

A photograph of a fighter jet on an aircraft carrier deck. The jet is in the center, with its wings spread, and is positioned on a runway marked with yellow lines. The background shows the ocean and a clear sky. The text is overlaid on the image.

# Automated Diagnostics Via an S1000D IETM Without the Painful Process DM Development

*Andrew Smith  
General Atomics*

# Topics to be discussed

- Importance of a real-time prognostics, health monitoring (PHM) system
- Old School – Printed fault trees
- ‘Improved’ Old School – IETM stepped through diagnostics
- PHM-to-IETM Proposition
- New School – PHM Empowered IETM fault diagnostics
  - Scheduled Maintenance – How do diagnostics tie in? = MR**C**BM
  - Fault Detection and Isolation = **C**BM
  - Preventive Maintenance (Prognostics) = **C**BM+
- Validated/Verified Data – Logistics
- Dynamic Fault Isolation Development

# Importance of a Real-time Prognostics, Health Monitoring (PHM) System

- **The need for PHM to monitor mission critical systems has increased as customers of these systems demand improved operational availability, greater reliability, increased safety, and reduced cost**
- **One of the key functions of a PHM system is to aid in reducing MTRR and cost of repair by optimizing and automating directed maintenance activities**
- **Maintenance activities can include scheduled, corrective, preventative and inspection procedures**
- **In order to accomplish the above objectives, real-time PHM systems should be tightly coupled to an enterprise Maintenance, Repair, and Overhaul (MRO) system and associated IETM**

# Old School – Printed Fault Trees

- **Labor intensive and increases budget**

- Relied on:

- Preliminary analyses; FMEA, FMECA, RAM, RCM, etc.
- Post FRACAS reports, PRs, IRs
- Accurate schematics, system and h/w requirements
- Take in account every inch, bit, wire, etc....
- You always found it... an engineering was aware of

- Manually built fault tree creation procedures

- Long hours developing fault trees on a white board
- Play mitigator between EEs, h/w and s/w engineers
- Long hours creating the trees in Visio or ???
- Re-write trees with every new discovery or field incident
- ...fault trees (paperwork) grew...real trees diminished, right?

**STATIC**

# Improved Old School – IETM Step Through Diagnostics

- **Still labor intensive and increases budget**
  - Still relies on:
    - Preliminary analyses; FMEA, FMECA, RAM, RCM, etc.
    - Post FRACAS reports, PRs, IRs
    - Accurate schematics, system and s/w requirements
    - Take in account every condition
    - You always found more than engineering was aware of
  - Still manually bound in isolation procedures
    - Long hours developing white board step-by-step procedures
    - Play mitigation between EEs, h/w and s/w engineers
    - Long hours creating procedures in SGML, XML or ???
    - Re-write steps with every new discovery or field incident
    - ...Now you're saving 'green trees' ...not 'green backs', right?

# PHM-to-S1000D IETM Proposition

- **Integrate real-time assessment of system health using model-based reasoning (logic) engine, used to minimize MTR through an S1000D IETM with automated fault isolation and prediction**
- **Automate Root Cause Analysis (RCA); created using software fault models that automate tests, and record measurements according to pre-developed questions and answers using FMECA & RCM analysis**
- **Conclusions are passed to the IETM, directing the user to the appropriate descriptive, procedural or FI DM – 3 methodologies**
  1. **If the PHM system predicts an incipient failure, the maintainer can be alerted and navigated to the appropriate corrective (repair or service) action(s)**
  2. **If a partial fault has been isolated, the maintainer will be navigated to an abbreviated FI procedure where a manual action is required**
  3. **If a root cause is determined, maintainer is presented with the conclusion, supporting evidence, and the corresponding repair procedure**

# New School – PHM Empowered IETM Fault Diagnostics

- **Three levels of maintenance assistance**
  - **Scheduled Maintenance** – Health management system determines optimal timing for specific maintenance activity, **MRCB**
  - **Diagnosis** – Attempted fault detection and isolation to LRU level with advisory, **CBM**
  - **Preventive Maintenance (Prognostics)** – Advisory based on component status – trending, remaining useful life usage monitoring of components and potential impact to other components, system or mission, **CBM+**

# Scheduled Maintenance – How does this tie in?

- **Health management determines optimal timing and escalation of specific maintenance activity**
  - Derived by analyses; RCM, A<sub>o</sub> and FRACAS
  - PHM inspired process; ‘MRCBM’ or ‘MWCBM’
    - 1) Monitors usage, operational feedback and date of last maintenance
    - 2) PHM triggers IETM and pushes maintenance associated data
      - Displays advisory notification to user for associated DMC for IETM navigation
      - IETM user acknowledges advisory notification
    - 3) PHM provides RUL data and timeframe for maintenance activity and navigates user to associated DMC (Proced)
    - 4) User acknowledges completion of activity
    - 5) PHM records completion status and timestamps

# Fault Detection and Isolation – CBM

- **Attempted fault detection and isolation to LRU level with advisory**
  - PHM detects fault, attempts isolation to LRU/WRA level
    - 1) Monitors usage, sensor and operational feedback and for deterioration
    - 2) PHM triggers IETM and pushes maintenance associated data
      - Displays advisory notification to user for associated DMC for IETM navigation
      - IETM user acknowledges advisory notification
    - 3) PHM provides fault data, specifications/limits surpassed and navigates user to associated DMC (Fault or Proceed)
    - 4) User acknowledges completion of activity
    - 5) PHM records completion status and timestamps

# Preventive Maintenance (Prognostics) – CBM+

- **Based on component status – trending, RUL, usage monitoring of components and potential impact to other components, system or mission**
  - PHM detects (incipient failure) trending fault, attempts isolation to LRU/WRA level
    - 1) Monitors usage, sensor and operational feedback, deterioration and date of last maintenance
    - 2) PHM triggers IETM and pushes maintenance associated data
      - Displays advisory notification for IETM DMC navigation
      - IETM user acknowledges advisory notification
    - 3) PHM provides fault data, specifications/limits surpassed and navigates user to associated DMC (Descript, Fault or Proced)
    - 4) User acknowledges completion of activity
    - 5) PHM records completion status and timestamps

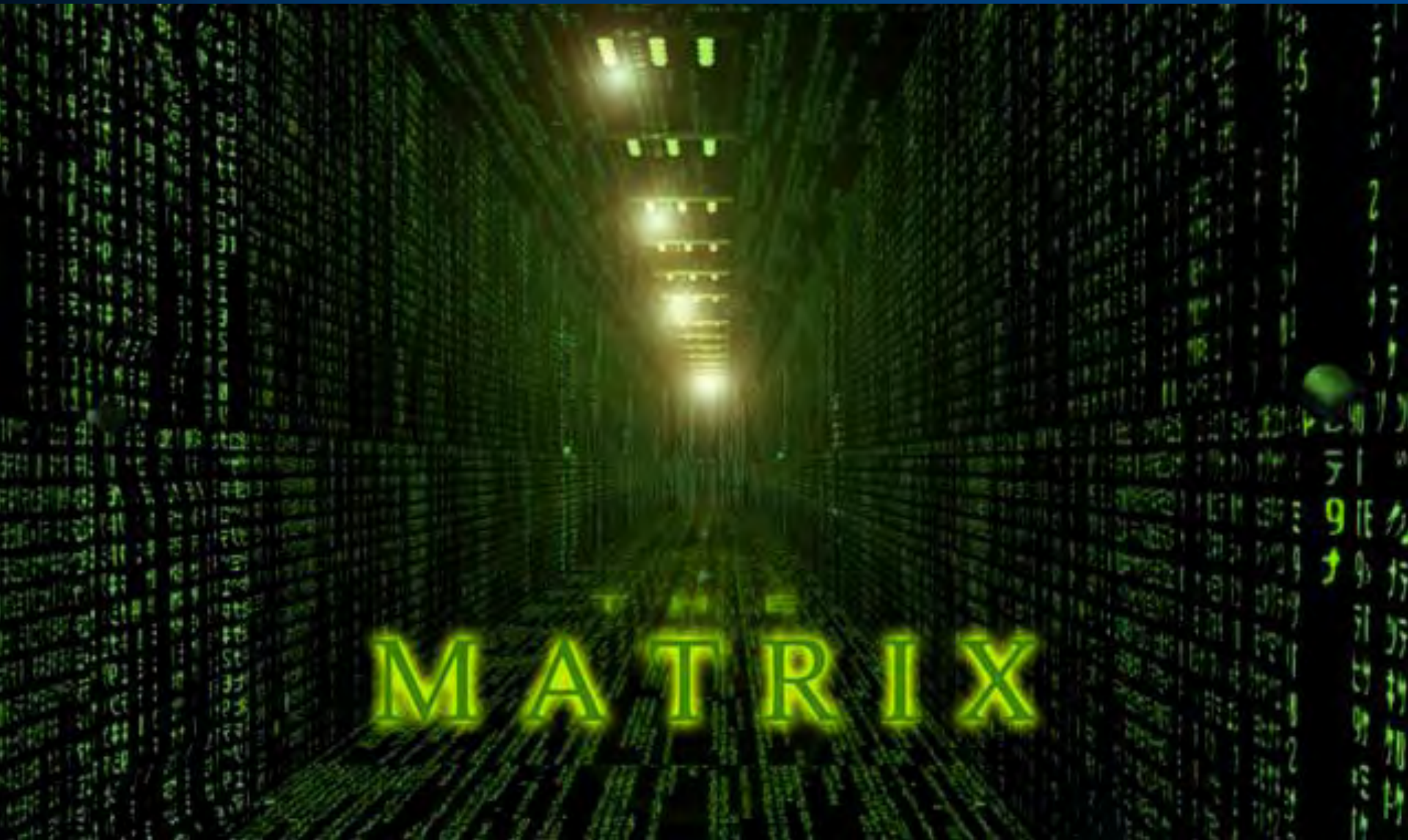
# Skeleton Data Modules Are the Key

- It's a different mindset – think outside of the box
- You still have a typical acquisition process; development of; FMEA, FMECA, RCM, etc. and all of this data goes through validation and verification
- The reasoning engine assigns maintainers to tasks assigned to findings (specifications)  
**“NEVER REMOVE THE MAINTAINER FROM THE DIAGNOSIS”**
- The reasoning engine provides better than a 90 percent solution to the LRU/WRA, the remaining percentage requires a maintainer to finish diagnostics
- PHM diagnostics are only as good as the system Built-In-Tests (BIT) are thorough

# Dynamic Fault Isolation Development

- **What comes in an IETM build and what's "On the Fly"**
  - Validated and verified descriptive and procedural (preventive and corrective) DMs are in IETM build
  - In addition, 'placeholder' DMs are also in IETM build
    - The data that populates the 'Placeholder' DMs is already validated and verified through the logistic analyses process
    - Descript and Fault DMs have all pertinent DMC and element/attributes required to parse during IETM build
    - These 'placeholder' DMs are created to support all SNS levels and sit empty until populated by PHM health data
    - PHM has knowledge of fault or maintenance codes relational to SNS
      - Descript DMs are populated with diagnostics performed and system health specs (within/outside of range)
      - Fault DMs are populated with any additional troubleshooting procedures that are unable to be performed via BIT or reasoning engine

# Summary



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