

Using Technology to Increase Throughput and Reduce Errors in Wire Harness Production

- Presenter:
 - Brent Stringham
 - Director of Sales, Marketing & Customer Service



Background

- Traditionally, wire harness shops use automatic wire/harness testers to detect wiring faults.
- Even when such faults are detected, diagnosis to the root cause can be difficult and time consuming.

3-Typical Wiring Faults

- Mis-wires
- Open circuits
 - Complete open
 - R -> expected
- Short circuits
 - Dead shorts
 - Insulation Resistance <- expected
 - Dielectric or HiPot failures (arcs)





Background

- Failure analysis requires a highly skilled technician to decipher schematics and reported failures. Requires detailed knowledge of
 - Wire harness under test (UUT)
 - Schematics
 - Test system nomenclature & architecture
 - Wiring harness fault conditions



:	CC	01713				52J-C75EB221-P
:		01714	PASS	164.1		OHM 52J-C75EB221-R
:	CC	01701				52J-C75EB221-B
:		01702	PASS	138.5		OHM 52J-C75EB221-C
:	FF	01713				52J-C75EB221-P
:		01711	FAIL	138.5		OHM 52J-C75EB221-M
:		01703	FAIL	113.0		OHM 52J-C75EB221-D
:		01701	FAIL	113.0		OHM 52J-C75EB221-B
:		00413	FAIL	87.40		OHM 1P-P1EB018B-C
:		00313	FAIL	87.40		OHM 52P-P1DB076D-B
:		00213	FAIL	61.80		OHM 52P-P1DB076A-P
:		00113	FAIL	61.80		OHM 72P-P1BA2P1B-6
:		00013	FAIL	36.20		OHM 72J-P1BA105-2
:	FF	01701				52J-C75EB221-B
:		00413	FAIL	10.60		OHM 1P-P1EB018B-C
:		00313	FAIL	394.6		OHM 52P-P1DB076D-B
:		00213	FAIL	394.6		OHM 52P-P1DB076A-P
:		00113	FAIL	369.0		OHM 72P-P1BA2P1B-6
:		00013	FAIL	369.0		OHM 72J-P1BA105-2
:	TT	01701				52J-C75EB221-B
:		01703	FAIL	317.9		OHM 52J-C75EB221-D
:		01705	FAIL	317.9		OHM 52J-C75EB221-F
:		01707	FAIL	317.9		OHM 52J-C75EB221-H
:		01709	FAIL	317.9		OHM 52J-C75EB221-K
:	TT	01702				OHM 52J-C75EB221-C
:	TT	01709				52J-C75EB221-K
:		01701	FAIL	292.3		OHM 52J-C75EB221-B
:		01703	FAIL	266.7		OHM 52J-C75EB221-D
:		01705	FAIL	266.7		OHM 52J-C75EB221-F
:		01707	FAIL	266.7		OHM 52J-C75EB221-H
:	TT	01710				OHM 52J-C75EB221-L
:			PASS	266.7		



Background

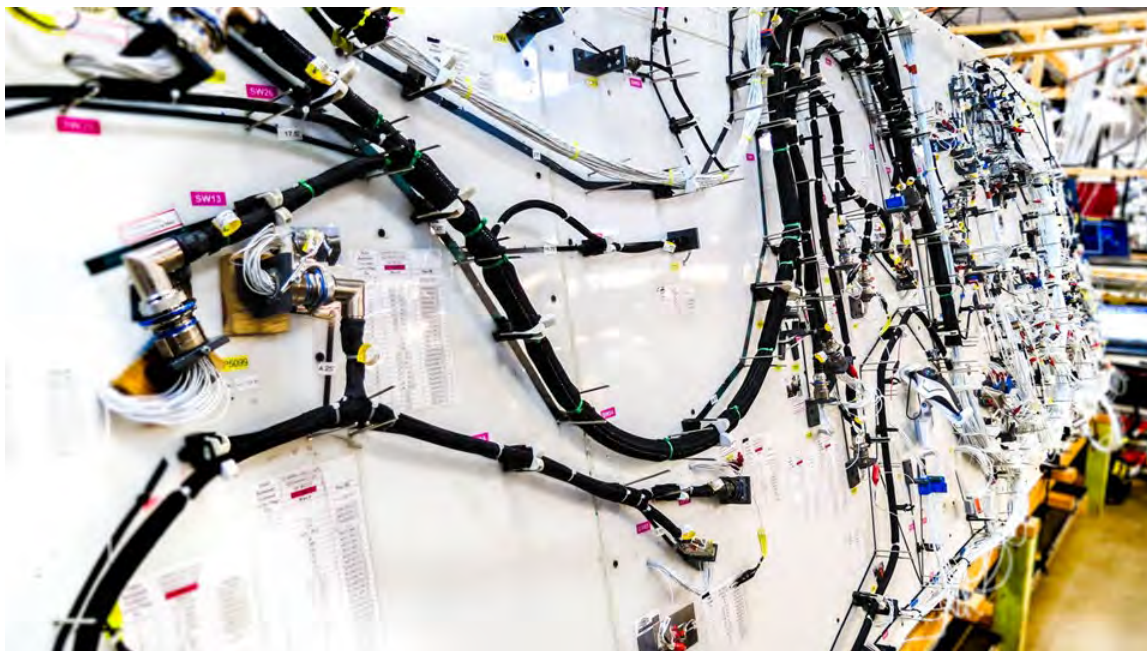
- Complexity increases with assemblies that have additional components (relays, lamps, switches, circuit breakers, resistors, diodes, etc.) and/or multiple connection points.

Circuit breaker



Background

- Additional time is required to diagnose problems with large, complex harnesses
 - On the form board
 - In the vehicle



Summary of Challenges in the Wiring Harness Industry

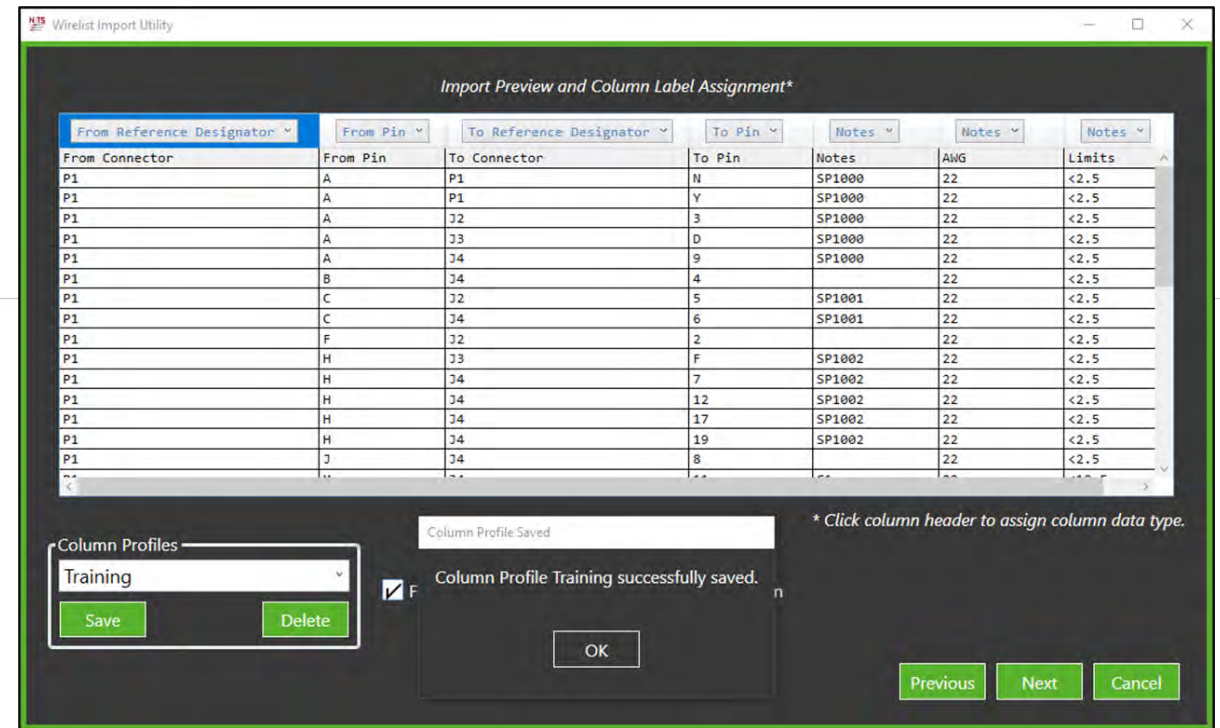
- Increased use of electronics places more importance on the wiring harness
- Wiring harnesses are becoming increasingly complex
- Building wiring harnesses continues to be extremely labor-intensives with > 80% of all operations handled manually
- Fragmentation between harness design and testing leads to manual data transfer
- Many harness engineering and manufacturing processes are outdated
 - Time-consuming, error-prone and inefficient
 - Reliant on tribal knowledge
 - Problems are difficult and time consuming to rectify

Potential Solutions

- Integration of wire harness design data with manufacturing & testing processes
- Augment insertion of wires into connectors to eliminate cross-wire errors
- Use harness design data to create adapter cable designs
- Auto generate testing programs to completely test the integrity of the wiring harness
- Advanced system architecture to allow complete testing of all wiring networks in lieu of individual wires.
- Advanced trouble shooting tools during harness testing

Wirelist Import

- Minimizes test programming errors
- Wirelist import function
 - Required – from/to connectors & pins to be tested
 - Include non-adapted points – splices, internal connectors
 - Components – part number, reference designators & electrical characteristics
 - Wire ID
 - Connector part numbers
 - Signal names
- More data = better testing



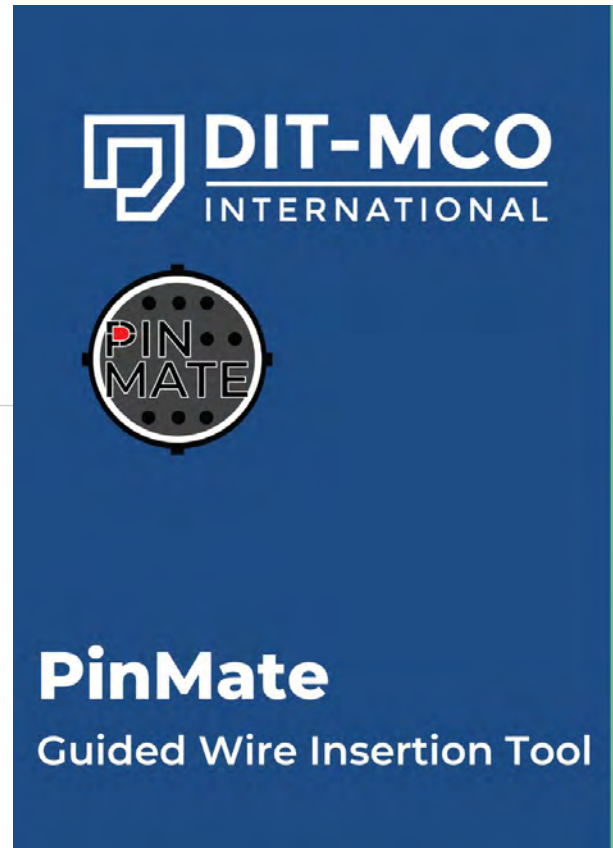
PinMate - Operator Assisted Guided Insertion

■ Features

- No adapter cables required
- Large connector library
- Lightweight, flexible
- Quick set-up
- Easy to use software

■ Benefits

- Helps eliminate mis-wires
- Improves throughput
- Saves time & money – up to 40%-time reduction
- Reduces eye strain & fatigue



PinMate technology was patented by Boeing and developed into a commercially viable product by DIT-MCO. Mis-wire errors driven to near **ZERO** in use for over 2 years in Boeing in-house wiring shops.

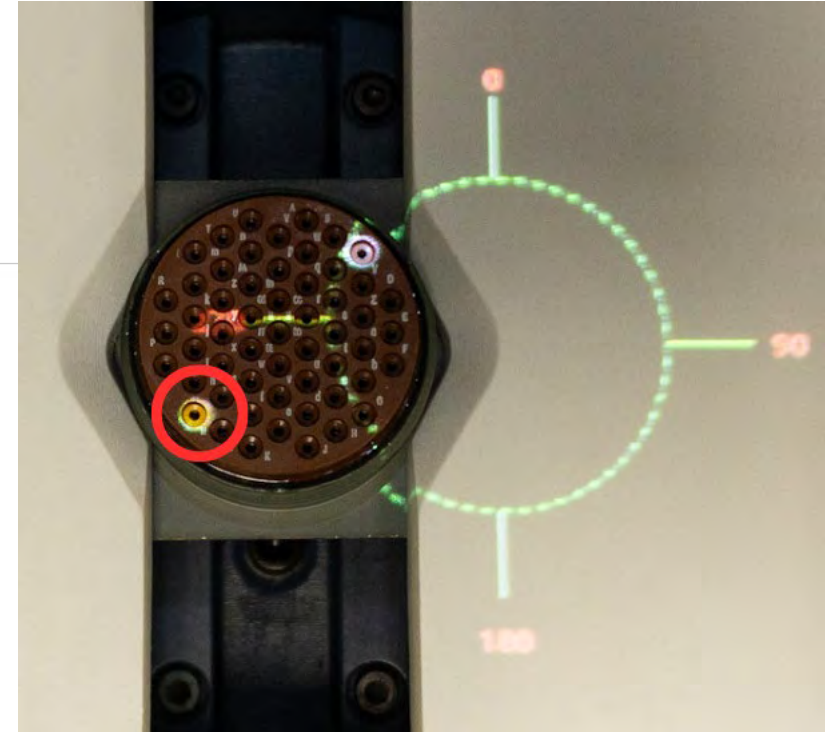
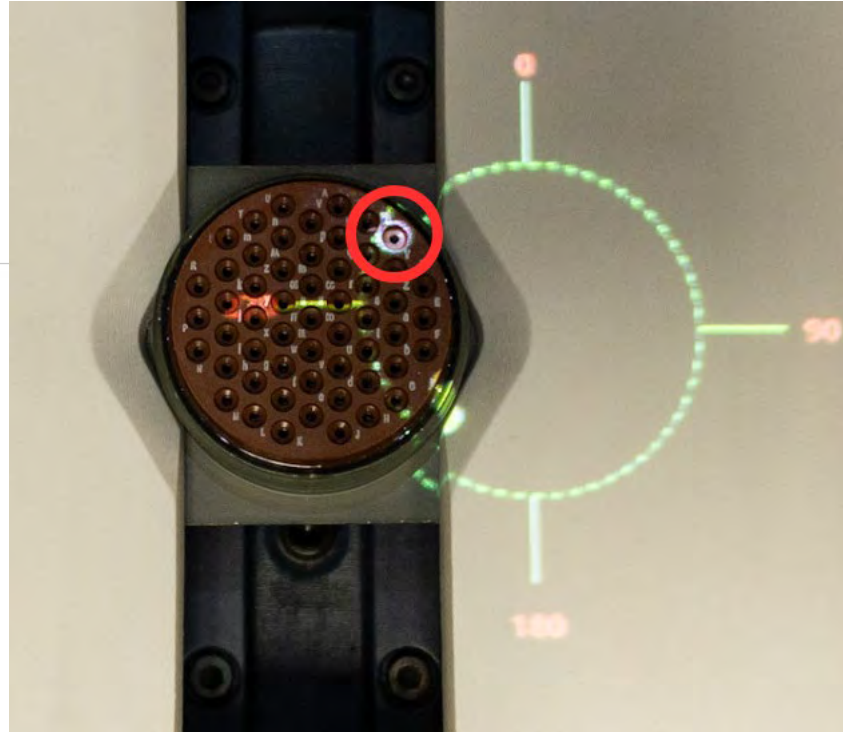
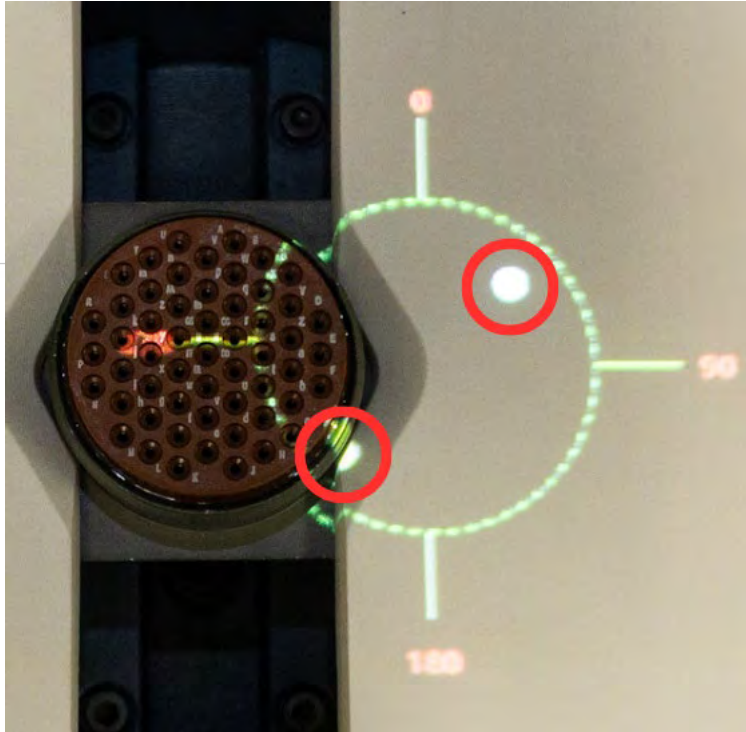
PinMate

- Easy to Use
 - Call up load program
 - Load connector into holder
 - Align connector
 - Insert spare pins/seal plugs (if used)
 - Enter wire IDs and follow prompts



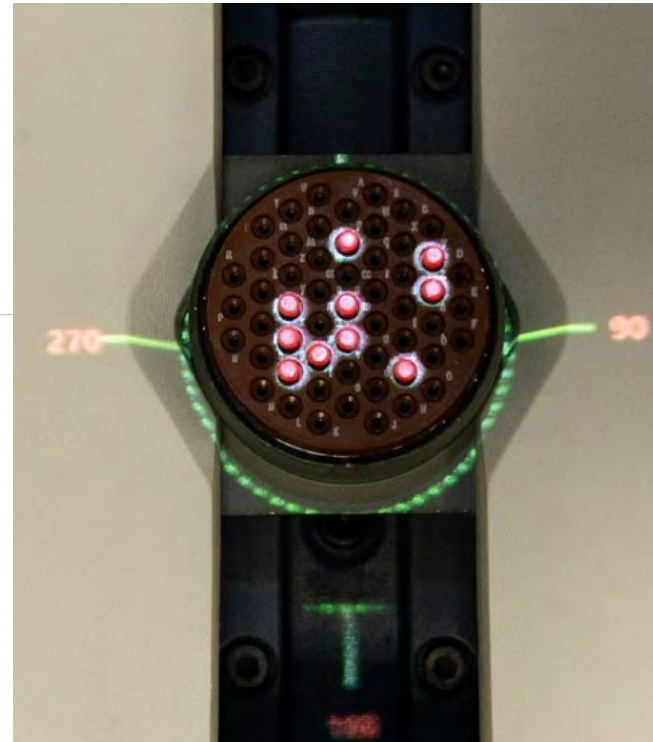
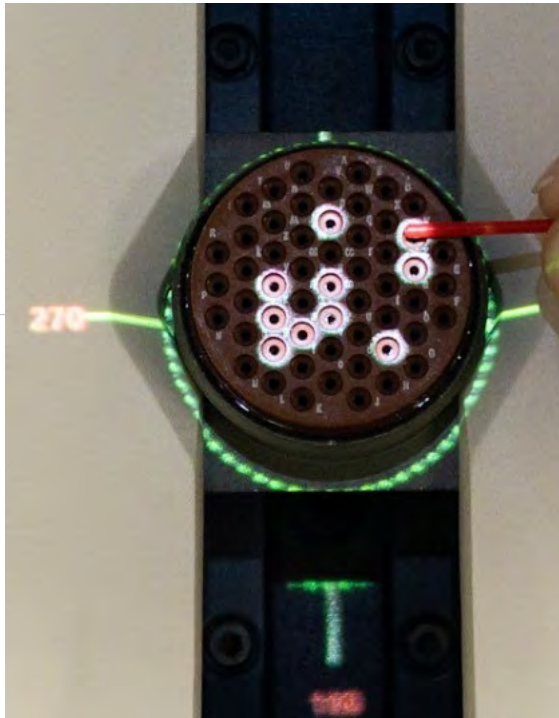


Align Connector Location



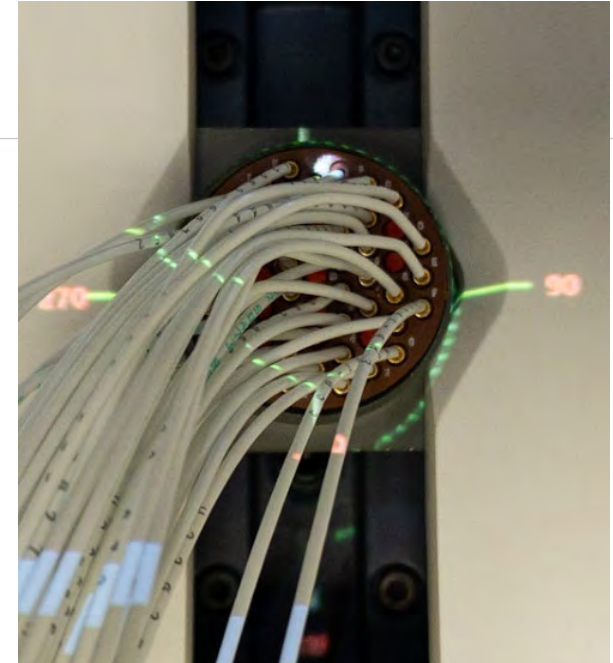
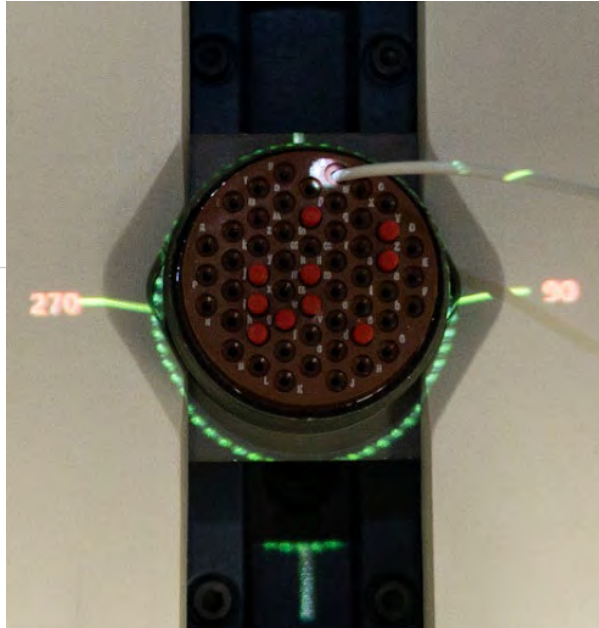
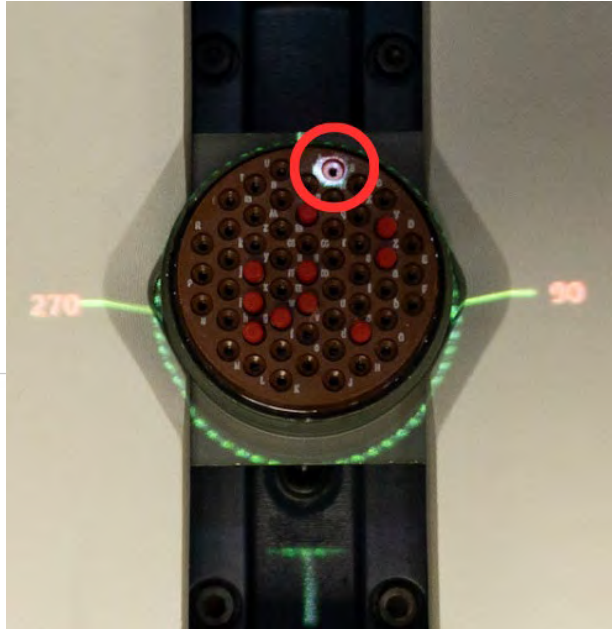


Seal Plug Installation





First End Wire Installation



Advanced Tools to Streamline Time to Test

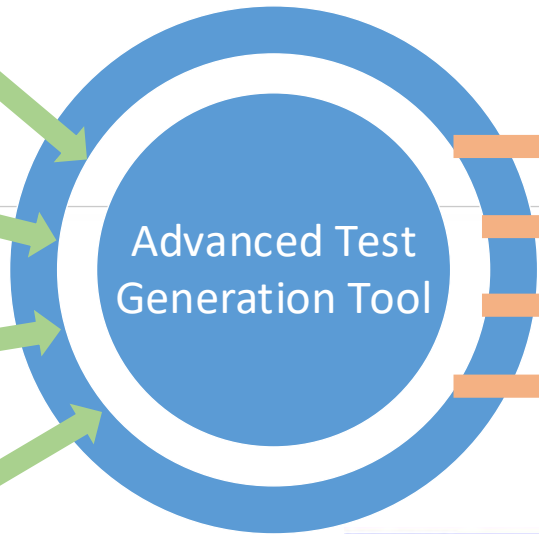
Circuit ID	Address	From Ref Des	From Pin	To Ref Des	To Pin	Address	Wire Name	Diagram	State ID
2	*140A1P1A40	-	308A1P1B	207	LC113A22-22	1158AV59257-			0
3	*140A1P1A68	-	*165J7F	-	100	LC197A22-22	1158AV59257-		0
4	*140A1P1C43	-	*318A1J955	-	135	MU111B22-42	1158AV59257-		0
5	*140A1P1C44	-	*318A1J523	-	132	TU223A22-42	1158AV59257-		0
8	*140A1P1C88	-	*318A1J687	-	134	TU283A22-42	1158AV59257-		0
7	*140A1P1C83	-	*318A1J957	-	137	MU112B22-42	1158AV59257-		0
6	*141SP40-	-	192A2P2	11	307	MX411A22-2V	1158AV59257-		0
9	*141SP41-	-	*192A712T	-	123	MX411A22-2B	1158AV59257-		0
10	*165J2A	-	294EC78	-	443	MX31A22-2V	1158AV59257-		0
10	*165J2B	-	294EC78	-	442	MX31A22-2E	1158AV59257-		0
11	*165J2H	-	308A1P1	B*	521	1LX303A20-4	1158AV59257-		0
12	*165J2N	-	308A1P1	X	514	1LX401A20-4	1158AV59257-		0
13	*165J2P	-	308A1P1	Y	515	1LX402A20-4	1158AV59257-		0
14	*165J2S	-	308A1P1	B*	518	1LX404A20-4	1158AV59257-		0
15	*165J2L	-	308A1P1	F*	522	1LX405A20-4	1158AV59257-		0
16	*165J2M	-	308A1P1	W*	524	1LX406A20-4	1158AV59257-		0
17	*165J2N	-	308A1P1	J*	526	1LX407A20-4	1158AV59257-		0
18	*165J2P	-	308A1P1	Q*	531	1LX408A20-4	1158AV59257-		0
19	*165J4G	-	*347A1P937	-	149	W0204B20-4C	1158AV59257-		0
20	*165J4H	-	*347A1P940	-	202	W0204B20-4C	1158AV59257-		0
21	*165J4L	-	308A1P1	H	501	1LX307A20-4	1158AV59257-		0

Detailed Wirelist

Test Parameters

Parts List

Test System Architecture



Comprehensive Test Program

Adapter Cable Design

Bill of Materials

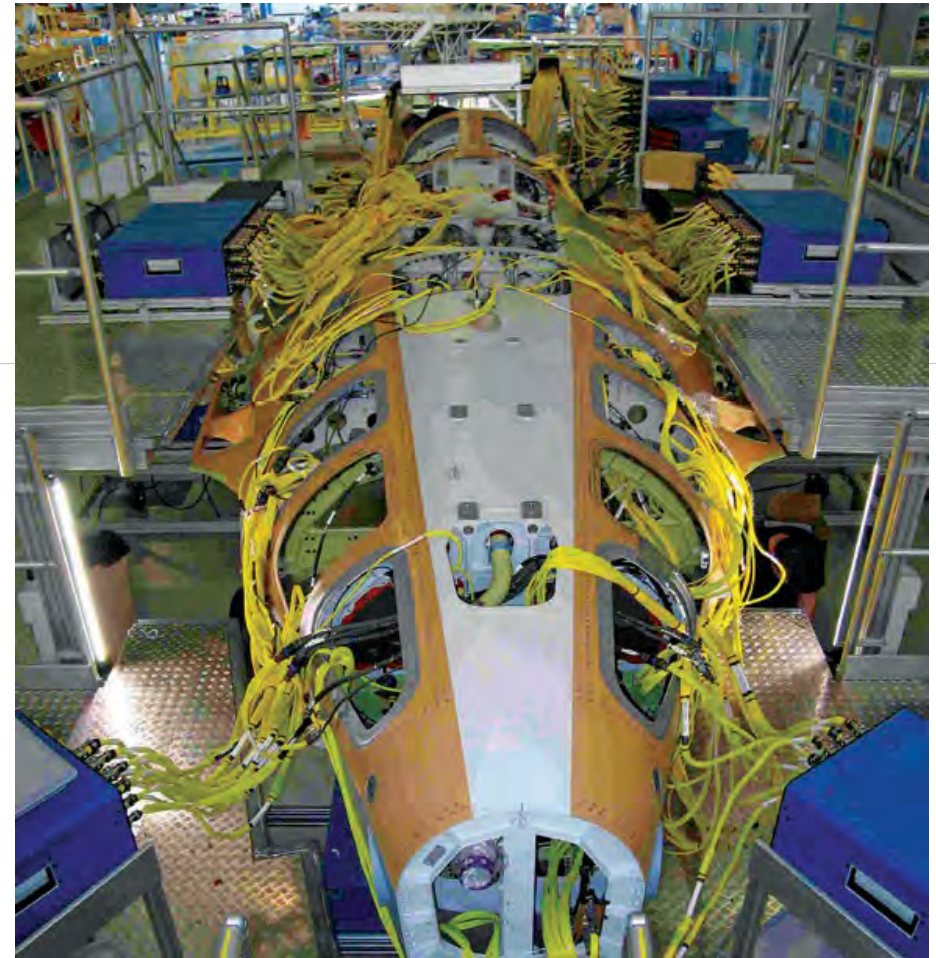
Hook-up Instructions

```
NETS(K) version 1.0.6400
02 NOV 18 10:38:19
: ENB TCM
: ACT EXAMPLEPROGRAM
: SMU 000.1A <002.5R 00.01S
: SMU 0500V >0100M 000.3S 00.15T
: SMU 1000V >0100M 000.3S 00.15T
: HTP 1500V <0001MA 0005S 000.1T
: A SMU 000.1A >01.35K <01.65K 00.01S
: B SMU 000.1A >01.43K <01.97K 00.01S
: H SMU 000.1A >021.6K <026.4K 00.01S
: L SMU 000.2A <0090K 0010S
: G CAP <0010UF 0002S
: Z DIO 0010V >0099K <0200R 000.1S
: ENB DIG CER
: WRITE DISPLAY
: SMU 000.1A <002.5R 00.01S
: FOR 134 136 1
: FOR 115 117 1
: AA 00015 00137 HIGH >30.00M OHM P1-T
: BB 00016 00137 HIGH 3.004K OHM P1-U
: HH 00024 00104 HIGH >30.00M OHM P1-C
: P1-E
: ENB RESISTORS
: SLC 7
: ENB RETURN
: DLC
: ENB SKP RETURN
: ENB RETURN
: DLC
: ENB HOT
: ENB HOLDING condition!
: Press stop or continue
: TEST hold
: Advance
: LL 00017 00022 HIGH >30.00M OHM P1-V
: P1-A
```

Adapter Assembly	
Adapter Name: EMSH0107#01	Rev Date:
Adapter Description: TEST HARNESS	Value:
Date Built:	Value:
Manufacturer: EMC	
Owner: EMC	
Product Side, Mating Connectors	
Product Connector Ref: J1	Qty: 16
Mating Connector Num: EE706-02 (Mate For)	BOM Part Number: M39029-4-111
Splice Length: 0	Contact Pin Size: 16 MIL STD
Notes:	
Part Library BOM Note: Leach Relay Slt S402-D1B0 (Mate For)	

Adapter Cable Design Challenge

- No time allotted in project plan
- Identifying UUT mating connectors
- Matching UUT points to test system architecture (50 – 128 points / test connector)
- Physical location of UUT connectors
- Requires detailed knowledge of test system architecture
- Connecting adapter cables in a large system
- **Time consuming and challenging process**



Adapter Cable Design Solution

Automation!

Inputs

- Wiring list including detailed connector information
- Location of connectors relative to Test System

Auto generate

- Complete adapter cable design
- UUT point/wire mapping to Test System architecture to streamline test program creation
- Random hookup
- EasyMate connectors
- Cost reduction

240 ± 6 IN

M1 **C1**

2190P1/FVS
20WR42103
76823 ASSY

3 PLCS

14, 11, 10, 15, 1, 13, 12, 9, 8, 7, 6, 5, 4, 3

BILL OF MATERIALS

ITEM NO.	CROSS REF	REF DES	QTY	UOM	CAUSE CODE	PART OR IDENTIFYING No.	MANUFACTURE OR DESCRIPTION	MATERIAL SPEC OR FINISH	SEE NOTE
1			1	EA		0002	CABLE ASSEMBLY		
2	M1	1	EA	10882		SPG100230-020	Connector EasyMate 25 Pin	DIT-MCO Invention	
3	C1	1	EA			D38999/20WB35PN	Connector Triaxial 20 Pin	MIL-DTL-22759	
4	1	13	EA			MS3503550000	Connector Pin 20x 20x13.6x10.3	SAE AS 30939	7
5	1	1	EA			MS3503551100	Connector Accessories Term Recept	SAE AS 30943	
6	1	1	EA			371262-1-13	Log. Plug/Recept Comp 20AWG 45 Shell	SAE AS 7248	
7	1	2	EA			371254-4-13	Shim 1/8 Dia. Part Used 2-13	MS10999-001	
8	1	2	EA			371414-002	Washer 1/8 Dia. Part Spring Load 45	MS10999-001	
9	1	2	EA			371414-001	Washer 1/8 Dia. Part Spring Load 45	MS10999-001	
10	1	2	EA			371414-001	Washer 1/8 Dia. Part Spring Load 45	MS10999-001	
11	1	240	IN			371414-001	Washer 1/8 Dia. Part Spring Load 45	MS10999-001	
12	1	1	EA			371414-001	Washer 1/8 Dia. Part Spring Load 45	MS10999-001	
13	1	1	EA			371414-001	Washer 1/8 Dia. Part Spring Load 45	MS10999-001	
14	1	1	EA			371414-001	Washer 1/8 Dia. Part Spring Load 45	MS10999-001	
15	1	1	EA			371414-001	Washer 1/8 Dia. Part Spring Load 45	MS10999-001	
16	1	1	EA			371414-001	Washer 1/8 Dia. Part Spring Load 45	MS10999-001	
17	1	1	EA			371414-001	Washer 1/8 Dia. Part Spring Load 45	MS10999-001	
18	1	1	EA			371414-001	Washer 1/8 Dia. Part Spring Load 45	MS10999-001	
19	1	1	EA			371414-001	Washer 1/8 Dia. Part Spring Load 45	MS10999-001	

DETAIL-0008

SPG100230-020 M1 Side View

D38999/20WB35PN C1 Side View

NOTES

- 0 Unlabeled details. None.
- 1 Unlabeled dimensions and tolerances per ASME Y14.5M-1992.
- 2 Manufacture per DIT-MCO 814MS procedure.
- 3 MFG:01 ACS-PRG-0201 ACS-PRG-4001 ACS-PRG-4002 ACS-PRG-4003 ACS-PRG-4004 ACS-PRG-4005 ACS-PRG-4006 ACS-PRG-4101 ACS-PRG-4102 ACS-PRG-4103 ACS-PRG-4104 ACS-PRG-4105 ACS-PRG-7004 ACS-PRG-7005
- 4 Use component manufacturer's dimensions and test connector standards when DIT-MCO 814MS standards are not possible or practical.
- 5 Reference designator location assignments may use "L" preceding a letter to denote a loose-lead letter. The practice "L" may precede or follow a letter to denote a loose-lead letter. Loose-lead letters may also be denoted in "lead-ends".
- 6 Reference designator location assignments may use these characters following a number or related location assignment:
 - "0" denotes "Open", normally a shield termination.
 - "1" denotes center connection for COAXIAL contacts, and immediate connection for TRIAXIAL contacts.
 - "2" denotes center connection for TRIAXIAL contacts.
 - "3, 4, 5, 6, 7, 8, 9" denotes separate connections for QUADRIAXIAL contacts.
- 7 Contacts normally requiring a shield termination COAXIAL, TRIAXIAL, and QUADRIAXIAL may have a 22AWG wire terminated in lieu of the shield. Strip jacket 75 in. unshielded conductor strands. Wire should contact at shield termination point. Repeat wiring ring or solder bridge as required. Trim off any loose strands. Plugging can also be done to allow present wiring to contain. Signal should be 8 to 12 inches and solder to the 22AWG wire.
- 8 Parts may be substituted without engineering approval if form, fit, and function are not affected.
- 9 Dimensions are furnished with the connector and are on the drawing for aid in manufacture. Do not include parts except for repair purposes.
- 10 "CAUTION" marked on a component is for a condition, which if not strictly observed, could result in loss or damage to equipment or property. These notices will have a yellow background.
- 11 Cable shall have sufficient personnel lead to prevent damage by strain relief. Minimum 1 yard of tape. Adjust hardware as shown to allow sufficient clamping force without damaging the cable.

DETAIL-0008

SEE SEPARATE PARTS LIST

DIT-MCO INTERNATIONAL Kansas City, MO

DESIGNED BY: D. Brimmond DATE: 4/15/2022

CHECKED BY: S. Ryland DATE: 4/15/2022

TOOL FAB DATE: 4/15/2022

SAFETY DATE: 4/15/2022

TEAM LEAD: K. Reed DATE: 4/15/2022

DRAWING TITLE: SPG-TESTER ADAPTER CABLE, SP2023-0008

DRAWING NUMBER: SP2023-0008

PROJECT: SP2023 SCALE: NONE REV: NC

Advantages of Advanced Test Generation

- Reduce programming time
 - Auto generates test program
 - Easy to use drop-and-drag editing tools
- Improve reliability of test program
 - All points will be tested with correct set of parameters
 - Test parameters will not exceed electrical limits of any components installed in the UUT
- Test program development process is database driven
 - Revision history and
 - Certification test process

ACT FILE BUILDER

WIRE LIST SELECTION

TEST SYSTEM SELECTION

2650 - Test System 1

UUT shape

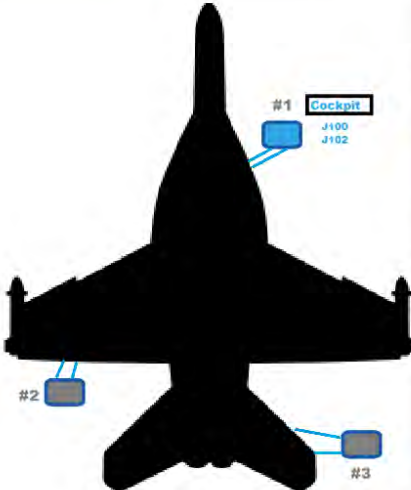
Fuselage

AVAILABLE CABLES				
Adapter Name	Ref Des	Adapter Type	Pin Count	Address
EU7H000802	P1	EasyLate	10	
EU7H000804	P1	EasyLate	10	
EU7H000801	P1	EasyLate	20	
EU7H000801	P1	EasyLate	70	
EU7H004301	P1	EasyLate	60	
EU7H004302	P1	EasyLate	60	
EU7H004401	P1	EasyLate	40	
EU7H004801	P1	EasyLate	10	
EU7H004802	P1	EasyLate	10	
EU7H004803	P1	EasyLate	10	
EU7H004801	P1	EasyLate	70	200
EU7H004802	P1	EasyLate	70	

LOAD WIRE LIST

LOAD REF LIST

LOAD SCHEMATIC



SW MODULE

#1

Location Map:
Cockpit

#2

Location Map:

#3

Location Map:

Module 1:
DIT-MCO SLOT

J0 0-149
J1 200-349
J2 400-549
J3 600-749
J4 800-949
J5 1000-1149
J6 1200-1349
J7 1400-1549

CONNECTOR REF DEGNR LIST

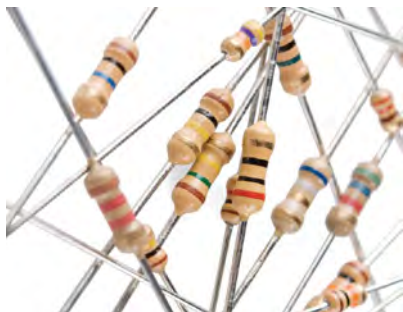
P3
P4
P5
P6
J500

17

Component Testing

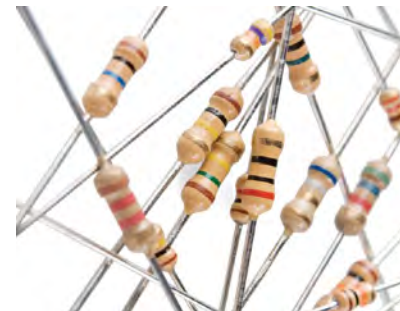
- Typical components
 - Relays
 - Switches / Circuit Breakers
 - Indicators/LEDs
 - Passive components

- Be aware of electrical specifications of in-harness components to avoid damage during bulk resistivity or other high voltage, high current harness testing



Component Testing

- Switches & Circuit Breakers
 - Test all positions for proper operation
 - Requires operator feedback to change switch positions & confirm proper results
- Indicators/LEDs
 - Understand electrical limits
 - Requires operator feedback to confirm proper results
- Passive components
 - Test components to specified limits

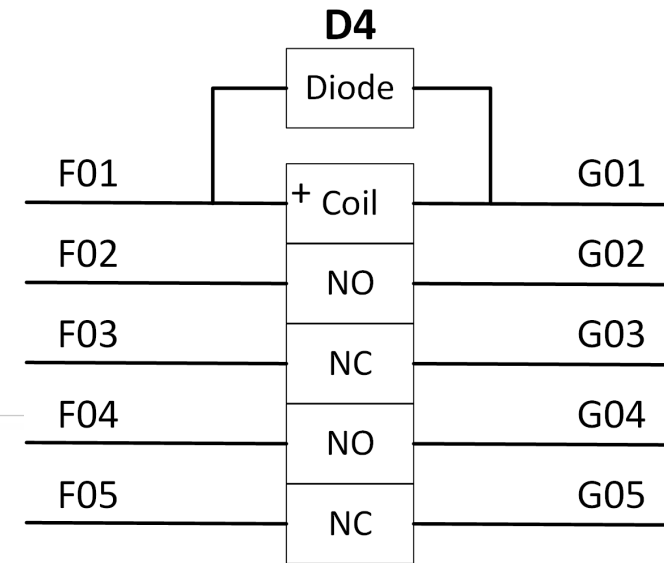


Component Testing - Relays

- In normal conditions
 - Continuity across NC (F03-G03, F05-G05)
 - Open across NO (F02-G02, F04-G04)
 - Coil resistance is 742Ω-906Ω (F01-G01)
 - Diode test on D4 (G01-F01)

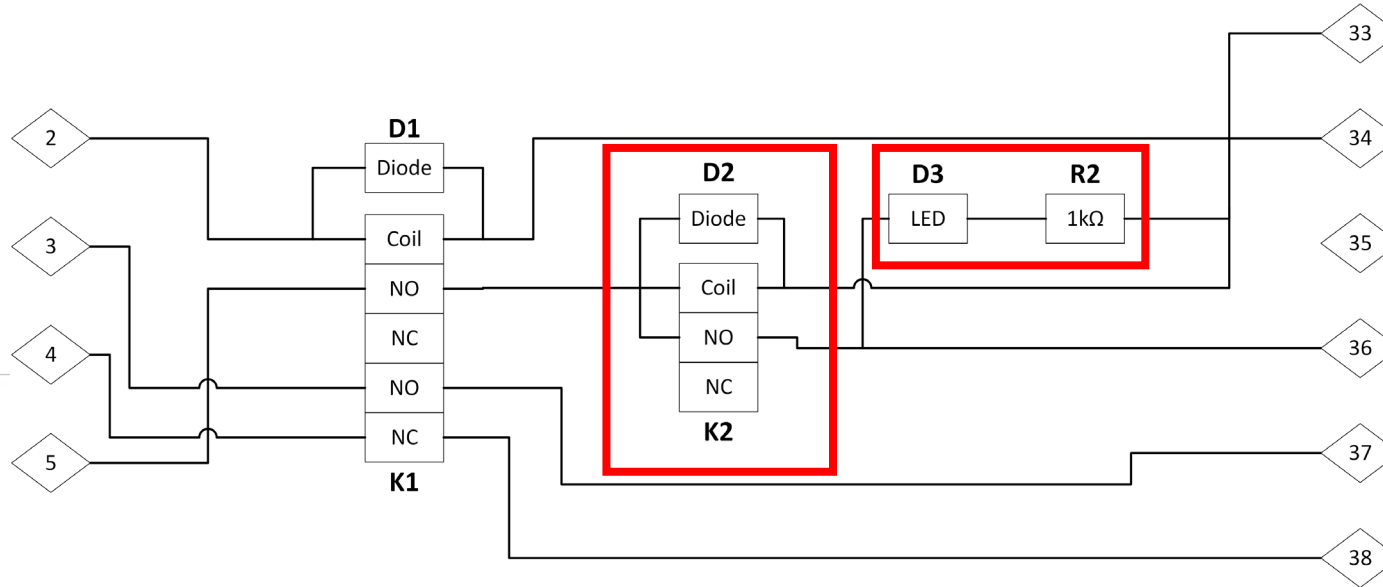
- If all above pass, proceed to test Relay energized
 - Apply appropriate voltage to coil (+ F01, Ground G01)
 - Open across NC (F03-G03, F05-G05)
 - Continuity across NO (F02-G02, F04-G04)

- De-energize relay, retest Normal condition
 - Remove voltage from coil (F01)
 - Continuity across NC (F03-G03, F05-G05)
 - Open across NO (F02-G02, F04-G04)
 - Coil resistance is 742Ω-906 Ω (F01-G01)



Relay
DPDT
Contacts: 250VAC
Coil: 824Ω +/- 10%
Coil voltage: 40-48 Vac, 400Hz

Relay Ladder Testing



- Understand relay logic required to properly test down stream components
- In above example, K2 will not actuate unless K1 is actuated, and the proper voltage is used on Address 5
- D3 and R2 cannot be tested without K2 being energized

Energization of Harness Components

External Energization

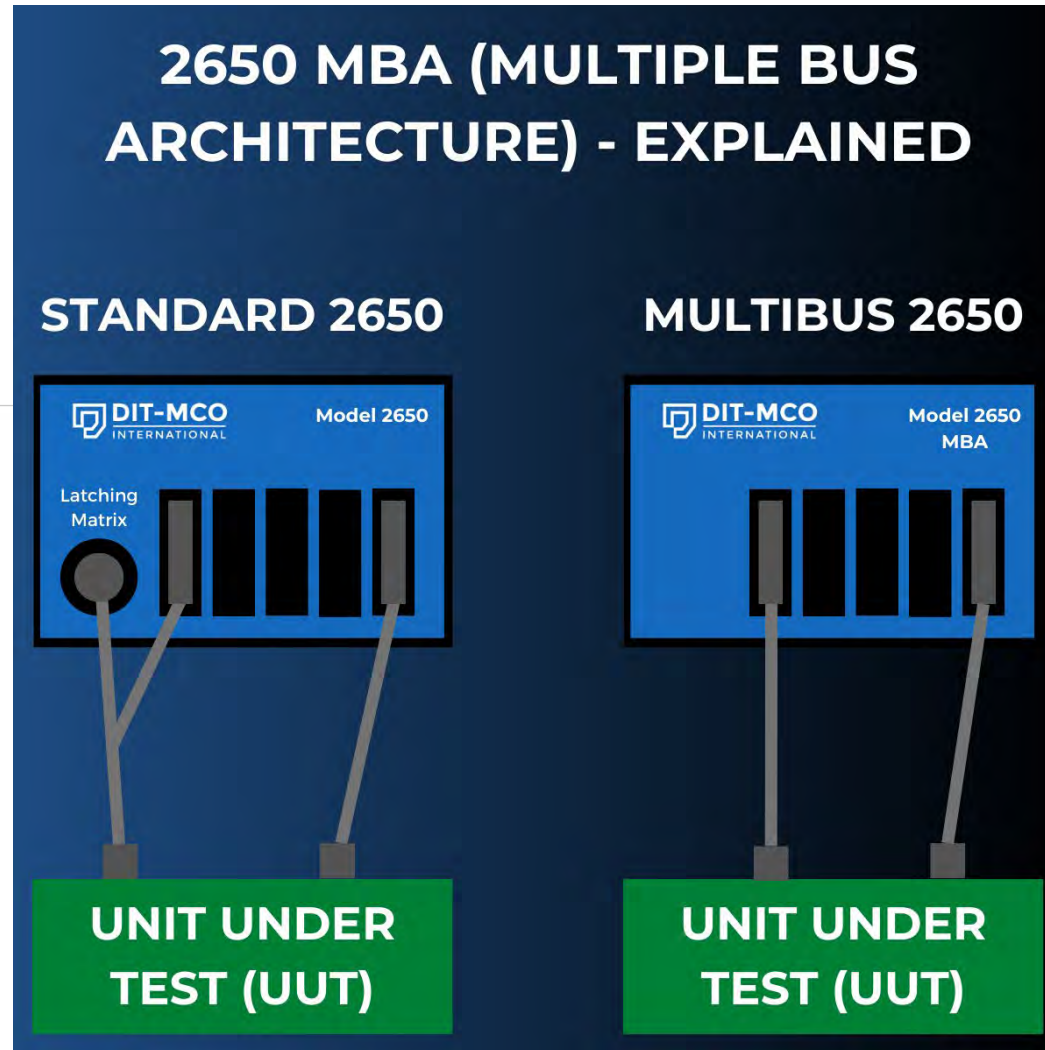
- Allows external power source to be applied to test point outside the test analyzer system
- Can accommodate broad range of external sources
- Requires special adapter cables
- Difficult to change as product design is modified
- Need to carefully program use of external sources to prevent unintentional damage to UUT or test system

Multi-Bus Architecture

- Multi Bus Architecture is a technology that allows any test point to also be a power source for relay activation.
- MBA simplifies the tester interface and test program generation.
- Simplifies adapter cables
- It accommodates product design changes without changing the test interface to the product.
- It eliminates the need to design an interface prior to generating a test program.
- Lower cost of ownership

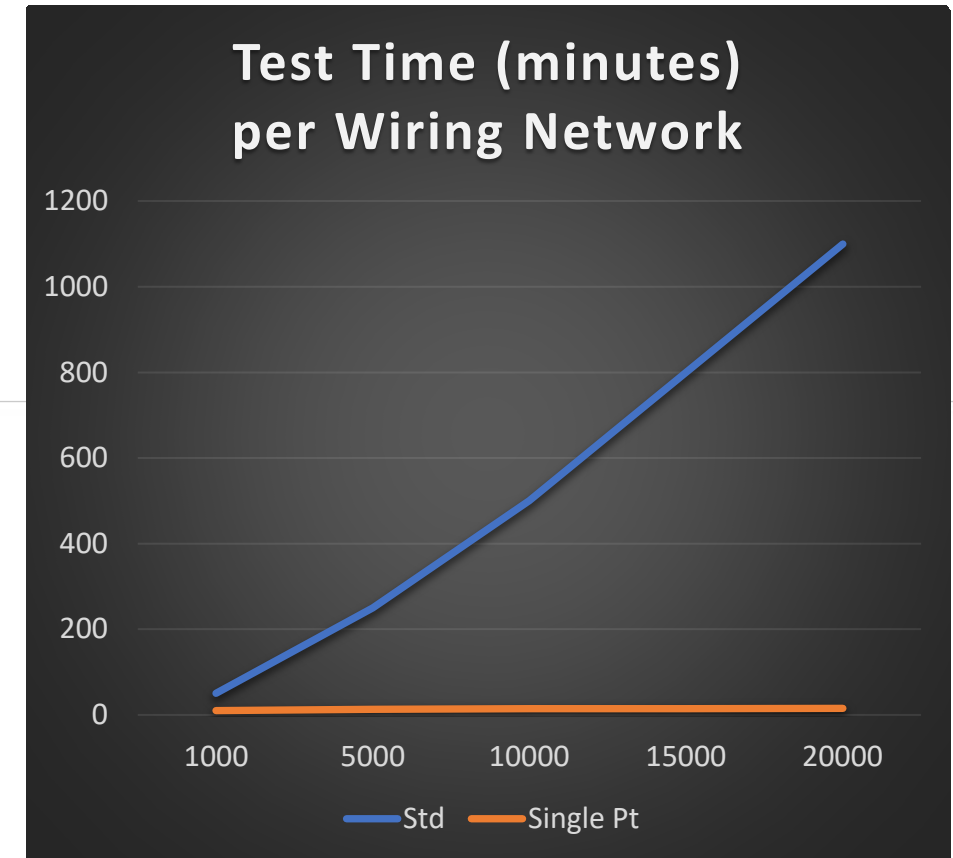


Energization of Harness Components



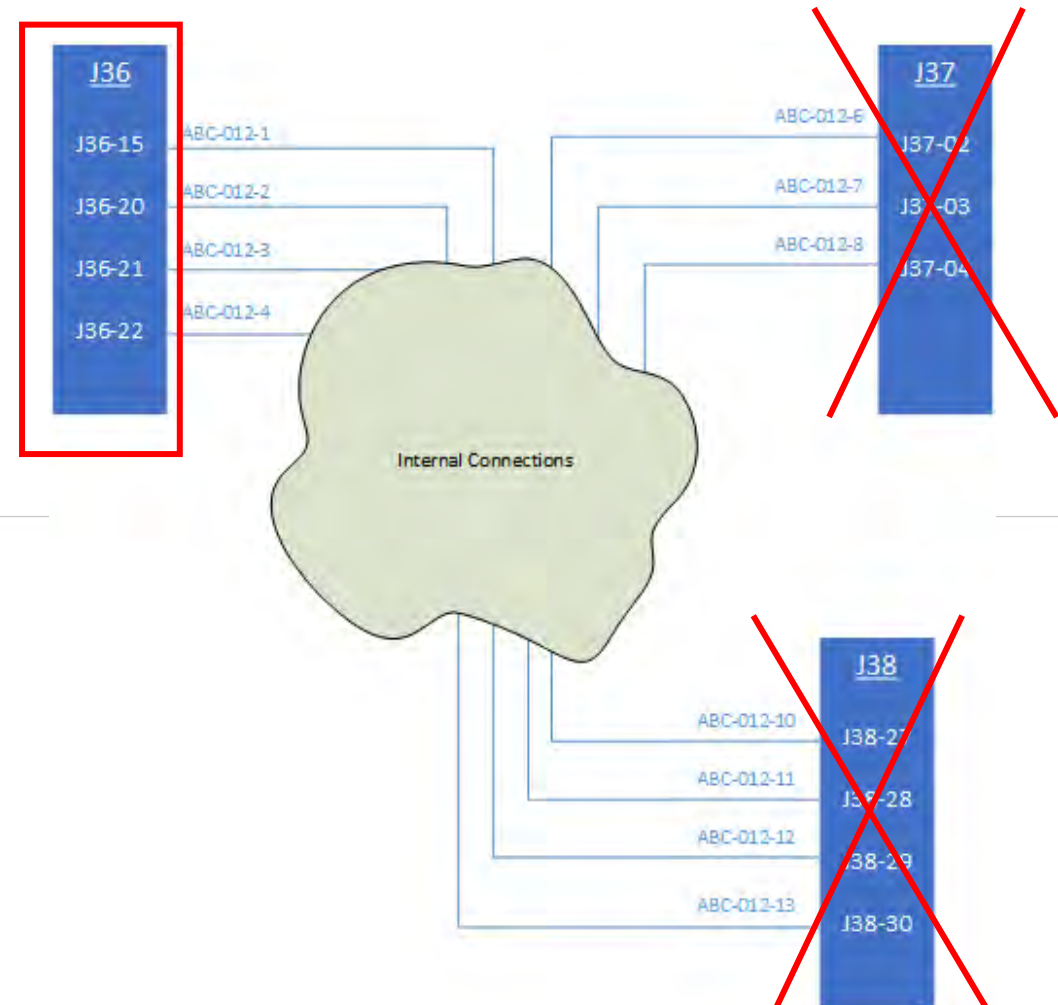
Wiring Network based Testing Benefits

- Faster insulation resistivity testing
 - Can test multiple networks simultaneously vs. testing a single point in a wiring network.
 - Insulation resistivity of wiring harness with 128 wiring networks can be tested in 7 test cycles vs. 127 test cycles with no errors.
 - Error identification takes ~50% of the cycles as conventional testing methods
- Can detect parallel insulation resistivity associated with near fault conditions across multiple wiring networks.
- Different networks can be tested at different voltage – isolating sensitive networks or networks with components



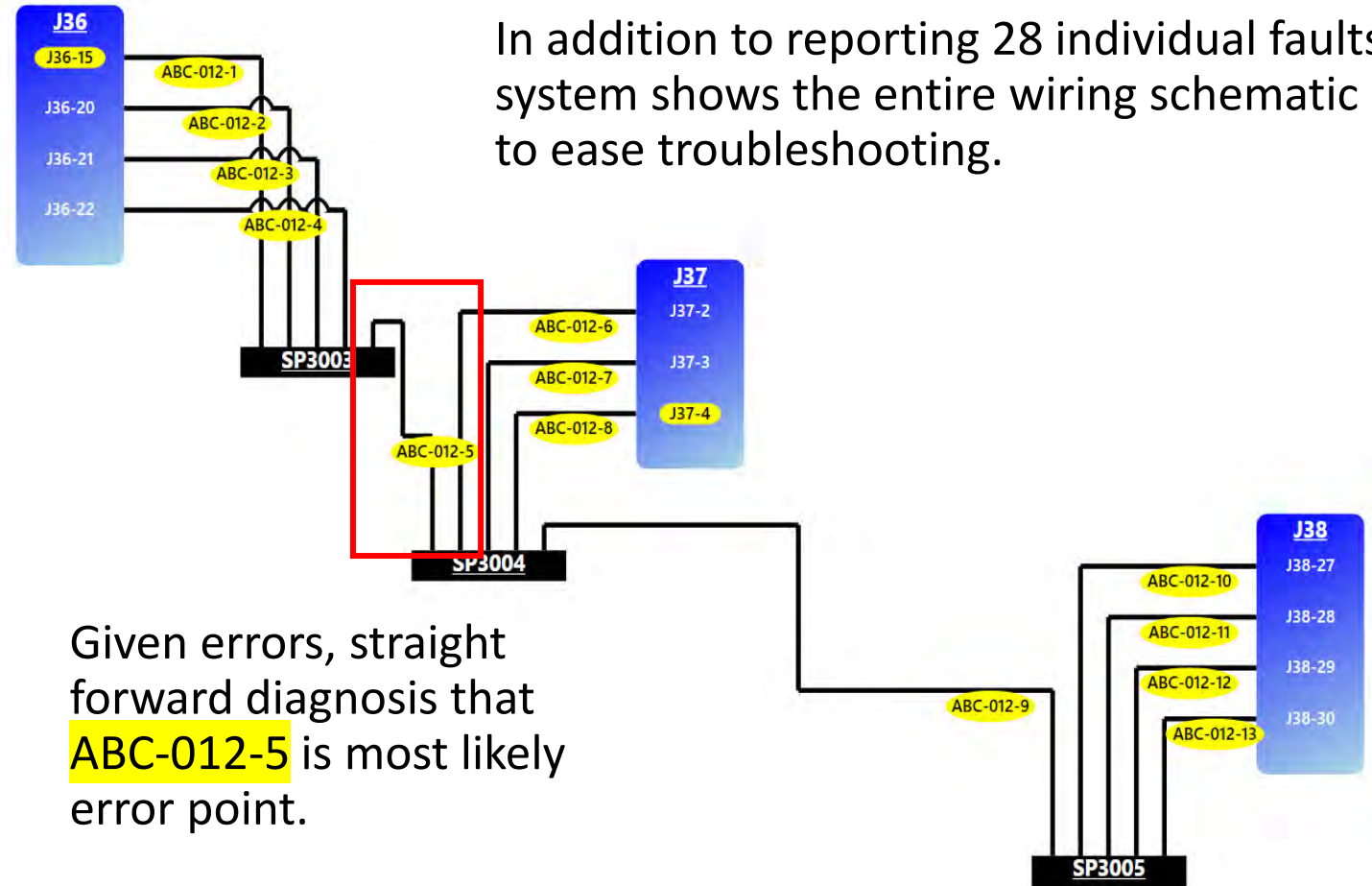
Traditional Fault Reporting

- Test system has access to From/To information only
- Given wiring network with 11 total connections over three different connectors
 - J36-15, J36-20, J36-21, J36-22, J37-2, J37-3, J37-4, J38-27, J38-28, J38-29, J38-30
- Continuity tests identifies & reports 28 individual faults.
 - 1 - J36-15 to J37-2 fault
 - 2 – J36-15 to J37-3 fault
 -
 - 27 – J36-22 to J36-29
 - 28 – J36-22 to J38-30 fault
- Technician would have little information to use to diagnose actual problem



Use Schematics as a Troubleshooting Tool

- System has access to complete wiring information
- Given wiring network with 11 total connections over three different connectors
 - J36-15, J36-20, J36-21, J36-22, J37-2, J37-3, J37-4, J38-27, J38-28, J38-29, J38-30
- Continuity tests identifies 28 individual faults
 - 1 - J36-15 to J37-2 fault
 - 2 - J36-15 to J37-3 fault
 -
 - 27 - J36-22 to J36-29 fault
 - 28 - J36-22 to J38-30 fault

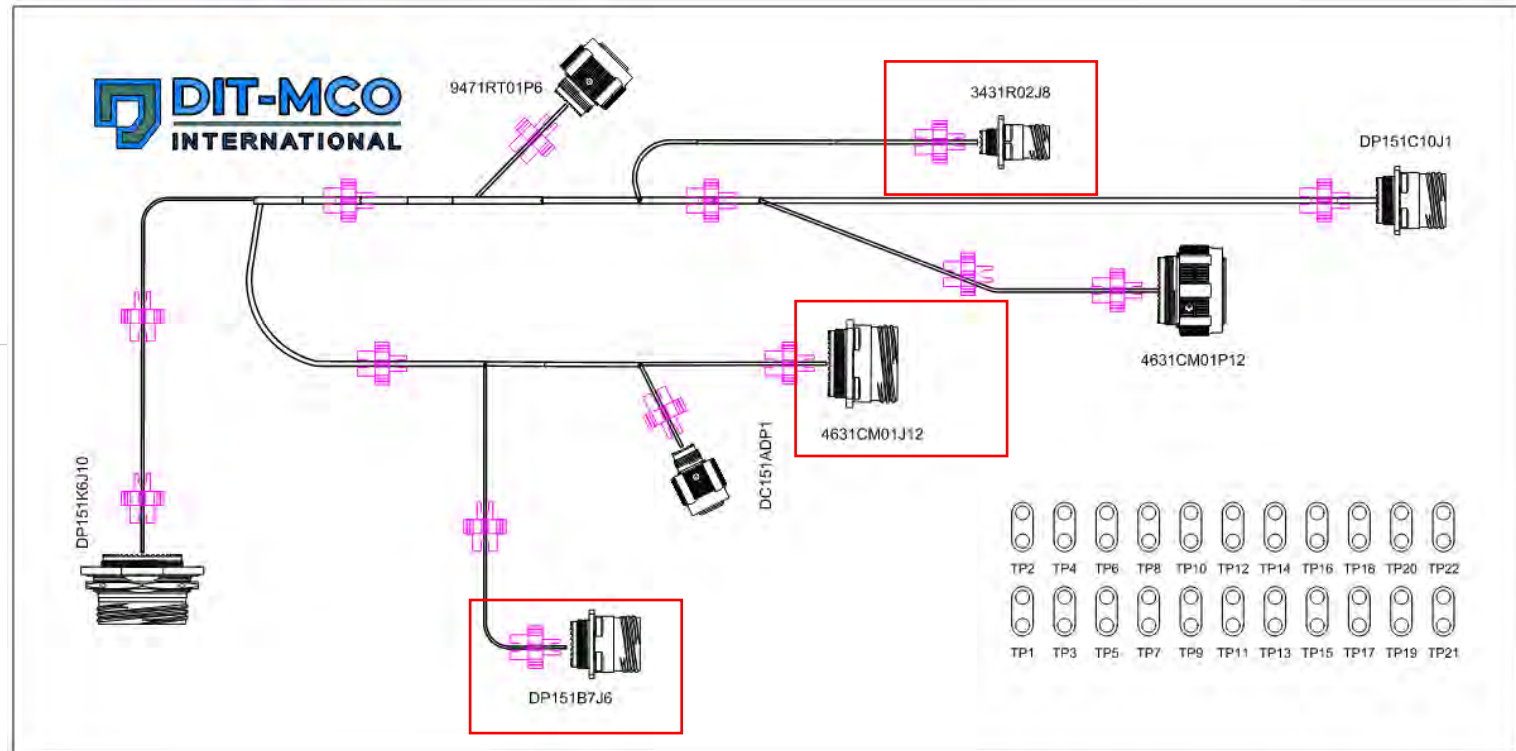


In addition to reporting 28 individual faults, system shows the entire wiring schematic to ease troubleshooting.

Given errors, straight forward diagnosis that **ABC-012-5** is most likely error point.

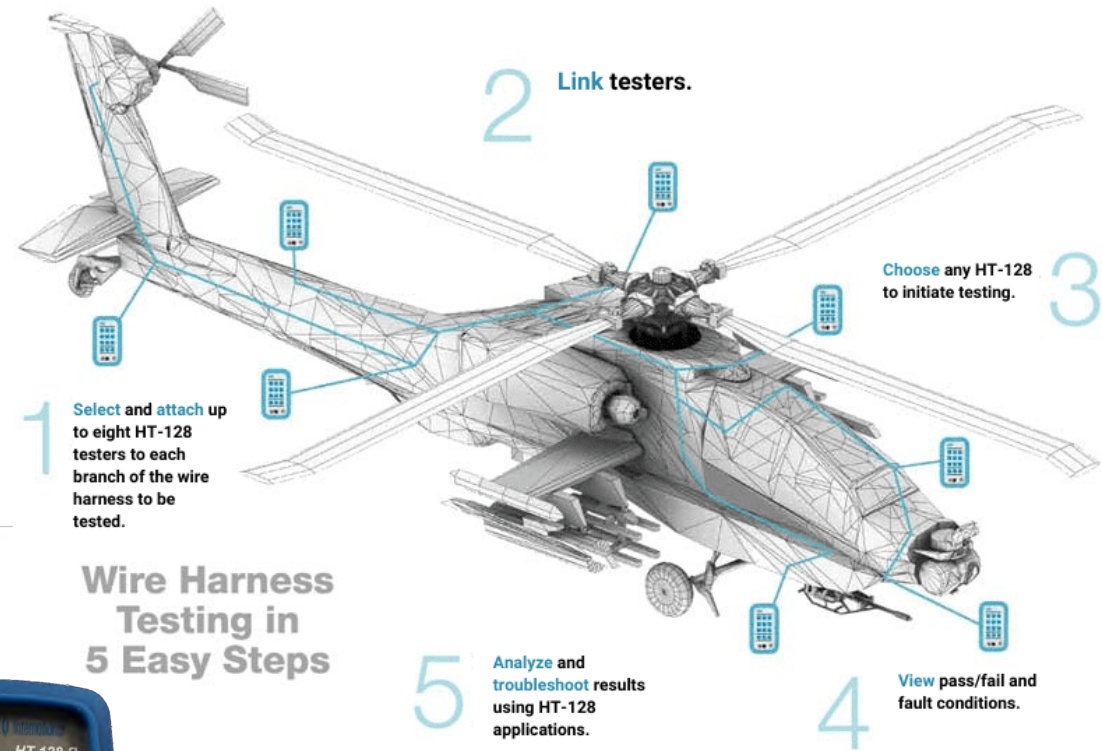
Connector Testing as a Trouble Shooting Aid

- Run test program
- Issue identified with 3431R02J8
- Operator stops test
- Run all tests associated with this connector
- After issue is resolved, resume full testing
- Simplify description – focus on benefits not process



Intelligent Handheld Troubleshooting

- **USEFUL** for post test troubleshooting
- **ECO** – just test changes
- Test installed cables without shorting plugs or long loop-back adapter cables
- More than continuity – Test for opens, shorts, crossed wires and high resistance connections
- Verify passive components (resistors, diodes)
- Cost effective and flexible to meet your needs
- Save time and money. Eliminate hours wasted on hand-beeping and troubleshooting
- Document test results



Plain Language Error Reporting with Likely Root Cause

- Traditional systems use cryptic fault descriptors

FF P3-7 P5-C SHORT <30.0K OHM

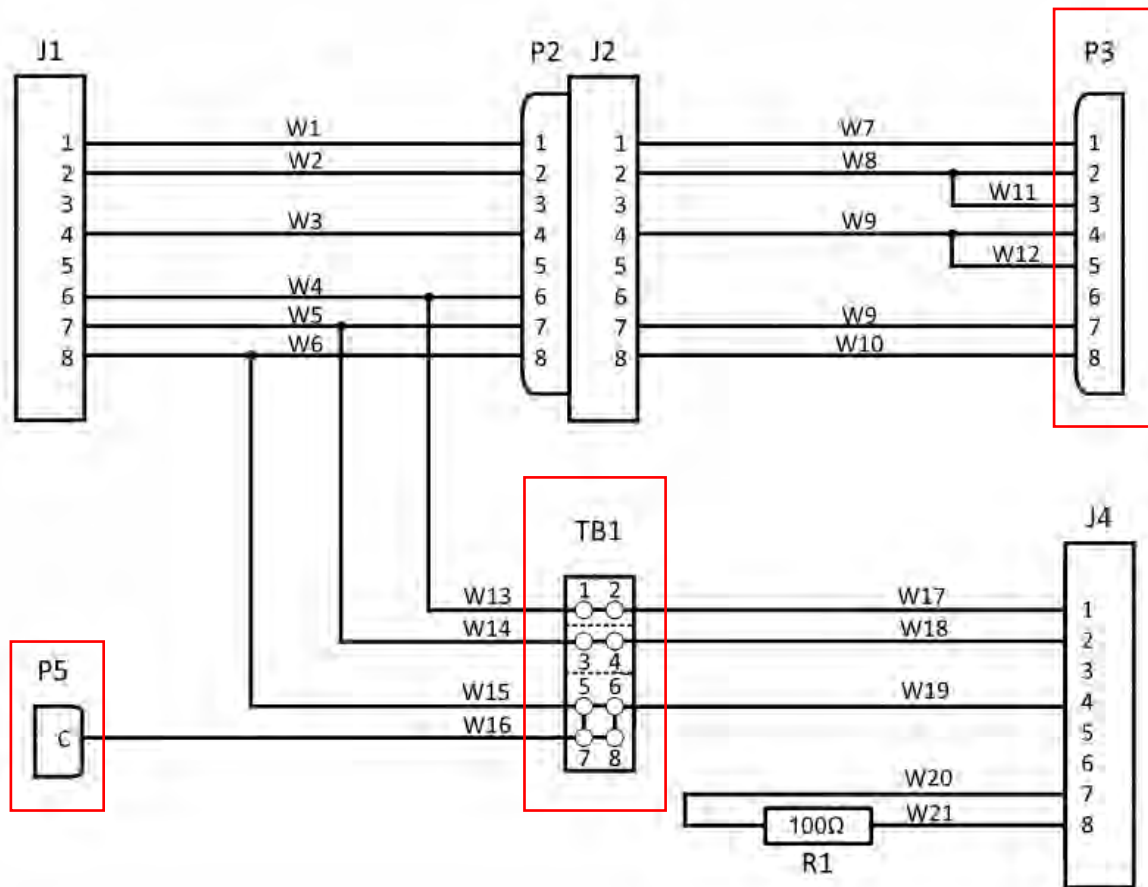
- Fault reporting does not identify root cause of the failure
- Troubleshooting is difficult
 - Need to understand system architecture
 - Need to understand cryptic error messages
 - Need to understand multi-page schematics
 - Need to understand likely failure modes



Proposed Solutions - Patent Pending

- DIT-MCO proposes to utilize machine learning and natural language output to provide less skilled technicians with easy-to-understand fault diagnosis.
- System quickly develops a list of possible root causes for each failure.
- Rank the possible root causes by order of likelihood.
- Utilizes cable construction, component types, connector layout, and a number of other parameters, to determine most likely point of failure.
- Translate difficult to decipher test results into full sentences.
- Available in multiple languages with proper syntax.
- Patent Pending

Example of a Short Circuit



FF P3-7 P5-C SHORT <30.0K OHM

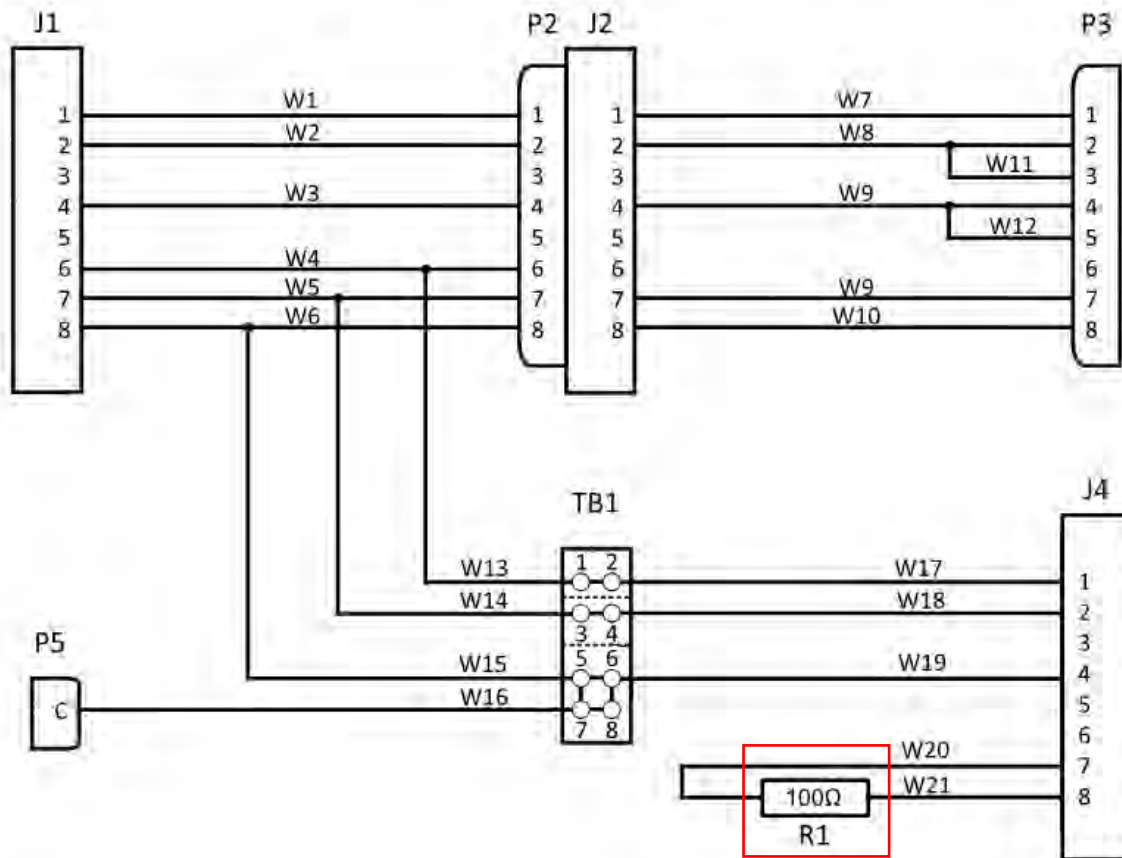
The proposed solution offers more detailed information such as:

Short circuit found between wires W9 and W16, is most likely found at TB1

A more detailed report might say:

Short circuit found between wire W9 and W16, is most likely found at TB1. If not found there, inspect wire W5 and W6 between J1-7 and P2-7 and J1-8 and P2-8 or wire W9 and W10 between J2-7 and P3-7 and J2-8 and P3-8

Example of a Component Failure



CC P4-7 P4-8 LOW 51.2 OHM

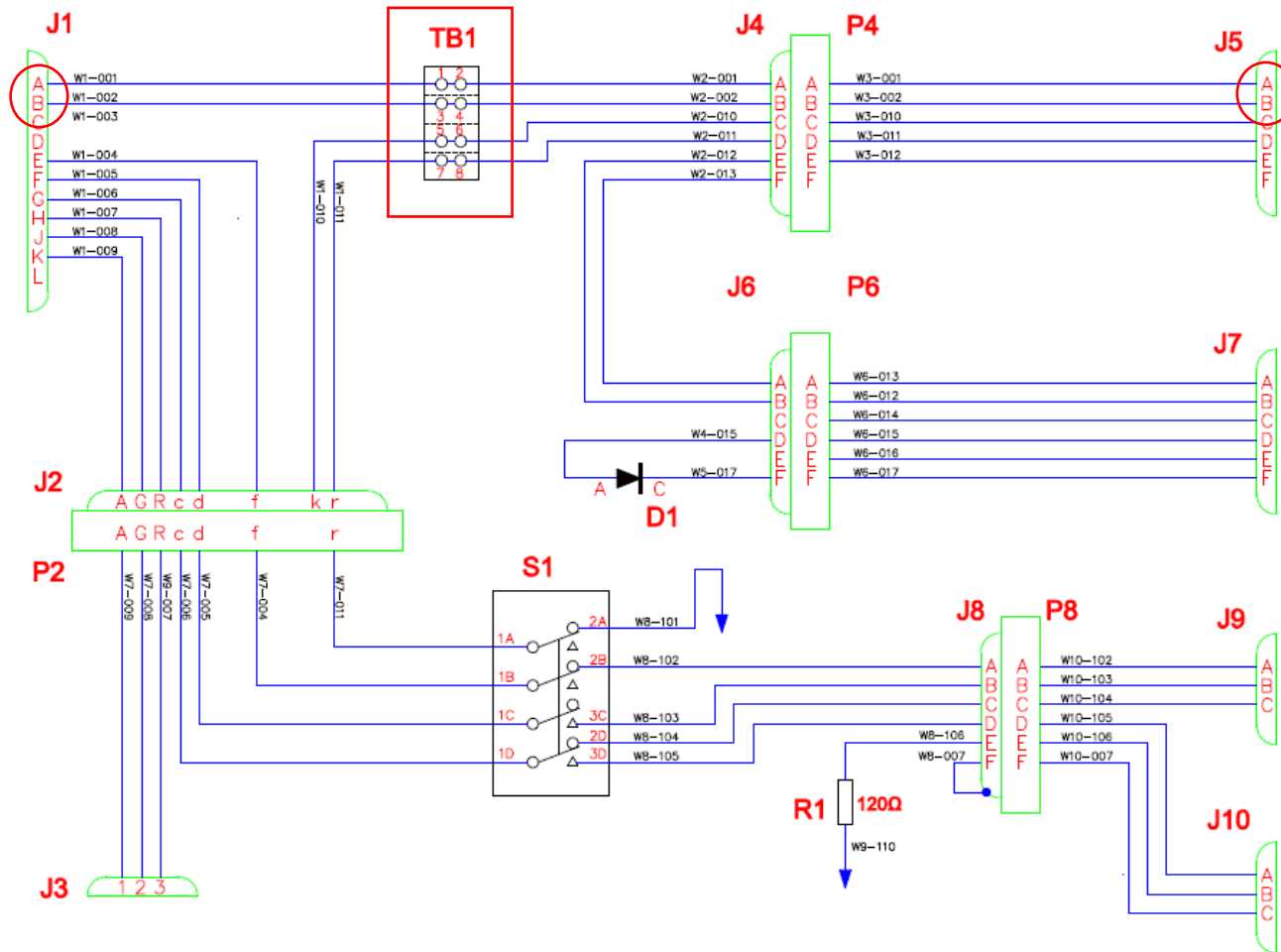
This reported error tells the technician that resistance is low but does not tell the technician there is a resistor in the circuit that has failed.

The proposal output would read:

Resistance failure between J4-7 and J4-8 most likely due to component R1. Value should be 100 ohms $\pm 10\%$ but is reported as 51.2 ohms

This gives the technician enough information to conclude that the resistor R1 needs to be replaced.

Isolating Probable Causes



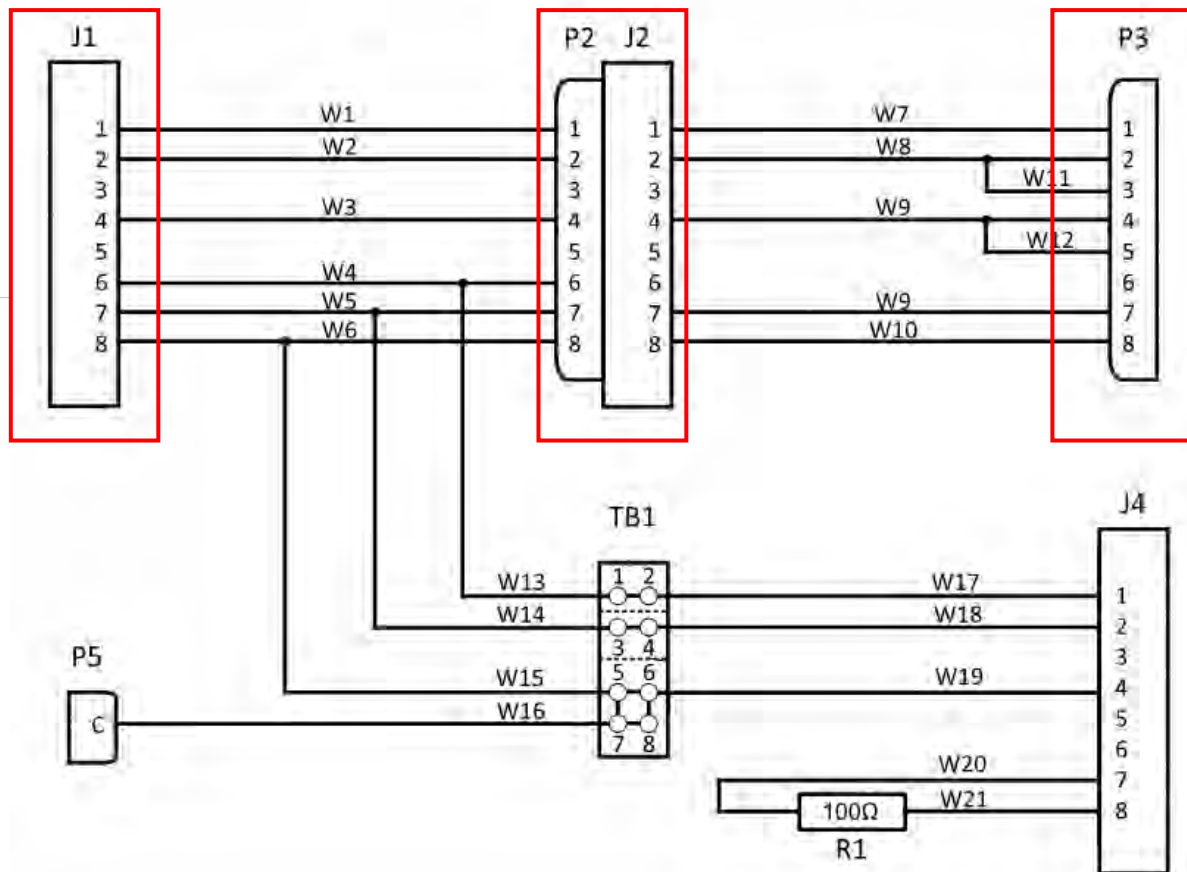
CC J1-A J5-A OPEN >30.0M OHM
 XT J1-A J5-B WIRED <0.100 OHM
 XT J1-B J5-A WIRED <0.100 OHM

The above indicates a miswire, however, there are a few places in the schematic that a miswire can occur.

Proposed solution will provide a user-friendly output:

Continuity failure between J1-A and J5-A is most likely pins 1 and 3, or 2 and 4 reversed in terminal block TB1

Isolating Probable Causes

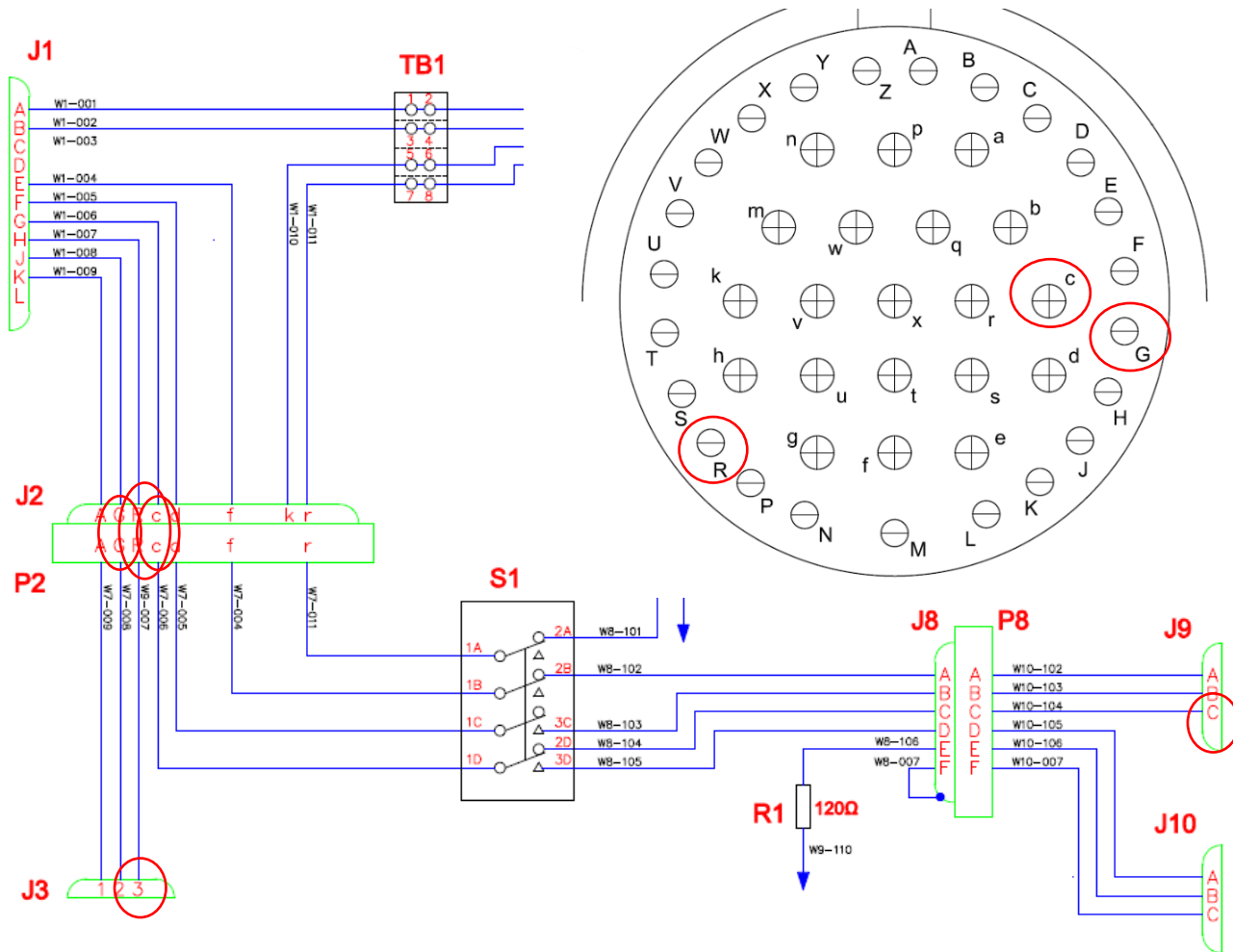


Additionally, the report can be configured to look at networks that share the same interface connections. For example, J1 and P3 both have connections to J4 through J2 and P2. The software can be configured to test through the contacts of a shared connector and use that information to help narrow down the root cause.

The output might read:

Continuity failure between J1 and P3 but not J1 and J4, nor P3 and P3, are most likely due to connectors P2 and J2 disconnected in the UUT

Example of Component Topology



CC J3-3 J9-C SHORT 0.100 OHM

There may be an instance where a short occurs between two wires that are physically distant from each other. Using machine learning the contact arrangement of connectors shared by the wires can be examined. In this case the contacts 'R' and 'c' in J2/P2 are adjacent on the schematic but not physically.

However, contact 'G' and 'c' are adjacent in J1.

The proposed solution might read:

Short circuit between J3-3 and J9-C is most likely found at J2/P2 adjacent contacts G and c.

Conclusions – Best practices in Wiring Harness Testing

- **INTEGRATE** all wire harness design data with manufacturing & testing processes
- **AUGMENT** guided pinning of connectors helps eliminate wiring errors
- **CREATE** adapter cable designs using wire harness data and automation design tools
- **GENERATE** automatic test programs to completely test the integrity of the complex wiring harnesses and integrated components
- **REDUCE** test times and improve reliability by using **wiring network** centric system architectures and testing algorithms.
- **TEST** wiring harnesses as they are constructed to minimize trouble shooting complex wiring harnesses only after manufacturing is complete
- **DISPLAY** informative, plain language error messaging with probable root cause and drastically reduce troubleshooting and error correction



Questions?



Thank you!

