Playing Nice Across Time & Space

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

mike.conroy@nasa.gov
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)

LAS (LaRC)

Orion (JSC)

Ares (MSFC)

Comm (JPL)

GO (KSC)
Simulation Speeds Communication

• It is non-threatening (‘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
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

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<thead>
<tr>
<th>Inputs Agree with Real World Data</th>
<th>De facto Standard</th>
<th>M&amp;S Management</th>
<th>People Qualification</th>
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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.

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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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Mission Metadata
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
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<tr>
<td>Reliable error estimates used, small errors across key elements</td>
<td>Results compare favorably to real-world system</td>
<td>Inputs agree with real-world data or from &gt; 3.5 summary M&amp;S</td>
<td>Quantitative and based on Non-deterministic &amp; numerical analysis</td>
<td>Sensitivity known for most parameters (all of the most sensitive cases)</td>
<td>De facto standard</td>
<td>Continual process improvement to improve result repeatability</td>
<td>Extensive experience and use of recommended M&amp;S practices &amp; tool</td>
</tr>
<tr>
<td>Formal method is used to assess unit testing errors</td>
<td>Results agree with experimental data for problems of interest</td>
<td>Inputs agree with exp. data for problems of interest or from &gt; 3.0 summary M&amp;S</td>
<td>Quantitative and based on Non-deterministic analysis</td>
<td>Sensitivity known for many parameters</td>
<td>Previous predictions were later validated by mission data</td>
<td>Process measured for repeatability</td>
<td>Adv. degree or extensive experience, recommended practice knowledge</td>
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<tr>
<td>Favorable results from key feature unit / regression testing</td>
<td>Results agree with experimental data or other M&amp;S on unit problems</td>
<td>Inputs traceable to formal doc., or from &gt;2.0 summary M&amp;S</td>
<td>Based on deterministic analysis or expert opinion</td>
<td>Sensitivity known for a few parameters</td>
<td>Used before for critical decisions</td>
<td>Established process for development and operations</td>
<td>Formal M&amp;S training and experience + recommended practice training</td>
</tr>
<tr>
<td>Favorable evidence of verification for concept &amp; math models</td>
<td>Concept and math models agree with general and textbook references</td>
<td>Inputs traceable to informal doc., or from &gt; 1.0 summary M&amp;S</td>
<td>Based on qualitative estimates</td>
<td>Sensitivity estimated, qualitative, based on analogy</td>
<td>Passes simple tests comparing with other similar tools</td>
<td>Roles and Responsibilities defined and managed</td>
<td>Engineering or science degree</td>
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SEE 7009 CAS Score = 0-1-0-0-0-1-1-1
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

<table>
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<th>System Engineering Phases</th>
<th>Pre A</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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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)

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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.