Driving Intuitive System Design with Usability Metrics: A Case Study

Pam Savage-Knepshield, PhD
Research Psychologist
CCDC Data Analysis Center HSI, C5ISR Field Element, APG, MD

4 March 2020
NDIA Human Systems Conference 2020
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

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?

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

User Needs
Current Capabilities
System Requirements

Plan
2016 - 2019

HSI Plan
Usability Metrics
Style Guide CDRL

Field
2020 - ?

Legend:
Begin – End Date

Understand
2016 - ?

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

Fielding Assessments
Post-Fielding Assessments

Evaluate
2019 - ?

Heuristic Evaluations (4)
Usability Testing (4)
Log Demos (3)
Customer Tests
Comparative Analytics (3)

Visualize
2016 - ?

Workflow Maps
Affinity Diagrams/Filets
Use Cases, Wireframes
Usability Issues / Issues Tracker
Style Guide

Literature Review
User Juries (7)
Online Surveys (2)
Observational Studies (10)
Workflow/Task Analyses (7)
WHY UCD?

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
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

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.

twitter.com
**DESIGN & TEST EMPHASIS**
Tasks that span all 3 characteristics are color-coded

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

**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

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**
   - EoU: “3” and “4”
   - CW: “1”, “2” and “3”

   **Unacceptable Ratings**
   - EoU: “1” and “2”
   - 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

**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?

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

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

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

2. Log issues in HSI Issues Tracker
3. User Rep & test facilitators prioritize issues
4. Collaborate with developer’s UCD team, review issues, root causes, potential mitigations
5. As issues are resolved, they are retested in follow-on usability tests to ensure effective mitigation
6. Progress is updated in HSI Issues Tracker and Usability Metrics Dashboard

Not actual data; notional data provided for illustrative purposes
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

SUS
75
80
100

TAM
5.5
7.0

Usability Issue Count

25% of ER3 tasks judged intuitive

- Restore database
- Create unit
- Export geometry
- Establish Meteorological Data

Not actual data; notional data provided for illustrative purposes
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