Aviation Safety Program
Integrated Vehicle Health Management Project

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“Develop technologies to reduce accidents and incidents through enhanced vehicle design, structures, and subsystems.”

“Aircraft-level health-management systems, including sensors and analytical tools, will be developed that will identify problems before accidents occur. Research in health management requires not only monitoring and detecting, but also confident prognostics of latent potential failures before they occur … with extensive verification and validation of automation systems.”

National Plan for Aeronautics Research and Development and Related Infrastructure

JPDO NextGen Research and Development Plan
Goal -- Validated multidisciplinary integrated vehicle health management tools and techniques to enable automated detection, diagnosis, prognosis and mitigation of adverse events during flight.
**Organization**

**Level 4**

- **Multidisciplinary Ground/ Flight Demos**
  - Leads: PI, PS, PM

- **Systems Analysis for Health Management**
  - Lead: Mary Reveley

- **Research Test and Integration**
  - Lead: Robert Mah

- **DASHlink**
  - Lead: Elizabeth Foughty

**Level 3  Associate Principal Investigators**

- **Detection**
  - API: John Lekki

- **Diagnosis**
  - API: Rick Ross

- **Prognosis**
  - API: Kai Goebel

- **Mitigation**
  - API: Eric Cooper

- **Integrity Assurance**
  - API: Eric Cooper

**Level 2**

- **Aircraft Systems**
  - **Airframe**
  - **Propulsion Systems**

  *Traditional Aircraft Subsystems – well represented in Levels 1, 3 and 4*

- **Software**
  - Lead: Paul Miner

**Level 1  Lead Researchers**

- **Advanced Sensors and Materials**
  - Lead: Tim Bencic

- **Modeling**
  - Lead: Kevin Wheeler

- **Advanced Analytics and Complex Systems**
  - Lead: Nikunj Oza

- **Verification and Validation**
  - Lead: Steve Jacklin
### NRA University and Industry Partnerships - Prognosis

<table>
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<th>Round</th>
<th>Proposal Title</th>
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<th>Supports IVHM 2.0 Milestones</th>
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<td>1</td>
<td>Ultra Efficient Multiscale Prognostic and Diagnostics Tools for Airframe and Propulsion Structures</td>
<td>Collier Research Corp.</td>
<td>1.2.2.4, 1.2.2.5, 1.2.3.4</td>
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<td>1</td>
<td>An Integrated Vehicle Health Management Approach to Heterogeneous Structural Systems</td>
<td>Arizona State University</td>
<td>1.2.2.2, 1.2.2.4, 1.2.2.5, 1.2.3.4</td>
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<td>2</td>
<td>Development of Early-Indicators for Failure-Prognosis of Power Semiconductor Devices</td>
<td>Auburn University</td>
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<td>2</td>
<td>Diagnostics and Prognostics for Electro-Hydro-Mechanical Systems</td>
<td>Impact Technologies, LLC</td>
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<td>2</td>
<td>Reliable Diagnostics and Prognostics for Critical Avionics Systems</td>
<td>University of Maryland</td>
<td>1.2.3.2, 1.2.3.3</td>
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- Candidates for EMA Failure Mode Focus Established
- Dynamic model of ‘Generalized’ EMA created
  - will be used to represent physics of degradation
Predicting Thermomechanical Deformation Response of Advanced Composite Materials

- Enables progressive failure and damage analysis.

Impact in Space Applications, Academia, and Industry

- Impact in Exploration Systems Mission Directorate: Researchers were able to reconcile issues on Orion related to rate dependency of Ti-6-4 modulus at elevated temperatures which was a critical concern for the Orion project.

- Impact in Academia: Approximately 35 technical publications (15 journal papers) have been cited at least 100 times. 58% of the citations are by authors unaffiliated with the cited paper since 2003.

- Impact in Industry: Approximately 15 Universities and 28 industrial companies/government labs have signed software use agreements since 2003.
Prognostics Data Challenge

- Prognostic run-to-failure degradation datasets ranging over different operational and fault conditions made available to the research community.

Impact in Industry

- 60 active participants from academia and industry; dedicated session in PHM’08 conference; 4 invited papers.

- Data sets made available as benchmark data sets: Additional 63 downloads within the last month.

- Special issue of the *International Journal of PHM on Data-Driven Methods for Making Predictions* will use this data set to assess performance.
IVHM Task 4.3: DASHlink Collaborative Website