DHS/ST/TSL-11/192

Human Factors Design-Specification Process for the Integrated Checkpoint Program

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June 2010

Final Report

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U.S. Department of Homeland Security
Science and Technology Directorate

Technical Report Documentation Page

1. Report No. DHS/STD/TSL-11/192	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Human Factor Design-Specification Process for the Integrated Checkpoint Program		**5. Report Date** **6. Performing Organization Code**
7. Author(s) Joshua Rubinstein, Ph.D. John P. Chin, Ph.D. Mark W. Smith		**8. Performing Organization Report No.** DHS/STD/TSL-11/192
9. Performing Organization Name and Address U.S. Department of Homeland Security Science and Technology Directorate Transportation Security Laboratory, TSL-1 William J. Hughes Technical Center Atlantic City International Airport, NJ 08405		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.**
12. Sponsoring Agency Name and Address U.S. Department of Homeland Security Science and Technology Directorate Transportation Security Laboratory, TSL-1 William J. Hughes Technical Center Atlantic City International Airport, NJ 08405		**13. Type of Report and Period Covered** **14. Sponsoring Agency Code** S&T

15. Supplementary Notes

John Chin and Mark Smith are support contractors provided by Hi-Tec Systems, Inc. Egg Harbor Township, NJ

16. Abstract

This document outlines the process that will be used for developing user interface design specifications for the Integrated Checkpoint Project (ICP) at the Transportation Security Laboratory's (TSL) Human Factors Lab. A User Centered Design (UCD) approach will be followed in compliance with ISO Standard 13407. This standard specifies five major activities: 1) Plan the human centered process, 2) Specify the context of use, 3) Specify new user and organizational concept of operations, 4) Produce design solutions, and 5) Evaluate designs against user requirements. This document describes the method and approach taken within these five areas.

17. Key Words Human factors, integrated checkpoint	**18. Distribution Statement** This report is approved for public release and is on file at the Transportation Security Laboratory Library, Atlantic City International Airport, New Jersey, 08405. This document is also available to the U.S. public through the National Technical Information Service (NTIS), Springfield, Virginia, 22161.

19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No. of Pages** 20	**22. Price**

DOCUMENT CHANGE HISTORY

Version	Description/Author	Date(s)	TSL Approval
0.1	Tech edits/PB	07/08/10	

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EXECUTIVE SUMMARY

This document outlines the process that will be used for developing user interface design specifications for the Integrated Checkpoint Project (ICP) at the Transportation Security Laboratory's (TSL) Human Factors Lab. A User Centered Design (UCD) approach will be followed in compliance with ISO standard 13407. This standard specifies five major activities:
1) Plan the human centered process, 2) Specify the context of use, 3) Specify new user and organizational concept of operations (CONOPS), 4) Produce design solutions, and 5) Evaluate designs against user requirements. This document describes the method and a tailored approach taken within these five areas.

Although a large array of activities can be performed under the auspices of ISO 13407, the process defined for the Integrated Checkpoint Project will be tailored to a subset of activities due to relevance, project timelines and resource constraints. The approach to the five areas is described below.

1. Plan the human centered process. The team will prepare an overall schedule that outlines the specifications development process for the Integrated Checkpoint project (ICP). Initially, planning will involve stakeholders who will help to define project scope and direction. Once key questions are answered, a follow-up kick-off team meeting should initiate the activities that will develop into a project schedule.

2. Specify Context of Use. Observational site visits will help to establish the context of use of a current implementation. This activity will help uncover hidden or implicit operational and architectural practices that constitute *de facto* system requirements, and thereby may influence the definition of a context for scenarios and use cases. For example, actual practice in the field may differ from written Standard Operating Procedures (SOPs) and CONOPS. Unforeseen tasks and unanticipated outcomes may be captured during field observations. Contingencies for unexpected outcomes should be understood in terms of use cases.

A task flow will be established to understand the operators' constraints and limits. Baseline information about how current tasks are accomplished helps to determine how future tasks may be redefined within new system implementations. Analysis software will be used to build and run a simulation model of tasks and task networks. Task definitions, flows, and times collected during the site visit to a Transportation Security Administration (TSA) Checkpoint will be used to build the simulation. Multiple simulation runs will yield metrics of times and task branching and will represent a quantitative model of the baseline (existing) system.

3. Specify New User and Organizational CONOPS. Introducing new technology, technology integration, or operator interfaces will often necessitate new procedures and tasks. Definition of both user procedures and organizational CONOPS will need to describe how the new implementation should work. An integrated display design will therefore be co-developed with a proposed CONOPS specific to that new technology integration. There will be no suggested modification to the existing CONOPS that have no immediate or direct relationship to the integrated display. Based on user scenarios, tasks, and proposed display design, a proposed new CONOPS and user interface design will define the following:

- System sensor information presentation
- Organization of display and definition of display controls
- Operator responses and inputs
- Alarm resolution passenger-routing for each outcome (i.e., when suspected threat diverts passenger to secondary screening)
- Changes to passenger traffic and control methods used at the checkpoint

4. Produce Design Solutions. The design solutions and associated user interface specifications will be developed into working prototypes, which then will be iteratively refined though repeating design-build-evaluate cycles. These cycles may be adjusted to be shorter or longer based on what is most effective. This incremental process of prototype development will allow for feedback through: a) expert evaluations, b) pilot testing and c) informal analysis and testing.

5. Evaluate Design against User Requirements. Once a high fidelity prototype operating in a simulated environment (passenger flow) is developed, screening operators will be recruited to participate in realistic checkpoint exercises, during which the user interface designs will be evaluated by basic measurements such as the speed and accuracy of executing tasks. Key metrics such as throughput will be calculated or projected based on testing results, then fed into the simulation analysis.

A final draft of a Human Factors Design Specifications document will provide the specifics of a final recommended integrated design and include:

- Static GUI & UI specifications of the display design,
- Task definitions and logical flows to define the specific dynamics of the GUI and UI,
- UML diagrams generated from source code of the high-fidelity simulation, and
- Screen snapshots of the high-fidelity simulation.

ACRONYMS

AIT	Advanced Image Technology whole body scanner
ATR	Automatic Target Recognition
CONOPS	Concept of Operations
IO	Image Operator
SO	Screening Operator
SOPs	Standard Operating Procedures
SSD	Shoe Scanning Device
TSA	Transportation Security Administration
TSL	Transportation Security Laboratory
TSO	Transportation Security Officer
UCD	User Centered Design
WTMD	Walk Through Metal Detector

1. Introduction

This document outlines the specifications and design development process that will be used for developing the user interface for the Integrated Checkpoint Project (ICP) at the Transportation Security Laboratory's (TSL) Human Factors Lab. A User Centered Design (UCD) approach will be followed in compliance with ISO standard 13407 (Figure 1). This standard specifies five major activities: 1) Plan the human centered process, 2) Specify the context of use, 3) Specify new user and organizational concept of operations (CONOPS), 4) Produce design solutions, and 5) Evaluate designs against user requirements. This document describes the tailored method and approach taken within these five areas.

Human Centered Design Process for Interactive Systems ISO 13407

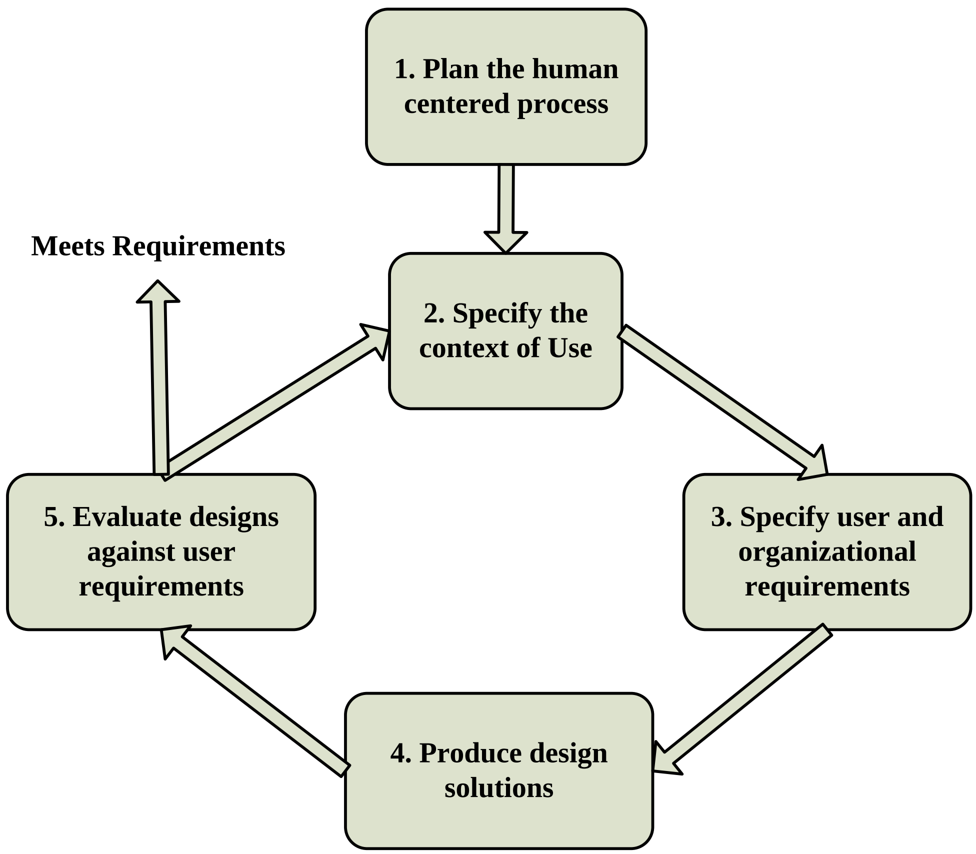

Figure 1. Design specification development processes adapted from ISO 13407.

The ISO 13407 process defined for the Integrated Checkpoint project will be tailored to a subset of activities due to relevance, project timelines, and resource constraints.

Significant tasks within each of the five major activities include:

a. Plan the Human Centered Process
    - Stakeholder Meetings
    - Kickoff Meeting
    - Create Schedule

b. Specify Context of Use
    - Observational Site Visits
    - Describe Workflow

c. Specify New User and Organizational CONOPS
    - Describe CONOPS Changes
    - Describe Screening Procedure Changes
    - Brainstorming Design Alternatives
    - Low Fidelity Prototypes
    - Modeling and Simulation

d. Produce Design Solutions
    - Iterative Prototyping
    - Hi Fidelity Prototyping

e. Evaluate Design Against User Requirements
    - Performance Testing

2. Plan the Human Centered Process

The team will prepare an overall schedule that outlines the human factors design specification development process for the Integrated Checkpoint project. Initially, planning will involve stakeholders who will help to define project requirements, scope and direction. Once key questions are answered, a follow-up kick-off team meeting will initiate the activities that will develop into a project schedule. The schedule will be modified and updated continually to incorporate progress and status on project tasks. Project requirements, scope and direction are obtained from multiple sources.

1. Project Initiator (funding agency, customer, stakeholder) specifies
    a. New technology features and capabilities
    b. New performance objectives
    c. New operational objectives (e.g., staffing, CONOPS)

2. End users, customers and stakeholders can provide requirements through
    a. Intended-user feedback and interviews
    b. Management feedback, briefings, and meetings
    c. Inner-agency operational and technical groups (e.g., integrated product teams)

3. For modifications of legacy systems, requirements can be derived from
    a. Existing agency documents (e.g., CONOPS, SOPs, Functional Requirements, Operational Requirements, Procurement Specifications)
    b. Site visits to evaluate legacy systems currently in use
    c. Laboratory evaluations of legacy systems
    d. Subject matter experts (e.g., security screeners)

3. Specify Context of Use

3.1 Establishing Context based on Current Checkpoint Configuration

Observational site visits will help to establish the context of use of a current implementation. This activity will help uncover hidden or implicit requirements towards the definition of a context for scenarios and use cases. Actual practice in the field may differ from written Standard Operating Procedures (SOPs) and CONOPS. Unforeseen tasks and unanticipated outcomes may be captured during field observations. A review of existing SOPs with stakeholders will help to clarify possible gaps found in scenarios and tasks, illustrated in Figure 2. Observations will be used to develop an understanding of the current checkpoint configuration CONOPS and use of the Advanced Image Technology (AIT) whole body scanner and the Walk-Through Metal Detector (WTMD).

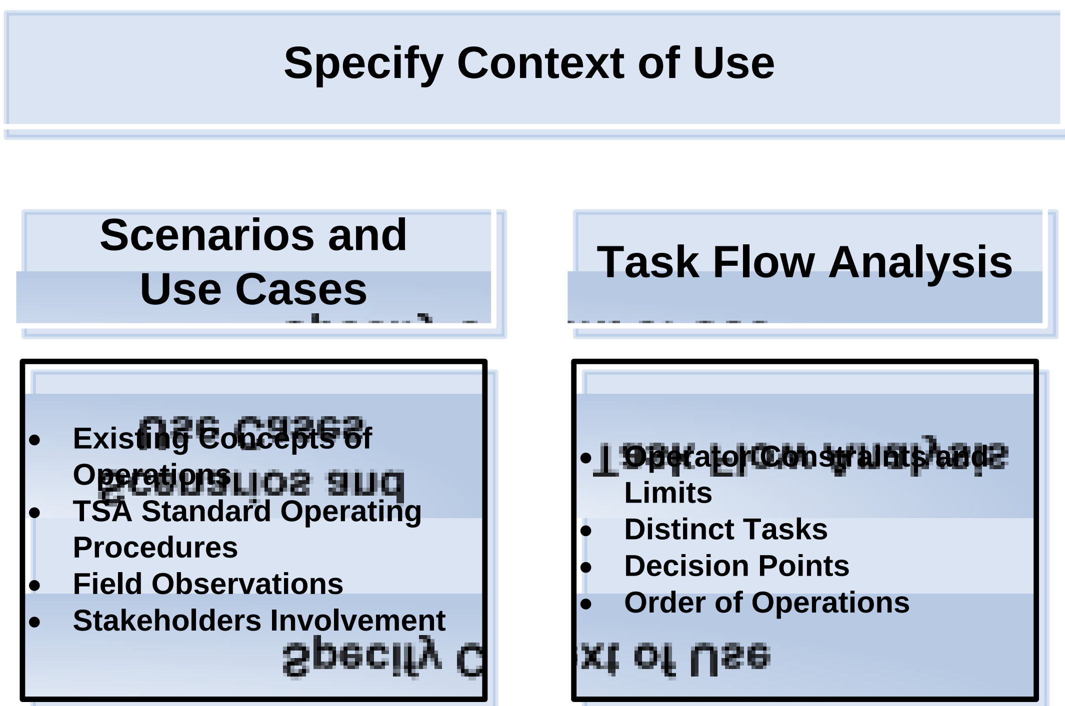

Figure 2. Activities to specify the context of use

Passenger flow at a checkpoint (see Figure 3) will be captured in use cases. A possible "no-go" outcome may occur when a suspected threat has been found, i.e., an "alarm result". For example, when using the WTMD, passengers may be asked to divest additional metal items that they may have forgotten to divest initially when WTMD alarms. Another example is when a remote Image Operator (IO) finds anomalies on the AIT image; passengers may be patted down while standing at their assigned spot (See Figure 3, Location G).   Those passengers requesting or requiring a private pat down may be relocated to a private screening location.

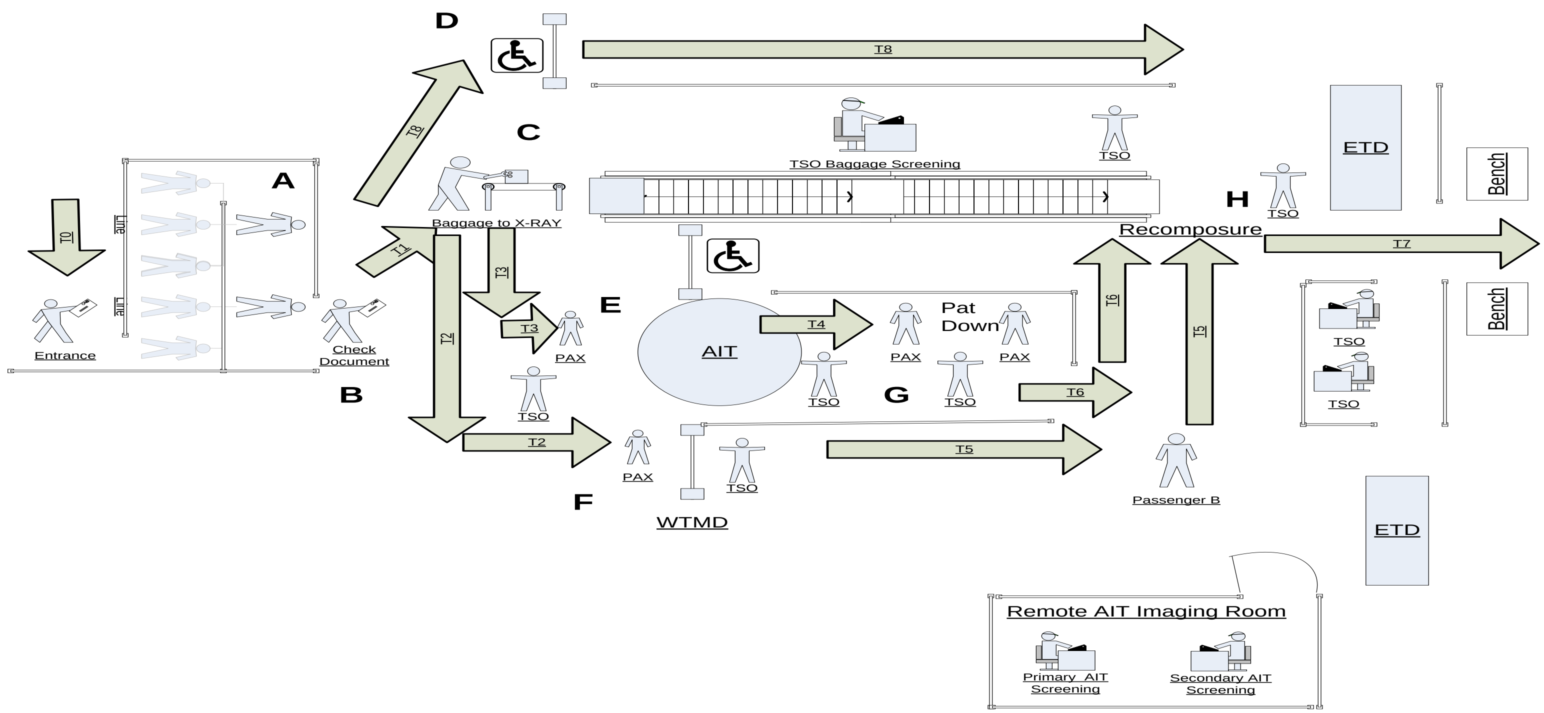

Figure 3. Primary AIT checkpoint layout

3.2 Proposed System and Concepts Under Development

A future integrated checkpoint display concept (see Figure 4) will be generated and reviewed with the TSA during stakeholder meetings. Figure 4 represents a high level conceptual illustration of the functional components of the integrated display. Specific design alternatives will be developed during brainstorming sessions based on field observations and input from subject matter experts.

Design considerations will include:

- Passenger Privacy
- Physical configuration/layout of the checkpoint
- User Interface of the Integrated Display
- Manning of stations at the checkpoint
- Operator tasks and communication
- Dynamics of passenger flow

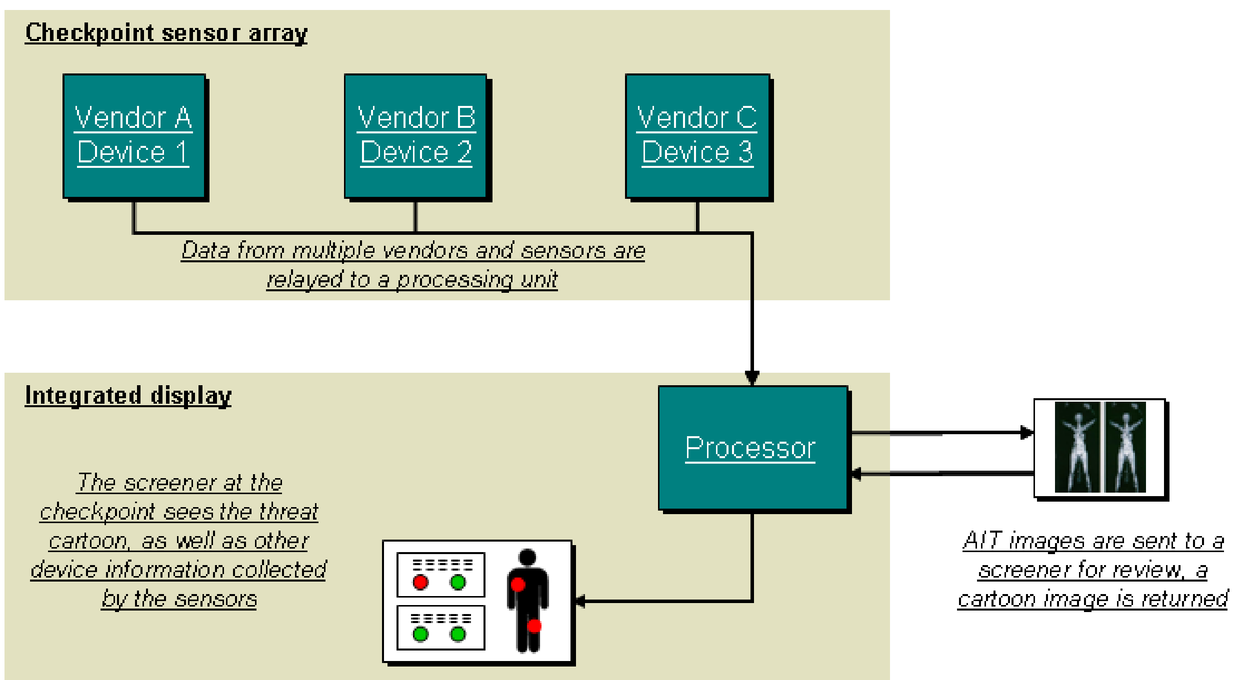

Figure 4. Conceptual illustration of an integrated display

After brainstorming initial high-level designs, candidate approaches will be analyzed and compared to the current task flows and timing of tasks. Design parameters may include changes in manning of stations at the checkpoint and the passenger flow guided by control points or methods. The result of the design analysis will be a preliminary high-level task flow and user interface design(s).

3.2.1 Automated Target Recognition

Automated Target Recognition (ATR) software has continued to improve and evolve and represents a technology that can potentially reduce checkpoint manpower requirements. Proposed design solutions will be examined using ATR technology in place of an Image Operator. Since ATR technologies may result in a higher alarm rate than the current human operator, the design challenge will be to generate solutions that will provide technological CONOPS and SOPs with False Alarm (FA) rates consistent with maintaining acceptable checkpoint through-put rates.

3.3 Task Flow Analysis

Following field observations and subsequent study of the tasks involved, a task flow will be established to understand the operator's constraints and limits. For example, the task of processing an image and rendering a decision regarding the presence of a threat might be decomposed into subtasks, each with a typical duration, likelihood of occurrence, entry/exit criteria, and dependencies on other subtasks. This analysis will clarify the variables impacting throughput and where bottlenecks may occur. The goal will be to understand and document what separate tasks should be performed in what order, and under what conditions, by the operator. Baseline information about how current tasks are accomplished helps to determine how future tasks may be redefined within new system implementations.

Analysis software will be used to build and run a simulation model of tasks and task networks. Task definitions, flow, and times collected during the site visit to a TSA Checkpoint will be used to build the simulation. Multiple simulation runs will yield metrics of times and task branching and will represent a quantitative model of the baseline (existing) system.

Once the context of use is understood and established by examining the existing CONOPS, SOPs, and task flow analysis, the next phase of specifying user requirements for the new implementation will begin.

A second simulation model will be constructed to represent a proposed task network of alternative designs as work progresses towards a final recommended integrated display design. Simulation model runs will yield metrics that will be compared to the baseline model in order to provide a preliminary comparison of task completion times and branching.

4. Specify New User and Organizational CONOPS

Introducing new technology, technology integration, or operator interfaces will often necessitate new procedures and tasks. Definition of both user procedures and organizational CONOPS will need to describe how the new implementation should work. An integrated display design will therefore be co-developed with a proposed CONOPS specific to that new technology integration. The work performed within this activity is illustrated in Figure 5.

4.1 User Interface and new screening CONOPS

There are several different possible definitions and uses of the term "CONOPS." The main focus of this analysis will be the impact of the new technology integration and how that integration will necessitate modified screener staffing, technology layout, and passenger control procedures. There will be no suggested modification to the existing CONOPS that has no immediate or direct relationship to the integrated display. For example, document checking or recomposure will not be directly impacted by the user interface design of the integrated display. On the other hand, the functionality afforded to users via the integrated display may potentially affect communications between the AIT Screening Operator (SO) and AIT Image Operator (IO). If so, then CONOPS related to the operations controlled by the SO and IO may be impacted. Based on user scenarios, tasks, and proposed display design, a proposed new CONOPS and user interface design will define the following:

- System sensor information presentation
- Organization of display and definition of display controls
- Operator responses and inputs
- Alarm resolution passenger-routing for each outcome (i.e. suspected threat diverts passenger to secondary screening)
- Changes to passenger traffic and control methods used at the checkpoint

Many of the initial design concepts and solutions will be generated through brainstorming sessions. These solutions will be further refined through the development of low fidelity prototypes.

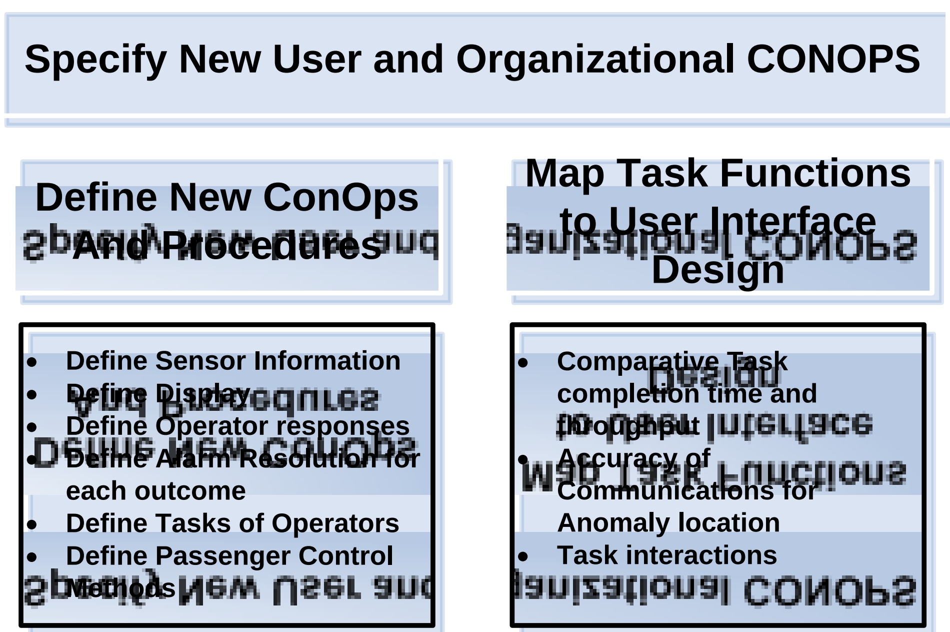

Figure 5. Activities for generating user specifications

4.2 Human Factors Design Specifications

Human Factors design specifications will be defined from Use Case Definitions and Task Flow Analysis. Design specifications will be mapped to specific tasks and associated metrics that may be multi-dimensional. For example, a single operator of the integrated display shall control passenger flow through three different sensors (AIT, WTMD and Shoe Scanning Device: SSD), resulting in a reduction in manpower requirements, equal or increased passenger through-put, and task completion times comparable to a non-integrated checkpoint with a dedicated operator for each sensor.

The final set of Human Factors design specifications will be validated with stakeholders to ensure that the right set of features is being developed.

5. Produce Design Solutions

Context and task analysis work, performed at the earlier stages of the overall effort, is used in this stage to explore and mature new designs. Candidate design solutions are evolved from early “brainstorming” sessions into low fidelity prototypes and associated task definitions and structures. Designs are matured through the analysis and design activities that drive the Integrated Display Design, illustrated in Figure 6.

5.1 Iterative Prototyping

Design solutions and associated user interface specifications will be developed iteratively into a prototype (see Figure 6). Working prototypes will be built and evaluated on a cycle of several days or a few weeks. This incremental and iterative process of prototype development will allow for feedback through: a) expert evaluations, b) pilot testing and c) informal analysis and testing.

Testing of prototypes and simulations will involve expert evaluations and small pilot testing based on the availability of Transportation Security Officers (TSOs).

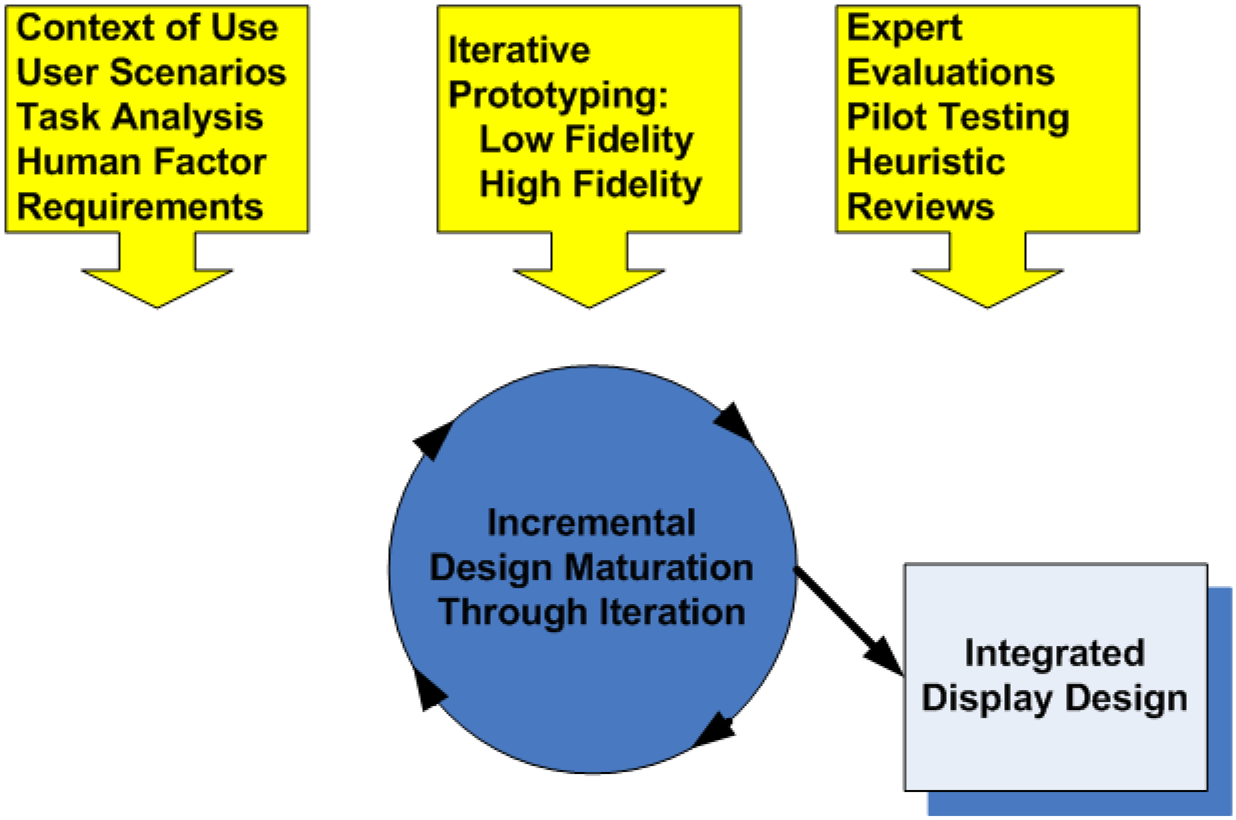

Figure 6. Iterative design process for the Integrated Display Design

Each iteration cycle will be used to design, build, and review both Integrated Display design alternatives and associated CONOPS. Early paper prototypes will allow stakeholders and other key team members to participate in a design-evaluation cycle. Paper prototypes will lead to simple static screen mockups and simple dynamic software simulations. Feedback from evaluators on the team and from end users at the TSA will drive changes to the prototypes.

The Integrated Checkpoint project places the iterative development of high fidelity prototypes and usability testing in a second phase separate from the initial low fidelity prototyping activities. Since access to end users (TSOs) is limited, testing prototypes with both TSOs and pseudo-passengers together may be required. Therefore, the test bed will simulate the flow of passengers during the high fidelity prototype testing of the user interface. A full-scale airport security checkpoint mockup will form the “test bed” of Integrated Display design and evaluation work.

6. Evaluate Design against user requirements

6.1 Human Factors Performance Testing

Once a high fidelity prototype operating in a simulated environment (passenger flow) is developed, screening operators will be used to test the user interface. The design will be evaluated by basic measurements such as the speed and accuracy of executing tasks by operators. Key metrics such as throughput will be calculated or projected based on testing results, and will then be fed into the simulation analysis tool. A test plan will be developed to structure and guide the performance testing activity.

6.2 Design Artifacts

Software tools will be used to generate Unified Modeling Language (UML) diagrams from the prototype source code. UML is a widely accepted method to specify and document object-oriented software systems. UML offers a standard way to visualize a system's architecture, including elements such as:

- actors
- business processes
- (logical) components
- activities
- programming language statements
- database schemas, and
- reusable software components

A final draft of a Human Factors Design Specifications document will provide the specifics of a final recommended integrated design:

- Static GUI & UI specifications of the display design,
- Task definitions and logical flows to define the specific dynamics of the GUI and UI,
- UML diagrams generated from source code of the high-fidelity simulation, and
- Screen snapshots of the high-fidelity simulation.

7. Reference

ISO 13407: Human Centred Design Process for Interactive Systems. 1999.

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