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Workload Features inside Air Traffic Control Electronic Transfer Environment

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Abstract:

Air Traffic Control (ATC) unit responsibilities during the traffic control start with the finalisation of the handover procedures and they finish by passing these responsibilities to following Air Traffic Services. So called Hand/Take over procedures. These activities could be assure by the Electronic handover/takeover device or manually. While inside the civilian ATC environment, there are precise working positions of planning controllers, who are responsible for the preparation of flight planning and all information for Executive Controller, inside the military ATC facilities, the Executive controller will prepare and provide all activities him/herself. Our research on this domain focuses on Workload analysis and a new approach to dynamic Workload SW products available for the military ATC Environment.

Keywords:

air traffic controller, coordination, electronic data exchange, flight progress strip, handover/takeover environment, workload

1. Introduction

The responsibility for the control of an aircraft shall be transferred from the ATC unit to the next unit at the time of crossing the common control area boundary as determined by the unit having control of the aircraft or at other point or time as it has been agreed between the two units [1]. Transfer of control takes place at the area of responsibility (AoR) border, that is, the airspace border between two ATC units. Instructions to aircraft are issued exclusively when they are taken over. Electronic handover procedure is the basic prerequisite for adherence to safety rules in controlled airspace.

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It is an appropriate method for maintaining efficient air traffic flow and, last but not least, for managed coordination that does not significantly increase the workload. The requirements for efficient electronic exchange of coordination data are increasing on the contrary. It lays down requirements for flight data processing systems with regard to interoperability, performance and quality of service of their flight data exchange functions [2].

According to the arrangement of the airspace, civilian Air Traffic Services (ATS) Brno is the main coordinating partner of military air traffic controllers in Náměšť. Handover/takeover points are published in the coordination agreement for the purpose of the electronic data exchange of Instrument Flight Rules (IFR) flights. The subjects of coordination are applications for approval, flight data corrections, coordination and control reports [3]. Civilian and military ATS personnel have been tested to compare their user environment and to optimize workflows. The empirical method brings a very useful feedback about possible workload characteristics.

2. Coordination and Data Exchange

During Handover/Takeover procedures, either inside Airfield Air Traffic Service units (in the military ATS LKNA environment there are working positions Tower, Radar and Precision) or between two adjoining Area Control Centres, Executive controllers have to deal with the increasing level of their Workload. These events belong to critical moments, when a number of non-precise activities lead towards a number of failures or could easily be degraded into severe incidents. For this reason, precise information via particular communication systems or devices should be exchanged. Tools of data communications interface of flight related information have to fulfil requirements of specific Air traffic standards, procedures and protocols. Results of implemented Information technology devices inside the Aviation environment are playing a vital role in presenting data in time on a specific controller positions. While inside one Air Traffic Service Unit the Voice-Tel communication is used, between Area Control Centres Data link protocols as well as Electronic communication, interface will operate. The example of data exchange between ATS Brno and ATS unit on Air Base Náměšť, under specific conditions, is represented in Tab. 1.

The measurement shows that solving very simple activities can be considerably influenced by an unexpected matter. It is significant that very often after a period of calm, the ATC must deal with several coordination calls simultaneously, several simultaneous calls to the operating frequency, or calls from the ground staff. The controller output is the issuing of qualified permits on operating frequencies, and aircraft crews should receive them regardless of the controller's complications.

Based on long-term experience and measurement results below, the Workload value, during Handover/Takeover procedures could be influenced by several factors:

- communication environment, ATC unit configuration (Com-Data Exchange technology, procedures),
- information exchange (exact, valid and complete information to provide control),
- time (sufficient time to release/accept handover/takeover information),
- ATC personnel (well-trained, monitored by Supervisor, possible interruption by another functional activity),
- sector management (under/over estimation of sector, area, or vicinity of the airport).

Tab. 1 Coordination and Electronic Data Exchange

	Electronic Handover	Electronic Takeover	Verbal Coordination	ACI Verbal Coordination	ATC Instruction Coordination
Subject of Coordination	IFR Flights	IFR Flights	VFR flights with FPL (below FL95)	Area crossing clearance. Release of control	Instruction for arriving and departing aircraft
Number of Measurements	25	25	25	50	25
Average Coordination Time [s]	8	5	10	11	14
Interrupted Actions*	3	1	4	5	4

* Coordination time period interrupted by another functional activity (call on frequency, operational call, environment elements)

2.1. Take Over Procedure

Electronic transmission of control begins with a colour change of the label belonging to the aircraft in question (Fig. 1). Simultaneously, an airplane acceptance confirmation table appears at the bottom right corner of the controller's radar screen (Fig. 2).

Fig. 1 Takeover action on radar screen [4]

In Fig. 1, the subject of coordination is a military aircraft with the call sign Smuggler21, flying from Prague Kbely Airport to Náměšť Airbase. Coordination takes place before the ODUKO point, the entry and coordination point for entering the terminal controlled area of Náměšť air traffic services. During the electronic handover, significant flight data is highlighted on the label, which serves for unambiguous radar identification of the aircraft. In terms of the distribution of attention, it is inconvenient

to pay attention to two tables at the same time. Although electronic flight handover does not last long, there is a field for streamlining this method with regard to the level of workload. The purpose of this enhancement is to focus on one place only instead of searching for application windows on the radar screen, which is significantly distracting. In situations where the controller performs several electronic transmission in a short time, the non-conceptual distribution of attention may have a negative impact on safety and air traffic flow. This innovative idea is based on the experience of long-serving air traffic controllers and also on the basis of comments of the tested staff from the mentioned ATS units.

2.2. Hand Over Procedure

This reverse flight handover procedure is slightly different. Firstly, it is needed to accept the flight, consequently the label changes colour designation. Secondly, in the label menu select the hand over. Then a table of address characters appears, which is divided into military and civilian (Fig. 1). After selecting these characters, an electronic request will be sent, which will appear on the recipient's screen. An overtaking controller confirms an electronic handover message when establishing a radio communication with the crew of aircraft in question.

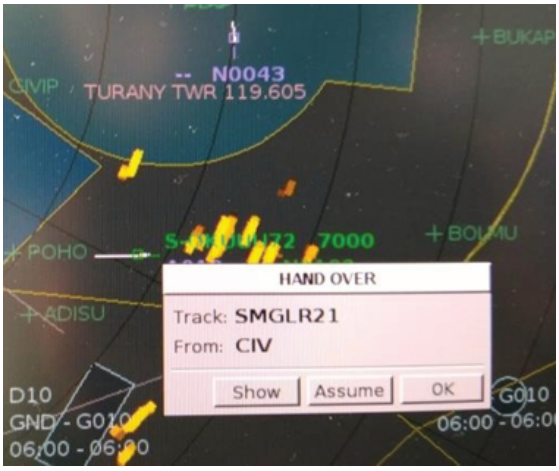

Fig. 2 Handover confirmation action on radar screen [4]

3. Usage of Flight Progress Strips

Flight progress strip (FPS) is an electronic or paper strip containing the data from one specific flight plan, used in air traffic control for the display of flight data on a display screen or flight progress board [5]. Fig. 3 shows a completed FPS which was printed for further air traffic control usage. ATC, in accordance with the working procedures of ATS unit, ticks the boxes or writes other auxiliary data. It is clear from the definition that there is a different technology to work with FPS and this will be the subject of our analysis. In military air traffic control, only paper FPS are used, and the purpose of the analysis is to determine their impact on workload compared to electronic strips.

CEF 626	IM	En / Cz C 31 / 13 R Wx ASM	EGXU	12:30	OSNEK F190 15:25
A3375	N0240		LKNA	15:34	
C295/M	F210	LDG			OPR/CZAF RMK/D.C. UK R050514 NETHERLANDS EUAT2014 GERMANY MDCNP REG/0455 21.3.2014

Fig. 3 Printed flight progress strip for IFR flight [6]

Paper FPS does not enter any information into a computer. Wherever paper strips are used, the controller must keep the written information in his mind, in order to update the air situation manually, but the operator may also have to update the corresponding information in the computer, so that all the calculations based on that information and presented in the form of computer assistance are correct. If the controller has too much work, updating information may suffer because it can be postponed, though it then becomes more and more difficult to catch up. Duplication of tasks by updating the same information in two different forms seems wasteful. However, doing the same task in two forms may help to prevent errors that are typical of one form only, and may also help to reinforce understanding and memory [7].

3.1. Paper Flight Progress Strip Management

In the military flight control environment, paper FPS are used. Although flight information about planned flight is displayed electronically, other changes or data deposit must be written manually. In the case of flight control without a flight plan, the entire FPS must be filled manually, which may be rather demanding and time consuming in high density of traffic. The actual filling of the FPS is governed by the operating regulations of the site manager.

Based on the regulations, it is mandatory to record flight data, but the procedure and design of the strip itself may vary due to the nature of the air traffic with respect to safety and air flow efficiency requirements. Finally, it is necessary to emphasize the greatest disadvantage of these paper strip forms operating systems which influences the fact, that the manually updated information is no longer shared in the flight management system among other ATC units.

If we compare paper flight strips against electronic FPS, there are still some positives. The Paper flight plans are independent from system and software failures. Regarding to the space on paper strip, non-standard fields can be flexibly used for additional information if needed. The difference between the automatically generated and manually filled strip can be seen in Figs 4 and 5.

3.2. Electronic Flight Progress Strip Management

This form of recording flight information is mainly used at civilian regional airports and at area control centres. This technology is advantageous where the executive controllers and planning controllers are involved together in air traffic control. Experimental measurement has found that inserting this information into the system is more time consuming (Tab. 2), but on the other hand, this flight data are available for other ATC member in the shift as well as for other ATC unit in the flight information region.

The use of Electronic strips offers more advantages than the paper ones. There are more visualization tools available, e.g. different colours may represent a field being updated/coordinated with other controller or communicated to the crew, different fonts and background shades may be used to highlight specific portions of

the flight strip, colours may change dynamically to attract attention. Electronic FPS can be linked to the ATM system safety features, e.g. if a controller inputs a conflicting clearance, the system may issue an early warning. Flight information can be updated and shared (coordinated) instantly [8]. The use of paper FPS is assumed here only in case of degradation processes.

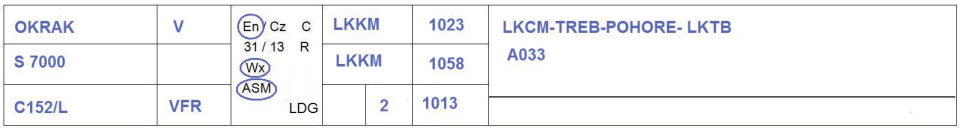

Fig. 4 Hand-filled strip for flights without a Flight Plan [6]

Fig. 5 Printed system generated strip with notes by ATC [6]

Tab. 2 Example of the time duration in FPS environment

Processing Activity	Paper FPS [s^{-1}]	Electronic FPS* [s^{-1}]	Number of Measurements
VFR flight without FPL**	11	14	20
IFR, VFR flight with FPL***	3	4	20
Changing existing data	2	2	20

*Measurement of data concerning electronic strips carried out on the TR7 simulator used in the regional Air Traffic Services.
**Filling out all flight information for flight without flight plan.
***Finding an existing plan (system – flight progress board), confirming information.

3.3. Flight Progress Strip Performance Evaluation

To give an idea of the time of data recording into the FPS, measurements were made to compare these two modes of operation. The subject of the measurement of time was the situation of recording data on flights with a flight plan, without a flight plan and the time of change already recorded data. Electronic data entry was evaluated at Brno regional airport during pre-on-the-job-training. The time of writing into the paper FPS was tested at Náměšť military Airbase.

As depicted (Tab. 2), recording information into electronic FPS is faster, probably because of the need to search for the right field in the system menu. Creating a strip for a flight without a flight plan is significantly more time consuming because it

is necessary to take/generate a blank strip and fill it with all available information. Changing data in existing strips was done within a minute of their creation, so it took such a short time and ATC knew where the strip was located or saved. Regardless of the advantages and disadvantages of these two types of FPS, this measurement provides an idea of how to optimize the work of recording flight data in terms of further use and sharing flight data. The resulting data are averaged, but their individual values did not change much, so it was not necessary to make higher number of individual measurements.

3.4. Interactive Pen Flight Progress Strips

This system is essentially a combination of the previous two ones. Simultaneous recording and automatic data input is the biggest advantage of this kind of strips. This new technology offers improved workflow comfort and reduced workload in complex situations. Fig. 6 [9] shows an example of an interactive whiteboard used at some civilian airports. The system offers many features. It can work as an ordinary pencil for the purpose of highlighting data; on the other hand it is also possible to tick or change the data with the bids of the shown characters that are subsequently recorded in the system. In terms of time-consuming data input, the time is negligibly higher, which does not reduce the bending of this technology. This modern system is a real simplification of work, but unfortunately, it is still expensive in comparison with previous devices. Therefore, this device is implemented in ATC station where it is effectively used.

This way of working can more effectively help in dealing with unexpected events. In case of time pressure, a single action replaces multiple activities at a particular time period. Workload and surprise factors can fundamentally influence the resolution of unexpected situations. Coping with any operational issue needs two approaches – prevention and recovery. Since prevention procedures will often have failed, the ability to recover is important and supportive training to increase the chances of this is therefore crucial [10].

It is clear that the introduction of such a facility would require conversion training and a trial period in operation that includes all possibilities of operation.

Fig. 6 Interactive flight progress board used in civilian ATS [9]

4. Conclusion

The matter of optimizing work with flight progress strips is upcoming. Army representatives are considering the purchase of a new air traffic services system for the next decades. The reason for potential purchase is to provide a better cooperation with civilian ATS and optimization elements as well. The development of automated systems in both military and civil ATS and EU requirements for higher level of civ-mil systems cooperation to provide more effective airspace use should be taken into consideration. The above measurements show that a combination of a paper and electronic strip can reduce workload and facilitate work of military air traffic controllers. Surprisingly, working in a solely electronic environment is not always the fastest despite its advantages. Obviously hand-working with a pencil is getting faster than working with a pc-mouse and clicking on the screen. Possible additional future advantages of fully electronic environment might strongly overpower the disadvantage of slower data input compared to pencil-pc way. This is an essential message for further development.

According to Eurocontrol research, it is necessary to emphasize the phase of transition to new work technology. „With a change from paper to electronic or combine flight progress strips it would seem that several actions can create potential errors, particularly in the perception and vigilance area concerned with the detection of visual information“ [11]. It is a change that requires conversion training. The results also show that a stripless system is not suitable for military environment. It is essential to keep a simple backup facility independent of current systems without increasing the Workload level [12]. The flight progress board is faster in terms of data retrieval and provides backup system capability in case of system failure. Based on these facts, the most effective method is to combine hand-pencil and electronic environment, meaning interactive flight progress board. This way of working with flight progress strips has already proved its worth at many airports abroad.

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