African Satellite Augmentation System (ASAS)

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Nomination of Regional Satellite Augmentation Systems (RSAS)

In this presentation, use of the ICAO known nomination Satellite-based Augmentation System (SBAS), which appear in the world classification of acronyms, will be replaced by the Regional Satellite Augmentation System (RSAS) as a more convenient and common nomenclature. In the similar way Local Area Augmentation System (LAAS) of the US/FAA will be replaced by the Local VHF Augmentation System (LVAS).
The Global Navigation Satellite Systems (GNSS) are represented by old fundamental solutions for Position, Velocity and Time (PVT) of determination systems such as GPS and GLONASS for the US or Russian military requirements, respectively. Both systems are old GNSS-1 infrastructures giving positions to about 30 m accuracy and they therefore suffer from certain weaknesses, which make them almost impossible to be used in the modern transportation scenario as the sole means of navigation for ships, as well as for land (road and railway) and aviation applications.
Development of Regional Satellite Augmentation Systems (GSAS)

A major goal of the International Civil Aviation Organization (ICAO) is near-universal utilization GNSS of the US GPS and Russian GLONASS military systems. ICAO proposes augmenting GNSS for increased civil aviation safety and capacity. Using the same GNSS solutions the International Maritime Organization (IMO) can also propose an enhanced traffic control and safety and security for civil maritime application, what can be suitable for land (road and rail) solutions as well. All RSAS networks will use GNSS and GEO satellites to provide Satellite Communications, Navigation and Surveillance (CNS) data between mobiles and all Traffic Control Centres (TCC).

In such a way certain TCC can get CNS data from the ship bridges and aircraft cockpits in any navigation and weather conditions.
Development of GSAS Network

- Approved by ICAO recently were developed and became operational the following three RSAS: the US Wide Area Augmentation System (WAAS), the Japanese MTSAT Satellite-based Augmentation System (MSAS) and the European Geostationary Navigation Overlay Service (EGNOS).

- In the meantime, were projected other four RSAS: 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 in the near future CNS Systems will propose to ICAO own project known as African Satellite Augmentation System (ASAS), as an African Project for Africa.
Existing RSAS Networks
Existing and Projected RSAS as Interoperable Networks Integrated in GSAS
Existing, Projected and Future RSAS as Interoperable Networks Integrated in GSAS
Advantages of RSAS

Technically both existing GNSS-1 systems used autonomously without RSAS are incapable of meeting civilian maritime, land and aeronautical very high requirements for integrity, position availability and precision in particular, so are insufficient for certain very critical sailing and flight stages.

Because these two systems are developed to provide navigation particulars of position and speed on the ship’s bridges or in the airplane cockpits, not only captains of the ships or airplanes will know well their position and speed, but also the people in TCC will be able continuously to receive augmented and even not augmented CNS data.

Augmented SAS have been developed to improve the mentioned deficiencies of current GNSS and to meet the present transport requirements for high-operating Integrity, Continuity, Accuracy and Availability (ICAA).
Prototypes of the RSAS Users Service Terminal
ESA 1 (A) and Personal Navigator 400 (B)
The ASAS will be designed and implemented as the primary means for maritime course operations of ships, such as ocean crossings, navigation at open and close seas, coastal navigation, channels, passages, approachings to anchorages and ports, and inside of ports. It will also serve for land (road and rail) solutions, rivers and inland waters, and for flight routes in corridors over Africa and Middle East, control all airports approachings and managing all airplanes and vehicles movements on airports surface.

It was intended to provide:
1) The transmission of integrity and health information on each GPS/GLONASS satellite in real time to ensure all users do not use faulty satellites, known as the GNSS Integrity Channel (GIC).
2) The continuous transmission of ranging signals in addition to the GIC service and to increase GPS/GLONASS signal availability.
3) The transmission of GPS or GLONASS wide area differential corrections has to increase the accuracy of civil GPS/GLONASS signals. This feature has been called the Wide Area Differential GNSS (WADGNSS).
Configuration of ASAS Network
1. Introduction of ASAS Network

As observed previous figure, all mobile users (3) receive navigation signals (1) from GNSS-1 of GPS or GLONASS satellites. In the near future can be used GNSS-2 signals of EU Galileo and Chinese Compass satellites. These signals are also received by all reference GMS terminals of integrity monitoring networks (4) operated by governmental agencies within Africa and Middle East. The monitored data are sent to a regional Integrity and Processing Facility of GCS (5), where the data is processed to form the integrity and WADGNSS correction messages, which are then forwarded to the Primary GNSS GES (6).
2. Introduction of ASAS Network

At the GES, the navigation signals are precisely synchronized to a reference time and modulated with the GIC message data and WADGNSS corrections. The signals are sent to a satellite on the C-band uplink (7) via GNSS payload located in Inmarsat/Artemis satellite (8), the augmented signals are frequency-translated to the mobile user on L1 and new L5-band (9) and to the C-band (10) used for maintaining the navigation signal timing loop. The timing of the signal is done in a very precise manner in order that the signal will appear as though it was generated on board the satellite as a GPS ranging signal.
3. Introduction of ASAS Network

The Secondary GNSS GES can be installed in Communication CNS GES (11), as a hot standby in the event of failure at the Primary GNSS GES. The Traffic Control Centres (TCC) terminals (12) could send request for CNS information by Voice, Data and Video (VDV) or VDVoIP on C-band uplink (13) via Communication payload located in Inmarsat or Artemis spacecraft and on C-band downlink (14) to mobile users (3). The mobile users are able to send augmented CNS data on L-band uplink (15) via the same spacecraft and downlink (16). The TCC sites are processing CNS data received from mobile users by Host and displaying on the screen their current positions very accurate and in the real time.
Coastal Movement Guidance and Control (CMGC)
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The CMGC infrastructure is a special security and control system that enables a controller at MTC to guide and monitor all vessels movements at sea in coastal navigation, in the cramped channel strips, approaching areas to the anchorage and ports, all movement in harbours: ships, land vehicles in port and around the port’s coastal environment, in poor visibility conditions at an approaching to the port. The controller issues instructions to ship Masters and Pilots with reference to a command display in a control tower that gives vessels position information detected via satellite and by sensors on the ground.
Segments of CMGC

1) GPS or GLONASS GNSS-1 Satellite provides accurate position data to the vessels or port vehicle’s.
2) GEO Satellite is transferring GNSS augmented or not augmented positioning data between vessels and Maritime Traffic Centres (MTC).
3) Control Tower is the centre providing control and monitoring the traffic situation on the channel strips, approaching areas, in the port and around the port’s coastal surface. The location of each vessel and ground vehicle is displayed on the command monitor of the MTC.
4) Light Guidance System (LGS) is managed by the controller at MTC.
5) Radar Control Station (RCS) is a part of current system for MTC.
6) Very High Frequency (VHF) Coast Radio Station (CRS) is a part of Maritime radio communications system for safety and security.
7) Coast Earth Station (CES) is a part of satellite communications system between CES terminals and shore infrastructures via GEO.
8) Pilot is small boat or helicopter carrying the special trained man known as a Pilot, who has to proceed vessels in and out of ports.
9) Bridge Instrument of vessel displays the ship position and course.
Maritime Satellite Surveillance
Surface Movement Guidance and Control (SMGC)

The SMGC infrastructure is a special security and control system that enables a controller at ATC to guide and monitor aircraft in air and on the ground, even in poor visibility conditions at approachings and an airport. The controller issues instructions to all pilots with reference to a command display in a control tower that gives aircraft position information detected via satellite and by sensors on ground. The command monitor also displays reported position information of landing or departing aircraft and all auxiliary vehicles moving onto the airport’s surface.
Segments of SMGC

1) GPS/GLONASS spacecraft measure the aircraft/vehicles positions.
2) ASAS is integrated with the GPS/GLONASS positioning data system and features of communicating data between the aircraft and the ATC via GES or VHF Ground Radio Station (GRS), pinpointing the aircraft’s exact position. Can be also used Ground Surveillance Radar (GSR).
3) Control Tower is the centre for monitoring the traffic situation on the landing strip and surface of the airport’s ground environment. The locations of each aircraft and vehicle are displayed on the command monitor of the control tower, and so, the controller performs 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 or not to the runway by turning on and off the central guidance line lights and stop line lights as a signal.
5) Aircraft Cockpit displays the aircraft position and routes on the headwind protective glass (head-up displays) and instrument panel display (head-down display).
Aeronautical Satellite Surveillance

Position Display

GEO

GPS or GLONASS

Positioning Data-GPS

Air Traffic Control Centre (TCC)

Position Data

Position Data

Ground Earth Station (GES)

Aproaching to Airport
ASAS Ground Network
Preliminary Stage of ASAS Project

As stated earlier, the basic GPS and GLONASS service fails to meet the high-operating ICAA requirements that are needed by mobile users. In order to meet the requirements for better ICAA is necessary to design the ASAS network over entire African Continent and Middle East. The ASAS network will improve the ICAA requirements of the basic GPS or GLONASS signals and allows them to be used as a primary means of ships navigation at coastal waters and approach to the anchorages, and for en-route flight of airplanes, Precision Approach (PA) and Non-Precision Approach (NPA) in the African coverage area. To start with the Project it will be necessary to form kind of Augmentation Standards Service (ASS) and to establish Transport Augmentation Board (TAB). The TAB team will be responsible for providing the leadership role in coordination the operational implementation of existing and emerging satellite CNS technologies into the African Continent and the Middle East. The TAB team has to be instrumental in the project and development of the criteria, standards and procedures for the use of both unaugmented and augmented GPS/LONASS signals by the ASAS and Local VHF Augmentation System (LVAS).
Development Phases of ASAS Network

1. Phase 1 (2013–2015) – Will start with initial ASAS commissioned of 55 GMS, 5 GCS uplinks, 5 GES, 1 Operational Control Centre (OCC) and 3 leased GEO satellites. The ASAS will enable wide en-route navigation, mobile navigation, NPA and PA.

2. Phase 2 (2015–2017) – Will finalize full ASAS infrastructures over Africa and Middle East and start with testing the Network. Redundant coverage of the initial ASAS operational restrictions will be removed. The ALAS with TCC ground structures will be deployed at major African seaports and airports. Precisely surveyed ground stations with multiple GPS receivers and processors will be established, including one or more pseudolites and VHF data link to support non and precise approaches to the seaports and airports. Finally, will be added road and rail TCC and 2nd/3rd civil RF to improve GNSS-1 and GNSS-2 robustness and ICAA.

3. Phase 3 (2017–2020) – Will provide reducing ground-based navaids and finalize the evaluation of ASAS network. Full constellations of GPS or GLONASS and new Galileo constellations with 2nd and 3rd civil GNSS RF available for ASAS and ALAS have to be modified accordingly to IMO and ICAO recommendations and regulations.
The current GEO Satellite Constellations Suitable for ASAS Space Segment is illustrated in Figure 9:

1. Inmarsat IOR
2. Inmarsat AORE
3. Artemis

In the same Figure is shown the Current GEO Satellites suitable for ASAS Ground DVB-RCS system integrated with Terrestrial Telecommunications for connection all Reference Stations (GMS), GCS and GES, including airports in Africa and Middle East:

1. Intelsat IS-802 Spot Beam and PanAmSat PAS-10 Ku-band
3. SES – NewSkies NSS-71 Ku & C-band
4. Eutelsat Ku & Ka-band W3A

South African Department of Science and Technology (DST) is planning to provide Multipurpose Space Segment of GEO satellites for CNS including L/C, Ku and K-band DVB-RCS regional and spot coverages.
ASAS Leased Space Segment and Range of Ground Coverage
Future South African Satellite CNS for ASAS and DVB-RCS Networks
ASAS Network Coverage


Middle East Countries (15): Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Palestine, Saudi Arabia, Syria, UAE and Yemen.
RSAS Ground Reference Station (A) and Augmented Shipborne GPS Receiver (B)
Garmin Augmented Airborne RSAS Receivers
RSAS Equipment for Ground Reference Station

Legend of NovAtel products:
A. WAAS RR G-II very precise GPS Receiver (Rx) as a part of each ground Reference Station (RS). Each RS needs 3 Rx integrated with Rx antenna
B. GUS-Type 1 Receiver as a part of Ground Earth Station (GES) Rx
C. GUS-Type Signal Generator as a part of GES Transmitter (Tx)
Note: Each GES needs 2 Rx and 2 Tx
RSAS GES with Antenna and Rx/Tx

Ground Earth Station

Power Amplifier

GUS signal generator

Test loop translator

GUS receiver

GPS omniantenna

RS485 RSAS input message

RS232 command input satellite

L1/L5 uplink

L1/L5 IF signals

L1/L5 RF loop back from satellite

L1 GPS and L1 GEO signals

C1 C5

L1 L5

GEO satellite
ASAS Space and Ground Segments

RS (GMS)

MS (GCS)

GES

GEO Spacecraft

OCC
General Military Geostationary Augmentation System (MGAS)
Navy and Airforces MGAS
Potential Users of ASAS Network

1. Maritime: Shipborne and Seaports Communications, Navigation and Surveillance (CNS), Seafloor Mapping and Seismic Surveying (GIS), Maritime Traffic Control (MTC) and Enhanced Safety and Security;

2. Land: Vehicleborne CNS (Road and Railway), Land Traffic Control (LTC), Enhanced Safety and Security, Tracking and Surveillance, Transportation Steering and Cranes;

3. Aeronautical: Airborne Navigation (Aircraft, Helicopters and Airports) and Surveillance and Mapping (GIS), Air Traffic Control (ATC) and Enhanced Safety and Security;

4. Agricultural, Forestry, Farming and M2M Control and Monitoring;

5. Industrial, Mining and Civil Engineering;

6. Structural Deformations Monitoring;

7. Meteorological, Cadastral and Seismic Surveying; and

8. Government and Military Determination and Surveillance (Police, Intelligence services, Firefighting); etc.
Who will Utilize ASAS Network?

1. State and Provincial Departments:
   DOD, DOT, Secretariat for Safety and Security, SA Police Service and all other departments need to improve CNS of Traffic Control and Management at Sea, on the Ground (Road/Rail) and in the Air, including Safety and Security

2. State and Private Organizations:
   Transnet, ACSA, ATNS, Tourist/Safari Centres, Power/Chemical Plants, Oil Refineries, Geodetic and GIS Organizations, Constructing, Mining and Transportation, Meteorological, Cadastral and Seismic Surveying, Agriculture/Farms, etc.
1. What CNS Systems did for Realization ASAS Project?

• In 2000 Prof. Ilcev initiated to write Manuscript: “Global Mobile Satellite Communications for Maritime, Land and Aeronautical Applications”. The book was published by Springer in 2005.

• In the meantime he realized Pilot project known as an African Satellite Augmentation System (ASAS) for entire Africa and Middle East, which draft was published in “PositionIT” in August 2005. This Project is a first serious research and access to the Radio and Satellite CNS for all transport systems at sea, on the ground and in the air for this Region.
2. What CNS Systems did for Realization ASAS Project?

- On behalf of the Minister of Transport (DOT), Mr. Jeff Radebe, MP, Prof. Ilcev got a fax of 20/04/06 that the Minister has directed the matter to his Special Advisor. On 20/08/06 Mr. Riad Khan director at DOT attended a presentation of ASAS project, and that is all, because Mr. Khan left DOT in 2008. After that, new Minister of Transport never sent reply on letters of Prof. Ilcev.

- In addition, on 25/08/06 Mr. Khan and Prof. Ilcev had a meeting in Midrand with Mr. Rick Blighton of Canadian company NovAtel regarding supplying Reference Receivers and other equipment for Ground Segment.
3. What CNS Systems did for Realization ASAS Project?

- On 8 and 9 December 2008 Prof. Ilcev was on the 4th GNSS Meeting of ICAO in Nairobi, Kenya. He presented ASAS project and ESA introduced the possibility to extend not autonomous EGNOS network to Africa and Middle East, without own ground infrastructure for about 100M $ in total. Our ASAS will be independent and autonomous network providing improvements of Maritime, Land and Air Traffic Control and Management and enhanced safety and security, with ground infrastructure and total cost of about 150M $.
4. What CNS Systems did for Realization ASAS Project?

• In the meantime Prof. Ilcev discussed via phone with directors from Department of Science and Technology (DST) Dr. V. Munsami. On 28 January 2009 in Pretoria Prof. Ilcev with Prof. G. Prinsloo, as DUT delegation, met Dr. V. Munsami from DST regarding Space Program and possibility of realisation ASAS project.

• On 23 February 2010 Dr. Munsami visited DUT and spoke with Prof. G. Prinsloo and Prof. Ilcev for establishment research centre for Space Program and he expressed positive impact regarding our ASAS project. We proposed to be at first provided Network for Southern Africa below 15º South.
5. What CNS Systems did for Realization ASAS Project?

- In April 2010 DST invited DUT to participate in discussion between the Russian Space Agency (Roscosmos) and to present ASAS project of Prof. Ilcev. In the same time Prof. Ilcev has been on conference in Leningrad, Russia, so Prof. Prinsloo gave presentation of ASAS project to Russian delegation. From 3 to 6 August 2010 Prof. Ilcev was invited to joint DST delegation in Moscow on bilateral meeting with Roscosmos regarding future collaboration in Space Program. In TIP Review of 2010 there is an article about these activities.
6. What CNS Systems did for Realization ASAS Project?

• In September 2011 Prof. Ilcev was invited to participate in discussion between the EU ESA and DST/SANSA regarding collaboration in Space Program and so call extension of EGNOS over Africa and South Africa in particular. We have again the similar situation that Europe is offering EGNOS extension. This offer is lasting without success almost 10 years, so is obvious that SANSA can consider our ASAS project as better and autonomous. In reality, the ASAS project is the best solution done by Africans for Africa.

• During meeting with EU, one delegate from Portugal asked, how EU is going to cover South Africa if is not still able to cover Eastern Europe. Prof. Ilcev asked how much will cost the extension, what EU has to provide for extension and what solutions have to be implemented?
7. What CNS Systems did for Realization ASAS Project?

However, EU didn’t gave right answers. On the first question, EU should reply that EGNOS needs certain number of Reference Stations (RS) and additional funds to provide coverage for Eastern Europe.

The cost of EGNOS extension should be about 100M US$, to cover Africa and Middle East will be needed at least 55 RS and finally the System has to provide CNS and enhanced traffic control especially for Air Traffic Control (ATC). Thus, the main goal of the GNSS augmentation system is to provide scenario that ATC has to know the determination of all aircraft in the air traffic controlled area without any limits and in any weather conditions, including to manage more safely their movements.
Who are Competitors of ASAS Project

1. At the end of 2007 ATNS abandoned the “Mini Project” with Ground Network of 13 Reference Stations associated to the EGNOS ground facility. The problem was that EGNOS Testbed couldn’t provide safety and security and would be entirely dependent on the proper operations, network and maintenance of the EGNOS master stations, GES, communications infrastructure and sometimes of GEO broadcast capacity.

2. As stated earlier, in Nairobi ICAO meeting ESA together with EC and ThalesAlenia is again offering EGNOS service, which is not reliable and acceptable for Africa and Middle East, see below:
Previous EGNOS Coverage Used 34 Reference Station (RS) is not providing service for entire Europe

SiS3: APV-1 Availability

Most of ECAC covered at 99% Availability
New EGNOS coverage is using 41 RS and also not providing full service for entire Europe

Estimated APV-1 Availability with 41 RIMS
ESA extension of EGNOS for Africa without RS covers Region up to 20 deg South just for communication and not CNS service, highlighted in dark, so it is not covering South Africa

**NPA Service Coverage:**

**FAA - MITRE Results**

Enhanced NPA service achieved through SBAS over Africa down to 20 deg. South Lat.

*Results prepared by MITRE for FAA, presented at ICAO NSP*

Measured data for the 29th April 2008 (10:14- 12:14 Zulu), removing MT27 contribution
EGNOS can provide full CNS Coverage for Africa only with deployment additional RS (RIMS), according to ASAS project minimum 55 RS or to establish Regional Infrastructure, what can be our own ASAS Network.

Depending on the extension area, technical implementation may vary from:

- Homogeneous extension with deployment of additional RIMS
- Regional infrastructure including additional processing capabilities
For what reasons Extension of ESA EGNOS cannot provide a real Network and CNS Service over Africa?

1. This Network needs minimum 55 RS, 5 Master Stations (GCS) and 5 GES.
2. EGNOS intention to cover Africa, Middle East, Russia, India, China and even South America without additional RS is not real, because:
   a) Canada is doing own CWAAS although its soil can be covered by the US WAAS.
   b) China is doing own SNAS and India GAGAN although both can be covered by Japanese MSAS.
   c) Russia has project SDCM and Africa ASAS
So, we don’t need anything from Europe and their EGNOS service, but just we need to develop our Own African ASAS network for all Africans.
What CNS Systems has to do regarding investors for Realization ASAS Project?

• The future Investors can be any government or group of countries in the Region, some private company or banks.

• Investors can be all 69 countries in Africa and Middle East dividing reciprocally total amount of 150M US $ for Ground Network and amount for lease the Inmarsat and Artemis spacecraft or to build own Space Segment.

• CNS Systems together with SANSA or any other African government can submit an official proposal of ASAS Project to ICAO. DUT is invited to be a partner in additional research and initiatives regarding future solutions.
The End

Thank you for your attention!

CNS Systems

DUT

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