

AIR FORCE RESEARCH LABORATORY



Application of Cognitive Task Analysis in User Requirements and Prototype Design Presentation/Briefing

Christopher K. Curtis
Christian E. Randall
Brian Tidball

Air Force Research Laboratory
Logistics Readiness Branch
Wright-Patterson AFB, OH 45433

Scott Bachmann
Darryl Stimson

NCI Information Systems, Inc.
2850 Presidential Drive, Suite 250
Fairborn, OH 45324

David E. Kancler
Megan E. Gorman
Mary McWesler

University of Dayton Research Institute
Human Factors Group
300 College Park
Dayton, OH 45469

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Human Effectiveness Directorate
Warfighter Readiness Research Division
Logistics Readiness Branch
2698 G Street
Wright-Patterson AFB OH 45433-7604

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14. ABSTRACT The goal of Aircraft Maintenance Intuitive Troubleshooting (AMIT) is to create job-aiding software, compatible with existing computer systems that will tell maintenance technicians what is really wrong with aircraft faster and more accurately than ever before.					
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Christopher Curtis
Capt Christian Randall
Capt Brian Tidball
Air Force Research Laboratory
Wright-Patterson AFB, OH

Scott Bachmann
Darryl Stimson
NCI Information Systems, Inc
Fairborn, OH

David E. Kancler
Megan E. Gorman
Mary McWesler
University of Dayton Research
Institute
Dayton, OH

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The need for AMIT was identified as critical to reducing persistent "Cannot Duplicate", "Re-test OK" and false removal patterns that have hampered maintenance performance and readiness and have increased operating costs.

The significance of AMIT will be in researching the troubleshooting process and cognitive demands and decision points in order to identify the gaps where emerging science and technology could be applied to improve performance.



Presentation Outline



- **Description of AMIT**
- **Method**
- **Results**
- **Application of Results**



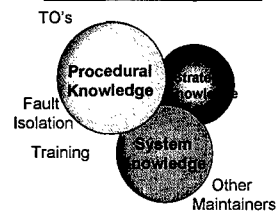
Aircraft Maintenance Intuitive Troubleshooting (AMIT) Program Description



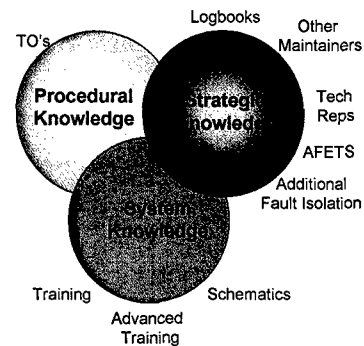
- Three year Air Force Research Laboratory Proof of Concept Demonstration
- Project Goal: Reduce aircraft downtime by improving human performance in maintenance troubleshooting of complex aircraft system discrepancies
- Project Objectives:

- Novice perform at or near expert level
- Expert demonstrates improvement

Novice Knowledge Base



Expert Knowledge Base





Technical Objectives



- **Goal: Capture and reuse expert knowledge and strategies**
- **Specific Objectives:**
 - Evaluate contextual filtering of knowledge
 - Evaluate efficient information on demand
 - Evaluate knowledge-centric approach using an intelligent broker
 - Quantify the effects of cognitive job aiding



Introduction – Why CTA



- **Baseline of expert's knowledge, thought processes, and goals (Chipman, Schraagen, & Shalin, 2000)**
- **Goals of AMIT CTA effort:**
 - Goal #1: Corroborate maintenance process with Process Interviews.
 - Goal #2: Identify cognitively complex areas of maintenance.
 - Goal #3: Define Expert vs. Novice Differences



Method

Pre-test and Execution



- **Pre-test**
 - Validate that our CTA technique gathered the intended information
 - Subject pool consisted of aircraft maintenance personnel with equivalent expertise to our intended subject pool
 - Performed locally at Springfield ANG, OH
- **Full Test: Three sets of interviews**
 - Nellis AFB, NV
 - Hurlburt Field, FL
 - Eglin AFB, FL
 - Subject Pool cuts across bases and specialties



Method

Data Collection Techniques



- **CTA techniques used**
 - Task Diagram (TD):
 - Link cognitive requirements to specific task segments
 - Task segments identified using SMEs and prior process based interviews
 - Knowledge Audit (KA):
 - Address specific cognitive requirements
- **Data collection**
 - Psychologist Interviewer, note taker, and SME
 - Collected backup recordings for later review



Method CTA Interview Process



- **Task Diagram**
 - Identify primary steps in fixing an aircraft
 - Identify steps requiring difficult decisions, expert knowledge
- **Knowledge Audit**
 - Cues that the maintainer notices,
 - Strategies employed to effectively perform maintenance,
 - Problems that might be difficult for a novice to navigate.
- **“Ideal World”**
 - Outside the box concepts
 - Look for themes (e.g., communication, information archiving, fleet wide data)

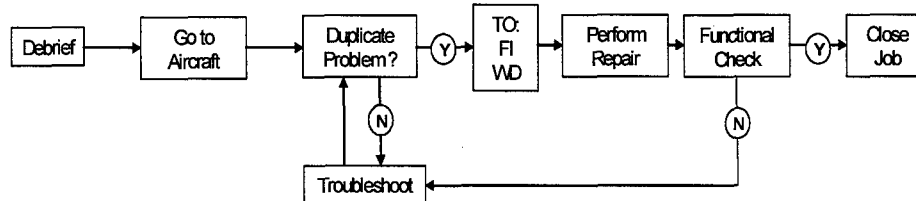


Results



Goal #1: Corroborate maintenance process with Process Interviews.

Confirmed: Task Diagram is consistent across aircraft bases and across specialties.

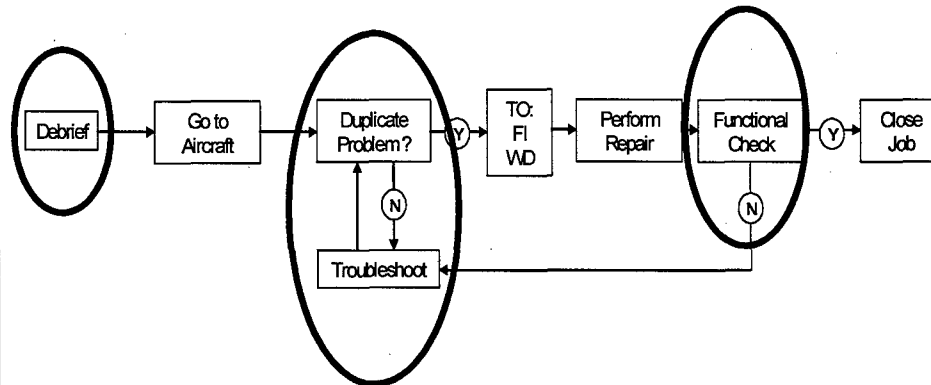




Results



Goal #2: Identify cognitively complex areas of maintenance.



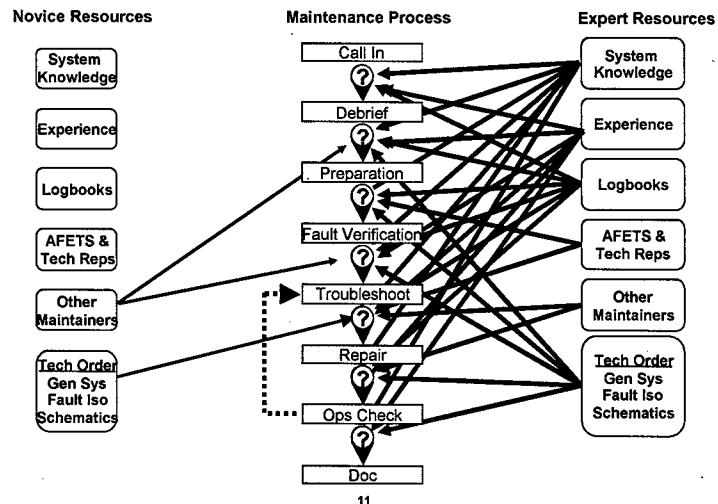


Results



Goal #3: Define Expert vs. Novice Differences.

Conclusion: Expert's are aware of, and draw from, a wider ranges of available resources.





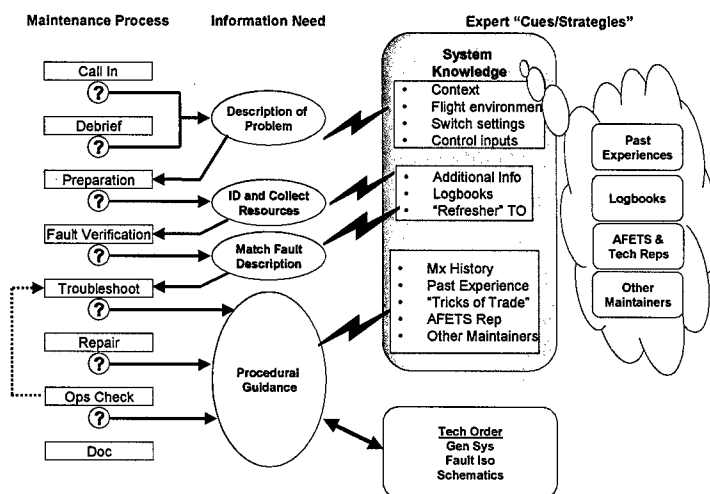
General Design Implications



- **Graphical System Representations.**
 - Connections to other systems.
 - Help maintainer build a mental model.
- **Electronic TOs.**
 - Information integration
- **Electronic Wiring Diagrams.**
 - Wiring Diagrams / Tech Order link
- **Access to Other Information Sources.**
 - Promote collaboration
 - Information push to novice



General Design Implications





Specific Prototype Applications



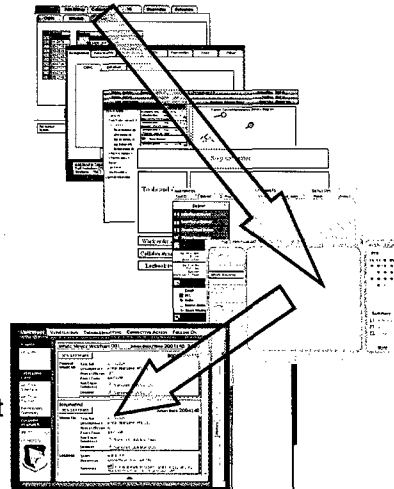
- **A UI framework to orient the user**
 - Connections to other systems.
 - Help maintainer build a mental model.
- **Support work beyond the TO**
 - Information integration
- **Electronic Wiring Diagrams**
 - Wiring Diagrams / Tech Order link
- **Access to Other Information Sources**
 - Promote collaboration
 - Information push to novice



Evolution of Prototype



- **Evolution**
 - Moved from data to context centric
- **User Evaluated**
 - Validated applied CTA concepts
 - Validated notional designs
 - Provided additional "expert" perspective
- **Optimal design layout**
 - Resolved competing Novice/Expert needs
 - Screen real estate limits
- **Data research**
 - Determined presentation needs
 - Integrated disparate sources with Expert Strategies





Detailed Design: AMUG



- Identified missing UI features/functions
- Identified unnecessary features/functions
- Clarified domain-specific terms and jargon
- Confirmed AMIT findings from CTA/Lit Review/Process Interviews
- Provided cross-categorical perspectives (different bases, weapon systems)



Current Prototype UI



Process Step Tabs

Data Links

JO TO
Select a Fault Code Using

PT TO
LRU History
Discrepancy Summary
LRU

DISCREPANCY | VERIFICATION | TROUBLESHOOTING | CORRECTIVE ACTION | FOLLOW ON

WEAPONS SYSTEMS FAULT DETECTION / PROTECTION

Display Area

Add logbook entry regarding action taken

Go Cancel

Information Access Tabs

Prompt for Knowledge Capture



Current Prototype UI Context Filtering of Knowledge



- Filtered by MX process step
- Filtered by WUC

Procedural Knowledge



Current Prototype UI

Efficient Information on Demand



- Search engine in background
- Eliminate multiple manual queries

DISCREPANCY	VERIFICATION	TROUBLESHOOTING	CORRECTIVE ACTION	FOLLOW ON
Ops Check				
JG TO				
Select a Fault Code Using FI				
FI TO				
LRU History				
Discrepancy Summary				
CND				
RADAR CONFIGURATION IN TAIL NO. 0770				
RADAR ANTENNA MODULAR LPRF PROG SIGNAL PROCSSR XMITTER DUAL MODE				
LRU 74AM0 - RADAR ANTENNA				
Part Number	Serial Number	History Entries		
75SR830601	11620	2		
11620 History				
A/C	BASE	DATE	AT	DISC
9000000720	LUKE	200323	A	FOR 007 CAME ON WITH MASTER CAUTION. FACT DID COME ON AGAIN. ACN DID NOT WORK. R/W'S SEEMED TO WORK. A-G
80000002123	LUKE	200309	A	FOR 831L MFL 007 AFTER SHUTTING ON AND OFF. FOR WOULD WORK FOR A FEW MINUTES THEN FAIL AGAIN.
		CORR ACT		
		R2 ELECTRONICS PACKAGE AND RAN END 2 END 2 TIMES AND PARTS THIS LRU WILL BE PROCESSED OUT AS A SERV		
		R2 ELECTRONICS PACKAGE RAN ETE NDN		

System Knowledge



Current Prototype UI Knowledge-centric Approach



- Problem to Resolution Tool
- Capture strategic knowledge

DISCREPANCY VERIFICATION TROUBLESHOOTING CORRECTIVE ACTION FOLLOW ON

Inspection

Follow On Maintenance

Review & Closeout

Review Log/PTR

Review Job

PTR for 0770 -- JCN 20051550401

EV FI CA RV

1 2 3 4 5 6 7

DISCREPANCY CORRECTIVE ACTION: The aircraft reports MFL112 with False targets. Replaced PSP and wrote up A/C for In-Flight Check.

Process Steps Completed

Process	Procedures	Results	Decisions	Comment No.
PV	PCR Ops Check	PASS	FC 9461XG, 9461AR	1
FI	9461AR			2
FI	9461XG		Perform IA-to-A Check	
PV	IA-to-A Checkout	Pass with False Targets	9461XG	4
FI	9461XG		PSP	
CA	Remove PSP, Install PSP			6
RV	PCR Ops Check	PASS		7

Comments

Strategic Knowledge



Conclusions



- **Ideal maintenance world never will exist**
 - Technical data has limitations
 - Designed by engineers based on ideal conditions
 - Maintainers have varied experience levels
 - Impossible to know all possible/potential faults & causes
- **Capture and reuse expert knowledge and strategies**
 - Combined knowledge base to aid technicians
 - Reduced preparation time
 - More first-time success repairs
 - Accelerated knowledge & skill progression
 - Supplement TO data with maintainer experience



Questions & Answers



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