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CONTROLLER PILOT DATA LINK COMMUNICATION IMPLEMENTATION TO AVOID CONTROLLER-PILOT MISUNDERSTANDING

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The main advantages of data link technologies usage in the air traffic control system to improve “air-ground” communication are considered in this article.

Розглянуто основні переваги цифрових технологій передачі інформації в системі контролю повітряного руху між диспетчером і пілотом.

Рассмотрены основные преимущества цифровых технологий передачи информации в системе контроля воздушным движением между диспетчером и пилотом.

Statement of purpose

The first Controller Pilot Data Link Communication (CPDLC) message was sent in 1993, this concept has been developed for 17 years, but yet has not received appropriate recognition.

Controller pilot data link communication is a means of communication between controller and pilot, using data link for Air Traffic Control (ATC) communication.

At the highest level, the concept is simple, with the emphasis on the continued involvement of the human at either end and the flexibility of use.

One of the keys to the future air traffic management system lies with the two-way exchange of data, both between aircraft and the ATC system and between ATC systems. In the future, it is expected that communications with aircraft will be increasing by means of digital data link. This will allow to provide more direct and efficient linkages between ground and cockpit systems. At the same time, extensive data exchange between ATC systems will allow efficient and timely dissemination of relevant aircraft data, reduce controller and pilot workload and allow an increasing of the system capacity.

Analysis of investigations and publications

ICAO has developed a communication systems architecture that provides a range of capabilities to suit the needs of Air Traffic Services (ATS) providers and their users, from basic low-speed data to high-speed digital voice, including the aeronautical mobile-satellite service.

Various air-ground communication data links will be integrated through an aeronautical telecommunication network based on an open system interface architecture.

Human factors related to specific data link applications are below (partly extracted from the ICAO Global Plan):

1) the definition of system and resource capacity should include reference to the responsibilities, capabilities and limitations of ATS personnel and air crews, who must retain situational awareness and understanding in order to carry out all of their responsibilities;

2) the responsibilities of pilots, air traffic controllers and system designers should be clearly defined prior to the implementation of new-automated systems and tools;

3) when operating a data link system, there will not be an increase in head down time that would adversely affect safe operation.

The purpose of the work is the investigation of dynamics of information loading growth of “ATC-pilot” channels and the influence of CPDLC concept’s introduction on the improvement of coordination between ATS units and aircrews, the reduction of loading of voice communication channel, fatigue and probability of misunderstanding.

Controller Pilot Data Link Communication as a system of communication between an Air Traffic Control and a pilot

Controller Pilot Data Link Communication as the fast implemented concept may be one of the highly effective methods of reducing workload in our country that is very important during the preparation to Euro 2012.

In brief it includes a set of clearance/information/request message elements which correspond to voice phraseology employed by ATC procedures.

The controller is provided with the capability to issue level assignments, crossing constraints, lateral deviations, route changes and clearances, speed assignments, radio frequency assignments, and various requests for information. The pilot is provided with the capability to respond to messages, to request clearances and information, to report information, and to declare an emergency. The pilot is, in addition, provided with the capability to request conditional clearances (downstream) and information from a downstream Air Traffic Service Unit (ATSU). A “free text” capability is also provided to exchange information not conforming to defined formats. An auxiliary capability is provided to allow a ground system to use data link to forward a CPDLC message to another ground system.

The sequence of messages between the controller at an ATSU and a pilot relating to a particular transaction (for example request and receipt of a clearance) is termed a ‘dialogue’.

There can be several sequences of messages in the dialogue, each of which is closed by means of appropriate messages, usually of acknowledgement or acceptance.

Closure of the dialogue does not necessarily terminate the link, since there can be several dialogues between controller and pilot while an aircraft transits the ATSU airspace.

Data link communications utilize standard pilot/controller message sets, with free text messages being used as required. When a required response is not successfully delivered, the message initiator is responsible to query the state of the response via an appropriate medium.

Execution of a clearance received via data link may begin upon pilot initiation of the action which sends the acceptance message, except when the clearance specifies otherwise.

Messages are to be reviewed and responded to in a timely manner upon receipt. If messages are queued, they are to be reviewed sequentially in the order of receipt, with the exception that messages with a higher urgency should be reviewed first.

When a controller or pilot communicates via voice, the response should be via voice. If a data link message which requires a closure response is subsequently negotiated via voice, an appropriate data link closure response for that message will still be initiated. Even though a voice response may have been provided, a data link response is necessary to ensure proper synchronization of ground and aircraft systems.

Procedures accommodate mixed data link and voice capability, and any potential failure modes, with no disruption of other tasks during critical times and with no more than minimal disruption in non-critical times (fig. 1) [1].

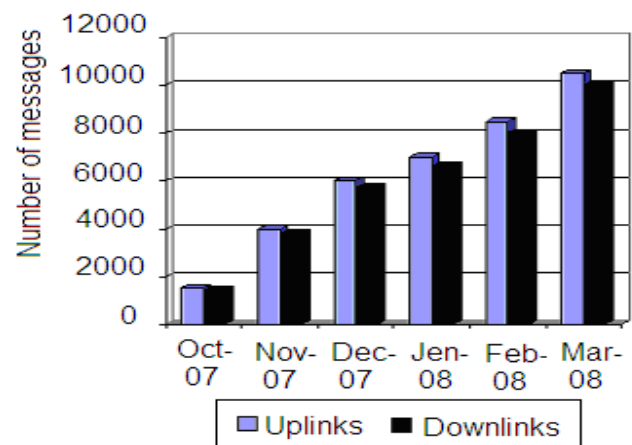


Fig. 1. Distribution of CPDLC message

Controller Pilot Data Link Communication concept does not have a long history but for this period of time it was resulted in significant reducing of ATC workload and increasing of airspace capacity (tab. 1) [2].

Table 1

Establishment of CPDLC on board the aircraft

Year	Establishment of CPDLC on board the aircraft
1993	Boeing application in the Honeywell FMS (Flight Management System) installed on board of B747-400
1995	First B747-400 certified
2000	Airbus developed the ATSU supporting FANS for A340/A330
2005	Boeing and Airbus developed the FANS enhancement package

The number of aircraft being equipped for CPDLC is increasing. According to current data American Airlines plan to have a total of 25 aircraft, B757s and B767s, equipped by August (fig. 2) [1].

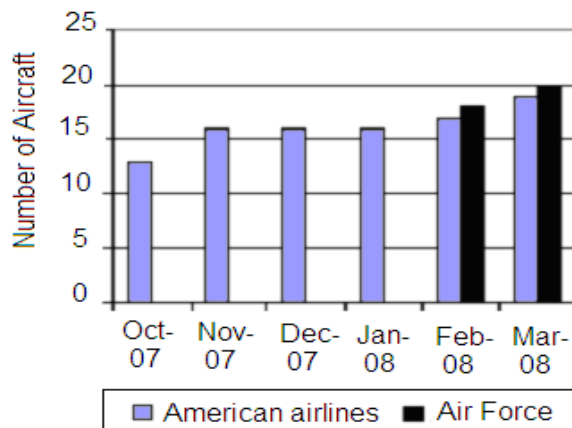


Fig. 2. Controller Pilot Data Link Communication equipped aircraft

Other carriers are forging ahead with data link equipage for domestic routes. For example, Continental Airlines (USA) was to have had four of its B757-300s equipped for CPDLC in May [2].

It is necessary to show the graph representation of CPDLC increase usage. Data for graphs are taken from Eurocontrol site (from 2005 to 2008) (tab. 2).

Over the past decade, air traffic has grown by more than 50%, airspace capacity increased by 80 %. European ATS providers now handle around 8,5 million flights per year – and as many as 30,000 flights a day at peak periods. Eurocontrol expects today’s traffic levels to double by 2020. Controller Pilot Data Link Communication is one of the new measures to avoid serious congestion. According to published data 70 % of errors committed by human (personnel) are connected with communication problems, which are correlated in the following percentage proportion (fig. 3) [3]:

- 6% – wrong instructions;
- 8% – message complexity;
- 12% – similar callsign at the same frequency;
- 14% – health problems: stress, panic, fatigue;
- 15% – readback, need for partial or full repetition of message;
- 19% – noise, interferences;
- 26% – ambiguous wording, jargon.

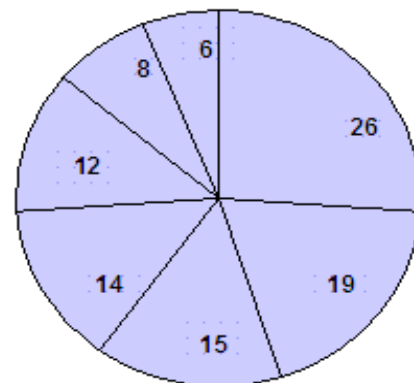


Fig. 3. Communication problems, correlated in the percentage proportion

To reduce the possible causes of misunderstanding the CNS/ATM concept introduces a set of new technologies and management methodologies to improve the air transport safety and flow.

Table 2

Capacity gain as a function of CPDLC equipage, %

Percent of ACFT equipped	Workload reduction	Capacity Gain
50	16	8
75	22	11
100	29	14

In the communication field, the main improvement is the replacement of the voice communication by the digital messages over a data link. The CPDLC is the CNS/ATM application that will enable pilot-controller communications over an Aeronautical Telecommunications Network data link.

This system is responsible for establish, manage and terminate a CPDLC communication between the ATS in the ground and aircraft systems in the air. Also, the CPDLC can deal with dialogues between two different ground services, working as a message forwarder. In the short term, this application will replace the actual voice communication over analog channels.

This replacement has some advantages. The understanding of a text message is greater than of a voice message, especially if the voice message has poor audio quality. The messages could be translated to any language automatically. The messages could be printed or read again without the need of retransmission.

The communication could be send only to desired destinations. The binary messages are faster to transmit than the voice messages. Because of this, the digital messages occupy less channel time, increasing the channel capacity the controllers could have faster and more accurate information about the flight, as the system could send automatic reports from the aircraft. There are more than 200 messages in the list, however, these messages reflects the original voice communication procedures.

The main benefits of CPDLC are reduced voice-channel congestion, less chance of being misunderstood, less fatigue and greater efficiency.

Additional communications channel

In addition to voice communications, CPDLC offers a second, independent communication channel to controllers and pilots, reducing the strain on busy sector frequencies. It is freely available at pilots' own choice.

Voice communications remain available for read-back at all times, or in the event of problems or abnormalities (fig. 4) [1].

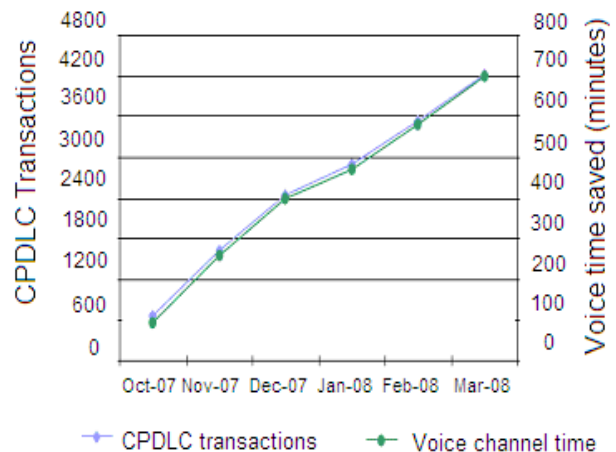


Fig. 4. Controller Pilot Data Link Communication transaction and voice channel time saved

Enhanced safety

Controller Pilot Data Link Communication offers an alternative, unambiguous communication channel (e.g. in the event of busy, blocked or deteriorated VHF radio frequency) with no risk of misunderstanding, since crews and air traffic controllers can actually read the messages.

Increased capacity

Controller Pilot Data Link Communication helps increase capacity of ATCs productivity by reducing voice-frequency load. Today, more than 50% of messages are already exchanged without the need for voice read-back. It is estimated that 75% CPDLC equipage rate will generate a capacity gain of 11% in Europe (fig. 5) [4].

Greater efficiency

With CPDLC, you will never again have to say the words "SAY AGAIN?" All messages are done in written form. And because you can read the text messages, the workload is reduced for both pilots and controllers. This is less tiring for crews and controllers.

Coverage

The Maastricht Upper Area Control Centre (EDYY) offers data-link services on a 24/7 basis to all aircraft equipped with the appropriate CPDLC avionics CPDLC avionics in the upper airspace (above FL 245) of [5]:

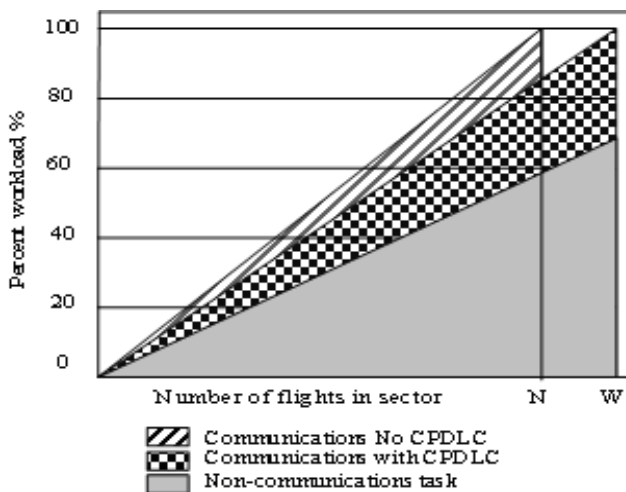


Fig. 5. Dependence of sector capacity on CPDLC usage: N – number of flights without CPDLC usage; W – number of flights with CPDLC usage

- Brussels Upper Flight Information Region;
- Hanover Upper Flight Information Region;
- Amsterdam Flight Information Region.

Data Link benefits are a direct result of the reduction in frequency congestion and reduction in frequency congestion is directly proportional to the data link messages transmitted; each data link message transmitted has an equal amount of benefit (fig. 6) [6].

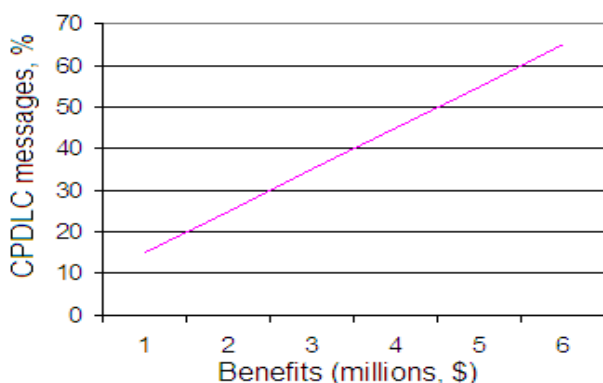


Fig. 6. Benefits of transmitted messages

The CPDLC Benefit is calculated by using the following equation [3]:

$$B = \frac{T}{E} * 100\%$$

where B – CPDLC benefit factor,
 T – total number of aircraft,
 E – equipped aircraft with CPDLC.

We have analyzed ETMS (Enhanced Traffic Management System) data position reports in Atlanta region from October 2005 along with the sector boundaries to 2007 adaptation to determine the specified airline percentage of aircraft in the benefit sectors at the identified time periods.

We then used these percentages to calculate the minutes saved in the air and on the ground due to the use of CPDLC.

The Total Time Saved per year - Airborne Minutes = 8,531

Ground Minutes = 7,079

This produces the annual cost saving for Airline1 at Atlanta to be \$454,215.

Generally CPDLC benefits can be represented like the diagram given below (fig. 7) [4].

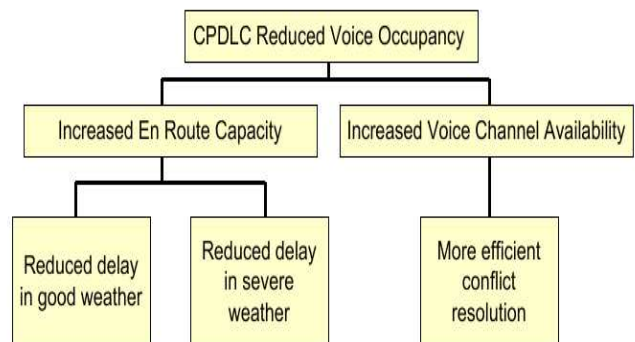


Fig. 7. Controller Pilot Data Link Communication benefits

Trials show very positive feedback from pilots and controllers. Increasing of capacity across the Link Airspace is expected on 11% and reduction in controller workload on 29%.

Conclusion

Controller Pilot Data Link Communication is one of the cornerstones of a new unified European system which will safely and seamlessly handle strong demand for air traffic services continuously.

By supplementing traditional voice communications with direct data links between aircraft and ATC, CPDLC allows controllers to handle more aircraft and manage them more safely.

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