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SPACE SERVICES BENEFITS IN AVIATION SYSTEM (S^2BAS)

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Current trends in air transportation show that the General Aviation traffic will expand in the future. The development of regional and small airports is expected to become a priority in the near future. In this respect, new National and European transport policies aim at increasing people's mobility while reducing transportation time, costs, and environmental impact by transferring air traffic towards areas/sites served by small airports. As a matter of fact, a considerable number of aircraft used for business and/or private tourism would utilize small airports in Europe if these airports were properly equipped with adequate support services. At the moment, small airports capabilities are restricted, due to the absence of traditional surveillance and air navigation services such as Instrument Landing System and control tower services, which are typically too expensive for small facilities with limited and sparse traffic.

In this context, Techno Sky - an Italian company leader in air navigation services - is in charge of an innovative project in partnership with the Integrated Applications Promotion (IAP) programme of the European Space Agency. The S^2BAS (Space Services Benefits in Aviation System) demonstration project aims to develop, deploy and demonstrate the provision of an integrated set of satellite-based cost-effective services targeted to small and regional airports capabilities. The set of integrated satellite-based services includes i) the provision of GNSS (Global Navigation Satellite System) based navigation assistance in the terminal area to assist flight approaches; ii) an advanced way for the production and distribution of up-to-date Obstacle Charts by means of satellite based Earth Observation data; iii) the management of remote airports through satellite communications, including the monitoring of real-time air traffic in the vicinity.

Considering the unique added-value and cost-effectiveness of the satellite based solutions applied to this purpose, an operational roll-out of the mentioned services after the completion of the project is forecasted. When available at operational level, it is foreseen that the S^2BAS services will support the growth of both commercial and tourist air traffic, and will contribute to the development of civil aviation as an alternative to road and rail transportations. This paper presents the results obtained and the challenges faced during the first phase of the project, provides technical insights about the space assets considered and discusses the added-value of the proposed solution with respect to the users' needs.

INTRODUCTION

The S^2BAS (Space Services Benefits in Aviation System) demonstration project aims to develop, deploy and demonstrate the provision of an integrated set of satellite-based cost-effective services targeted to small and regional airports.

The S^2BAS Project Team is lead by Techno Sky (a company part of the Italian Air Navigation Service Provider, ENAV) and includes other 8 companies that encompass all expertise necessary to the success of the project. The Project Team is composed by the following companies, their main contributions being: ***Techno Sky*** (Management, System Engineering and Demonstration), ***Nextant*** (System Engineering and System Deployment),

IDS (Concept and Operation and System Engineering), ***Telespazio*** (GNSS Signal Integrity and Satellite Communications), ***e-Geos*** (Earth Observation), ***Laboratorio Tevere*** (Navigation and Communications), ***Centro Studi Demetra*** (Legal Aspects), ***BIP*** (Business Aspects) and ***SlamAir*** (Concept and Operation and Demonstration). Moreover, S^2BAS is supported by several external organizations including the Italian Regulatory Authority (ENAC), the Italian ANSP (ENAV) and the Italian Aero Club Authority (Aero Club d'Italia).

The project is composed of 2 phases: Phase 1 (Definition) and Phase 2 (Demonstration). This paper reports the status of the project.

CURRENT SYSTEMS AND THEIR EVOLUTIONS

The following section presents background information about the available existing solutions, their known limitations and the trends of evolution in the aviation sector.

Air navigation aids and GNSS (Global Navigation Satellite System) in the aeronautical domain

Flight navigation and landing assistance is traditionally provided by ground based systems such as Non-Directional Beacons (NDB), VHF Omni-directional Range (VOR), Distance Measuring Equipment (DME).

However GNSS based navigation is rapidly increasing and is expected to become, in the near future, the primary mean for navigation and landing according to the ICAO GNSS Implementation Strategy as it provides a reliable and cheaper alternative compared to the above.

Flight Information Service

Traditionally aeronautical and meteorological information are provided by means of a Flight Information Service (FIS) that provides information on aerodromes and airspace, traffic, weather and potential hazards to the flight.

Recent years have seen several international initiatives to significantly improve the flexibility of FIS.

Remote Airport Management

"Remote Airport Management" (e.g. Remote Towers) is an innovative operational concept currently under investigation in the most recent ATM innovation programs of US (FAA's NextGen initiative) and Europe (SESAR initiative).

At small and mid-sized airports, traffic is unevenly distributed over the day, with occasional peaks when the workload is higher. Instead of keeping several air control towers and airdrome handling centres open, resources can be co-located and managed remotely from a common control centre and therefore increase safety and achieve economy of scale.

Flight Procedures

Nowadays most small airports in Europe are only provided with VFR (Visual Flight Rules) procedures. As mentioned earlier, with the introduction of navigation rules based on GNSS technologies, more and more of these small airports will use GNSS based procedures in the future. Cost-efficient tools and smart processes to generate and update these new procedures are needed.

Obstacle Chart preparation

To ensure the required level of safety, ANSPs (Air navigation Service Providers) are periodically required to perform expensive campaigns aimed at producing the so-called Aerodrome Obstacle Charts. Obstacle Chart map buildings, trees and all other landscape elements having a relevant elevation over the ground in the airfield vicinity

Currently these campaigns are mainly performed by the use of expensive aero photogrammetric techniques and site surveys by means of traditional topographic techniques.

THE S^2BAS CONCEPT OF OPERATIONS

S^2BAS focus is on improving the underutilization of many of the European small airports and airfields, moving them into a customized airspace concept with tailored services.

Consequently aircrafts that fly between small airports will need to be suitably equipped for navigation, surveillance and communication capabilities and better awareness of meteorological situation.

The S^2BAS solution aims at making small airports compatible with a customized Airspace Concept that will reduce procurement and maintenance costs, making it "low cost" and "highly safe".

The general philosophy underlying the new S^2BAS Airspace Concept is the establishment of an area of flight operations called SCA (Self Contained Area), which is a cylindrical volume surrounding one small airport containing entry and exit operations to or from the ground surface. This volume shall be defined for each specific airport or group of small airports, and shall take into account aspects like terrain, obstacles, traffic density, and noise abatement procedures.

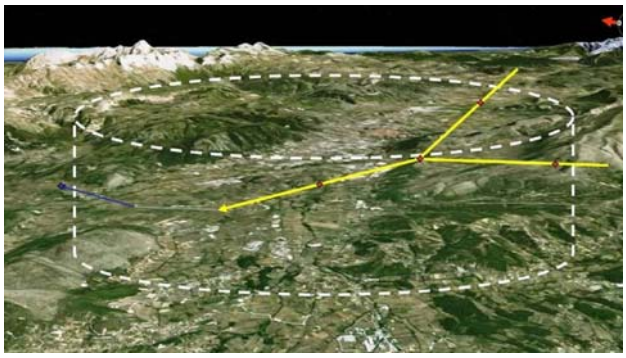

Figure 1: Example of Self Containment Area

Inside this volume, free flight and self-separation (safety distance) between S²BAS equipped aircraft will be allowed in all Visual Meteorological Conditions (VMC). To reach this goal the aircraft within the SCA will be provided with the following real-time information:

- Surrounding air\ground traffic information
- Aerodrome Information
- Ground services information
- Meteorological Information
- Aeronautical Information
- Environment (e.g. Tourist information).

In S²BAS parlance such information is called General Information and is delivered to the pilots through the "General Information Service" (GIS). S²BAS "General Information Service" will consist in extending the concept of provision of traditional Flight Information Service.

A specific office called Automatic Virtual Information Office (AVIO), will serve a cluster of unmanned airports to provide aircrafts with the General Information Service. This office will be i) mostly automatic since it will not generally require any human intervention, ii) virtual since it will provide the required information without being a physical information office iii) remote since it will manage a cluster of unmanned airports.

EXPECTED BENEFITS

The key benefits that S²BAS system will deliver are:

- Increase of the traffic volume served
- Increase of the accessibility to the territory
- Extend the surveillance coverage beyond the limits of NRC (Non Radar Coverage)
- Increase aircraft categories allowed to fly in severe weather conditions and during night on small airport
- Improve of the on board navigation aids
- Optimize of the airport resources.

USER NEEDS

The project consortium has identified a set of stakeholders that would directly or indirectly benefit from the S²BAS services:

- General Aviation (GA) Pilots
- ANSP (Air Navigation Service Providers), NCAA (National Civil Aviation Authorities)
- Aircraft Operators, Heli-Assistance, Aeroclubs
- Civil Protection
- Airport Operators, Airport Ground Handlers
- Regions, Provinces, Municipalities.

Stakeholder representatives were contacted to gather useful insight regarding actual operational experience and needs. An extract of the stakeholders view is presented hereafter.

The General Aviation (GA) Pilots consider improvements of operations and services at small airports mandatory to overcome current limitations and increase operational activity of these categories of airports. According to their opinion these services are to be provided by suitable low-cost avionic and communication systems in an integrated manner.

They consider these services should focus on:

- Safety improvement
- On flight awareness increase: availability of surrounding traffic information
- Provision of Aeronautical and Meteorological Information
- Provision of Touristic Information regarding local airport area and related events.

They consider safe navigation assistance and the availability of digitized GNSS based VFR procedures (e.g. used for transfer and approaches) as very important.

In parallel, interviewed ANSP representatives recognized that, according to current flight rules and scenarios, small aerodromes are underutilized because the costs for fitting traditional equipments is too high with respect to the volume of traffic managed.

According to ANSP representatives, situation awareness (i.e. knowing what is happening or will happen around the aircraft) can surely be improved through more effective information management. The following information categories have been considered key to improve VFR pilots' and Air Traffic Services officers' (ground officers) situation awareness:

- Traffic Information (position and heading of neighbouring aircrafts)
- Meteorological and touristic information in the vicinity of the Aerodromes.

NCAA are positively convinced that:

- Satellite navigation systems is the best solution to improve the flight operation for small and low cost aircraft;
- Satellite technologies, already used by Commercial Aircraft Pilots during flight operation, are a reliable support for small aircraft;
- Satellite information allows the knowledge of aircraft position with high accuracy and reliability.

Assumed this, they are also convinced that:

- new available technologies, as well as new regulations are considered a great contribution to increase the safety level of air activity;
- the desired integrated satellite based technologies will play an important role to support flight operation in all weather conditions even where ATS (Air Traffic Services) and Information Services are, today, not completely available as well as will be the best way to promote the growth of both commercial and tourist air traffic as a valid alternative to road and rail transportation.

Aircraft Operators, Heli-Assistance, Aeroclubs and Civil Protection consider as positive aspects:

- the establishment of advanced flight courses, aimed at current needs and demands of the work market, which include (besides the use of traditional navigation systems) the use of new CNS/ATM (RNAV/GNSS) systems for instrument flight (IFR);
- the strengthening of flight school, by increasing the number of basic VFR courses and adopting training methods that include newly developed pseudo-instrumental flight techniques;
- the enhancing of touristic activities, also through the use of airplanes equipped with new generation avionics.

Airport Operators and Airport Ground Handlers are positively impressed by the possibility to improve with a unique solution airport operational capabilities (in terms of resources utilization, efficiency, safety for minor airports) and get the best by airport capacity growth in terms of economical benefits.

Regions, Provinces and Municipalities think that satellite navigations will offer a good opportunity to support flight operations and related ground services. They consider of high importance:

- an integrated use of satellite-based technologies to allow regional and minor airports to play a more important role;
- the provision of an integrated set of satellite-based low-cost services targeted to small and regional airports (both "manned" and "unmanned") to promote the growth of both commercial and tourist air traffic.

SATELLITE ASSETS CONTRIBUTION

In S^{2}BAS, space assets are mobilized at three levels (as show in Figure 2):

- for the provision of GNSS (Global Navigation Satellite System)/EGNOS based navigation assistance in the terminal area to assist flight approaches;
- for the detection of ground obstacles in the airport vicinity (so-called Obstacle Charts) by mean of satellite based Earth Observation data;
- for the remote monitoring and management of isolated airports and airfields through satellite communications.

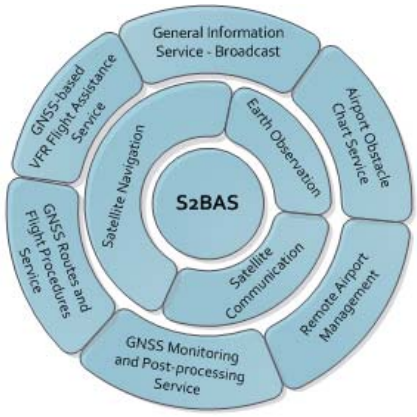

Figure 2: S^{2}BAS space assets and services

S^{2}BAS SERVICES

The S^{2}BAS system shall provide its users with the integrated set of services listed below:

GNSS routes and flight procedure definition

This service is responsible for the generation and distribution of the GNSS flight procedures.

Airport Obstacle Chart Services

This service is responsible for the generation and distribution of Airport Obstacle Charts using images from the COSMO-SkyMed satellite constellation.

General Information Service

This service is responsible for the provision of General Information to S²BAS equipped aircraft. General Information encompasses aeronautical, meteorological and environment (e.g. tourist) information, air/ground traffic information, aerodrome information, ground services information.

This service extends the concept of the traditional Flight Information Service.

Airborne GNSS-based VFR Flight Assistance Services

This service is responsible for the provision of flight support to pilots using a satellite-based navigation system capable of visual assistance (2D, 3D) regarding the position, the attitude, the route, the air traffic, the terrain and the obstacles charts of the interested airports.

(Remote) Airport Management Services

This service is responsible for the management of S²BAS equipped airports resources and allows the operator to visualize the position and identification approaching/leaving aircrafts as well as the position and status of the airports resources on a dedicated HMI (mobile objects whose position is of interest).

GNSS Monitoring and Post-processing Services

The GNSS Monitoring service is responsible for both real-time and off-line monitoring of the GNSS signals received in the SCA with the aim of verifying their integrity.

The Post-processing service shall allow a S²BAS operator to consult and query data to assess performances of the S²BAS (by the use of proper analysis tools).

The picture below (Figure 3) highlights the relationships among each S²BAS service and the flight phase the service is related to.

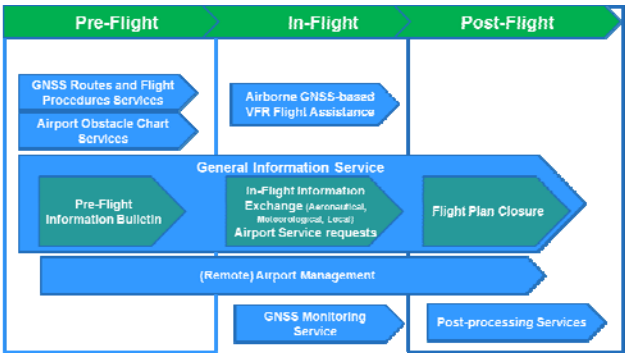

Figure 3: S²BAS services versus Flight Phases

SYSTEM ARCHITECTURE

The S²BAS is composed of an airborne segment and a ground segment. The airborne segment consists of the equipment/subsystems to be deployed on-board of the aircraft and the ground segment consists of the equipment/subsystems to be deployed at unmanned airport sites, ground central information processing and distribution nodes and Automatic Virtual Information Offices (AVIOs). Finally, part of the ground segment is composed of an off-line environment aimed at designing GNSS Procedures and Obstacle Charts. Figure 4 provides an initial breakdown of the S²BAS.

The **On-Board segment** is composed of an On-Board NAV/COM Unit and a Cockpit Display.

The On-Board NAV/COM Unit broadcasts aircraft data (identification, current lat/long position, geometric height and ground speed) to other aircrafts and to the S²BAS ground segment. It receives GIS-B (General Information Service - Broadcast) data from the S²BAS ground segment and aircraft data broadcasted by other aircrafts in its surroundings.

The Cockpit Display provides the pilot with:

- CDTI (Cockpit Display of Traffic Information);
- a 2D/3D SVS (Synthetic Vision System) displaying terrain, obstacles, navigation routes and navigation visual aids;
- a presentation of GIS-B data (aeronautical, meteorological and general purpose information).

Furthermore it allows pilots to formulate and send service requests (e.g. to automatically turn-on ground lighting system) to the S²BAS ground segment.

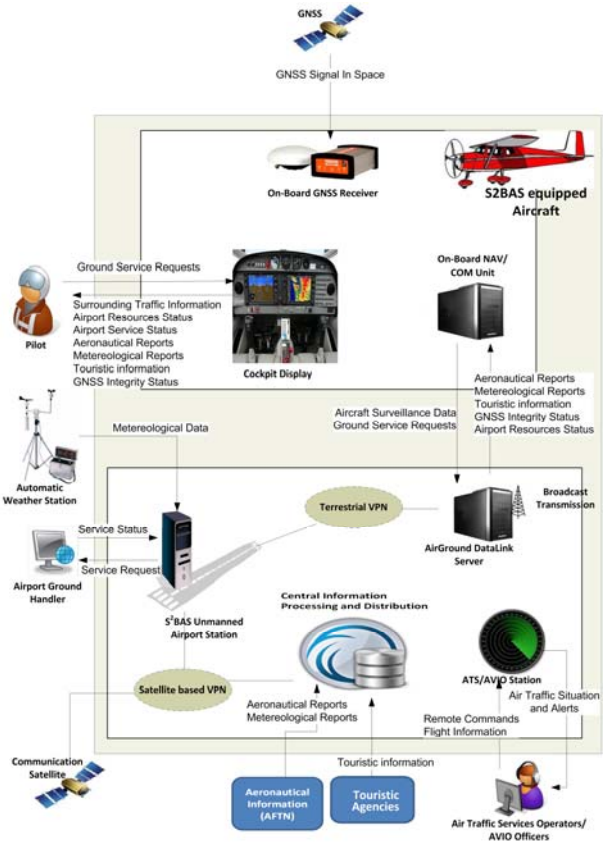

Figure 4: S^{2}BAS System Architecture

The **Ground segment** is composed of Unmanned Airport Stations, Air/Ground DataLink Servers, a Central Information Processing and Distribution system and ATS/AVIO Stations.

The "S^{2}BAS Unmanned Airport Station" is located on the unmanned airport sites and is connected to the rest of the system by a secured VPN (Virtual Private Network) that can be a Satellite-based VPN in the case of remote unmanned airport sites inaccessible or not easily accessible by a terrestrial communication networks. Its role is to processes meteorological data from automatic weather stations, manages airport resources (e.g. it drives service requests coming from the aircraft (e.g. ground lighting) and to perform real-time verification of S^{2}BAS Integrity information reliability.

The "Air/Ground DataLink Server" is the ground subsystem responsible for the exchange of data with S^{2}BAS equipped aircraft.

The "Central Information Processing and Distribution" component stores, process and distributes, in a centralized manner, all the information needed to provide the whole set of S^{2}BAS services (e.g. GNSS flight procedures and Obstacle Charts).

The "ATS/AVIO Station" is the interface towards AVIO Officers.

Finally the "GNSS Flight Procedures and Obstacle Charts Design" environment is an off-line environment aimed at designing GNSS Procedures and Obstacle Charts (see Figure 5).

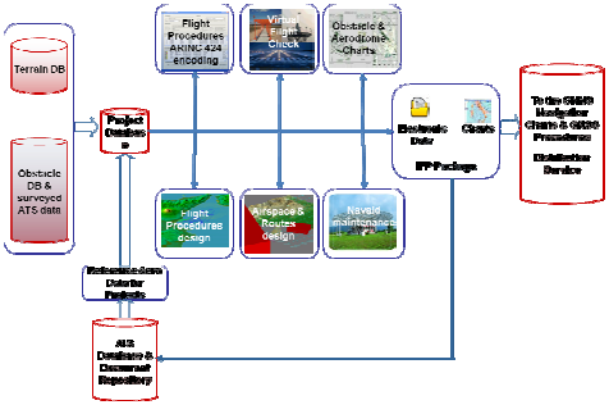

Figure 5: "GNSS Flight Procedures and Obstacle Charts Design " architecture

The "GNSS Flight Procedures and Obstacle Charts Design" environment will make use of very high resolution Cosmo-SkyMed orthoimages and Digital Surface Models (DSM) to generate a base Obstacle Chart that will map buildings, trees and all other landscape elements having a relevant elevation over the ground. This map will be adopted as reference data in order to allow further analysis performed through Cosmo-SkyMed data. The COSMO-SkyMed constellation's high revisit frequency combined with very high spatial resolution (1 meter) and advanced processing technologies (feature extraction, 2D - 3D change detection) can be fruitfully exploited for this application (Obstacle Charts creation and update).

PHASE 1 ACHIEVEMENTS

During this first phase of the project needs and User Requirements from Italian and European users have been collected. System Requirements have been generated and a preliminary architecture has been derived. Additionally, the exploration of Legal and Business issues, together with an impact analysis on social-economics aspects will be performed. The project has now reached its first important milestone of Phase 1 – the Baseline Design Review.

NEXT STEP: PHASE 2

Phase 2 will target the refinement of requirements and architecture. Design, development and verification activities will take place and will be followed by the definition and execution of the flight trials.

The demonstration system will be installed at the airports of Roma Urbe and L'Aquila (Italy). A number of performance indicators will be measured during the trials such as the increase of safety provided by the system.

The business plan, taking into consideration the commercialization of the S^2BAS equipments and the impact assessment will be completed.

At the current stage it is considered that S^2BAS will have the following impacts on the General Aviation sector:

- Improvement of regularity, fluency and economy of the air traffic
- Assurance of safety standards for small airports
- Assurance of the aircraft safety
- Improvement of the airport capacity
- Increase of the business, thanks to the increase of the traffic volume served
- Assurance of a high level assistance in an emergency scenario
- Valorisation of the territory and possibility to create employment in the local area due the socio and economical impact.

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