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ADS-B - AUTOMATIC DEPENDENT SURVEILLANCE - BROADCAST
(A step towards new concepts of air traffic control)

ABSTRACT

The current system of air traffic is facing many drawbacks and problems that restrict its further development and makes it difficult to follow the trends of increase in the traffic volume.

By means of their technology, the systems such as ADS-B create the basis for further building, upgrading, improving and developing of a completely new concept of the air traffic system. Through their functions they fully fit into and support the basic functions of communication, navigation and surveillance which form the basis of the new concept that needs to be implemented as soon as possible.

KEY WORDS

ADS-B, air traffic, new technologies

1. INTRODUCTION

Along with the great world economic development over the last several years, there has also been great increase in passenger air traffic. Therefore, the need arose to improve the air navigation system, and thus ICAO (*International Civil Aviation Organization)* founded in 1983 the *FANS Committee – Future Air Navigation System*. The study systematically carried out by this Committee confirmed that the only solution to overcome the current navigation restrictions and to meet the requirements set by the aviation development in the 21st century would be in introducing a new concept of air traffic management called CNS/ATM (*Communications, Navigation, Surveillance /Air Traffic Management*). In September 1991, at the 10th Conference on Air Navigation in Montreal, the ICAO members officially accepted the CNS/ATM system as the air traffic concept of the 21st century.

2. FUNCTIONS OF CNS / ATM SYSTEM

The basic subsystems of the future CNS/ATM system include:

- ***Communication*** – The improved system will reduce the need for verbal communication between the ground controller and the pilot on board. By greater digital data exchange the aircraft will periodically emit and receive information via satellite or other communication links, thus greatly reducing the possibility of error due to misunderstanding or poor radio connection, and simplify the work done by the crew and air traffic control services.
- ***Navigation*** – Future navigation systems will enable autonomy in relation to the ground radio-navigation devices, opening up possibilities for selecting optimal and at the same time more economical routes. Thus, very fast operative implementation of some systems has been planned, such as e.g. GNSS (*Global Navigation Satellite System*), which along with the improvement of the current systems RNAV (*Area Navigation*) allows higher quality coverage of the whole earth's surface, and is now being used for route navigation and for imprecise approaches to landing. In combination with other similar systems, and with development of adequate procedures its application in precise approaches to landing may be expected very soon.

Tracking – Air traffic management and tracking systems will be more accurate and precise owing to the fast data exchange and processing, thus allowing full display of the traffic situation in real time, increasing thus the density and safety of traffic. Currently, the program includes the development projects of software for processing of data obtained from the aircraft, allowing the computers on the ground and in the air

fast and precise defining and solving of traffic problems. This will significantly reduce the volume of air traffic control tasks, and also improve the traffic planning process.

In modelling such a new concept of air traffic system it is certainly necessary to take into account the requirements set by the air carriers, which include absolute increase of safety, the capability of the system to follow the planned traffic volume increase, the reduction of system exploitation costs (including direct operating costs and infrastructure costs on the ground and in the aircraft itself), and introduction of the system into operative implementation within reasonable time periods.

In order to insure maximum possible safety, efficiency and exploitation of operating concepts within the CNS/ATM system, such as e.g. the so-called "Free Flight" which is being developed under the auspices of the US FAA (*Federal Aviation Administration*), enabling the pilot to select the shortest and most economical flight route, it is necessary to develop new technical solutions on the aircraft which will allow using all potentials and possibilities provided in the transition from the traditional practice to more efficient concept of air traffic management. The development of such an adequate concept of aircraft avionics represents a step toward fully integrated and airborne solution, which is of key significance for air carriers whose aim is to satisfy the criteria of future concepts such as the so-called "Free Flight". Such new concepts and solutions have to comply with all the possibilities and performances of the existing aircraft types, but also take into account the growing number of "digitised" aircraft, all this with the aim of adopting and implementing real transition strategies towards a possible future structure and aircraft avionics concept. Such an approach must be adopted both for all commercial aircraft and for aircraft for general purposes and military aircraft. It is precisely with this goal that the main task of the program NUP – NEAN Update Program (*NEAN – North European ADS-B Network)* sponsored by the Council of Europe is the analysis of integration and implementation of the ADS-B system for data transmission, and based on this, the development of concrete suggestions.

3. AUTOMATIC SURVEILLANCE SYSTEM

ADS-B - *Automatic Dependent Surveillance – Broadcast* is the latest technology allowing full overview of air traffic. Within the ADS-B system every traffic participant (which apart from aircraft can be applied to other vehicles as well), periodically emits data such as the position, call sign, speed, and other useful information. These data can at the same time

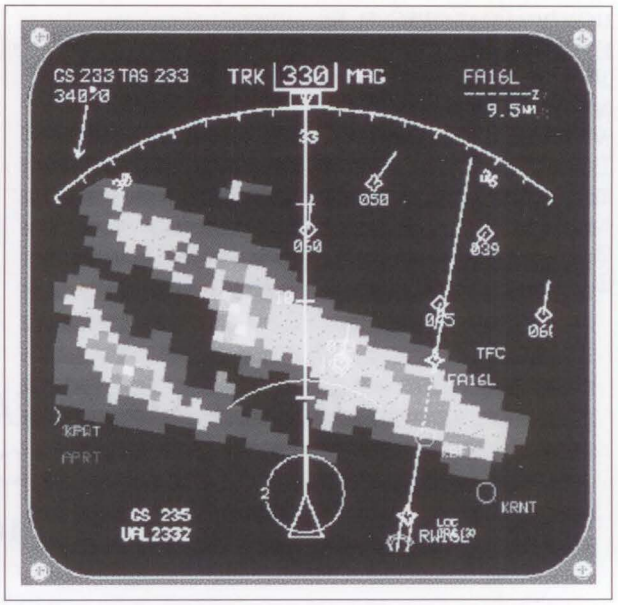

Figure 1 Information from ADS-B system on the cockpit display by means of CDTI

be received by other aircraft in the air and by the air traffic control, greatly improving the overview of traffic. With increasingly wide implementation of global navigation systems, such as the already mentioned GNSS, the information about the speed (horizontal and vertical) and the intentions of other aircraft in real time can be followed very precisely from the ground or another aircraft by means of CDTI (*Cockpit Display of Traffic Information*) (Figure 1).

The existing air traffic system undoubtedly imposes certain restrictions which hinder further development. However, since the development is inevitable and increasingly present, radical changes need to be implemented. This is supported also by the fact that air traffic shows an increase of five percent annually, which means that the European air traffic will have doubled by the year 2012. Some analysts claim that the existing system, which is fighting to maintain the current traffic functioning at a satisfactory level, will not be able to cope with traffic in the near future. The hindrances in the existing system are the facts that the position of other aircraft is known only to the ground controller, that the real intention of the aircraft is not known to other traffic participants and that there is double guidance of flight path by the controller and the pilot, etc. Also, in the air traffic itself as well as on the runways problems occur in aircraft separation, and the drawback in guiding the aircraft across manoeuvring surfaces seriously influences the traffic capacity due to "bottlenecks" on the ground. Inefficiency caused by various communication methods between the pilot and the controller and among the controllers themselves is additionally emphasised by the very narrow transmission spectrum of verbal information via VHF frequency area (*Very High Frequency).* High costs and

the absence of globalisation impose great pressure on the air carriers in the commercial and operating sense.

Europe has responded to the drawbacks of air traffic system which are most clearly seen in the traffic saturation, greater number of delays and increasing costs of air traffic control service by introducing the systems such as B-RNAV (*Basic Area Navigation*), 8.33 kHz frequency distribution and RVSM (*Reduced Vertical Separation Minima*). Regardless of causing additional costs to air carriers, the advantage of some of them can be measured at a very low percentage, although RVSM has the potential to significantly increase the traffic capacity. Anyway, not one of these proposals will have any major influence on reducing air traffic control costs while there is an increase in the number of air carriers in Europe.

The future CNS/ATM system has to surpass the restricting concept based on ground-radar control and must focus on the aircraft possibilities. Eurocontrol has presented its vision of the future EATMS (*European Air Traffic Management System*) as a wish to provide all the air traffic users with maximum freedom of movement in compliance with the requirements set by the safety, economy, environment, and national safety. Eurocontrol has also clearly expressed its attitude that the EATMS development depends on the exchange of roles and responsibilities between the positions on the ground and in the air, made possible at the moment due to the advances made in technology. These improvements will allow better understanding and interpretation of the aircraft path, i.e. its intentions. Future EATMS system will thus lead to better distribution of tasks between the air traffic controller and the pilot, as well as to improvement of human-machine contact onboard, improving thus their interrelations.

The future CNS/ATM system requires also that the level of information transmitted air-to-air, and if necessary air-to-ground and ground-to-ground is satisfactory. This information needs to contain consistent and unambiguous data that can be directly used for display and/or implementation in the air and on the ground, not needing any further interpretation or processing, thus eliminating the process of guessing which is present in the current system. In order to simplify the operation of the future system and to increase the safety and reduce the minimum aircraft separation, the pilot has to be able to follow the traffic flow process, which has been only partly achieved by the TCAS/ACAS system (*Traffic Alert and Collision Avoidance System / Automatic Collision Avoidance System*). Since the size of the managed airspace is getting reduced, and the size of the free flight airspace is being increased, there are two clearly defined levels of information exchange:

- air-to-air communication in free flight airspace, and
- air-to-air and air-to-ground communication in the managed airspace.

Obviously, the size of the managed and the free flight airspace will depend on the distribution of traffic at the local level and on the infrastructure availability. The actual globalisation of air-to-air communication and direct transmission of information with the data on the aircraft position will provide aircraft crews with huge possibilities of overviewing the traffic situation in the air. With the future possibility of synchronising time, these two new elements will create the basis for any form of a new air traffic system, independent from the ground infrastructure. With additional projection of the planned aircraft paths in real time, an overall display of traffic information in the cockpit is obtained, eliminating the possibility of undesired guessing. All these elements together will improve and simplify the algorithms used for calculations and traffic alerts, thus simplifying also the basis for a fully automatic mid-air collision avoidance system installed onboard aircraft. The final result will be radically improved display of information as well as human-machine interface, thus achieving satisfactory level of compatibility and quality, precisely the one needed for the future CNS/ATM system.

In order to achieve all these goals radical improvement needs to be realised both in the air and on the ground, requiring significant deflection from the traditional techniques and technologies of the current ground-radar system. More precisely, automatic technical solutions are necessary onboard aircraft based on the technology which can support a whole spectrum of various applications.

The ADS-B system is based precisely on such technology which is in compliance with the principles of CNS/ATM system, thus allowing wide application both of this system and of a whole number of other sophisticated technologies based on it. Therefore, the ADS-B system represents the foundation of the future CNS/ATM system. The realisation of the basic principles of communication, navigation and air traffic monitoring can be presented through three functions of the ADS-B system.

4. ADS-B FUNCTIONS

4.1. Air-to-air function

The ADS-B system supports the CDTI technology. CDTI represents a very efficient way of displaying air traffic in the cockpit based on the data obtained by the ADS-B system, since every aircraft fitted with this system automatically emits information with data about its code call, position, speed, altitude, course and the planned flying route. In this way the pilot is provided with a safe selection of the most economic flying path

independent of the ground devices, increasing the safety since there is an overview of the whole traffic situation in the air, as well as in the intentions of other aircraft, thus making it possible to reduce the restricted aircraft separation minima regardless of the weather conditions, disburdening and increasing traffic capacity on approaches to landing. The display and processing of data obtained from other aircraft will additionally improve the mid-air collision avoidance system, as well as the aircraft or barrier proximity warning system, since calculation will be based on information about actual positions and intended paths of all aircraft in real time, and the possibility will be provided to display all information that is not in accordance with the flight plan of a certain aircraft. CDTI will also allow the display of meteorological data, such as stormy clouds, turbulence zones, etc. completing thus the image of the airspace and improving the quality and safety of flying.

4.2. Air-to-ground function

Apart from constant communication with aircraft, the ADS-B system provides the possibility of parallel communication with air traffic control centres on the ground. In this way the information containing data on the current and future (intended) aircraft path are received and processed at the air control centres, thus, apart from providing complete overview of the traffic process, further disburdens verbal radio-communication between the pilot and the controller, and provides the controller with timely signal of a possible occurrence of critical situations based on the data about the intended aircraft paths, at the same time offering possible solutions of traffic problems. Errors due to misunderstanding or not understanding are thus reduced to minimum. On the other hand, in order to disburden the controller and the possibility for the pilot to have a complete overview of the traffic situation regardless of the visibility, as well as due to the more efficient way of planning the traffic process, air traffic density may be increased along with the increase in the quality and safety.

4.3. Ground-to-ground function

As well as in the air, information about aircraft and also other airport vehicles fitted with the ADS-B system can be received, and thus the movement of aircraft monitored during their stay on the airport manoeuvring surfaces. This greatly increases and speeds up the guidance of aircraft from the runway to the parking position and vice versa, significantly increasing the traffic flow capacity on the ground and consequently in the air as well.

High-quality and reliable communication is of key importance for the functioning of the ADS-B system, including also the CNS/ATM system, allowing fast, safe and efficient exchange of data between the systems on the ground and in the air. To establish the functioning of the whole network of such communications represents a very complex task both in the technical as well as in the operating sense. Having this aim in mind, programs such as Eurocontrol Link 2000+ have been started, with the task of gradually introducing the ATN system (*Aeronautical Telecommunications Network*), as well as implementing it in air traffic. The ATN system represents precisely such global digital communication network which is in the final phase of improvement by ICAO, and whose aim is to replace the current fixed network AFTN (*Aeronautical Fixed Tele-communications Network*). Single elements of the ATN system, such as VDL digital communication links are being tested in operation. Thus the ADS-B system which is functioning by means of VDL (*VHF Data Link*) Mode 4 link, which along with high capacity of data transmission about the aircraft flight provides the possibility of transmitting speech (verbal) messages, and besides has also a wide range (more than 200 NM) and low power consumption, as well as complete independence of the ground systems, will fully meet all the requirements of the future CNS/ATM system.

5. CONCLUSION

The increased number of delays, traffic capacity restrictions, workload of the air traffic controller and the pilot, high costs, and indicators of constant growth of air traffic volume, all indicate clearly that there is a need for changes. Various improvements and additional upgrading of the existing air traffic control systems will not result in any major increase of the capacities, i.e. reduce the current costs of air traffic control system.

The existing problems require revolutionary solutions that will result in more efficient and automatic air traffic control system, which is precisely the vision of ICAO's CNS/ATM system. Certainly, the transition to such a new concept cannot be realised overnight, but rather needs to be based on the development and gradual operationalisation of new technologies and technical solutions that meet all the requirements of the future CNS/ATM system. It is precisely the ADS-B system which represents such a technology which, apart from being in accordance with the principles of the future CNS/ATM system, provides the basis for further implementation and the development of the whole number of other, similarly sophisticated technologies and applications (CDTI, VDL-Mode 4 etc.), insuring the whole future air traffic system further high-quality development.

The development and transition phases towards new concepts have to be realised before the current system collapses, and therefore the option of **"not doing anything"** simply does not exist.

SAŽETAK

ADS-B – SUSTAV AUTOMATSKOG NADZORA ZRAČNOG PROMETA

Sadašnji sustav zračnog prometa suočava se s mnogim nedostatcima i problemima što mu onemogućuje daljnji razvoj i praćenje trendova povećanja prometa.

Sustavi poput ADS-B preko svoje tehnologije stvaraju bazu za daljnju izgradnju, nadogradnju, unaprjeđenje i razvoj potpuno nove koncepcije sustava zračnog prometa na način da se preko svojih funkcija u potpunosti uklapaju i podržavaju osnovne funkcije komunikacije, navigacije i praćenja na kojima se temelji taj novi koncept kojega je potrebno početi primjenjivati što prije.

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