Designing Interaction for the Flight Deck

Aviation complexity converges on the flight deck.

The integration and automation provided by computers have reduced visible system complexity but have greatly increased the effects of individual human-system interactions.

When a piloting team is situated to make high-value decisions, a simplified system interface does not reduce overall complexity. The decision-making process becomes more significant, creating a new focus for innovative design.
Goals
In the face of complexity and high-value decision making, humans collaborate. A narrowing of the human-system interface provides potential for a widening of human-human interaction.

Current flight-deck design mediates the pilots’ decision-making process. Good design can mitigate complexity and increase overall system robustness.

We believe there’s an opportunity to support collaboration and enhance decision making through use of multi-touch, multi-user, surface-computing technology.
Humans, in flight, are exposed, and design for this highly vulnerable user group must be thorough. A strong focus on user needs and an elevated level of system robustness are required to prevent catastrophic errors.

Control topology, whereby disparate systems are given their own space, reinforces pilot control during times of emergency. Surface-computing technology cannot, currently, provide the modeless interaction required for aircraft control.

What surface computing can do, though, is provide great improvement for aircraft synoptic systems. Data displays currently struggle to provide pilots with an adequate cognitive map of the aircraft. Surface computing provides an opportunity to illuminate the complex web of data relationships that create an airplane.
Increased flight-deck collaboration provides answers to many of the current challenges facing the commercial-aviation industry. Interaction through multi-user surface computing can increase pilot engagement and understanding of system interactions.

Considering the future pilot shortfall facing the commercial-aviation industry, we believe that multi-user surface computing offers an excellent opportunity to enhance knowledge sharing between pilots, and provides a medium through which learning can occur.
The Objective

Implementation of multi-touch, multi-user, surface-computing technology into the commercial flight deck to illuminate data relationships, enhance collaborative problem solving, and promote the sharing of knowledge
Ideation
A Visit to Boeing

To better understand the work space, we traveled to Boeing’s 787 Dreamliner Gallery. The highlight of our visit was interaction with the high-fidelity flight deck mockup. This interaction provided hands-on experience with the physical layout and gave implications for the work space. After examining the flight deck, we investigated potential opportunities to design for face-to-face pilot collaboration.

Physical Flight Deck Characteristics

The flight deck contains mirrored displays for both pilot and co-pilot. There is very little untapped real-estate, and the instrument panels feel very far away. Very few locations lend themselves to two-handed interaction.

Pilot Experience

There are two forward-facing seats for two pilots on the flight deck. Because the pilots face forward, there is little opportunity for face-to-face pilot collaboration.
Currently, surface technology cannot provide physical feedback during interaction. Surface technology does, however, offer great potential for gesture-invoked system interaction. Gestures provide a more natural way for humans to interact with a system, and we were inspired by the science fiction movie industry’s use of gesture-enabled technology.
Gesture Development

With the knowledge that we would design a large surface for face-to-face collaboration, we began to develop and explore appropriate gestures for use with the system.

In addition to natural gesturing associated with manipulation of the multi-touch surface, we saw the potential for transferring information from static instrumentation to the surface display. For example, the “drag and drop” gesture could grab any display, such as the PFD, and drop it onto the surface.
A Space for Engagement

Our main design solution involves replacing the center console with a multi-touch surface table. This table would function as a sort of meeting place where pilots could interact with the surface technology as well as with each other.

The prime location for a surface table designed to foster face-to-face collaboration is the center console. We created a low-fidelity flight deck mockup to get a strong sense for the location and dimensions of our solution.

The pilots’ chairs must be capable of swiveling at least 180 degrees, and the surface table must be tall enough to provide leg space. These changes would also eliminate the need for a J-track.
Interface Development

A major challenge in designing the interface is in meeting the pilots’ differing needs of information orientation. Orientation is dependant on the direction a pilot faces.

Another challenge is determining how touch can be best used manipulate the table. The interface should be such that intentional, tactile interaction with the surface is accepted, and casual or accidental tactile interaction with the table is ignored.
Task Identification

In order to determine pilots’ interactions with the centralized surface table solution, we identified common tasks that pilots carry out during flight.

We separated these tasks into two categories: tasks the pilots carry out in tandem and tasks that pilots carry out in parallel. Tandem tasks involve pilots dividing labor to accomplish a goal. Parallel tasks are carried out independently and redundantly to provide confirmation through identical results.
Task Identification

We conceptualized tasks that could be carried out with the aid of a central surface table. For example, training scenarios and games that could be undertaken during cruise would encourage collaboration, increase engagement, and help pilots to share knowledge.
Solution
Location

Using the findings regarding the layout and physical arrangement of the flight deck, we chose to place the COACT between the seats and just aft of the control levers.

This location is perfect for allowing collaborative action between the pilots as they face each other during downtimes in activity such as cruise.

Additionally, the front-most portion of the console is still available to pilots when they face forward, increasing the amount of visible screen real estate during active flight.
Gestures

We implemented a variety of gestures into COACT's interface, including the key gestures shown on the right. Two of the more significant of these are the “Drag and Drop” and “Snap to Edge” gestures.

“Drag and Drop” provides the user with a more intuitive way of calling up copies of display screens on the console than simply accessing them through a menu. This is achieved by physically grasping the space in front of a display and “dropping” it onto the console.

The “Snap to Edge” gesture solves the major perspective issue encountered when users view a display from different angles. Upon contact, objects on the COACT automatically align with any edge. Sliding an object across the console allows easy transfer of information from one pilot to the other.
In an environment as dynamic as the flight deck, a given state of information is often not as important as the ways in which that information changes. By maintaining a detailed archive of systems information throughout the flight, the COACT affords pilots unprecedented analysis ability.

While viewing any standard display, the user can “rewind” to view the system state at any instant in the past and in certain cases can “fast-forward” to predict changes yet to come (e.g. fuel consumption).

Analysis applets, such as a 2-D plot tool, allow pilots to quickly plot specific pieces of information for more detailed consideration.
Application: Training

One application of the COACT is for in-flight training. During cruise, the pilots can initiate training programs with a variety of foci.

This training will be part of the continuing education required by airlines. Challenging scenario prompts can present the pilots with uncommon scenarios that must resolved through analysis of simulated flight data.

Training scenarios present a unique opportunity for pilots to pass their experience and knowledge between each other. These scenarios also help to maintain pilot awareness and engagement during potentially dull periods of low cognitive load.
Application: Synoptics

The large form factor of the COACT, as well as its physical interactivity, allow the introduction of an advanced synoptic system. Current synoptics are limited to numerous, small, complex system diagrams that are often buried within layers of menus. In contrast, the COACT synoptic system is a wireframe representation of the entire aircraft.

Individual portions of the aircraft can be tapped to zoom in for greater detail. The currently used system diagrams can also be accessed via selection of the relevant systems.

Arising issues and uncommon events will be recognizable more quickly than with current synoptics, as visual cues of unexpected system changes are presented on the wireframe itself at the actual points of interest.
Application: Route Planning

When an uncommon event requires the rapid execution of an emergency or diverted landing, the COACT provides pilots with a powerful, yet intuitive, platform for planning and implementing changes to the flight route.

One-stop access to charts, systems information, and other pertinent data affords collaborative decision-making about changes and streamlines the process beyond currently used methods. Projected aircraft range data, calculated by the system, can be used to weigh options.

Once an option is greenlit by the captain, it can be sent from the COACT to ATC for approval.
Benefits

Ultimately, the potential benefits of the COACT system are immeasurable.

Not only does it afford unprecedented face-to-face collaboration between pilots, but it also allows flight problems to be handled in a careful and organized manner by consolidating information in one central location.

Furthermore, the COACT's advanced data recording would allow the pilots, airlines, and FAA to review the thought process and decision-making involved in the course of a flight.

We have shown a set of potential uses of the COACT system. In addition, the platform has the versatility to evolve for almost any need. Third-party developers can explore uses beyond imagination for years to come.
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