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

A User-Centered Design (UCD) Approach to Military Software Development

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OVERVIEW

• Background:
  – Challenges
  – Our roles
  – System description

• User-Centered Design
  – The Process
  – Agile Development
  – Human Systems Integration

• Sampling of UCD activities and products

Advanced Field Artillery Tactical Data System (AFATDS)
System designs with poor user interfaces cost the Army time, money, and more

- 40 – 120 hour training classes per system
- Contractors in the field to support usage
- Wait times for field assistance to arrive
- Steepest learning curves
  - Integrating battle systems
  - Keeping systems communicating
  - Troubleshooting issues encountered
  - Fighting the user interface

“… solutions are not designed for what we do … they need to understand what we do …”
OUR ROLES ARE CRITICAL

As researchers, engineers, designers, and content developers *we shape* how people learn, how they accomplish their goals and mission, and how they connect with each other.

The earlier we understand user needs, the better we can work with development teams to ensure system designs meet user needs and human-system interaction is appropriate for their missions and the environments in which they work.
THE SYSTEM: ADVANCED FIELD ARTILLERY TACTICAL DATA SYSTEM (AFATDS)

System Capabilities
Empower commanders to plan and execute delivery of lethal and non-lethal fires through
– integrated fires and situational awareness visualization
– increased collaboration among Army and Joint Fires Staff

Operational Usage
Automated support for planning, coordinating, controlling and executing fires and effects – mortars, field artillery cannons, rockets and missiles, close air support, attack aviation and naval surface fire support systems

Impetus for Modernization
- Transitioning software to web-based apps that can be accessed via the secure internet
- Reduce time to train
- Improve ease of use

Source: https://peoc3t.army.mil/mc/fsc2.php
USER-CENTERED DESIGN (UCD)
UCD: A RESULTS-FOCUSED PROCESS

Characteristics

- An iterative process involving users throughout design & development
- Explicit understanding of users, tasks, environments (context)
- Identify system functionality that requires design emphasis: critical, frequent, problematic
- Design driven by user data and refined by user evaluation

Lessons Learned: Catalysts for Success

- UCD process as a “requirement”
- An agreed upon UCD plan/process with usability metrics
- Multidisciplinary UCD team with access to users
- User advocates and UCD champions
- Selecting UCD activities to obtain needed design data
- Early and frequent involvement of all in the process
- Developing a realistic schedule to support Agile development
UCD & AGILE DEVELOPMENT

Commonalities
• They are philosophies
• Iteration is fundamental to both

Differences
• Leads: developers or designers/human factors?
• Design approach: holistic or chunked functional capabilities?
• Highest priority: customer or end-user?
• Iterative feedback: development teams or end-users?
• Measuring progress: working software or end-user satisfaction?

Teaming
Work together to develop an easy to use and learn system that enables users to be proficient, achieve their goals, and maintain readiness within schedule, cost, and resource constraints
• UCD activities and timelines support Agile development
• Responsiveness to shorter timescales
• Be inclusive, transparent, and accountable
• Focus on what is really important – to the user and customer
• Change course as necessary based on team feedback and lessons learned
Human Systems Integration (HSI)
The Army’s Program to integrate human considerations into the system acquisition process to enhance Soldier-system design, reduce life cycle costs, improve safety and survivability, and optimize total system performance (Army Regulation 602-2, 27 Jan 2015)

AFATDS HSI Plan
Describes how human considerations will be identified, assessed, and addressed appropriately during the system acquisition process
• UCD Process definition, framework, and user working group
• UCD Activities
• Usability Metrics
  – Effectiveness, efficiency, user satisfaction
  – Safety-critical
  – Training effectiveness
• GUI Style Guide (contracting deliverable)
• Top N Design Best Practices
DESIGN GOALS

Design Goal
Easy to use and easy to learn systems that enable users to be proficient, achieve their goals, and maintain readiness

• Obtain design direction from users
  – Leverage users’ existing knowledge
  – Streamline the user interface
  – Avoid replicating current design issues

• Evaluate and iteratively improve design against usability and trainability metrics
  – **Intuitiveness.** MOS-trained users will complete non-safety critical tasks on the first attempt 85% of the time upon first exposure to the system
  – **Trainability.** After completing new equipment training (NET) or embedded training, the first attempt for success is raised to 90%
  – **Benchmark against industry standard**
    Score of 80 or better on the System Usability Scale

Implement a UCD process in accordance with AR 602-2 to achieve goals
UCD ACTIVITIES

Understand
- Literature reviews
- Focus Groups / User juries
- Interviews
- Surveys
- Workflow mapping
- Acquisition documents
- User & subject matter expert interviews
- Previous Army HSI Assessments
- Product reviews / Competitive analysis
- Reverse engineering
- Task analysis (cognitive, heuristic, etc.)
- Observational studies (contextual, ethnographic)

Visualize
- Personas
- Scripted scenarios
- Storyboards
- Use Cases
- Conceptual design(s) / Wireframes
- Workflow process models
- Affinity diagrams (fishbones, filets)
- Models / Mock-ups (hardware & software)
- Rapid prototypes
- Best in Class comparative analysis

Evaluate
- Compare to metrics
- Interviews / Surveys
- Integrated product team working groups
- Source selection
- Comparative evaluation
- Expert reviews / Heuristic evaluations
- Usability testing / Benchmarking / Laboratory experimentation
- Logistics demonstrations
- Customer tests
- Comparative usability studies / Participatory design techniques
- Large-scale experiments (Warfighter Training Exercises)
- SME Observation / Inspection (contextual & ethnographic)
- Assessments (Safety, Manpower, Human Factors, etc.)

THE AFATDS UCD PROCESS

User Needs
Current Capabilities
System Requirements

HSI Plan
Usability Metrics
Style Guide CDRL

Plan

Field

Post-Fielding Assessment
Online Survey

Understand

Literature Review
User Juries (7)
Online Survey (1)
Observational Studies (10)
Workflow Mapping (7)

Evaluate

Heuristic Evaluations (4)
Usability Testing (6)
Log Demos (3)
Customer Tests
Comparative Analytics (3)

Visualize

Workflow process diagrams
Affinity Diagrams/Filets
Use cases
Style Guide
Wireframes

Critical design input from over 750 Warfighters with more than 6,000 yrs of FA experience

Acronyms
CDRL: Contract Deliverable
Log Demo: Logistics Demonstration
General procedure, sample of activities and results

• Literature Review
• Online Surveys
• Focus Groups/User Juries
• Contextual Inquires/Observational Studies
• Workflow Process Mapping
• Usability Testing
INTERACTING WITH OUR END-USERS

GENERAL PROCEDURE

Obtain Institutional Review Board (IRB) Approval
Submit research determination request to Army Research Lab IRB to ensure the rights and welfare of human subjects are protected during their participation in our UCD activities. The IRB package includes
- Research Determination Request form
- Consent form
- Demographics questionnaire
- Other data collection instruments, on request

Conduct UCD Activities
- Introductions
- Goals
- Method
- Consent form
- Demographics questionnaire
- Collect data
- Results provided to unit, stakeholders, and developers
UCD ACTIVITIES OVERVIEW

Gain a deep understanding of users and their needs to drive design and trade-offs

**Quantitative Data: on-line and in-person questionnaires**
- Answers the question “How Much?” “How Many”?
- Qualitative data is needed to understand the “How” and “Why”

**Qualitative Data: discussion, interviews, and on-line survey comments**
- Provides a deeper understanding than quantitative research alone
- Complements quantitative data

Accommodate and augment human-system interaction and human performance
Objectives: Identify design attributes that have historically increased workload and user frustration/dissatisfaction

Method: Perform literature review of relevant documents
- Army Research Laboratory HSI Assessment, 1996
- IBM Global Services Usability Heuristic Assessment Report, 2001

Results
- Button labels. Inconsistent labeling of buttons to “Save” data
- Data entry
  - Must backspace over existing characters before entering new data
  - Excessive use dialog boxes and screens
  - Inconsistent tabbing between fields
- Feedback. Lack of meaningful help and feedback messages
- Mission progress. No single screen showing real-time mission processing/progress
- Terminology. Unfamiliar and inconsistent terminology
- Troubleshooting. Lack of troubleshooting support
- Wizards. Lack of wizards to simplify some of the more complex tasks
ONLINE SURVEYS

Advantages

• Easy to develop and administer
• Low cost and overhead
• Reach a wider audience by remote, online administration
• Absence of an interviewer
  – May encourage more open and honest responses
  – Provides more time to respond
  – Data will raise more questions

Disadvantages

• Limited sampling and respondent availability
• Bias due to question non-responses
• Absence of an interviewer
  – Respondent identity; no checks by questioners
  – Questions must be kept simple; questions are open to interpretation by respondents
  – Data reliability issues (survey fraud)

Results

• Enabled formulation of research questions for discussion during focus groups
• Identified what is working well and what is not in the fielded system
• Identified the most critical, frequent, and problematic tasks for design emphasis

IRB Determination received ARL-15-136, 17 December 2018
### Online Survey Results

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>1. Add units to a map</td>
<td>1. Process fire messages</td>
<td>1. Unhelpful help messages</td>
</tr>
<tr>
<td>2. Configure and troubleshoot communications</td>
<td>2. Configure and troubleshoot communications</td>
<td>2. Configure and troubleshoot communications</td>
</tr>
<tr>
<td>3. Save and restore a database</td>
<td>3. Create target lists</td>
<td>3. Interoperability</td>
</tr>
<tr>
<td>4. Edit geometries</td>
<td>4. Send messages</td>
<td>4. Save and restore a database</td>
</tr>
<tr>
<td>5. Synchronize time</td>
<td>5. Save and restore a database</td>
<td>5. Weather data</td>
</tr>
<tr>
<td>6. Create target lists</td>
<td>6. Create geometries</td>
<td>6. Air support requests</td>
</tr>
<tr>
<td>7. View range fans</td>
<td>7. Create units</td>
<td>7. Delete geometries</td>
</tr>
</tbody>
</table>

*NOT ACTUAL DATA
DATA HAS BEEN FABRICATED FOR ILLUSTRATIVE PURPOSES*
FOCUS GROUPS

Objectives: Identify aspects of the user interface that require design emphasis and those that are used the most, the least, or not at all. Identify capability gaps/requirements. Establish a usability baseline.

Method
1. Overview briefing
2. Large group: usage and usability questionnaire
3. Small groups: moderator-led discussion

Target Participants
Experts (e.g., Digital Master Gunners)
FOCUS GROUP RESULTS

AFATDS Characteristics Liked the Best

- User interface: 23%
- Other: 20%
- Communications Workspace: 13%
- Speed of service: 13%
- Maps: 9%
- Fire mission capability: 7%
- Geometries: 6%
- Units: 6%

Example verbatim comments
- “… notifications that pop up to let us know important information.” (UI)
- “Being able to filter radio mixes.” (Communications Workspace)
- ”Loading software is less time-consuming.” (Speed)
- “I like the RPF [raster product format] map and DTED’s [digital terrain elevation data] and use them all the time.” (Maps)
- “Building geometries with a click of a button.” (Geometries)
- “The Initiate Fire Mission window allows rapid fire mission initiation.” (Fire mission)
FOCUS GROUP RESULTS

Usability Baseline, Capability Gaps, GUI Design Emphasis

• Analyzed comments to identify issues
• Usability Baseline
• Over the course of 2 days stakeholders gathered and assessed the merit of each issue, its priority, and the technical feasibility of potential mitigations

EXAMPLE: Difficulty knowing when communications have dropped.
• “Comms always dropping is the biggest issue we’ve had.”
• “In order to monitor comms connectivity, the comms workspace must be kept open.”

Technical Assessment/Priority.
High priority. Research is needed to understand how comms status should be visualized in a dashboard that does not detract from mission focus. Examine this functionality as implemented in other mission command systems.
CONTEXTUAL INQUIRIES & OBSERVATIONAL STUDIES

Objectives: In a near-operational environment, identify aspects of the user interface that require design emphasis and those that are used the most, the least, or not at all. Obtain improvement and enhancement suggestions (capability gaps/user needs) during tactical operations from end-users.

Target Participants
• Field artillery personnel and those with whom they interact
• Available echelons (organization levels in the Army hierarchy)

Method
1. Identify key research questions (focus group and online questionnaire results provided a lot of data for this)
2. Observe users at work
3. Talk to them about their work, the tools they use, who they interact with, the shortcuts they use, their frustrations, delights, and work-related “fantasies”
4. Document observations
5. Identify gaps in observations
6. Develop additional interview questions
7. Verify documented observations with those being observed
8. Share results

OBSERVATIONAL STUDY RESULTS
National Training Center, Fort Irwin, CA

AFATDS with 3 screens*
1 Current Map, Firing Battery status**, Comms Wksp, Unit Wksp, Geometry Wksp, Free Text
2 Mission Status, Target List Current, Active Target List
3 Msg Cntr, Geometry Wksp, Scheduling Wksp, Basic Target Info

Battalion Fire Direction Center (FDC)

Asst Fire Direction Officer (FDO)
Immersed in ammo management/tracking

BN FDO
FDC Chief
AFATDS Op
AFATDS Operator “In Trng” Profiler Operator

Comms:
- Brigade chat room (dedicated laptop)
- FM radios
- VOIP telephone

*Bolded items are screen contents most frequently observed.
**Unit created product.
WORKFLOW PROCESS MAPPING & RESULTS

Objectives: Document how the system is used to accomplish fire missions. What functionality is used? Not used? What is irrelevant? What is missing? What needs improvement?

Target Participants
• Experienced AFATDS users.
• At a variety of echelons and in different types of units (cannon, rocket/missile, etc.)

Method
• Users perform “typical” tasks while actions and system responses are documented
• Flowcharts documenting results are verified by participants
• Results are shared

Results
• Patterns of use and disuse

Patterns of use and disuse
Annotated workflows – issues, suggested mitigations, and enhancements

IRB Approval ARL-17-204, 17 August 2017
Objectives: Identify what is working well and what is not. For usability issues, identify their risk and severity as well as potential mitigations.

Target Participants
• Range of experience from novice to experienced to expert
• At a variety of echelons and in different types of units

Method
• Users perform “typical” tasks
• Task performance is timed
• Issues encountered and requests for assistance are logged along with user-suggested mitigations
• Users make ease of use and cognitive workload ratings; “unacceptable” ratings are probed to understand underlying issue and user-suggested mitigations that would raise the rating to an acceptable level

Results
• Identifies usability issues along with their associated risk
• Identifies user-suggested mitigations

IRB Approval ARL-18-133, 10 August 2018
STARTUP/INITIALIZE
ASSESSED ITEMS COMPARED AGAINST THE
85% USABILITY TARGET

IMPLEMENT A SETUP/INITIALIZATION WIZARD
Implement a plug and play wizard for this task while considering relevant feedback for this task. 90% prefer a wizard (or a more wizard-like approach to setup/initialization)
• “It would be better to have a wizard walk you through this.”
• “Implement a wizard to breeze right through everything.”
• “Wizard to assist step-by-step instructions..”
• “Wizard to follow flow for ease of use”
• “Prefer to have a wizard.”

Task Ratings

No Assistance Needed to…

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Lessons Learned

• Ensure that all understand what UCD is and what it entails. If users are not involved, then it is not UCD
• Agree upon insertion points with development for incorporating user feedback this will help set realistic schedules
• Be inclusive, transparent, and accountable
• Increase manpower and buy-in by training team members to conduct UCD activities
• Create user advocates and UCD champions by demonstrating the value and return-on-investment of UCD
• Focus on what is really important – to the user, but don’t lose sight of what is important to the developer and customer
• Be flexible and change course as necessary based on team feedback and lessons learned
• Share the results of designing and developing systems/apps that are useful and usable and satisfy your end-users!
SPECIAL THANKS TO ALL THOSE SUPPORTING AFATDS UCD ACTIVITIES…

IT TAKES A TEAM!