Evaluation of COTS Wiring Diagnostic Systems

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for department 06252

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COTS Evaluations

- **Purpose: To evaluate the integrated capability and usability of wiring diagnostic systems to detect and locate electrical wiring defects**
- **Equipment selection requirements included:**
  - **current commercial availability (not in development)**
  - **applicable for use in an aircraft environment**
  - **capable of locating detected wiring defects**
- **Evaluations based on inspections of AANC Wiring Test Bed**

- **This study addressed the basic performance of a given diagnostic against a broad set of predefined wiring conditions at the AANC wiring test bed. These diagnostics were not necessarily designed to locate the full range of defects they were exposed to at the AANC. This study draws no conclusion regarding the ability of a specific diagnostic technique to be modified for improved performance in the future.**

Important Notes on COTS Evaluation Program

- **Insulation and installation type defect categories with the Wiring Test Bed are very difficult to detect.**
- **All equipment tested under the COTS evaluation program have some capability to detect these types of defects, however they are understandably limited to specific scenarios.**
- **There may be other features that commercial wiring analyzers possessed that were not evaluated in this program. This program focused on detection and location capabilities and usability.**

AANC Aircraft Wiring Defect Testbed

Contains:

- **known defects fabricated to emulate common aircraft wiring defects as identified in the ATSRAC (Aging Transport Systems Rule-making Advisory Committee) Final Report dated December 2000**
- **new and naturally aged components**
- **aircraft specification electrical wiring and connectors**

- **Connectors on each end of closed container**
- **Ten foot wire lengths (approximate)**
- **Bundled in various configurations**
- **>1000 individual wires and >75 connectors**
- **Ten defect category types**
- **Known non-defective components**
- **One part of capabilities of AANC Wiring Test Bed program**

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AANC Wiring Test Bed

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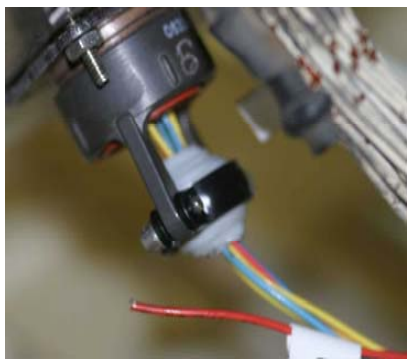
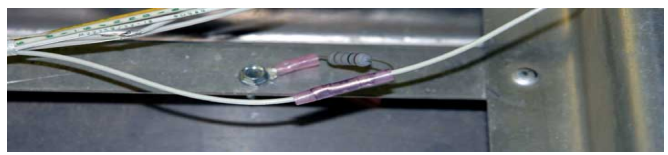
AANC Wiring Test Bed Defect Types*

- DT1 Insulation Abrasion
- DT2 Breached Insulation
- DT3 Cracked Insulation
- DT4 Conductor Strand Breaks
- DT5 Over-pressured Clamps



- DT6 Small Bend Radius
- DT7 Faulty Splice
- DT8 Charred Insulation
- DT9 Open Conductor
- DT10 Shorted Conductor



*Test bed and defects discussed in Session 36 “Electrical Wiring Interconnects System Laboratory”, M. Dinallo, R. K. Howard, Sandia National Laboratories

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COTS Evaluations Method

- **Protocols - based on prior AANC methodology**
- **Survey - commercially available equipment**
- **Selection – identify candidate technologies**
- **Acquisition – buy or rent diagnostic systems**
- **Inspector Training - diagnostic systems**
- **Evaluation - using AANC Wiring Test Bed**
- **Documentation – DOT/FAA Final Report**

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Protocol Development

- **Based on: *Process for Planning and Conducting Experiments in the Aging Aircraft NDI Validation Center***
- **Provides implementation documentation**
- **Assures consistent and fair evaluations**
- **Included in DOT/FAA Final Report**

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Commercially Available Equipment Survey

- Obtained equipment selection input from:
  - AFRL Aircraft Wiring Program
  - Commercial Airline Operators
  - Aircraft OEMs
  - Industry Literature Search

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Selection of Candidate Technologies

- **AVAILABILITY was the most influential decision factor**
- **Particular interested in equipment capable of detecting and locating insulation and installation defects**
- **Originally selected 4 technologies**
- **Eventually evaluated 8 technologies**

COTS Diagnostic Systems Evaluated

- Cable Test – MPT5000L
- CK Technologies - Model 1175-10
- DIT-MCO - Model 2135
- Northrop Grumman – AMWIT 1000
- Eclypse International - ESP Plus
- Jovial Test Equipment – Shortstop
- Phoenix Aviation – ARCMAS
- 3M Company – 900AST

Inspector Training on Diagnostic System

- Inspector trained to operate system for inspection of AANC Wiring Test Bed
- OEM training attended in most cases
- OEM identified equipment capabilities prior to training (based on physics of the system)
- Blind study – inspectors did not have prior specific defect information
- New inspector for each system

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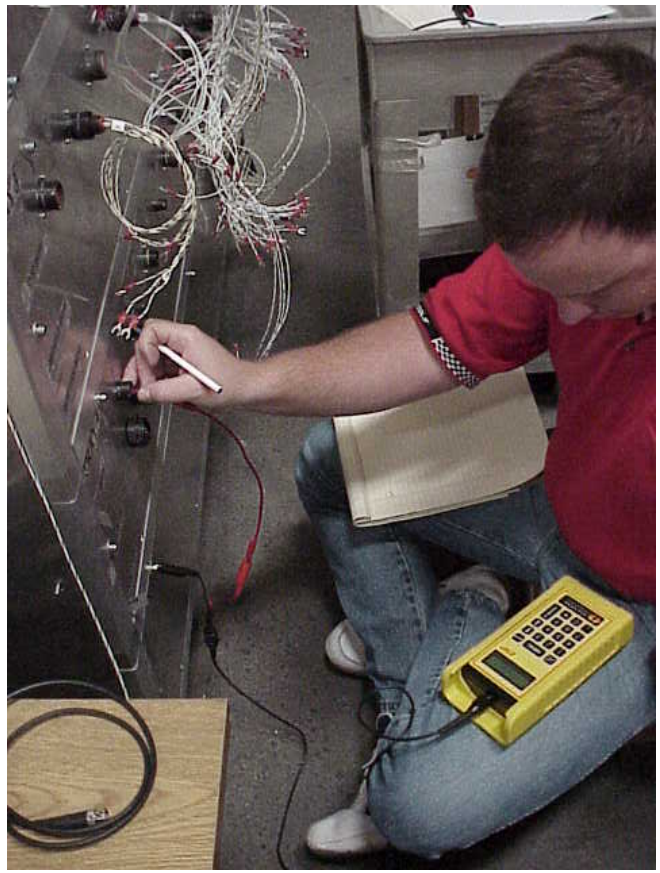
Evaluation of Diagnostic System

- Detect and locate defects in AANC Wiring Test Bed
- Quantitative results
  - Continuity defects – DT9 opens & DT10 shorts
  - Insulation and Installation defects – all other types
  - Location accuracy
- Other comparison data
  - Size, wt., etc.



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Multipoint RC Testers

- Cable Test- MPT5000L
- CK Techologies- Model 1175-10
- Dit-MCo – Model 2135

- Multipoint tester- good for cable assembly diagnostics
- High programmability
- Resistive-Capacitive
- Insulation Resistance Measurement
- Hi Pot capability (no location)

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Cable Test - MPT5000L

- Multipoint Tester
- High flexibility
- Resistive-Capacitive type tester
- Hi Pot capability (2kV on tested system)

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Cable Test - MPT5000L

	Total Defect	Detected Defects	Located Defects	Location Tolerance
DT9 Open	12	12	10	±18 inches
DT10 Short	14	14	N/A*	N/A
Insulation / Installation defects	62	3**	1	±18 inches

* Equipment provides “closest connector” information

** one defect was high resistance, others were located by Hi Pot

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CK Technologies - Model 1175-10

- Multipoint tester
- High flexibility
- Resistive-Capacitive
- Insulation Resistance Measurement
- Hi Pot capability

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CK Technologies - Model 1175-10

	Total Defect	Detected Defects	Located Defects	Location Tolerance
DT9 Open	5	5	1	±18 inches
DT10 Short	12	12	N/A*	±18 inches
Insulation / Installation defects	61	2**	1	±18 inches

* Equipment not designed to locate shorts.

** Faulty splice characteristic of open and over tightened clamp characteristic of short.

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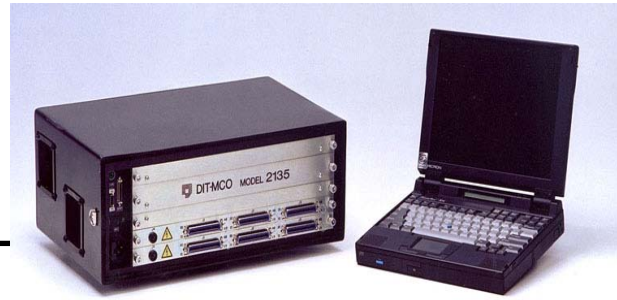
DIT-MCO - Model 2135



- Multipoint
- High flexibility
- Resistive-Capacitive
- Insulation Resistance Measurement
- Hi Pot capability

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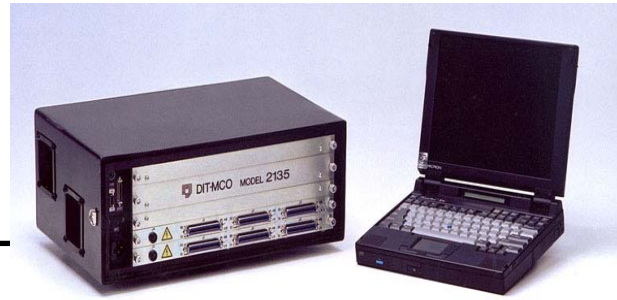
DIT-MCO - Model 2135



	Total Defect	Detected Defects	Located Defects	Location Tolerance
DT9 Open	4	4	1	±18 inches
DT10 Short	13	11	7	±18 inches
Insulation / Installation defects	53	2*	1	±18 inches

* Both defects exhibited symptom of an open

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Single Point Reflectometry Testers

- Single point
- Reflectometry-based systems
  - TDR or SWR
- Defect detection algorithms- some TDR understanding helpful in most cases

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Northrop Grumman – AMWIT 1000

- Single point system
- TDR (Time Domain Reflectometry) based system
- Automated Velocity of Propagation determination
- Automated defect detection algorithm
- TDR waveform display

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Northrop Grumman – AMWIT 1000

	Total Defect	Detected Defects	Located Defects	Location Tolerance
DT9 Open	5	5	5	±18 inches
DT10 Short	13	13	12	±18 inches
Insulation / Installation defects	27	1*	1	±18 inches

* Bad splice with open characteristic

Eclypse International - ESP Plus

- Single point system
- SWR (Standing Wave Reflectometry) based system
- Hand held
- Automated Velocity of Propagation determination
- Two software versions evaluated
  - v1.07D
  - v1.04A

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Eclypse International - ESP Plus

	Total Defect	Detected Defects	Located Defects	Location Tolerance
DT9 Open	7 5**	6 5	5 (V1.07D) 3 (V1.04A)	±18 inches
DT10 Short	7 13**	7 13	5 8	±18 inches
Insulation / Installation defects	32 27**	1* 1*	1 1	±18 inches

*Defect was faulty splice exhibiting characteristic of an open

** Two different units were tested on two separate occasions

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JTE- Shortstop
(Jovial Test Equipment)

- Single point
- TDR based system
- Hand held
- Tone to identify open vs. short
- Automated VoP programming algorithm

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JTE - Shortstop

	Total Defect	Detected Defects	Located Defects	Location Tolerance
DT9 Open	6	6	6	±24 inches
DT10 Short	13	13	5	±24 inches
Insulation / Installation defects	34	0	0	±24 inches

Phoenix Aviation - ARCMAS

- Single point
- TDR based system
- Hand held
- TDR waveform display
- Automated fault detection capability
- ARCMAS (Automated Realtime Cable Analysis and Monitoring Systems)

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Phoenix Aviation - ARCMAS

	Total Defect	Detected Defects	Located Defects	Location Tolerance
DT9 Open	5	5	5	±18 inches
DT10 Short	8	8	7	±18 inches
Insulation / Installation defects	31	1	1	±18 inches

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3M Company – 900AST

- Single point system
- TDR and resistive based system
- Handheld
- TDR waveform display

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3M Company – 900AST

	Total Defect	Detected Defects	Located Defects	Location Tolerance
DT9 Open	6	6	6	±18 inches
DT10 Short	14	14	9	±18 inches
Insulation / Installation defects	37	0	0	±18 inches

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Summary Tables

- Size & weight
- Cost
- Training requirements
- Ease of use
- Delivery schedule - availability

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Summary Table 1

Vendor	Equipment	Size	Weight	Cost (US $)
Cable Test	MPT5000L	Table Top	70 lb	$14,672
CK Tech	1175-10	Table Top	48 lb	$22,650
DITMCO	2135	Table Top	30 lb	$21,830
Eclypse	ESP Plus	Hand Held	1.2 lb	$5500
JTE	Shortstop	Hand Held	1 lb	$349
Northrop Grumman	AMWIT	Table Top	28 lb	$unknown
Phoenix Aviation	ARCMAS	Hand Held	2 lb	$7000
3M	900 AST	Hand Held	2.5 lb	$4800

Summary Table 2

Vendor	Equipment	Training	Ease of Use	Availability
Cable Test	MPT5000L	2-3 days	More Complex	4-6 weeks
CK Tech	1175-10	2-3 days	Complex	30 days
DITMCO	2135	2-3 days	More Complex	60 days
Eclypse	ESP Plus	< 1/2 day	Simple	2 weeks
JTE	Shortstop	< 1 hour	Simple	2 weeks
Northrop Grumman	AMWIT	1/2 day	Simple	10 months
Phoenix Aviation	ARCMAS	< 1 hour	Simple	Unknown
3M	900 AST	< 1/2 day	Moderate	2 weeks

Overall Summary of Evaluations 1

- No COTS diagnostic system tested was capable of consistently detecting or locating any defect types other than DT-9 Opens and DT-10 Shorts, unless the defect manifests as an open or a short.
- Location capabilities of systems varied. Some located only shorts, some only opens, some could locate either.
- Velocity of Propagation determination appeared to be an issue for reflectometry-based systems.
- Several systems had issues with automated interpretation routines.

Overall Summary of Evaluations 2

- Systems with a high degree of programmability were more difficult for the operator to use.
- Interfacing to aircraft connectors was an issue with multipoint testers.
- All equipment manufacturers are welcome to visit the AANC Wiring Test Bed to demonstrate their equipment's capabilities as well as to facilitate future equipment development.

Links

[1] AANC Wiring Lab Defect Descriptions
http://www.sandia.gov/aanc/AppendixPage.htm

[2] Link to ATSRAC Final Report
http://www.mitrecaasd.org/atsrac/index.html

[3] AANC Wiring Lab Website
http://www.sandia.gov/aanc/WiringLabHome.htm

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