U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – DATA & ANALYSIS CENTER

Driving Intuitive System Design with Usability Metrics: A Case Study

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APPROVED FOR PUBLIC RELEASE.

OVERVIEW

- System Description
- Why Modernize?
- User-Centered Design Process
- Usability Measures & Targets
- Usability Testing Results
- Usability Metrics Dashboard
- Lessons Learned

Sponsored by PEO C3T, PM Mission Command, PdM Fire Support Command and Control
in close collaboration with the Fires Center of Excellence
ACM Fires Cell-Targeting and the Directorate of Training Development and Doctrine & Leidos

Performed in accordance with AR 602-2
Army Human Systems Integration in the System Acquisition Process

SYSTEM DESCRIPTION

Forward Observer

AFATDS Operator

Fires & Effects

Army & USMC high-level concept of operation

Advanced Field Artillery Tactical Data System (AFATDS)

Primary command and control system for Long-Range Precision Fires Cross-Functional Team initiatives:

- Extended Range (ER) Cannon Artillery
- ER Guided Multiple Launch Rocket System

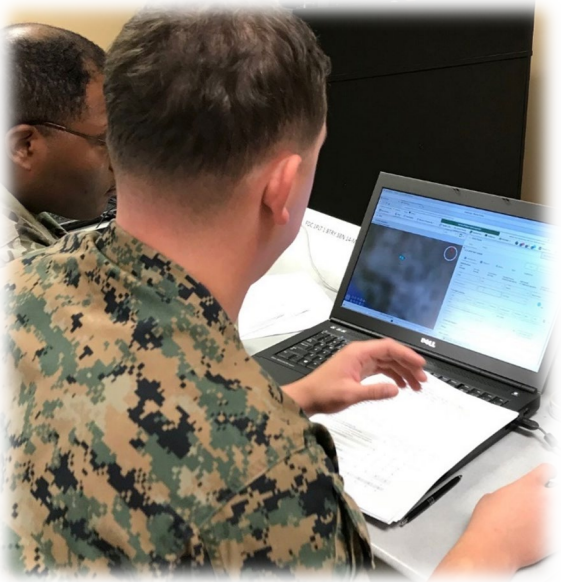
Also primary C2 system for other weapon systems providing automated support for planning, coordinating, controlling and executing fires and effects:

- Mortars and Cannons
- Rockets and Missiles
- Close Air Support and Attack Aviation
- Naval Surface Fire-Support systems

Source: https://peoc3t.army.mil/mc/fsc2.php

WHY MODERNIZE AFATDS?

Legacy AFATDS



Modernized AFATDS

Background

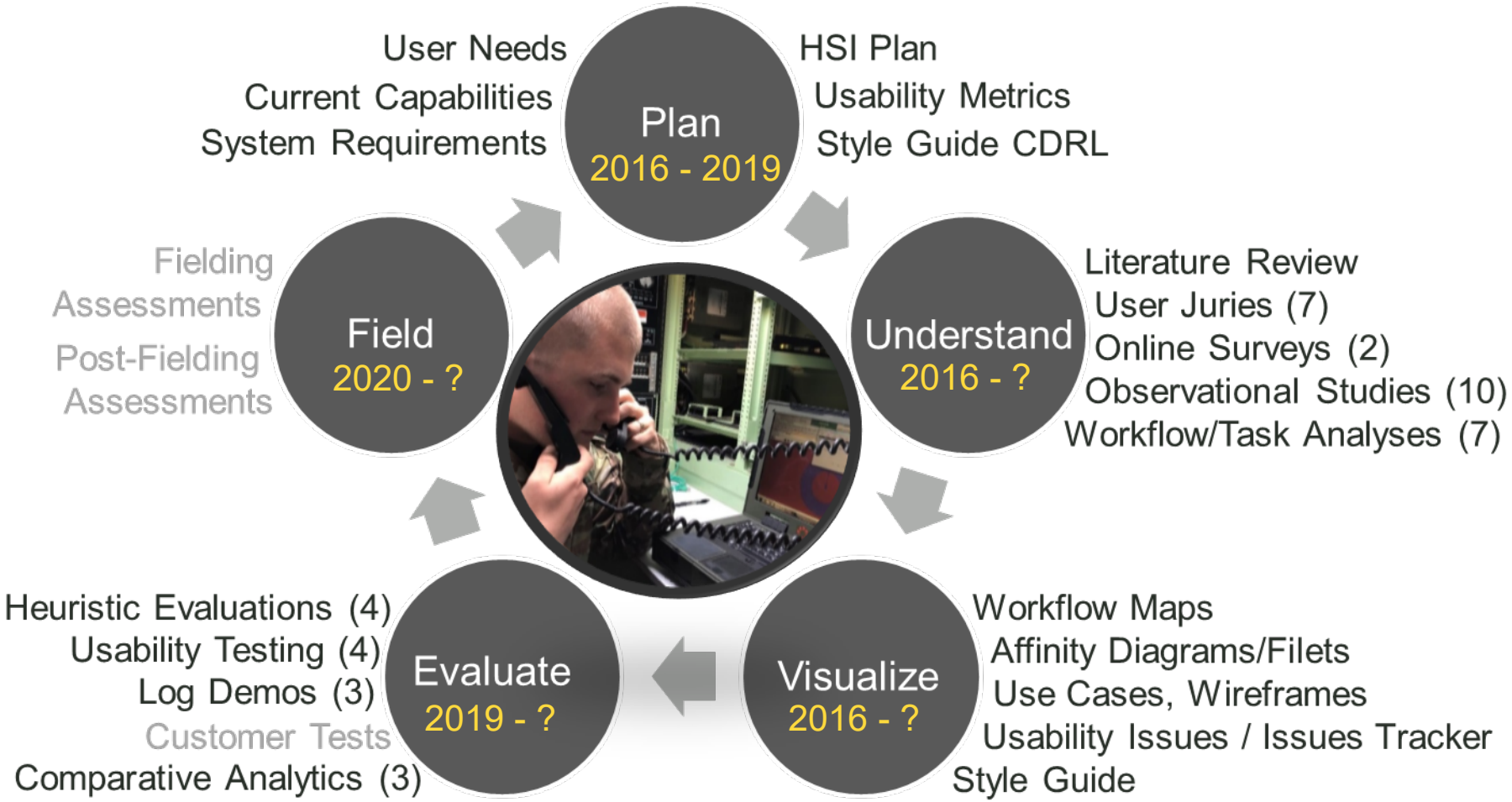
Software is more than 30 years old

- 1981 DARPA sponsored development
- 1984 first contract awarded
- 1996 first fielding

Fast Forward to 2017

- Modernization contract awarded
- Transition to web-based app
- Improve access to training
  - Embedded individual & collective training capability
- Design an intuitive user interface
  - Reduce time to train from 120 to 40 hours
  - Simplify complex cognitive work

USER-CENTERED DESIGN PROCESS

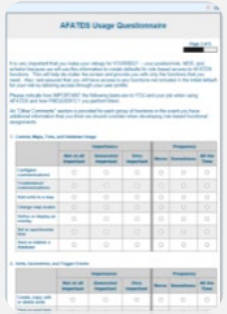


Legend: Begin – End Date

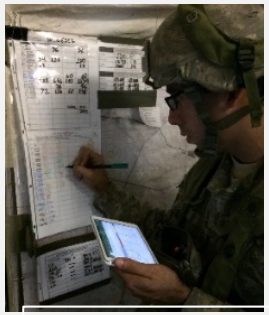
Critical design input received from 994 Warfighters with over 8,589 years of FA experience

WHY UCD?

Focus Groups



Online Surveys

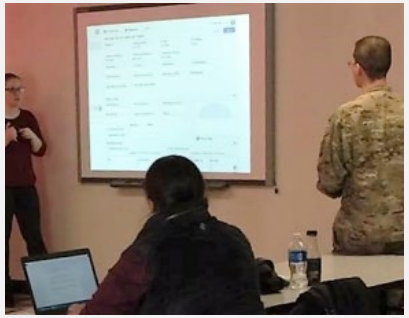


Exercises

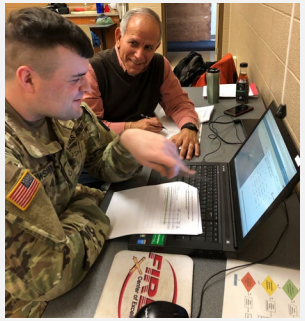
Drill Weekends

Contextual Inquiries

Workflow Capture



Heuristic Evaluation



Usability Testing

To Meet Our Design Goals

- Leverage users' existing knowledge
- Tailor content to subsets of users
- Streamline workflows & align with field artillery doctrine
- Avoid replicating current design issues

Because It Works

- Iterative process involving users throughout design & development
- Design driven by user data and refined by user evaluation
- Iteratively test designs with users until usability targets are met for critical tasks

IRB Approval ARL-15-071, ARL-15-136, ARL-15-132, ARL-17-204, ARL-19-073, ARL-18-133, ARL-19-154

UNDERSTANDING USERS & THEIR NEEDS

UNDERSTANDING USERS & THEIR NEEDS

Objective of the Field Artillery
Destroy, Neutralize, Suppress Enemy with Integrated Fires to Enable Maneuver Commanders to Dominate in Unified Land Operations

twitter.com

The Five Requirements for Accurate Fire

1. Accurate target location and size.
2. Accurate firing unit location.
3. Accurate weapon and ammunition information.
4. Accurate MET information.
5. Accurate computational procedures; requires strict adherence to continuous independent checks.

DESIGN &TEST EMPHASIS

Tasks that span all 3 characteristics are color-coded

Most Critical	Most Frequent	Most Problematic
• Add units to a map	• Process fire messages	• Unhelpful help messages
• Configure and troubleshoot communications	• Configure and troubleshoot communications	• Configure and troubleshoot communications
• Save and restore a database	• Create target lists	• Interoperability
• Edit geometries	• Send messages	• Save and restore a database
• Synchronize time	• Save and restore a database	• Weather data (MET)
• Create target lists	• Create geometries	• Air support requests
• View range fans	• Weather data (MET)	• Delete geometries
• Weather data (MET)	• Perform attack analysis	• Synchronize time
• Distribute status update	• Synchronize time	• View maps
• View ammunition status	• Display an overlay	• Create target lists

Two datasets

- Open-ended on-line questionnaire
- Closed-ended in-person questionnaire with follow-on semi-structured interviews

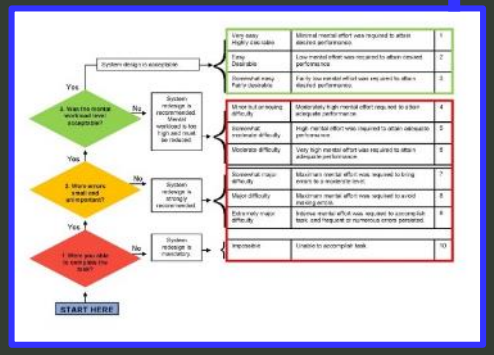
Not actual data; notional data provided for illustrative purposes

USABILITY TARGETS

Ease of Use Ratings

It was easy to...	Strongly Disagree	Disagree	Agree	Strongly Agree	CW Rating
3a. Know how to get started on this task.	1	2	3	4	
3b. Select the Map Mod.	1	2	3	4	
3c. Change the format to UTM.	1	2	3	4	
3d. Save entered data.	1	2	3	4	
3e. Know that entered data was saved.	1	2	3	4	

EoU & CW questions tailored to each task and GUI elements encountered



Modified Cooper-Harper (MCH) Cognitive Workload (CW) Rating Scale

1) Industry Benchmarking

- Mean score of 80 or better on the SUS
- Mean rating of 5.5 or better on the TAM

2) User Satisfaction

85%* of participants judge ease of use (EoU) for each assessed item as "acceptable"

3) Efficiency

85%* of participants judge cognitive workload (CW) for each assessed item as "acceptable"

Acceptable Ratings	Unacceptable Ratings
EoU: "3" and "4"	EoU: "1" and "2"
CW: "1", "2" and "3"	CW: "4" through "10"

3) Effectiveness

85%* of participants *do not require assistance* to complete a task

- Interaction behavior and requests for assistance are documented
- Root causes and mitigations are elicited

*100% for safety-critical tasks

USABILITY TESTING OVERVIEW

Usability testing: one-on-one and buddy tag teaming

Objectives: Identify (1) what is working well, (2) what is not, (3) severity of issues, and (4) user-suggested mitigations

Target Participants

- Range of experience from novice to expert
- Representative mix from echelons and types of units

Method

- Users are timed as they perform “typical” tasks
- Issues encountered and requests for assistance are logged along with user-suggested mitigations
- Users make EoU and CW ratings; “unacceptable” ratings are probed to understand underlying issue & potential mitigation

Results

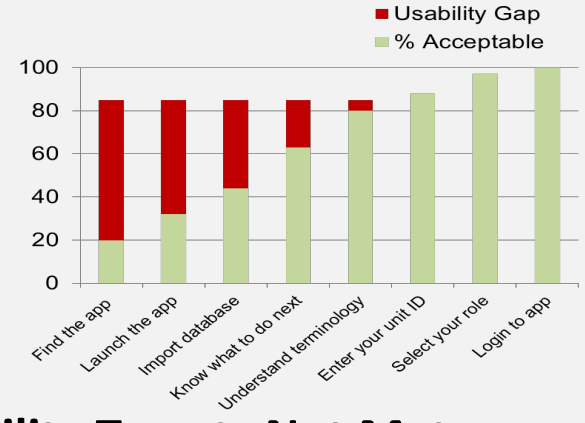
- Usability issues and their severity
- User-suggested mitigations

IRB Approval ARL-18-133, 10 August 2018; ARL-20-006, January 30 2020

USABILITY TESTING
ISSUE IDENTIFICATION AND TRACKING

How do we ensure designs are intuitive?

❶ Identify issues, their severity, root causes, and Warfighter-suggested mitigations



85% Target

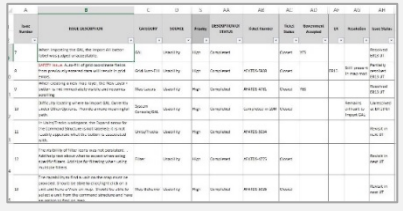
Usability Targets Not Met
- 55% did not require assistance
- 5 steps did not meet EoU or CW targets

Mitigations: Streamline Workflow
- Provide configuration/set-up wizards
- Enable only viable options
- Persist specific settings after shutdown to simplify and facilitate future logins

Issues
Root Causes
Priority
Mitigations
Status

❷ Log issues in HSI Issues Tracker

❸ User Rep & test facilitators prioritize issues



❹ Collaborate with developer's UCD team, review issues, root causes, potential mitigations

❺ As issues are resolved, they are retested in follow-on usability tests to ensure effective mitigation

❻ Progress is updated in HSI Issues Tracker and Usability Metrics Dashboard

Not actual data; notional data provided for illustrative purposes

WHEN USABILITY TESTING IS NOT ENOUGH

Paper Prototyping Fire Mission Processing Screens

Participatory Design
Paper Prototyping Sessions

- When issues identified in usability testing require thoughtful group discussion to identify solid mitigations
- Subject Matter Experts are unable to provide definitive design guidance
- Design visualization varies by user population and requires tailored information presentation for each
- Risk is high that an early design concept will not meet user needs

Procedure

Participants discuss, markup, and layout screen contents so content supports that task's operational workflow

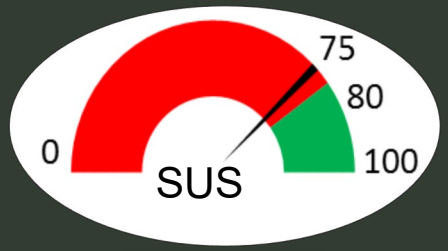
USABILITY METRICS DASHBOARD

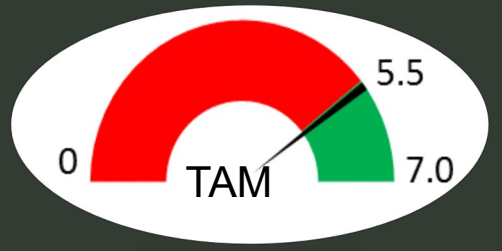
OVERALL: Positive User Experience

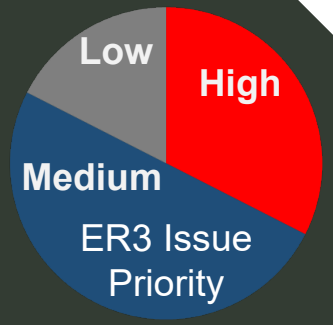
Usability Issue Count

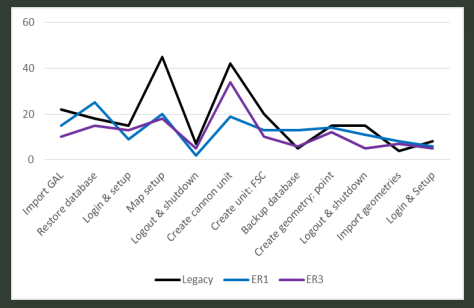
ER1: 80

ER3: 40 (~50%)

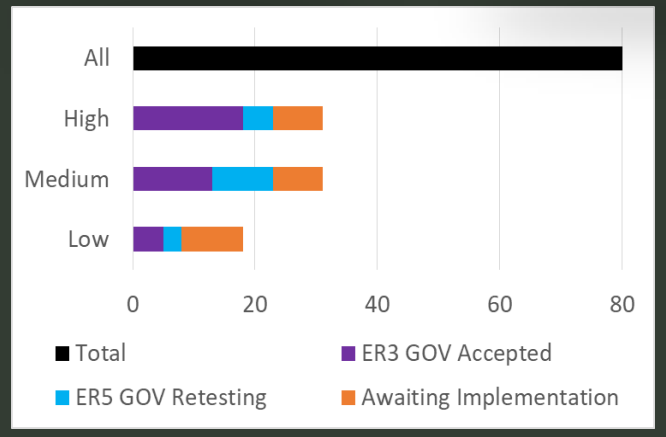




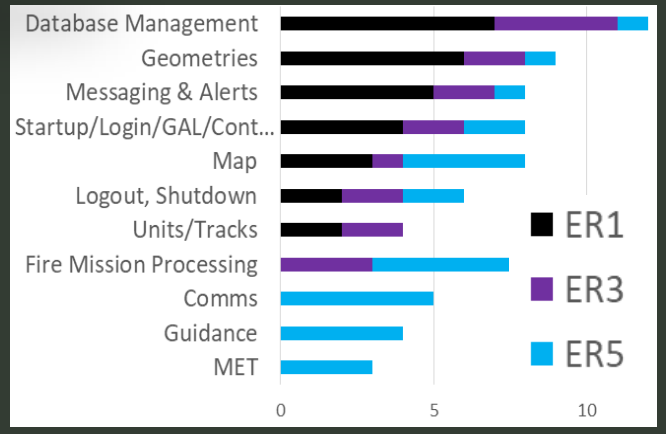




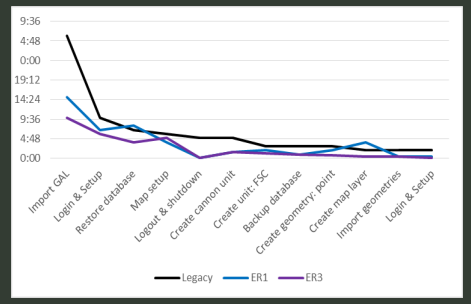
Steps per Task



ER1 Issues (80)
Mitigation by Severity & Status



Test Coverage: Number of
Tasks by Category and ER



Time per Task

25% of ER3 tasks judged intuitive

❶ Restore database ❷ Create unit ❸ Export geometry ❹ Establish Meteorological Data

Not actual data; notional data provided for illustrative purposes

LESSONS LEARNED

Catalysts for Success

- User advocates and UCD champions
- UCD process as a “requirement”
- Design goals identified up-front
- UCD expertise to guide the process and selection of activities to obtain needed design data
- UCD activities identified to obtain the foundational design information
- A multidisciplinary, cross functional team with access to users
- *Early* and *frequent* involvement of *all* in the process
- A vendor-PM agreed upon HSI plan including UCD activities & usability measures and targets
- Stretch targets keeping in mind that the only way to meet them is through iterative design
- A realistic schedule to support Agile development including timelines for usability test results to be included in sprints; they should be part of the development process, not “rework”
- Iterative usability testing conducted until targets are met