UCF Space Day
Life Cycle Design
(in 15 minutes or less)

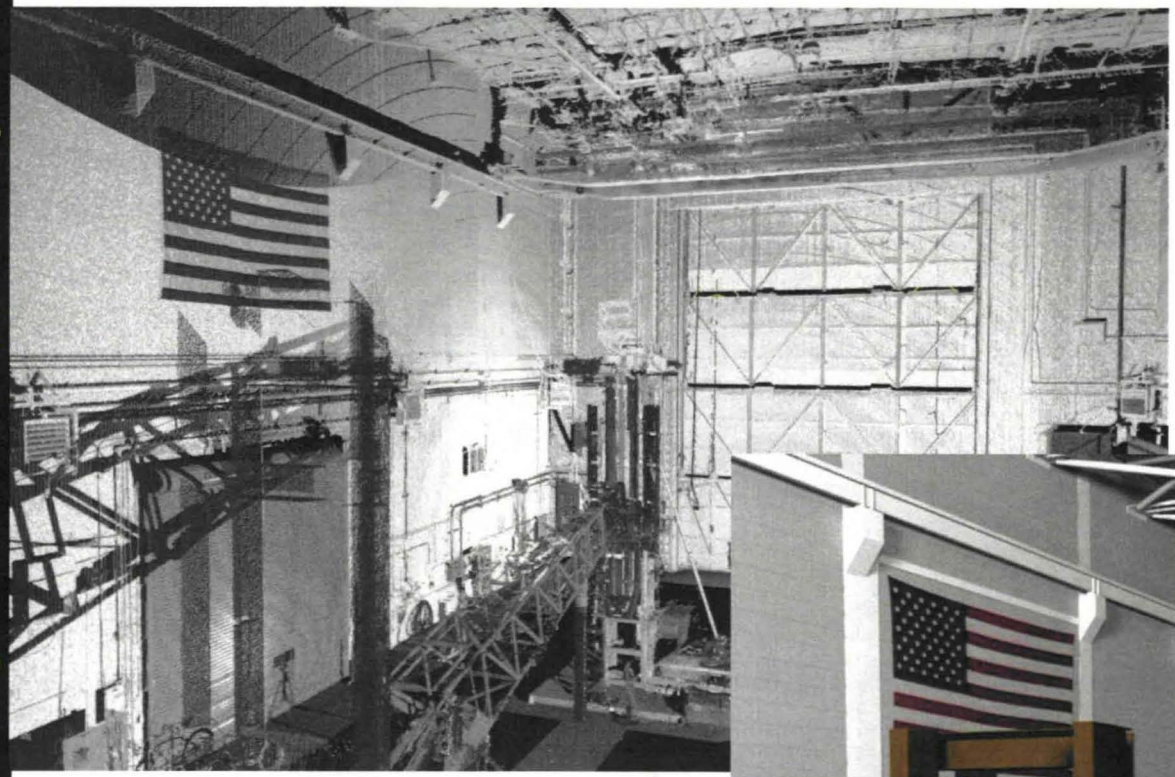
Mike Conroy (mike.conroy@nasa.gov)

www.nasa.gov

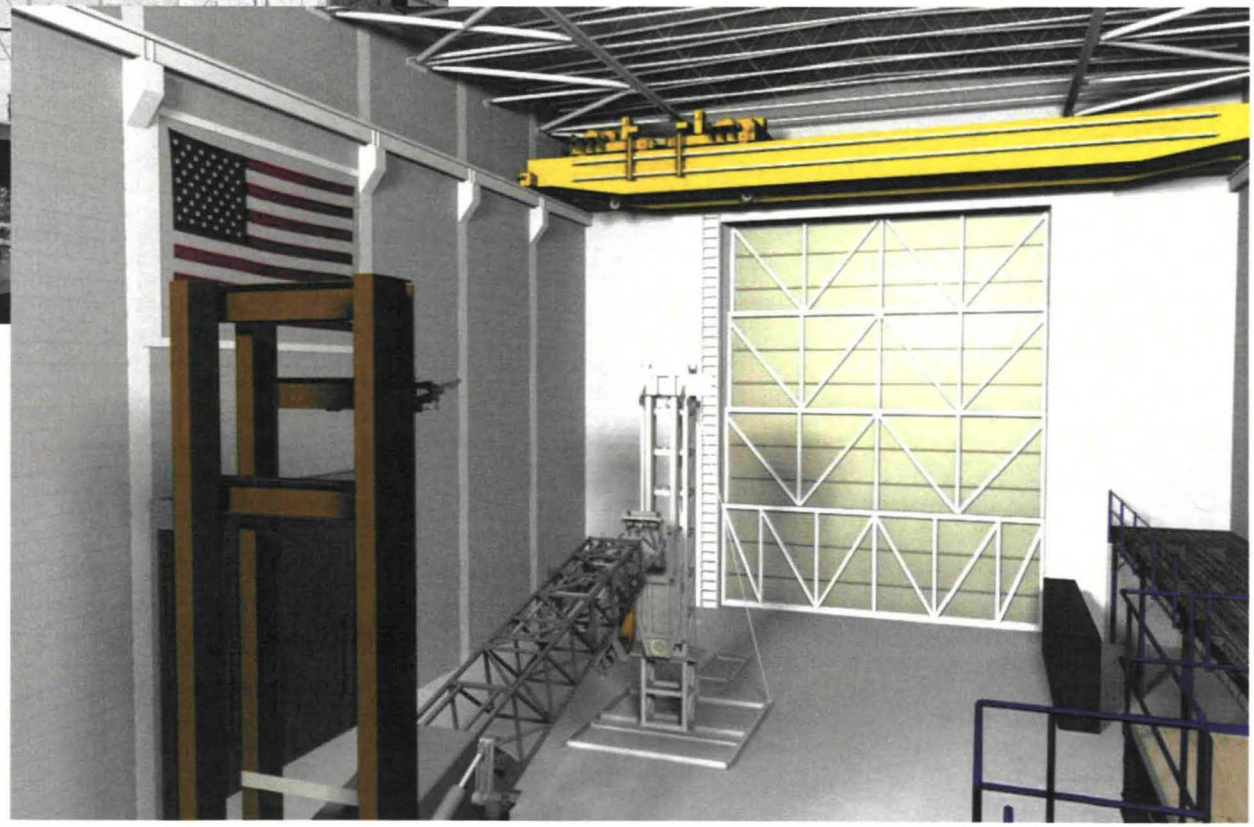
Life Cycle Design Drivers @ Kennedy

- We are typically at the end of the flight system lifecycle
  - Or, the receiving side of the fence
- But, we own lifecycles for :
  - Facilities, Control Systems, Transportation, Support Equipment
- These drove the need for:
  - Reverse Engineering (stuff designed in 1950's)
  - PDM/PLM (data from EVERY CAD package ever)
  - Process Modeling (DES, Flows, Constraints)
  - Cost Modeling, System Assurance
  - Design Visualization (will it fit, can I reach it, see it, do it)
  - Full System Simulation (early integration, interface verification)
  - Partners and Teammates
- And These Enabled
  - Successes, and Un-Ambiguous Communications

Reverse Engineering

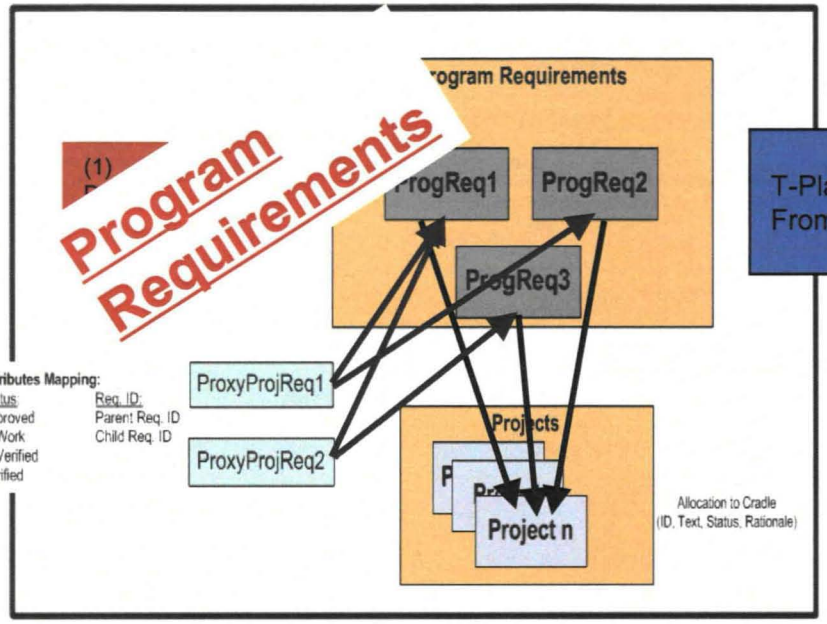


Drawings are NEVER wrong.

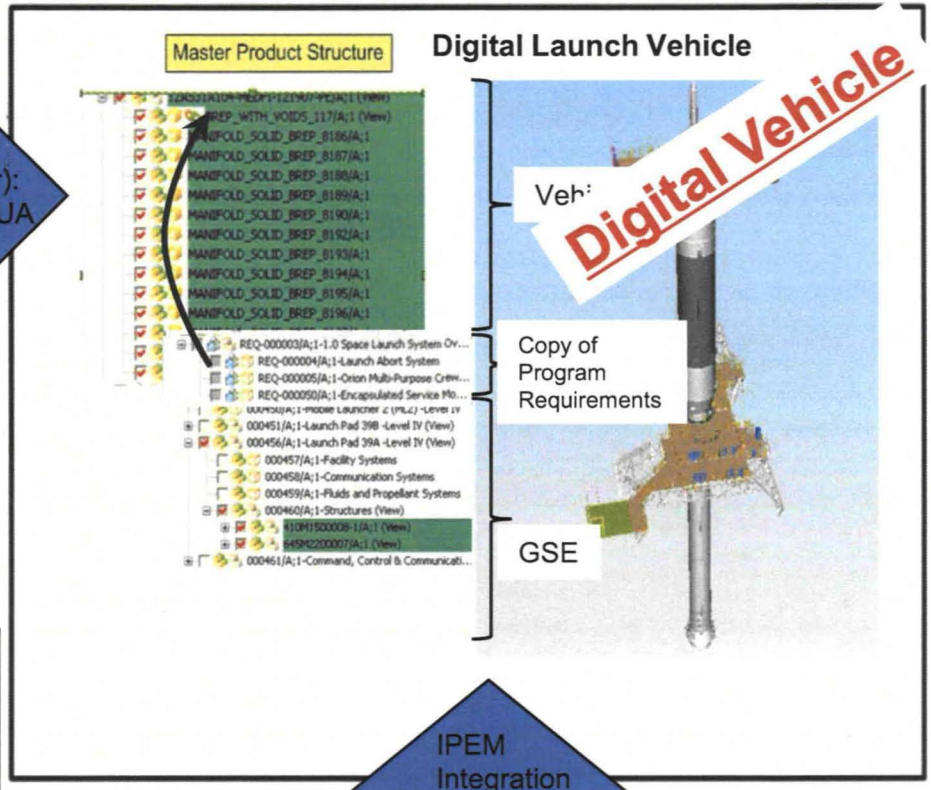


Did you know some Concrete Columns can migrate up to 10 inches?

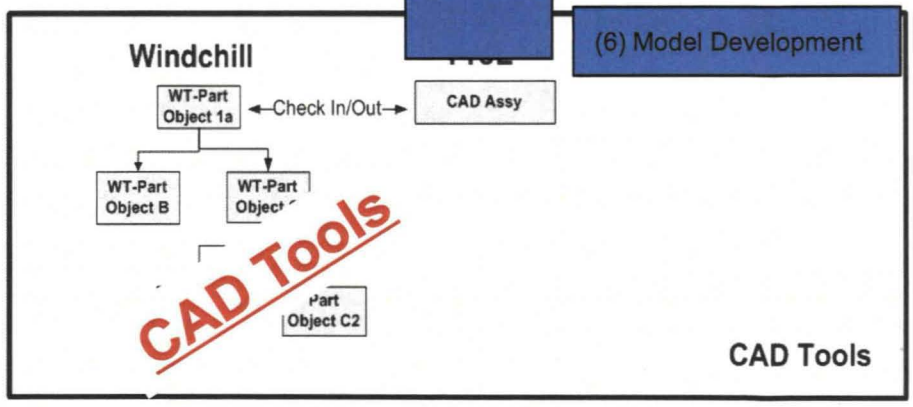
PDM/PLM = Req. Based Digital Vehicle



T-Plan (Integrator): From TcSE to TcUA



IPEM Integration



DCE POC & Pathfinder will:

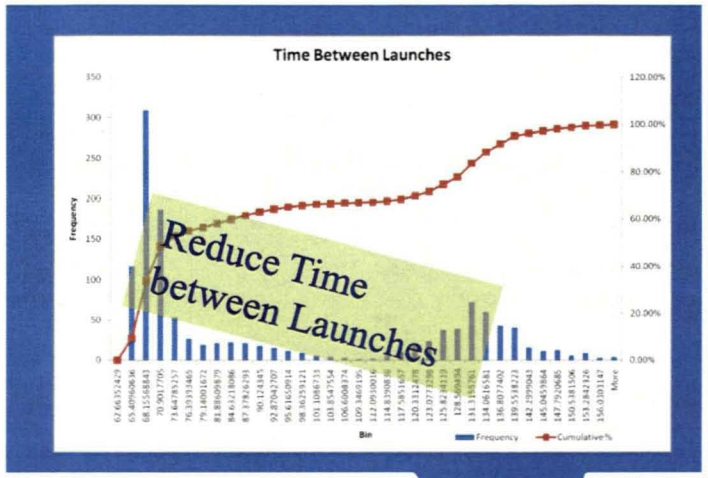
Develop/demonstrate the capability of sharing, passing and statusing of 3D neutral format design models and their corresponding product structures (indentured EBOMs) between disparate product data management (PDM) systems

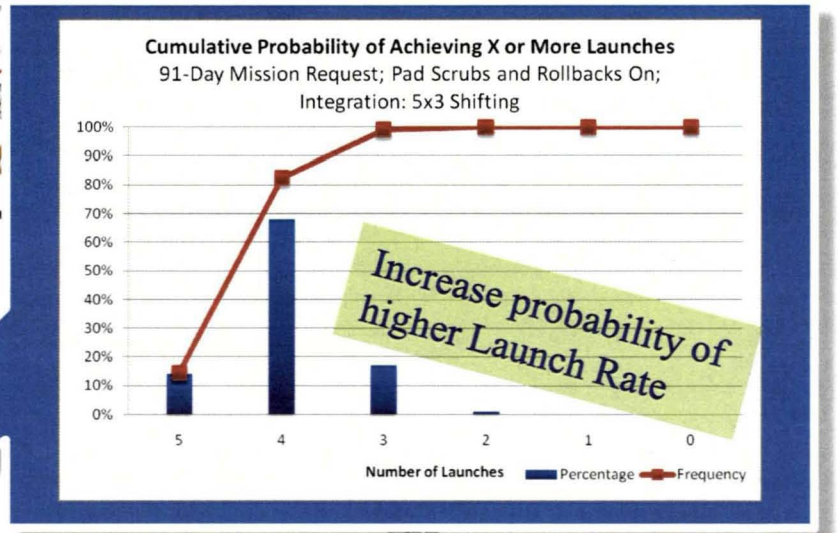
Steve Kennedy (steven.e.kennedy@nasa.gov)

Discrete Event Simulation (DES)

Represent System Processes in a time-based model…

… to perform systems performance analysis (capacity/time/resources)





180 days

79 days

669 days

6 days

669 days

200 days

RPOD Ops

ISS Attac

LEO Config
LEO Loiter

Ascent
+ Ascent Abor

Prod & Refurb

Standalone Ops
Integ Ops

Pad Ops

Post-Flight Processing
Refurb

Recovery

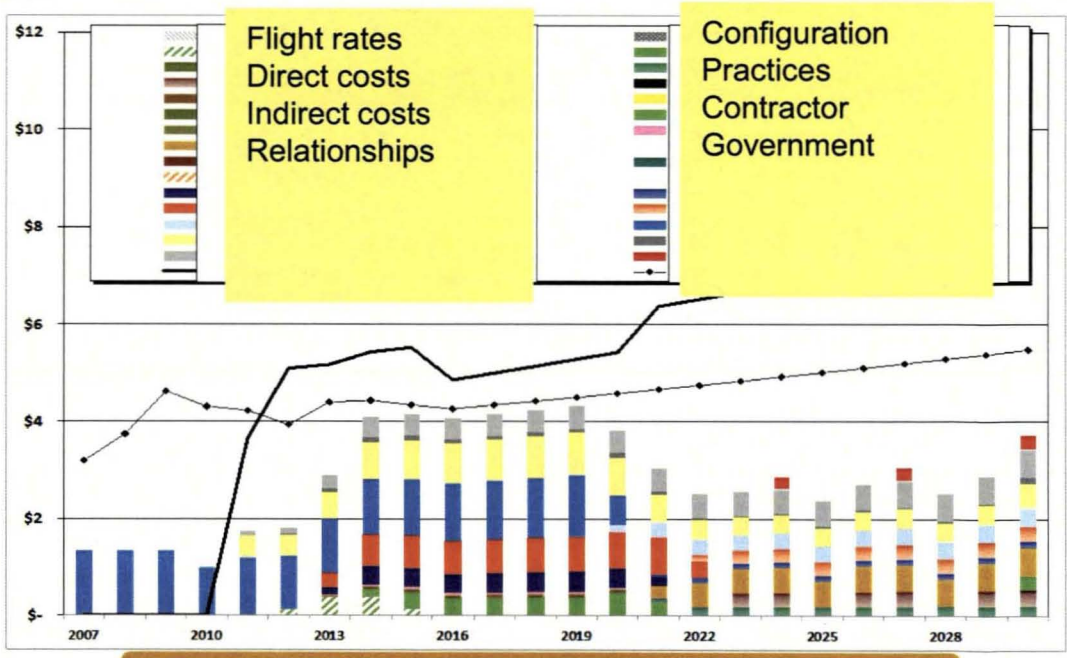
Post-Flight Processing
Refurb

Improve End-to-End System Production

Martin Steele (martin.j.steele@nasa.gov)

Life-Cycle Cost Estimation, Modeling, Analysis

- State-of-practice: Kennedy supports agency life-cycle cost estimation / analysis through quantitative, numerical modeling
  - Domain includes entire architectural view to just KSC ground operations field
  - Architectural analysis are macro-level, integrative, expertise intensive.
    - Launch vehicle, in-space element such as capsule, reusable vehicles, landers, habitats, ground ops, mission ops, etc.
  - Tasks may reuse or build upon prior models, or start models from scratch; Current tool of choice is Excel
  - Labor intensive effort involved for correctness, configuration control of many "what-if's" or "scenarios", and for automation, repeatability.

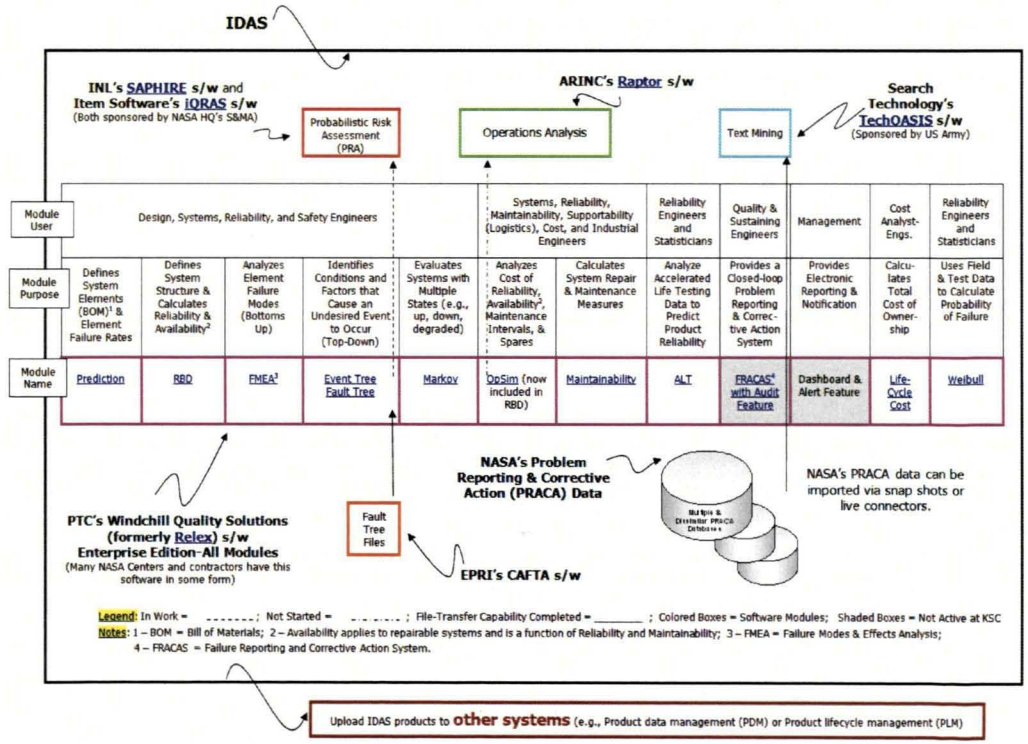


Budget Modeling Life-Cycle Output vs. a Target Resource Goal

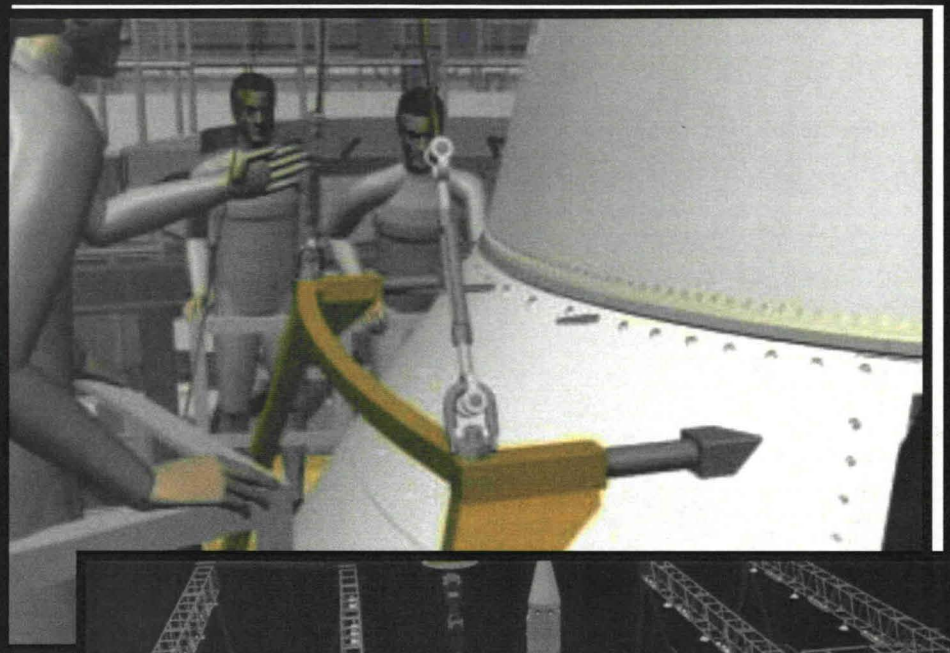
Edgar Zapata (edgar.zapata-1@nasa.gov)

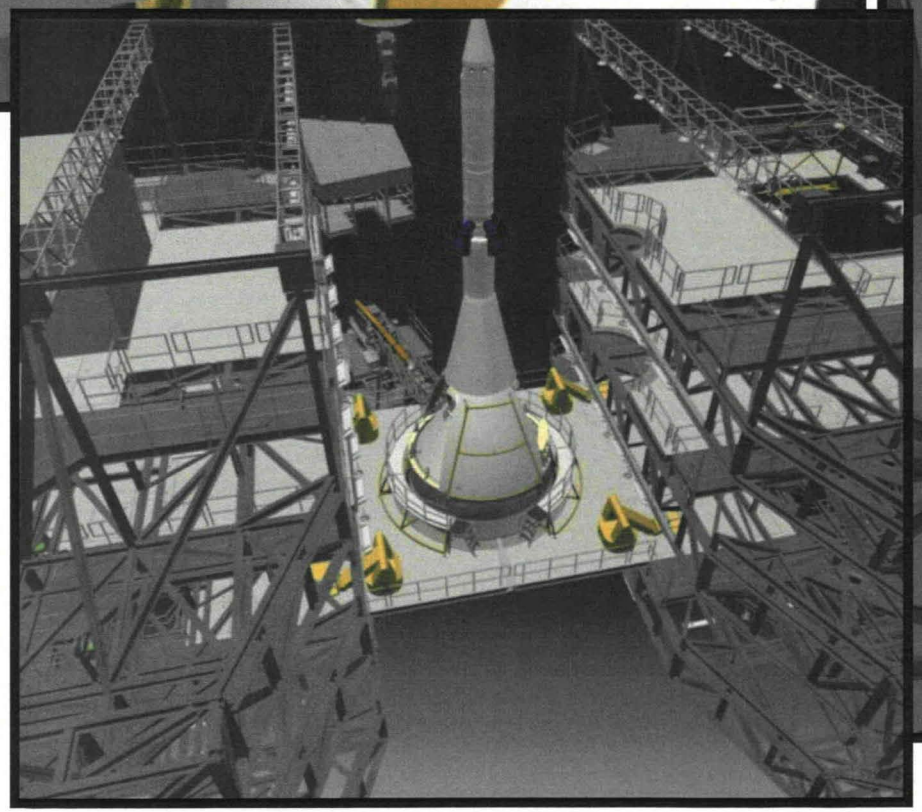
Engineering Assurance Modeling & Analyses

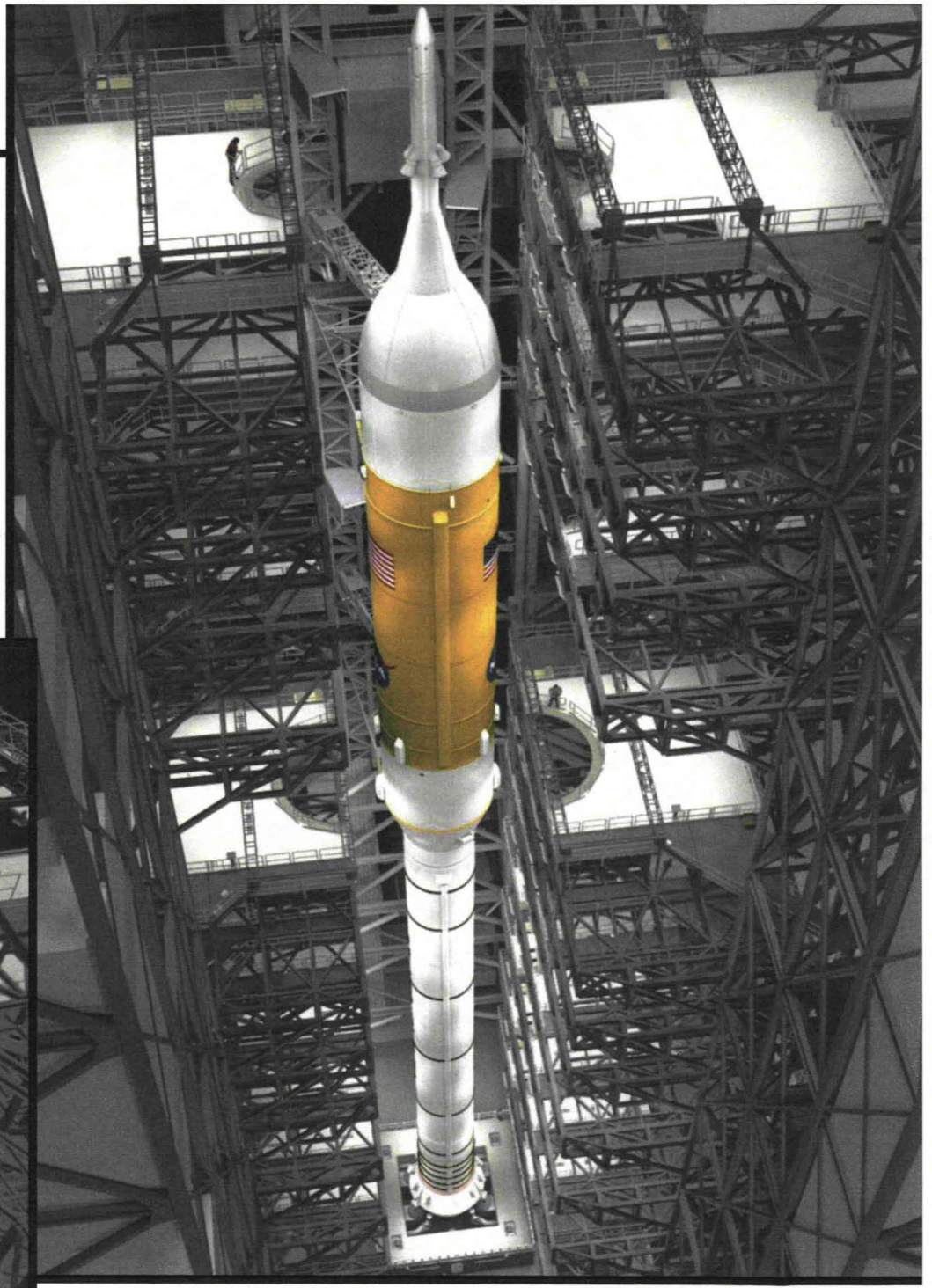
- Kennedy provides a set of COTS tools called the Integrated and Design Assurance System. IDAS **enables employees to "learn and do" engineering assurance analyses across a system life cycle**.
  - These modules allow engineers to predict and analyze operating outcomes such as reliability, maintainability, availability and safety at any stage of a complex system's life
- IDAS allows an **equipment list** (bill of materials) to be imported and used t**o populate the modules**.
- IDAS is **paperless**, provides **online training**, **supports teams**, and allows users to build, run, and view analyses then **upload results to Kennedy's PDM**.
- IDAS supports all KSC programs. For Constellation's ground systems, it was used by KSC Systems Engineers in conjunction with KSC Design Engineers to identify and execute 100+ design changes prior to build.



Design Visualization

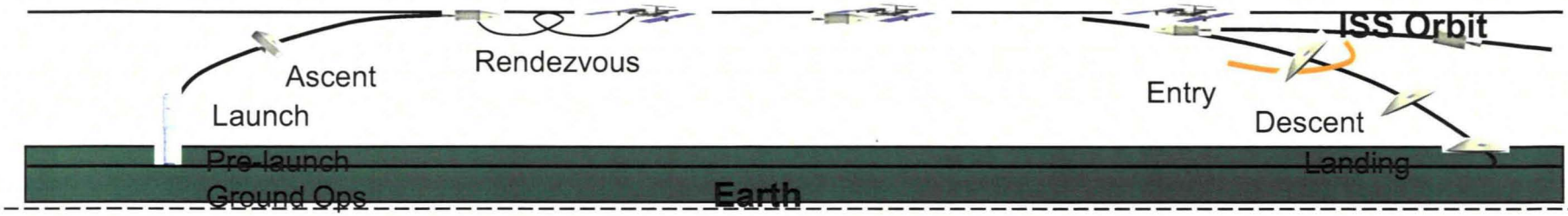




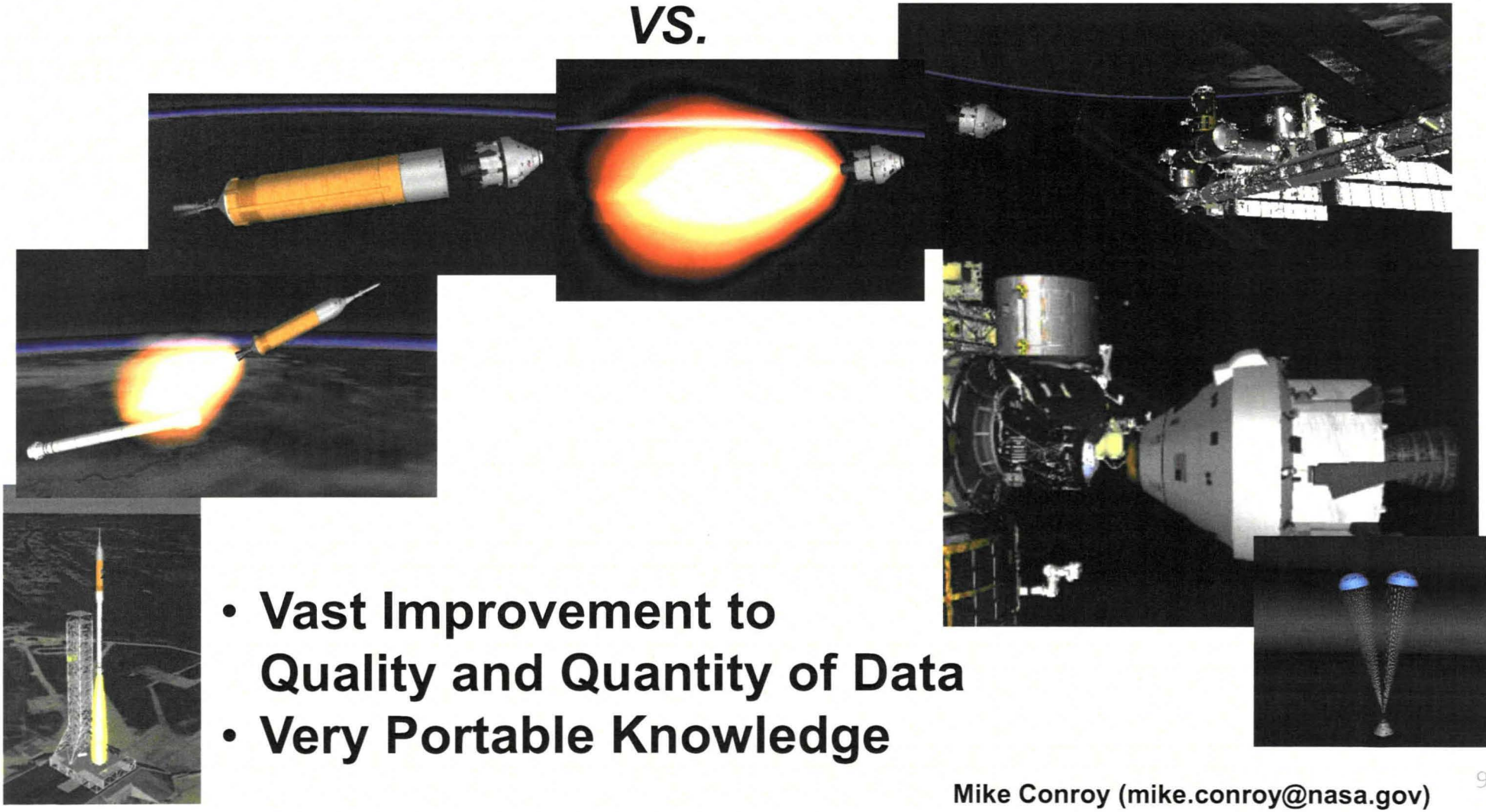


Tracey Kickbusch (tracey.e.kickbusch@nasa.gov)

System Simulation



VS.



- **Vast Improvement to Quality and Quantity of Data**
- **Very Portable Knowledge**

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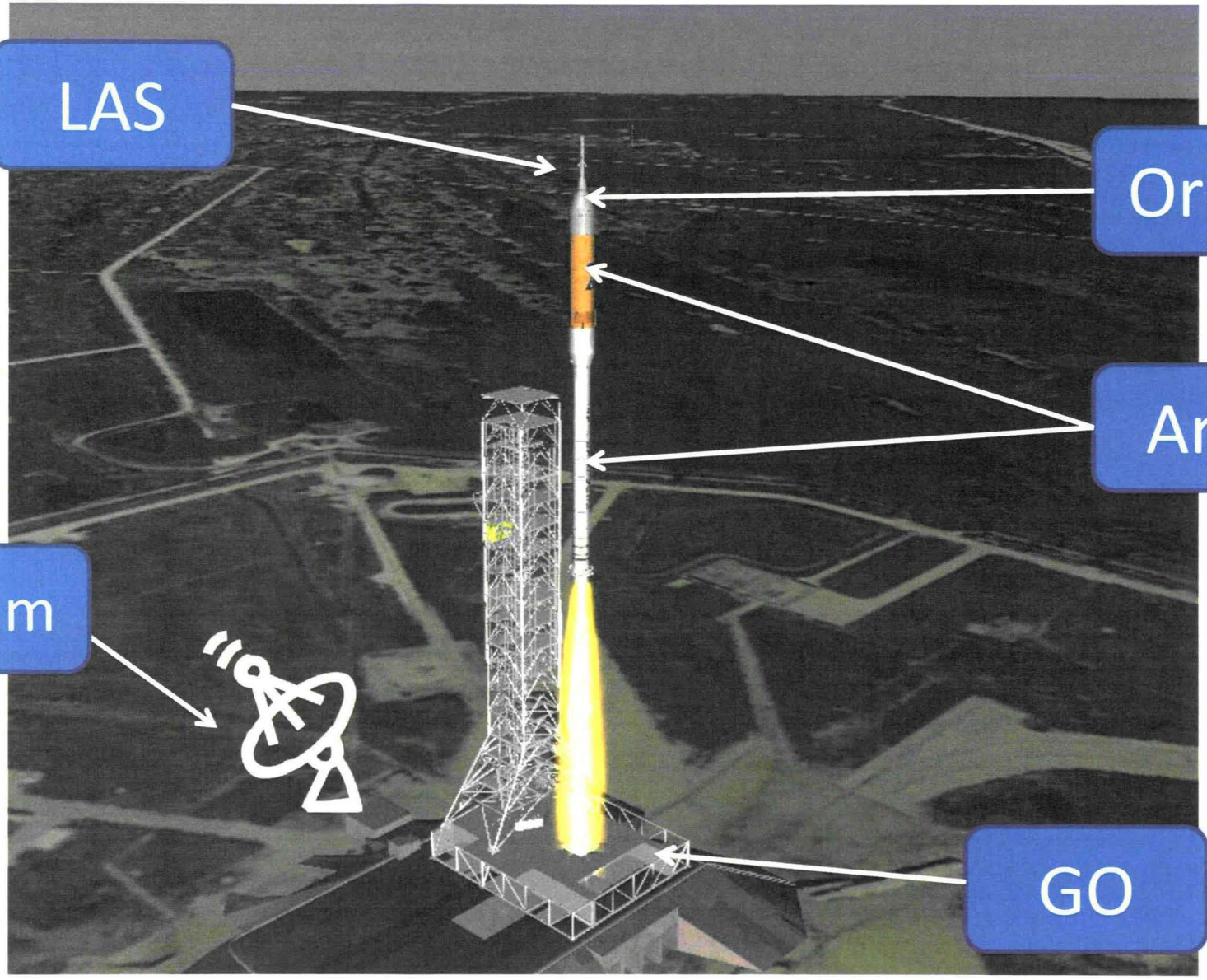
Early Integration



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CfLCD

- Center for Life Cycle Design
  - A Foci for System and Life Cycle Thinking
  - Concept Development, Innovation, Design, Development, Manufacturing, Operations
  - Purposing and Re-Purposing
  - Government, Industry, Academia, International
  - Smackdown for Workforce Education and Development
    - Opportunity here, UCF does not have a team
  - Complex System Conceptualization and Instantiation

- Addressing All of the Above
  - Stepping far enough back from the problem to see all of it
  - Share the Problems that are discovered
  - Share the Opportunities as they emerge

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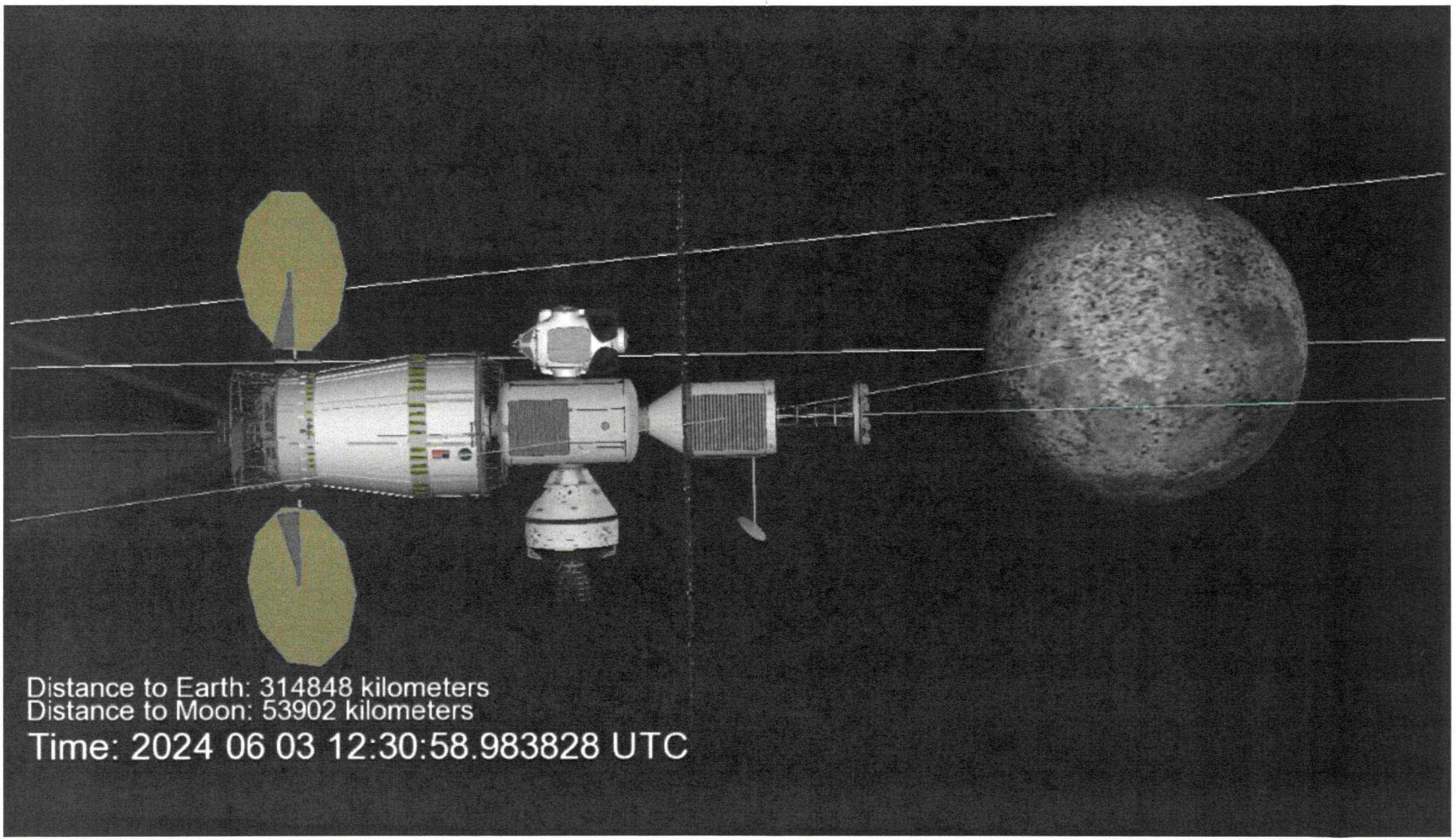
Priscilla Elfrey (priscilla.r.elfrey@nasa.gov)

Goal: Simulation Based Architecture Maturation

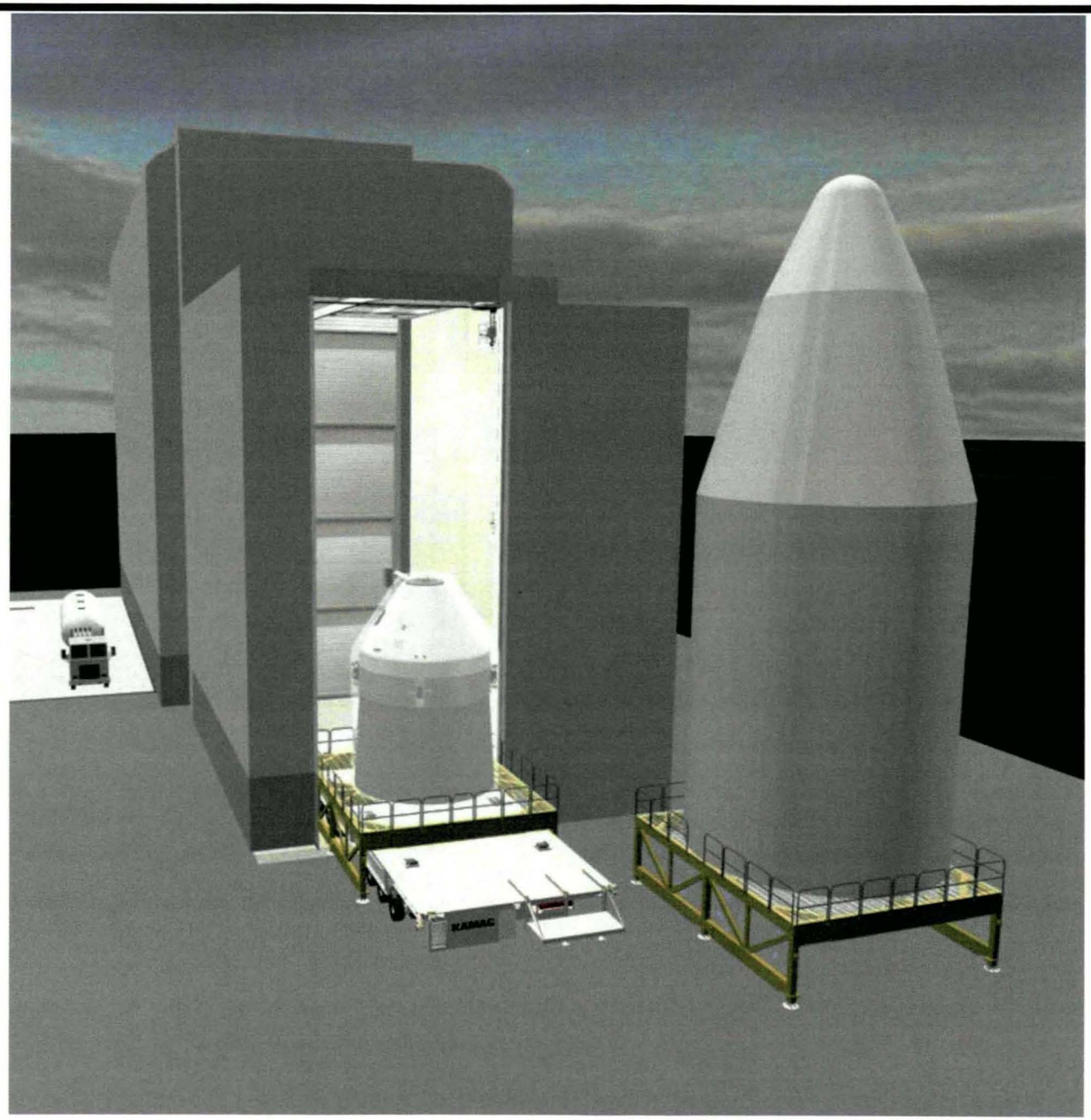
- System Representations, in a Relevant Environment



Rebecca Mazzone (rebecca.mazzone@nasa.gov)

Representative Un-Ambiguous Communications and Cool Stuff

Really, it will NOT fit



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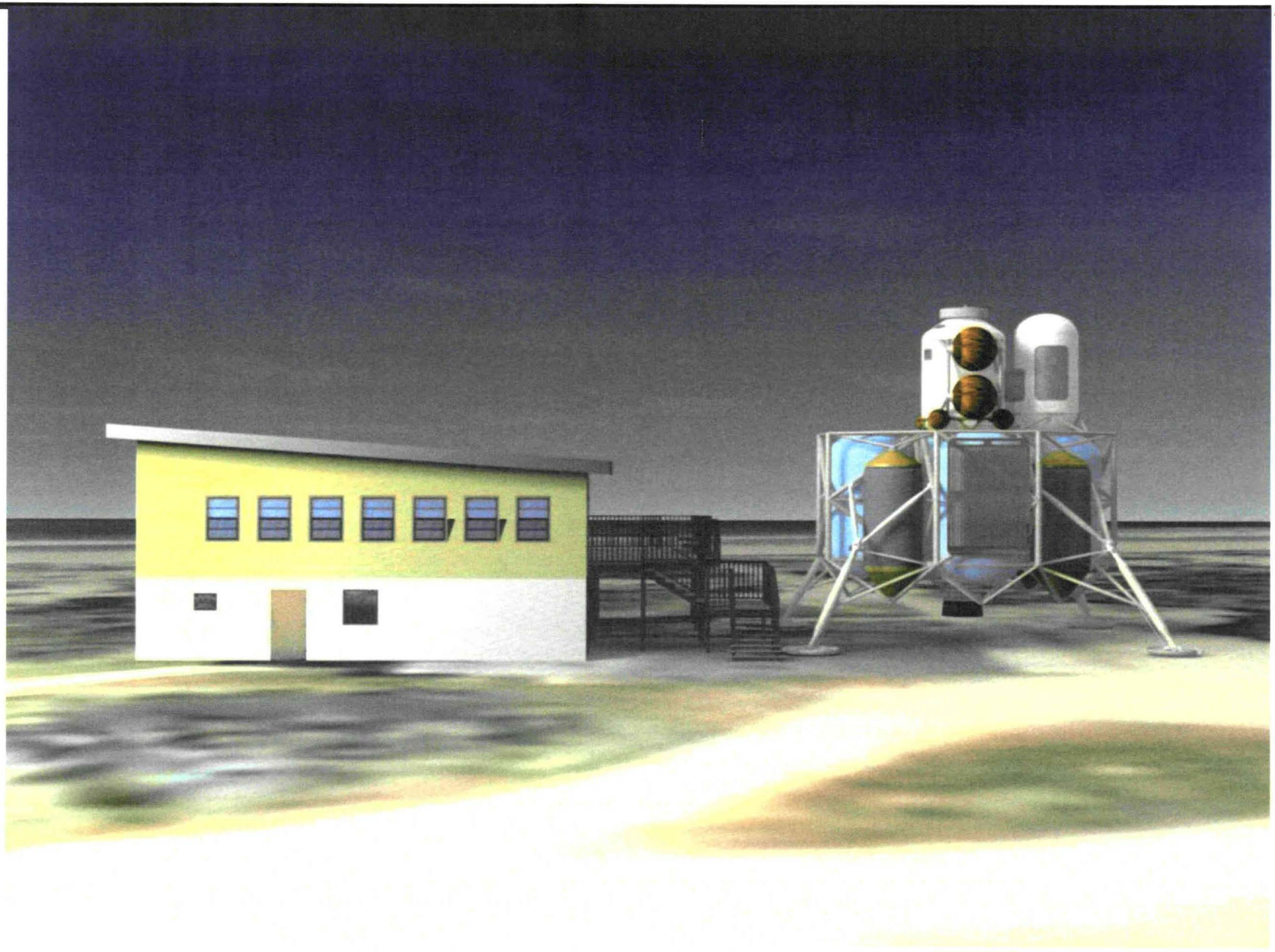
Yes, Altair, it IS to scale



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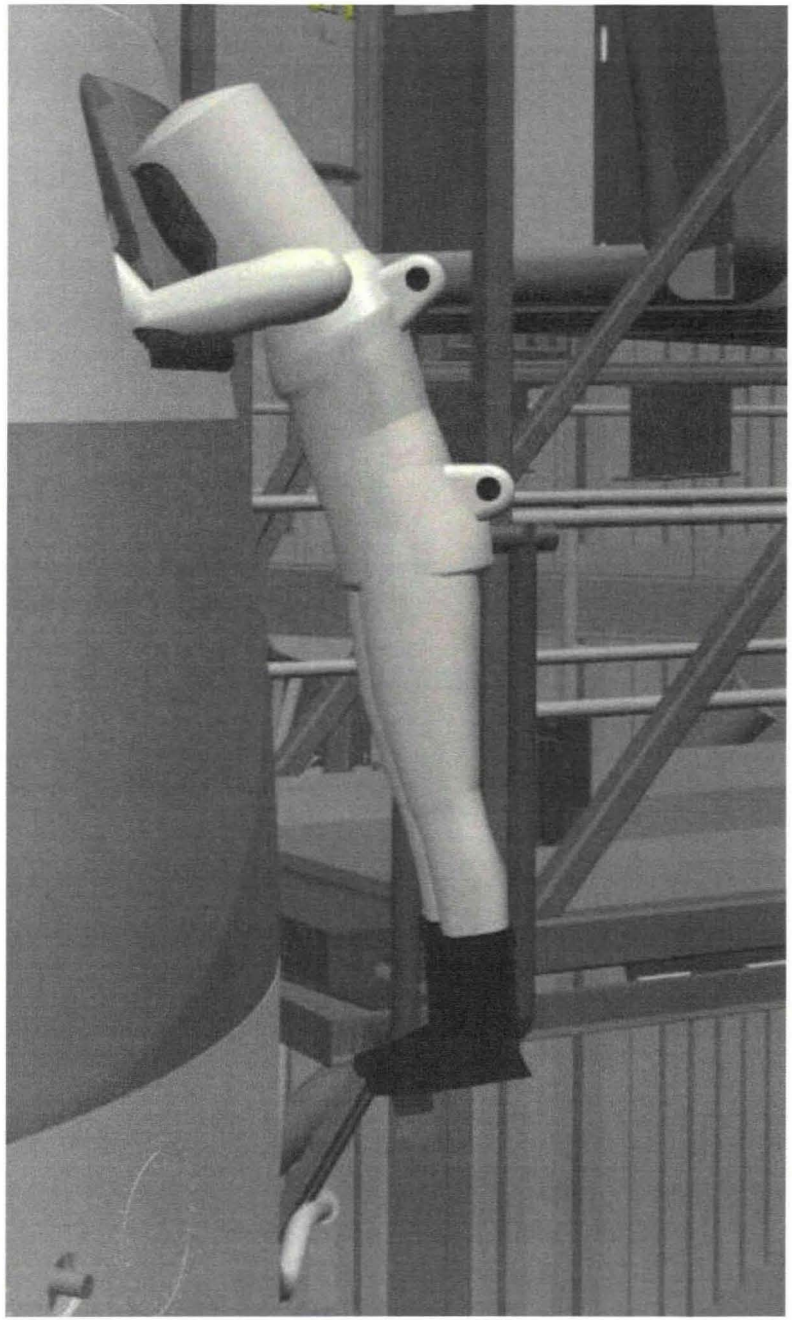
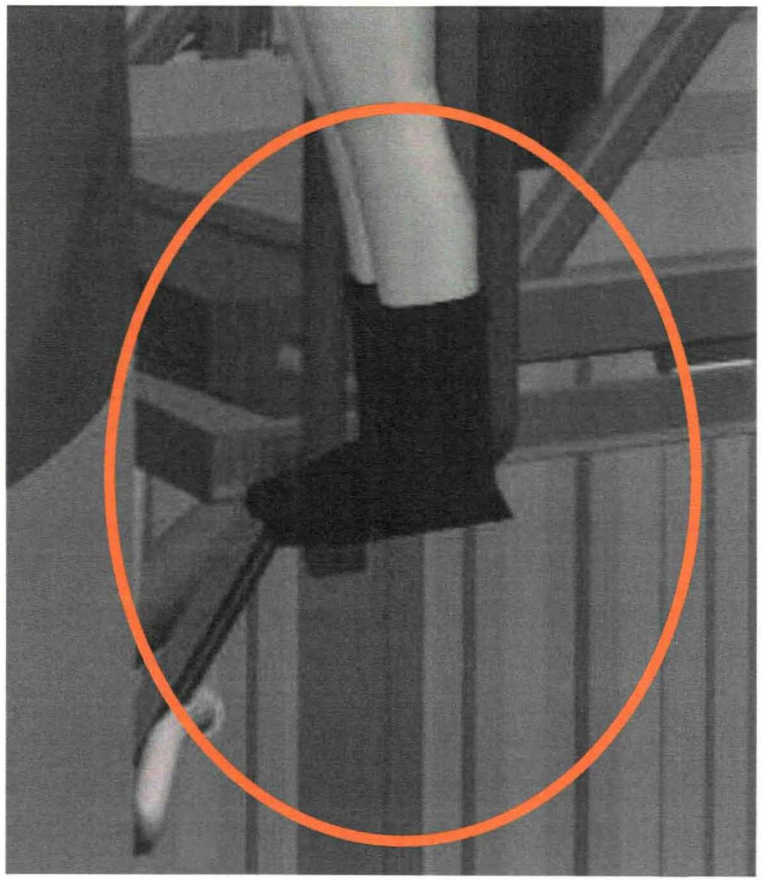
Safety said NO!





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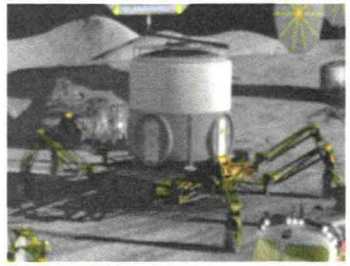
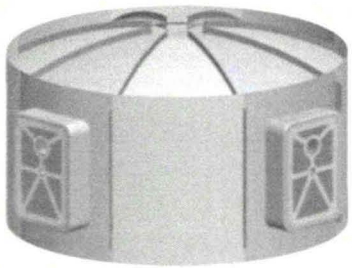
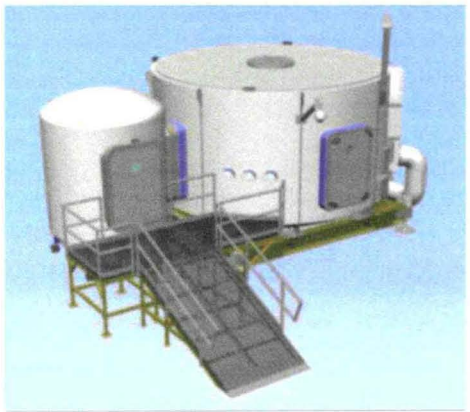
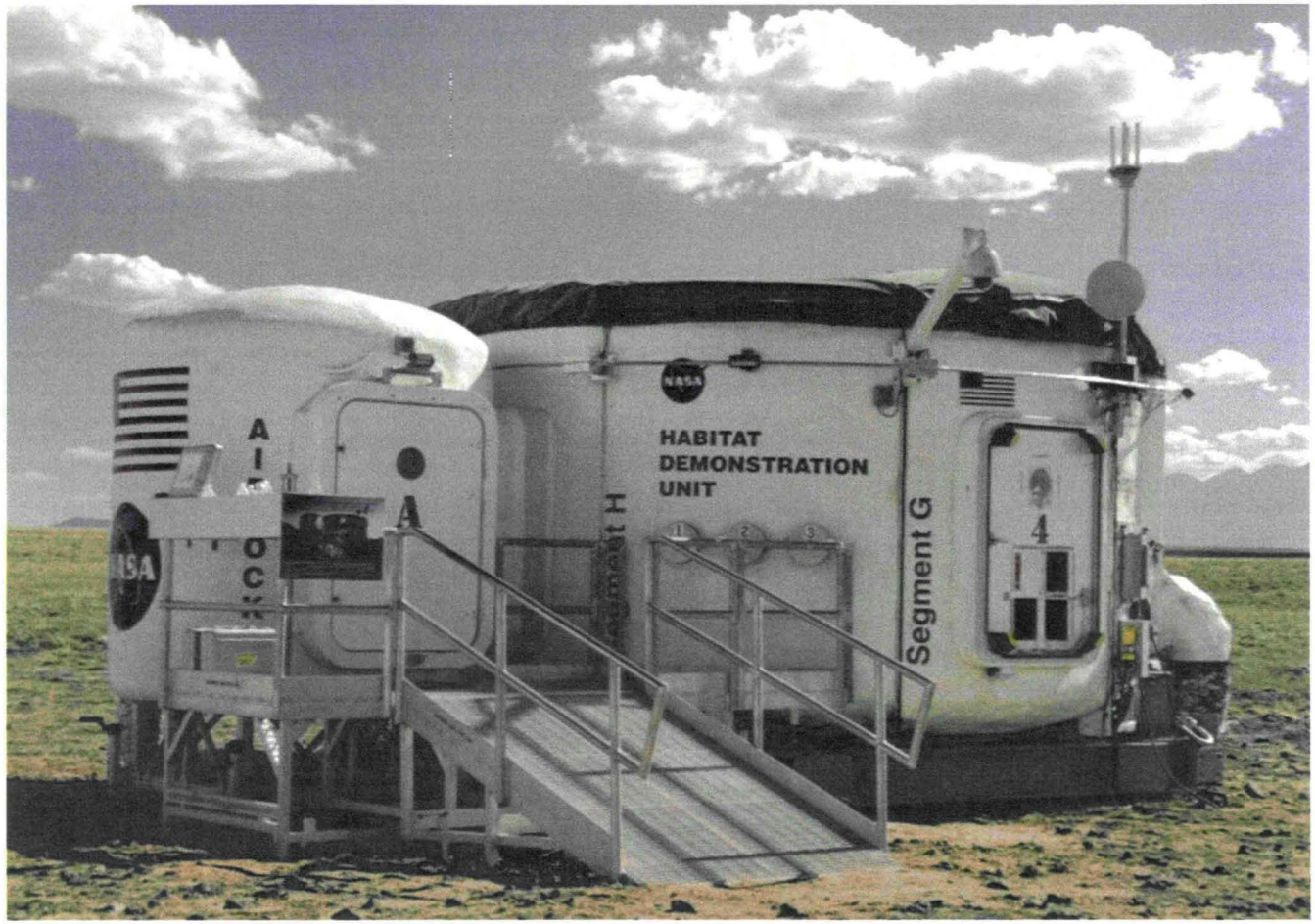
HDU Concept Realization









Concept

Design

Development

Done

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Back-Up
Preliminary Opportunities
and contact information

Reverse Engineering Opportunities

- Point Cloud Reduction:
  - So the data can be used in lower order tools
  - Does Color Help
- Smart Model Development
  - We can now use the points as solid objects, but only in highest order tools ($200K++)
- Intelligent Tools
  - Data Interpretation
    - What do all these points really represent
    - What is missing, in time to actually get it

PDM / PLM Opportunities

- Plan is to develop the requirements, standards, DRDs and data architectures to improve:
  - NASA Engineering's Model Based Systems Engineering (MBSE),
  - Cross center/prime/program collaboration,
  - Engineering release capabilities (initially Requirements)
  - CAD/PS management – (amongst disparate tools & orgs)

- This will in turn:
  - Provide insight into a range of process solutions by enabling technology application
    - (PDLM, Engineering Release, Data Interoperability, Standards)
  - Feed all the other Opportunities

The Future of Process Analysis is…

What

Ubiquitous model and data fully integrated with the "real world"

How

Instantaneous Model building, data availability, & systems analysis

To make this a reality:	Applicable fields:
Easier (and more rapid) model building Build the model as you build the real world system (MBSE)	Computer Science, Industrial Engineering
Easier & more complete data availability Both valid & live data	Computer Science/Engineering Electrical, Industrial, Mechanical Engineering
Interactive display of simulation data shown in context of the real world system	Computer Science/Engineering
Display of real world system with live data mixed with simulation data	Computer Science/Engineering, Electrical, Industrial, Mechanical Engineering
Seamless integration with other types of simulation and project management system	Computer Science/Engineering Electrical , Industrial, Mechanical Aerospace, Engineering
Real-time optimization	Computer Science/Engineering Industrial Engineering

Life Cycle Cost Opportunities

- Needs:
  - Tools, methods, or practices that can organize or structure information quickly into numeric calculations with Scalability, Flexibility, and "Reusable Libraries"

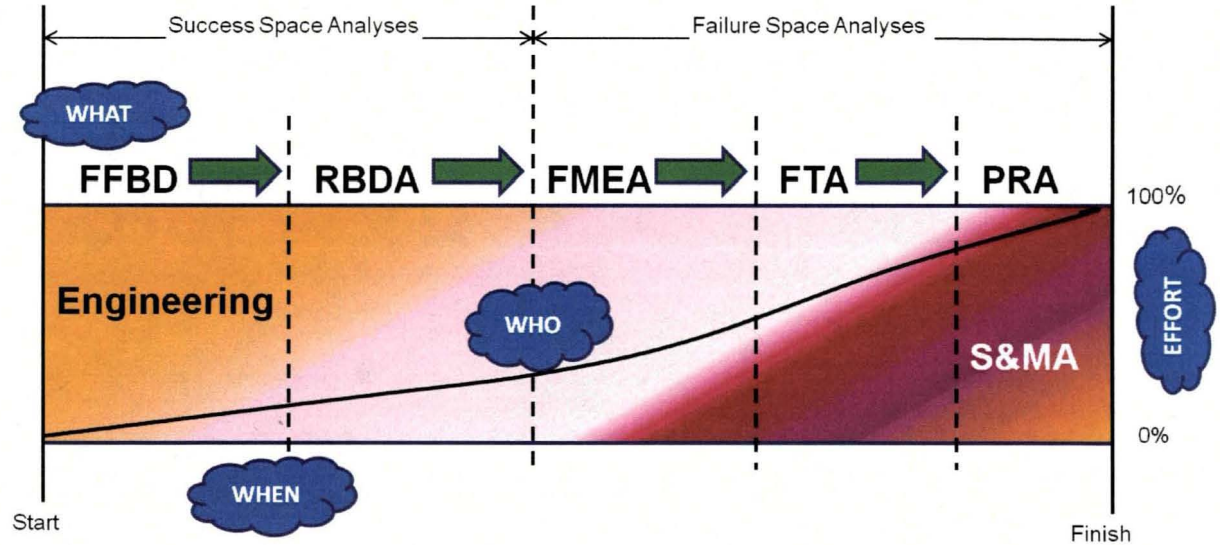
- Past efforts (xml, ontologies, dedicated software/wizards, etc.) have provided new challenges that continue
  - Huge Data
  - Evolving Dynamic Systems
  - Massive Flexibility

Engineering Assurance Opportunities

- Data transfer from one vendor's tool to another vendor's tool is a challenge and sometimes nonexistent. When a vendor's tool cannot accept data from a competing tool it encourages camps to form and users to waste time competing on which tool should only be used.

- The training of engineers on engineering assurance analyses needs to include the purpose of the various methodologies and how these methodologies can produced in an integrated manner. The sequence show is one way. Analyses in themselves have a life cycle—especially in engineering design.

An Idealized Life Cycle for Engineering Assurance Analyses



Analytical Products:
FFBD = Functional Flow Block Diagram
RBDA = Reliability Block Diagram Analysis
FMEA = Failure Modes & Effects Analysis
FTA = Fault Tree Analysis
PRA = Probabilistic Risk Assessment

Theme:
This work sequence (WHEN) builds and uses analytical products (WHAT) in an optimum manner—especially during the Design Phase. The appropriate mix of experts (WHO and EFFORT) make and deliver the right analytical product at the right time. In addition to serving the intended purpose at the desired time, each analytical product serves as an input that expands the technical fidelity of analytical products that follow.

Tim Adams (tim.adams@nasa.gov)

Design Visualization Opportunities

- Agent Based Inspection
  - An agent architecture, interface that will allow the inclusion of agent based intelligence into the simulation

- Polygon Reduction
  - Work done in these tools is fine, but is limited in portability. The hard problem is polygon reduction from the 10's of millions used here to the millions available in lesser tools.

System Simulation Opportunities

- Expansion of Talent Base
  - Smack Down:
    - Simulation of relevant systems (lunar base, ISRU, communications)
    - Is International, Strong Faculty leadership in Europe, and it shows
    - Real World Tools, Technologies, Problems and Solutions
- Agent Based Analysis
  - Rich representations of systems in synthetic environment, need synthetic analysts
- Symantec Technologies
  - Huge data, How do you store, catalogue and prepare for future utilization
- Maturation of Standards
  - We need more than we have