MEANS OF USING CPDLC WITH ATC PROCEDURES IN TERMINAL MANEUVERING AREA

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The paper deals with practical simulation of air traffic control situated in terminal maneuvering area of Kosice airport. To reach desired results, there was designed a software application for data link communication simulation (DLCSim) which allows direct connection between controllers and pilots. DLCSim is based and meet the conditions set by EUROCONTROL organization. The work focused on searching appropriate way to place CPDLC system and his usage in dynamic environment of arriving and departing traffic. Frequent consultation with expert from EUROCONTROL organization, air traffic controllers and technicians working for Slovak Air Traffic Services, and pilots operating on airplanes like B378, or ATR 72-600 on regular basis, make this experiment as close to the reality as it is possible.

Keywords: CPDLC; data link; voice communication; frequency congestion; workload; flight simulation; TMA

1. INTRODUCTION

Today we can see expanding airspace of free route navigation with step by step implementation of data-link communication within the Europe also known as CPDLC. This new type of communication went through a years of research and development and is slowly becoming the part of routine communication between air traffic controller and pilot. Increasing traffic is not only issue of area controlled airspace, but also significant problem within terminal maneuvering area (TMA). This dynamic environment creates huge frequency congestion preventing active control of inbound and outbound traffic. The need of voice communication replacement is growing every day with persistently blocked frequency, repeating long messages, and with occurrence of dangerous wrong readbacks and hearbacks. Air traffic controller has to correct the wrong acknowledgements and repeat messages, what only leads to increased frequency congestion. The capacity of voice communication is very limited in today's traffic density. The intense workload has become unthinkable part especially on air traffic controller’s site. Reduction of TMA Frequency Congestion Using CPDLC is real time simulation, the first of series simulation based on EUROCONTROL requirements. The experiment is work of joint cooperation between Department of Air Traffic Management, Department of Air Preparation and Department of Avionics.

2. SIMULATION OBJECTIVE

The main objectives of the simulation were to assess existing procedures in communication between air traffic controllers (ATCo) and pilots in the approach phase of flight, the impact of using data link (D/L) communications and new procedures on traffic flow, and the air traffic controllers and pilots overload with respect to mutual communication. All simulation procedures and software application (DLCSim) developed for such purposes were developed based on EUROCONTROL requirements.

2.1. Specified Data-Link Communication Objectives

Objectives were specified for general use of data link communications for procedural control as follows:

- Reduce number of orders
- Define common errors
- Eliminate errors using D/L
- Create user friendly environment software application for ATCo
- Create electronic only environment
- Identify usage of combination of voice and D/L communication
- Compare congestion using voice and D/L communication

Added objectives for pilots:

- Research congestion for pilots using D/L
- Measure time needed for response

2.2. Simulation Environment

For the simulation was chosen Kosice International Airport with connections to multiple countries like Czech Republic, England etc. The airport is situated in the east of Slovakia, approximately 6 km south of the city center. Procedural control requires different procedures and separation minima than radar control that is why it is not possible to use all of standard terminal control areas, standard arrival and departure procedures as well as STAR and SID charts. So in order to proceed with simulation, I have developed slightly different new arrival and departure procedures based on actual ones. New procedures and charts were created with minimum changes to the actual ones.

In the table below (see Table 1) is shown the new boarders of terminal maneuvering area (TMA) used for simulation with exact name, coordinates, distance from VOR/DME KSC and boarders with next controlled areas. All navigation points are real and used by air traffic controllers in real situations.

Table 1. Enhanced LZKZ TMA info

Name	Coordinates	Distance from KSC	Boarders
KSC	484059N 211453E		
LENOV	492446N 212621E	40 NM	Warszawa ACC
MARKA	485406N 204137E	25,6 NM	Poprad APP Bratislava ACC
TAKOS	483457N 201600E	40 NM	Bratislava ACC
KEKED	483123N 211729E	9,8 NM	Budapest ACC
MALBE	484926N 222230E	32 NM	LVIV ACC

New Arrival and Departure charts were made from original charts provided by Slovak Air Traffic Services. Vertical Boarders remain the same as the real used in standard procedures up to flight level FL125. Minimum flight altitude on tracks and minimum sector altitudes are set by official charts published by Slovak Air Traffic Services.

2.3. Place of Research

Real-time simulations were performed at Technical University of Kosice in a single operational room as shown on Figure 1.

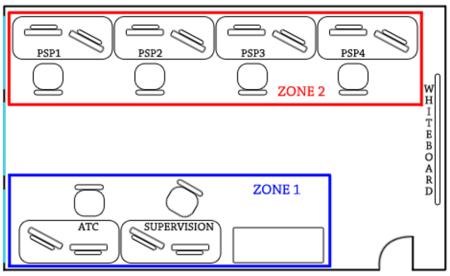

Figure 1. Operational Room Design

Figure 2. Operational Room Real View

3. EXPERIMENT

The objective of this experiment was to compare congestion and flexibility of voice communication and communication provided by data link system. Experiments were based on exercises created for Košice Airport using data collected from real traffic situated in the airport and around its area.

There were four controllers and three pseudopilots who took part in five exercises, both with voice and data link communication, but the last one. That makes total number of 36 exercises executed. In the last exercise controller had been asked to use data link communication, and when he feels that he needs to use voice he was able to proceed in chosen way. Exercises had growing trend, so participants could settle in and get used to new application software and its interface. DLCSim was also partly developed by adapting to requirements from participants point of view and suggestions, improving controllers interface and application software overall efficiency. All exercises were recorded and stored, both voice and data link messages records.

The traffic was based on real airplanes we can find flying to and from Košice Airport. For example can be named airlines as: Wizzair, Austrian Airlines, Travel Service, or CSA. In exercises is also included non real traffic, so congestion could grow in time and simulation could lead to satisfying results. For pseudopilots were prepared document (pilot log) made in Excel.They were able to report at any time information requested by ATCo, easily react to commands and adapt to new situations.

3.1 Application Software

For the purposes of this experiment was developed software application (DLCSim) to simulate all data communication between ATCO and pilots. This version allows sending the messages important for ATCO-pilot communication which was defined by EUROCONTROL in Link2000+. DLCSim provides also actual METAR data for specified airport where ATCO is connected to. The whole graphical user interface (GUI) is designed to meet EUROCONTROL requirements for human-machine interface (HMI) for ATCO and pilot workstations. DLCSim consists of two main modules: ATC Module and Pilot Module. All necessary information about DLCSim can be found on [1].

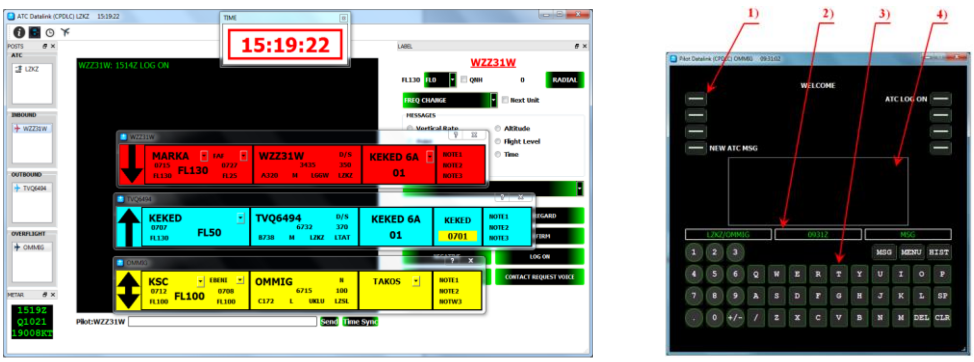

Figure 3. DLCSim ATC and Pilot Module

3.2. Situational Awareness

One of the greatest concerns was losing situational awareness while using data link. But as soon as controllers get used to work with DLCSim application software, they managed to name exact airplanes location with the same precision while using voice communication. There was recorded non difference in situational awareness between voice and data link communication, while giving orders for pilots.

4. RESULTS

If we look at the parts like *log on* or *log off* messages, or for example clearance for ILS approach, data link communication is by considerable amount time-saving and it is reducing controller's workload. At the other type of messages, controllers seem to spend equal, or more time using D/L. Orders for climb, descent, or requesting information from pilots actually slightly increased the controller workload.

During the exercise appeared messages from pilots without any direct order from ATCo. For example reports like passing points, crossing, or reaching cleared flight levels, or after crossing transition level reaching cleared altitudes. This type of messages cut in average almost 11% from total exercise time. This amount is significant and can be reduced by using data link communication to minimum of voice frequency congestion. After realizing there is no need for confirmation of the message received when using data link, controller workload is minimal.

The last exercise was created to simulate the possibility of combination the voice and data link communication. Controllers had the possibility to choose which messages to send by data link as priority communication and which massages to send by voice. The exercise was more difficult than they have had experienced from the beginning of their procedural training. With the raising experience with DLCSim software application controllers manage to complete this difficult exercise with no significant problem, all by using data link communication.

Even thou, from statistics, experiences and personal interviews the best way is to use combination of both voice and data link communication. Statistics were created from total amount of 36 data files collected from voice and data link communication during exercises.

Tabel 2. Overall Statistics

Type of message	Time from exercise (%)
Report MSG by pilot	10,8
Log on / off MSG	16,4
Overall	27,2

Tabel 3. Individual Messages Statistics

Type of message	Average time Voice (s)	Average time Data Link (s)	Saved time (s)	Percentage difference (%)
Log on	23	10	-13	56,5
Log off	10	8	-2	0,2
Climb / Descent	10	13	+3	30
Report MSG requested by ATC	13	16	+3	23
Connected MSG	16	16	+0	0
ILS	15	10	-5	33,3

4. PILOT WORKLOAD

Communication is a two-way process that is why research only in the environment of air traffic control is not enough. Cockpit crew is going through a lot of work and procedures during the approach phase. Another increasing workload for pilots is using voice communication. Not only the pilot has to be always on gourd for call from controller, but there is always a place for misunderstanding or miscommunication. Repeating the same message is only leading to enhanced frequency congestion. Much worse situation could happen, if pilot or controller misunderstands each other, what could lead to loosing separation minima or accident. Data link system in cockpit has not only potential of reducing pilot's workload, but also is removing the possibility of miscommunication between controller and pilot to minimum. Human influence is still a factor, but its impact is reduced by significant number.

For the research, pilots performed several flights on B58 flight simulator (see Figure 4) using only data link communication. The crew was created from one pilot and one copilot to simulate standard crew configuration. These flights were focused on pilot's workload, when using data link communication, while they went through all standard procedures necessary for arrival or departure.

Figure 4. Operational Room Design

During the flight pilot and copilot were subjected to greater amount of messages than we recorded from controllers exercises, so their workload could be tested on higher level. Reaction time of pilot handling communication was better than expected with positive reaction from the whole crew. The standard report messages or direct orders have met with reaction time from 9 - 12 seconds. More complex messages or combined messages increased crew's reaction time to 15-20 seconds. In simulated exercises were not tested any non-standard, nor emergency messages.

In many situations pilots favor data link over the voice communication. Cockpit crew does not need to listen to all communication on frequency, just wait for audio signal when message had arrived. At this time, voice communication should be still used as primary communication and data link can support it as a backup, or its replacement at some stages of flight. According to pilots, data link has potential to become primary communication, and voice communication would be provided only in non-standard and emergency situations.

5. CONCLUSION

This experiment should give an answer to the question, if pre-formatted messages would decrease the voice communication usage. After the evaluation, the controllers agreed that it could bring decrease to voice communication congestion. As concluded from experiment final acquired data, broadcasting the information like log on, log off messages, or clearances for ILS approach might save channel usage by significant amount of time. However in other cases, exceptional situation and unexpected events are not the main concern of the voice communication congestion, thus pre-formatted messages and data link communication is not the solution for that kind of problem, but only creates more workload for controllers who would have to manage them.

All controllers acknowledge the data link as easy to use, time saving and safety increasing tool. After personal interviews all of them agreed that data link could be used as a secondary communication channel for standard messages increasing flight safety and controllers capacity. The data link communication proves itself as a tool for significant decreasing voice communication congestion and reducing controller´s workload. All controllers confirmed that in specific situations, data link is giving them additional time for solving other problems connected with airspace control.

Using data link communication requires greater attention and more anticipation according to the transmission delay when sending message. Nevertheless data link was found as a promising tool even in the as dynamic phase as is the approach and departure phase

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