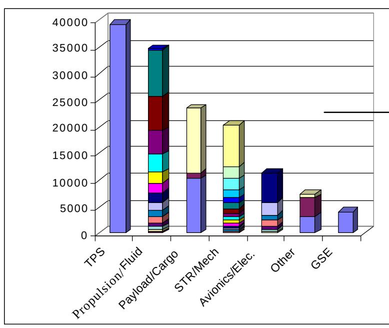
Integrated Vehicle Health Management (IVHM) System Space Propulsion Technology Assessment Workshop

April 2001

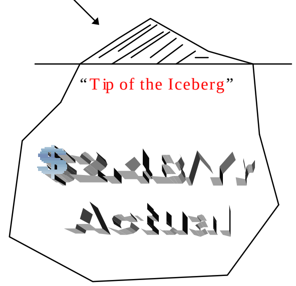
Current Baseline Health Management

- **Excessive Scheduled & Unscheduled Maintenance Manhours are Expended to Perform Pre/Post Flight, Troubleshooting and Corrective Maintenance Actions on the Existing STS Vehicles**
- **This Results in Lengthy Turnaround Times (117 Days) and High Costs ($400M/Launch)**
- **System Health Status is Primarily Performed with Labor Intensive Integrity Inspections and Corrective Maintenance (Visual Inspections and BIT)**

Shuttle Resources
Analysis of System Vs. Labor



Yet "Total" Man-hours per flow will be "only" about 600-700K (which includes engineering, operations planning, quality, support, etc).



DIRECT Man-hours per orbiter flow, OPF Orbiter activity only. Does not include SSME or OMS/RCS Offline Work, ET, SRB, MLP, Pad. Snap-shot from STS-85 (late 1997). Total~140,000 M hrs.

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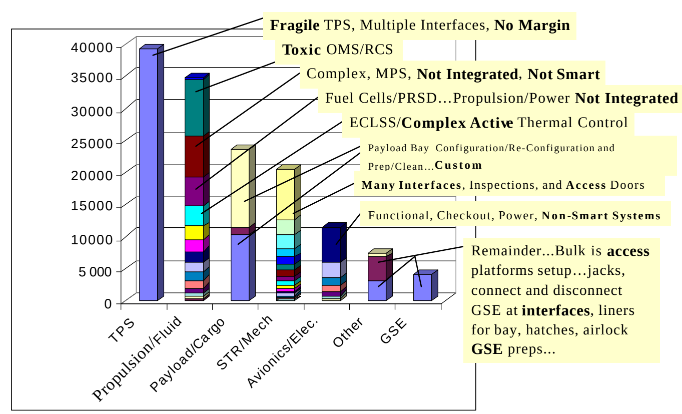
Why the cascade effect?



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- **An Automated and Integrated On-Board & Ground Health Management System is Required to Enhance Safety, Reduce Costs/Launch and Minimize Turnaround Time for 2nd & 3rd Generation RLVs**

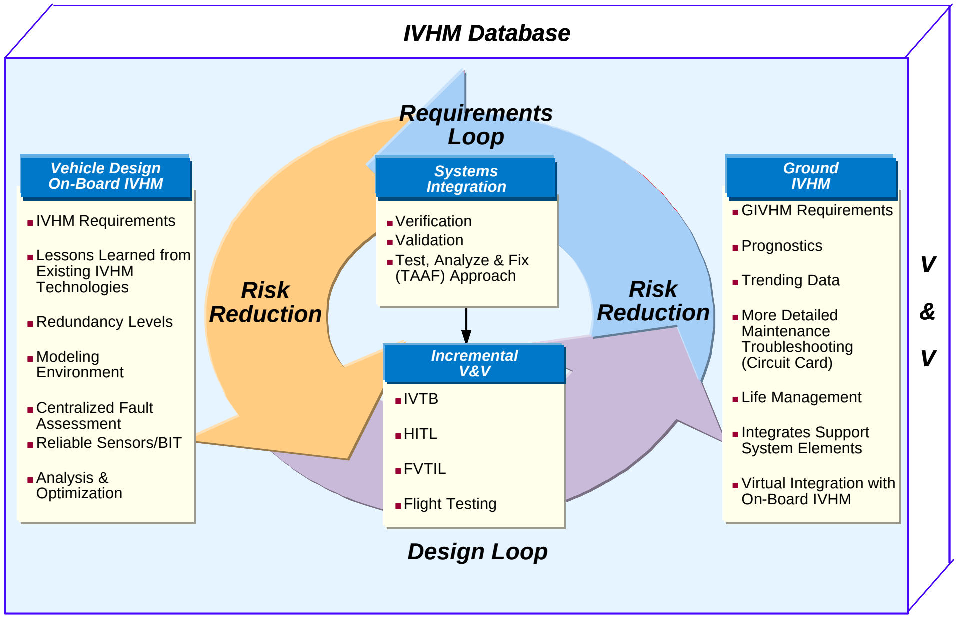
IVHM Requirements

Function	2^{nd} Generation RLV (2010)	3rd Generation RLV (2025)
Safety	< 1 Loss of Crew/10,000 Flights	< 1 Loss of Crew/100,000 Flights
Reliability	< 1 Loss of Vehicle/1000 Flights	< 1 Loss of Vehicle/10,000 Flights
Cost	< $1000/lb Payload Cost/LEO	< $100/lb Payload Cost/LEO

"Challenge"

Potential Solution IVHM

- **Develop an Integrated IVHM Design Process, Design, and Technologies to Support IVHM and RLV Goals**
  - **Vehicle**
    - Mission Status/Vehicle Status
    - Payload Status/Consumables Status
    - Supports On-Board Training
  - **Systems**
    - Structures/Propulsion/Subsystems/ Avionics
    - Integration with Planning Systems & System Managers



  - **Components – RLV Replaceable Units**
    - Circuit Cards
    - Black Boxes
    - Cables, Brackets, Wiring, Clamps, etc.
    - Sensors
  - **Ground Support System Elements**
    - Support Equipment/Technical Data/Facilities/Supply Support/Training

Technologies to Implement Solution

- **Sensor/BIT Technology**
  - Wireless Sensors/Video Sensors/Non-Intrusive Sensors/Intelligent Sensing
  - Acoustics Sensors/Fiberoptic Sensors/Temperature & Strain Sensors
- **Model Base Reasoning/Intelligent Architecture Technology Provides Framework For:**
  - Context Models
  - Modeling Environment
  - Neural Networks, Fuzzy Logic, Probabilistic Reasoning
  - Wireless Networks/Communications
  - Hierarchical/Autonomic Network
  - Integration with Adaptive Structural/Avionics Management (Reconfiguration)
  - Integrated Sensor Suites
- **Prognostics Technology**
  - Conditioned Based Maintenance/Recognition Techniques
  - Statistical Analysis and Predictive Assessment

IVHM Summary

- Integrate On-Board IVHM with Ground IVHM
- Incorporate MBR Technology
- Ensure Incremental Test, Analyze & Fix to Grow IVHM Reliability
- Select Reliable Wireless Sensors
- Utilize Adaptive Intelligent Controllers/Executives
- Design Simplicity into IVHM