"Common CHI for En Route ATC Automation in FFP1 and Beyond"*

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Unique computer-human interface (CHI) challenges are arising with the pending deployment of automation developed to assist air traffic controllers and managers. In the US, a set of Free Flight Phase 1 (FFP1) decision-support tools will provide computer generated scheduling and sequencing advice from Traffic Management Advisor (TMA) and conflict probing advice from User Request Evaluation Tool (URET). These tools were originally developed independently using their own CHIs. Recently, the air traffic community requested that future tools be implemented as an integrated functionality with a consistent look and feel modeled on Eurocontrol's innovative Operational Display and Input Development (ODID) IV. M.I.T. Lincoln Laboratory presented an initial comparative study of FAA and Eurocontrol tools that identified several key inconsistencies between the newly deployed Display System Replacement (DSR), the upcoming FFP1 and the future ODID-like CHIs at ATCA 1999. This paper expands the survey to add the ETMS Traffic Situation Display (TSD) and to include a comparison of all look and feel aspects of each tool ranging from the purpose and system requirements to the display and coordination features. Excerpts from the completed survey are presented in Table 1, accompanied by preliminary descriptions of resulting human factors issues that need resolution to achieve a common CHI for future air traffic control and management. In support of the FAA, the Laboratory is now applying the findings from this effort and previous controller testing in collaboration with MITRE CAASD to identify and assess CHI features to be used for a demonstration of integrated operational concepts. This effort, along with continued CHI requirements testing, communication with FAA vendors and concept demonstrations conducted in coordination with the air traffic community will lead to a comprehensive list of prioritized issues regarding a common CHI.

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Introduction

Improvements to the existing CHI are necessary to facilitate use of new decision support tools designed to assist air traffic controllers and traffic management coordinators in the face of increasing growth in air traffic. The use of new CHI technologies is expected to alleviate workload and support the desire for more cost saving direct routing. Throughout Eurocontrol, the European Air Traffic Management Programme (EATMP) is currently refining Operational Display and Input Development (ODID) with design principles that help achieve an operationally suitable user interface. In the US, controllers have begun to use prototypes of FFP1 decision support tools for both scheduling and conflict probe functions. Meanwhile, ODID was well received by US controllers involved in Eurocontrol's series of experiments during the early 1990's and the nation's air traffic community has recently requested that an ODID-like CHI be introduced to DSR. The FAA is beginning to focus on the introduction of an ODID-like CHI and initial integration of the FFP1 tools. The ODID-like CHI, with its minimal information display and interactive color coded guidance, has the potential to increase efficiency and productivity through employment of modern graphics.

It is appropriate to model the common CHI on the best of ODID and its successors while cognizant of the limitations and capabilities of the FAA's DSR and mindful of maintaining look and feel consistency with an integrated user interface. For example color, while contributing to the effectiveness of each CHI separately, is inconsistent among the DSR, FFP1 and ODID designs. The amount of colors used exceeds human factors recommendations in many situations. Additional issues such as the impact of system assisted coordination and conflict prediction on controller workload need to be examined to validate alternatives with objective data and establish usability of new features.

A comprehensive set of CHI issues continue to be uncovered in the pursuit of converging on a common CHI that will be generally applicable. These issues include communication and coordination (automated and verbal), design philosophy, input methods, display windows and color use. Many of these issues lend themselves to rapid prototyping and testing with controller-in-the-loop high fidelity real time simulations aided by an environment such as the Laboratory's CHI Requirements Engineering Model (CREM). The most basic display issue is that of usable surface area, especially for radar control where situational awareness is paramount to the primary task of separating aircraft (represented by radar "targets"). Much of the 30% increase in usable display area gained by replacing the 19" diagonal PVD with the 20" square DSR Main Display will be taken up by new functions. DSR display windows of electronic buttons have replaced hardware knobs that surround the PVD. Automation and decision support tools will introduce even more windows and lists, typically presented as opaque "views" on the radar and/or data display. For example, in the EATMP CHI, the Sector Inbound List (SIL) and message lists are all permanently displayed on the radar screen. So judicious use of the remaining visible area is an important CHI consideration for supporting the primary, often time-critical task.

Data block label menus, currently found only in the EATMP CHI, enhance interactivity and support system assisted coordination, but they also briefly obscure the display. Also, the use of Eurocontrol's lists and labels for presenting abbreviated flight plans (upon selection) is questionable in the US because viewing the entire route at all times is considered essential. Nevertheless, future US en route ATC operational concepts call for the use of paper flight strips to be minimized (if not eliminated), so electronic display of the information currently provided in the strips will be necessary. A multiple flight plan readout view is already being planned for presentation on the DSR radar display, with up to five flight plans in an opaque view.

All these CHIs differ dramatically in color use and all use color without redundant cues. Color foreground and background combinations should be tested for legibility, consistency and memory recall of rarely used colors. DSR uses monochrome blinking tags versus Eurocontrol's color changing labels to indicate handoffs (or handovers). Controller response times have been studied with the CREM to judge the impact on operations of color vs. blinking handoffs and label menu vs. keyboard use [1]. Initial results indicated both menu input method (with cursor defaulted on next entry) and color changing indicators are responded to faster than existing CHI conventions. Further testing is needed to replicate and expand these findings, especially since color will become obviously important and potentially confusing to controllers with the advent of FFP1 CHIs, e.g.; DSR standard yellow data blocks with yellow URET warnings.

The EATMP CHI enables On-Line Data Interchange (OLDI) a fully automated message handling method that replaces telephone communications, monitors traffic and detects potential conflicts. OLDI implements the SYstem Supported COordination (SYSCO) concept that was enthusiastically received by controllers from both the FAA and Eurocontrol during the ODID simulations. The OLDI messages are categorized as transfer of communication, coordination and notification. In addition, the EATMP Arrival manager assists with sequencing and scheduling.

In the US, to reduce controller workload, several tasks have already been automated with the implementation of increasingly sophisticated and capable technologies. However, to date the automation has not alleviated the preponderance of verbal communications frequently requiring telephone use. Indeed, certain forms of automated assistance have not replaced speech but have required its products to be entered into the system to keep the flight information in the system updated. Verbal versus non-verbal communication is a major difference between the FAA and Eurocontrol CHIs. Whereas EATMP foresees fully automated coordination (with telephone back up) most communication in the US will continue by telephone in the near term. The loss of listening to "party line" speech must be assessed as well before committing to non-verbal communications.

The FAA has expressed concern over perceived disconnects between CHI design research and the system development process. Human factors issues need to be assessed against a set of predetermined criteria derived from the operational users' needs and high

level requirements. All front-of-the-glass considerations should be at least identified before the research proceeds to the *initial* development stage. Unless CHI risks are resolved early in the development process, major difficulties can arise in implementing new systems. Conducting a CHI comparison accompanied by controllers-in-the-loop testing are critical early efforts. Votes taken by review committees without benefit of experimental data have proven unreliable in precluding design flaws. Controllers need to understand a new CHI by actually experiencing it. The investment in carefully chosen experiments and objective measurements to correlate with users' opinions and qualitative data controls development risks. Appropriate integration of research into existing or proposed CHI development efforts ensures a proper response to knowledge gained in experimentation.

Conclusion

Current levels of air traffic are already taxing the system with related increases in controller workload. Projected demands will exacerbate the situation internationally. Both the FAA and Eurocontrol are addressing this concern by upgrading equipment and deploying decision support tools for controllers. The FAA will support free flight with tools that have been developed using independently designed CHIs. Eurocontrol has developed an interactive CHI with a philosophy of minimal information display and ease of use. The FAA has begun to explore introducing the Eurocontrol CHI innovations into the newly deployed DSR and soon to become available FFP1 tools while integrating their functionality with a common look and feel modeled on an ODID-like, common CHI. M.I.T. Lincoln Laboratory has begun to address the challenge of introducing a common ODID-like integrated CHI by testing controller reactions and assessing current and proposed CHIs through a comparative study. Human factors issues and general lessons learned through these activities have been identified in the pursuit of defining a common CHI that will enhance productivity, preclude confusion and reduce controller workload. Presently, the Laboratory is collaborating with MITRE CAASD on the development of an Integration of Operational Concepts demonstration in coordination with the FAA's Air Traffic DSR Evolution Team (ATDET) to further define the issues and seek solutions. Initial feedback from ATDET on the future CHI for an ODID-like URET and integrated URET and TMA is being communicated to the FAA/NASA Interagency ATM Integrated Product Team (IAIPT) En Route Area Work Team as part of a continuing research effort in development of a common CHI.

References:

[1] http://atm-seminar-98.eurocontrol.fr/finalpapers/track1/picardi2.pdf

[2] "A comparative study of existing and proposed FAA and Eurocontrol CHIs for En-route ATC" thesis by van der Avoird, Hoving and Roeloffs, August 1999 and Picardi, et al, *44th Annual ATCA Conference Proceedings*, Fall 1999.

	DSR	URET	CTAS-TMA	EATMP	ETMS-TSD
Purpose	Data entry and color display, Host interface	Conflict detection, Trial Planning, coordination	Sequence and schedule arrivals	Harmonize and integrate ATC systems	Maximize NAS throughput, minimize delays
Design	Upgraded color display and console	"What if" probe and resolution	Strategic decisions, preference set-up	Maximum info, minimum display	Team problem solving, situational awareness
Positions	Radar, data, assistant controllers	Data controller	TMCs and radar controller	Planning and Tactical controllers	TMCs at TMU, ATCSCC
Monitor	R=29'' D=15'' A=15'' diag.	D=20.1" diag. flat panel	TMU=17" diag.	R=29" diag.	TMU=17" diag.
Display of flight plans	Newly designed paper strips	Paper strips and A/C list	Paper strips and sequence list	No strips, extended data blocks	N/A, no active control
Primary windows	Situation display and meter list on R	Aircraft list on D	TGUI at TMC Meter list on R	Radar window	Traffic Situation Display (TSD)
Secondary windows	Display control and status view, CRUD, Time view display	Plans Display, Graphic Plan Display (GPD), Response Display	PGUI at TMC: Weather overlay, Traffic count, Load graph	Display toolbar, SIL, Message In /Out windows	WX and traffic monitor alert related menus, windows and plots
Coordination method	Phone, upgrades will introduce data link features	Non-voice (Plan or Response display) Kybd inputs	Kybd inputs	Fully automated with phone back up Inputs on screen	To ATCSCC via Direct Distribution Function and phone
Data block appearance and interaction	M-1 PVD format No interaction	Selectable data block on GPD, provides 2 info levels for 'Plan options'	PGUI: No amendments. TGUI: Overlay, Call sign and delay	Standard, selected, extended Interactive menus' cursor defaulted on next entry	No amendments, fyi 4 levels, route or destination/origin

Table 1. Summary of key DSR, FFP1, EATMP and ETMS CHI differences. [2]