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# **IVHM for the 3<sup>rd</sup> Generation RLV Program –Technology Development**

**Bill Kahle  
Ames Research Center**

[william.kahle@msfc.nasa.gov](mailto:william.kahle@msfc.nasa.gov) (256) 544-3225

*Integrated Vehicle Health Management*

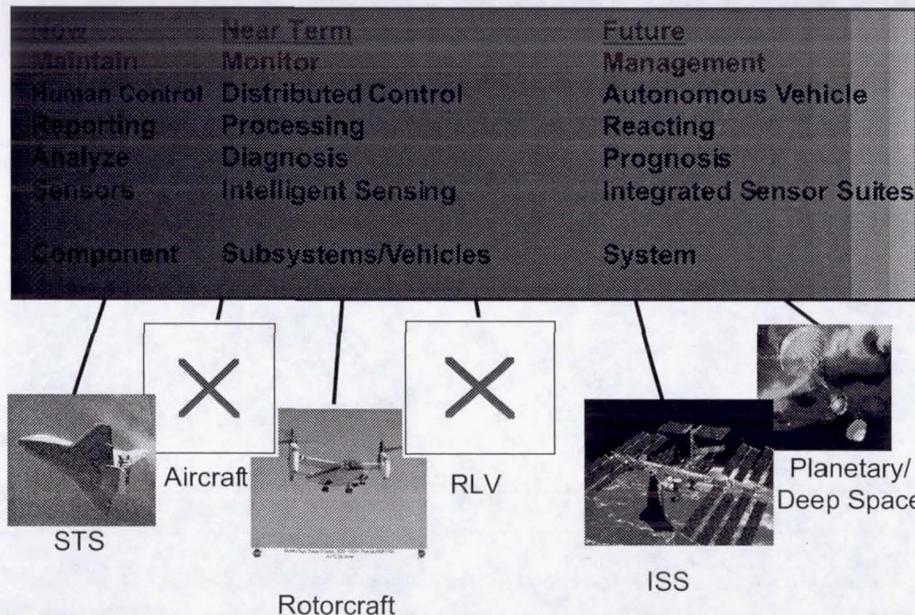
◆ **Project Objectives:**

Develop and integrate the technologies which can provide a continuous, intelligent, and adaptive health state of a vehicle and use this information to improve safety and reduce costs of operations.



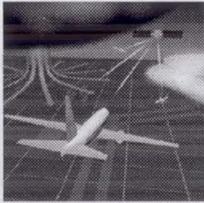
◆ **Technology Objectives:**

- Develop, validate, and transfer next generation IVHM technologies to near term industry and government reusable launch systems.
- Focus NASA on the next generation and highly advanced sensor and software technologies
- Validate IVHM systems engineering design process for future programs

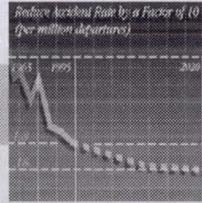


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**IVHM Project**



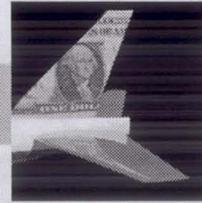
Global Civil Aviation



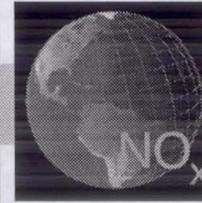
Reduce Accident Rates, 10x



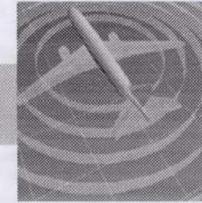
Increase System Throughput, 3x



Reduce Cost of Air Travel by 50%



Reduce Emissions, 5x



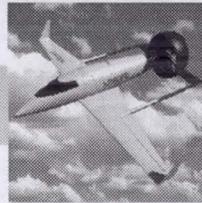
Reduce Noise, 4x



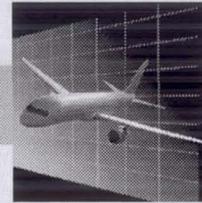
Revolutionary Technology Leaps



Reduce Transoceanic Travel time by 50%



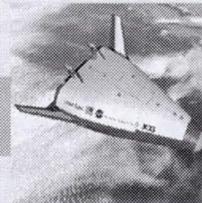
Invigorate GA 20K units Annually



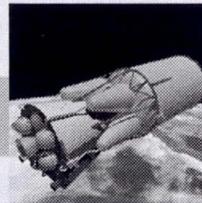
Cut Development Cycle Time in Half



Access to Space



Reduce Launch Cost to LEO, 100x by 2020



Reduce In-Space Transport cost, 10x by 2022

### IVHM Objectives

- Safety
- Reliability
- Mission Assurance
- Reduced Maintenance Costs
- Efficient Vehicle Turn-Around

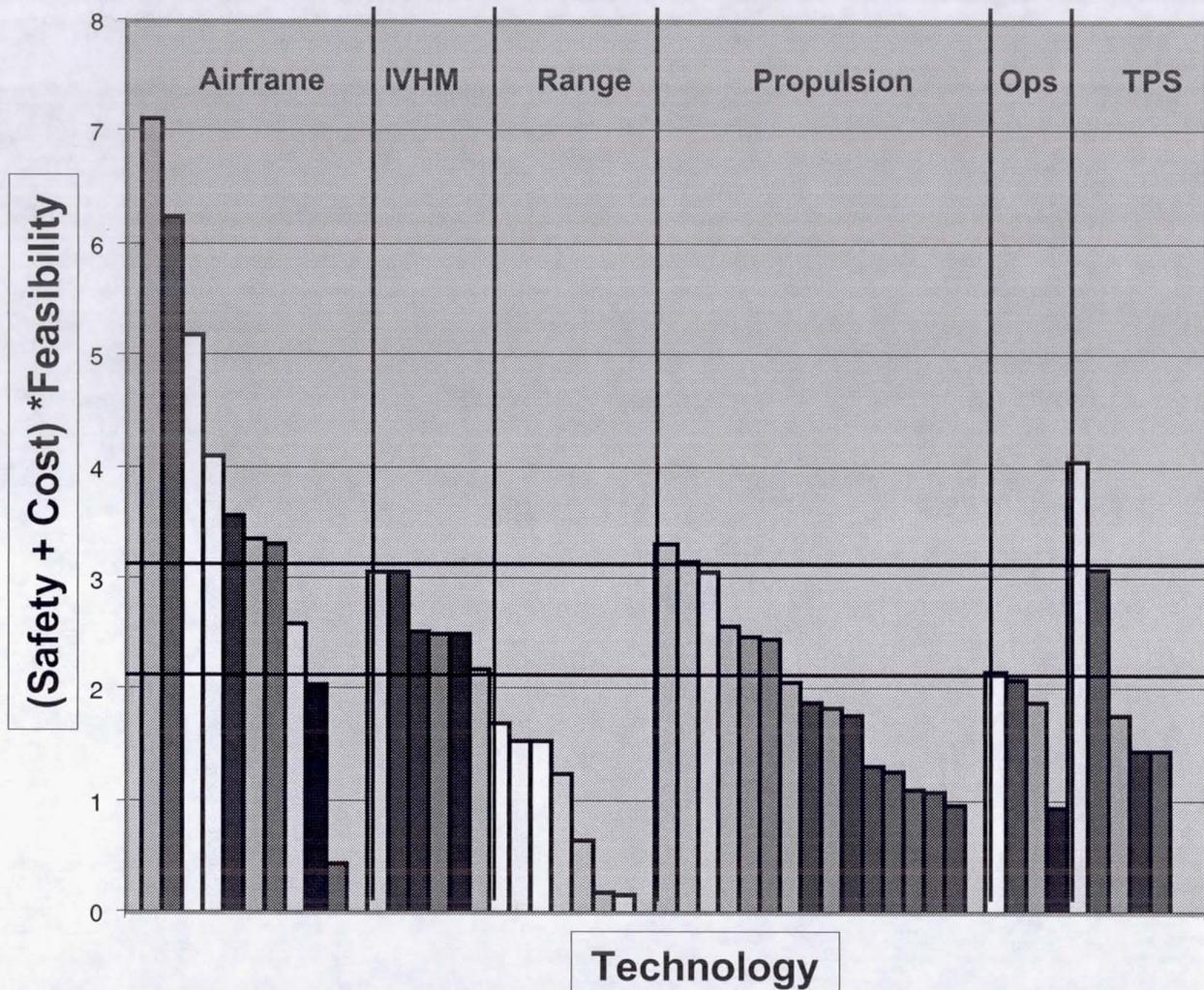
### IVHM Methodologies

- Sensor Technology
- Information Technology
- Communication Technology

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# IVHM Support of NASA Pillars and Goals

## SpaceLiner Technology Ratings Reported Through ISTP

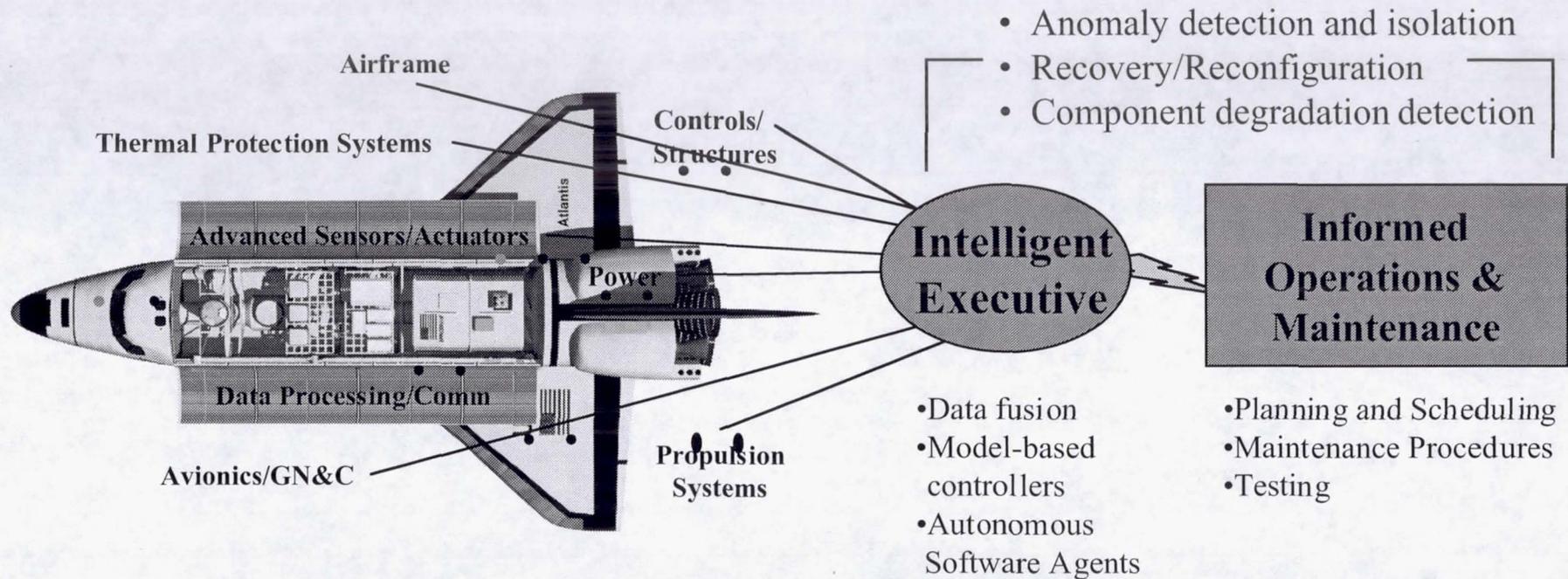


- Safe structures design technologies
- Advanced mat, fab, mfg and asbly
- Aero/Aerothermodyn tools rapid des
- Integrated design environment
- RLV crew interface technology
- Nonlinear airframe dynamics
- Cryotank structures
- Structurally integrated avionics
- Hot and cooled airframe structures
- Aerodynamic perf & cntrl via morph
- Airframe design and databasing
- Avionics IVHM
- Power IVHM
- Ground segment IVHM
- SE&I IVHM
- Structure IVHM
- Propulsion IVHM
- Advanced checkout and control
- Intelligent instrumentation and inspe
- On-site demand
- Umbilicals
- Payload systems technology
- Integrated storage and recovery
- Zero-loss transfer
- MagLev development
- HC TSTO RBCC Airbreather
- NPSS for space trans prop (ISE,IAEE
- H2 SSTO RBCC Airbreather
- Long life high T/W HC ROCKET
- Long life light weight prop mat & str
- Information rich test intstrumentatic
- PDEBCC Rocket
- TSTO TBCC airbreather
- PDEBCC Airbreather
- SSTO TBCC airbreather
- High performance hydrocarbon
- Long life high T/W H2 ROCKET
- Propulsion life prediction
- High (better than densified) density t
- Green mono prop RCS
- Integrated propulsion mgt system
- Decision support models
- Weather instrumentation systems
- Space based range
- Spaceport range systems
- Sharp Body TPS demo (Sharp L1)
- Develop adaptive intelligent/ IVHM s
- Quick change-out TPS
- Highly reusable TPS
- Quick TPS inspection
- ISE tool development for TPS life cy

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# 3rd Generation RLV Technology Ratings

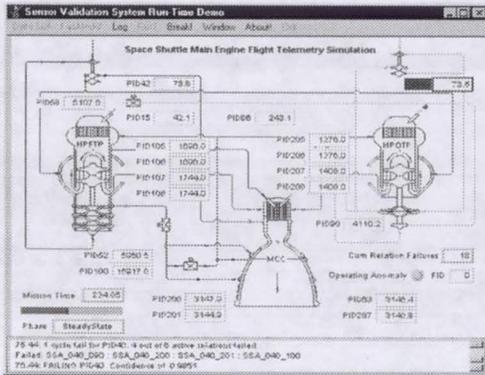
**Collect, process, and integrate information about the health of a launch system including the vehicle, subsystems, components, sensors, and ground support systems to make informed decisions and take appropriate actions to ensure the success of a mission**



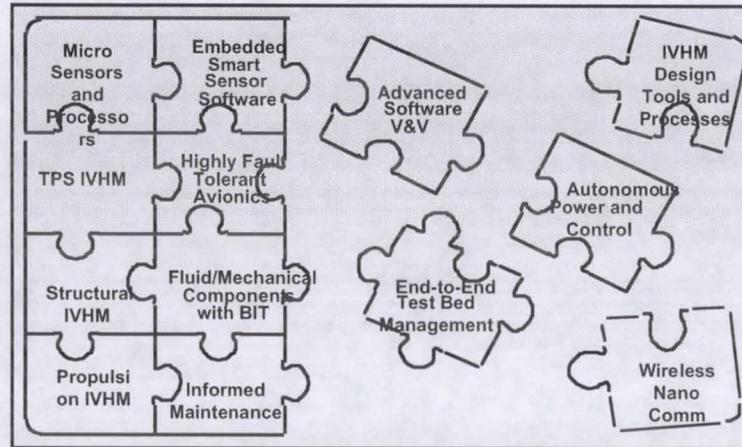
*The Union of Advanced Hardware and Software -  
Providing higher reliability, with greater robustness, at lower costs*

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**IVHM**

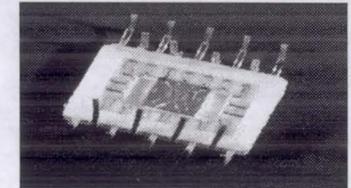


**Propulsion IVHM**  
GRC and MSFC



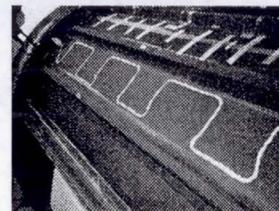
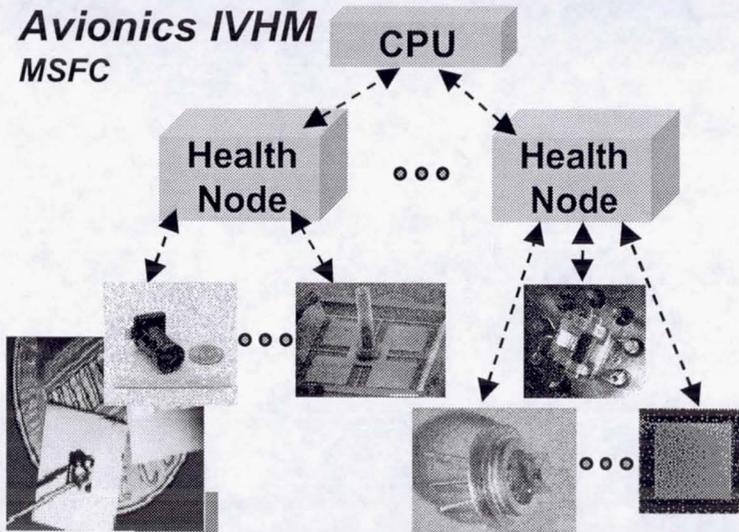
**Systems Engineering and Integration IVHM**  
ARC

**Core Technologies (ARC)**  
Information Technologies  
Sensors  
Communications

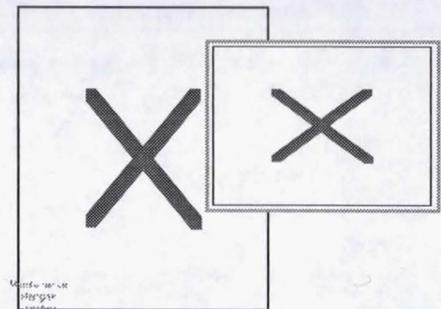


**Power IVHM**  
GRC

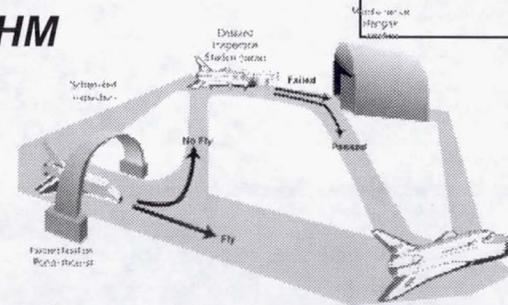
**Avionics IVHM**  
MSFC



**Structures IVHM**  
LaRC



**Ground IVHM**  
KSC



**Thermal Protection Systems IVHM**  
ARC

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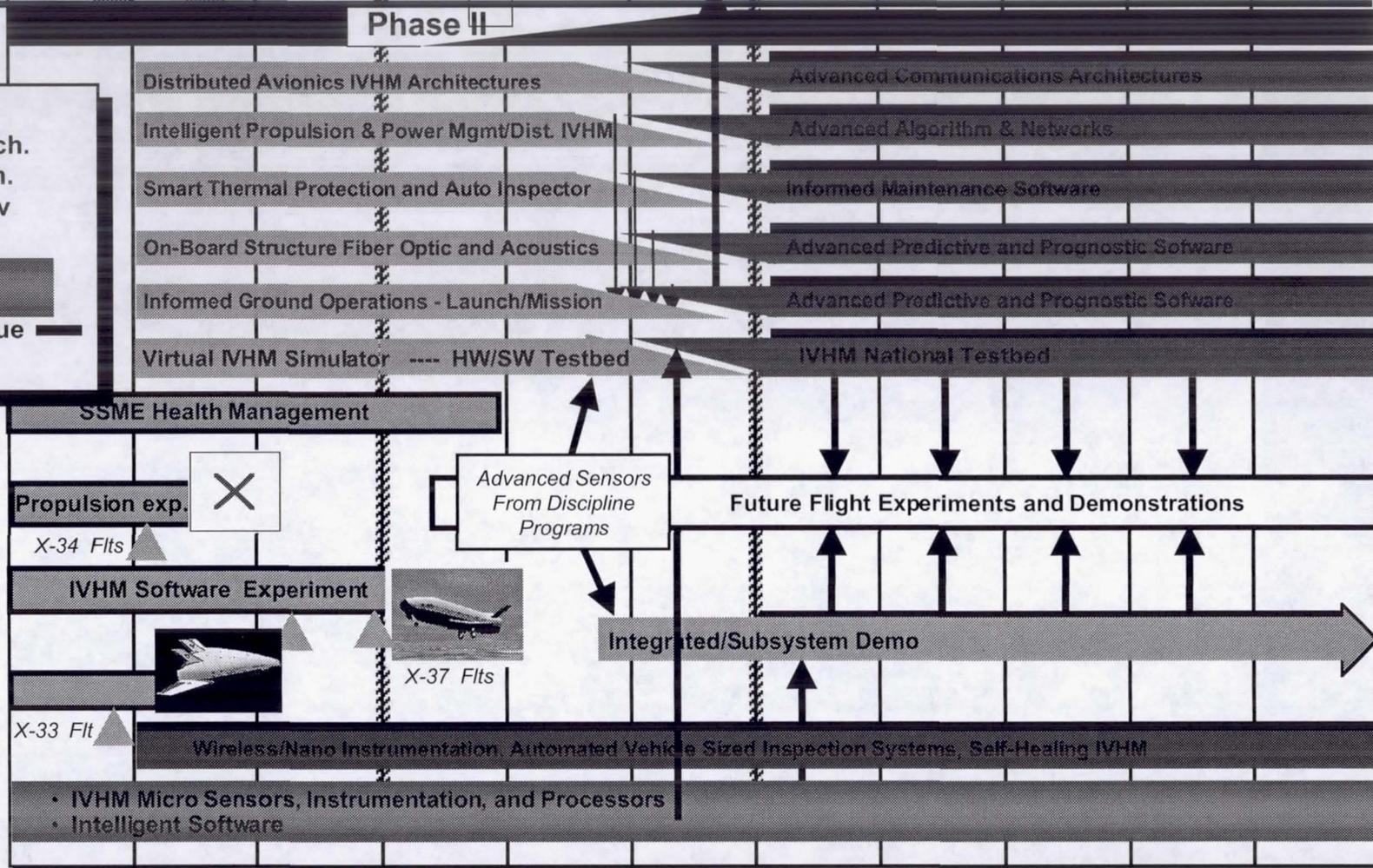
# IVHM Elements

# Major Milestones & Decisions

FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10
X-43, X-34	X-33, X-38	X-37	Concept Downselect		Ops Demo	Competition				

# Key Tasks

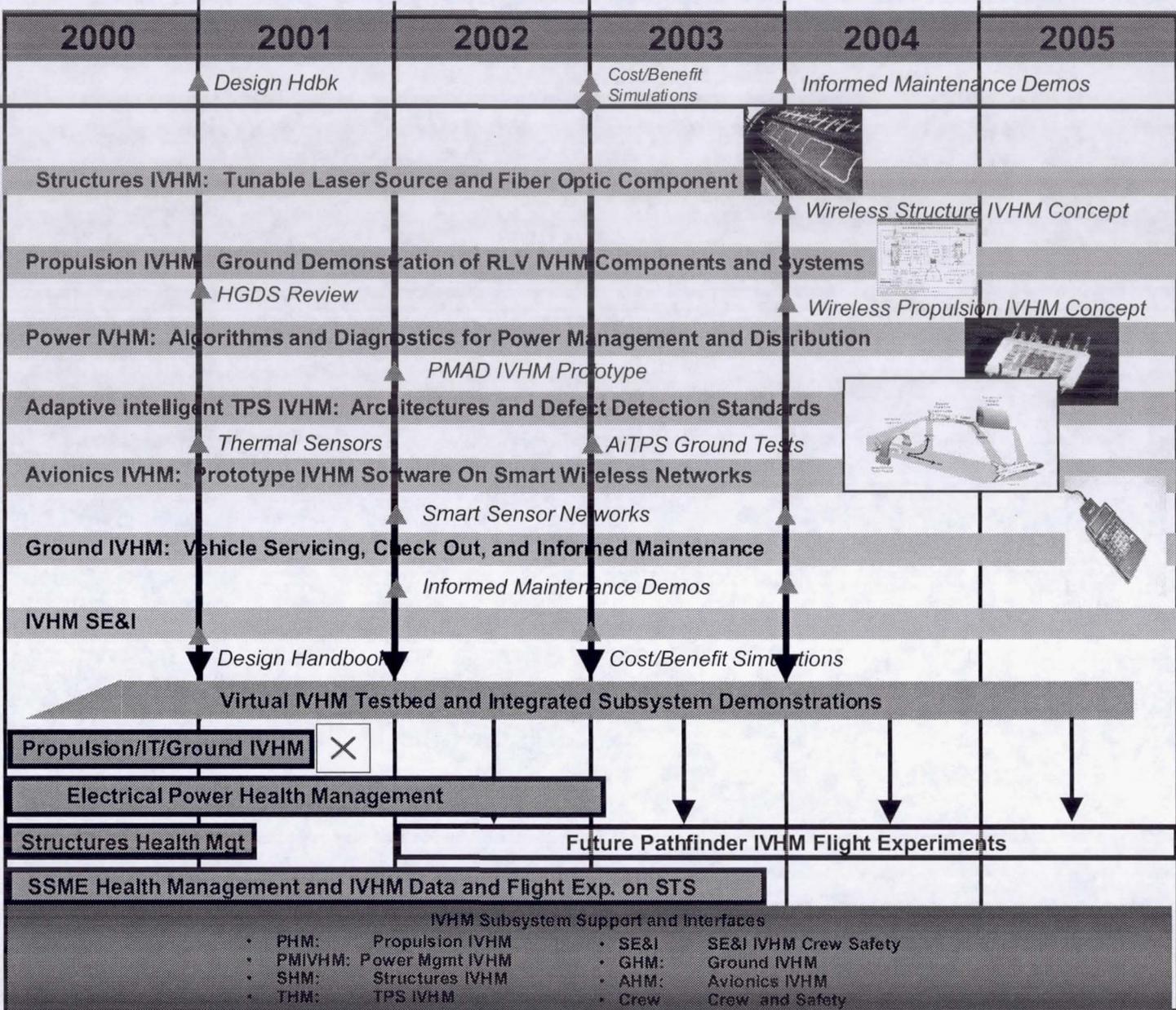
- Advanced Tech.
- Focused Tech.
- Advanced Dev
- **Flight Demo**
- Foundation Technology
- 3rd Gen Unique



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# IVHM Level II Roadmap

Major Milestones  
Commit to flight  
configuration  
Decisions



### Key Tasks

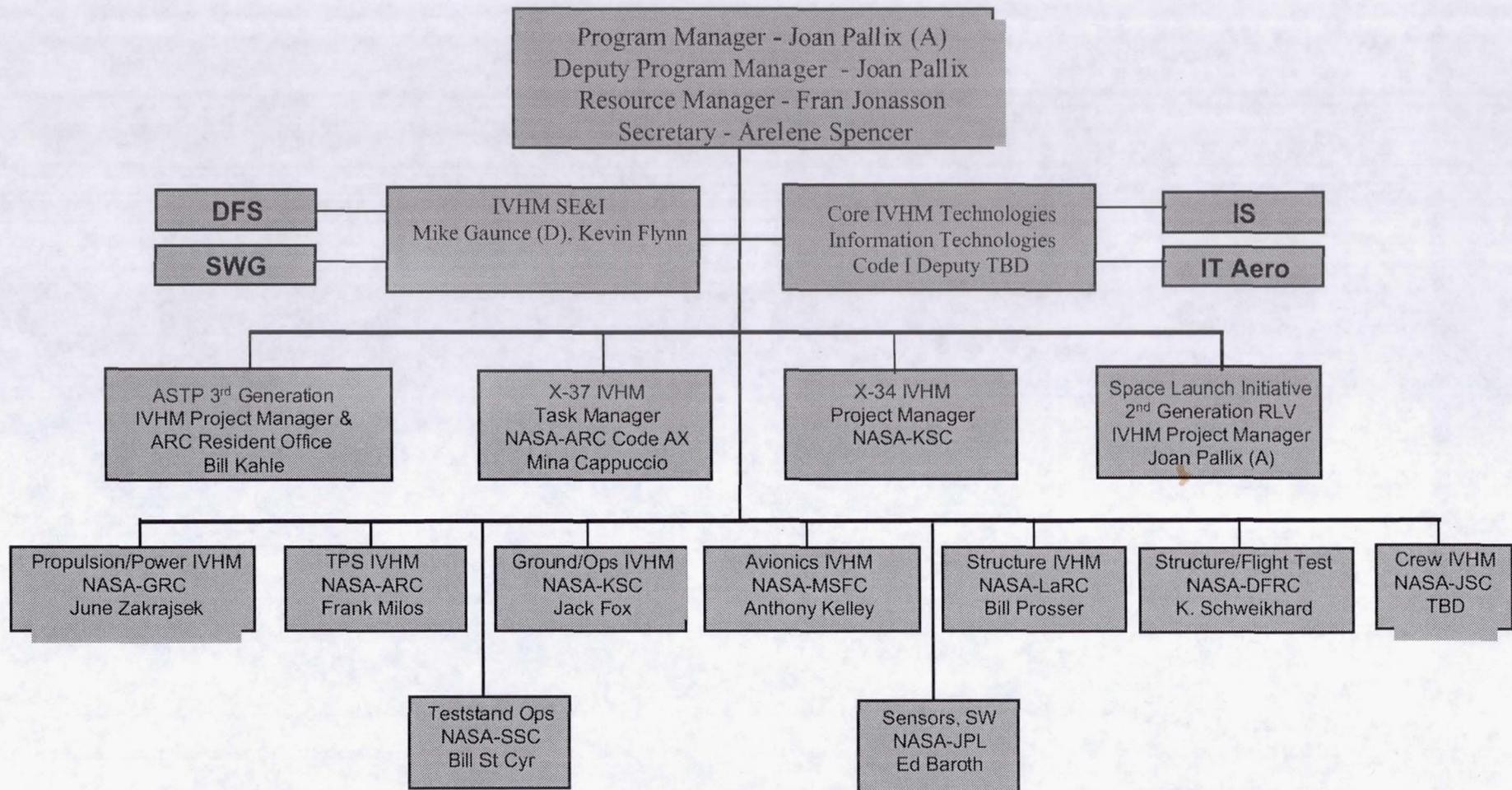
- Component/ Subsystem Demo
- Integrated Demo
- **Flight Demo**
- Foundation Technologies
- Companion System Definition

## Integrated Vehicle Health Management IVHM Roadmap

- ◆ **Advice**
  - **Scope - Develop a university and university sponsored research institute team to act as a peer review for project and program strategies and tactical planning**
  - **Initial discussions held with a few universities. Others to follow.**
  - **Continue to leverage activities of the IVHM National Team to survey and gain access to the best ideas from universities.**
- ◆ **Collaboration**
  - **Scope - Universities identified as contributors in IVHM Projects:**
    - Smart, Self Healing Sensory Systems
    - Self Learning, Self Correcting Propulsion Systems
    - Structures IVHM
- ◆ **The project office is seeking new partnerships with the academic community.**

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**University Partnerships**



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## **ARC Is Coordinating IVHM For Space Transportation**