Prognostic Health Management

Honeywell Capabilities and Needs

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Honeywell

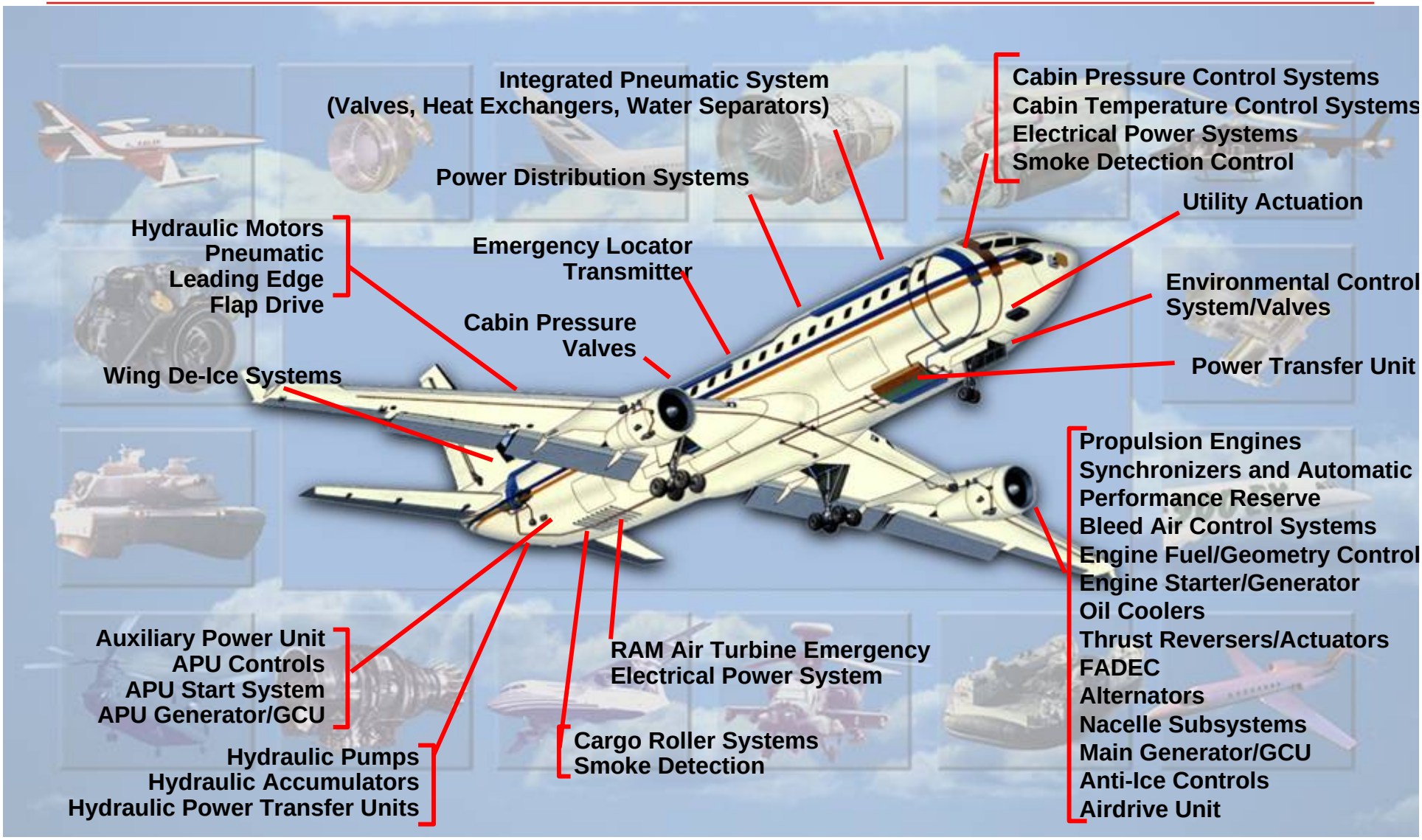
Presentation Outline

Honeywell

- Honeywell Aerospace VHM Business Overview
- Honeywell Roles with Sandia PHM COE
- PHM Related Capabilities
- Honeywell SMART Lab Overview
- PHM Related Programs/Needs
- Recommendations for PHM COE

Engines, Systems & Services Capabilities

Honeywell



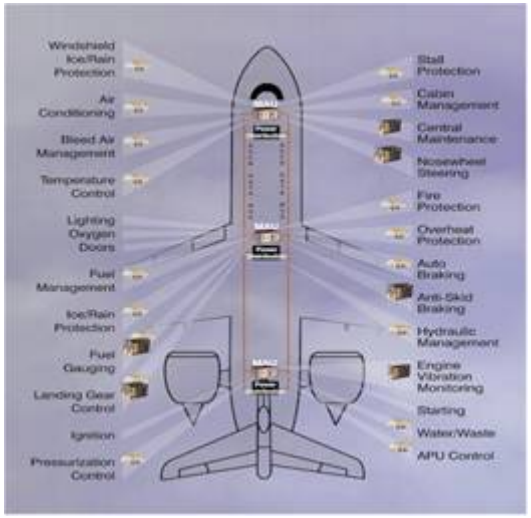
Broad Portfolio of Products & Technology

Aerospace Electronic Systems Capabilities

Honeywell

- **Honeywell is a leading supplier of Commercial, Military and Space Avionics**
  - **Commercial:**
    - $2B+ annual
    - 44% of world market
  - **Military: about $1.4B**

- **Avionics systems**
- **Flight safety systems**
- **Communication, navigation and surveillance systems**
- **Airport lighting**
- **Integrated systems**
- **Flight management systems, cockpit display systems, data management and aircraft performance monitoring systems**
- **Vehicle management systems and inertial sensor systems for guidance, stabilization, navigation and control**
- **Aircraft interior and exterior lighting**
- **Automatic test systems including computer-controlled, functional testers, portable test and diagnostic systems, and advanced battery analyzer chargers**

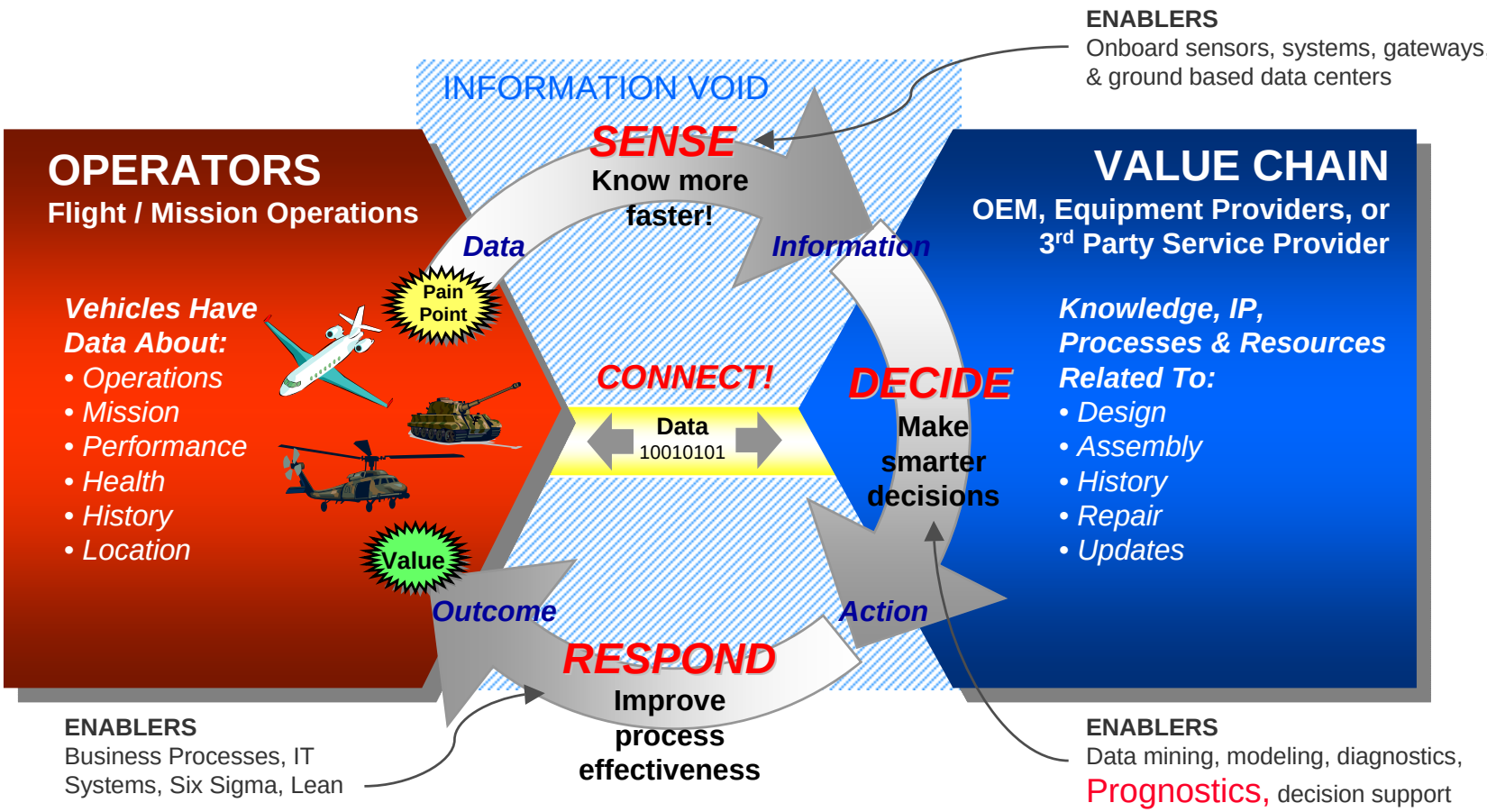


- **Inertial sensor products including gyroscopes**
- **Supply chain logistics and inventory management**
- **Differential GPS landing systems**
- **Precision sensors and components**
- **Tactical guidance inertial measurement units**
- **Radar altimeters**
- **MEMs foundry services**
- **Electric drive systems**
- **Mobile range safety solutions**
- **On-board signal/data processing systems**
- **Space systems avionics, radiation hardened electronics, momentum control, pointing, vibration isolation, guidance and navigation, semi-conductors and data control**

Broad Portfolio of Products & Technology

Aerospace VHM Business Overview

Honeywell



Providing Full-Circle Value-based Solutions

Honeywell Roles with Sandia PHM COE

Honeywell

- **VHM Technology Provider**
  - **Sandia PHM COE provides a forum for transitioning emerging technology to HON customers**
  - **Available and Emerging HON capabilities in:**
    - Specialized/Smart Sensors
    - Prognostics/Diagnostics Algorithms for Electronics, Machinery, Structures
    - Prognostics Modeling, Simulation, V&V
    - Models for integration of PHM into maintenance operations
- **VHM Technology Consumer**
  - **Sandia PHM COE provides forum for:**
    - Cooperative Research and Development
    - Transitioning technology from 3rd parties into HON solutions
  - **Applying VHM Technology:**
    - Health Management Systems delivered to HON customers
    - Systems and tools to support Maintenance Service Agreements on HON avionics, engines and equipment

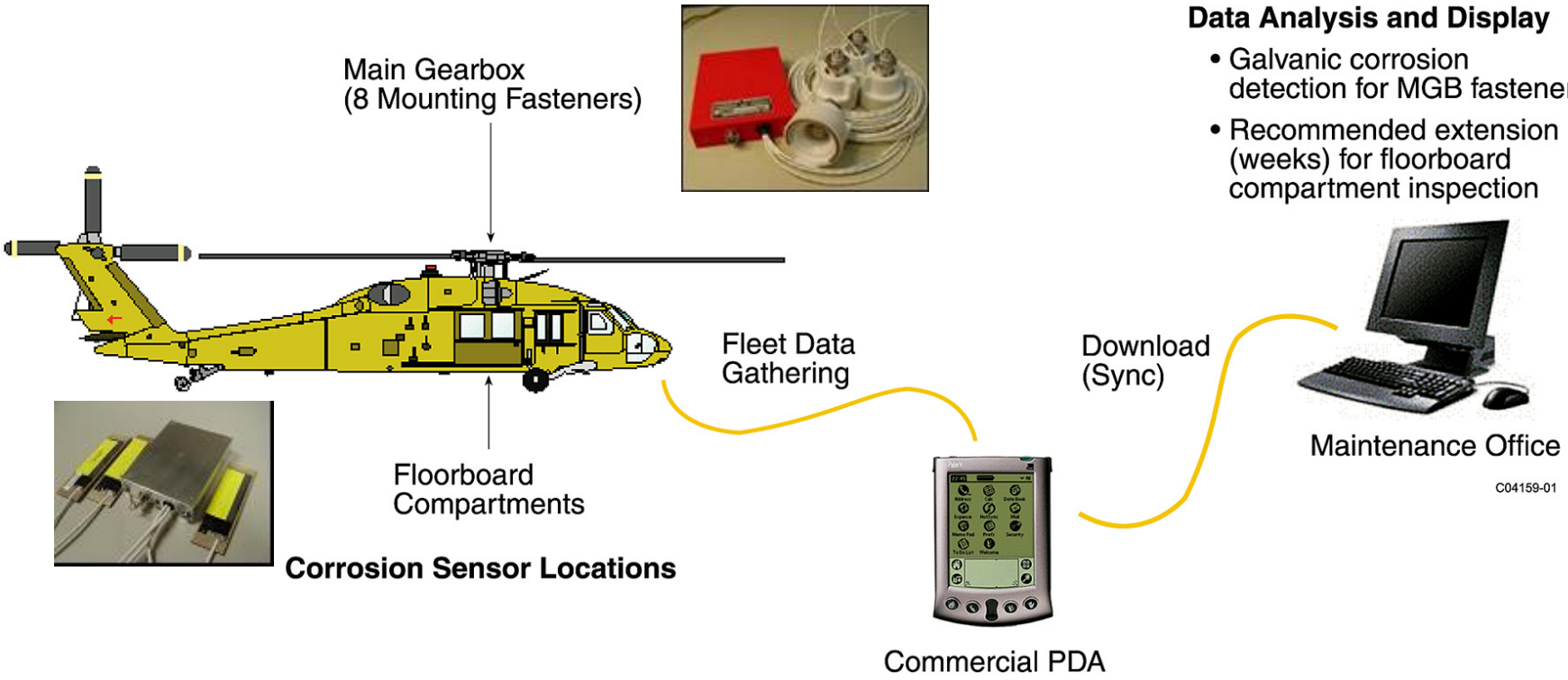
Sandia PHM COE is a Two-Way Street

Available & Emerging HON PHM Technology

Honeywell

Corrosion & Corrosivity Monitoring System (C2MS)

Honeywell

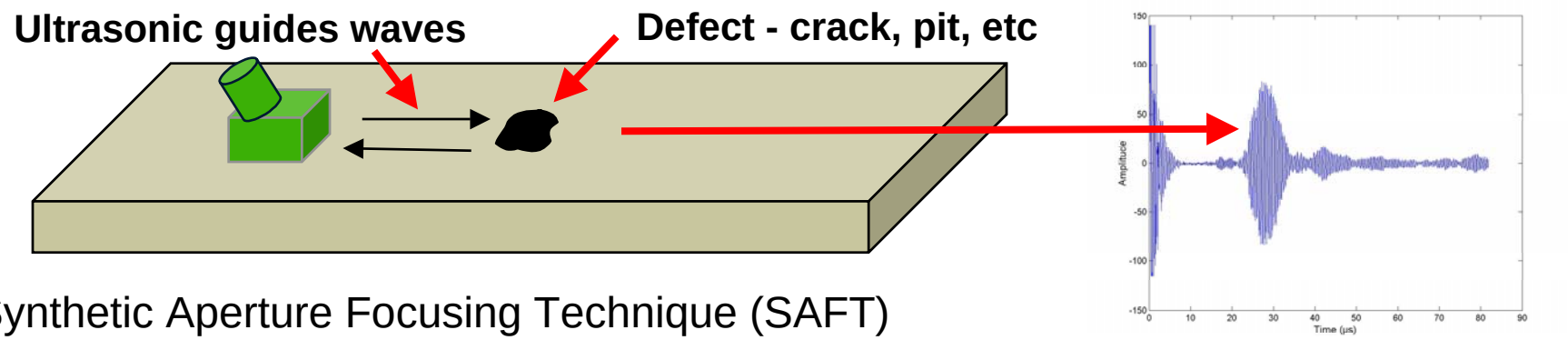


- **<u>Main Gearbox</u> sensors detect galvanic corrosion in the mounting fasteners. The sensors detect when there is a failure in the protective coating/sealant system and moisture has penetrated into the fasteners.**
- **<u>Floorboard Compartment</u> sensors continuously monitor the corrosivity of the environment inside the compartments and provide a recommended maintenance date.**

Seeking Technology Insertion Partners

Structural Monitoring - SAFT

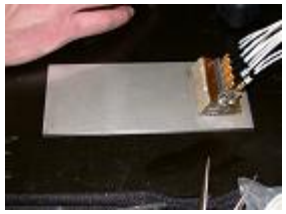
Honeywell



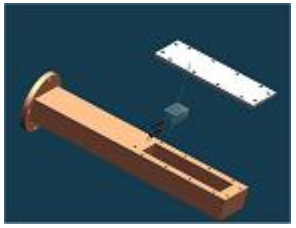
Synthetic Aperture Focusing Technique (SAFT) combines information from multiple transducers to form an image of the defect

Hardware processor

Piezoelectric array

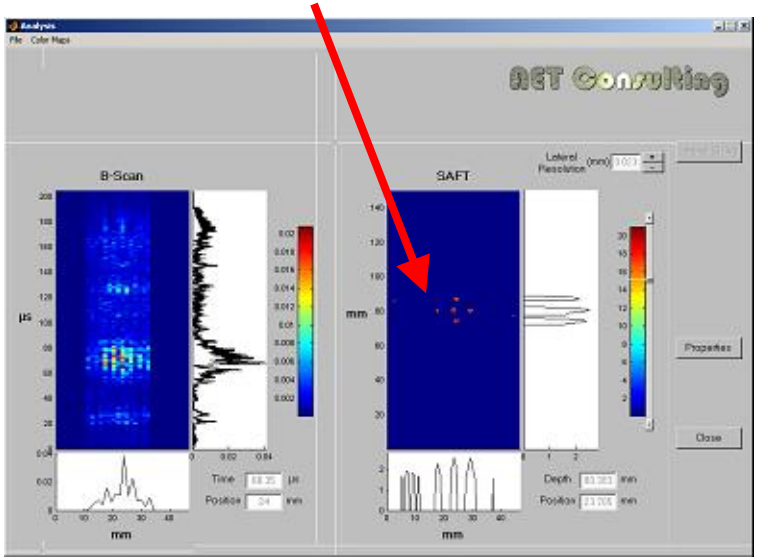


Intelligent Ultrasonic Probe (IUP)



IUP Testing

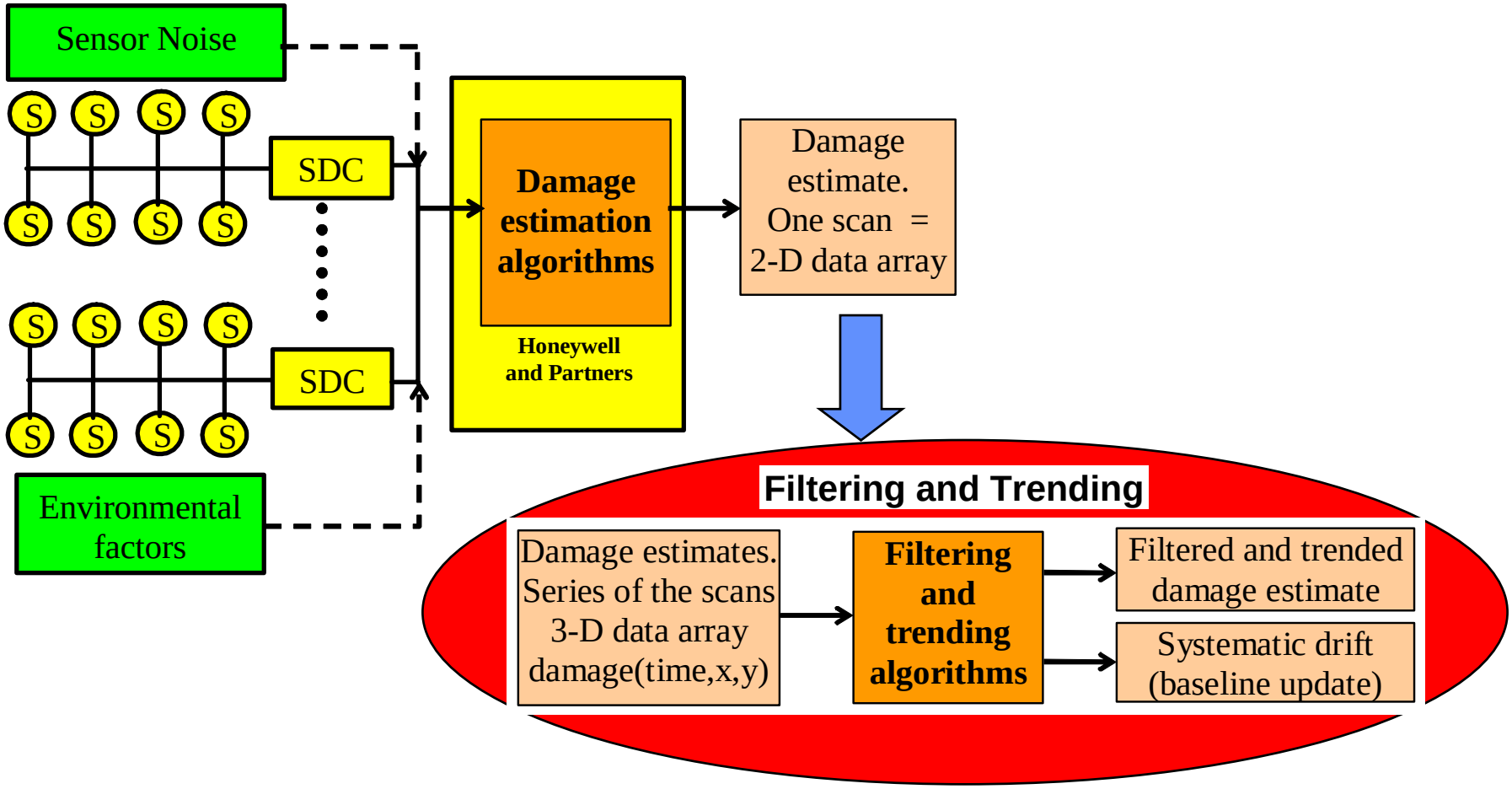
SAFT Image of 4 clustered pits



Seeking Technology Insertion Partnerships

Composite Structural Monitoring

Honeywell

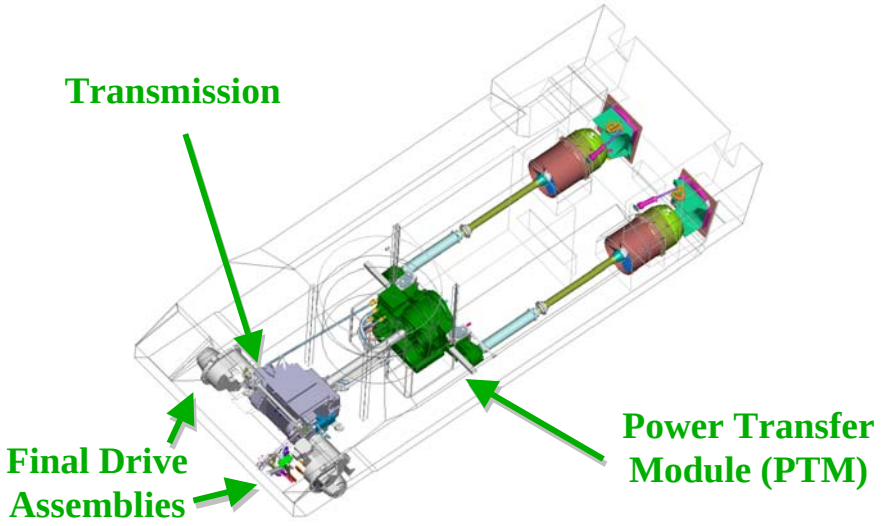


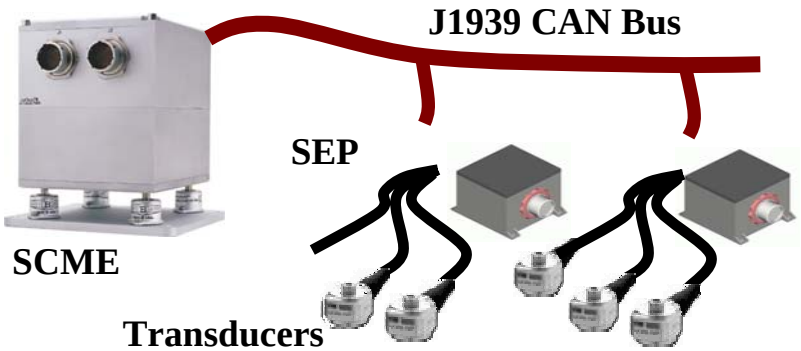
Seeking Cooperative R&D Partnerships

Expeditionary Force Vehicle Drive Train Prognostics

Honeywell

- **Role**
  - Pre-mission go/no-go decision
  - Warnings during mission
  - Condition Based Maintenance
- **Prediction horizon:**
  - Required: 1 mission (24hrs)
  - Goal: 7 missions.
- **Prognostics coverage**
  - Marine: Power Transfer Module (PTM)
  - Automotive: PTM, Transmission & Final Drives (for tracks)
- **40+ faults targeted**
  - Gears
  - Bearings
  - Clutches
  - Brakes
  - Fluid Loss
- **Maximal usage of vehicle sensors & data**





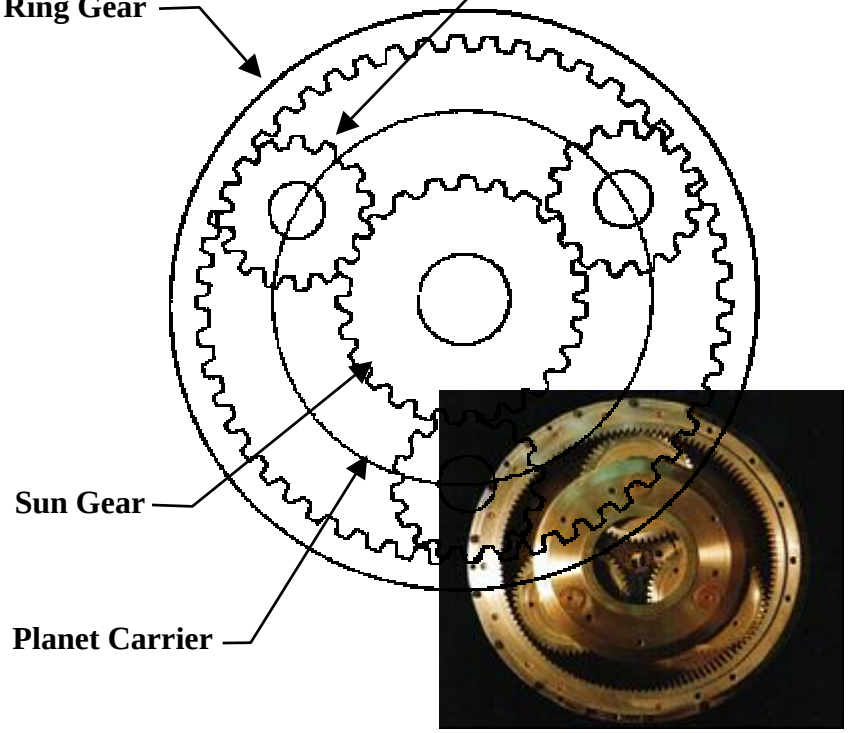
Seeking Technology Reuse Partners

Planetary Gearbox Diagnostics/Prognostics

Honeywell

- **Technology:**
  - Gearbox Vibration analysis and prognostics algorithms acquired from Australia DSTO
- **Status**
  - Algorithms Demonstrated on HON Chadwick Division VXP
  - Seeking quality test data to mature analysis methods

VXP Processor Unit

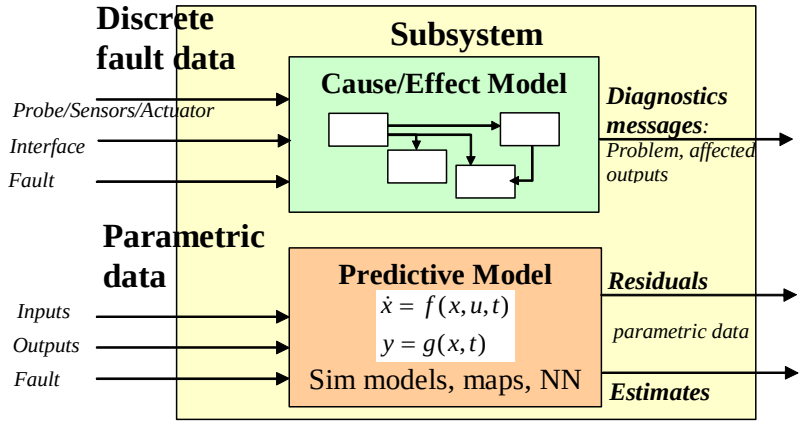


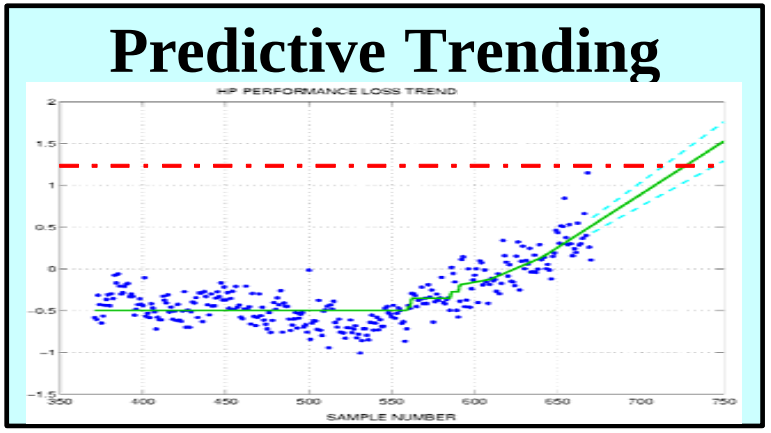
Seeking Technology Insertion Partners

Parametric Fault Prediction

Honeywell

- **Multivariable estimation and prognostic trending**
- **Discriminates between sensor drift and system fault**
- **Provides parametric data for key subsystems**
  - Trending damage accumulation
  - Performance Degradation
- **Demonstrated Internally for HON Applications**
- **In Development for UCAV F124 Engine**





Seeking Technology Reuse Partners

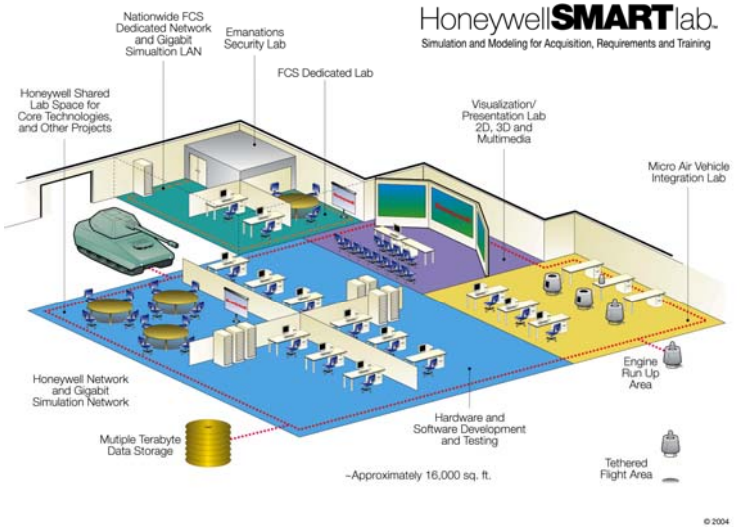
Needs & Opportunities for Technology Insertion

Honeywell

Honeywell SMART Lab

Honeywell

- **Providing Simulation-Based Acquisition (SBA) support to DoD and Commercial project throughout their life cycle**
  - **Support Honeywell's Future Combat Systems projects**
  - **Augment FCS System Integration Labs and tests**
  - **Build SMART Lab for networking and software integration**
  - **Provide M&S and visualization tools and resources**
  - **Establish M&S processes that align with major project phases**
  - **Provide engineering services to external customers for their SMART requirements**



- **Facilities**
  - **16,000 sq.ft. hardware and software workspace & computing resources suitable for DoD and commercial applications**
  - **High-Speed Networks**
  - **Visualization & collaboration center**
  - **TEMPEST Lab**
- **Software tools**
  - **Simulated operational scenarios: HLA, Computer Generated Forces (CGF) & terrain databases**
  - **Visualization tools – 2D map views & 3D displays**
  - **Integrated Software Development Environments**
  - **Network analysis**
  - **Simulation control**
- **Hardware**
  - **SGI, Irix**
  - **Sun, Solaris**
  - **Intel, Linux Red Hat**
  - **Intel, Windows 2000 Advanced Server and Professional 2000**
  - **Power PC, Linux Yellow Dog**

Simulation & Modeling for Acquisition, Requirements and Training

Future Combat Systems - PSMRS

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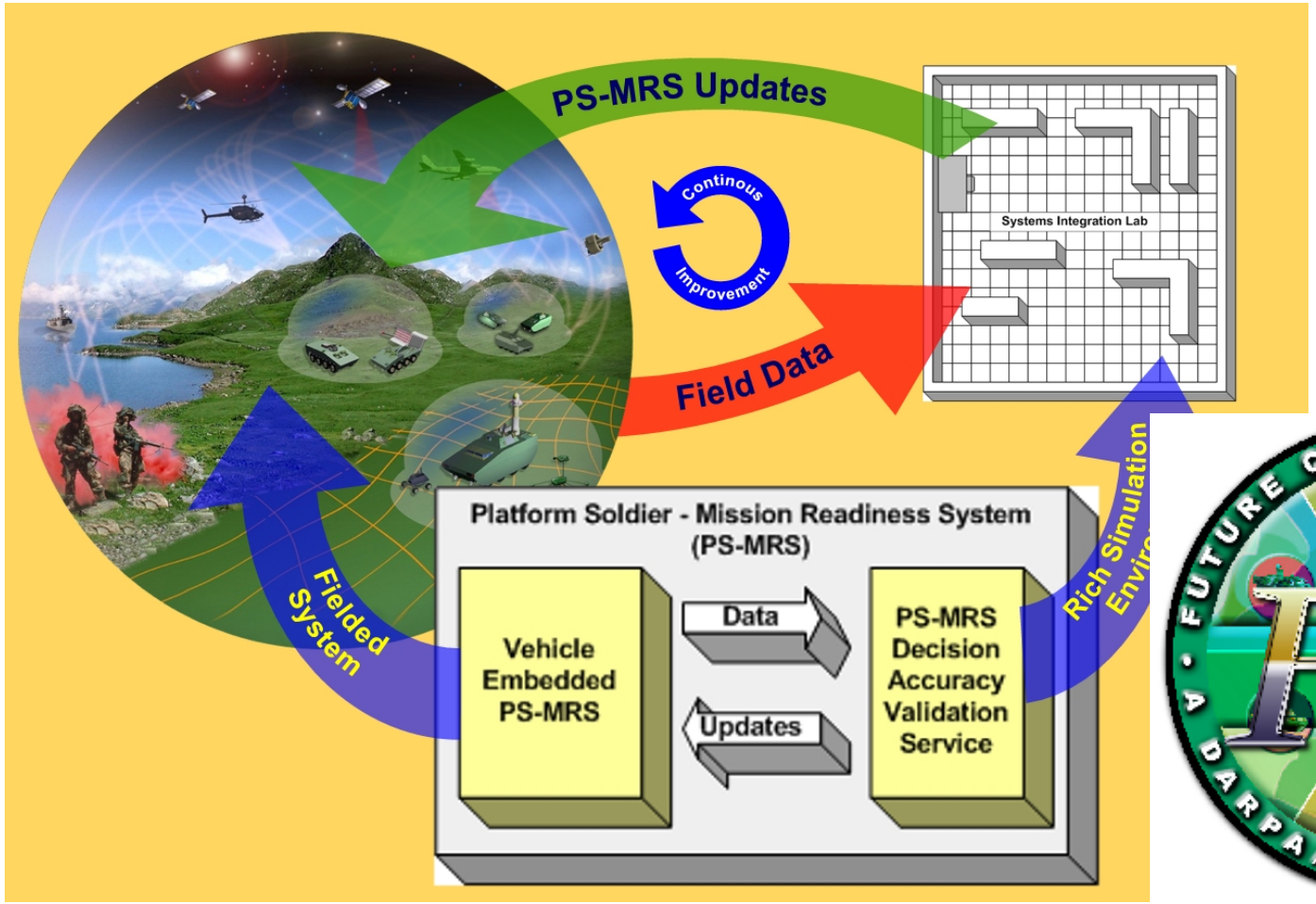

Seeking Technology for Readiness Assessment

Predictive Trend Monitoring

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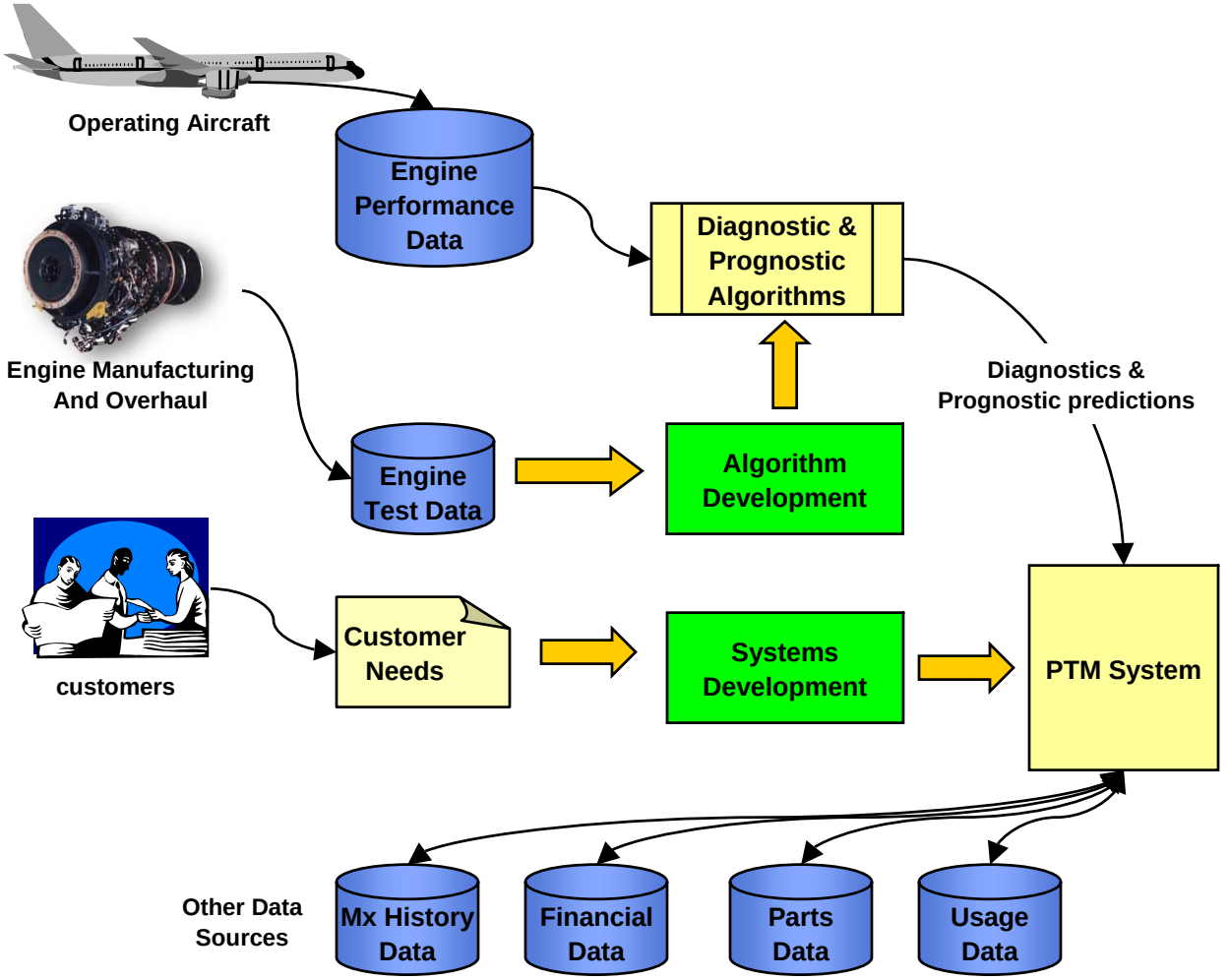

System Benefits

- Operators
  - Failure predictions
  - Go/No Go Decisions
  - Pull recommendations
  - Maintenance Tasking
- Repair and Overhaul
  - Parts predictions
  - Work scoping
- Engineering
  - Improved Reliability analysis
  - Feedback to design process

Seeking Technology for Engine/APU Maintenance

Aircraft Maintenance and Operations Support

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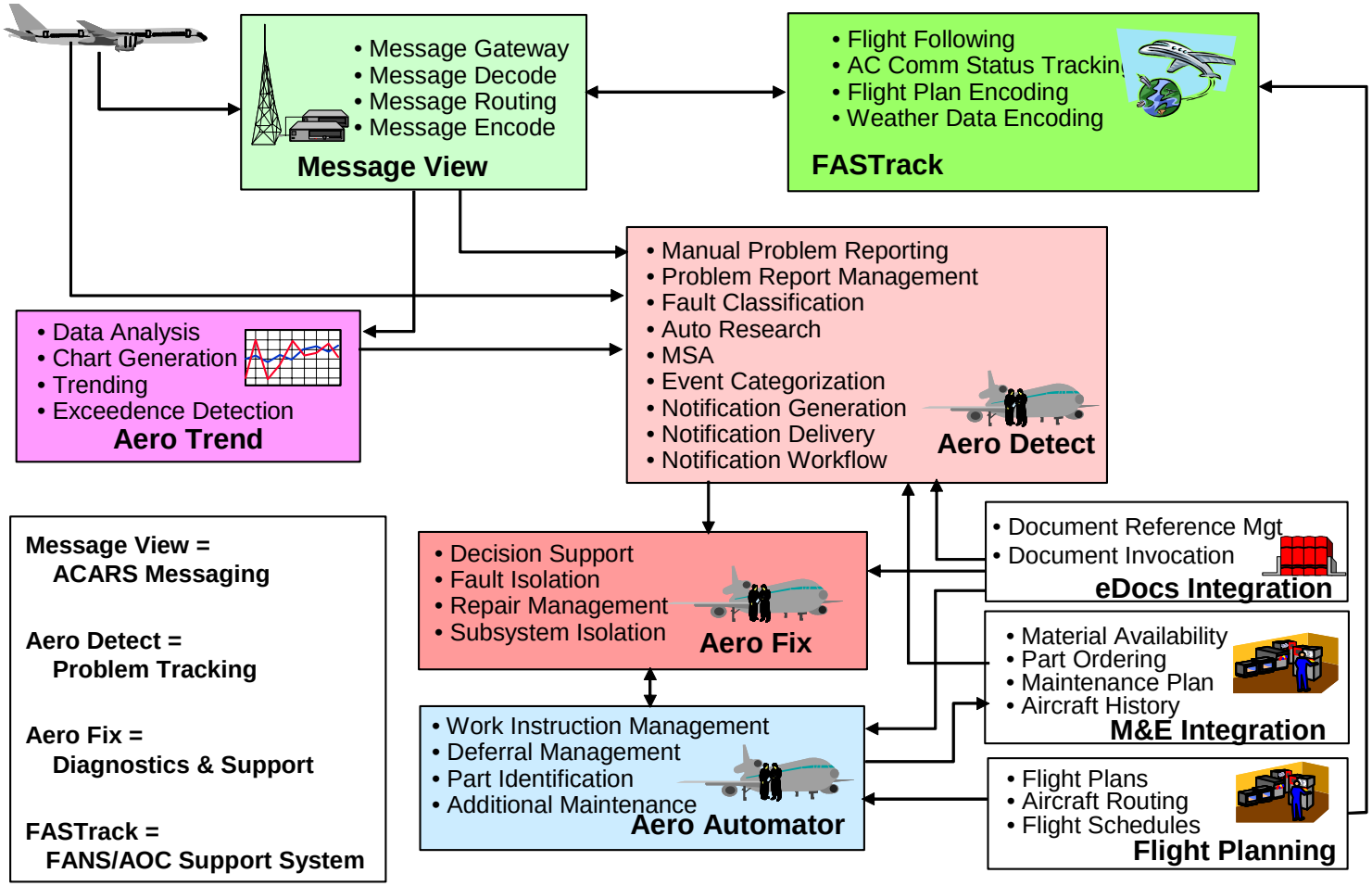

Seeking Technology for Commercial Application

Summary – Capabilities and Needs

Honeywell

PHM Technology	Honeywell Need	Honeywell Capability/Offerings
Independent means of quantifying PHM technology and hardware performance	Standards Definitions and means to quantify against them	Proprietary Methodologies
Prognositcs Modeling & Simulation - complementary analog of the test & validation facility	Technology insertion partners	SMARTLab
Prognostic Data Library (source and repository) for future technology insertion and lessons learned data	Standard data sets - challenge problems	Application specific data sets & results
Integration of PHM into the Maintenance Operation - Data Harvesting and Management	Technology insertion partners	Proprietary Models
Innovative Smart Sensor Technologies	Yes - HON often buys these	Vibe, Corrosion, MEMS manufacturing
Electronics Prognostics Methodology & Algorithms	New techniques	Statistical methods
Machinery Prognositcs Algorithms	Technology insertion partners	Proprietary algorithms
Structures Prognostics Algorithms	Low cost detectors; structural test facilities	Subsystem Integration
Incipient Corrosion Detection and Prognosis Algorithms	Technology insertion partners	Flight-tested corrosion monitoring
Automated Detection of Incipient Faults - Replaces manual test and troubleshooting	See Prognostics	See Prognostics
Specialized Diagnostics Sensing Technologies in Acoustic Emmission, SAW Detection/Analysis	Non-Intrusive Engine Bearing Fault and Leak Detection	Proprietary structural crack detection algorithms
Software Diagnostics and Prognostics	Technology insertion partners	Proprietary algorithms
Automated Trending and Prognosis (Prediction) of Failure, ETC	Robust subsystem monitoring; Technology insertion/integration partners	Proprietary methods

Sandia PHM COE – Potential Value

Honeywell

- **Key Needs that COE can provide:**
  - **Source for transition of emerging technology into Honeywell offerings**
    - Sensors
    - Algorithms
    - SMART Lab transition
  - **Forum to develop standards for quantifying PHM technology performance**
  - **Facilities and resources to evaluate performance of PHM technology**
    - Algorithm Testing
    - Standard Data Sets
  - **Brokerage to introduce emerging Honeywell technology to R&D partners, customers and insertion opportunities**
    - Novel prognostic sensors and algorithms
    - PHM Integration Methodologies
    - VHM Automation Technology

Sandia PHM COE Can Provide Capability and Facilitate Collaboration

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www.honeywell.com