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Defining the ATC Controller Interface for Data Link Clearances

Final Performance Report

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1.0 Overview

The Controller Interface (CI) is the primary method for Air Traffic Controllers to communicate with aircraft via Controller-Pilot Data Link Communications (CPDLC). The controller, wearing a microphone/headset, aurally gives instructions to aircraft as he/she would with today's voice radio systems. The CI's voice recognition system converts the instructions to digitized messages that are formatted according to the RTCA DO-219 Operational Performance Standards for ATC Two-Way Data Link Communications. The DO-219 messages are transferred via RS-232 to the ATIDS system for uplink using a Mode-S datalink. Pilot acknowledgments of controller messages are downlinked to the ATIDS system and transferred to the CI.

A computer monitor is used to convey information to the controller. Aircraft data from the ARTS database are displayed on flight strips. The flight strips are electronic versions of the strips currently used in the ATC system. Outgoing controller messages cause the respective strip to change color to indicate an unacknowledged transmission. The message text is shown on the flight strips for reference. When the pilot acknowledges the message, the strip returns to its normal color. A map of the airport can also be displayed on the monitor. In addition to voice recognition, the controller can enter messages using the monitor's touch screen or by mouse/keyboard.

2.0 Research

The research goals for the Controller Interface were to:

1. Ease Controller to Pilot communications using datalink
2. Enhance Ground Controller environment
3. Make system transparent to air traffic controller
4. Make more information available to the controller
5. Improve groundside traffic management
6. Reduce controller workload.

2.1 Voice Recognition

Voice recognition was determined as a prime candidate for the input device. A Verbex voice recognition system was used. A Plantronics noise-canceling headset/ microphone with Push-to-Talk was the user data input device.

The Voice Recognition system is trained to recognize specific phrases that are common to the air traffic control environment. The controller, wearing a microphone/headset, aurally gives instructions to aircraft as he/she would with today's voice radio systems. We see this as eventually incorporated into the tower VHF radio communications system.

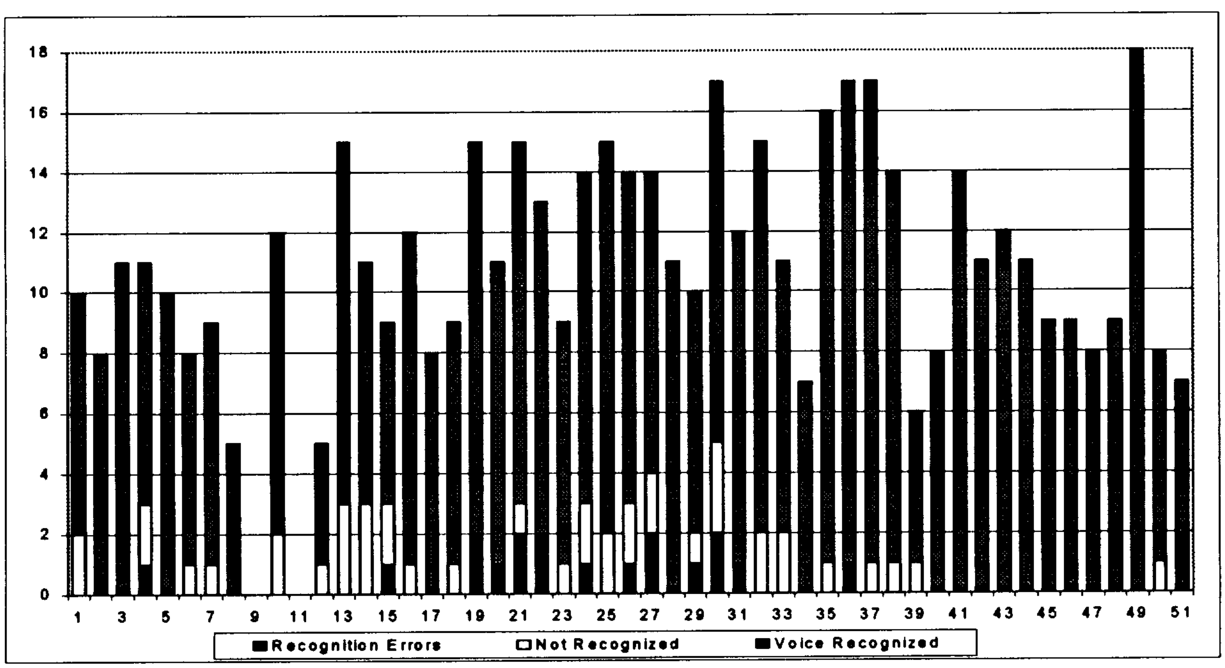

Figure 1. Voice recognition results

During the Atlanta Flight Demonstration in August 1997, the voice recognition system was able to recognize and correctly process 97% of all controller aural inputs. (Figure 1)

2.2 Display formats

The Windows based CI screen is the primary method for display of communications with aircraft via Controller-Pilot Data Link Communications (CPDLC). Electronic flight strips were selected as the primary method of conveying aircraft status to the Controller. The Flight Strips are very similar to the paper flight progress strips currently used in the ATC system. An example of the display format is shown in Figure 2.

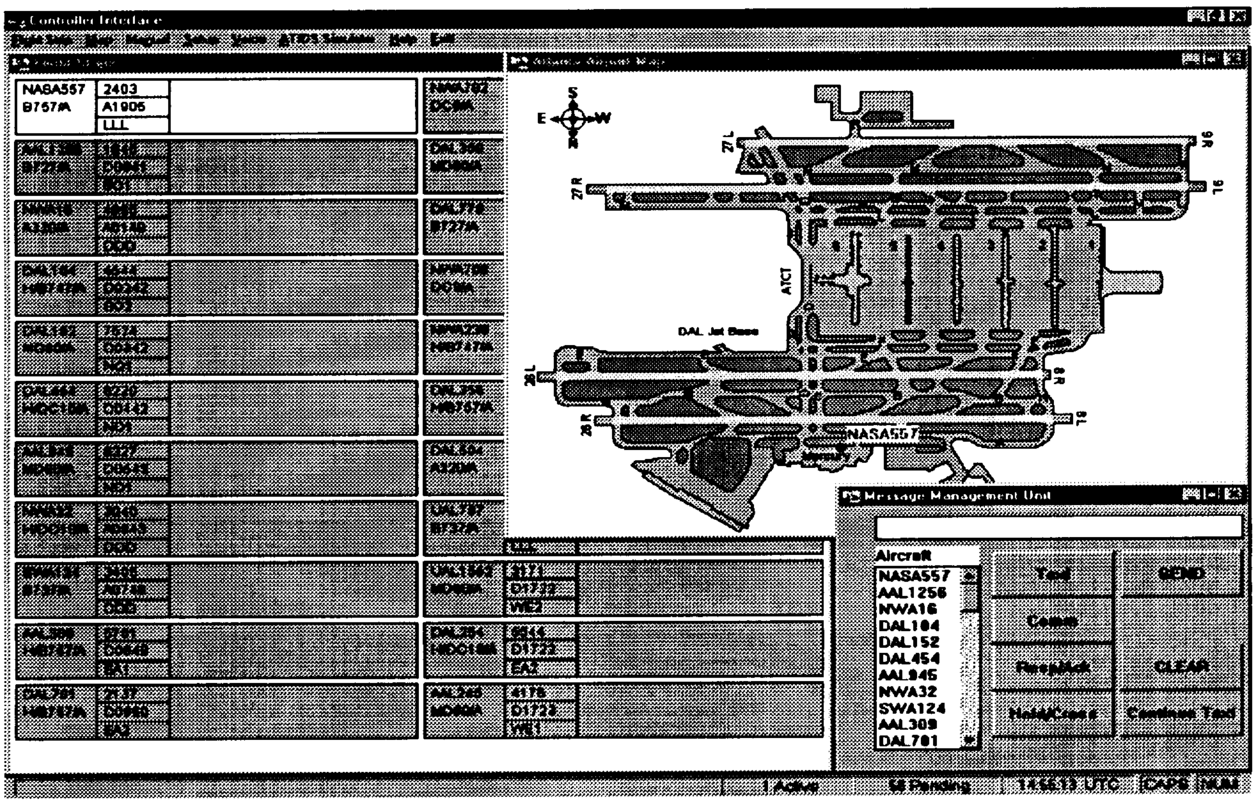

Figure 2. Controller Interface display format in Atlanta

2.3 Touchscreen

A NEC 17" monitor with an attached Trident Systems - Capacitive touch screen was used to investigate alternatives to voice recognition. The touchscreen eliminated the need for the mouse and keyboard as input devices. The touchscreen was valuable in reducing the amount of "heads-down" time required by the controller.

3.0 Hardware

A Gateway 166MHz Pentium PC with 64 MB RAM was selected as the computing platform for the Controller Interface. A 17" SVGA monitor is used for the display medium.

4.0 Software

All Controller Interface software has been developed using Borland C++ 4.52. The C++ (version 4.52) creates 16-bit applications that can run on Windows 3.1 and also Windows 95.

4.1 Controller Interface Application

The Controller Interface Application uses a Multiple Document Interface to allow multiple windows to be displayed simultaneously. An Event driven system is used as is common to Windows application programs.

4.2 Flight Strip Window

The Flight Strip Window depicts aircraft data and messages in a format similar to the paper flight progress strips (FAA Form 7230-7.1, 7230-7.2, 7230-8) using color to depict the status of aircraft.

4.3 Map Window

The Map Window allows the user to see an airport diagram and can depict location and path of aircraft operating on the airport surface.

4.4 DO-219 Formatting

Controller-Pilot Data Link Communications are formatted to RTCA's DO-219 Standard. Ground messages that are not included in DO-219 have been created to supplement the Standard. Messages are sent over an RS232 serial link.

5.0 Bibliography from Published papers

Mattson, P., and Rankin, J., "Research and Design of an ATCT Ground Controller CPDLC Workstation", Proceedings of the 42nd Annual Air Traffic Control Association Conference, September 1997.

Rankin, J., and Mattson, P., "Controller Interface for Controller-Pilot Data Link Communications", Proceedings of the 16th Digital Avionics Systems Conference, October 1997.

Rankin, J., and Mattson, P., Controller-Pilot Data Link Statistics from NASA's 1997 Atlanta Flight Test", Proceedings of the 17th Digital Avionics Systems Conference, October 1998.

6.0 Abstracts from Published papers

6.1 1997 Air Traffic Control Conference at Washington DC, October 1997

Research and Design of an ATCT Ground Controller CPDLC Workstation

Introduction

Research efforts at St. Cloud State University (SCSU), Minnesota, have investigated the air traffic controller's role in NASA-Langley's Low Visibility Landing and Surface Operations (LVLASO) project. SCSU is researching methods and procedures for airport ground traffic as part of NASA's Terminal Area Productivity Program (TAP) which has resulted in the definition and design of the necessary Controller Interface (CI) device. This research focuses on 1) the display of traffic information to the controller, 2) the conversion between controller clearances and Data Link formats needed for transmission, and 3) the controller input of clearances per DO-219 specifications.

NASA's overall program goal is to increase airport terminal operations in low visibility conditions to the capacity found in good weather. To achieve this goal, there must be increased situational awareness for both controllers and pilots. The controller must be aware of all traffic on the airport surface. This includes identification, position, direction, and intent. For pilots, situational awareness includes their position, nearby traffic, and a taxi route to their surface destination. Prior experiments at NASA-Langley have shown the benefits of an Electronic Taximap in the flightdeck that displays taxi clearances. These taxi clearances have traditionally been prepared off-line and then datalinked from the controller's workstation. The CI allows a controller to input taxi commands real-time using Voice Recognition and Touchscreen as well as a mouse, trackball, and/or keyboard.

According to Jane's Airport Review and Aviation Week and Space Technology, three other countries (China, Tahiti, & Russia) have tested similar methods for the enroute environment; this is the first time we know of that the CPDLC is to be used/tested in a terminal environment.

The CI is a combination input device and graphical display which is able to transmit, display, and receive clearances with aircraft through data link channel using Voice Recognition and Touchscreen. The CI provides for increased situational awareness for ground controllers including aircraft identification, position, direction, and intent. The protocol for communicating between ATC and aircraft has been defined by Radio Technical Commission for Aeronautics (RTCA) in their Minimum Operational Performance Standards for ATC Two-Way Data Link Communications (DO-2 19) and is incorporated in the CI.

6.2 1997 Digital Avionics Systems Conference at Anaheim CA, October 1997

Controller Interface for Controller-Pilot Data Link Communications

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ABSTRACT

The Controller Interface was designed to generate Air Traffic Controller messages per RTCA DO-219 for Controller-Pilot Data Link Communications (CPDLC). The Controller Interface is part of the Low Visibility Landing and Surface Operations (LVLASO) project being researched by NASA's Langley and Ames Research Centers.

The messages implemented in the Controller Interface were tailored for the Ground Controller to handle airport surface traffic. Of primary concern were messages related to taxi routes and hold short instructions. These messages drive the moving map display in the NASA 757 research aircraft.

The Controller Interface, using voice recognition and a touch screen for controller input, was tested at Atlanta Hartsfield Airport in August 1997.

6.3 1998 Digital Avionics Systems Conference at Seattle WA, October 1998

Controller-Pilot Data Link Statistics from NASA's 1997 Atlanta Flight Test

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Controller-Pilot communications at NASA's Low Visibility Landing and Surface Operations (LVLASO) flight test (Atlanta, GA 1997) used a Mode-S datalink to reinforce normal VHF radio communications. The Controller-Pilot Datalink Communications (CPDLC) channel followed a modified version of the RTCA DO-219 standard to uplink taxi routes and hold

clearances to NASA's 757 research aircraft. A Controller Interface (CI) workstation encoded the ground/local controller's instructions into the DO-219 format. The CI also used electronic flight strips and a graphical map to increase the controllers' situational awareness.

Each controller clearance issued the NASA 757 aircraft was also sent across the CPDLC datalink. A test controller listened to the actual ATC radio transmission. The test controller then repeated the transmission for the CI's voice recognition system. The CI encoded the message and sent it to the Airport Traffic Identification System (ATIDS) over an S-Band modem. The CI was located in the Renaissance Hotel near the Atlanta Hartsfield airport; the ATIDS system was in the ATC tower on the airfield. The ATIDS system communicated with the NASA 757 via one of five Mode-S R/Ts arranged around the northern half of Hartsfield. Once the message was received at the aircraft it was routed to an I/O Concentrator. The message was then sent to an SGI computer that generated the moving map and HUD graphics. CPDLC acknowledgments and downlink messages reversed the path.

This paper investigates the statistical success of the CPDLC messages. Round trip time from the CI to and from the 757 displays are presented. "Lost" messages that did not appear on the display are analyzed for the fault source. Incorrect messages due to misunderstanding the controller's radio transmission and inaccurate conversion to DO-219 format are examined.

The summary discusses CPDLC issues to be investigated such as the channel: VHF Datalink Broadcast or Mode-S. Other issues are voice only versus voice plus datalink.