Who We Were

- Mike Conroy
  - Manager, Constellation, SE&I, SAVIO, Software SIG, Modeling and Simulation Team (MaST)
  - Got the job in a Re-Organization Briefing
  - Used to:
    - Lead CxP Data Presentation and Visualization
    - Lead Kennedy Operations Simulation
    - Be part of OCE Engineering Processes Team (ISE)
- Rebecca (Bec) Mazzone
  - Manager, Constellation, SE&I, SAVIO, Software SIG, MaST, Data Presentation and Visualization (DPV)
  - Used to:
    - Lead Distributed Observer Network Project within DPV

Topics of Interest

- We MUST be able to share, use and re-use information if we are going to work together to explore Space

- I Want To:
  - SHARE some past experiences
  - SHARE some current work (and current challenges)
  - SHARE some successes, and
  - SHARE some recommendations for the future

SESP 2012

NASA Modeling and Simulation

The Constellation Version
(the past experiences)

Constellation Case Study

- Constellation was made up of multiple Projects
  - Each made up of more projects, each made up of even more projects down through Level 5
- Projects were in various Lifecycle Phases
  - Some had hardware being built, some would not produce systems for years
- Those Projects needed to be able to work together for at least 50 years
  - Many generations of humans, teams, programs, partners & tools
  - Not all alive at the same time
- There is not a lot of evidence of prior planning
  - The projects were up and running a few years before the program guidance

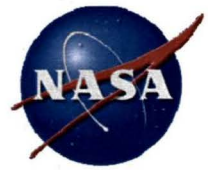
Challenges

- There is not a lot of evidence of prior planning
  - Sub-Projects were running a few years before the program was developed, with their own tools, processes and standards
- There was an assumption that the new Product Data Manager (PDM) was going to make it all better
  - Um, if you have a mess, and you automate it, you get an automated mess
- M&S was a massive distributed team (160 at one time), that shrank massively (12)
  - Neither number was right, it took 3 re-organizations to shrink
- I found out I had the leadership role in a teleconference
  - At the same time everyone else did

So, Some Assumptions

- There are common elements to work with
  - *Knowledge*: Decisions, Experiences, Expertise
  - *Information*: Reports, Recommendations, Rationale
  - *Data*: Numbers, Pictures, Models, Equations
- Knowledge is hard to share
  - It is in peoples heads; they are attached to them
- Data is fairly easy
  - Just record it; lots and lots of disks
  - Finding it later is another matter, possibly for another generation
- Information is somewhere in the middle
  - It requires data, but also a lot of other stuff

How We Found the Common Elements



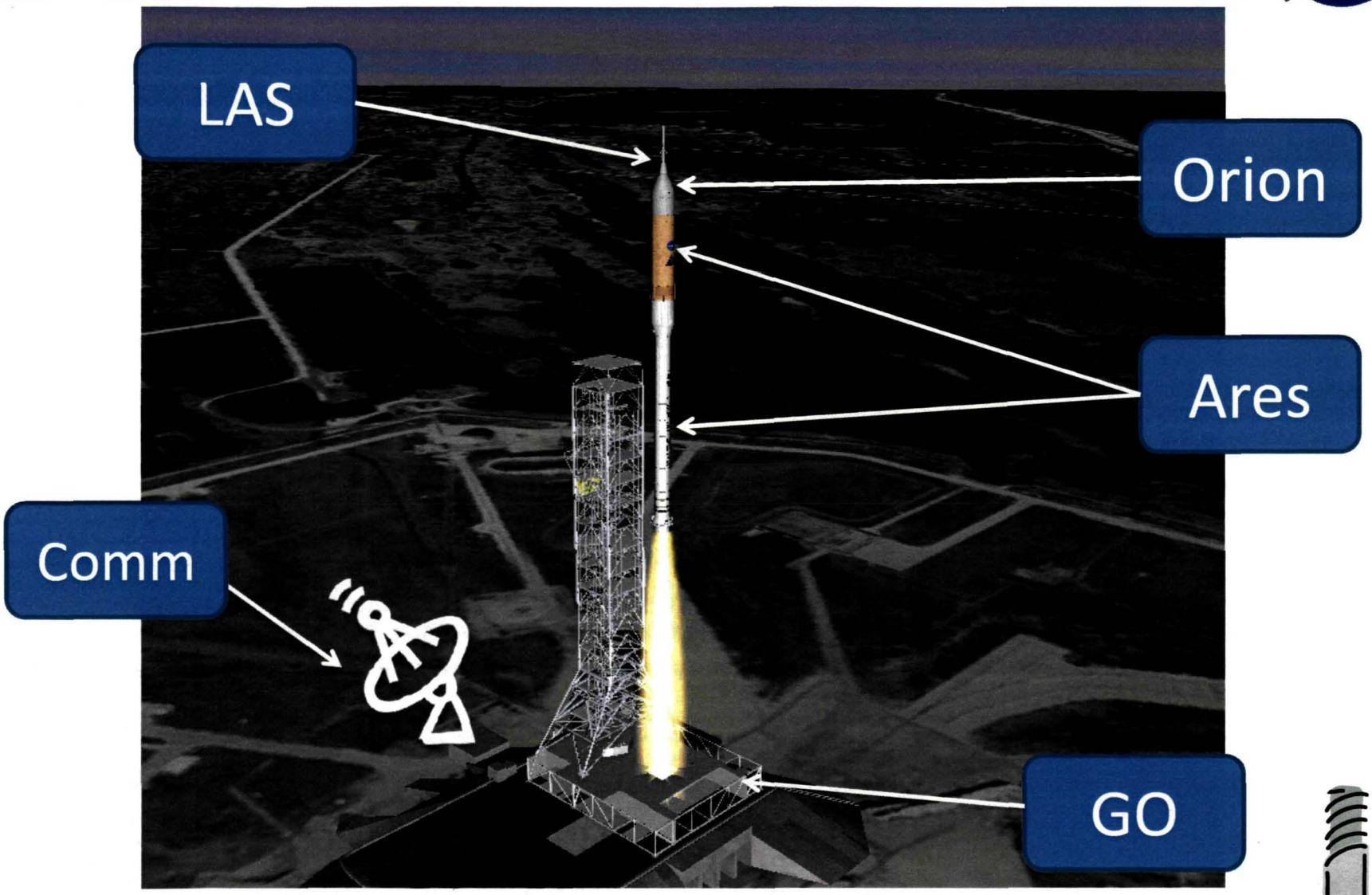
- Looked at Constellation Tools
  - Found where each is stored
  - Mapped how the Data flowed through the system
  - Identified how to get Information out
  - Normalized so others can understand (Knowledge)

- We noticed some tool/location groupings
  - Physics Based Tools
    - System State Information, Structural Information
  - Physical Environment Tools
    - Temporal / Spatial Information
  - Supply Chain Tools
    - What you need when you need it

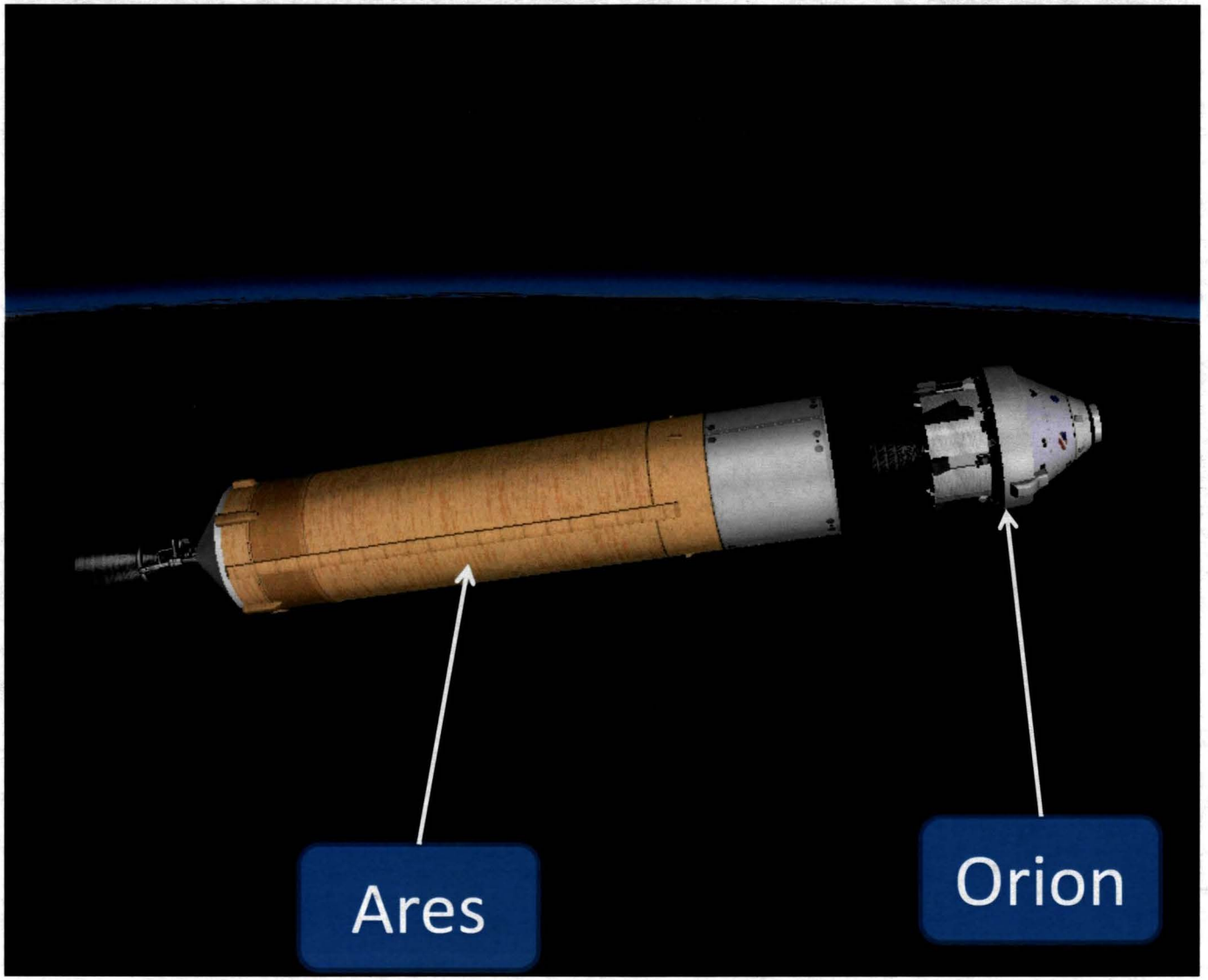
Once We Found Them

- Now we could put them all together:
  - Modeling and Simulation Labs (MSL) #1
    - A full mission flight simulation from Kennedy to ISS
  - Virtual Mission (VM) #1
    - MSL 1 plus assembly, prep, paper processes and test phases
- We ran a large, distributed simulation, with multiple system models and shared the data across the country
  - Teach the Projects to talk to one another
    - MAVERIC and ANTARES on Flight Side
    - Ground Operations Simulation
    - LAS Simulation and ISS Simulation
  - Let People and Simulations talk to one another
    - High Level Architecture, TRICK, DSNet, DON
- I Looked Like This…

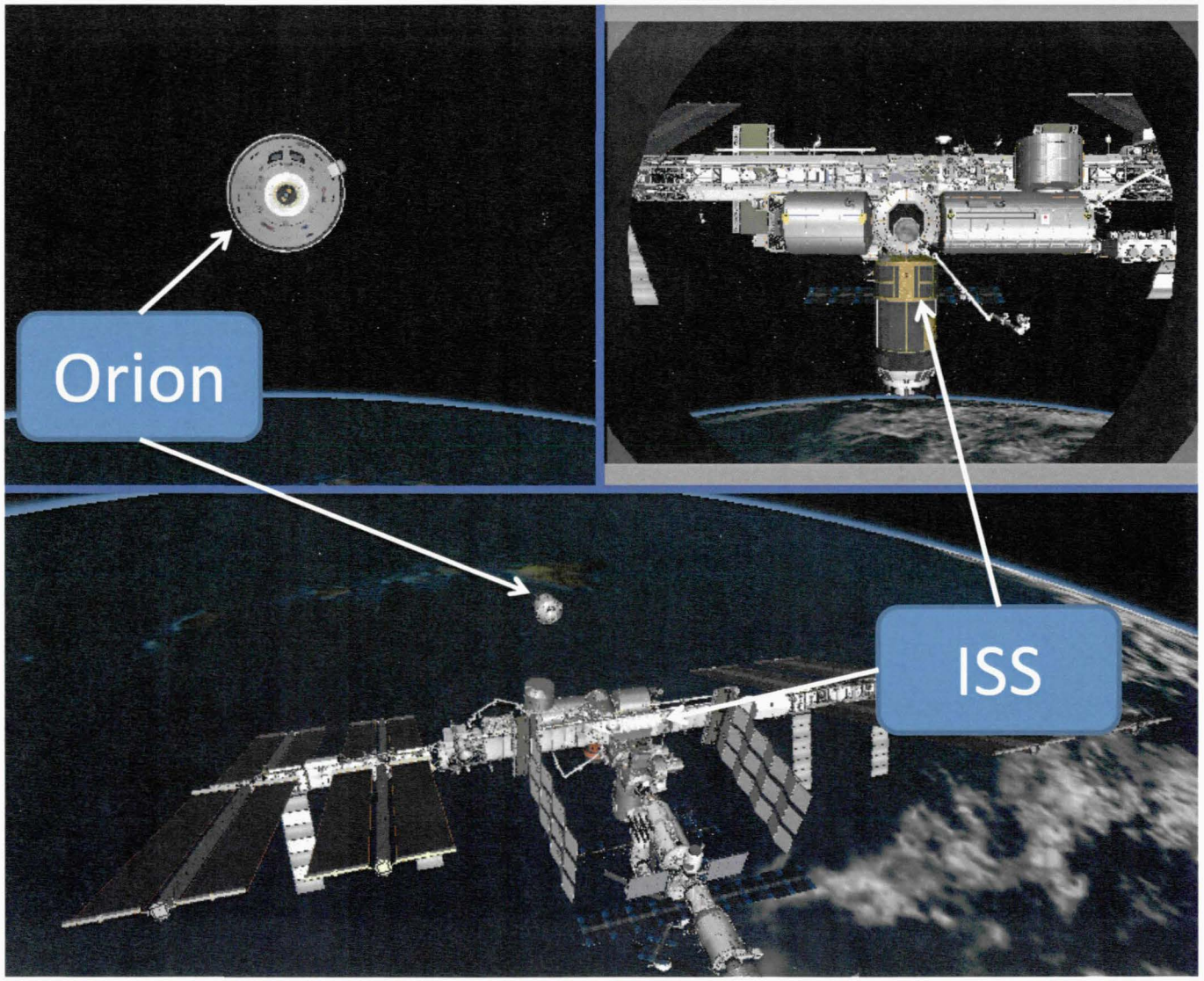
Ares 1 Launch



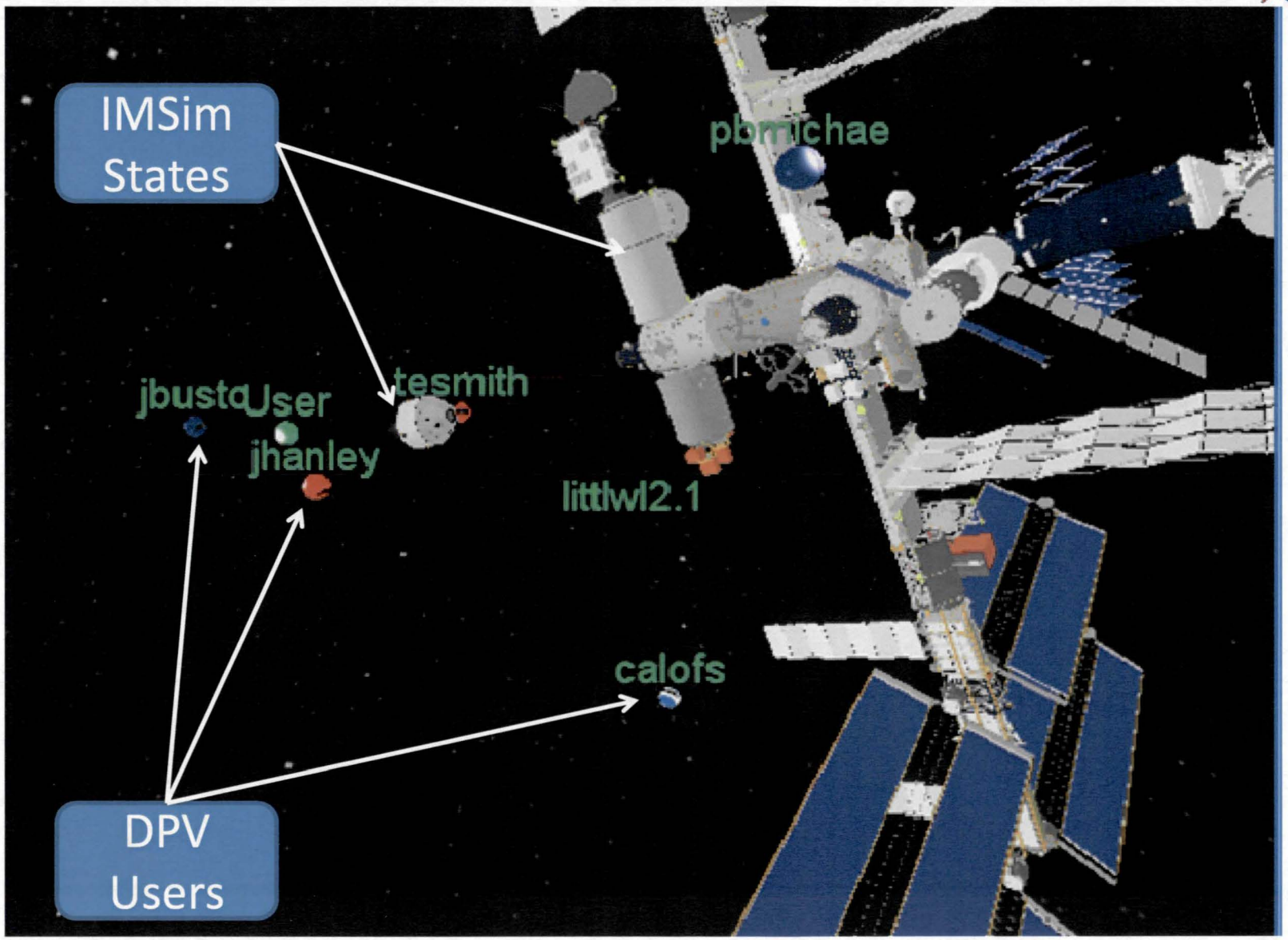
Upper Stage / Orion Separation



Orion to ISS Docking



Streamed Data to a Game Based Visualizer



A year or so later…

- We had Distributed Simulation, Distributed Visualization, Common Data Formats, Centralized Storage, Royalty Free Tools, Common Interfaces and were on the way to Program wide data integration

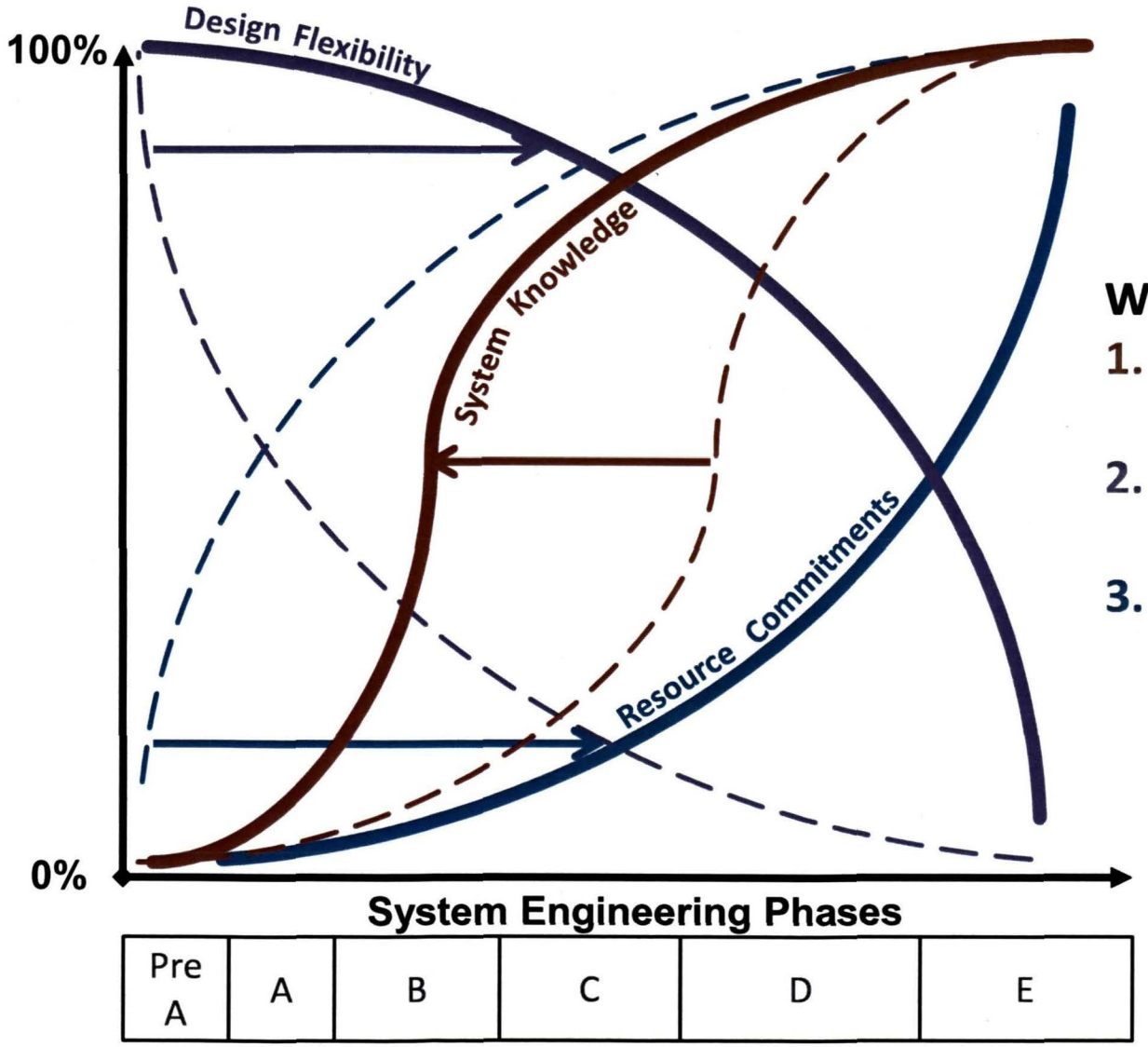
- On my flight to unveil the next step, the Constellation Program was Canceled. We wrote lessons learned and saved the data.

- Here is what we were going to do about System of System Challenges

Part of the SoS Challenge

(the current work)

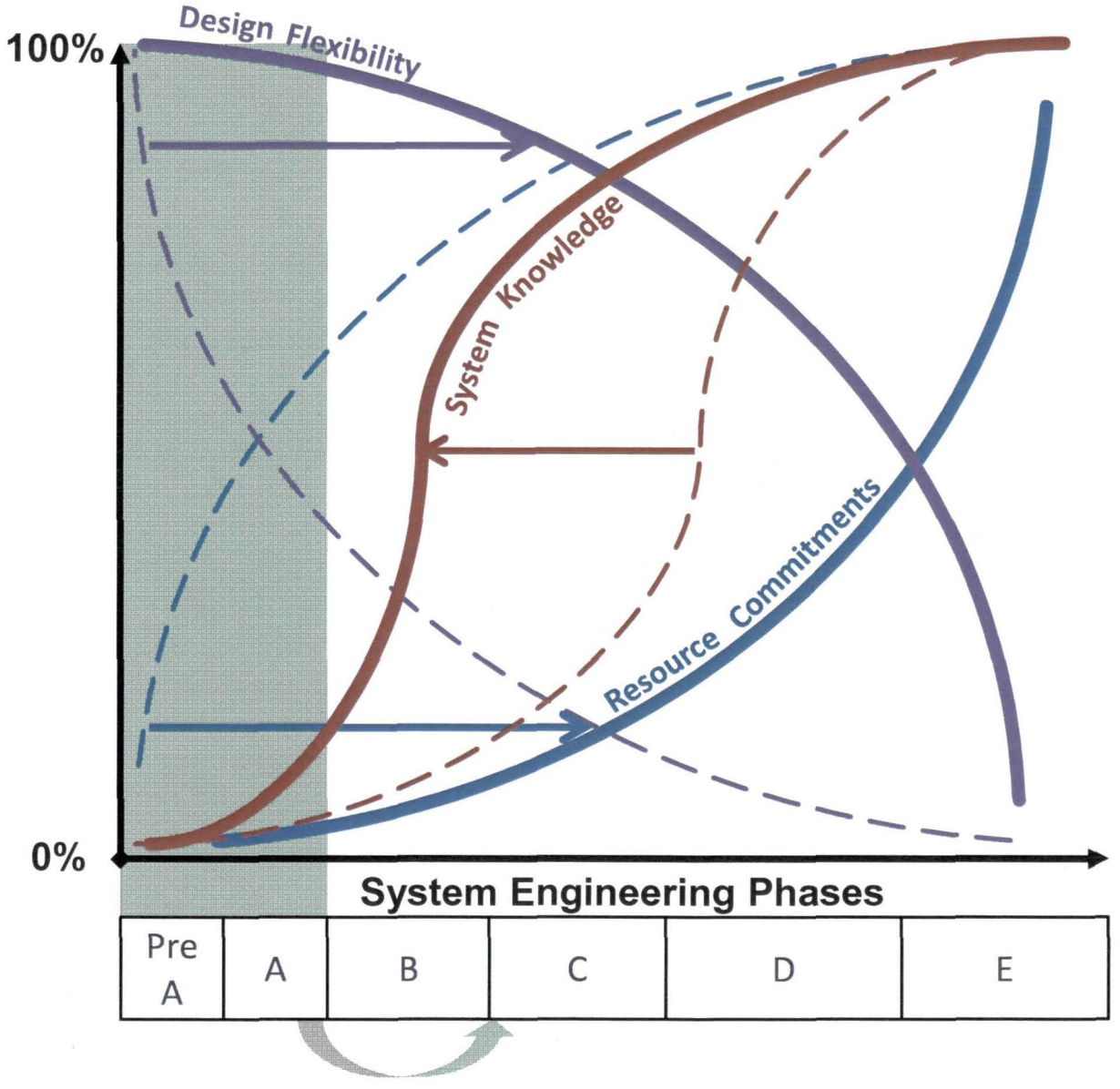
Everyone has a chart like this:



We All Want To:

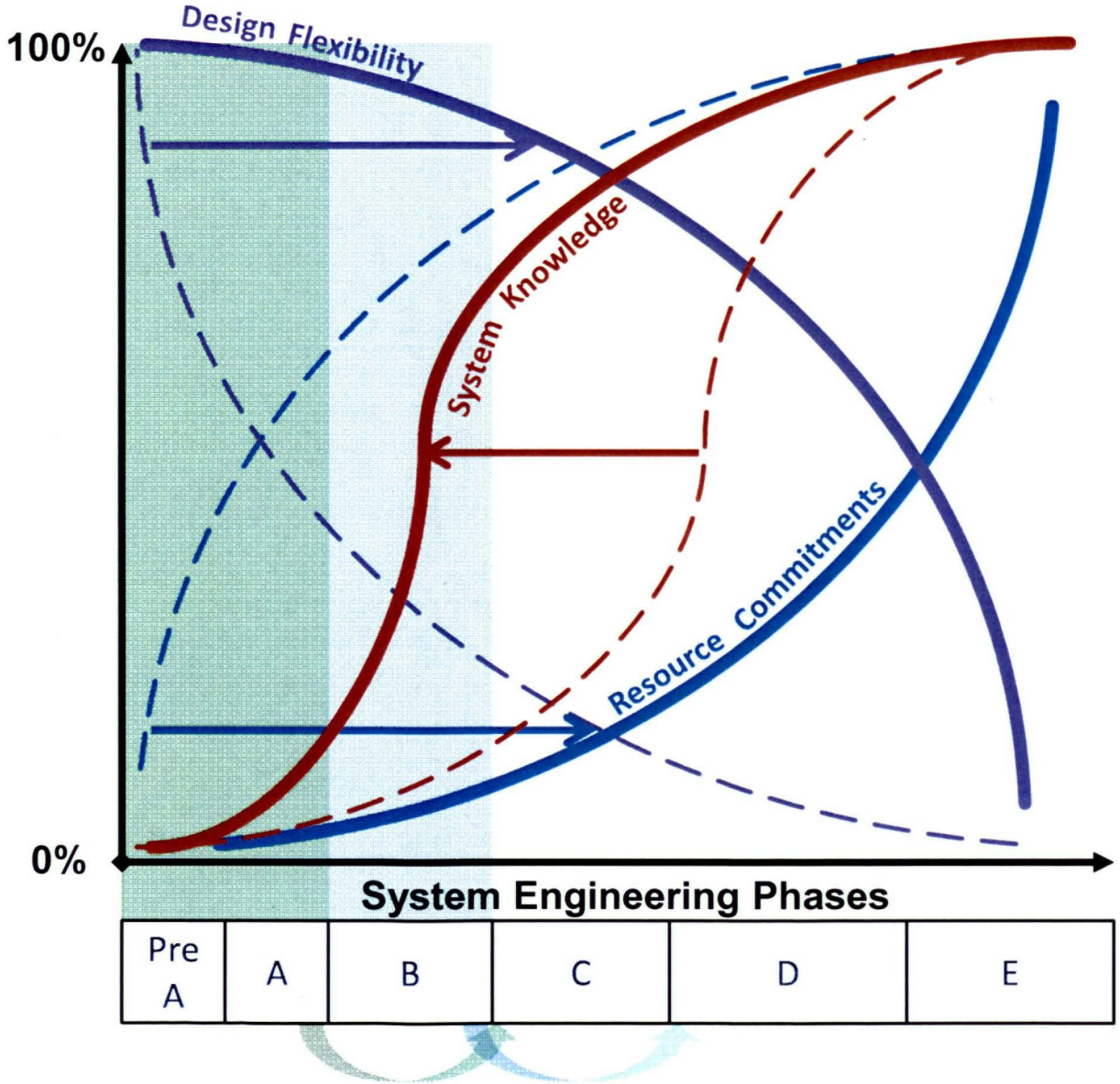
1. **Have System Knowledge Sooner**
2. **Preserve Design Flexibility**
3. **Delay Resource Commitments**

We Believe Simulation Based Concepts



"Pre-A – A" provide "B" with **Sim. Based Concepts**, and enough detail to **allow** Sim. **Based Validation** at the end of Phase B

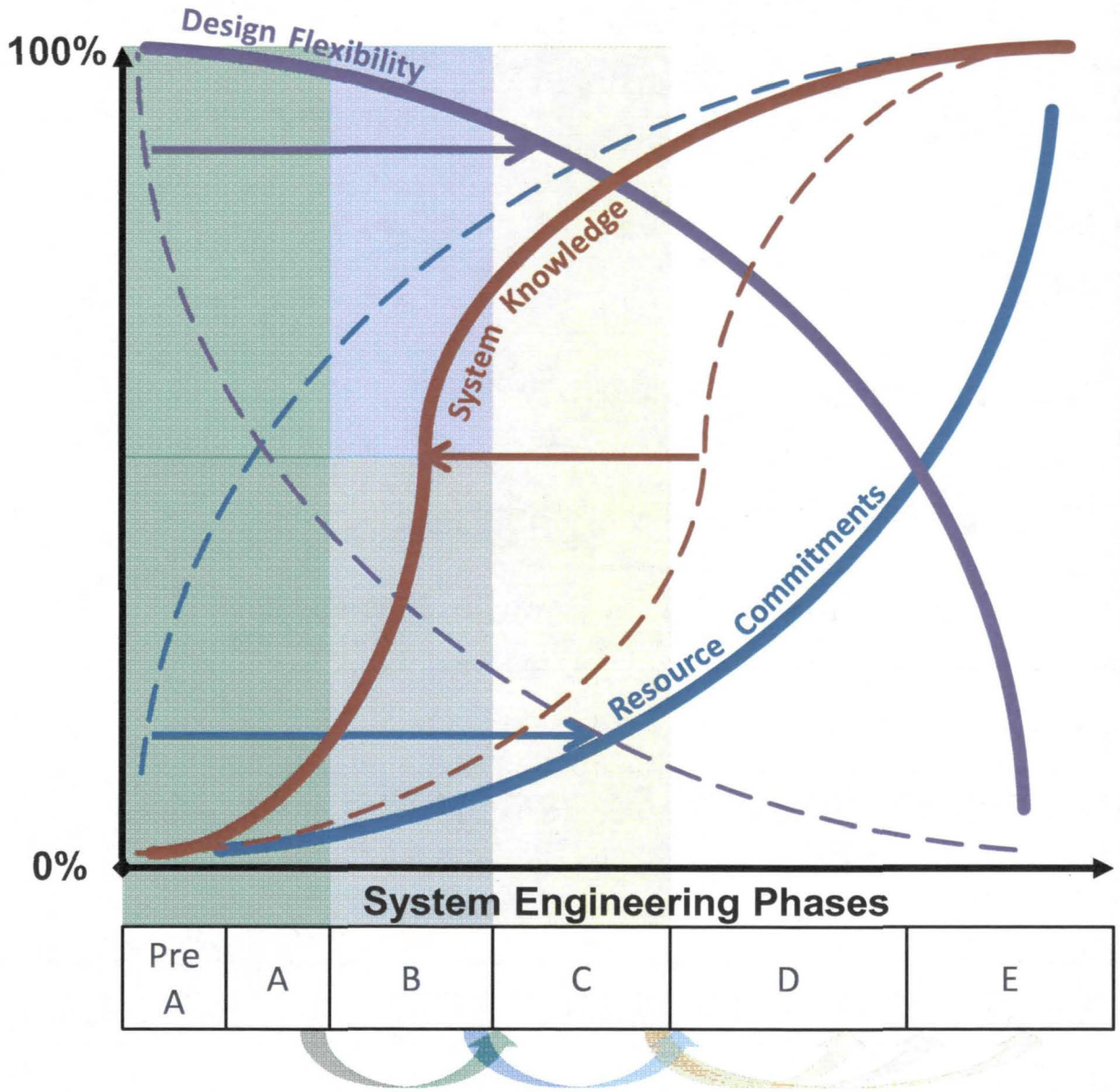
Will Enable Simulation Based Designs



"Pre-A – A" provide "B" with Sim. Based Concepts, and enough detail to allow Sim. Based Validation at the end of Phase B

"B" provide "C" with Sim. Based Prelim. Designs, and enough detail for **Sim. based Requirements AND Validation** at the end of Phase "C"

And Support Simulation Based Products

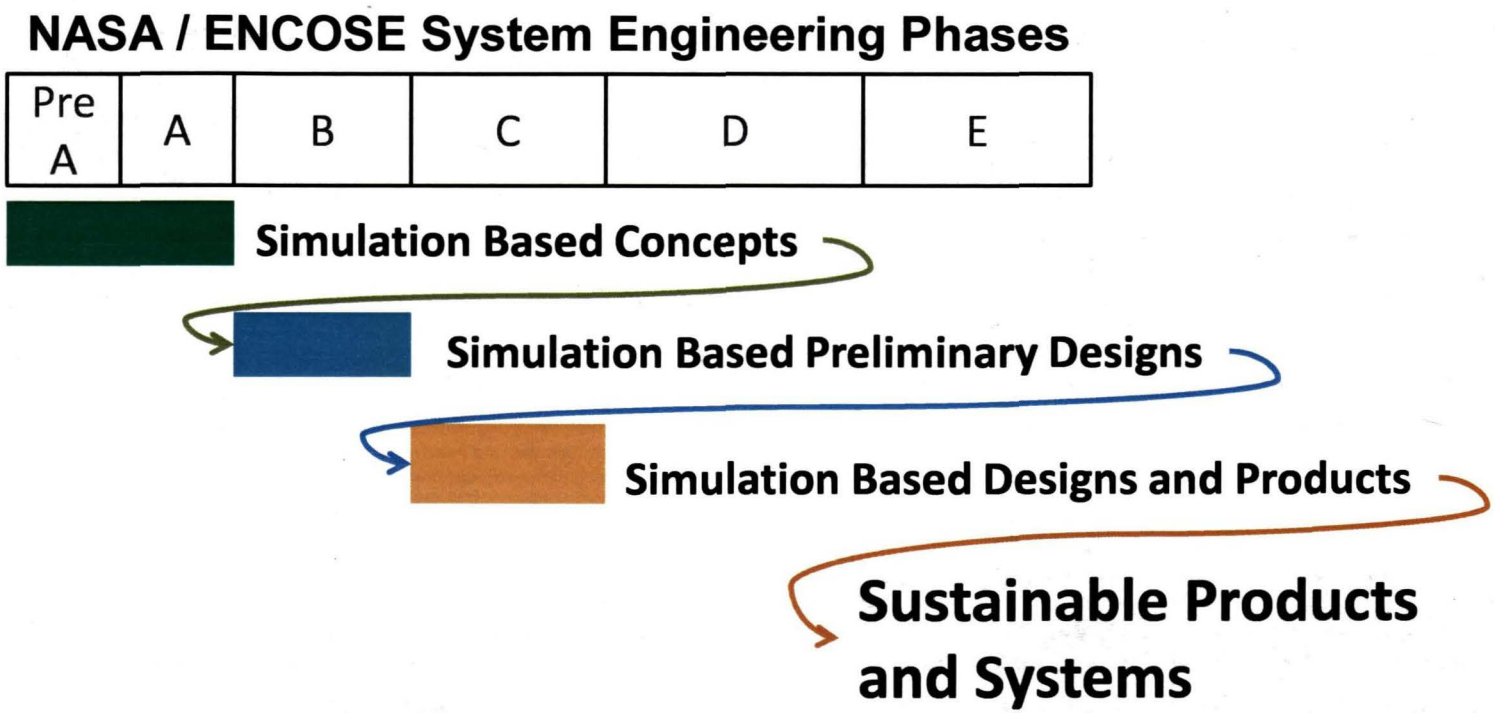


"Pre-A – A" provide "B" with Sim. Based Concepts, and enough detail to allow Sim. Based Validation at the end of Phase B

"B" provide "C" with Sim. Based Prelim. Designs, and enough detail for Sim. based Requirements AND support Validation at the end of Phase "C"

"C" provide "D" with Simulations, Concepts and Designs to support more **Operable, Sustainable and Maintainable Products.**

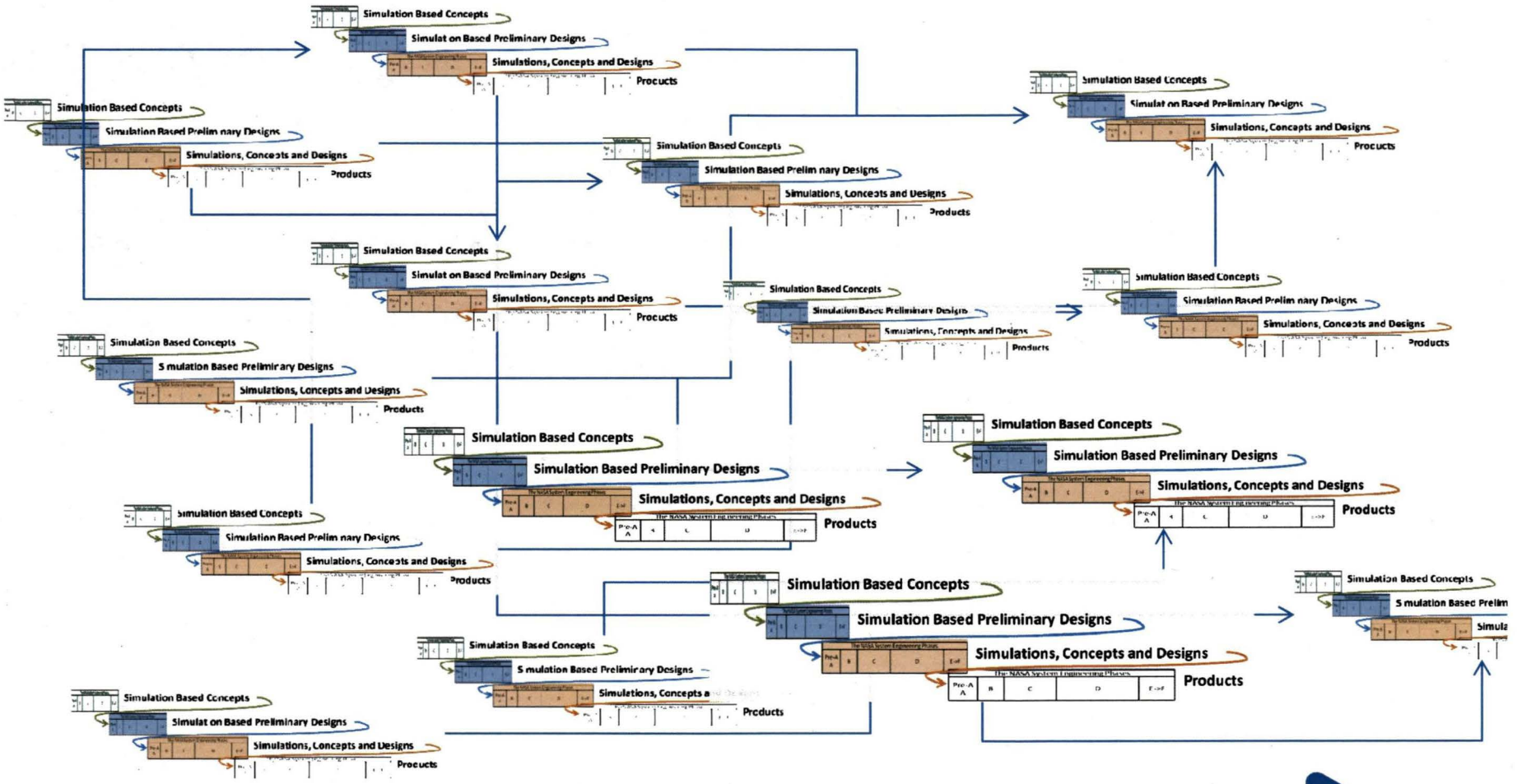
And Lead to Sustainable Products & Systems



***And**, we create artifacts along the way that can be shared to increase understanding and elicit additional expertise*

And This is Good!

50+ Year Lifecycles Make It Hard



SESP 2012

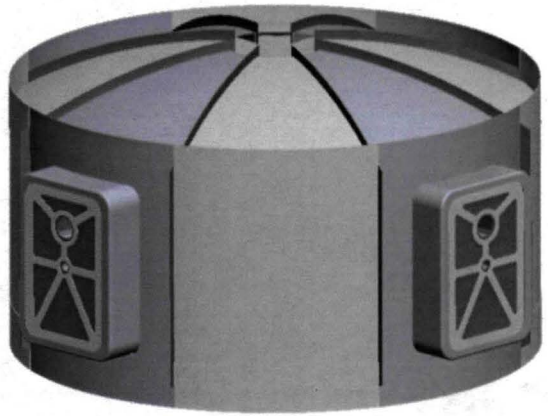
Success Story
Habitat Demonstration Unit

a success

HDU Overview

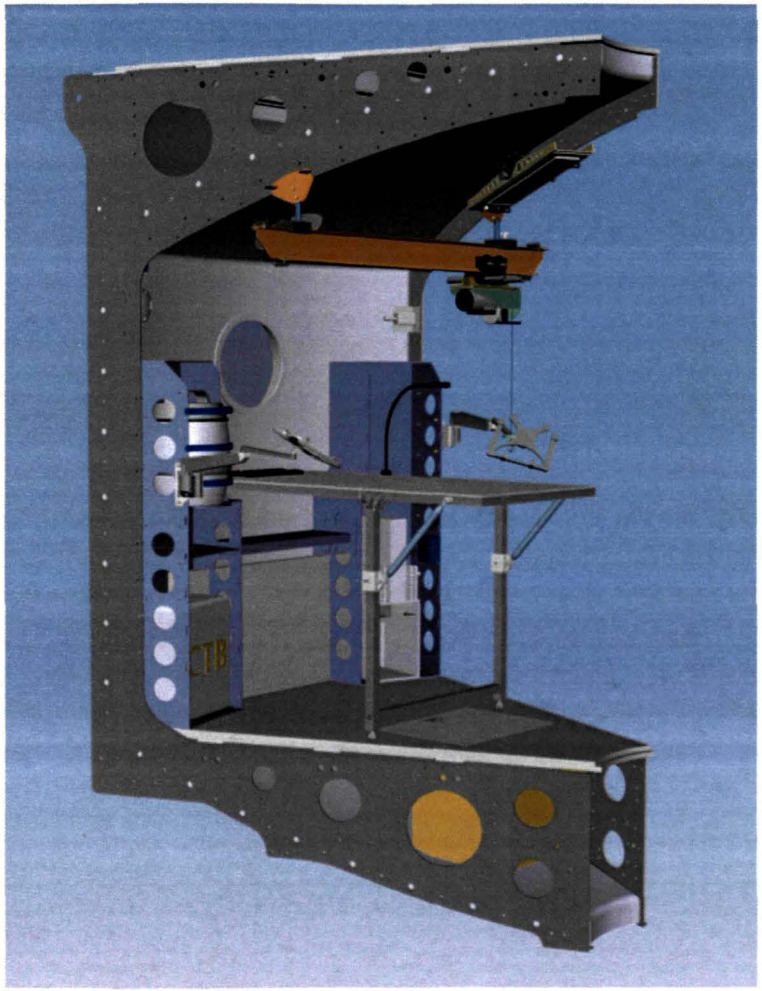
- Vision
  - Develop, integrate, test, and evaluate a Habitat to advance understanding of mission architectures, requirements and operations concepts
- Timeline
  - Project Kick-off: June 2009
  - Shell: October 2009 – April 2010
  - Systems Integration: April – August 2010
  - Desert RATS September 2010
- Participation
  - Jointly managed across JSC, KSC & JPL
  - Shell Construction at LaRC
  - Assembly and Integration at JSC
  - Subsystems from ARC, GRC, JPL, JSC, KSC, LaRC, MSFC

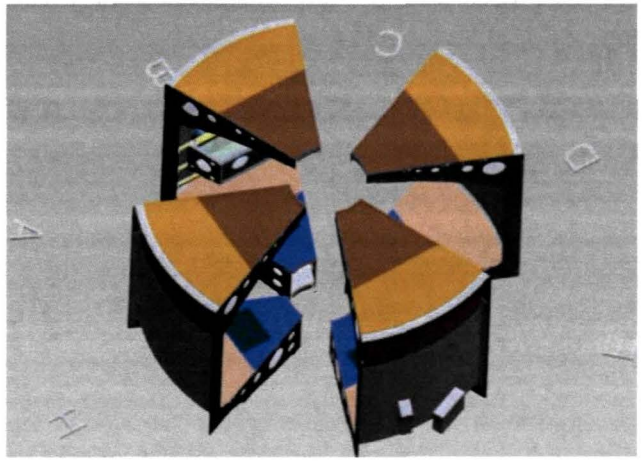
Lunar Reference Concept (PEM)

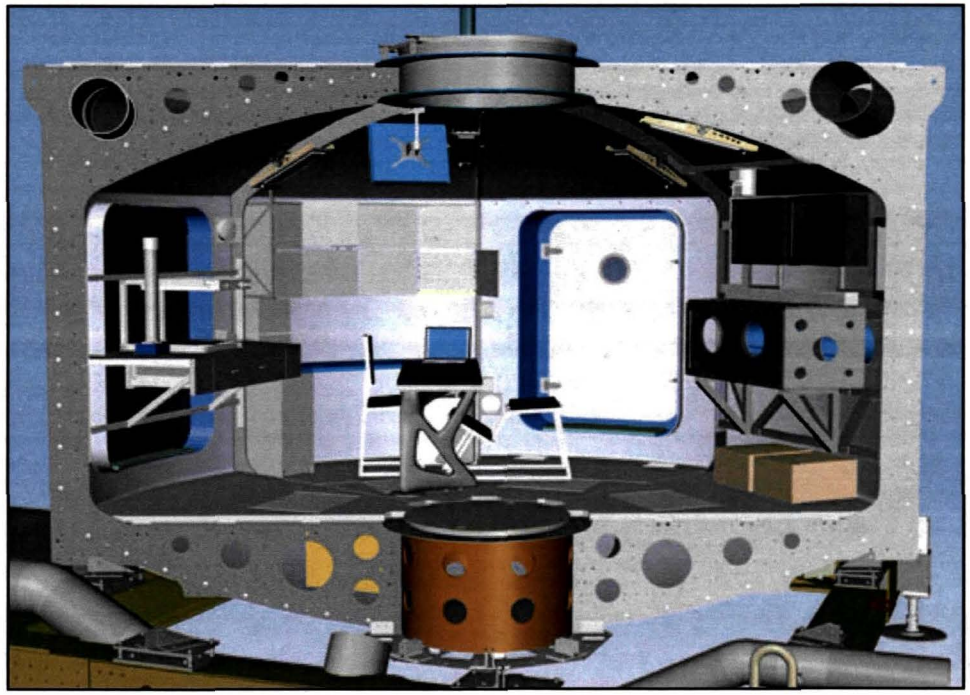


HDU Concept

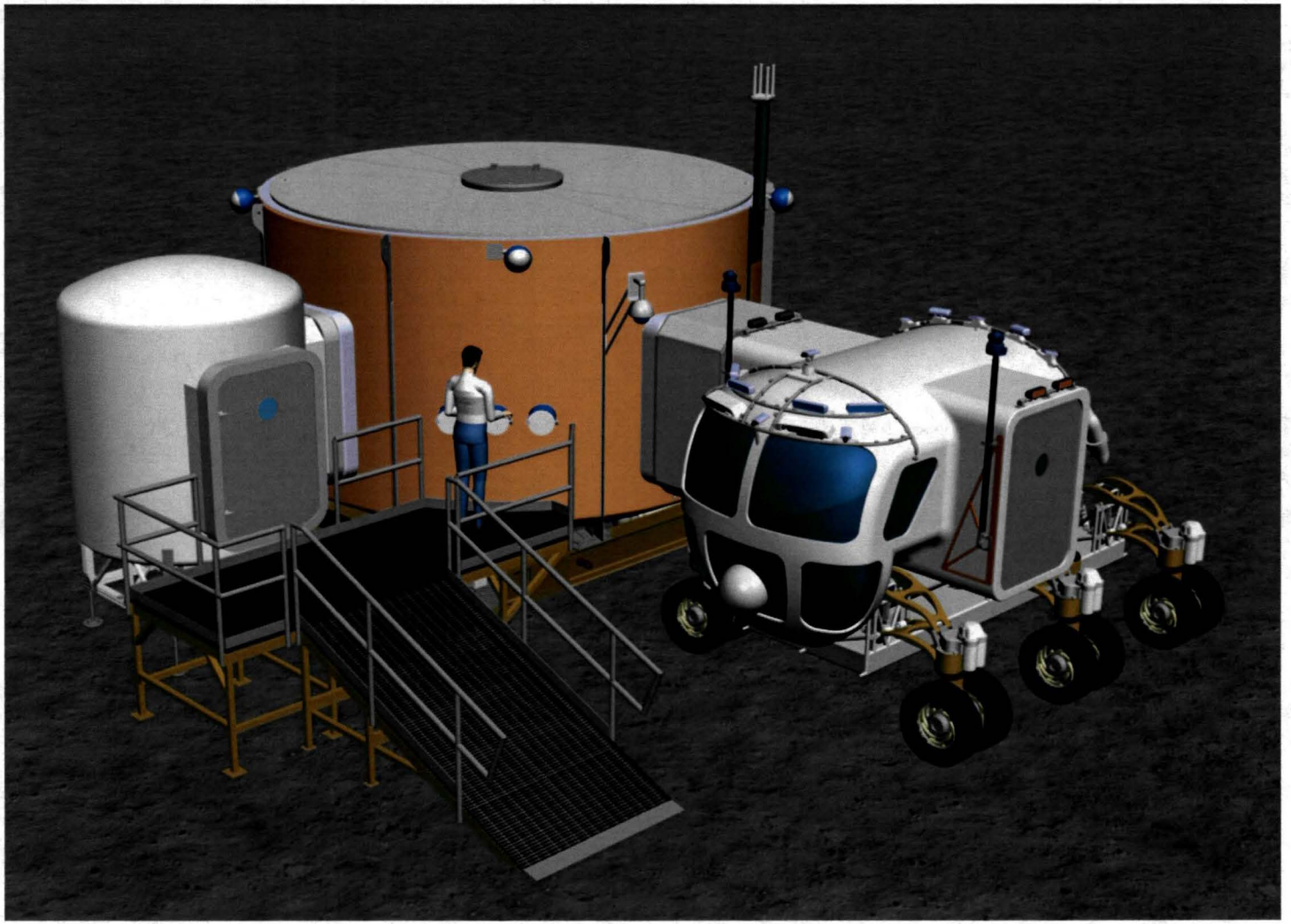
Virtual Integration - Interior



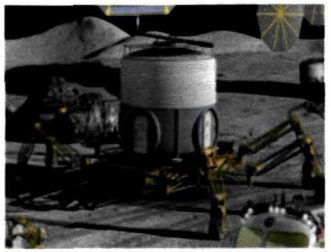


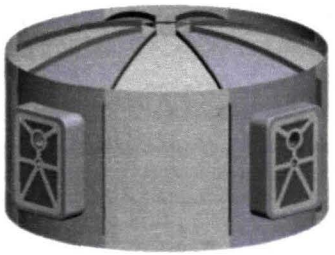


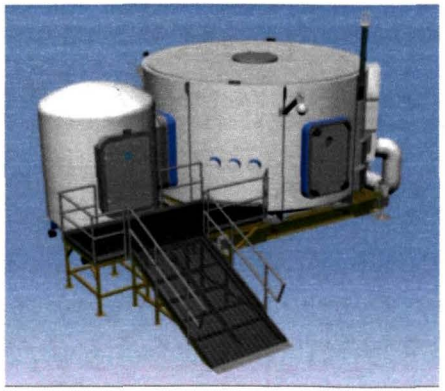
Virtual Integration - Exterior



Concept Realization







Concurrent Design

- 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

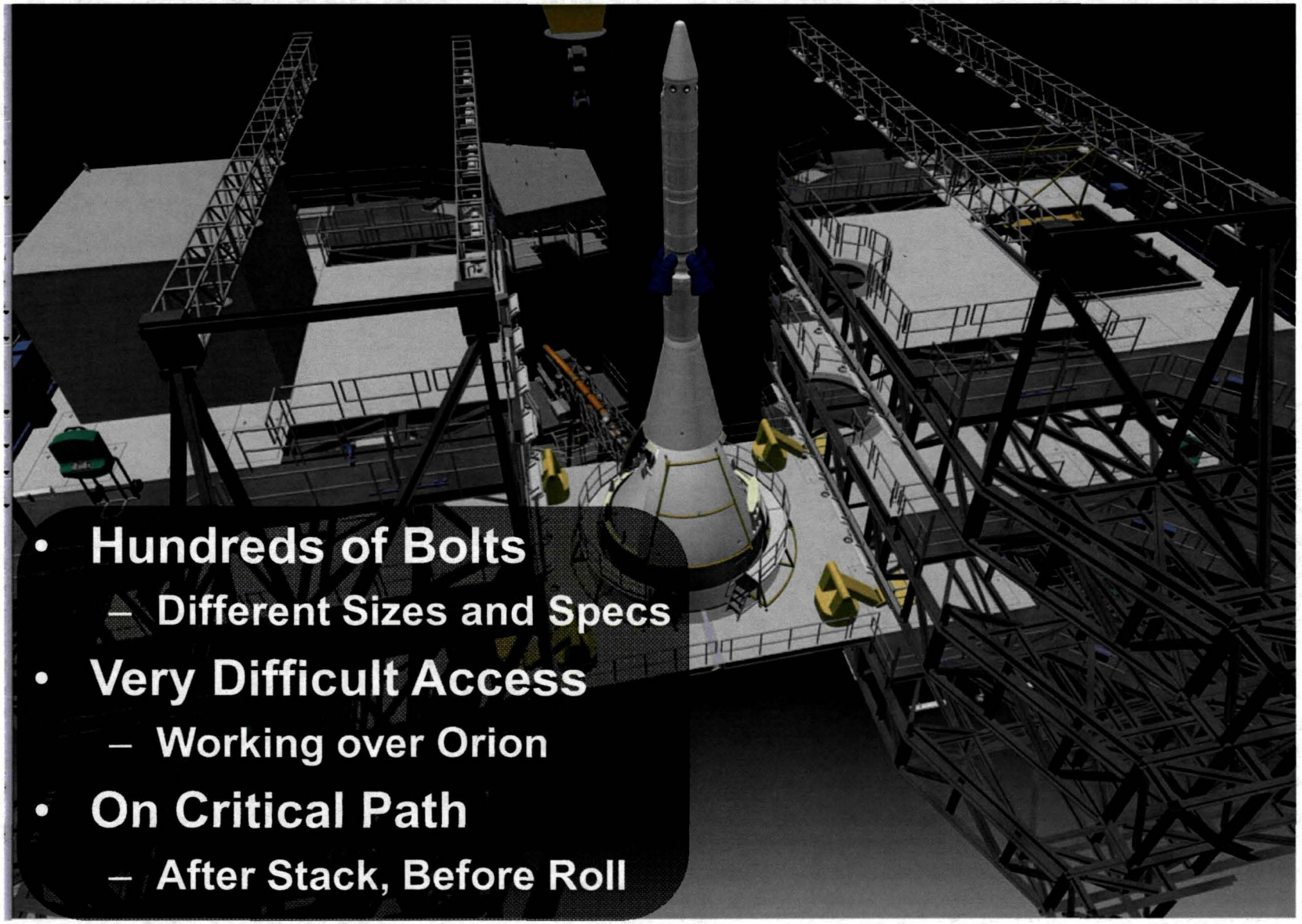
- Not just because of Simulation
  - HDU leadership broke down the decisions such that critical elements were decided on first
    - Even if only allocations
  - Simulation Screen Shots became a key communication path

SESP 2012

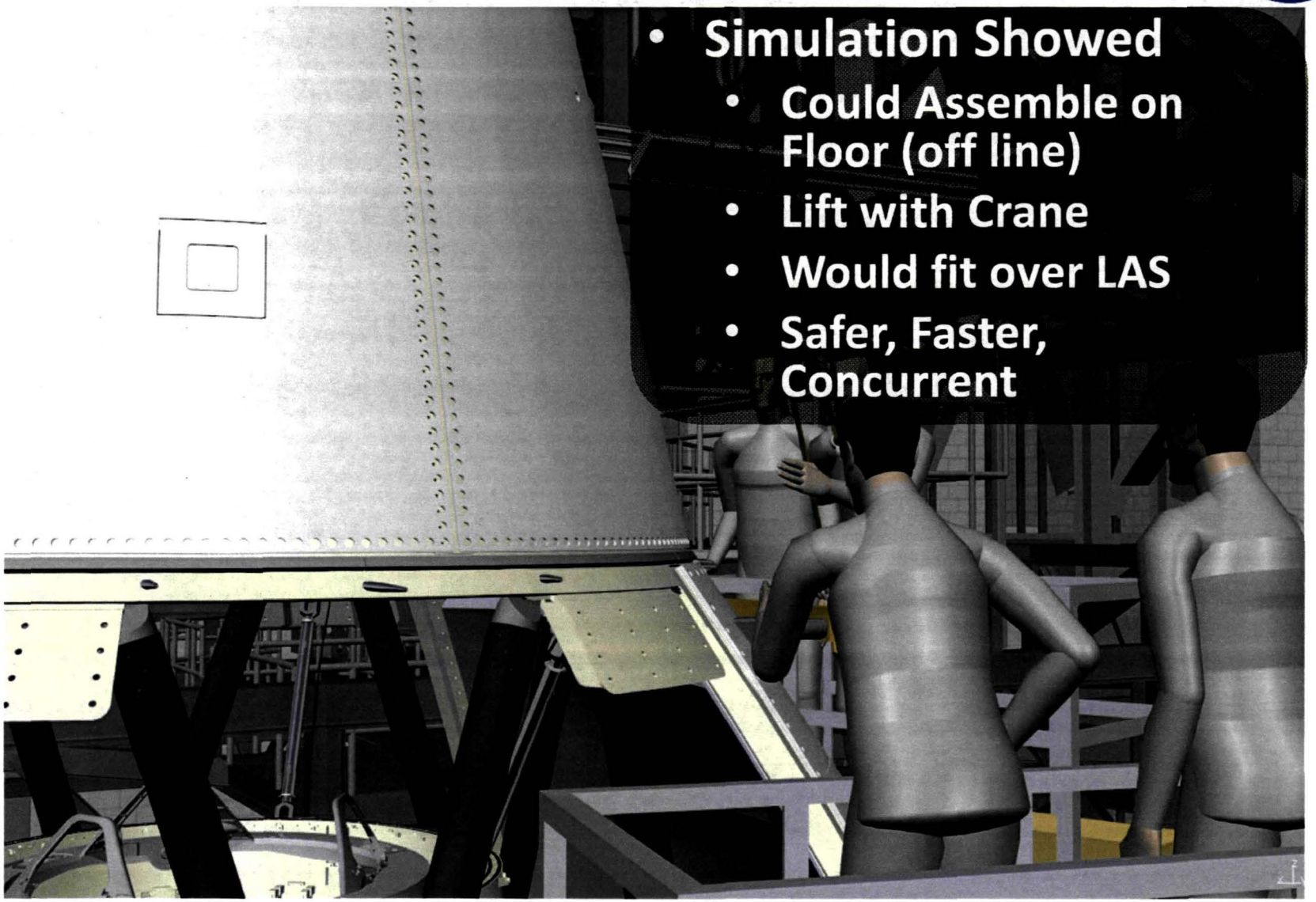
Success Story
OJIVE Panel Study

Another success

How to Install in VAB After Stack Integration



OJIVE HF Detail (Delmia)



Today Steps

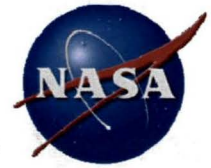
(now)

SESP 2012

Some Realities, Definitions, Assumptions and Observations

From the NASA Model Centric Architecture Model Use and Re-Use Team (Conroy, Mazzone, Lin)

New Realities



- The people working on the project were likely not born when it started
- Tools have come and gone many times
- You must save information that will be used in 20 years
- You must have information from 20 years ago
- The project team speaks at least 5 languages
- The latest plan is to make cost, schedule and performance targets through Software and Model Re-Use

- We Really Need to Know How to Re-Use Models
  - Using them correctly in the first place would not be bad either

- From NASA's Integrated Model-centric Architecture…

As Engineers / Managers:

- 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 things, and how they behave, **determine** the next step(s) and **communicate** the results of the study
  - With as much detail as is necessary for that study

We Have Roles and Rules

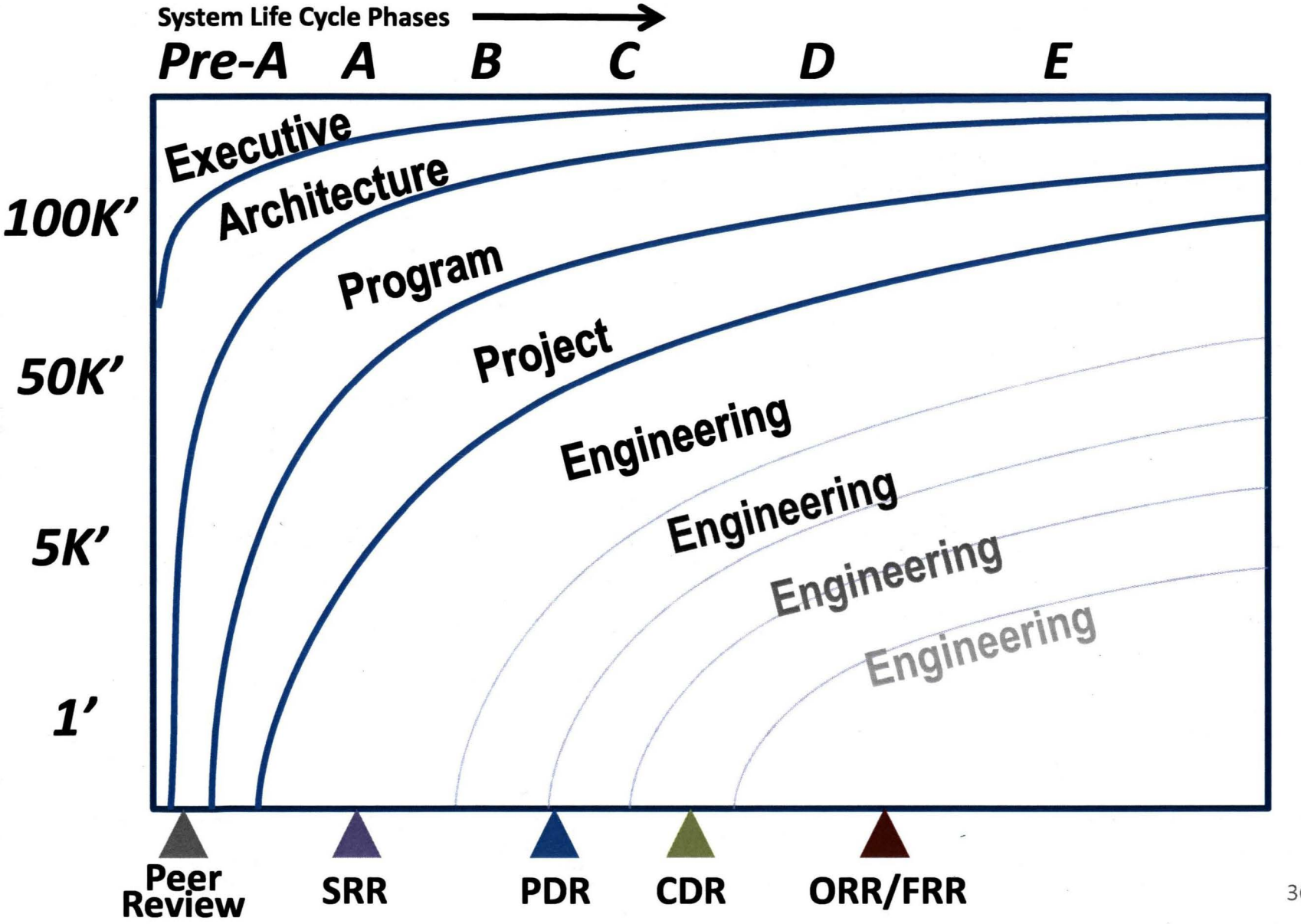
Roles:

- Executive:
  - Mission, Policy, Partnerships, Resource Plans, Goals
- Architecture Development:
  - Concepts, Partnerships, ConOps, Milestones, Parametrics, Cost
- Program Development:
  - Systems, SoS, SysML, IRDs, Milestones, ConOps, MBSE, Cost
- Project Development:
  - MBSE, Requirements, Design, ConOps, ICDs, Cost, Schedule
- Engineering:
  - Design, Systems, Procedures, Cost, Schedule, Mass, SW, Stuff

Rules:

- Communication
  - Role Above = Customer = Provider of $$ and Goals
  - Role Below = Supplier = Provider of Stuff that Works
  - You must talk up in their language
  - You can talk down in your language
- Scope
  - Each role has norms (organizational physics, motivation, rewards) that must be respected
    - (chain of command)
  - You can look across roles, but must honor local norms

Roles and Rules Have Boundaries and Gates



And, Role Portfolios Change Over Time

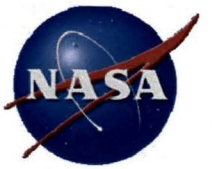
- Executive
  - Early artwork, sketches, goals and directives replaced by Mature parametric data, system models, system simulations and decisions
    - (pictures and spreadsheets)
- Architecture
  - Early concepts, basic systems simulations and parametric information replaced by Mature architecture level models and simulations
    - (pictures, spreadsheets, animations, SysML, sims)
- Program
  - Early system models, program simulations and scenarios replaced by Mature program models and simulations
    - (spreadsheets, databases, animations, SysML, sims, project, IPM, DES)
- Project
  - Early concepts, basic systems simulations and parametric information replaced by Detailed system models and simulations
    - (databases, SysML, simulations, project, DES, videos)
- Engineering
  - Early concepts, basic systems simulations and parametric information replaced by CAD and system models and simulations
    - (Pro-E, SysML, simulations, project, models, simulations, videos)

SESP 2012

Recommendations for Information Use and Re-Use

Before anything else we MUST

Have a Common Score Sheet for Information



- A way to communicate the rigor, fidelity, certainly and pedigree of work, across distances and years, must exist and be used.
- We created a standard grading system (NASA Std 7009)
  - 8 categories, 5 scores per category (none to very high)

Verification	Validation	Input Pedigree	Results Uncertainty	Results Robustness	Use History	M&S Management	People Qualification
4	4	4	4	4	4	4	4
3	3	3	3	3	3	3	3
2	2	2	2	2	2	2	2
1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0

Have Sharing Methods and Tools

- Methods:
  - I share information with my parents. I get it from my children, integrate the results, add value and give the results to my boss.
  - I share information with my children. I get it form my boss, decompose as necessary, and give it and an additional data to my children.

- Tools, Product Data Management
  - I need a place work, with my team structure, my options and my studies, options and alternatives.
  - I need a place to release information, in the project or product structure, to my parents or children, with appropriate credibility information.

Have a Project Stand Up Template or Pattern

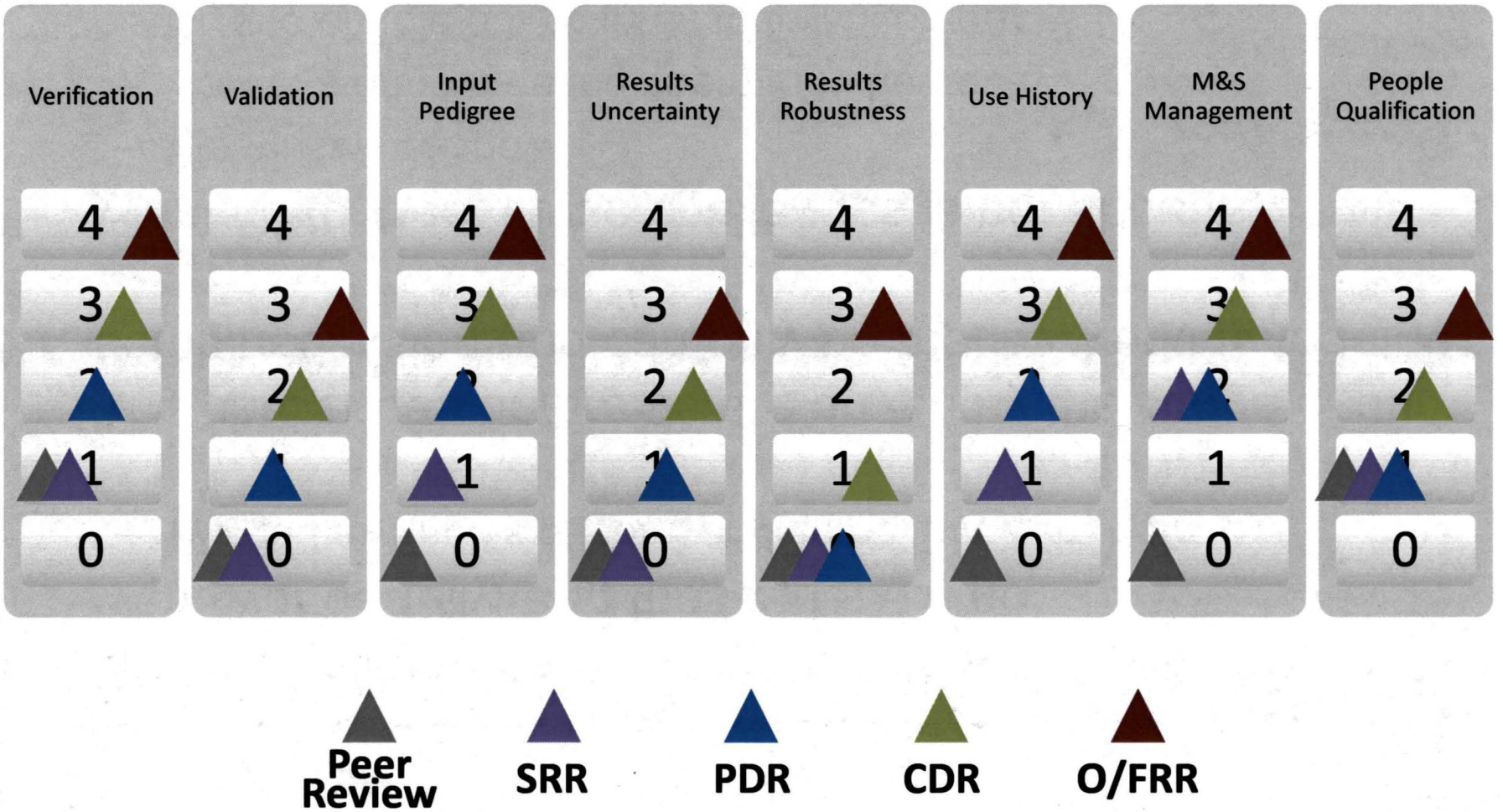
- Leadership
  - Creates and shares the architecture, con-ops, scenarios, decompositions and plans.
- System Engineering
  - Leads the MBSE effort, decomposes and owns the system model and stands up the PDM
- Engineering
  - Creates relevant system and sub-system models, assigns work, decomposes and composes information and controls tasks
- Everyone
  - Shares data up and down, with associated credibility information and complying with project guidelines

Have a Review Process

- Program / Project Manager
  - Identify goals and dates, products, expected credibility, integration / testing dates, artifacts and formats that will enable later information utilization
- System Engineer(s)
  - Create list of Review products that are necessary for the review
  - Lead Review and ensure necessary artifacts exist, are shared, and are preserved.
- Data Systems
  - Preserve the appropriate artifacts for existing use and re-use by future generations, along with all the necessary supporting information that will ever be needed.

Have a Credibility Progression, By Reviews

- As Systems mature, it is suggested that Credibility Increase. Below are CxP based Suggestions.



Conclusions

- We have all had programs, projects and missions that went wonderfully, and those that did not
  - We had examples of both, and some that were both
- The challenges before us are driven by the scope of our combined vision and can only be met by working together
- Wanting to meet these challenges is not enough
  - We must know how.
  - How to start to meeting them together today,
  - How to enable our children to finish tomorrow,
  - From wherever they are.
- We must know how to play nice across space and time

Thank you very much.
Questions?

mike.conroy@nasa.gov

bec.mazzone@nasa.gov