

Introduction to Human Factors and the Human Centered Design Process

From Human HIS Knowledge Sharing 17Dec2009 Centered Design Process

<http://www.nasa.gov/centers/johnson/slsd/about/divisions/hefd/project/hsi-videos-hcd.html>

Gordon A. Vos, PhD

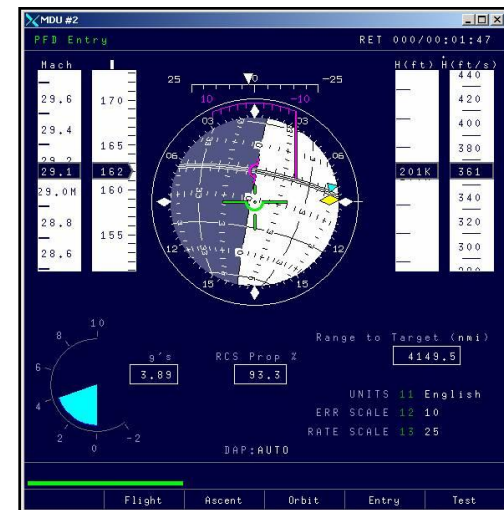
With thankful acknowledgement to Keith Kozak, Roger Koppa, Aniko Sandor, Tina Holden and Jennifer Boyer

Human Factors in design:

- Design for the human/system interface and account for both cognitive and physical limits.

Key Measures/Goals

- Improve effectiveness
- Improve efficiency
- Improve safety
- Improve satisfaction
- Improve tactile feel
- Decrease errors
- Reduce fatigue
- Reduce the learning curve
- Ensure operability and usability
- Meet user's needs and wants
- Positive perception of product



Early involvement is key: “You can use an eraser on the drafting table or a sledgehammer on the construction site.” – Frank Lloyd Wright

Applications of Human Factors:

- Computer Technology
 - Hardware
 - Software
- Consumer Electronics
 - Televisions
 - Audio
 - Integrated Solutions
- Cell Phones
- Appliances
- Tools
- Vehicular
- Marine
- Aviation
- Space
- ***Everything people interact with!***



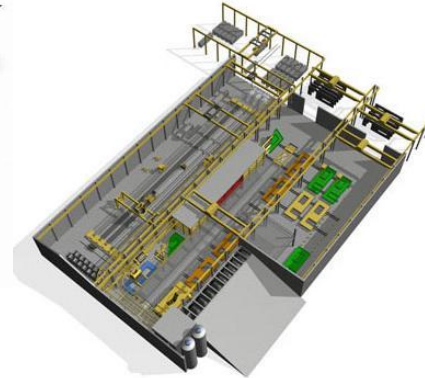
- **HF is applied to Human Machine Systems:**

- Manual Systems
- Mechanical Systems
- Automated Systems



- **HF focuses upon human interaction with:**

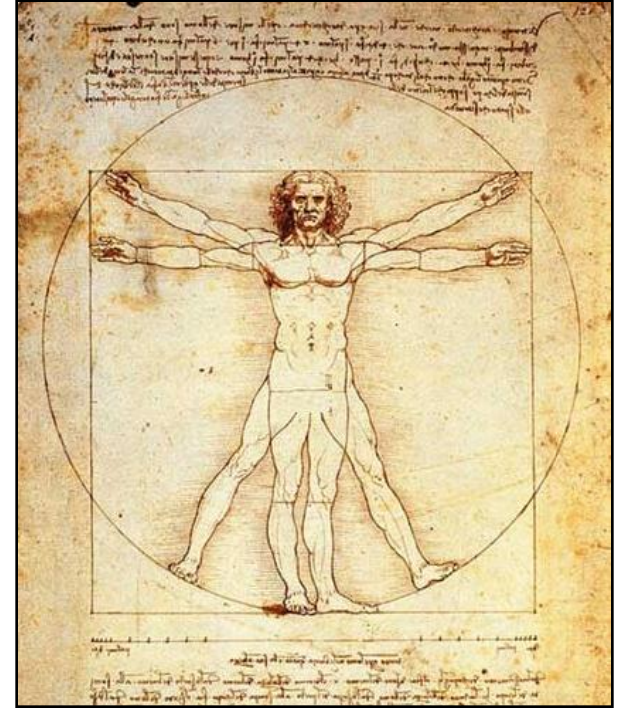
- Products
- Equipment
- Facilities
- Procedures
- Environments



- **Emphasis is on human beings, and on engineering to meet the capabilities of humans**

How does human factors positively impact design?

- **Human Factors in Design Considers Human Limitations:**
 - Information Theory
 - Memory Resources
 - Attention Resources
 - Compatibility Expectations
 - Input Modalities
 - Anthropometrics
 - Strength capability
 - Visual acuity
 - Acoustic sensitivity
- **This ensures that the final product/system/environment can be effectively utilized by the end user, without exceeding their capabilities**
- **Failure to consider these factors can lead to:**
 - User frustration
 - Fatigue
 - High error rates
 - Accidents
 - System failures

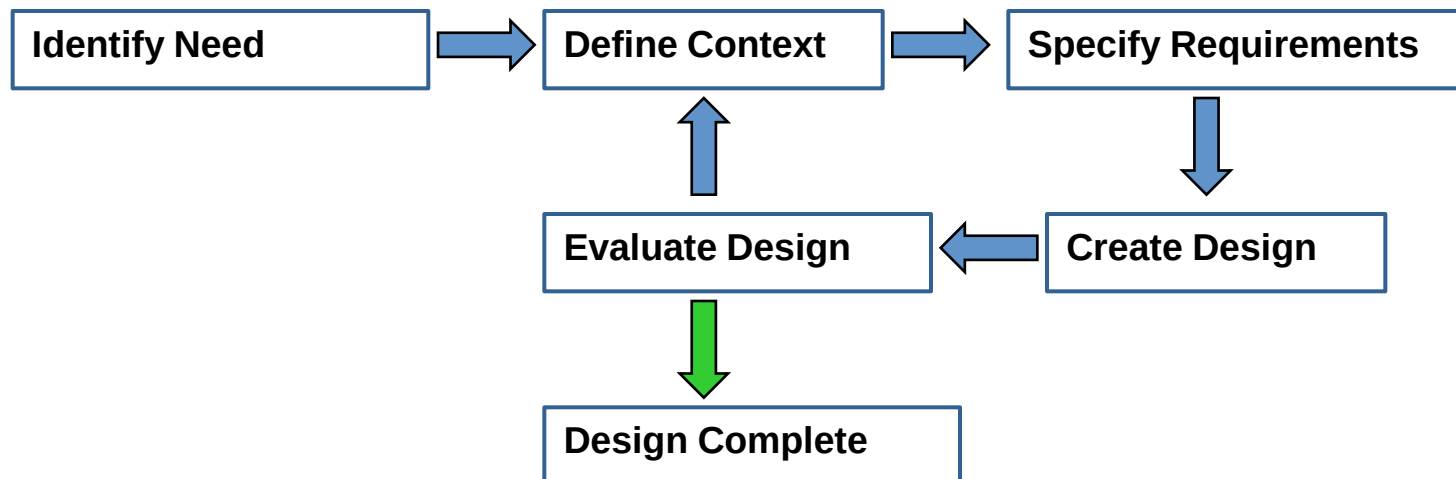


- **Human Factors is a uniting and core component of *Human Systems Integration (HSI)***
- **Human System Integration**
 - A comprehensive, multidisciplinary, technical and management process
 - Integrates human considerations within the system development process
 - Ensures that the human contribution toward system performance is consistently addressed throughout the system life cycle
- **Human factors and HSI implement this approach through the human centered design process**

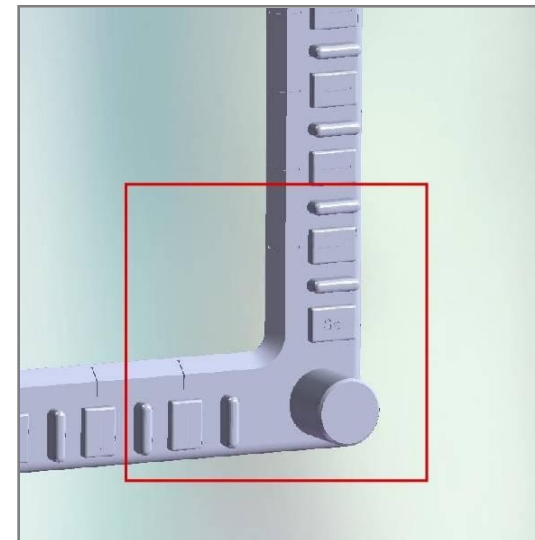


The Human Centered Design Process

- **Human Centered Design Process implements consideration of the user throughout planning and design.**
- **An ISO has been published that documents the underlying tenants of the human/user centered design process.**
 - ISO 13407 provides a level of consistency in the way HCD/USC is implemented, and focuses upon process, not specifics.
- **There are 4 fundamental steps to the process:**
 - **Define the context of use:** what are the tasks or objectives associated with the design.
 - **Specify requirements:** what expectations or requirements must the design accommodate
 - **Create design solutions:** prototyping, rendering, mockup building
 - **Evaluate designs:** usability testing and ergonomic assessment



- **User Needs/Task Analysis**
 - Identify their needs, knowledge levels, expectations, and their behavior. This may be done by observing users in their work environment, task analysis, surveys, and focus groups.
- **Design**
 - Engineer the product with your target clients in mind (tailor products to their needs and abilities).
- **Heuristic Evaluation**
 - Product evaluation that compares the design against established guidelines.
- **Testing**
 - Usability testing
 - Ergonomics evaluation
 - Human in the loop evaluation
- **Leverage Field Feedback**
 - Assess feedback from actual users to shape future designs or redesigns.



- **Product Fit**

- Does the product meet the users needs and expectations? Are the right features included, do they—and can they—use those features?

- **Errors**

- Objective measure provided by the overall task error rate and the frequency and severity of the error. How many users make mistakes and are they able to recover?

- **Efficiency**

- Objective measure yielded by time on task. How long does it take the user to complete the task? Often correlated with satisfaction.

- **Satisfaction/Perception**

- Satisfaction measures are subjective measures provided by the user.

- **Learnability**

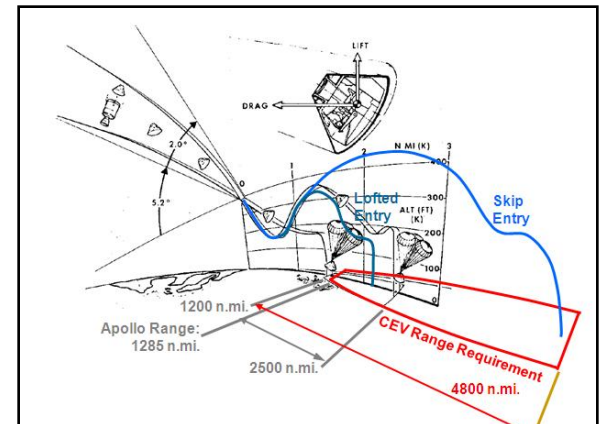
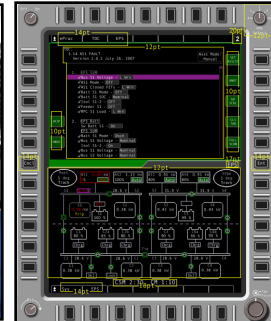
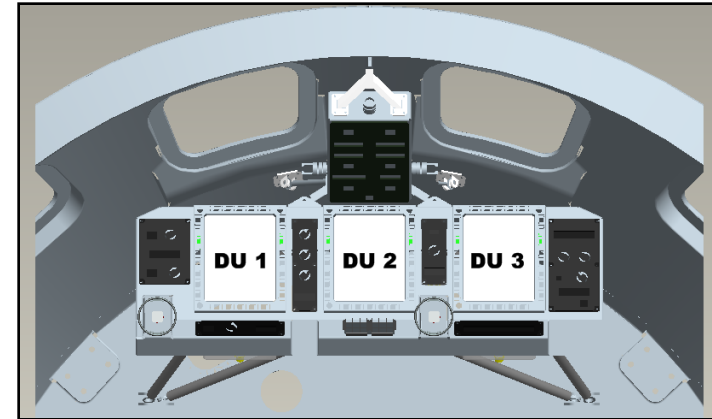
- How easy the system is to learn. Can be expressed by a learning curve and typically is associated with error and efficiency rates over time to show trending

- **How does this relate to NASA?**
 - Habitability and Human Factors Branch at JSC
 - Human Systems Integration Division at ARC
 - Human Systems Integration Group with CxP
 - Orion and EVA flow down of requirements
 - Orion Human Engineering



How does Orion Human Engineering implement human factors?

- Orion Crew Exploration Vehicle (CEV) Human Engineering (HE) personnel lead and participate in hardware evaluations
 - Cursor control devices, edge keys, physical displays, seats, and much more
- We drive the Orion Handling Qualities testing profile
- CEV HE leads or participates in assessments of software displays and display formats.
- We are a core stakeholder in technical reviews related to the Orion design requirement documents.
 - Tracking DRD's and requirements flow
 - Writing Review Item Discrepancies (RIDs) against the Orion Prime design
 - Writing and reviewing TDS documents and methodologies for verification
- We are developing CEV Display Standards and associated documentation
- HE conducts task analyses for CEV items such as seats, windows, hatches, and stowage.
- We conduct lighting analyses for interior lighting levels in the crew module.
- HE also coordinates with the Anthropometry and Biomechanics Lab to perform measurement of Human-in-the-Loop test participants and conduct related analyses of evaluation test results.



Example: Orion D&C Evaluation - Edge Key Selection

- **Objective**
 - Select the shape and spacing of edge keys, barrier heights, and button depression forces
- **Method**
 - Unpressurized and pressurized glove box evaluation
 - Various button sizing, shape, spacing, and depression force
- **Conclusion**
 - Selection of current baseline design



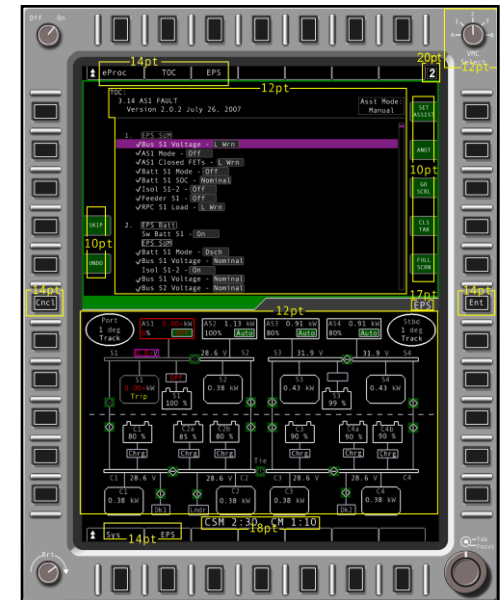
Human-Centered Design in the Development of Display Formats for Orion



Neta Ezer, Ph.D.
Orion Human Engineering - Software

Purpose of Displays

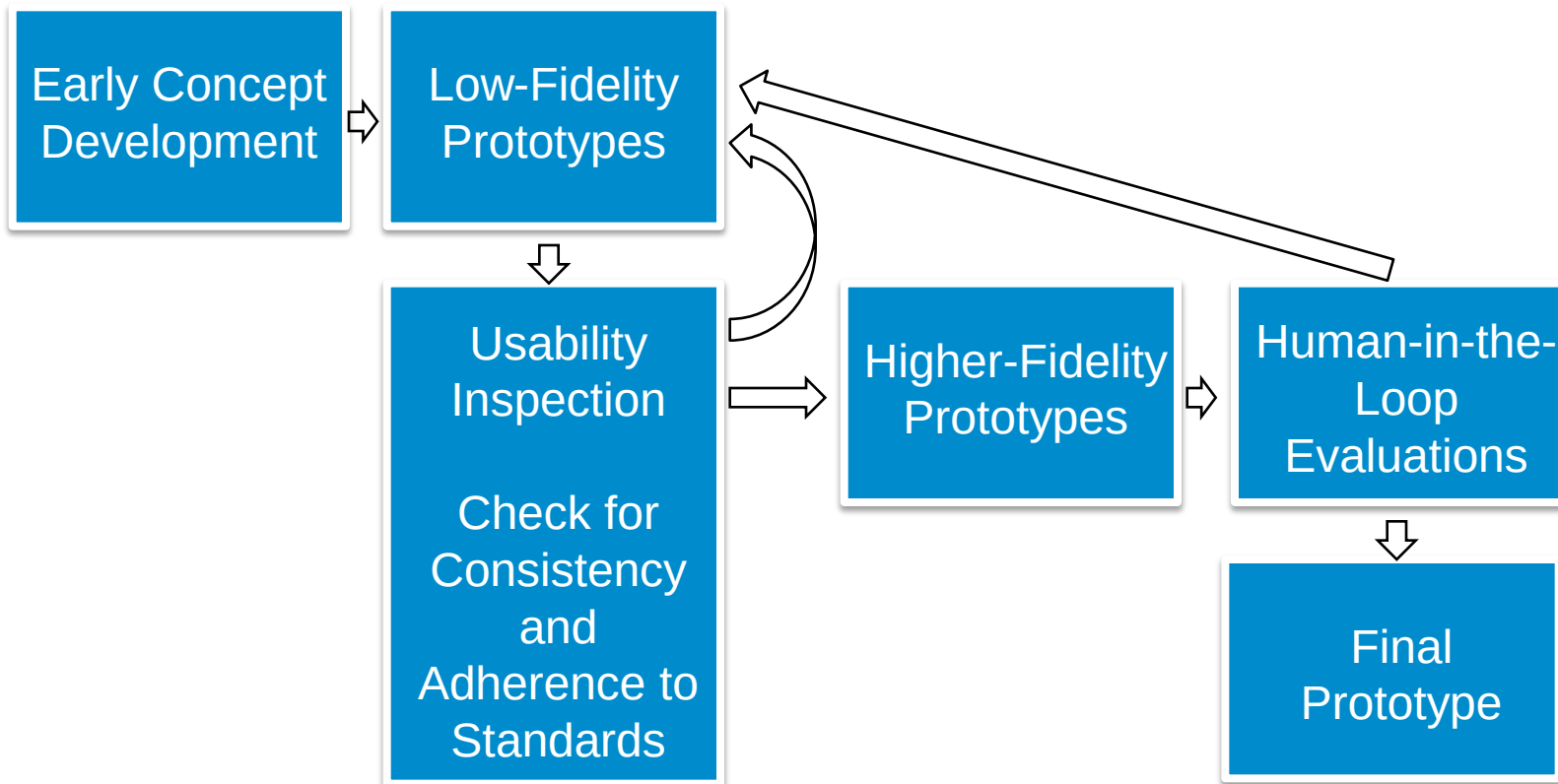
- Displays used to convey information to crew that cannot be directly sensed or inferred
- Well-designed displays:
 - present information in ways that are easily and accurately interpreted
 - are organized to direct attention to the appropriate information for a task and increase efficiency
 - utilize crew expectations and knowledge
 - provide appropriate feedback to crew actions
- Interfaces should allow crew to perform tasks efficiently and accurately



Display Format Design Process

- Developing a series of well-designed displays for Orion requires:
 - Input from multiple stakeholders
 - system experts and engineers
 - software developers and programmers
 - designers
 - crew office
 - human factors experts
 - mission operations experts
 - safety and mission assurance
 - Iterative design through prototyping and evaluation
 - human factors design principles
 - standards and consistency
 - Human-in-the-loop evaluations
 - measure usability through crew performance and satisfaction
 - identify areas for redesign

Display Format Design Process



Usability Testing of Display Formats

- Before evaluation:
 - Develop test plan and test materials
 - select tasks participants will perform based on:
 - frequency of use
 - criticality of use
 - need to exercise components of display format
 - develop questionnaire
 - script for evaluators to ensure consistency across participants
 - Obtain approval from the Committee for the Protection of Human Subjects
 - Set up test environment in the appropriate facility and perform practice evaluations

Usability Testing of Display Formats

- Evaluation
 - 6-8 crew members who are unfamiliar with the design of the display format
 - individual sessions lasting 1-2 hours
- Evaluation Procedure
 - Informed consent
 - Overview of format
 - Static evaluation of layout and individual components
 - Dynamic evaluation with manual procedures (paper)
 - Dynamic evaluation with electronic procedures

Static Evaluation

- Get initial impressions of display format
 - overall layout
 - organization
 - amount of information
 - text appearance
 - terminology and abbreviations
 - color
- Get participants to start thinking about these issues for later parts of the evaluation

Dynamic Evaluations with Manual and Electronic Procedures

- Participants work through procedures and interact with the display format, first without and then with the assistance of electronic procedures
 - Allows participants to:
 - view and interact with series of components
 - experience going through notional procedures with the display format
 - navigate through areas of display format using control devices
- Data Collected:
 - Participant comments
 - Participant actions through data collection software
 - Observation of behaviors

Questionnaire

- Participants asked to provide ratings on characteristics of display format
Used to:
 - provide a score that can be used to compare the subjective usability of different display formats
 - compare the subjective ratings of different display format characteristics
 - help identify areas that need to be improved
 - elicit more comments
- Additional questions specific to the display format

Analysis and Redesign

- Data collected during the evaluation (participant comments, observations, performance data, questionnaire responses and ratings) are used to:
 - Calculate error rates
 - consistent mistakes may indicate a poorly designed component
 - Identify participants' preferences and satisfaction with the design
 - Does the design match with their expectations and knowledge?
 - Uncover issues with design and identify area to improve
 - Identify well-designed components that may be incorporated into future display format designs

Analysis and Redesign

- The synthesis of subjective and objective data form the complete picture of the usability of the display format
 - results and recommendations conveyed to design team
 - findings integrated into a redesign
 - facilitate development of the Orion Display Format Standards as a tool to ensure good design and consistency

Summary

- Incorporating crew and other stakeholders throughout the design process for Orion display formats has resulted in:
 - Fast turnaround from concept generation to format development
 - Improvements to design being made when it is relatively inexpensive to make them (low-fidelity prototypes)
 - The establishment of an effective process to design and evaluate future display formats