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

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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? = MRCBM
  - Fault Detection and Isolation = CBM
  - Preventive Maintenance (Prognostics) = CBM+
- 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 MTTR 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 s/w requirements
    - Take in account every if this, then...
    - You always found more...than engineering was aware of
  - Manually built fault isolation 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 [illegible]
    - You always found more than engineering was aware of

STATIC

  - Still manually build fault isolation procedures
    - Long hours developing white board step-by-step procedures
    - Play mitigator 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 MTTR 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, **MRCBM**
  - **Diagnosis** – Attempts real-time 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+**

DYNAMIC

Scheduled Maintenance – How does this tie in?

- **Health management determines optimal timing and escalation of specific maintenance activity**
  - Derived by analyses; RCM, A_o and FRACAS
  - PHM inspired process; 'MR**C**BM' or 'MW**C**BM'
    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 Proced)
    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 [illegible] ning eng[illegible] oint is ass[illegible] are assigned to findings (specifications)
- 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

"NEVER REMOVE THE MAINTAINER FROM THE DIAGNOSIS"

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