Design and Infrastructure of Space ICT via Stratospheric Platform Systems (SPS) for Aeronautical Applications – Part 2

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Abstract: In this paper is introduced design and infrastructure of Space Information and Communication Technology (ICT) via Stratospheric Platform Systems (SPS) for aeronautical applications, which has to provide communication and navigation data transfer for improved Air Traffic Control (ATC) and Air Traffic Management (ATM). Today there are in use two significant communication facilities, such as well known Terrestrial Communication Network (TCN) and Satellite Communication Systems (SCS), while SPS as an alternative has attracted the attention of the communication infrastructures worldwide. The new SPS networks are the latest space techniques with advanced technology for fixed and all mobile applications including military and rural solutions. The SPS unit is a station located as space object at an altitude of 17 to 50 km as a specified and fixed point relative to the Earth. The SPS systems employ unmanned or manned, solar or fuel energy airships or aircraft carrying payloads with transponders and antennas. The SPS networks and solutions are considered in this paper as a novel aeronautical application for providing Communications, Navigation and Surveillance (CNS) systems and techniques for any hypothetical flight air corridors and airport infrastructure. The CNS applications for development of aeronautical tracking, determination and transfer of Global Navigation Satellite Systems (GNSS) data via SPS, such as Global Aircraft Tracking (GAT), Space Data Link (SDL), GNSS Augmentation SDL (GASDL), Space Automatic Dependent Surveillance - Broadcast (SADS-B) and Space Automatic Identification System (S-AIS) are proposed.

Key words: ICT, SPS, ATC, ATM, TCN, SCS, GNSS, GAT, SDL, GASDL, SADS-B, S-AIS, WCS, IMO, SOLAS, VHF, SAS, GEO, MEO, LEO, CNS Applications

4. Airships SPS

Stratospheric Platform Systems (SPS) are the latest space technology integrated with cutting-edge CNS technologies for fixed and mobile applications, including military solutions. These systems are using unmanned or manned on solar or fuel energy aircraft and unmanned on solar power airships only, both carrying payloads onboard with transponders, antenna systems and Telemetry, Tracking and Command (TT&C) equipment.

With a few very cost effective remote controlled and solar powered airships as a better solution, a territory of some province, region or country can be covered for fixed and mobile applications including urban, suburban rural and remote areas, farms, forests and other environments with a low density of population. Today there are four general telecommunications architectures, which can be used to deliver broadband wireless local loop service to fixed and mobile consumers. Two of these architectures are space-based Geostationary Earth Orbit (GEO) and Non-GEO or Low (LEO and Medium Erath Orbit (MEO) satellite systems and the other two are terrestrial rooftop cellular-like millimetre wave repeaters and stratospheric relay platforms.

The new airship projects offer cost-effective special unmanned and non-fuel solar cell powered balloons with an estimated endurance of several months. In comparison aircraft and airship it is difficult now to say which one will be better for the future reliable SPS, such as SkyStation Global Network, SkyLARK Network, StratCon (StratoSat) Global Network, TAO Network, etc.

4.1. Sky Station Global Network

The Sky Station stratospheric airship system is being built by Sky Station International Inc. (SSI) and an international consortium of companies including Finmeccanica S.p.A. Alenia Aerospace of Italy, Thomson-CSF of France, Scaled Composites Inc. of the USA, Lindstrand Balloons Ltd. of the UK and Spar Aerospace of Canada. In fact, the new SPS technology known as Stratospheric Telecommunications Service (STS) will commence with the first Sky Station platform deployment in 2004. Sky Station platforms will be implemented in accordance with user demand, as expressed by responsible organizations in each country.

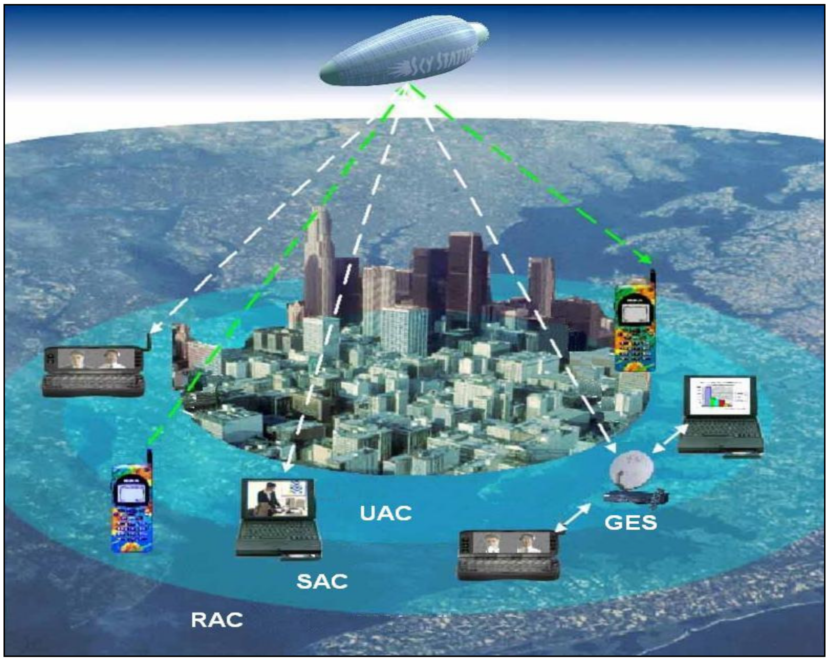

Figure 13. Sky Station Stratospheric Platform Configuration – Source: Sky Station International Inc.

Thus, Sky Station SPS network satisfies this demand by delivering personal T1/E1 broadband services to the mass 3G market at a lower cost than existing or announced alternatives. With data rates bursting to 2 Mb/s uplink and 10 Mb/s downlink, subscribers will enjoy high speed Internet browsing and hosting, as well as other broadband services, such as video conferencing. In **Figure 13** is shown the Sky Station Space segment, which comprises one spaceship with access link for three coverage ranges: Urban Area Coverage (UAC) - up to 75 km in diameter, Suburban Area Coverage (SAC) – up to 150 km in diameter and Rural Area Coverage (RAC) – up to 600 km in diameter. The ground segment includes several GES, mobile digital phone users, videophones, Internet access and E-mail service.

4.2. TAO (SkyNet) SPS Network

A Research and Development (R&D) program on SPS airship is in progress since April 1998. The final goal of this project is to realize the SPS airship system, being capable of an acceptable long-duration station-keeping flight at a stratospheric altitude of about 20 km. The achievements will enable advanced wireless fixed and mobile communications, digital direct broadcasting, modern broadband transmission and high-resolution observations and monitoring of the remote, rural and global environment. This advanced SPS program is promoted in collaboration with the Communications Research Laboratory of Japan (CRL), National Space Development Agency of Japan (NASDA), Japan Marine Science and Technology Centre (JAMSTEC) and the Telecommunications Advancement Organization (TAO) of Japan.

4.2.1. Airship Platform System Description

The stratospheric platform is an unmanned airship kept at a stratospheric altitude of about 20 km for multimedia communications and Earth observation purposes. It is equipped with communications payload, observation sensors or other equipment. The SPS system is designed similar to a satellite space segment as a relay station to receive signals from ground stations using feeder links and to retransmit them to subscribers using service links. Therefore, an airship like a satellite is carrying a payload with corresponding transponders and antenna system. The launch of SPS into position is much simpler than putting a satellite into any orbit.

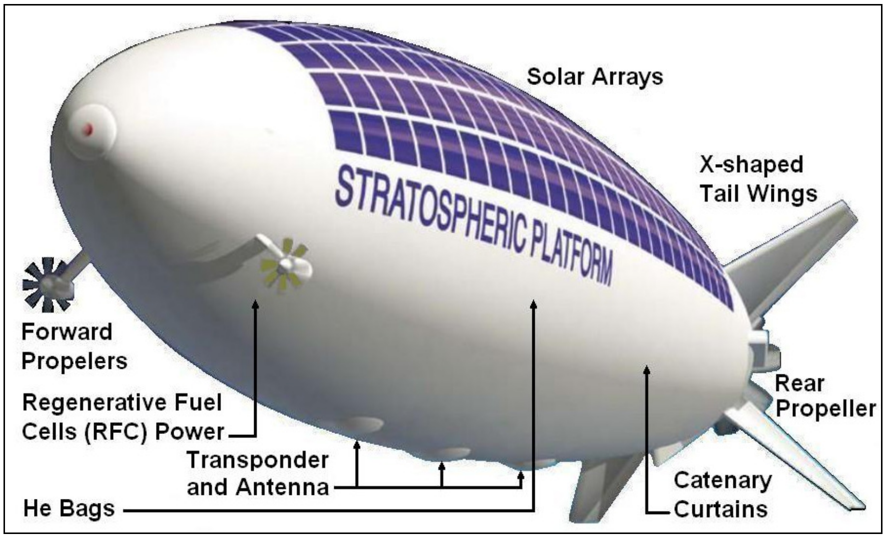

Figure 14. TAO Stratospheric Platform with Main Components – Courtesy of Book: by Ilcev

After careful preparation in the hanger space, the airship is launched in 4 Ascent phases through the troposphere and Interface location point in the stratosphere and finally, it shifts to the station-keeping position. The recovery phase goes in the opposite direction, namely, the airship is slowly moved from the station-keeping position towards the Interface point and from there descends down to the ground in 4 descent phases.

The airship construction has a semi-rigid hull of ellipsoidal shape, with an overall length of about 200 m, illustrated in **Figure 14.** It is composed of an air-pressurized hull for maintaining a fixed contour and internal special bags filled with the buoyant helium gas. Two air ballonets are installed inside the hull to keep the airship at a required attitude. For a load balance to the lifting force, catenary curtains are connected to the lower rigid keel, directly attached to the envelope. Propulsive propellers are mounted on both the stem and stern of the airship and tail fins are installed on the rear end of the hull. A solar photovoltaic power subsystem of solar cells and Regenerative Fuel Cells (RFC) is provided to supply a day/night cycle of electricity for airship propulsion.

The length of an airship SPS station in general is about 250 m and 60 m diameter. This is about 4 times as long as Jumbo jet passenger airplanes and so its weight is about 32 tons. Thus, 50% of the weight corresponds to those of structures and membrane materials. Hence, solar arrays and fuel batteries, related to the electric power system, are also heavy. And the weight of mission equipment is supposed to be about 1 ton.

The necessary condition for an airship to float at a certain altitude is that the gravity and buoyancy forces, which are exerted on the airship, are in a state of equilibrium. When the shape and volume of the airship are supposed to be constant, unlike a balloon, the buoyant force at an altitude of 20 km becomes about 1/15 that at sea level. Accordingly, a buoyancy of 15 times as much is necessary for equilibrium. Therefore, in order to float a SPS in the stratosphere, it is necessary to make the weight of the airship light and to make the buoyancy as large as possible. Inside the airship there are several internal bags filled with He gas to obtain enough buoyancy.

4.2.2. Network Coverage and Ground Segment

The main question of the future system is how many airships are necessary to cover all a particular territory or country and can this system is going to be global? Thus, to provide coverage for all the territory of Japanese islands will be necessary arrangement of 16 SPS stations and 6 to cover territory of the UK shown in **Figure 15**, under the condition of 22 km airship altitude with a minimum elevation angle of 10^{o}. A single airship can cover a certain service area independently, so that, for example, the service can be started from an area with a large population and the number gradually increased.

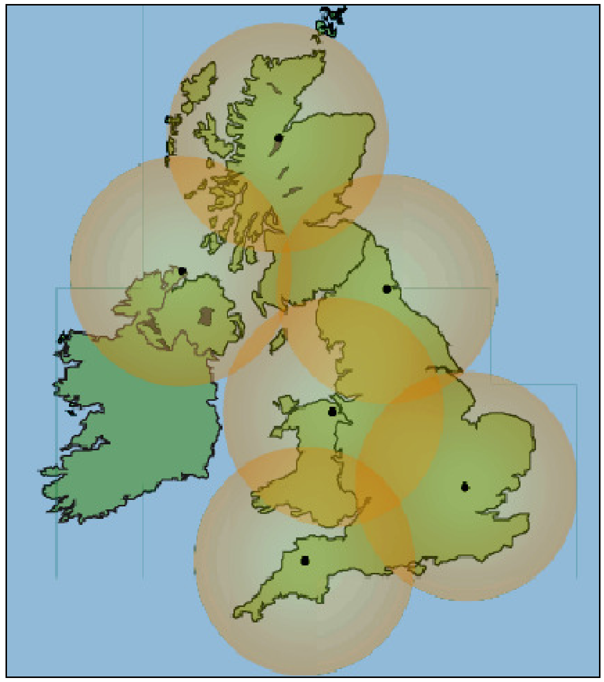

Figure 15. Possible Coverage of UK with 6 SPS – Source: by Ilcev

According to the general airship architecture f shown in **Figure 15**, it will be possible to cover the whole of South Africa with 6 SPS-type TAOs for CNS applications. In fact, according to **Table 2** here is proposed that footprint of one TAO airship covering South Africa has to be about 200 km at up to 25 km altitude and with a minimum elevation angle of 10°, whereas in the same way it will be possible under same conditions that 18 airships can cover Greece, including all the islands. However, the lower the minimum elevation angle, the larger the coverage area but the propagation or blocking loss becomes high at the edge of the servicing area. A practical minimum elevation angle for CNS is 5°, while 15° is more commonly considered in order to avoid excessive ground clutter problems. This possibility of flexible business development is one of the merits of SPS systems. The service area that one airship can cover generally depends on certain available numbers of Tx, Rx, antennas, methods of modulation and transmission and so on. Onboard the airship there is mission equipment to provide the following fixed and mobile communications services:

1. Earth observation/remote-sensing, disaster monitoring and meteorological observations;

2. Broadband communications and broadcasting are possible with small-sized and very low-power terminals, because of much shorter propagation distances compared with existing satellite systems. The system also needs reduced number of GES terminals, due to significantly better LOS conditions, less wave-blocking and multi-path effects compared with existing ground systems. Meanwhile, compared with satellite systems, the propagation distance is shorter by about 1/1800.

3. By establishing interplatform multimedia broadband links, high speed communications and broadcasting networks, comparable to optical fiber systems will be possible, which may enable the realization of novel communications and broadcasting systems.

4. Optimum system configurations are possible owing to the flexible operations of platform systems, which can enable expansion to a world communications system including digital TV broadcasting, broadband, DVB-RCS standards for VDV, Intelligent Transport Systems (ITS), GNSS Augmentation Integrations, Traffic Control and Management and so on.

Complete fixed and mobile broadband multimedia services for all applications are are already shown in **Figure 4.** Fixed terminals can be a self-contained PC in office with modem, or as an integrated part of an advanced LAN/WAN, laptop, fixed telephone in rural office or mobile or cellular phones via GES and Internet. Mobiles without LOS with SPS connected to GES can use visible SPS station and provide connection via IPL.

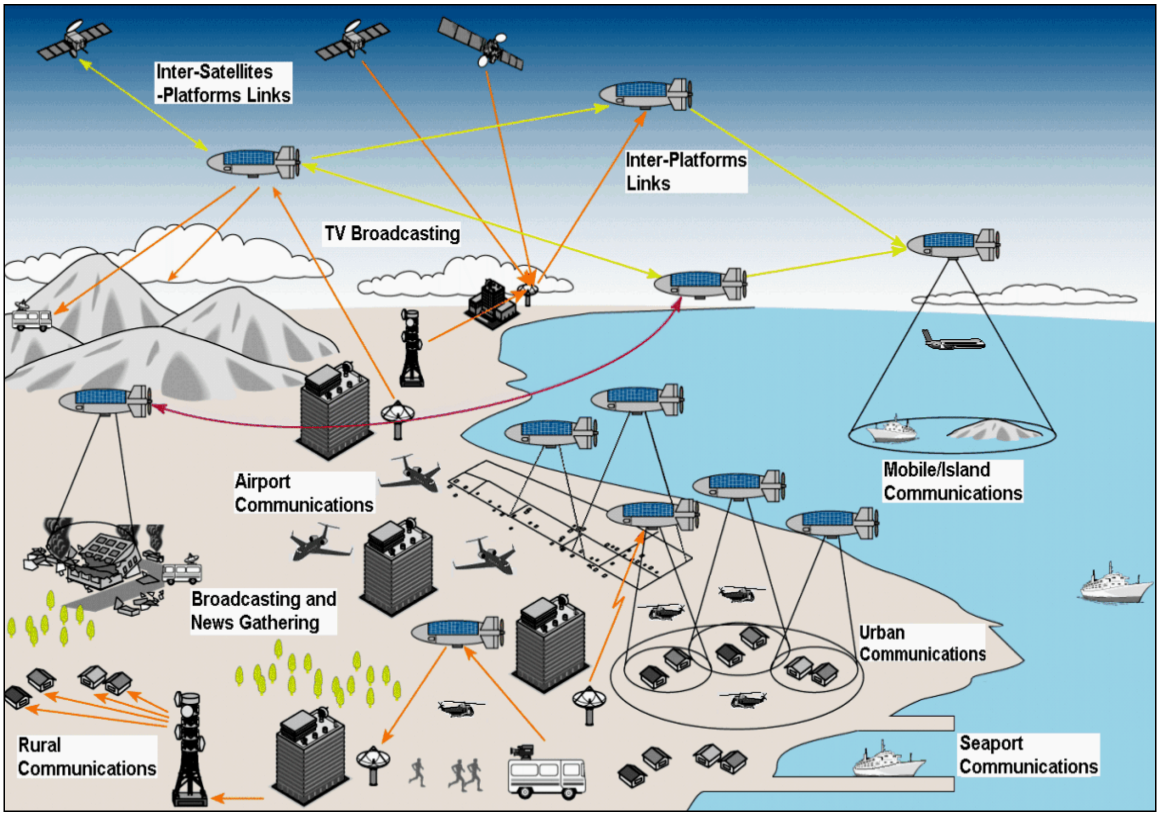

Figure 16. Systems Integration of SPS Networks with Satellite Constellations for Mobile Applications – Source: Ilcev

Mobile broadcast, broadband and multimedia access will offer maritime, land, aeronautical and personal handheld services including Platform News Gathering (PNG). Mobile terminals can be palmtop or laptop interfaced to the transceiver with adequate antennas or self-contained mobile or portable/in vehicle transceivers with auto tracking antenna and personal handheld terminals with built-in antenna. However, the SPS service also can provide GPS/GLONAS not augmented and augmented signals.Maritime mobile communications will provide two-way commercial, distress and safety communications for ships, fishing fleets and other kinds of boats integrated with GEO and GNSS systems. In the framework of this service, there will be additional activities like buoy and lighthouse control, marine pollution, maritime investigation and SAR missions.

Land mobile communications will provide services for all kinds of ground vehicles like buses, trucks and cars, including trains and personal mobile terminal, cellular service and emergency communications for natural disasters, which can be enhanced with equipment for tracking and GNSS facilities. The SPS has to substitute or integrate current cellular systems. Aeronautical mobile communications will provide commercial and distress service for all kinds of aircraft integrated with GEO, GPS and other GNSS to provide CNS service.

5. Integrated Satellite and SPS Networks

The SPS will be deployed together with terrestrial and GEO/MEO/LEO satellites networks to provide another degree of flexibility for system integration that can be easily adjusted to the needs of the all kind of transportation systems, network operators and users' traffic demands. In fact, SPCP terminals will play a complementary role in future mobile system infrastructure e.g. consisting of LAN and WAN, cellular and satellite mobile systems to ease the deployment and roll out of the 3G/4G and beyond 3G these services. In **Figure 16** is presented SPS and satellite integrated networks for all fixed and mobile applications, especially useful for airborne and airports communication systems.

Figure 17. Hypothetical SPS Network for Aeronautical Communications – Sources: Ilcev

The seamless integration of advanced multimedia services over heterogeneous networks is one of the key objectives in the development of future mobile communication systems. Anyway, satellites have played an important role in some niche markets, such as navigation and localization services, broadcast and some specific applications such as Earth observation and remote sensing. However, despite its advantages in terms of coverage and bandwidth, the level of penetration of fixed satellite communications in the current telecommunications infrastructure is still low. Two of the main limits in the performance of satellite broadband communications are the throughput degradation of TCP/IP over satellite links, as well as the limited satellite capacity in point-to-point mode.
While SPS present some advantages over satellite and terrestrial systems, as discussed earlier, although they present some limitations as well. For example, SPS coverage area is limited to a radius of approximately 200 km considering an elevation angle of 15º. Therefore, all these negative effects and disadvantages of GEO/MEO/LEO satellite and SPS systems will be lees presented if proper integration occurs in the future. In such a way this integration will offer more reliable and effective service worldwide, especially for mobile applications.

5.1. Integration of SPS Network for Local Aeronautical Communications

The trouble with the future developments usually is unpredictable and unacceptable for some institutions and nations, because simply they are not still ready for novels. In this context, to become commercial is necessary to increase funds for research and projects of SPS fixed and mobile networks. SPS is still a topic under research and development in many countries. To date, there is not an operating SPS network and not even a decision has been made for the choice of the platform. Some theories and practical trials have been proved, usefulness has been demonstrated and in principle the deployment of SPS will provide clear advantages, but unfortunately, technical, regulatory and operational issues have still not been resolved.
Within the SPS market, the SPS network is an essential for civilian applications use, but certainly is not the most important application for aeronautics. As already noted, this is just evidence that some institution and nations are not ready or they consider that SPS cannot overcome existing radio, cellular or even satellite systems. Besides, SPS operations in civil airspace are now being conducted worldwide. The development of SPS networks and operations for public and civil use is expected substantially to increase in the coming years. Although SPS standards to assist and guide regulatory development by individual ICAO member States is evolving, state laws and regulations for SPS operation and design are not yet in place. However, according to trends in aeronautical CNS systems is that SPS networks are very suitable for future aeronautical communications on medium and short distances, shown in **Figure 17.**

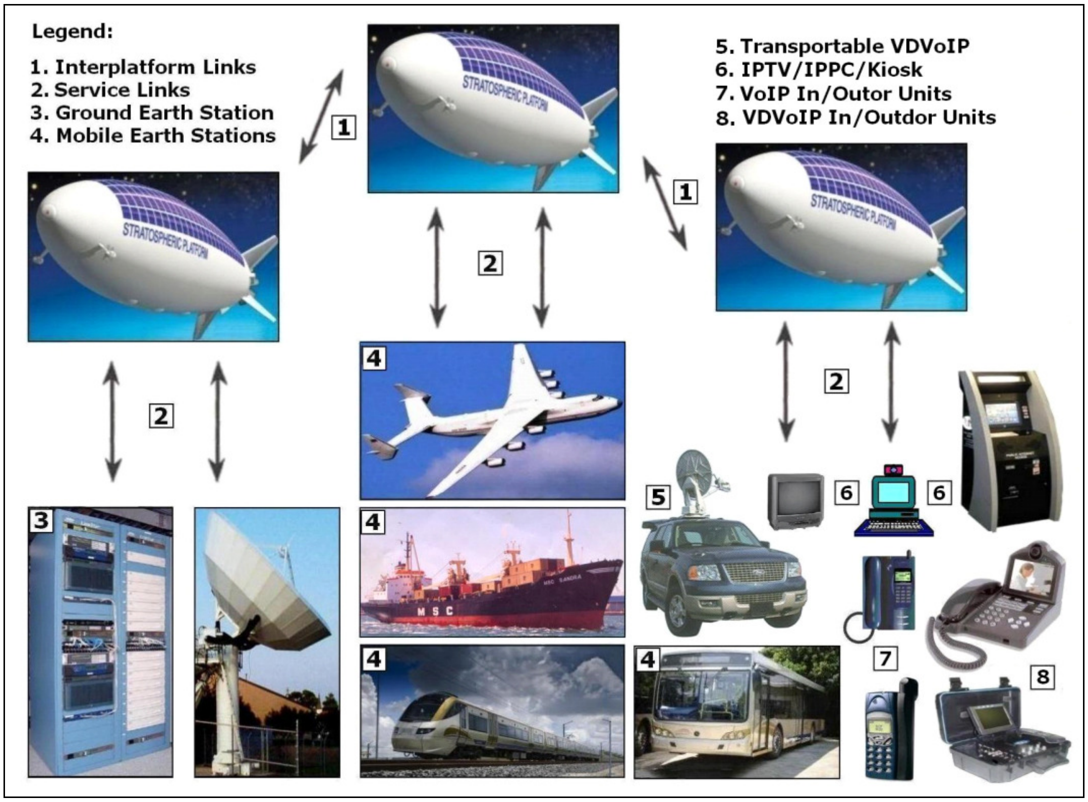

Figure 18. DVB-RCS Mobile and Fixed Networks via SPS Stations – Source: Ilcev

This solutions can substitute current VHF radio system or to be just sustainable back up for local area approaching to airports. The SPS network operations in civil airspace are now being available and will be conducted worldwide. The implementation of these unmanned operations for civil aviation solutions use is highlighted. A predictable technology for the next decade in the field of civil ATC and particularly for aeronautical CNS services based on SPS network is presented. The technological trends in the field of platforms and the communications and its impact on the world of SPS are finally addressed.

5.2. Integration of SPS with Aeronautical DVB-RCS Networks

The satellite architectures can be integrated with SPS airships to overcome some of the shortcomings of satellite communications, such as Interactive Digital Broadcast System (IDBS). The IDBS technique is used for the provision of Internet access via satellite, which is based on an asymmetrical configuration where the forward channel is typically DVB/MPEG-2. For both configurations, the satellite receives an aggregate traffic from single-user terminals, for which the SPS can be considered as a traffic filter. Therefore, SPS is forwarding to the satellite only the link-level packets, which are received error free, thus avoiding some transport level re-transmissions, which could pass through the satellite.

The SPS airship can also be used to avoid the access to the satellite when the user and the gateway station are under the coverage of the same SPS, enhancing satellite capacity. In **Figure 18** is illustrated the mobile and fixed network using as a relay SPS airships. The network can contents minimum 2 SPS airships connected between each other via optical inter-platform links. The integration of SPS terminals with Digital Video Broadcasting-Return Channel via Satellite (DVB-RCS) space system can provide symmetric and asymmetric DVB-RCH configurations.

In case of the symmetric DVB-RCH configuration the forward and return channels go through the SPS. At this point the SPS airship is relay between DVB-RCS GES and GEO satellite, so SPS is not considered for the feeder link. It is usually characterized by a lower BER than that of a satellite user terminal link.

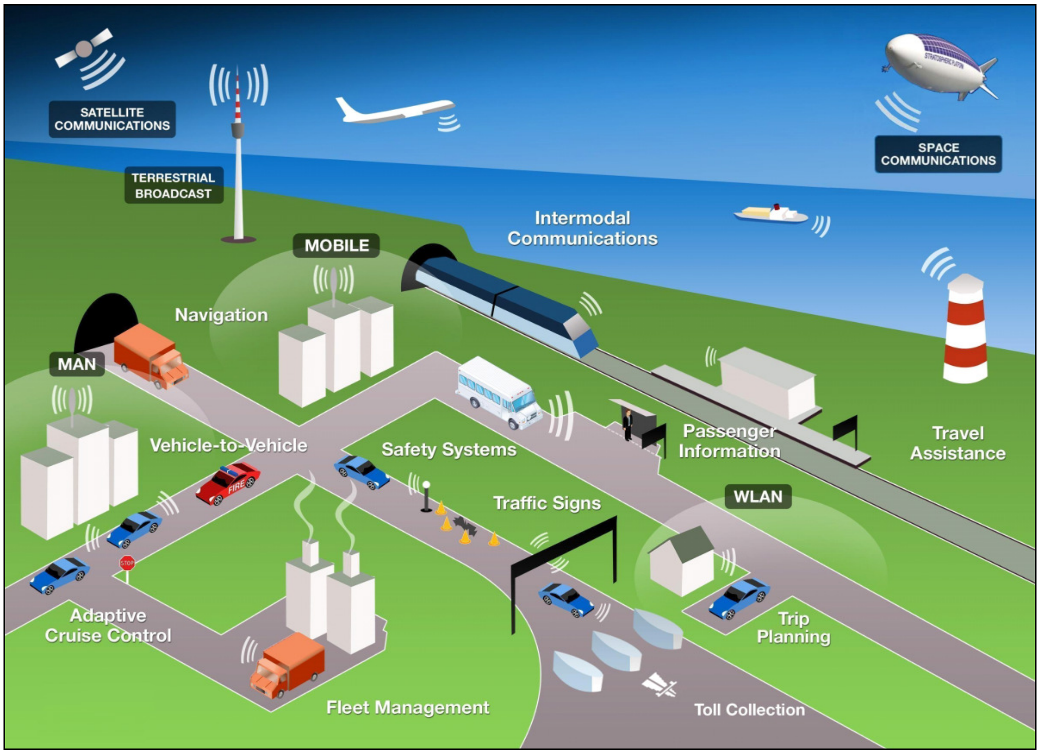

Figure 19. Intelligent Transport Systems (ITS) via SPS – Source: Ilcev

On the other hand, if another SPS airship is located as relay between GES and GEO satellite, the scenario includes SPS in the feeder link. The forward and return links are symmetrical at the user end, since both go through the SPS. The provision of services is split between SPS and satellite, however SPS units are used to provide mobile services, mainly voice, and broadband services to high-mobility users; whereas broadband services to fixed users are provided by satellite.
The asymmetric DVB-RCH configuration is designed that the forward channel for this architecture is the DVB/MPEG-2 transmission provided by a GEO satellite, whereas the return channel goes through the SPS airship. However, the return channel does not suffer from high congestion and low bandwidth, which is considered as an advantage. The SPS can be mainly used for to provide services to mobile users while the transfer of high data volumes is achieved through the satellite. In such a way, the role of the satellite is therefore related to the possibility of reducing the SPS-ground station link capacity requirements, with a consequent increase in the SPS–user link capacity.

5.3. Integration of SPS with Intelligent Transport Systems (ITS)

This integration includes telematics and all types of communication equipment in mobiles, between mobiles (mobile-to-mobile) and between mobiles and fixed locations (mobile-to-infrastructure). The ITS networks are not restricted to road transport only, they also include the use of Information and Communication Technologies (ICT) for rail, water and air transport including navigation systems, which is shown in **Figure 19.**
In general, the various types of ITS rely on radio services for communication and also use specialized technologies, such as GEO/MEO/LEO satellites and SPS transponders. Thus, Wireless Communications Systems dedicated to ITS for Road Transport and Traffic Telematics will provide network connectivity to vehicles and interconnect them. The railways industries have agreed to use GSM for the signaling on high-speed railways, as well as for conventional railways when interoperating across national boarders. Maritime applications support routine maritime operations, including navigation, as well as safety purposes at sea and inland waterways. Finally, aeronautical applications extend from professional services, such as ATC systems, flight CNS and safety system and service for crew and passengers via onboard Voice, VDV via Radio, Satellite and SPS links.

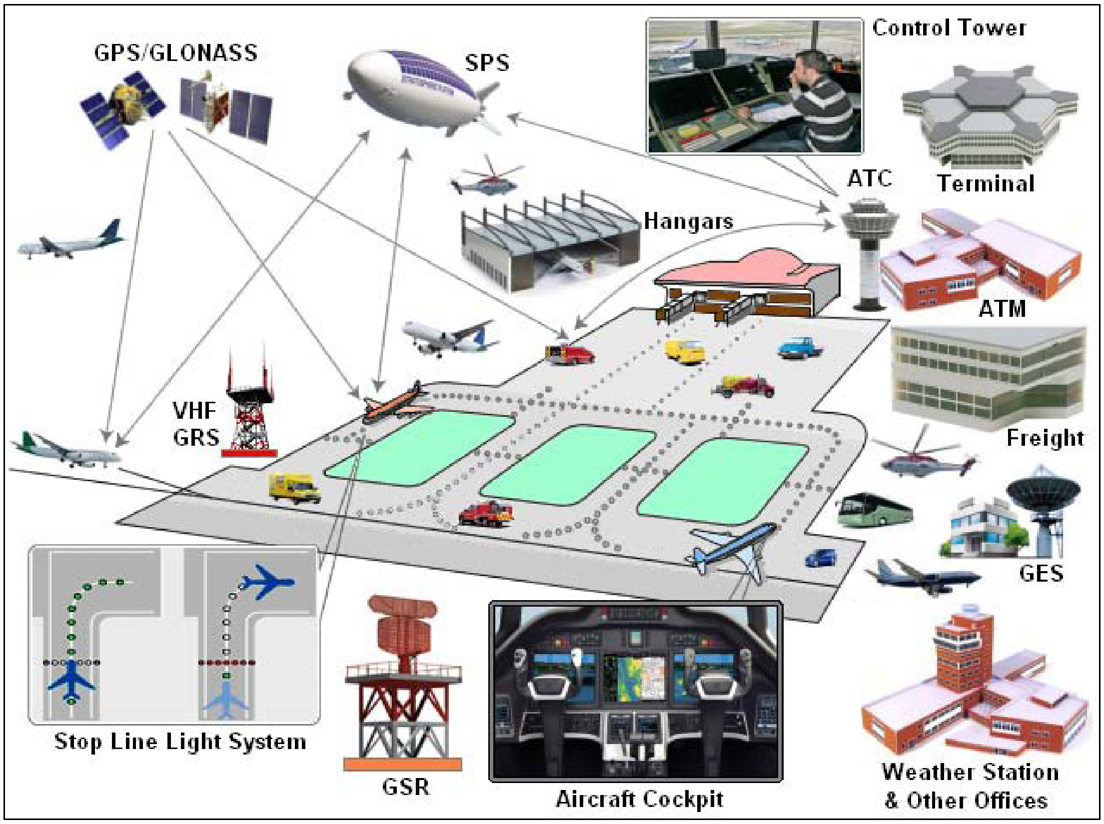

Figure 20. Aeronautical SMGC Subsystem via SPS Stations – Sources: Ilcev

5.4. Integration of SPS with Surface Movement Guidance and Control (SMGC)

The SMGC infrastructure is a special security and control system that enables a controller at ATC site to guide and monitor aircraft in air and on the ground, even in poor visibility conditions at approaching to airport. The ATC controller issues instructions to all pilots with reference to a command display in a control tower that gives aircraft current position information detected via satellite and by sensors on the ground. The command monitor also displays reported position information of landing or departing aircraft and all auxiliary vehicles moving onto the airport's surface. The airport's controller in Control Tower can collect all navigation and determination data from all aircraft, to process these signals and display on the surveillance screens, which shows positions and courses of all aircraft in nearby flight areas, outside of VHF radio and Radar ranges, so they can be controlled, informed and managed by traffic controllers in any real time and space.

In such a way, the ATC traffic controller provides essential control, traffic management, and guide and monitors 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 aircraft flying in very poor visibility conditions at an approaching to the airport. Each aircraft and land vehicles circulating on airport surface can have installed onboard special radio transponders known as GPS Receiver/Transceiver Unit using SPS station constellations. Thus, the traffic controller issues instructions to the aircraft's pilots or vehicle driver with the reference to a command surveillance display in a Control Tower that gives all aircraft position information in the vicinity detected via SPS stations and by sensors on the ground, which scenario is shown in **Figure 20.**

The command monitor also displays reported position data 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/GLONASS and SPS stations. 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. The development of head-down and head-up display in the cockpit that gives information on routes and separation to other aircraft is in progress.

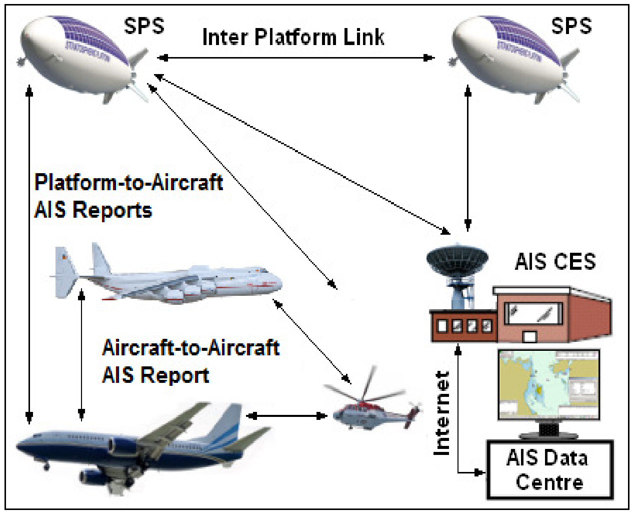

Figure 21. Proposed AIS via SPS – Sources: Ilcev

6. Automatic Identification System (AIS)

The modern determination technology today has developed Radio AIS (R-AIS) infrastructure using radio broadcasting solutions via VHF-band for maritime applications, and in the meantime is made proposal for maritime AIS via spacecraft satellites S-AIS. The similar technology can be proposed for aeronautical AIS using VHF ground stations and Satellite AIS (S-AIS). Thus, in the similar way is proposed the Platform AIS (P-AIS) via SPS using VHF-band, shown in **Figure 21.**

According to IMO regulations each vessel has to install onboard VHF AIS transponders, which automatically broadcast regularly to the coast station ships identification, like name, call sign and navigation data (position). This data is programmed when the equipment is installing onboard and also all this information is automatically transmit on regular basis. The signals are received by AIS transponders fitted on other ships or by Base Station at shore. The received information can be displayed on a screen or chart plotter, showing the other vessel's positions in much the same manner as a radar display. There are developed two types of VHF AIS Transceivers (transmit and receive), such as "Class A" and "Class B".

6.1. Proposed Aeronautical Automatic Identification System (AIS)

The aeronautical R-AIS can provide service via VHF ground Base Stations to collect all identification signals of aircrafts flying in the VHF coverage. The Base Station will forward this information to the AIS Data Centre and retransmit to all aircraft in its VHF coverage. In the same time all aircraft in the same VHF coverage can exchange their identification data. The identification signals can contain the name of aircraft, call sign, position, speed and altitude.

To spread AIS coverage can be use SPS as P-AIS as relay station to connect certain Base Stations in one region or country. Hence, the P-AIS scenario will work on the same way as R-AIS using VHF-band, shown in **Figure 21.** To provide more broad coverage can be used S-AIS via GEO, MEO and LEO constellations. At present Little LEO Orbcomm and some Nano-satellites are developing S-AIS networks via VHF-bands.

6.2. AIS Information Management System (IMS) via SPS Network

The AIS IMS via SPS constellation solution solves the increasing challenge that each sub-supplier needs his own data and communication infrastructure. The IMS network unites all data logging and communication into a single secure and maintainable solution. It gives the aircraft fleet owner control of the information flow and security for his fleet.

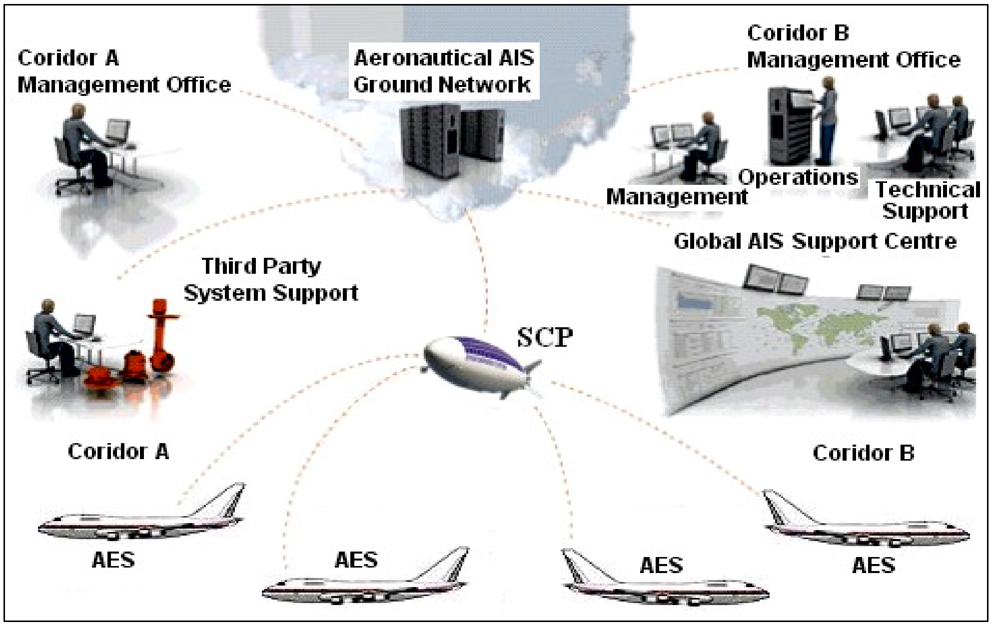

Figure 22. Proposed AIS Information Management System (IMS) via SPS – Sources: Ilcev

The IMS network can be developed for local or regional AIS space infrastructures as a collaboration platform for aeronautical applications. This network can be designed to enable continuous access to data both onboard aircraft and on the ground through an interactive Web based solution and to provide efficient information flow via SPS, shown in **Figure 22.** Thus, the AIS IMS network can use whether satellite or SPS constellation to provide more reliable coverage and communication of data. This system also enables secure and reliable information sharing between airports, aircraft and ground infrastructures.
The IMS via SPS provides a complete and up-to-date information portal for better traceability and quality of AIS communications between aircraft and ground facilities, improves decision making and support, reduces need for service personnel, improves troubleshooting, enhances safety and security through visualization and supervision and other features. The IMT service-oriented architecture enables an information highway for applications across control and to business systems including safety and security.

7. Development of CNS Systems via SPS Network

The development of CNS system via SPS network is important for support of tracking and determination solutions of aircraft in local environments or to support ATC in some airport area. In the following context will be introduced four significant CNS networks via SPS such as: GAT, SDL, GNSS Augmentation SDL and Satellite Automatic Dependent Surveillance.

7.1. Design of Network for Global Aircraft Tracking (GAT)

The GAT system has to be similar to the existing maritime Long Range Identification and Tracking (LRIT), which is compulsory system onboard ships established by IMO, as the best solution for vessel tracking worldwide. The system consists of the shipborne information transmitting equipment, the Communication Service Provider(s), the Application Service Provider(s), the LRIT Data Centre(s), including any related Vessel Monitoring System(s), the LRIT Data Distribution Plan and the International LRIT Data Exchange. The authors of this paper concluded that new acronym Global Ships Tracking (GST) is the more convenient designation than LRIT.
The ICAO and other aeronautical organization can establish similar system known as GAT employing small tracking equipment using existing satellite constellation of Inmarsat, Globalstar, Iridium or Orbcomm.

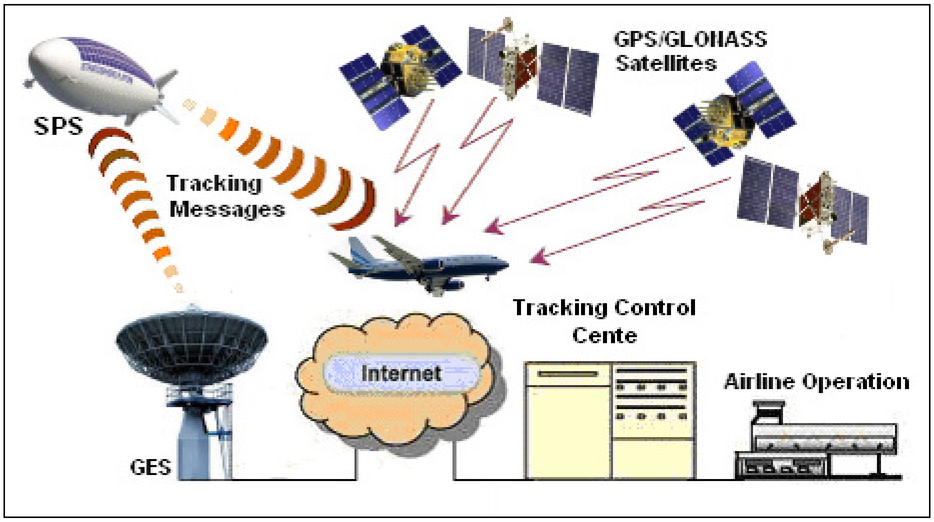

Figure 23. Global Aircraft Tracking (GAT) – Sources: Ilcev

The ICAO and other aeronautical organization can establish similar system known as GAT employing small tracking equipment using existing satellite constellation of Inmarsat, Globalstar, Iridium or Orbcomm. On the other hand GAT network can be established via SPS, shown in **Figure 23**. The GAT equipment onboard aircraft receives GPS/GLONASS signals and sends own position via SPS any short time interval to the GES, and via Internet to the Control Centre and Airline Operations. This is the best solution to help Search and Risqué (SAR) forces easily to find the rack of landed aircraft on the ground or at see. It is not appropriate in 21 century that SAR forces couldn't find Air France aircraft crashed in 2009 over Atlantic in 2 years and in area about 2-3000 miles. In fact, if this aircraft had onboard GAT, SAR forces should find him in about few hundred miles and in several days. The authors of this book also sent an official proposal to ICAO regarding development of GAT system, but they never sent a reply.

7.2. Space Data Link (SDL)

The SDL network is a part of total aeronautical communication solution for as follows:

1. SDL Tracking Messages Service – The concept of this service is similar to VDL Mode 4 system, shown in **Figure 24**, it is able to provide a satellite or SPS broadcasting and broadband link supporting communication, navigation and surveillance functions.

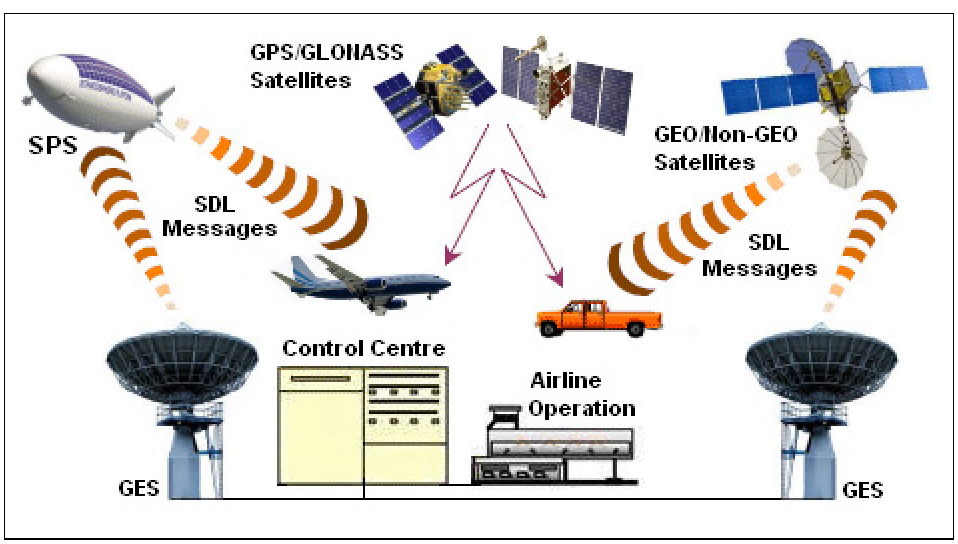

Figure 24. Satellite Data Link (SDL) – Sources: Ilcev

The SDL unit in aircraft of car is getting GPS/GLONASS signals and transmits Short Burst Messages (SBM) of position via GES to Control Centre and Airline Operation. Thus in mobiles, such as aircraft and surface vehicles, have to be installed radio transponders or tracker devices. Mobile transponders can operate autonomously inside the coverage of certain SPS or another SPS via inter-platform links.

The SDL transponder can support the similar services that provide VDL4. The transponder allows pilots and air traffic controllers to ”display” aircraft traffic in the air and on the airport surface including vehicle movements with the highest possible precision. The GES terminals can cover one or more SPS airships with overlapping coverage.

The GES units can easily interface with other surveillance systems through the standardized Asterix protocol, enabling a complete surveillance picture at the airport derived from several sources. Ground stations and a ground-based network will provide increased functionality and capability for wide area coverage of advanced ATM applications. The functionality of the ground station is tailored to system specific service applications by its software configuration.

2. SDL of SBM and High Speed Data (HSD) Service – Every aircraft and helicopter caring transponders or satellite communication devices will be able to send and receive SBD or HSD for CNS purposes. As part of our total aeronautical communications solution, ARINC Direct delivers its customers global SDL services and accurate AOC messages. Two-way text messaging, flight movement data, text and graphical weather, NOTAM alerts, and in-flight route planning are just a few of the applications made possible by Inmarsat and Iridium satellite services around the world. Both operators also provide valuable redundancy for satellite services while requiring minimal equipage or upgrade costs, creating a cost-effective and vital communications service for aircraft. ARINK Direct also provides real-time information on departures, destinations, movement times, engine parameters, delays, positioning, maintenance and winds aloft.

7.3. GNSS Augmentation SDL (GASDL)

The Regional Satellite Augmentation System (RSAS) network infrastructure is a combination of ground and space equipment to provide augmentation of standard GPS or GLONASS signals, shown in **Figure 25.** The functions being provided by RSAS are:

The RSAS network infrastructure is a combination of ground and space equipment to provide augmentation of standard GPS or GLONASS signals. The functions being provided by RSAS are:

- Differential corrections are determined to improve accuracy;
- Integrity monitoring is predisposed to ensure that determination errors are within tolerable limits with a very high probability and thus ensure safety; and
- Ranging is proposed to improve availability.

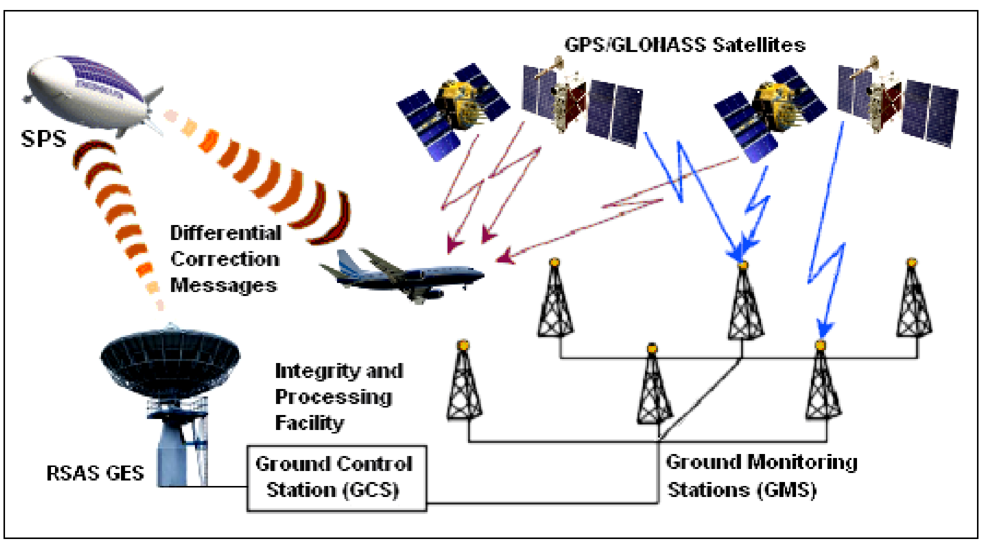

Figure 25. GNSS Augmentation SDL (GASDL) – Sources: Ilcev

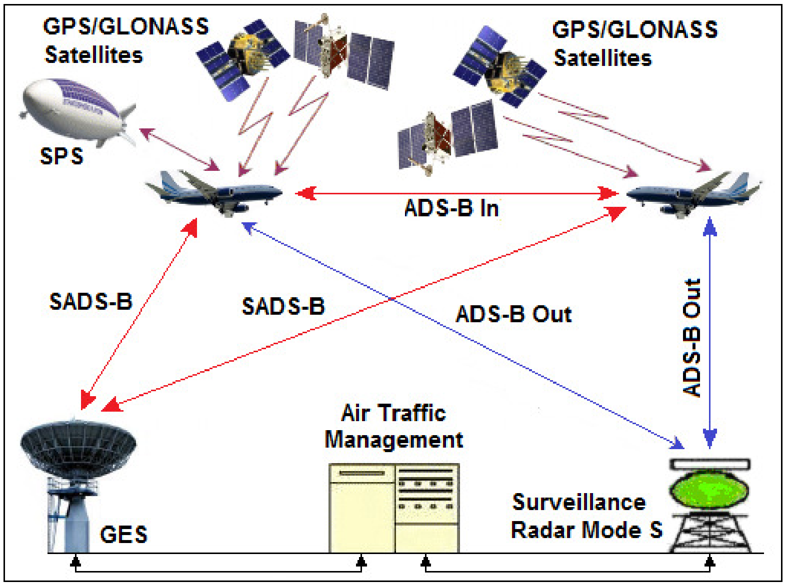

Figure 26. SADS-B Application – Sources: Ilcev

The numbers of Reference Stations or Ground Monitoring Stations (GMS) are receiving not augmented signals of GPS or GLONASS satellites, processing and forwarding this data to Master Station or Ground Control Station (GCS). The GCS terminals process the data to determine the differential corrections and bounds on the residual errors for each monitored satellite and for each area.

Therefore, GCS network is providing determination of the clock, ephemeris and ionospheric errors (ionospheric corrections are broadcast for selected area) affected during propagation. The corrections and integrity information from the GCS terminal are then sent to each RSAS GES and uplinked to the SPS airship.

Thus, these separate differential corrections are broadcast by RSAS GES through SPS data link via GNSS transponder at the same frequency used by not augmented GPS receiver. Augmented GPS Rx is receiving augmented signals of GPS and determined more accurate position of aircraft. Not augmented GPS Rx can also receive augmented signals if is provided an adequate software or hardware.

The most important stage in this network is to provide technical solution that augmented position of aircraft can be sent automatically via SDL or voice to GES and Control Centre. Finally, these positioning signals can be processed by special processor and displayed on look like radar display, whish traffic controller is using for ATC and ATM.

7.4. Space Automatic Dependent Surveillance - Broadcast (SADS-B)

The Automatic Dependent Surveillance (ADS) system is a surveillance technique in which aircraft automatically provide, via a data link, data derived from onboard navigation and position-fixing systems, including aircraft identification, four-dimensional position and additional necessary data as appropriate.

The SADS-B system is a modern space broadcasting from aircraft to provide position, velocity, altitude, positional integrity, flight identity, 24-bit aircraft address and other data that have been detected and computed by onboard aircraft sensors.

Typical SADS-B application is similar to the Radio ADS-B (RADS-B) with differences that the SADS-B network is covering long distances and is using service of GES, shown in **Figure 26.** A single GES can provide coverage in the areas of one or more SPS airships for enroute, terminal, and aerodrome surface surveillance. The SADS-B system requires new equipage onboard aircraft and for airport infrastructure. The accuracy and integrity of SADS-B is subject to the source of the navigation data (usually GNSS).

8. Conclusion

The SPS networks and stations are very cost-effective solutions for aeronautical CNS systems, tracking, determination and AIS applications in areas not covered by VHF-bands. The SPS doesn't need many ground facilities and huge expenses for launch and technical maintenance as spacecraft does. Similar to all satellite networks, between SPS airships can be arranged inter-link, so in this case applicability of such system becomes more efficient and the need of ground station will be reduced. Moreover, the SPS payload can be equipped by some extra equipment to provide more safety and security of flight. The problem is that out of SPS coverage has to be employed any satellite constellation to cover oceanic flights.

The main objective of SPS networks is to provide azimuth and elevation angle, similar to satellite, as well as to provide higher speed than mobile and TCN, including Fibre Optic Networks (FON). Through SPS, it will be possible to implement new Ultra-High-Speed (UHS) data transmission techniques of vortex beams transmitting 2.5 Tb/s, real-time superchannel transmission of 1 Tb/s superchannel transmission over oceanic optical OFDM distances over 10,000 km and the first worldwide transpacific transmission of 16 KAM signals. Also, the SPS network tested the world's first transpacific transmission of 16 KAM signals, photonic networks and optical time multiplexing (OTDM) systems ranging from 10 Gb/s to 10.2 Tb/s over 29 km, laser beam communication and laser light speed communication.

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