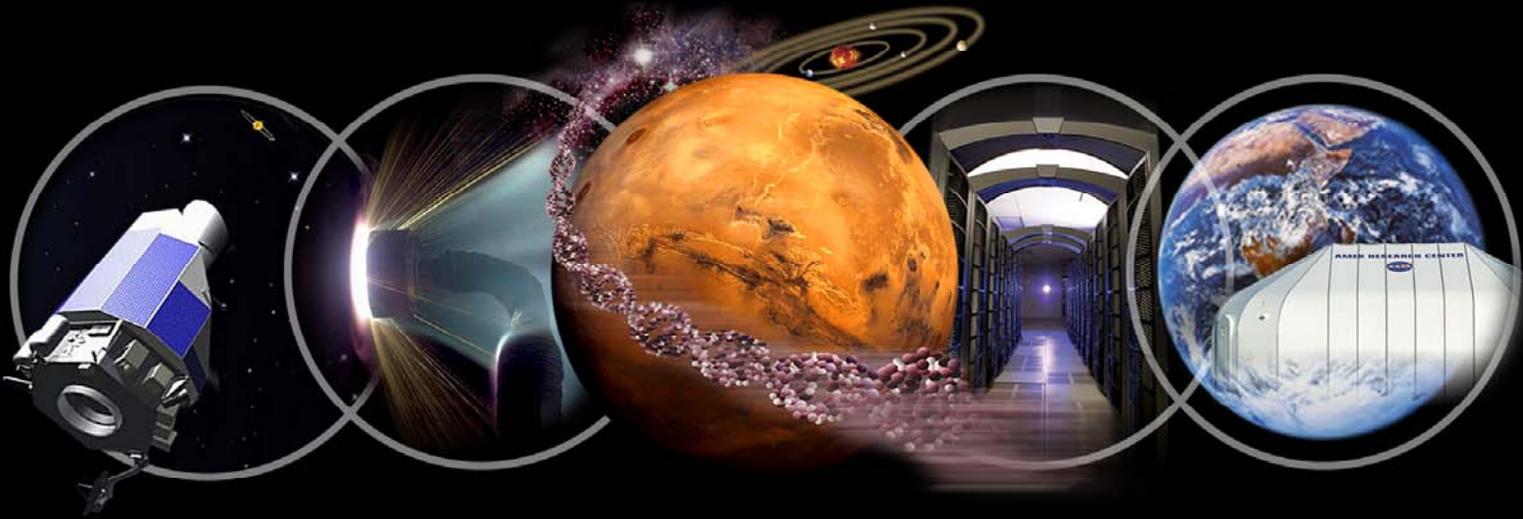


Discovery ➡ Innovation ➡ Solutions



# Integrated Systems Health Management

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ISHM POC, Computational Sciences Division

Ames Exploration Systems Technology Partnerships Forum

July 22-23, 2004



Visibility ➡ Excellence ➡ Impact





# ISHM

*Vision*

**Increase the safety, reliability, affordability, and effectiveness of NASA missions through integrated health assessment and management of complex, mission-critical vehicles, structures, and systems.**





# ISHM

## *Definition*

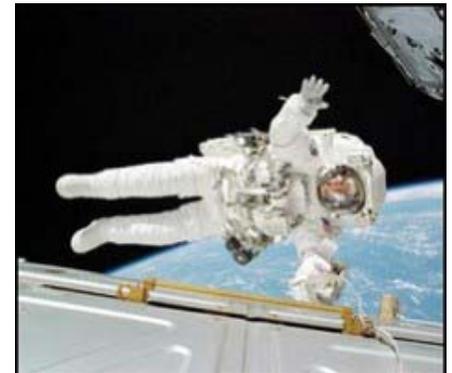
**I**ntegrated Systems Health Management

**N**ot a specific technology, system, or architecture.

**M**anagement, not "monitoring."

**A** system engineering discipline encompassing a variety of technologies and methods.

**A**pplicable to any complex system - vehicles, habitats, space suits, software, networks ...





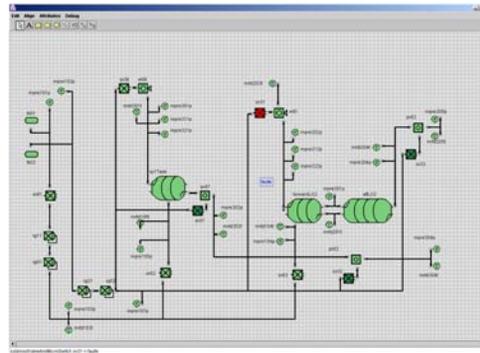
# ISHM

## Ames Legacy

**Deep Space One: First in-space experiment with autonomous command and control (Remote Agent Experiment) (joint work with JPL) (1999)**



**SLI (Strategic Launch Initiative): Ames leadership in IVHM for OSP and NGLT**

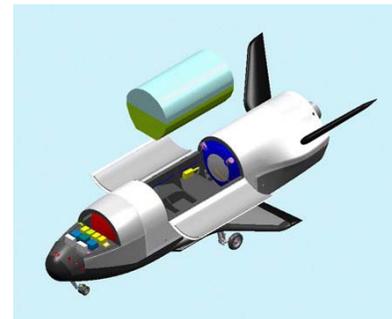
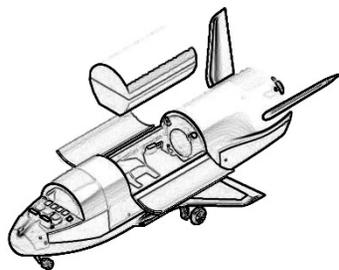
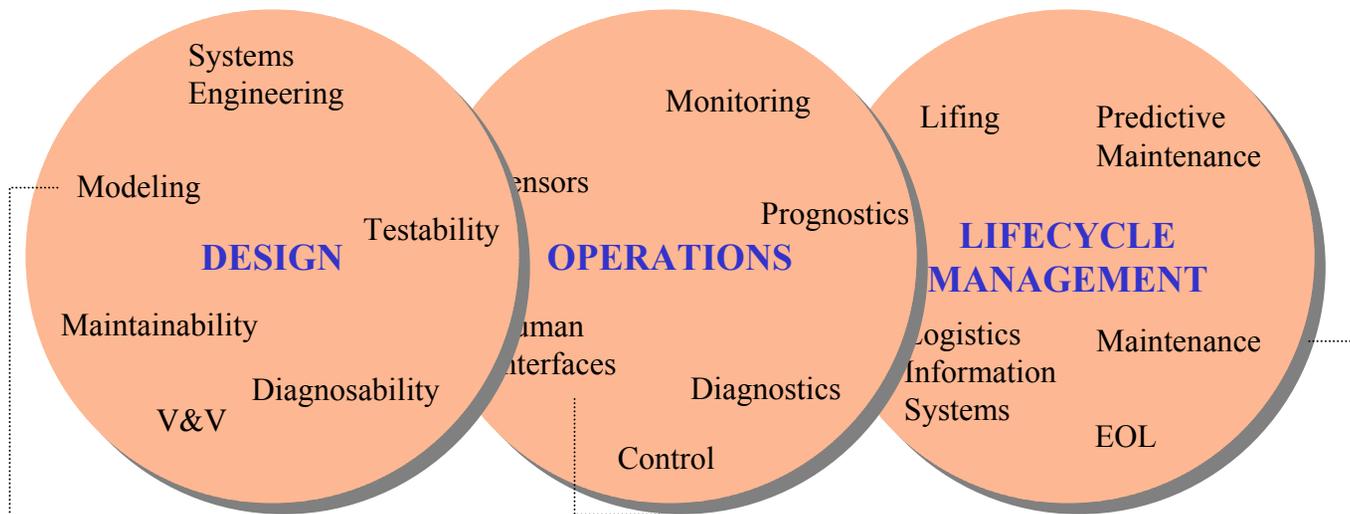


**PITEX: Propulsion IVHM Technology Experiment (2nd Generation Reusable Launch Vehicles Program)**





# ISHM Scope



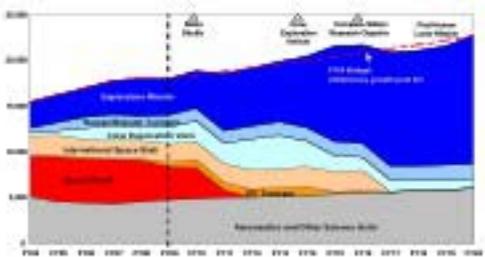


# Exploration Systems

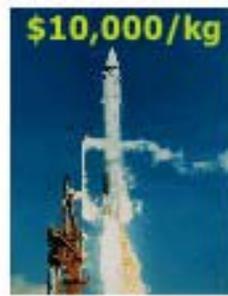
*Affordability and Reusability*



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# Exploration Systems

## *Drivers for ISHM*

### **Reusability**

- Gradual shift from expendable to reusable architectures
- Long system lifetimes with limited maintenance capability
- Systems will fail over time; missions must continue
- In-space maintenance will be a necessity

### **Affordability**

- Need to reduce total cost of ownership of systems
- Mission operations and logistics: two major cost reduction targets
- Launch costs remain steady: need alternatives to hardware redundancy



*ISHM is Key To Affordable Space Exploration*



# ISHM

## *Value to Exploration Systems*

*SAFETY/RELIABILITY*

*AFFORDABILITY*

*EFFECTIVENESS*

Reduced maintenance costs; reduced operations staffing

Component and subsystem-level prognostics, diagnostics, and fault accommodation

Fault accommodation enables continuation of missions despite failures



# Exploration Systems

## *Five Challenges for the ISHM Community*

### **1. Rapid turnaround for reusable space systems**

- Prognostics and informed logistics

### **2. Health management across subsystems and systems**

- Advanced diagnostic methods; standards and interfaces

### **3. Trusted health management systems**

- Verification and validation; automated software synthesis; fault accommodation and recovery

### **4. Flexible and effective human-system interactions**

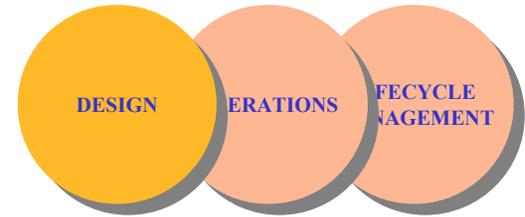
- Human factors; adjustable autonomy

### **5. Design for health management**

- Health management design tools; codesign of function and health management; systems analysis and optimization



# Ames Collaboration Areas in ISHM Design



## Design for ISHM

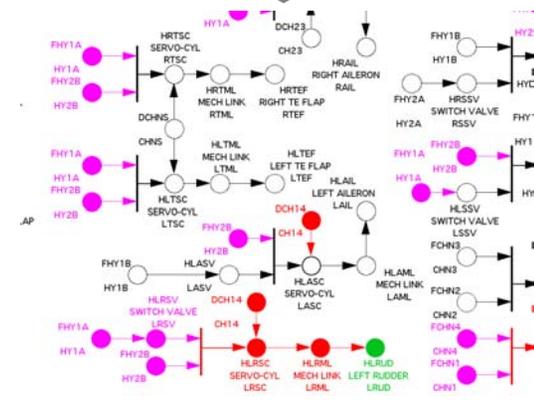
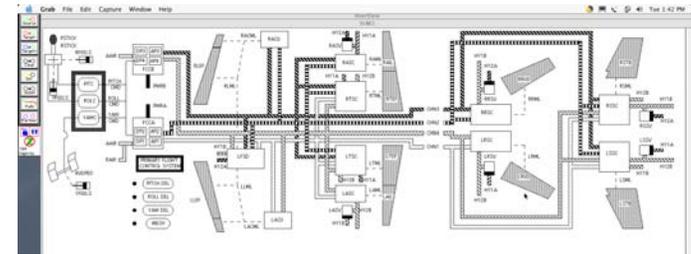
- Codesign of function with health management
- Model-based hazard analysis
- Diagnosability and testability
- Sensor selection
- Systems Analysis and Optimization

## Verification and Validation

- V&V of model-based controllers
- Static and runtime analysis

## Automated Software Synthesis

- Automated generation of monitors and classifiers from high-level specifications





# Ames Collaboration Areas in ISHM Operations



## Monitoring and Data Analysis

- Data mining and analysis for “novelty detection”
- Data-driven failure modeling
- Learning dynamic network topologies from sensor data

## Diagnosis

- Model-based diagnosis and recovery
  - Livingstone
- Hybrid diagnosis
- Immunity-based methods
- Commercial diagnostic tools

## Control

- Mitigation of potential catastrophic failures

## Human Factors

- Intelligent Spacecraft Interface Systems
  - Human performance assessment
  - Eye movement analysis



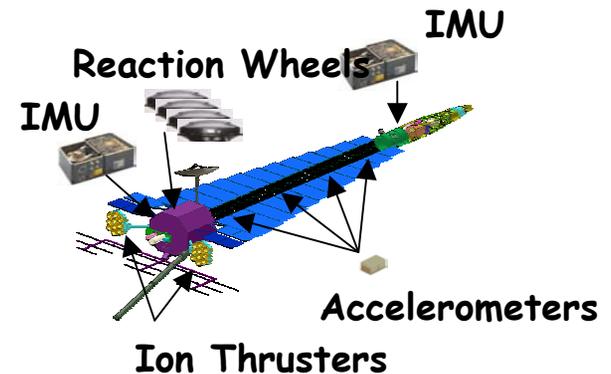
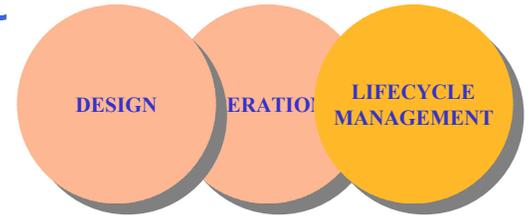


# Ames Collaboration Areas in ISHM Lifecycle Management

## Prognostics

- Statistical and signal analysis methods
- Data-driven failure modeling
- Damage metric and signature modeling
- Physics of failure modeling for mechanical systems
- Structural modeling and prognostics

## Knowledge management





# Ames Collaboration Opportunities in ISHM

## *Summary*

### **Trusted Partner to Industry and Academia**

2GRLV, OSP, NLGT are successful examples of Ames collaboration with industry

Strong links to the research community

### **Cutting Edge Technologies**

Covering operations, lifecycle management, and design aspects for ISHM

Several efforts spanning the entire TRL range

### **Relevance to Exploration Goals and Objectives**

Understanding of exploration mission needs

Experience designing flight experiments

Involvement in defining exploration missions as a Science Center