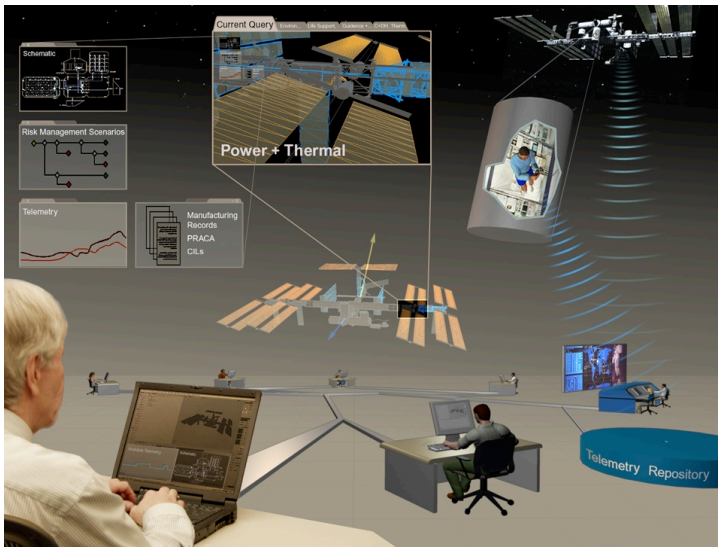
Virtual Iron Bird – a Systems Thinking Environment

A Virtual Iron Bird is a *Knowledge-Integrating Virtual Vehicle*. It is a 3D CAD-based visualization-model integrated with functional and behavioral models of the vehicle. It is intended to assist vehicle system engineers as they research and evaluate design and operational tradeoffs.

Background

SimStation is an instance of a Virtual Iron Bird. It actually serves as a knowledge management system for the vehicle. The illustration shows an imaginary case of an engineering team researching a concern with the rotary joints that keep the solar array wings pointed at the sun. The team shares ready access to geometry, schematics, telemetry histories, risk scenarios, and engineering documents. A behavioral simulation is in use to evaluate operational tradeoffs, such as how changes in vehicle attitude control strategies will reduce wear on the joints. The datasets are cross-indexed and linked within the context of the analysis, so the team spends less time looking for basic information and more time thinking about solutions and communicating them within a shared environment.

There are already a great many tools for simulating and managing the ISS. For the most part, however, these tools are disconnected from each other. They're useful because skilled engineers run them while working within a large engineering organization. Similarly, NASA and its contractors already have an enormous and reasonably effective engineering repository. However, it is a *document* repository. While documents are currently the lifeblood of engineering organizations, they cannot be operated on by software and combined to answer unanticipated queries. Given the constraints of these tools, it takes years of intensive study and working experience for engineers to develop a *big picture* understanding of space station design and operations. Knowledge is widely scattered and no tools exist that cover all aspects of station design and operations. SimStation's goal is to span this range of knowledge to a moderate depth and provide guidance to appropriate in-depth tools. As such, SimStation sits on top of the document repository, helping users navigate to find answers in ways complementary to the full-text indexing capabilities already available. Similarly, SimStation will in a sense sit on top of existing high-fidelity simulations, by providing a quick-look capability to help system engineers brainstorm potential solutions quickly and decide which potential solutions merit more costly detailed analysis.



Research Overview

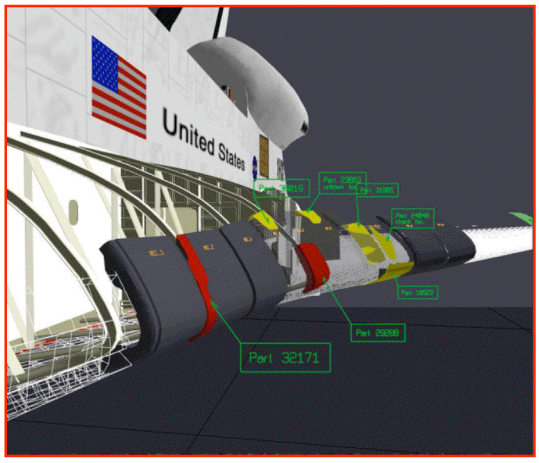
To address the dual nature of the challenge, SimStation builds upon two powerful ideas: System Dynamics (Forrester, Jay W. 1961 Industrial Dynamics, Portland OR, Productivity Press) and Mirror Worlds (Gelernter, Mirror Worlds). System Dynamics or Systems Thinking was developed by Forrester as a method of understanding and characterizing extremely complex systems like ecologies or economies. Whereas traditional forms of engineering analysis focus on separating the individual pieces of what is being studied, Systems Thinking focuses on how the individual pieces being studied interact with the other elements of the system. Systems Thinking involves including more and more interactions to study the often non-intuitive behavior that immerges from those interactions. System Dynamics has proven its value in a wide range of situations, particularly in complex problems that involve helping many actors see the *big picture* and not just their localized portion of it. This approach has been popularized by the SimCity series of educational software games developed by Will Wright, Jeff Braun and a development team at Maxis/Electronic Arts, and by a wide range of business simulation packages. By choosing the name SimStation, a name that echoes these predecessors, we have set a very high bar for our project.,

Virtual Iron Bird – a Systems Thinking Environment

We want to disseminate SimStation broadly throughout the ISS engineering community, and a limited access version to the public for education and awareness of the program. Many SimStation design choices stem from these twin foci of wide dissemination and helping people explore the big picture, notably in the areas of simulation level-of-detail and in the use of commercial off-the-shelf technology.

SimStation runs on engineering desktops and laptops and can perform some functions standalone, particularly the 'quick look' trade studies. We are also developing a web-based version, called SimStationOnLine,

The *complex systems* description fits the ISS perfectly and aerospace systems in general. We believe that new ideas are needed to enable engineering organizations to meet the challenge of NASA's new exploration vision. How NASA solves the challenges of the International Space Station will form a baseline for future exploratory missions. Simulations and knowledge management are increasingly requirements for the development of ambitious aerospace vehicle projects. Aerospace systems are challenging to manage, and system interactions are growing more complex. Success often depends on a limited number of people with amazing abilities to mentally visualize complex systems. Sharing these visions within the team is a challenge that we are trying to support with SimStation. We observe that working meetings frequently come to a halt at the point where a senior person asks how something is happening, and a team leader has to answer with a promise to come back with a response within the next few days. We imagine great gains in efficiency if a team can access existing knowledge right there when the question first comes up, and then continue the reasoning process with minimal interruption. We seek to provide that sort of access to information.



As an organization, NASA is more family than bureaucracy. NASA's high profile disasters are taken very personally by all involved, and have been thoroughly studied and reviewed over and over again; notably Apollo 1, Apollo 13, Challenger, and Columbia. These have been very expensive disasters, physically, financially and emotionally, and all the more so in that the public shares in this. In retrospect each of these disasters could have been prevented by better understanding, communication, and foresight. Nobody on the NASA team wants to repeat such lessons. Getting a coordinated view of complex aerospace systems is at best extremely tedious and bordering on impossible. Sharing a coordinated view through a knowledge management system is a high priority for all

Relevance to Exploration Systems

Virtual vehicles as knowledge integrating environments offer a dramatic evolution in managing full life-cycle systems integration for the constellation of exploration vehicles.

H&RT Program Elements:

This research capability supports the following H&RT program /elements:

ASTP Software, Intelligent Systems & Modeling

TMP Advanced Space Operations

Points of Contact:

Mark Shirley, NASA
(650) 604-3389
mshirley@mail.arc.nasa.gov

Tom Cochrane, Raytheon
(650) 279-8335