Human-Computer Interfaces Required in a Modern Air Traffic Control Research Simulator

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Introduction

A wide variety of human-computer information and operator control interfaces are employed in the *Surface Development and Test Facility* (SDTF) at NASA's Ames Research Center, Moffett Field, California. This multi-user, full scale air traffic control research simulator provides the "look and feel" of an actual level 5 airport tower cab through the use of virtual reality technology and other techniques (Haines 1997, Haines et al. 1997, <http://surface.arc.nasa.gov/sdtf>. The SDTF offers its users a variety of state-of-the-art information displays and controls representative of those now used in large U.S. airports and also advanced, futuristic displays and controls.

Two factors determined the number, placement, angular size, shape, luminance, spectral output, and other characteristics of the visual (and other displays and controls in the SDTF: (1) equipment and procedures currently in use in level 5 tower cabs, and (2) anticipated (but still relatively undefined) future research support requirements. The broad array of information (and related control equipment) currently found in America's largest airport tower cabs includes: runway lighting systems; regional and local weather; ground-to-air and ground-to-ground radio (auditory) communications-; emergency communications; airline flight plan data; flight data-strips; and displayed radar data.

ATC Information Classes

Many different classes of information are displayed in a major air traffic control (ATC) tower. At the most general level there is historic (look-back), current (ongoing), and future (predicted) information. Within these classes is information related to the aircraft (identification, taxi route, gate assignment, departure control, approach and landing control); environmental factors (wind and weather, visibility, emergency situations, e.g., runway obstructions), and the virtual reality-based simulation system itself (initial system validation and periodic maintenance, calibration, test logistics, current status). SDTF interfaces are designed to permit rapid and accurate assessment and control inputs within each of these complex and interrelated information classes.

Display Modes - GUI Selection

The design and implementation of each graphical user interface (GUI) is driven by the kinds of real-time, operational uses each class of information is to be put. Consider the operational positions in a major airport tower (Table 1). Some positions share the same data while others rely on unique information. Some displays present only one data set while others may be accessed at various levels.

Table 1: Current Level 5 Tower Personnel and Primary Duties

Position	Primary Duties
Local Control	Authorizes takeoffs, landings, and aircraft transit through tower jurisdiction airspace.
Ground Control	Authorizes movement of all vehicles (air and ground) within airport movement area.
Flight Data Control	Compiles and distributes flight plan statistical data, receives and relays weather data, NOTAM information, monitors navigational aids,makes tower visibility observations.
Cab Coordinator	Coordinates all operations inside and outside the tower cab.
Supervisor	Supervises the overall ATC operation of the airport.
Ramp Control	Coordinates gate assignments, push-back operations and initial departure sequencing (may be located in separate facility).

The SDTF uses interconnected Silicon Graphics Inc., "Reality Monster" processors and approximately one hundred Pentium processors to support the highly complex yet versatile simulation environment where everyone present (approximately twenty persons) has different levels of access to a master database and operating controls relevant to their own duties.

Direct view (so-called "inside-out") displays include: (1) a 360-degree wraparound 26 foot diameter external visual environment surrounding the entire tower cab (software by Raytheon Systems Co., Arlington, TX), (2) high brightness 21" flat-panel touch-screen displays and controls, and (3) standard CRTs of various sizes and resolutions. Virtual reality, head-mounted displays (with voice-actuated inputs) also may be used in the future for such airport applications such as see-through-fog and rain and other low visibility operations as well as forward looking infrared (FLIR) goggles.

A second type of display used is the "outside-in" view such as one might have of the entire airport property looking down from thousands of feet altitude. The large format D-BRITE airport environment display is one such interface. It shows all aircraft (moving and stationary, with accurate identification tags), runways, taxiways, gates, etc., presentable at different scales. Multiple D-BRITE displays are suspended from a continuous 360-degree ceiling support track that makes it possible to rapidly reconfigure the facility to represent any particular level 5 tower cab.

Space - Time Considerations

The accurate flow of time-critical and location-critical information to all facility personnel imposes special requirements on the software and hardware. Indeed, a variety of human-computer interface layout and design considerations must be taken into account. They include: (1) manual, automated, and mixed operational control paradigms, (2) low and slow vs. vast and fast information input rate situations that can impact personnel boredom, error rate, and workload, (3) fixed function vs. reconfigurable workstations, (4) reliable cross-platform transfer of data, (5) effective generation, modification, transport, and storage of paper flight strips used to track each aircraft from departure to landing, and (6) management of personnel workload and ensuring high morale and safety.

One must also possess a comprehensive understanding of air traffic control procedures that are in use today.
A case in point is the current joint FAA - NASA effort to help airport facilities operate more efficiently. It is known as the "Surface Movement Advisor" (SMA). Its many GUIs (and supporting algorithms) provide for optimizing gate resources, balancing taxi departure loads, reducing voice radio traffic, and improving crew scheduling and gate rescheduling. These GUIs are implemented on a 21" high brightness, flat-panel, liquid crystal display with touchscreen capability. GUI examples may be found at <http:// surface.arc.nasa.gov/sma/> The SDTF will support further planned SMA refinements (e.g., data warehousing and data mining, improving performance through actual customer use and feedback, integration of Center TRACON Automation Systems (CTAS) and the Final Approach Spacing Tool (FAST).

In summary, the array of human-computer interfaces employed in NASA's SDTF requires application of both practical and theoretical knowledge of how the air traffic controller perceives information, how it is processed, and how each task should be carried out. The SDTF is designed to support all of these important research questions.

References

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