NAVAIR Wiring System Initiatives

Presented By: Pall B. Arnason
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Naval Air Systems Command, Patuxent River, MD
We Are Responsible For Three Things

1. We Ensure That the Fleet and the OEMs Get Good Parts
   - Maintain Quality Parts Lists (Suppliers) Backed up by Testing.
   - Maintaining and Transitioning Specifications

2. We Ensure Adequate Wiring System Designs and Installations
   - Assess New Aircraft Wiring Installations As Well As Third Party Modifications
   - Evaluate Installations for SOF, Workmanship, Performance and Maintenance Issues
   - Review Flight Clearance Requests
   - Aging Wiring System Assessments
   - Quantify Risk and Recommend Solutions and Options

3. We Ensure That Aircraft Wiring Systems Are Maintained Properly
   - Ensure That Fleet Gets Proper Training
   - Ensure That Wiring Maintenance Manuals Are up to Date
   - Ensure That Proper Tooling is Available
   - Ensure That Technology Solutions Meet Fleet Needs
Wiring Issues

Why Should You Care About Wiring Systems?
- An Indispensable System
- Impacts Safety and Mission Readiness
- High Cost of False Equipment Removals
- Complexity and Density Is Increasing
- Experiences Aging Effects

- Safety Degrader
- Readiness Degrader
- Millions Of MMH
- Escalating Cost
NAVAIR Wiring Systems Issues

What Does Our Data Tell Us?

- Chafing Conditions Are A Primary Factor In A Large Percentage Of Our Wiring System Related Safety Issues
- We Are Experiencing At Least Two Electrical Fires Per Month
- Intermittent Failures And Anomalies And Faulty Components Are Costing Us Millions In False Equipment Removals
- Maintenance Man-hours Per Flight Hour Are Increasing As Our Aircraft Age
- Polyimide Wiring Continues To Be An Issue (P-3, EA-6B, And C-2 Have Targeted Rewiring Programs)
- Corrosion Continues To Plague Our Wiring Systems
Wiring - QPL and Specifications

• Goal - Stop discrepant parts for reaching our fleet - 20-29% of wiring components submitted to our QPL process do not comply with the governing specifications.

• NAVAIR maintains 38 Wiring Product QPLs covering contacts, connectors, wires, terminals, tools, circuit breakers ...

• Cost Avoidance ($1.3M/ year saves at least $8.9M/ year)

• NAVAIR maintained MIL-W-5088, which is now an industry document (AS50881)

• NAVAIR participates in industry specification groups

• Example Payoffs: Prevented Arc Tracking Wire ($100+M savings) and Smoking Wire from reaching fleet. Issued 93 failure letters from 1997-1999..

Concern: Lower Surveillance Levels may allow Discrepant Parts to Reach Fleet.

There has been a reported 250% increase in GIDEPs.
AIR-4.4.4 Airworthiness Responsibilities

As Part of the Flight Clearance Process AIR-4.4.4 Typically Performs or Reviews:

• Load Analysis (Load vs. Source)

• Power Quality Assessment (MIL-STD-704)

• Wiring and Interconnect System Design Review (Governing Specifications)
AIR-4.4.4 Airworthiness
Responsibilities
Support Elements

- Participate in Technical Meetings, Design Reviews, Working Groups and IPT Meetings
- Provide Technical Advice on State-of-the-Art Processes and Materials
- Review Proposed Wiring and Interconnect System Design and Implementation
- Interpret Specifications and Standards
- Review Conversion of Military Specifications/Standards to Performance Specifications and Industry Standards
- Invoke Lessons Learned During Engineering Reviews
- Wiring Metrics Program
AIR-4.4.4 Airworthiness Responsibilities

- Detailed Review of Wiring and Interconnect System
  - Drawing Review
  - Material Selection
  - Electrical Circuit Protection
  - Wiring Terminations and Connectors
  - Bonding, Grounding and Shielding
  - Required Separation From Structures, Tubing, Mechanical Systems and Redundant Circuits
  - Identification of Wiring and Equipment
  - Consistency in Installations
  - Design Implementation
  - Aging Wiring Material Condition
  - Training
  - Risk Assessment
Aging Aircraft Wiring Options

- Do Nothing
- Incorporate Risk Mitigation Technologies and Techniques
- Partial Rewire w/ Mitigation
- Full Rewire
- Full Rewire w/ Proactive Mitigation

TRAINING

Quantify Impact
Baseline

Technical Training Deficiency

Develop Survey Baseline

Analyze Data
(Nalda/MTTR/HMRs)

Fleet Surveys

MTRR/Course Review

Map Issues

Recommendation(s)
## Hazardous Risk Matrix

<table>
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<tr>
<th>HAZARD CATEGORIZATION</th>
<th>SEVERITY</th>
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<tbody>
<tr>
<td></td>
<td>CATASTROPHIC (1)</td>
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<tr>
<td>FREQUENT (A)</td>
<td>1</td>
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<tr>
<td>= or &gt; 100/100K flt hrs</td>
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<tr>
<td>PROBABLE (B)</td>
<td>2</td>
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<tr>
<td>10-99/100K flt hrs</td>
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<tr>
<td>OCCASIONAL (C)</td>
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<td>1.0-9.9/100K flt hrs</td>
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<td>REMOTE (D)</td>
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<td>IMPROBABLE (E)</td>
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<tr>
<td>= or &lt; 0.1/100K flt hrs</td>
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### Severity
- **Catastrophic** - Class A (damage > $1M / fatality / permanent total disability)
- **Critical** - Class B ($200K < damage < $1M / permanent partial disability / hospitalization of 5 or more personnel)
- **Marginal** - Class C ($10K < damage < $200K / injury results in 5 or more lost workdays)
- **Negligible** - All other injury/damage less than Class C

### Probability
- Occurrence for discreet events may replace **Frequency** based upon the chart below:

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**Severity** is the worst credible consequence of a hazard in terms of degree of injury, property damage or effect on mission defined below:

- **Catastrophic**
- **Critical**
- **Marginal**
- **Negligible**

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**Probability** of occurrence for discreet events may replace **Frequency** based upon the chart below:
Hazard Risk Index (HRI) is 6 (6.67 / 100,000 flight hours) will
• increase to HRI 4 if wiring incidences double as predicted
• or HRI 5 if wiring around the engine controls or flight controls
  causes a hard landing or crash
Example Age Distribution of Aircraft with Polyimide Wiring

- Total Example Aircraft with M81381 Wire
- Reported Fire & Arc Failures since 1987
- Reported M81381 Wire Failures since 1987

- PPOF of M81381 Wire Fire and Arc Failures
- PPOF of All Failures due to M81381 Wire

- All Failures due to Kapton
- Kapton Fire and Arcing Failures Only
# Example Cost/NMC AC/Aborts vs. Wiring Options Over Ten Years

<table>
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<tr>
<th>Wiring Options</th>
<th>Cost (M$)/NMC AC/Aborts</th>
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<tr>
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<td>Total Cost (M$)</td>
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<tr>
<td>1</td>
<td>132</td>
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<tr>
<td>2</td>
<td>254.3</td>
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<tr>
<td>3</td>
<td>148.8</td>
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<td>143.1</td>
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<tr>
<td>5</td>
<td>135.5</td>
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<td>Total Aborts</td>
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<tr>
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<td>379</td>
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<td>Total NMC Aircraft</td>
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<td>132</td>
</tr>
<tr>
<td>2</td>
<td>104</td>
</tr>
<tr>
<td>3</td>
<td>113</td>
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<td>4</td>
<td>103</td>
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<tr>
<td>5</td>
<td>86</td>
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HRI Rating After Implementation: 4, 5, 14, 6, 11, 10
Wiring Maintenance Manual Update

- Joint Service Manual
- NAVAIR Revising and Updating With Joint Service Participation
- Simplifying Over Two Dozen Volumes Into Three
- Updating Technical Information
- Volume One Due Out in 2003
- Subsequent Volumes in 2004 and 2005
- E-Business Initiative; Hot-Link To Aircraft Wiring Information System (AWIS)
Enhanced Maintenance Codes

Old WUC Example
42830 - Electrical Power System Wiring

New WUC Example
4257D - MPDB AC Power Wiring FS 347-359 RH

Old Mal Code Example
615 - Shorted
160 - Broken Wires, Defective Connection

New Mal Code Example
W00 - Chafing against combustible/bleed air lines
W01 - Chafing against structure/components/non-combustible line
W02 - Chafing against control cables/flight control components
W03 - Chafing against other wire/WBA
W46 - Arced/burned/shorted wiring – due to chafing against structure, equipment or fluid/pneumatic lines (including overheat detection elements)
W47 - Arced/burned/shorted wiring – due to unknown or other causes (including overheat detection elements)
W48 - Broken/open wiring (including overheat detection elements)
W49 - Broken splice
W50 - Broken terminal lugs/studs

* Conditional (Non-Failure)
C-2A(R) WIRING DISCREPANCY LOCATION CODES

5.2 R/H CENTER WING SECTION
5.21 EXTERNAL
5.22 FUEL TANK INTERNAL
5.23 T.E. INTERNAL
5.24 L-E INTERNAL

5.1 L/H CENTER WING SECTION
5.11 EXTERNAL
5.12 FUEL TANK INTERNAL
5.13 T.E. INTERNAL
5.14 L-E INTERNAL

5.3 L/H NACELLE & MLG
5.31 NACELLE-EXTERNAL
5.32 NACELLE-INTERNAL
5.33 WHEELWELL

4.1 L/H OQCA

4.2 R/H OQCA

1.0 COCKPIT
1.1 EXTERNAL
1.2 INTERNAL

3.0 NOSE SECTION
3.1 EXTERNAL
3.2 INTERNAL
3.3 WHEELWELL

6.1 L/H OUTER WING PANEL
6.11 EXTERNAL
6.12 INTERNAL

2.0 FORWARD EQUIPMENT COMPARTMENT
2.1 EXTERNAL
2.2 INTERNAL

8.1 CARGO COMPARTMENT & CENTER FUSELAGE
8.11 EXTERNAL
8.12 OVERHEAD INTERNAL
8.13 L/H INTERNAL
8.14 R/H INTERNAL

8.2 CARGO COMPARTMENT & CENTER FUSELAGE
8.21 EXTERNAL
8.22 OVERHEAD INTERNAL
8.23 L/H INTERNAL
8.24 R/H INTERNAL

8.3 CARGO COMPARTMENT & CENTER FUSELAGE
8.31 EXTERNAL
8.32 OVERHEAD INTERNAL
8.33 L/H INTERNAL
8.34 R/H INTERNAL

9.0 AFT FUSELAGE & EMPENNAGE
9.01 FUSELAGE EXTERNAL
9.02 FUSELAGE INTERNAL

NADEP NORIS CODE 444
Wiring System Tool
Development Examples

- Self-contained, OMA, heat gun
- Used to perform 95% of routine wire repairs
- No heavier than 10-15 pounds
- Rechargeable/Replaceable battery pack
- Holder to protect worker from the hot tool

- Aircraft Wiring Repair Kits
- Used to repair and assemble electrical wiring harness components at the Organizational and Intermediate maintenance levels
Off-Board Diagnostics Developmental Timeline

- ECAD Stage I
- AWA Stage I
- Handheld Stage I

- ECAD Stage II
- AWA Stage II
- HH Stage II

- ECAD Stage III
- AWA Stage III
- Handheld Stage III

- EA-6B, C-2 Initial Transition
- Prioritized PMA-260/AIR-6.0 Procurement

**Development**

**A/ C Test**

**Initial Buy**

**“Rest of the Fleet” Procurement**

**ECAD: COSSI/OSD Funded Electronic Characterization and Diagnostic System (Portable) Targeted For O-Level**

**AWA: ONR CTTO/ASN RDA/CTMA OSD Funded Automatic Wire Analyzer Development**

**TEST SYSTEMS**

(MIL-STD-810 EXPLOSIVE ENVIRONMENT)

- Standing Wave Reflectometer - With Plain Test Display
- Ruggedized Laptop
- Test Box/Expansion Units

**Handheld Initiative** - Collaborative Effort with Air Force (New Start)
Development Flight Test Prod. Install

**Wiring Diag. SBIR**

**EMD/Transition**
Lead: P-3, PMA-290A
Additional Retrofits: F/A-18, EA-6B, F-14, AV-8B, V-22, JSF

**Smart Connectors**
- 'Hockey Puck' connector saver
- Flight hardware processor/sensor development

**Phase I**
- Off-Off-Board Diagnostics (Smart Wiring) Developmental Timeline
- Smart Wiring Harness

**Phase II**
- Smart Connector
- Smart Wiring Integration Assembly (Organized Wiring)

**Phase III**
- Lead: P-3, PMA-290A
- Additional Retrofits: F/A-18, EA-6B, F-14, AV-8B, V-22, JSF
Example Aging Wiring System Roadmap

<table>
<thead>
<tr>
<th>Year</th>
<th>03</th>
<th>04</th>
<th>05</th>
<th>06</th>
<th>07</th>
<th>08</th>
<th>09</th>
<th>10</th>
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**Wiring**
- Wiring Engineering Support
- Wiring and Equipment Installation Assessment Program
- Data Analysis / Fleet Tracking
- Wiring Training
  - MR Wire Harness Replacement

**Arc Fault CB Testing and Planning**
- (ONR/ AF/ FAA Funded)
  - Arc Fault CB Installations

**Wire Diagnostics Testing and Planning**
- (ONR/ ASN RDA/, OSD COSSI)
  - On Board Wire Diagnostics Installation

- Off-board diagnostic systems development completed
- First Fleet buys scheduled for FY’05

Total Rewire Not Historically funded
Related Near Term Initiatives

- Next Generation Wire
- Corrosion Resistant Connectors
- Training Aids
- Accelerated Aging Investigations
- Advanced Wiring Architectures
- Fiber Optics
- Expanded Fleet Wiring Surveys
Related Work With FAA And NTSB

- Assisted FAA With Development Of Aging Transport Non-structural Systems Plan
- Plan Became Basis for Aging Transport Systems Rulemaking Advisory Committee (ATSRAC)
  - Participated In Aging Systems Task Force Sub-group (Intrusive Inspections)
- Partnered With FAA and Air Force On Arc-fault Circuit Breaker Program
- Continue To Partner With FAA On Science and Technology Initiatives Related To Wiring Systems
- Assisted NTSB With Development Of Wiring Systems Lessons Learned Data Library
- Participated In the Development of Report To The President On Wiring System Safety
  - Member Of Wiring System Safety Interagency Working Group
Joint Council On Aging Aircraft

• Primary Members:
  - US Air Force Aging Aircraft Planning Director
  - US Army AMCOM Deputy Commander for Transformation
  - US Navy Aging Aircraft Program Director
  - DLA Aging Aircraft Program Manager
  - FAA Aging Aircraft Programs Director
  - USCG Aging Aircraft Branch Chief

• Adjunct Members:
  - NASA, Marine Corps, and Academia
Joint Council On Aging Aircraft

- JCAA Formed Wiring Steering Group

  - Focus Areas of Wiring Steering Group:
    - Science and Technology (S&T)
    - Acquisition
    - Training
    - Policies

- Focus Areas of Wiring S&T Subgroup
  - Diagnostics and Prognostics
  - Circuit Protection
  - Maintenance and Design Tools
  - Data Management
  - Failure Modes and Effects
  - Materials
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Questions?

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Reminder:

Naval Aerospace Vehicle Wiring Action Group (19-21 November, Comfort Inn, Orange Park, FL)