Dream Chaser: Design of a Commercial Spacecraft's Cockpit

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Abstract

The Dream Chaser spacecraft is an innovative lifting body vehicle designed to transport crew and cargo to and from the International Space Station. A group of graduate students at the University of Colorado, Boulder is developing a preliminary cockpit design architecture for the Dream Chaser space system, focusing on displays, controls, and layout based on advances in cockpit technology balanced with NASA heritage systems.

Background

NASA's Commercial Crew Development (CCDev) program challenges private American companies to design a spacecraft to replace the space shuttle in transporting crew to and from the International Space Station (ISS). One of the competing vehicles is the Dream Chaser from Sierra Nevada Corporation (SNC). The Dream Chaser's design is based on the NASA HL-20 outer mold line, and it is unique in that it is the only lifting body vehicle within CCDev.

The Dream Chaser will launch atop a man-rated Atlas V rocket. It is designed to carry seven passengers to and from the ISS. When returning to Earth, Dream Chaser will use a gliding entry and land on a conventional runway. The mission phases are shown in Figure 1.

Figure 1: Dream Chaser mission phases. Image credit: SNC

Human Factors

Basics of display design:

- Maintain simplicity, consistency, and standardization
- Use logical and consistent abbreviations
- Allow for a range of display brightness levels
- Maximize contrast between foreground and background

Task analysis:

- Broken down into three basic levels:
  - Phase of flight
  - Functions
  - Tasks
- Includes duration and allocation

Evaluations:

- Examine human-machine interaction and interfaces
- Test field of view, ability to reach controls, seat positions, etc.
- Test subjects include two former NASA astronauts, human factors experts, and pilots
- Two rounds of evaluation testing

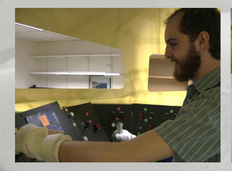

Figure 4 (left): Test subject performing gloved evaluation

Figure 5 (right): Determination of reach zones during evaluations

Figure 8: SolidWorks® CAD model

Mockup Construction

Mockup:

- Dream Chaser's inner mold line provided by SNC
- Life-size model of cockpit built inside of inner mold line
- Increases authenticity and effectiveness of human factors testing

Figure 6: Low-fidelity mockup

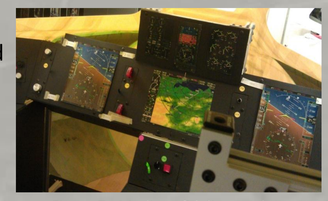

Figure 7: Medium-fidelity mockup

CAD model:

- Provides a visual of theorized cockpit design
- Permits analysis of control sizes and positions to be performed without altering the mockup

Results

- Current control and display placement is adequate, according to the human factor evaluations conducted thus far
- Non-critical functions allocated to outside panels
- Panel angle verified
- Seat adjustability ranges recommended

Future Work

- Finalize displays and controls architecture
- Complete system integration and navigation methodology
- Define layout of controls
  - Task vs. function grouping
  - Verify allotted control area is sufficient
- Expand task analysis
- Update the mockup to a higher fidelity
- Perform new sets of human factors evaluations

Concept Design

Primary considerations:

- Displays
  - Navigation
  - Interaction
  - Sizing
  - Content
- Controls
  - Determination of hardware
  - Placement of hardware

Display architecture:

- 3 primary display units:
  - One unit for the pilot
  - One unit for the copilot
  - One shared unit between the pilot and copilot

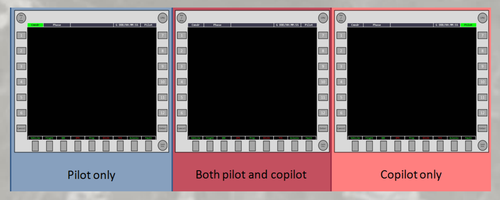

Figure 2: Display input ability

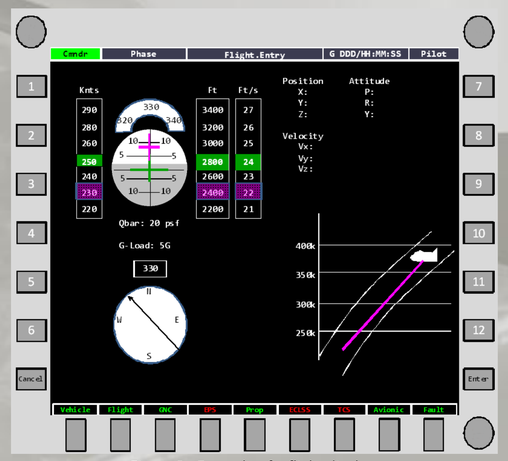

Figure 3: Example of a flight display

Display menu levels:

- Level 1
  - Task-based screens
  - Subsystem-based screens
- Level 2
  - Detail screens
  - Selectable inputs

Input devices:

- Bezel buttons - edge keys around each display unit
- Small individual keypads for pilot and copilot

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Background Image Credit: Sierra Nevada Corporation