



Modernisation of Avionics and C.N.S. Facilities

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Abstract— Last four/five decades have seen revolutionary development in the field of electronics, computer and automation. Naturally avionics and C.N.S facilities also have adopted these technologies to the best of their advantage. The present paper shows how these technologies have modernized the aircraft cockpit and how C.N.S facilities have been modernised to give smooth and safe flying. The description is based on author's observation of the development in civil aviation for the last more than four decades and future trends in this field.

Keywords— Negotiated trajectories, cockpit, stormscope, C.B. clouds, RAIM

I. INTRODUCTION

Avionics is a specialized branch of aeronautical/aerospace engineering. The term consists of aviation and electronics. It consists of the electronic system used on aircraft, artificial satellite, and spacecraft. Avionics systems comprise of communication, navigation, the display and management of multiple systems that are fitted to aircraft to perform individual functions.

It plays a vital role in modernisation like FAA's Next Generation Air Transport System (Next GEN), Europe 's Single European Sky A.T.M. Research (SESAR).

These programs provide-

1. Published routes and procedures resulting in improved navigation and routing.
2. Negotiated Trajectories- Adding data communication to create preferred routes dynamically.
3. Delegated Separation resulting in enhanced situation awareness in the air and on ground.
4. Low Visibility/Ceiling Approach/Departure resulting in allowing operations with weather constraint, with less ground infrastructure.
5. A.T.M. Efficiency resulting in improving the Air Traffic Management process.

Aircraft Avionics-It is in the cockpit of the aircraft and consists of control, monitoring, communication, navigational, weather and anti collision system. These are powered by 14 or 28 volts D.C. power supply. However, larger aircraft or military combat aircraft use A.C. system operating at 400 Hz. 115 volts A.C.

C.N.S. (Communication, Navigation, Surveillance) Facilities-Basically ground based C.N.S. Facilities are complementary to airborne avionics for smooth flight operation.

II. AVIONICS VENDORS

A list of international avionics vendors is given below-

1. Panasonic Avionics Corporation
2. Honeywell (now owning Bendix/King)
3. Rockwell Collins
4. Thales Group
5. GE Aviation Systems
6. Garmin
7. Parker Hannifin
8. Avidyne Corporation

III. COMMUNICATION

Communication connects the flight deck to passengers as well as to ground A.T.C. (Air Traffic Control). On board it is provided by P.A. (Public Address) system and intercom, Air to ground V.H.F. communication is provided in 118.00 to 136.975 MHz with channel spacing of 8.33 KHZ from adjacent channels for Europe and 25 KHZ for other places. V.H.F communication is used for line of sight propagation from aircraft to aircraft or aircraft to A.T.C. on ground. It is amplitude modulated and is in simplex mode. H.F. communication is also used for Tran's oceanic flight. Now a day's satellite communication is also used. ACARS (Aircraft Addressing and Reporting System) is also used.



IV. NAVIGATION

Radio navigation determines the position and direction of the aircraft on or above the surface of the earth. Avionics can use satellite based systems like G.P.S. (Global Positioning System) and WAAS (Wide Area Augmentation System), ground based systems like V.O.R. (V.H.F. Omni Range)/D.V.O.R. (Doppler V.H.F. Omni Range), LORAN (Long Range Navigation), D.M.E. (Distance Measuring Equipment) or any combination. Navigation systems calculate the position of the aircraft automatically and display it to the flight crew on moving map displays. With the development of multifunction receiver and on board flight management system all the facilities will be integrated into a single display.

Modern Cockpit Instrument Panel “glass” officially known as an Electronic Flight Information System (EFIS) or Primary and Multifunction Display (PFD and MFD respectively) is being manufactured by Garmin as G1000, by Avidyne as Entegra and by Chelton as flight Logic EFIS glass cockpits.

PFD shows basic flight information like air speed indicator, altimeter, heading indicator and course deviation indicator. A small map called “inset map” can be enabled in the corner. The buttons on the PFD are used to Squawk code on the transponder. PFD can also be used for enabling and activating the flight plans.

MFD shows a moving map on the right side and engine instrumentation on the left. Screens available from MFD in addition to map also include set up menu for information about nearest airports, NAVAIDS, Mode S traffic reports, terrain awareness, XM radio, flight plan programming and GPS RAIM prediction.

GLASS COCKPIT has GPS, communication and radio navigation components built directly into the system. Since it consolidates components in a centralized location it becomes costlier to repair and replace but due to modular components it reduces down time.

As an example we may take up Garmin Integrated Avionics Unit.

It is a combined communication and communication and navigation radio and also serves as primary data aggregator. It provides a two way V.H.F. trans receiver, a V.H.F. navigational receiver with glide slope, a GPS receiver and supporting processors. Each unit is paired with a GDU display which acts as a controlling unit. GIA63W is an updated version which includes Wide Area Augmentation System support. GTX32 transponder provides standard mode C replies to A.T.C. interrogations while GTX33 provides Mode S bi-directional communication with A.T.C. and therefore can indicate traffic in that area as well as can announce itself spontaneously via “Squittering” without prior interrogation.

V. AIRCRAFT COLLISION AVOIDANCE SYSTEM

To supplement A.T.C. most large aircrafts and some small aircrafts use traffic alert and collision avoidance system (TCAS), which can detect location of nearby aircraft and provide instruction for avoiding midair collision.

To help avoid collision in controlled flight into terrain (CFIT) aircrafts use ground proximity warning system (GPWS), which make use of radar altimeters. However, since GPWS only “looks down” and does not “look ahead” hence to overcome this problem modern aircrafts use a terrain awareness warning system (TWAS).

WEATHER SYSTEMS: Weather radar and lightning detectors are used. Heavy precipitation (as sensed by radar) or severe turbulence (as sensed by lightning detector) indicate strong convective activity or severe turbulence. Hence the pilot has to deviate around these areas. Since weather radar detects precipitation which is preceded by lightning, “stormscope” detects lightning earlier and can warn pilot beforehand to avoid C.B. (Cumulonimbus) clouds.

In addition to these information, extended radar pictures (such as NEXTRAD) are available through satellite data connections allowing pilots to see weather condition much beyond the range of their on board systems.

Modern displays allow weather information to be integrated with moving maps along with terrain and traffic conditions on a single screen simplifying navigation.

AIRCRAFT MANAGEMENT SYSTEM is used as described above.



VI. COMMUNICATION, NAVIGATION AND SURVEILLANCE FACILITIES

These facilities are the backbone of safe and efficient Air Traffic Management. Basically ground based C.N.S. facilities are complementary to airborne avionics for smooth flight operation. Even before take off pilots are briefed about the status of C.N.S. facilities, meteorological conditions, and any changes at the airport of departure or arrival, through NOTAM (Notices to Airmen). After take off till landing aircraft is always on air ground V.H.F. communication (voice or data) with the A.T.C. The V.H.F. line of sight communication is normally 200 N.M. After that the aircraft is in contact with the next airport or if there is no airport or it is in an oceanic region then it is in contact on H.F. or SATCOM..

Ground based navigational aids and Satellite Navigation System complements aircraft avionics so that pilots with the use of their instrumentation can fly precisely along the intended route and conduct precision approach and landing. Terrestrial navigational aids used are V.O.R./D.V.O.R. , D.M.E.(now a days M.S.S.R. Mode S coverage is also used) and landing aids like I.L.S., D.M.E. Progressive use of satellite based navigation system like G.N.S.S., W.A.A.S., GAGAN etc, are being encouraged.

VII. PERFORMANCE BASED NAVIGATION

Due to difficulty in providing terrestrial navigational aids along the air routes in view of non availability of suitable accessible sites (like forests, mountains, ocean etc.) and difficulty in getting skilled and trained manpower for maintaining these facilities satellite based communication and navigation is progressively being encouraged. Consequently P.B.N. concept has come up.

It is a future airspace strategy for modernization. This involves transition from airspace, air routes and instrument flight procedures (including holds) based on conventional navigational systems like V.O.R./D.V.O.R., D.M.E., N.D.B. to an airspace defined in terms of performance based navigation. It will be further developed to 3D and 4D user preferred trajectories. It will ensure global standardization of RNAV and RNP specification to avoid any proliferation of the use of navigation specification worldwide.

As per I.C.A.O. PBN Manual (Doc.9613) it is defined as

“Area navigation based on performance requirement, for aircraft operating along an A.T.S route, on an instrument approach procedure or in designated airspace where airborne performance requirements are expressed in navigation specifications in terms of accuracy, integrity, continuity and functionality needed for the proposed operation in the context of a particular airspace concept. Within the airspace concept the availability of GNSS Signal in Space (SIS) or that of some other applicable navigation infrastructure has to be considered in order to enable navigation application.”

PBN is described through RNAV and RNP applications with respective RNAV and RNP operations. PBN is one component of airspace concept. The others are Communication, A.T.S. Surveillance and A.T.M. PBN comprises of three components namely the navigation specification, the navigational aid infrastructure and the navigation application.

The navigation specification defines the performance requirements in terms of accuracy, integrity, continuity for proposed operation in a particular airspace. These specifications also describe how these performance requirements can be met. This results in indicating which navigational functionalities are required to achieve the prescribed performance. Associated with these specifications are the requirements related to pilot knowledge and operational approval. A navigation specification is either an RNP or RNAV specification.

AN RNP SPECIFICATION INCLUDES A REQUIREMENT FOR ON BOARD SELF CONTAINED PERFORMANCE MONITORING AND ALERTING WHILE AN RNAV SPECIFICATION DOES NOT.

The navigational aid infrastructure consists of ground or space based navigational aids, which have been specified in each navigation specification. The availability of the navigational aid infrastructure has to be considered to enable navigation application

The navigation application refers to the application of navigation specification and navigation infrastructure in the context of an air space to A.T.S. routes and instrument flight procedures.

NOTE: Precision approach and landing systems such as I.L.S., M.L.S. and G.N.S.S. Landing System (GIS) form part of navigational aids but are not included in PBN because they are not based on area navigation techniques. PBN IMPLEMENTATION: ICAO PBN Manual (Doc.9613) describes PBN concept, air space concept and how PBN concept is used in practice.



It provides implementation guidance for Air Navigation Service Providers as follows-

- (a) It describes on board performance monitoring, alerting and safety assessment.
- (b) Provides I.C.A.O. s' RNAV and RNP specifications which are to be used by States as a basis for certification and operational approval.

VIII. SURVEILLANCE

However, as an additional safety measure Air traffic Control uses surveillance systems as an independent means of monitoring the position of the aircraft and providing safe separation. The surveillance system may be co-operative or non co-operative. Co-operative systems communicate with the equipment on the aircraft like S.S.R. transponder and M.S.S.R. Non co-operative systems like P.S.R.(A.S.R., A.R.S.R.) locate the aircraft by transmitting pulses of radio waves which are reflected by aircraft hull, received at ground by radar receiver and processed to determine the position of the aircraft.

IX. A.D.S.B.

In U.S.A. NEXTGEN system each aircraft will use satellites to derive its position information and then broadcast to other aircrafts and A.T.C. After obtaining its position information, the aircraft will broadcast it on UTA (Universal Access Trans receiver) data link in U.S.A and on 1090ES (1090 MHZ. Extended Squitter) at other places in the world. So far it was done by traditional radar based surveillance of aircraft but instead of using the ground based radar to interrogate aircraft and determine their positions, each aircraft will use GPS to find its own position and then use it.

For this purpose aircraft must have a GPS receiver as a position source and a data link transmitter to actually send the ADS B data. GPS receiver should be IFR certified. In U.S.A. U.A.T. data link equipment will be required but for other places in the world 1090ES will be used.

Since most aircrafts use Mode S transponder for data link using the feature called "Extended Squitter" it can be transmitted on 1090 MHZ frequency. Thus Mode S transponder with extended squitter is the international standard for ADS B.

ACCURACY: Actually satellite derived ADS B aircraft position will be more accurate than ground radar derived position of the aircraft because radar updates position of the aircraft in 12 seconds (once in each rotation of radar antenna) whereas ADS B updates once every second and is based on WAAS GPS position information. So the more accurate position information will allow to reduce separation minimums.

X. CONCLUSIONS

Basically the requirement for modernization for avionics and C.N.S. facilities has come up in view of heavy air traffic. The pilot needs to be provided with all data and alerting system that he needs on a single display so that his work load reduces and he can perform safe flying. Similarly modernization of C.N.S facilities ensures safe, accurate and reliable complement to the aircraft avionics so that pilot performs flight operation smoothly. Satellite based communication and navigation systems will ensure operation even in difficult geographical terrains where terrestrial navigational aids are not feasible. However, vulnerability of GPS signals is another problem, which needs to be tackled by further research. To verify if pilots along with CNS facilities do not commit any mistake in misjudging the position of the aircraft surveillance systems are used which independently give the position of the aircraft to A.T.C. Primary radars can detect the position of non co-operative aircrafts also. Thus advance information will be available if they intend to do some mischief like 11th September 2001 incident or loss of track of Malaysian Airlines aircraft recently. Thus modernization is aimed at safer and better flights.

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