# Passive Wireless Sensors

## Vehicle Health Management Applications

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July 27-28, 2011
NASA Passive Wireless Sensor Tag Workshop
Houston, Texas

# Boeing Aircraft Health Management Technologies

*Military Fixed and Rotary Wing Platforms*

*Boeing Commercial Aircraft*

**Reduced Life Cycle Cost**

**Efficient Supply Chain**

**Improved Mission Reliability**

**Improved Availability**

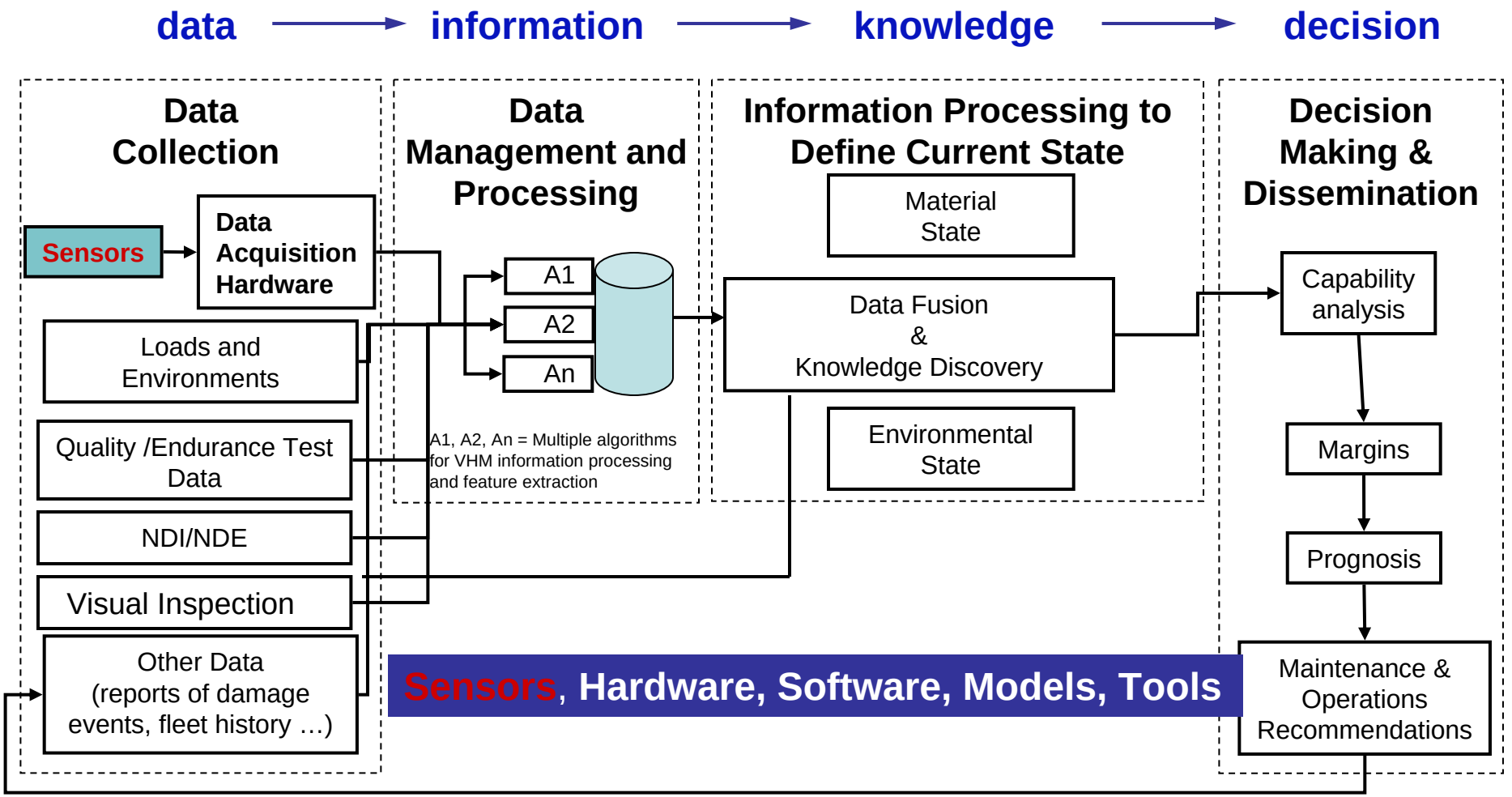
**Improved Operational Plans**

Government

Academia

Industry

# Vehicle Health Management System Elements



# Technology Transition Challenges

*Efficient acquisition of emerging technology*

*is a key feature in use and fielding of these technologies*

- ***Complexity*** *of aerospace products and services* ***is*** *ever* ***increasing***
- ***The gap*** *between the technologies Boeing needs and those it can afford to develop and implement* ***is*** *ever* ***widening***

System that are easy to install and maintain with minimal need for power and wires are enablers for development and fielding of a comprehensive vehicle health management system

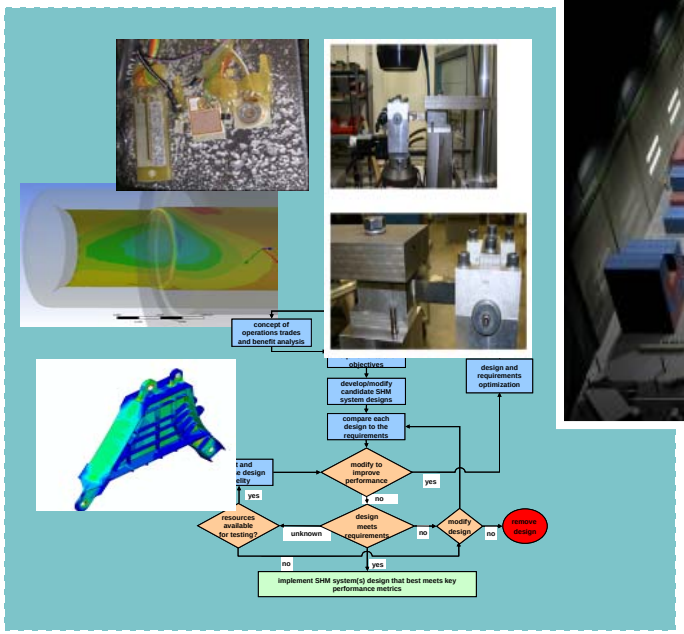
# VHM Technology Implementation Barriers

- **Sensors**:
  - **Power**
  - **Weight**
  - **Wiring**
  - **Installation**
  - **Reliability/maintenance**
  - **Data acquisition hardware**

# Platform Life Cycle Data

Test Data

Aircraft Operation and Maintenance Data




Design and Development

Manufacturing

Operation and Sustainment

# Sensors Application Areas

### Flight Control
Electro-Mechanical Actuators
Hydraulic Actuators
Linkage
Hydraulic System

### Structures
Airframe Structure

Dynamic Components

### Electrical System
Generators
Converters
Contactors
APU
Batteries
Cooling System

### Drive System
Gears
Bearings
shafts
Lubrication
Housing

### Propulsion
Blades
Bearing
Gas path
valves

### Electrical Wiring
Wiring insulation
Pins connections

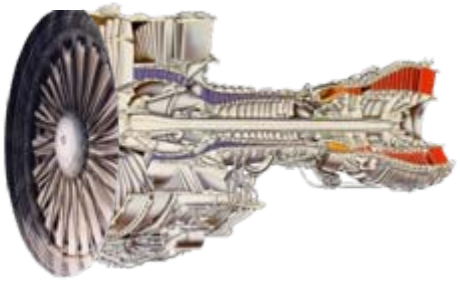
### Avionics
Power Supply
Electronics

### Rotor System
Rotor blades
Rotor hub
Tie bar
rotor shaft

### Fuel System
Fuel Pumps, Motors, Valves

### Under Carriage
Landing Gear
Tires, Wheels, Brakes

# Propulsion



**Temperature sensors**

- Small, light weight and highly reliable sensors that could withstand the extremes of the engine gas path

**Pressure sensors**

- Able to withstand the high temperatures in the pneumatic and air start system

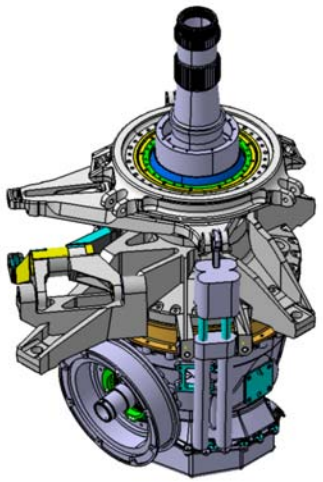
**Position sensors**

- Position sensors that would support valve operational monitoring

**Challenges:**

- High temperature MEMS sensors for temperature, pressure and position
- Reliable RF Communication, installation reliability and sensor stability

# Drive System



Temperature sensors

- Gears
- Bearings

Strain sensors

- Shafts moments
- Torque

Challenges:

- Reliable communication through complex RF paths and out of sight components
- Lubrication and reliability of the installation
- Isolation of torque from axial and bending moments
- stability over life

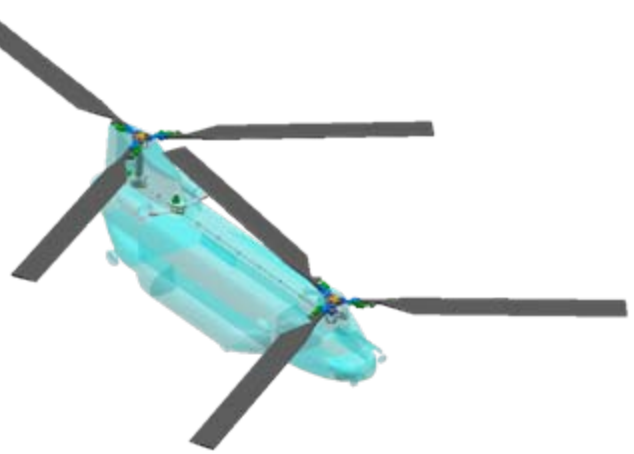
# Rotor System

Strain sensors

- Dynamic components loads

Pressure sensors

- Pressure profile



**Challenges :**
Reliable Installation and Maintenance
Isolation of Pressure from Strain
Stability over life

# Electrical Power System


Temperature & Pressure sensors

- Cooling System
- Gearbox
- Generator

Position sensor

- Valves

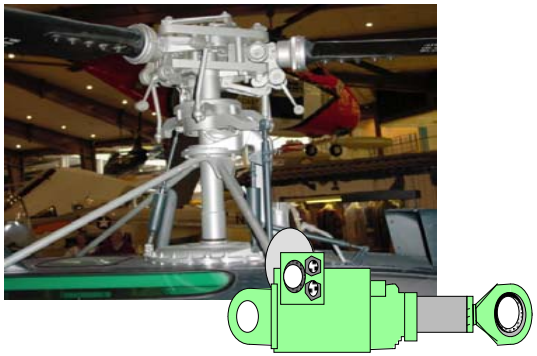
**Challenges:**

• Reliable communication through complex RF paths and out of sight components-

• Harsh environment

• EMI Considerations

# Flight Control System



Strain &Torque sensors

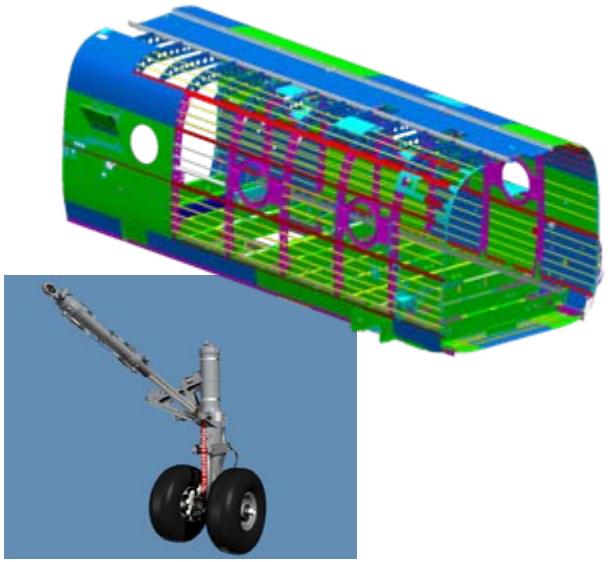
- Shafts and Links

Pressure &Temperature sensors

- Hydraulic system

**Challenges:**
Reliable communication through complex RF paths and out of sight components
Reliable Installation
Accurate Readout

# Landing Gear and Structure



Strain sensors

- Landing Gear Structural Components
- Airframe Structure

Pressure sensors

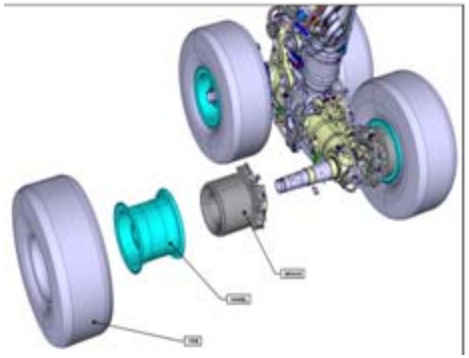
- Hydraulics

**Challenges:**

• Reliable communication through complex RF paths and out of sight components

• Harsh Environment

# Tires/Wheels/Brakes



Temperature sensors
- Tires
- Brake Pads

Pressure sensors
- Tires

Strain sensors
- Wheels
- Connecting Pins

Position Sensor
- Pad Thickness

**Challenges:**
- Reliable communication through complex RF paths and out of sight components
- Reliable Installation- Contaminated Environment
- Accurate Readout over life

# Summary

**Challenges:**

- Reliable communication through complex RF paths
- EMI considerations
- Reliable installation
- Harsh environment
- Sensor accuracy
- Stability over life
- Cross talks

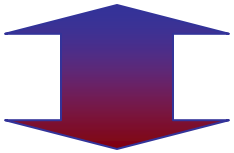
# Research Focus

- Passive wireless sensors shall meet at the minimum the requirements for resolution, accuracy, repeatability and durability of traditional sensors
- The system expandability and the communication quality as the number of interrogated sensors increases are discriminating features
- The EMI for long range interrogation need to be addressed.
- Out of sight sensors implementation
- The synchronization of multiple sensors need to be developed
- The synchronization of multiple interrogators need to be addressed
- The size, weight and power requirements of the interrogators need to be minimized
- Reliable installation and operation over the life of monitored component

# Closing Remarks

Passive wireless sensors:

- provide a great benefit to vehicle health management systems by reducing their weight and power penalties
- facilitate development of advanced capabilities



Vehicle Health Management Systems are a prime opportunity for application of passive wireless tags

# Questions