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AUTOMATIC DEPENDENT SURVEILLANCE (ADS)

ABSTRACT

The function, working principle, the principles of usage and the advantages of modern Automatic Dependent Surveillance system (ADS). The functions of the mentioned system are manifold and its primary function is to enable the automatic exchange of various data between air traffic control units with the aim of maintaining the safe separation of aircraft. Data such as call sign, aircraft position, time, altitude, vector information, speed, meteo information etc. can be forwarded periodically or on request, and are received automatically in the aircraft via flight management computer (FMC). Also, the overview of the possible communication systems which enable the usage of ADS is given, with special emphasis on ADS as part of further global development of navigation and air traffic safety system, which was approved by the International Civil Aviation Organisation (ICAO). Finally, a new, improved version of Automatic Dependent Surveillance, ADS - B (Broadcast) is briefly outlined, a version which enables omni-directional emission of addressed information.

KEY WORDS

ADS, ADS-B, CNS, ATM, FANS

1. INTRODUCTION

One of the main factors of further enhancement of air traffic safety is the existence of reliable communication and aircraft control devices, which are also a condition for the safe and efficient operation of air traffic control system. Such operation implies safe separation of aircraft and reliable pilot - air-traffic controller communication. Air traffic control aids are mostly communication systems which use very high frequencies (VHF) and whose range depends on the aircraft altitude, or surveillance radar systems installed in the continental airspace of various countries. In inaccessible continental areas, such as deserts or in oceanic airspace where the mentioned radar systems and navigational aids cannot be built, high frequency (HF) communication aids are used. These types of communication enable the operation of procedural air traffic control, which is based on aircraft reports and the knowledge of the exact aircraft positions and their flight plans. Due to very high purchase- and maintenance costs, radar systems and VHF navigation aids are not installed nor used in continental areas with low air-traffic density. Nowadays, navigation over oceanic and inaccessible continental areas is provided by modern independent navigational systems such as INS and satellite navigation (GPS).

To continue maintaining the necessary level of air traffic safety the International Civil Aviation Organisation (ICAO) has established the Special Committee on Future Air Navigation Systems (FANS), which should, as its name says, study, identify and assess new technologies and try to enhance the already existing navigation systems. This development and study is known under the name of Communications, Navigation and Surveillance/Air Traffic Management (CNS/ATM).

FANS is mostly based on the global satellite technology, and would enable further safe enhancement of air traffic density, accurate aircraft position determination and data transmission. FANS consists of the following subsystems: Automatic Dependent Surveillance, Aeronautical Telecommunication Network and Global Navigation Satellite System (Figure 1).

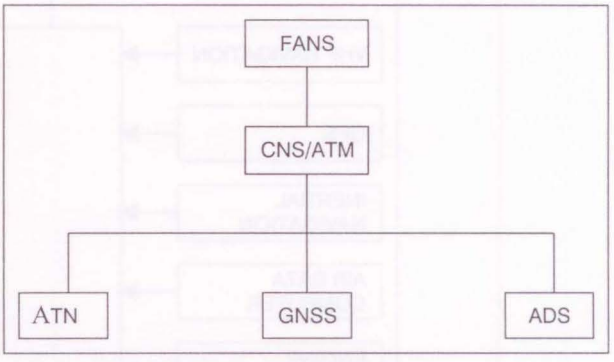

Figure 1 - FANS Structure

2. THE CONCEPT AND WORKING PRINCIPLE OF ADS

ICAO, the international aviation umbrella organisation and its Committee on FANS have prescribed

the implementation and usage of ADS and some other new navigation systems in three new documents:

- Circular 226 - Automatic Dependent Surveillance,
- Document 9694 - Manual of Air Traffic Services Data Link Applications,
- Circular 256 - Automatic Dependent Surveillance and Air Traffic Services Data Link Applications.

ADS is defined as an air-traffic control system which allows all the data necessary for the aircraft separation to be automatically transmitted via communication link to the appropriate air traffic services unit which has the control over the areas where only procedural air traffic control is performed. Thus, ADS becomes one of the essential factors for air traffic safety enhancement.

Data, received by the appropriate Air Traffic Services Unit from the aircraft, can be periodically or on request transmitted as two different reports, the so-called Periodic Report, and report on other pertinent information - Event Information.

Periodic Report is sent in precise, prearranged time intervals and contains two types of information: basic and optional information.

Basic information are those transmitted obligatorily: aircraft call sign, 3-D position of aircraft (geographic latitude and longitude and altitude), time stamp and Figure of Merit (FOM - value index which shows the accuracy of the information on the aircraft position).

Optional information, which the Air Traffic Services unit may ask for in addition to the basic one, is: the flight number, ground vector (ground speed, track, angle of decent or climb), air vector (IAS or Mach number, heading, rate of climb or descent), meteo information (wind speed and direction, temperature, turbulence), and projected profile (next way-point, estimated altitude at next way-point).

Report on other essential information includes the following data: current aircraft altitude while in climb or descent, navigation point that the aircraft is passing, deviation from the communicated heading.

ATS unit requesting some of the above mentioned information is the only unit that will receive the requested data, i.e. those data will not be transmitted via network to the other ATS units.

Data transmitted to the ATS units are obtained automatically, without the help or participation of the crew members, by using the Flight Management System (FMS), which calculates, processes and shows various data received from the different aircraft subsystems. Data displayed by the FMS are: navigational and aerodynamic data, engine performance data and the filed flight plan data.

Monitoring and processing of the new data is done by the Flight Management Computer (FMC - Figure 2), which enables the reception of the navigational data (e.g. GPS, INS, Loran-C), engine performances and the surrounding air. Data is directed to the screens of the Electronic Flight Instrument System (EFIS), known also as Primary Flight Display and Navigational Display, where the display of the data is renewed and it is also sent to the autopilot and to the auto-throttle. Two-directional exchange of data is performed by the - Control Display Unit (CDU). FMS

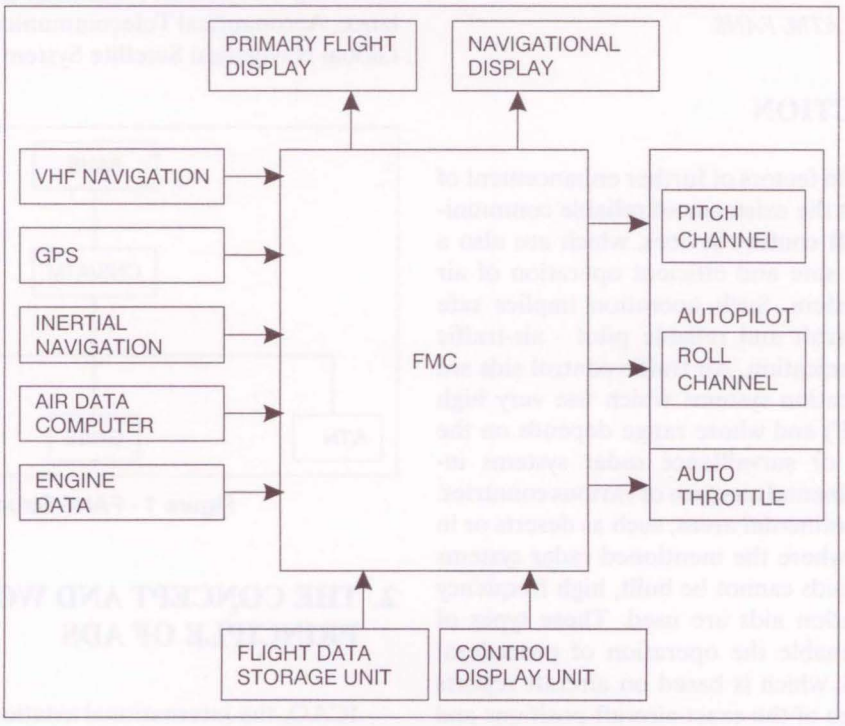

Figure 2 - Flight Management Computer

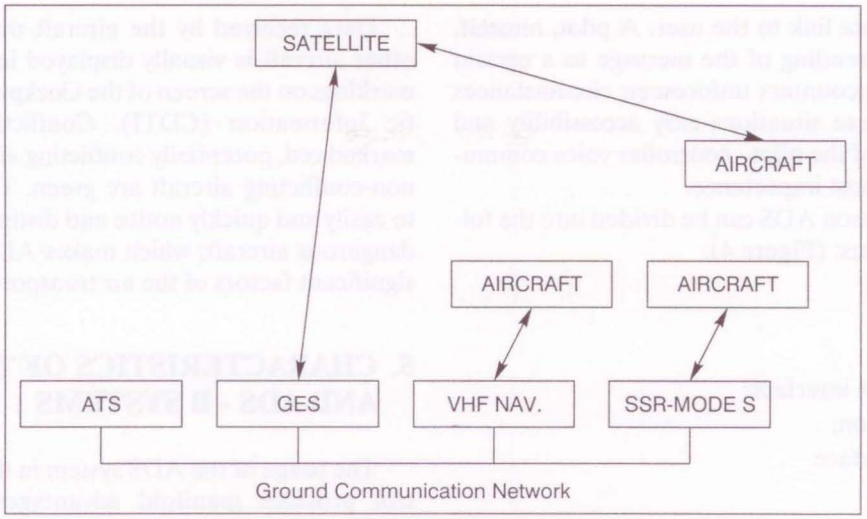

Figure 3 - Types of communication used for ADS

with the help of the autopilot controls the usage of the auto-throttle, it controls the speed, altitude and heading of the aircraft, and recommends the most efficient rate of descent or climb. Moreover, it recommends the most efficient cruising level. This recommended level, the pilot can accept only in co-ordination and upon permission of the air traffic control unit. FMS database contains two types of information: aircraft data and navigational data.

3. ADS COMPONENTS

ADS system can be divided into three subsystems: communication, ground-based and aircraft based subsystems.

Advanced ground-to-ground and ground-to-air communication systems are needed to transfers the data request, as well as, data itself from a certain ATS unit to the aircraft and back. ATS unit sends a data request directly without the action of the air traffic controller and is transmitted via Ground Communication Network to the indispensable station of the ADS system, called Ground Earth Station (GES) which the received request transfers to the satellite. For the data transmission to the satellite the SHF radio band is used. Then the request is transmitted to the wanted aircraft by using UHF radio band. When the request on aircraft data automatically reaches the, an ADS subsystem on-board the aircraft recognises it and sends the FMS stored data as an answer via same route to the ATS unit. This type of communication does not burden the pilot, nor require his/her direct participation and is made possible by the Air Traffic Management (ATM), whose subsystem ADS is.

It is important to emphasise that ADS system does not necessitate the existence of a satellite for its operation. It is possible to use ADS surveillance if the aircraft is within airspace with radar coverage (but the existence of Mode S transponder on board the aircraft is obligatory) or within the airspace with VHF of HF navigation aids. The possibility of usage of various communication aids can be seen in Figure 3.

According to the above mentioned, it can be concluded that the ground-based subsystem depends on the type of ground-to-air communication being used, and it consists of the Ground Earth Station, navigation aids VHF and HF radio band, Ground Communication Network and its users. The term users means air traffic control units and air companies. The users have the possibility to view the requested data on two screens. On the first screen the geographical map is shown with the exact position of the aircraft (altitude, geographical latitude and longitude) and its call sign, while the rest of the data is shown on the other screen.

Communication subsystem consists of the ground communication network (transfer of data ground-to--ground) and digital data link, which includes VHF and HF communication, satellite communication (ground-to-ground, air-to-ground, air-to-air), and the usage of Mode S with Secondary Surveillance Radar.

Aircraft-based ADS subsystem is represented by the already mentioned FMS, which automatically

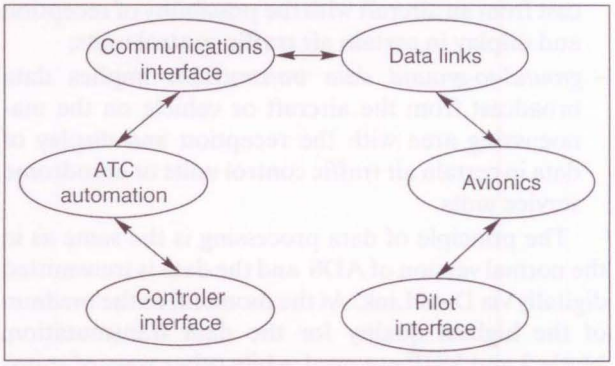

Figure 4. - ADS components

sends data via data link to the user. A pilot, himself, can activate the sending of the message to a certain user if aircraft encounters unforeseen circumstances or danger. In these situations easy accessibility and quick activation of the pilot - controller voice communication is of utmost importance.

That is the reason ADS can be divided into the following components: (Figure 4):
- pilot interface
- avionics;
- data link;
- communication interface;
- ATC automation;
- controller interface.

4. ADS - B SYSTEM

The abbreviation ADS - B stands for Automatic Dependent Surveillance - Broadcast. It is a more developed and recent version of ADS system, the real application of which will be carried out in the near future. This system, in contrast to the ordinary ADS which sends messages to the exactly specified address, periodically broadcasts the aircraft position (altitude, geographic latitude and longitude) obtained by GPS, call sign and vector information (heading, speed). Data is broadcast without a specified end-address within the specified airspace. Each aircraft in that airspace, if equipped with the necessary equipment, can receive and process the information on the aircraft that broadcast it. Thus, in the areas outside the radar coverage, where only procedural separation of aircraft is operated, each piece of data confirming the existence of other potentially conflicting aircraft is useful for the safety of the aircraft. The broadcast data can be received by other users, such as ATC units and airlines using the ADS - B ground station.

ADS - B is of threefold purpose:
- *air-to-air data transmission* implies data broadcast from one aircraft with the possibility of the reception and display of data in other aircraft;
- *air-to-ground data transmission* implies data broadcast from an aircraft with the possibility of reception and display in certain air traffic control units;
- *ground-to-ground data transmission* implies data broadcast from the aircraft or vehicle on the manoeuvring area with the reception and display of data in certain air traffic control units or aerodrome service units.

The principle of data processing is the same as in the normal version of ADS and the data is transmitted digitally via Data Link. At the moment, as the medium of the highest quality for the data transmutation, Mode S and VHF are used, while other ways of transmission are still in the research phase.

Data received by the aircraft on the position of other aircraft is visually displayed in multiple-colour markings on the screen of the Cockpit Display of Traffic Information (CDTI). Conflicting aircraft are marked red, potentially conflicting aircraft yellow and non-conflicting aircraft are green. This enables pilot to easily and quickly notice and distinguish potentially dangerous aircraft, which makes ADS - B one of the significant factors of the air transport safety.

5. CHARACTERISTICS OF THE ADS AND ADS - B SYSTEMS

The usage of the ADS system in the air traffic control provides manifold advantages. For example, ADS:
- provides accurate information on aircraft position, indispensable to the air traffic control units;
- enhances air traffic safety by maintaining safe separation;
- increases airspace capacity;
- enables ATS units easy identification and monitoring of aircraft via visual aircraft data display;
- alerts air traffic controllers to the conflicting and potentially conflicting aircraft;
- enables quick and simple transition to voice communication in case of danger or unpredicted circumstances;
- reduces air traffic controllers' work load;
- reduces frequency channel occupancy time;
- reduces system maintenance and operation;

The usage of the ADS - B shows the following benefits:
- automatic air-to-air surveillance;
- air traffic safety enhancement;
- enables controllers accurate knowledge of the traffic situation in the air;
- accurate monitoring of aircraft movement in the areas not covered by radar;
- reduction of aircraft delays during take-off and rolling;
- reduction of runway occupancy time.

Disadvantages of the ADS system are experienced in the inadequate global infrastructure coverage needed for the usage of ADS, and the fact that all aircraft are still not technically equipped to use ADS.

In Figure 5 a relation between the present surveillance system of aircraft and the system of air traffic control that is starting to be used (and is going to be used more in the near future) is shown. It can be concluded that the system of future will be more complex, with various different possibilities of pilot - controller communication and reliable identification of the exact position of the aircraft in the airspace.

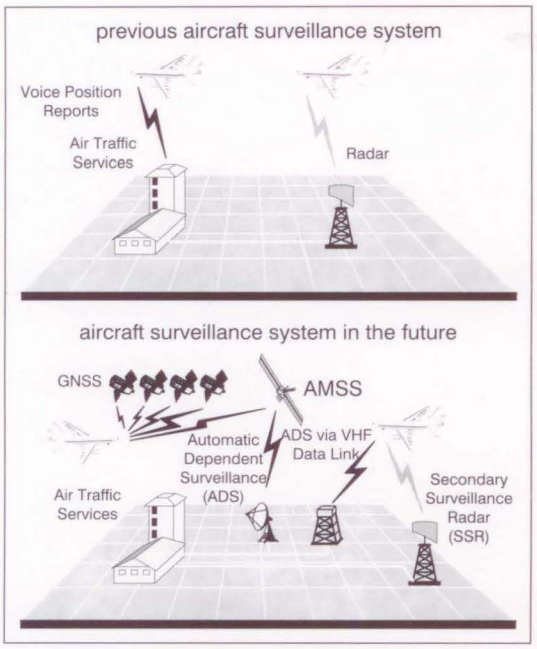

Figure 5 - Differences between the present and future surveillance systems

6. CONCLUSION

ADS and ADS - B systems represent a major breakthrough in the development of monitoring and air traffic control systems. Although the above mentioned systems will mostly find its application in the non-radar coverage areas (airspace over the oceans, deserts and other inaccessible continental areas), due to its good characteristics and cost-effective development, acquisition and maintenance, it will be possible to use them in all other airspaces. To make the application of ADS and ADS - S systems global, together with all the participants of the air transport being adequately equipped, there has to exist a series of international, legal bodies which will prescribe standards and recommendations for the regulation of implementation and application of each new aircraft surveillance system, such as ADS. ICAO and its FANS Committee have made significant steps in that direction prescribing the implementation phases and usage of ADS in three legally binding documents.

SAŽETAK

SUSTAV AUTOMATSKOG NADZORA ZRAČNOG PROMETA (ADS)

U tekstu je obrađena funkcija, načelo rada, način korištenja i prednosti suvremenog sustava automatskog nadzora i kontrole zračnog prometa ADS - Automatic Dependant Surveillance. Navedeni sustav ima višestruku funkciju, a primarna je omogućavanje automatske razmjene različitih podataka sa službama kontrole letenja u cilju održavanja sigurnosnoga razdvajanja zrakoplova. Podaci kao npr. pozivni znak, pozicija zrakoplova u prostoru, vrijeme, visina, vektor kretanja, brzina, meteo informacije i dr. mogu se prosljeđivati periodično ili na zahtjev, a dobivaju se automatski u zrakoplovu pomoću računala leta. Ujedno je dan pregled mogućih komunikacijskih sustava koji omogućuju rad ADS, uz poseban naglasak na ADS-u kao dijelu daljnjeg globalnog razvoja navigacije, te sustava sigurnosti zračnog prometa odobrenog od krovne Međunarodne organizacije za civilno zrakoplovstvo - ICAO. Na kraju je ukratko opisana i nova, poboljšana inačica sustava automatskog nadzora ADS - B (Broadcast), koja omogućuje svesmjerno odašiljanje adresiranih podataka.

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