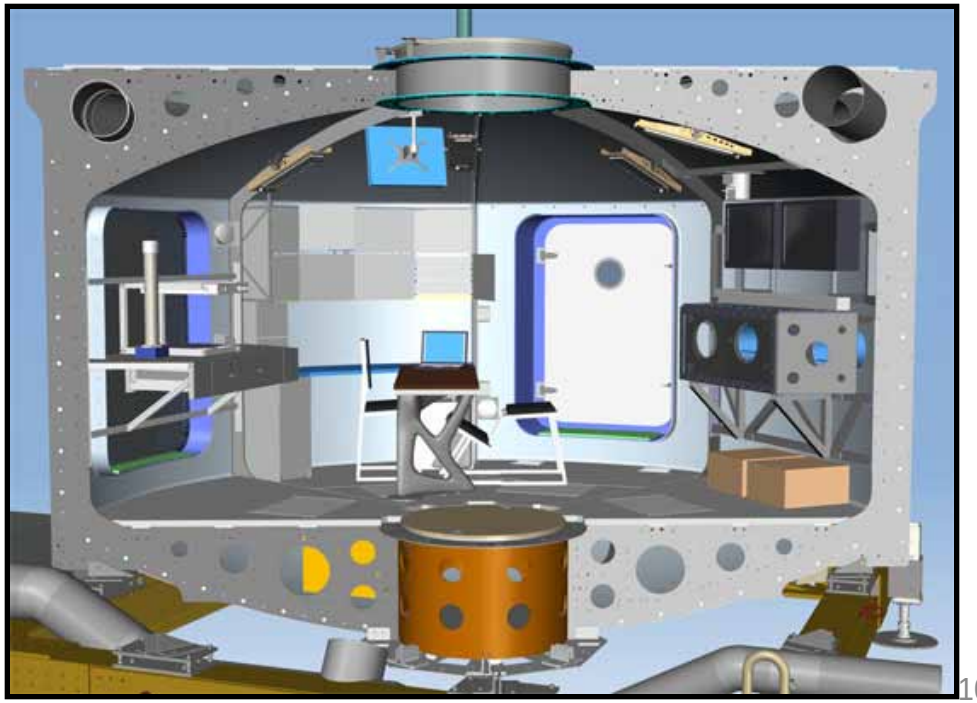


HDU Concept

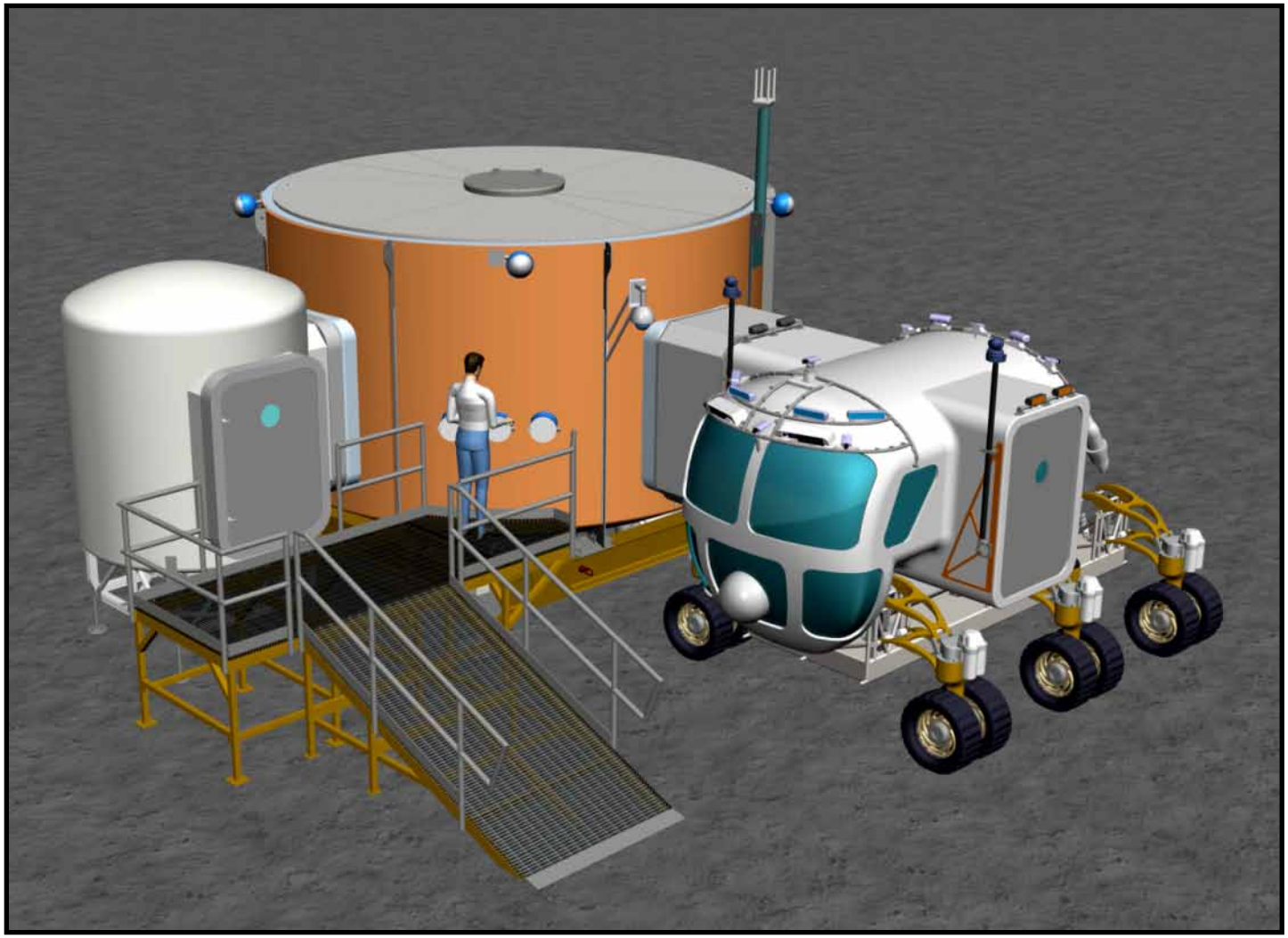
CAD Based Integration - Interior



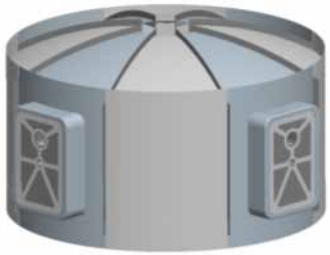




CAD Based Integration - Exterior



Concept Realization (15 Months to Field)



Concurrent Design Lessons

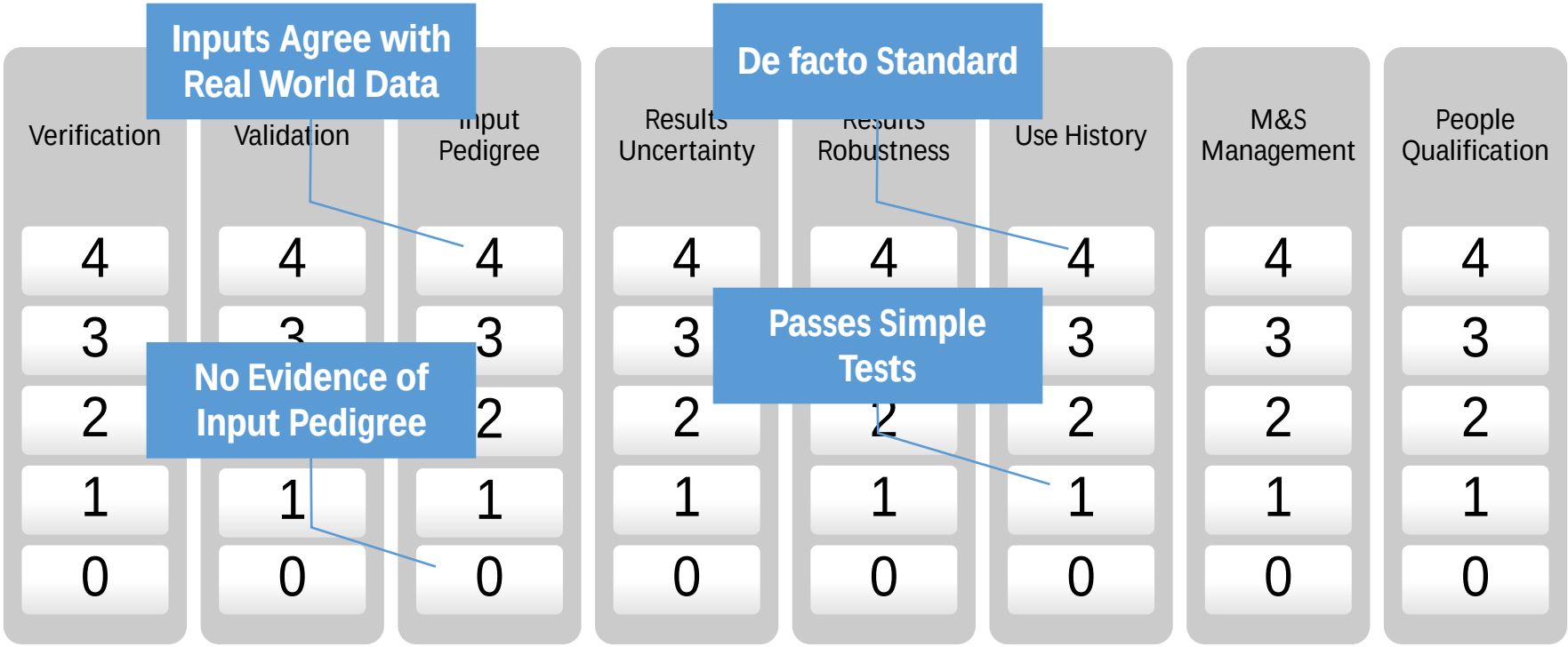
- CAD integration rapidly grew to system simulation, then concurrent development
  - Concepts were matured in design sessions
    - Concept developed, “model” updated, package base lined
    - Design completed, “model” updated, systems built
    - Multiple Centers, Teams, Projects, Time Zones and Budgets
- **Success not just because of Simulation**
  - **HDU leadership prioritized decisions such that time critical elements were decided on first**
    - **Even if only allocations**
  - **Simulation Screen Shots became a key communication path**
    - **Timely, Enhanced Understanding, Converged Ideas**

Self Grading Observation

NASA Standard 7009, Modeling and Simulation

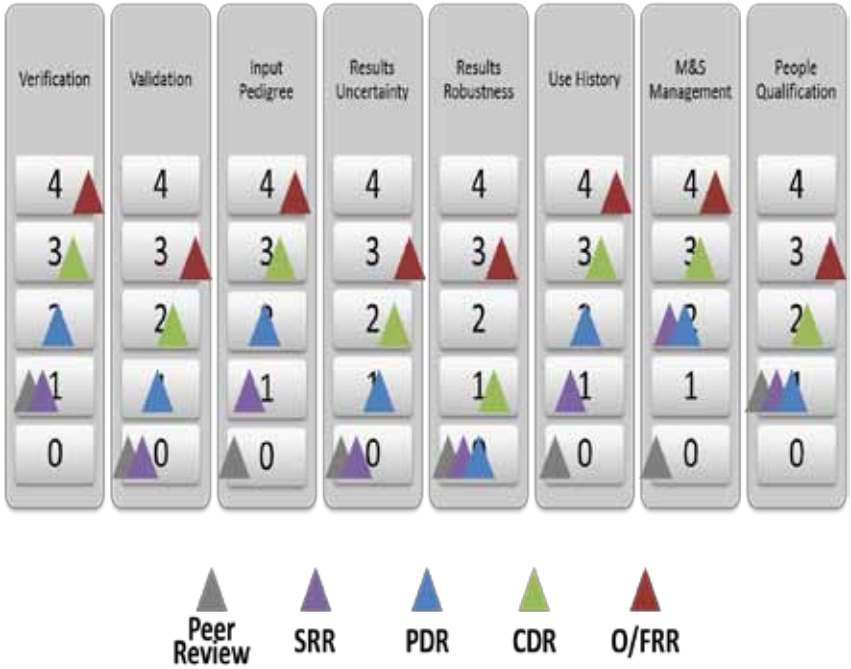
The Numbers on the Score Sheet

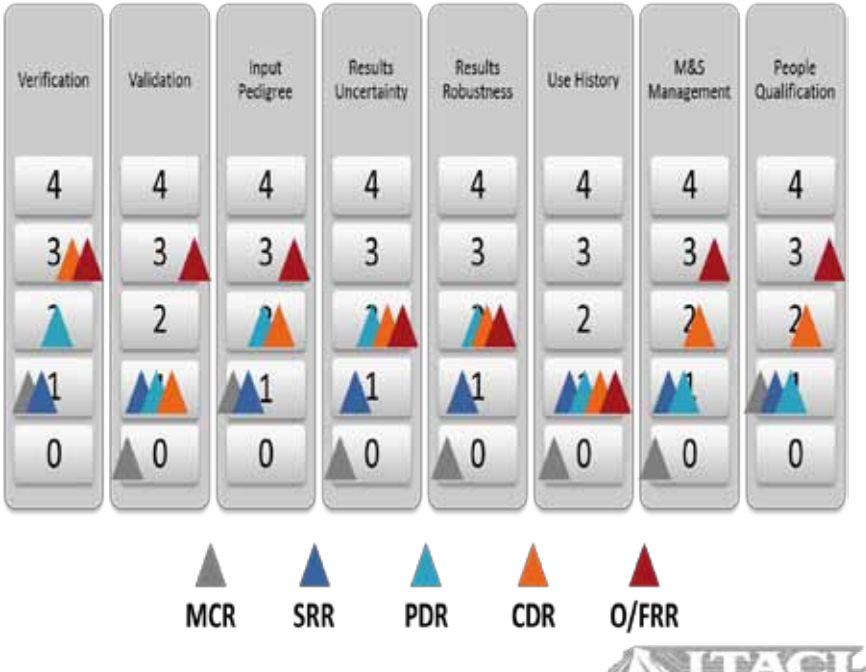
- To communicate the rigor, fidelity and pedigree of our work (Credibility), across distance and years
- We used NASA Standard 7009
  - 8 categories, 5 levels per category
  - Range from “No Evidence” to “Best Possible” Credibility



As Programs Mature, Credibility Increases

- Compare the planned Constellation (crewed) maturation with a flight experiment (no crew)
  - The experiment first pass has higher credibility, but the end result is only 2's and 3's.
  - They do more work up front before commitment, but do not need the later, expensive, high fidelity simulations.





Standard Grades

- This lets engineers, scientists, analysts and others identify what they created, and what it could be used for.
- It also lets leadership understand what something should NOT be used for.

This Might Work Observation

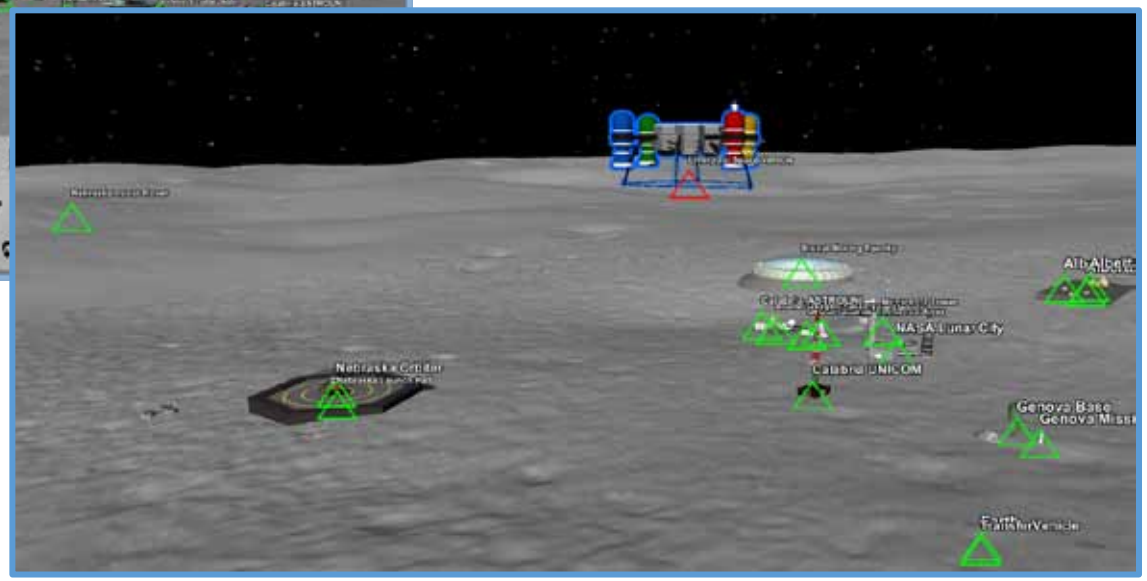
SEE 2015, a template for integrated exploration

Simulation Exploration Experience

- Cooperative Student Event
  - US, Canada, Europe so far
  - Simulate a Lunar Base with NASA Tools
    - HLA (MAK, Pitch, Forward Sim)
    - Trick (NASA Open Source)
    - Federations (rovers, flyers, surveyors, buildings, terrain)
    - DON, Distributed Observer Network (Game Based Visualizer)
    - Model Process Control data, creates persistent simulations

- We would welcomes others…

Data from SEE 2015 Event

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Going Forward

- Just wanting to meet huge new challenges is not enough
  - We must learn how to start meeting them today
    - With our partners, **wherever they are**
  - We must enable our children to finish tomorrow
    - Simple and persistent mechanisms to communicate with them **whenever they are**
- We must Learn how to Play Nice Across Space and Time

Questions?

More Observations?

Backup Stuff

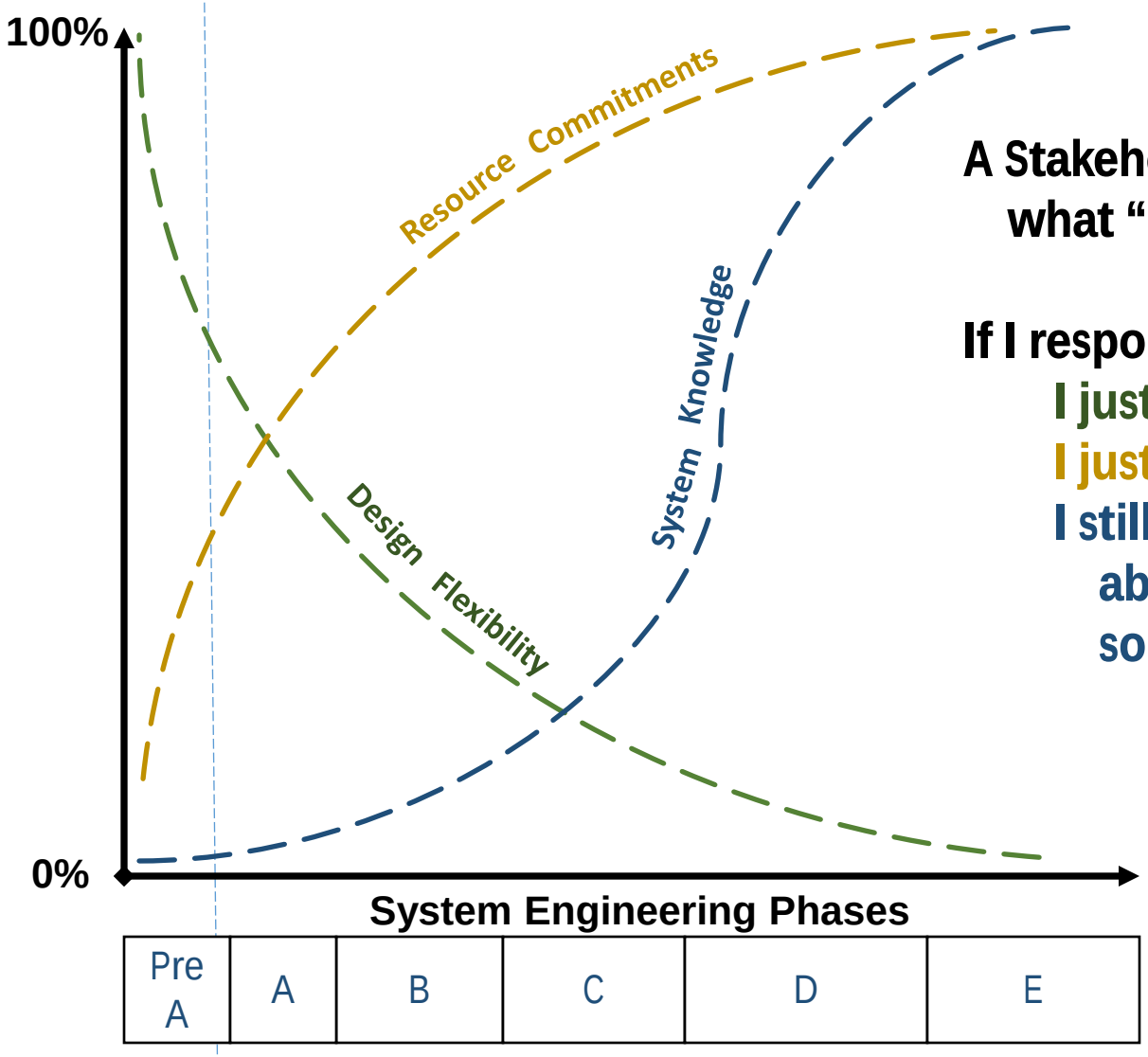
SEE 7009 CAS Score = 0-1-0-0-0-1-1-1

Verification	Validation	Input Pedigree	Results Uncertainty	Results Robustness	Use History	M&S Management	People Qualification
4 Reliable error estimates used, small errors across key elements	4 Results compare favorably to real-world system	4 Inputs agree with real-world data or from > 3.5 summary M&S	4 Quantitative and based on Non-deterministic & numerical analysis	4 Sensitivity known for most parameters (all of the most sensitive cases)	4 De facto standard	4 Continual process improvement to improve result repeatability	4 Extensive experience and use of recommended M&S practices & tool
3 Formal method is used to assess unit testing errors	3 Results agree with experimental data for problems of interest	3 Inputs agree with exp. data for problems of interest or from > 3.0 summary M&S	3 Quantitative and based on Non-deterministic analysis	3 Sensitivity known for many parameters	3 Previous predictions were later validated by mission data	3 Process measured for repeatability	3 Adv. degree or extensive experience, recommended practice knowledge
2 Favorable results from key feature unit / regression testing	2 Results agree with experimental data or other M&S on unit problems	2 Inputs traceable to formal doc., or from >2.0 summary M&S	2 Based on deterministic analysis or expert opinion	2 Sensitivity known for a few parameters	2 Used before for critical decisions	2 Established process for development and operations	2 Formal M&S training and experience + recommended practice training
1 Favorable evidence of verification for concept & math models	1 Concept and math models agree with general and textbook referents	1 Inputs traceable to informal doc., or from > 1.0 summary M&S	1 Based on qualitative estimates	1 Sensitivity estimated, qualitative, based on analogy	1 Passes simple tests comparing with other similar tools	1 Roles and Responsibilities defined and managed	1 Engineering or science degree
0 No Evidence	0 No Evidence	0 No Evidence	0 No Evidence	0 No Evidence	0 No Evidence	0 No Evidence	0 No Evidence

Design Process Observation

"The" System Engineering Chart

A Stereotypical Design Process



A Stakeholder wants to know what "It" will look like.

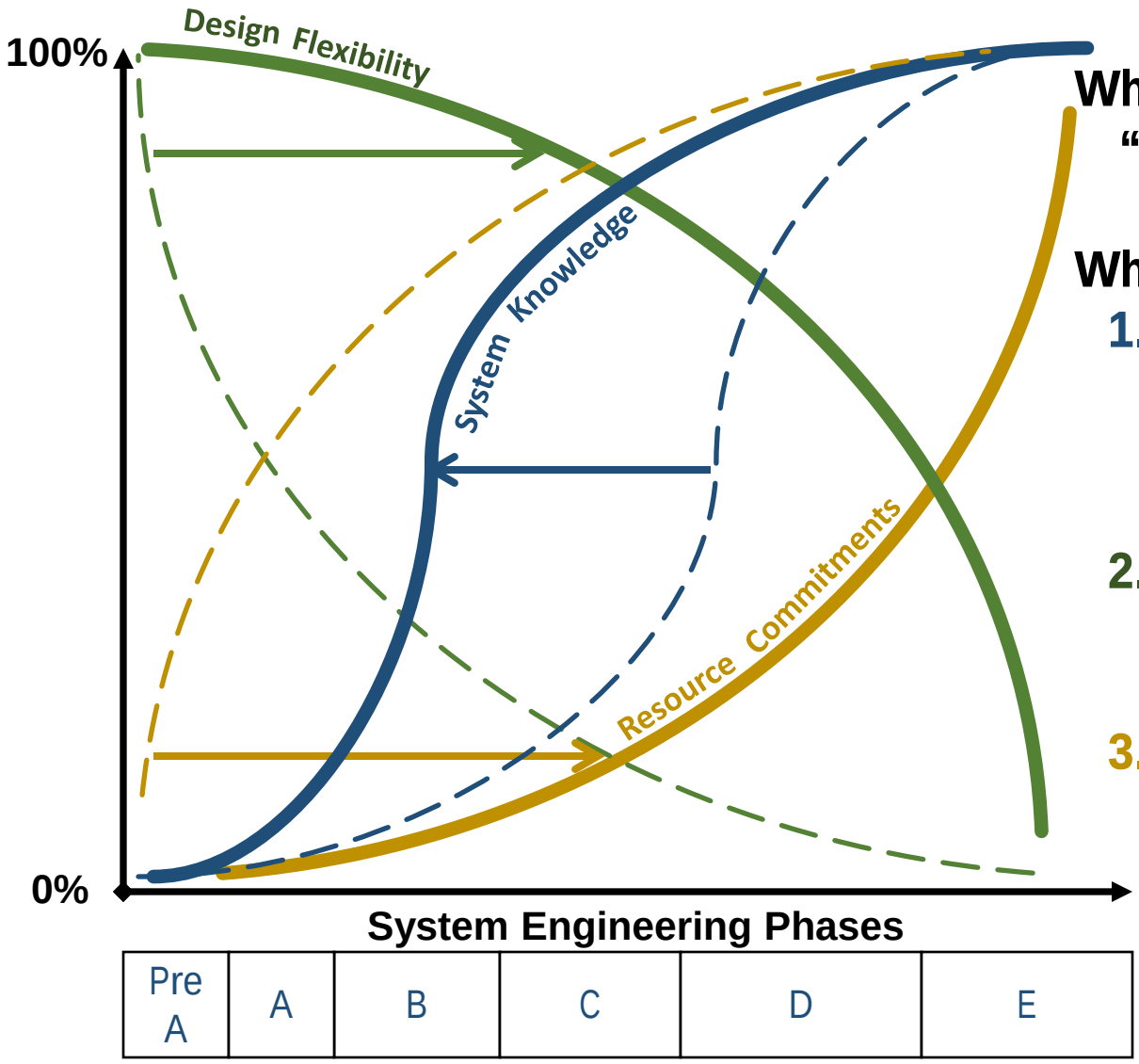
If I respond with anything:

I just lost design flexibility

I just defined the cost plan

I still really know very little about the system or solution

I Really Want is…

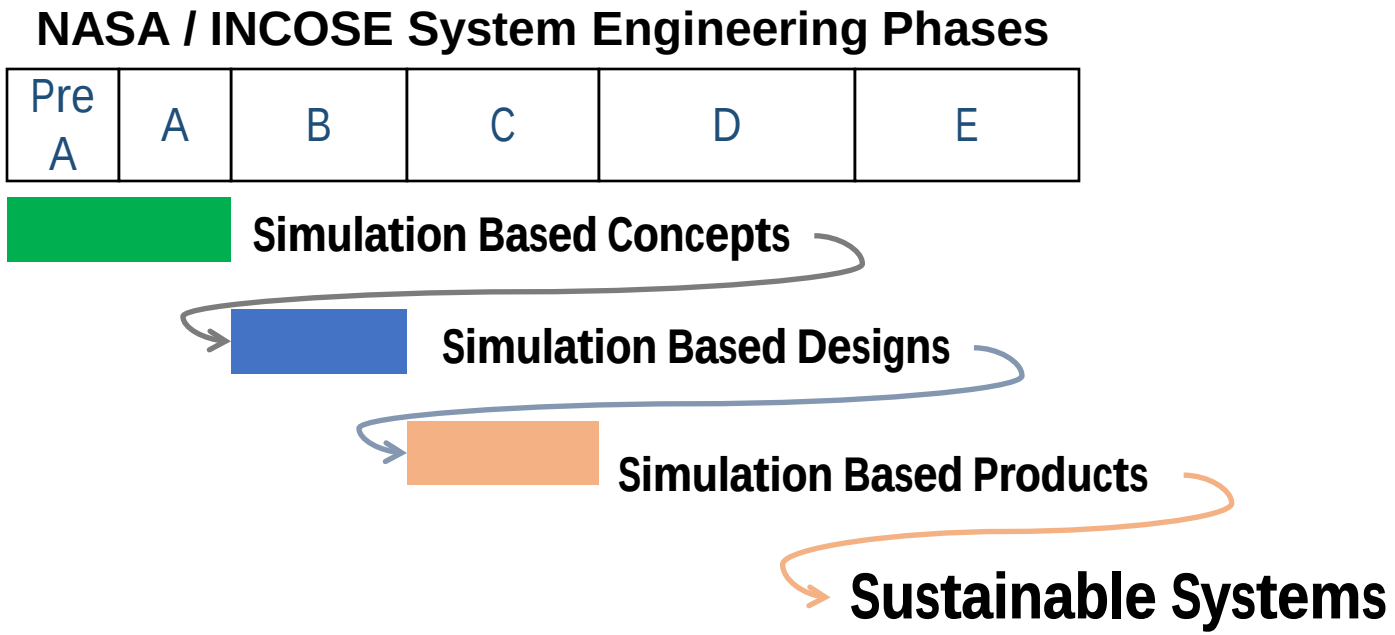


When Stakeholder asks "What will it look like?"

What "We" Really Want:

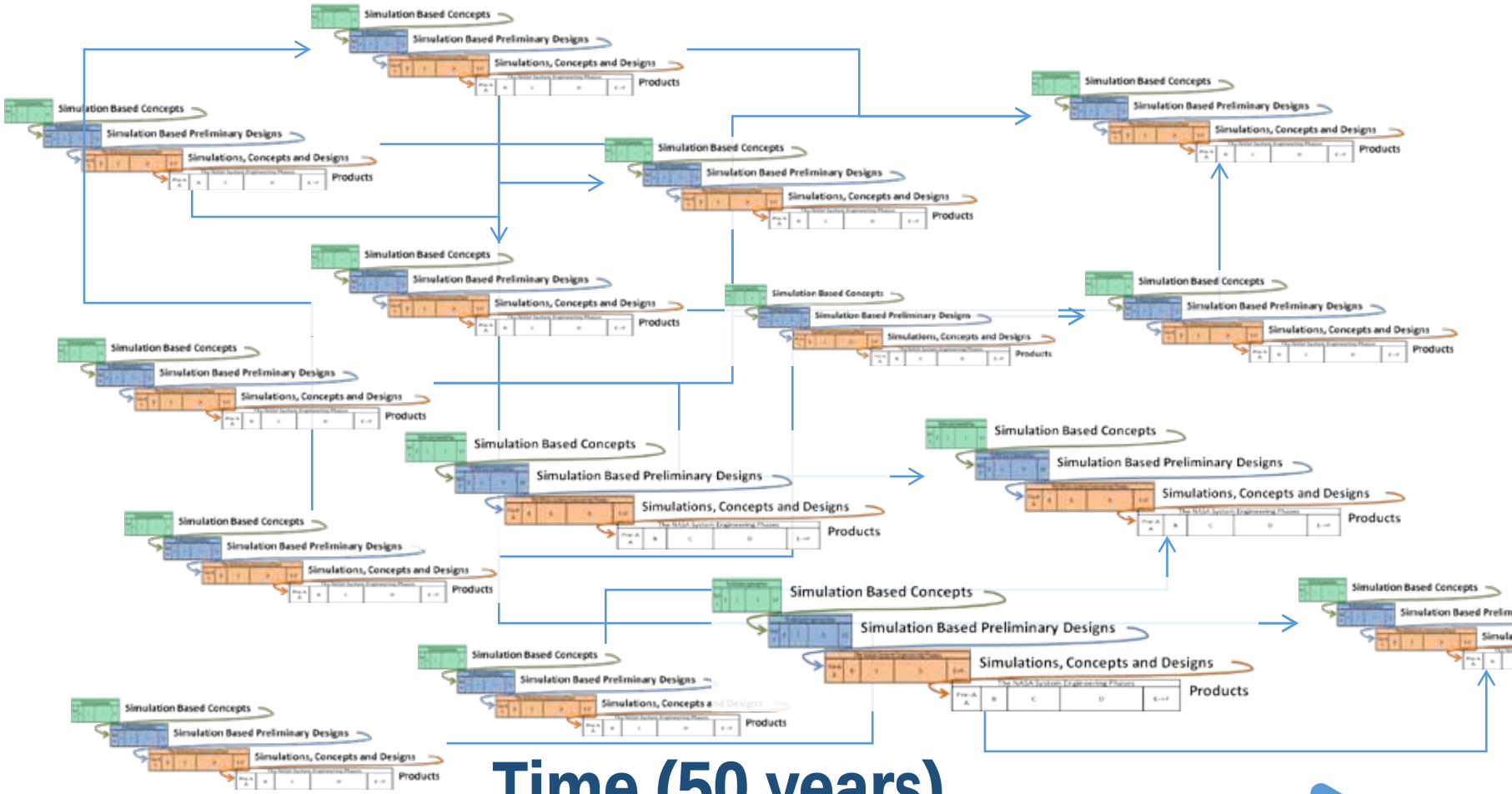
1. **I can show you in a few months, not years (Early System Knowledge)**
2. **Then you can help steer me (Design Flexibility Preserved)**
3. **And we can look at the financial burn (Delayed Resource Commitments)**

Sustainable Systems



***And**, along the way we create artifacts that we can share, that increase understanding and allow us to access additional expertise*

Multi-Decadal and Interdependent are Hard



Persistent Simulation

- Persistent Simulation for Multi-Decadal Teams
  - Or, Playing Nice Across Time and Space

- Bio – Mike Conroy / Modeling, Simulation, IT Technology Manager / Kennedy Space Center
  - Experience from Expendable Launch Vehicles, Space Shuttle, a multi-year sentence in financial management, computer networks and data systems, engineering environments, contracts, group management and Modeling and Simulation for the Constellation Program.
  - Now leading Kennedy Simulation and IT Research management while building simulators and game based tools for NASA Exploration efforts.