

***Automated Predictive Maintenance Capability Designed-In  
as Part of Component Development  
(Prognostics Technology)***

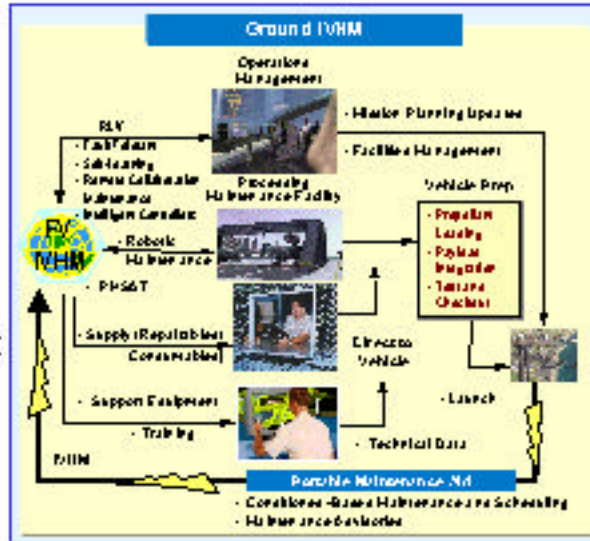
***Space Propulsion Technology  
Assessment Workshop***

***April 2001***

## ***Automated Predictive Maintenance Capability Designed-In as Part of Component Development***

## Technology Required

- Prognostics to Perform Condition Based Maintenance (TRL 3/4)
- Cost/Time To Mature Technology Propulsion S/S: \$15M/3 Years



## Safety & Reliability Preliminary Assessment

- Safety will Improve Based on More Accurate Prediction of Pending Safety Critical Failure Modes
- Mission & Basic Reliability - Will Improve Due to Pro-Active Maintenance versus Reactive Maintenance – Fewer Induced Maintenance Events
- Decrease in Unscheduled Maintenance

## Maintainability Preliminary Assessment

- Prognostics & Conditioned Based Maintenance will Allow Longer Operational Service Life
- Reduced Maintenance Manhours Required Due to Longer Mean Time Between Maintenance Intervals
- Maintenance Concept -
  - Organizational Level - Software Maintenance/Re-Load/Functional Checkout for GIVHM
  - Shop Level – Same as “O” Level
  - Depot Level – Prognostics Software Code Update & Modifications By Contractor

## Support System Preliminary Impact

- Support Equipment – Workstation(s) for GIVHM
- PHS&T – Transportation & Storage of GIVHM S/W & H/W
- Fewer Maintenance Procedures Required Due to Automated IVHM Capability
- Less Training Required Due to Automated IVHM Capability
- Facilities – Workstation Analysis Facility
- Provisioning – More Accurate Spares Provisioning
- Software Supportability – Increased Software Maintenance for Prognostics Software

# ***Cost & Time to Mature IVHM Prognostics Technology***

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**Cost to Mature  
(\$M)**

5 M	
10M	
15M	
20M	
25M	
30M	
35M	

**Time to Mature  
(Years)**

1	
2	
3	
4	
5	
6	
7	



***100% IVHM to Identify All Failures in Adequate Time to  
Implement Corrective Action/Abort  
(Total IVHM)***

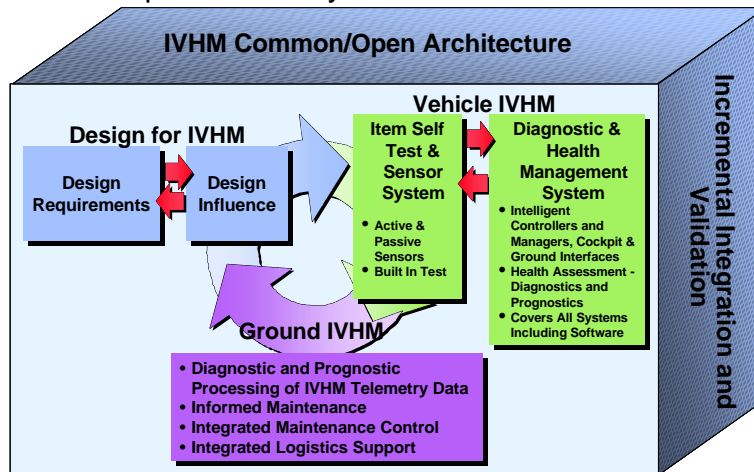
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# 100% IVHM to Identify All Failures in Adequate Time to Implement Corrective Action/Abort

## Technology Required

- Integrated Vehicle Health Management System - Sensors/BIT/MRB/Intelligent Hierarchical Architecture & Prognostics Technologies (TRL 3/4)
- Cost/Time To Mature Technology
  - Propulsion Subsystem: \$50M/4 Years



## Safety & Reliability Preliminary Assessment

- Safety will Improve Based on Total Integrated Vehicle and Ground IVHM System Approach. Improves Enhanced Fault Isolation and Intelligent Management Control
- Mission & Basic Reliability - Improved Due to More Informed Health Detection, Assessment, Prognostics, Fault Isolation and Checkout. Improves Enhanced Fault Isolation and Intelligent Management Control
- Decrease in "Could Not Duplicate & Re-Test OK" Maintenance Actions Due to IVHM System
- Decreased Unscheduled Maintenance
- Condition Based Rather than Scheduled Maintenance

## Maintainability Preliminary Assessment

- Reduced RLV Turnaround Time Based on Enhanced Integrated Vehicle Health Management Maintenance Concept
- Reduced Maintenance Manhours Required Due to Improved Informed Maintenance. (Lower MTTR & TAT)
- Fewer Skill Levels Required
- Maintenance Concept -
  - Organizational Level - IVHM S/W Reload/BIT/Sensor Repair in Place or Remove and Replace
  - Shop Level - BIT Repair on RLV Repairable Units/Software Code Checked Out and Upgrades Incorporated
  - Depot Level - BIT Repaired & S/W Upgraded at Contractor Facility, Sensors Discarded Locally

## Support System Preliminary Impact

- Support Equipment – Less Support Equipment Required to Perform System Checkout Due to Enhance IVHM System
- PHS&T – Reduced Costs
- Fewer Maintenance Procedures Required Due to Enhanced IVHM System
- Less Training Required Due to Enhanced IVHM System
- Provisioning – More Accurate Spares Provisioning
- Software Supportability – Increased Software Maintenance
- Decreased Cost per Sortie

# ***Cost & Time to Mature Integrated Health Management Technologies***

**Cost to Mature  
(\$M)**

10 M	
20 M	
30 M	
40 M	
50 M	
60 M	
70 M	

**Time to Mature  
(Years)**

1	
2	
3	
4	
5	
6	
7	

