SPECIAL EFFECTS OF THE REGIONAL SATELLITE AUGMENTATION SYSTEM (RSAS)

This paper introduces the special effects of the new developed Regional Satellite Augmentation System (RSAS) as an integration component of the Global Satellite Augmentation System (GSAS) employing current and new Satellite Communications, Navigation and Surveillance (CNS) for improving Air Traffic Control (ATC) and Air Traffic Management and of GPS or GLONASS and enhancement of safety and emergency systems including transport security and control of aircraft freight, logistics and the security of the crew and passengers onboard aircraft and helicopters. The current infrastructures of the first generation of Global Navigation Satellite System (GNSS-1) applications are represented by old fundamental solutions for Position, Velocity and Time (PVT) of the satellite navigation and determination systems such as the US GPS and Russian (former-USSR) GLONASS military requirements, respectively. The establishment of Local satellite Augmentation System (LSAS) and Surface Movement Guidance and Control (SMGC) are also discussed as a special infrastructures in airports areas, integrated with existing and future RSAS and future GSAS.

1. Introduction

The current infrastructures of the GNSS applications are represented by old fundamental solutions for Position, Velocity and Time (PVT) of the satellite navigation and determination systems such as the US GPS and Russian (former-USSR) GLONASS military requirements, respectively. The GPS and GLONASS are first generation of GNSS-1 infrastructures giving positions to about 30 metres, using simple GNSS Receivers (Rx) onboard aircraft, and they therefore suffer from certain weaknesses, which make them impossible to be used as the sole means of navigation for aviation applications. In this sense, technically GPS or GLONASS systems used autonomously are incapable of meeting civil aeronautical very high requirements for Integrity, Continuity, Accuracy and Availability (ICAA) for ATC and ATM and are insufficient for certain very critical navigation and flight stages, so they have to be augmented. In addition, the RSAS mission cannot be managed without Aeronautical Mobile Satellite Communications (AMSC).

Because these two systems are developed to provide navigation particulars of position and speed in the airplane cockpits, only captains of the aircraft know very well their position and speed, but people in ATC are not able to get in all circumstances their flight data without service of new CNS facilities. Besides of accuracy of GPS or GLONASS, without new CNS is not possible to provide full ATC in every critical or unusual situation. However, augmented GNSS-1 solutions of GSAS network were recently developed to improve the mentioned deficiencies of current military systems and to meet the present transportation civilian requirements for high-operating Integrity, Continuity, Accuracy and Availability (ICAA). These new developed and operational CNS solutions are the US Wide Area Augmentation System (WAAS), the European Geostationary Navigation Overlay System (EGNOS) and Japanese MTSAT Satellite-based Augmentation System (MSAS), and there are able to provide CNS data from mobiles to the TCC via Geostationary Earth Orbit (GEO) satellite constellation [01, 02].

These three RSAS are integration segments of the GSAS network and parts of the interoperable GNSS-1 architecture of GPS and GLONASS and new GNSS-2 of the European Galileo and Chinese Compass. This includes Inmarsat CNSO (Civil Navigation Satellite Overlay) and new projects of RSAS infrastructures, such as the Russian System of Differential Correction and Monitoring (SDCM), the Chinese Satellite Navigation Augmentation System (SNAS), Indian GPS/GLONASS and GEOS Augmented Navigation (GAGAN) and African Satellite Augmentation System (ASAS). Only remain something to be done in South America and Australia for establishment of the GSAS infrastructure globally.
2. Flight Radio and AMSC System

The present mobile Aeronautical Radio Communications (ARC) for general international purposes has to be replaced by GSAS integrated with all RSAS networks worldwide to enhance cockpit-to-ground and vice versa voice and data traffic or even to employ Voice, Data and Video over IP (VDVoIP) transmissions, for both commercial and safety purposes. The ARC system uses a current service of HF and VHF/UHF radio RF bands. The main type of voice communications above the each FIR is HF (non-DCPC). Over land, VHF voice communications (DCPC) and VHF data link for D-ATIS/AEIS are used. This data link also uses the ACARS configuration, with a character transmission system (character-based). On the other hand, terrestrial communications use analog telephones and the Aeronautical Fixed Telecommunication Network (AFTN). This communication system has, like ACARS, been operational for over 20 years [03, 04].

![Figure 1. SELA Subsystem](image)

Courtesy of Book: “Global Mobile Satellite Communications” by Ilcev [03]

3. Wide Area Navigation System

The Wide Area Navigation (WANAV) system is a way of calculating own position using the Flight Safety Satellite Equipment (FSSE) facilities and installed air navigation devices to navigate the desired course. Until now, the airways have made mutual use of the FSSE, which often led to broken line routes. However, in the case of WANAV (RNAV – an original version) it has been possible to connect in an almost straight line to any desired point within the area covered by the satellite equipment and service.

In any event, setting the WANAV routes has made it possible to ease congestion on the main air routes and has created double tracks. This system enables more secure and economical air navigation routes [03, 05].

4. In Flight Special Effects of the RSAS Networks

The special effects of the RSAS networks used for secure communications, navigation, surveillance, logistics, ranging, tracking, control and management of air and surface traffic are Safety Enhancements in Low and High Altitudes, Reduction of Separation Minima, Flexible Flight Profile Planning and Surface Movement Guidance and Control.

These effects are very important to improve aircraft communication facilities in any phase of flight, enable better control of aircraft, provide flexible and economic flight with optimum routes, enhance surface guidance and control and to improve safety and security [03, 06].

4.1. Safety Enhancements at Low and High Altitudes

A very important effect of the new RSAS network is to provide Safety Enhancement at Low Altitudes (SELA) via GES, shown in Figure 1.

Current system for short distances between aircraft and GRS is provided by VHF voice equipment, so the pilot will have problems establishing voice cockpit radio communications when the aircraft’s flying position is in the shadow of high mountains. Meanwhile, all aircraft in flight can receive satellite navigation and communications even at low altitude and where there is no navigation and communications coverage due to mountainous terrain. This is very important for secure flying during bad weather conditions and reduced visibility. The RSAS system is able to
also provide Safety Enhancement at High Altitudes (SEHA) shown in Figure 2, by using faded radio or the noise-free satellite system [03, 07].

Figure 2. SEHA Subsystem

Courtesy of Book: “Global Mobile Satellite Communications” by Ilcev [03],

Figure 3. RSM Subsystem

Courtesy of Book: “Global Aeronautical CNS” by Ilcev [01]

4.2. Reduction of Separation Minima (RSM)

One of the very important RSAS navigation effects is the Reduction of Separation Minima (RSM) between aircraft on the air routes by almost half, as shown in Figure 3. The current system has an RSM controlled by conventional VHF/UHF and HF Radio and Surveillance Radar systems, which allows only large distances between aircraft. Besides, the new CNS/ATM system controls and ranges greater numbers of aircraft for the same air space corridors, which enables minimum secure separations, with a doubled capacity for control of aircraft. Hence, a significant reduction of the separation minima for flying aircraft will be available with the widespread introduction of the new augmentation satellite technologies on the CNS system [01, 08].

4.3. Flexible Flight Profile Planning (FFPP)

The next positive effect of RSAS spacecraft system is Flexible Flight Profile Planning (FFPP) of optimal altitude and route, shown in Figure 4. The current system uses fixed air routes and flying altitudes. At this point, the fixed route is controlled by the aircraft on-board navigation instruments only, which is a composite and not the shortest route from departure to arrival at the airport. Moreover, FFPP allows the selection of the shortest or optimum route and flying altitude between two airports. In this sense, with thanks to new wide augmentation satellite technologies on CNS system FFPP will be available for more economic and efficient flight operation. This means that the aircraft’s engines will use less fuel by selecting the shortest flying route of new CNS/ATM system than by selected the fixed route and altitude of current route composition [01, 09].

4.4. Surface Movement Guidance and Control (SMGC)

The new LSAS network can be also implemented as a Surface Movement Guidance and Control (SMGC) system integrated in any RSAS infrastructure. It is a special aeronautical security
and control system that enables an airport’s controller from Control Tower on the ground to collect all navigation and determination data from all aircraft, to process these signals and display on the surveillance screens. On the surveillance screen can be visible positions and courses of all aircraft in vicinity flight areas, so they can be controlled, informed and managed by traffic controllers in any real time and space. In such a way, the LSAS traffic controller provides essential control, traffic management, guide and monitor all aircraft movements in the vicinity of the aircraft, approaching areas to the airport, aircraft movement in airport, including land vehicles in airport and around the airport, even in very poor visibility conditions at an approaching to the airport. Thus, the controller issues instructions to the aircraft’s Pilots with the reference to a command surveillance display in a Control Tower that gives all aircraft position information in the vicinity detected via satellites and by sensors on the ground, shown in Figure 5.

Figure 4. FFPP Subsystem

![FFPP Subsystem](image)

Courtesy of Book: “Global Aeronautical CNS” by Ileev [01]

Figure 11. SMGC Subsystem

![SMGC Subsystem](image)

Courtesy of Book: “Global Mobile Satellite Communications” by D.S. Ileev [03]

The command monitor also displays reported position information of landing or departing aircraft and all auxiliary vehicles moving onto the airport’s surface. This position is measured by GNSS, using data from GPS and GEO RSAS satellites. An airport controller is able to show the correct taxiway to pilots under poor visibility, by switching the taxiway centreline light and the stop bar light on or off. Otherwise, the development of head-down display and head-up display in the cockpit that gives information on routes and separation to other aircraft is in progress. The following segments of SMGC are shown in Figure 11:

1) GPS or GLONASS Satellite measures the aircraft or airport vehicles exact position.

2) RSAS is integrated with the GPS satellite positioning data network. In addition to complementing the GPS satellite, it also has the feature of communicating data between the aircraft and the ground facilities, pinpointing the aircraft’s exact position.
3) Control Tower is the centre for monitoring the traffic situation on the landing strip around the airport’s environment. The location of aircraft and vehicles is displayed on the command monitor of the control tower. The controller performs ground-controlled distance guidance for the aircraft and vehicles based on this data.

4) Stop Line Light System is managed by the controller, who gives guidance on whether the aircraft should proceed to the runway by turning on and off the central guidance line lights and stop line lights as a signal, indicating whether the aircraft should proceed or not.

5) Ground Surveillance Radar (GSR) is a part of previous system for ATC of aircraft approaching areas, in airport and around the airport air environment.

6) Very High Frequency (VHF) is Ground Radio Station (GRS) is a part of ARC via VHF or UHF Radio communications system.

7) Ground Earth Station (GES) is a main part of satellite communications system between GES terminals and ground telecommunication facilities via GEO satellite constellation.

8) Aircraft Cockpit displays the aircraft position and routes on the headwind protective glass (head-up displays) and instrument panel display (head-down display) [01, 03].

7. Conclusion

The RSAS has been set up to identify the possible applications for global satellite CNS, safety and security and control of aircraft, freight and passengers and Search and Rescue (SAR) service in accordance with ICAO regulations and recommendations. The new aeronautical satellite CNS using GEO satellites with Communication and GNSS payloads for ATC/ATM is designed to assist navigation both en-route PA and NPA as well as during landing and in airports. The potential benefits will assist ATC to cope with increased air traffic and to improve safety and reducing the infrastructure needed on the ground. The Communication payloads usually at present employ transponders working on L/C, Ku and recently on Ka-bands for Digital Video Broadcast-Return Channel via Satellite (DVB-RCS), which can be used for RSAS and to connect all airports. Because that Ku-band is experiencing some transmission problems and is not so cost effective, there is proposal that Ka-band will substitute Ku-band even in mobile applications including aviation and maritime.

References

[05] MSAS, “MTSAT Update”, NextSAT/10 CG, Japan Civil Aviation Bureau, MSAS, Tokyo, 2009.