Development of Space CNS for Maritime Transportation Augmentation System (MTAS)

Dimov Stojce Ilcev
Space Science Centre (SSC), Durban University of Technogy (DUT), Durban, South Africa

Abstract: The development of the MTAS was to identify the possible applications for enhancement of Digital Selective Call (DCS) MF/HF/VHF Radio; Satellite Communications, Navigation and Surveillance (CNS); GPS and GLONASS; and safety systems including security and control of vessels, logistic and freight at sea, on inland waters and the security of crew and passengers on board ships, cruisers, boats and hovercrafts. These enhancements include many applications for the better management and operation of vessels and they are needed more than ever because of world merchant fleet expansion. Just the top 20 world ships registers have about 40,000 units under their national flags. Above all, the biggest problem today is that merchant ships and their crews are targets of the types of crime traditionally associated with the maritime industries, such as piracy, robbery and recently, a target for terrorist attacks. Thus, IMO and flag states will have a vital role in developing International Ship and Port Security (ISPS). The best way to implement ISPS is to design an Approaching and Port Control System (APCS) by special code augmentation satellite CNS including tracking and monitoring of all vehicle circulation in and out of the port area. The establishment of MTAS as a part of Global Satellite Augmentation Systems (GSAS) or GNSS-1, such as the US WAAS, European EGNOS, Japanese MSAS, Chinese SNAS, Indian GAGAN and future GSAS including African Satellite Augmentation System (ASAS) will meet all these requirements and will complement the services already provided by DGPS or Local VHF Augmentation System (LVAS) and MF radio beacons.

Key Words: GNSS, GPS, GLONASS, GSAS, CNS, EGNOS, MSAS, WAAS, SNAS, GAGAN, ASAS, GMS, GCS, Space Segment, Ground Segment, WANAV, SELR, SESR, RSM, FSPP, CMGC

1. Maritime Augmentation Mission

The navigation transponder of GEO payload is a key part of the entire system. Namely, it sends signals of Global Navigation Satellite System (GNSS) to mobiles in the same way as other GPS or GLONASS satellites and improves the Integrity, Accuracy and Availability (IAA) of the positioning system. Thanks to the large number of Mobile Earth Stations (MES), the GNSS signal is able to incorporate data on GPS spacecraft status and correction factors, thus greatly improving the reliability and accuracy of the present GPS system, which comes to few tenths of metres. The augmented GPS/GLONASS accuracy will be just a few metres, allowing maritime and land traffic to be controlled solely by satellite, without ground radar or radio beacons facilities.
To complement the GPS channel, communication channels allow bidirectional transmission between ships and CES. The ship sends its position and navigation data to the local Coast Guard, Traffic Control Centre (TCC) or Port authorities and to the relevant ship-owner. This enables ship movements to be managed and to enhance safety at sea and to improve operating efficiency. The satellite will forward flexible and safe routing information to ships, as determined by the shore centre, decreasing fuel consumption, reducing sailing times and enhancing the safety and security systems. The CNS/MTAS is divided into three Maritime services known as CNS systems. As usual, the MTAS system consists in space and ground infrastructures.

1.1. Space Segment

The space segment for MTAS infrastructure and mission, as a part of GSAS configuration, can be some new designed GEO and/or leased Inmarsat, Japanese MTSAT, European EGNOS (Artemis) or any existing GEO with enough space for GNSS transponder inside of payload. The spacecraft GNSS payload can provide global and spot beam coverage with determined position on about 36,000 km over the equator.
The MTAS spacecraft also can have an innovative communication purpose payload for Maritime Mobile Satellite Service (MMSS), which will be similar to the Inmarsat system of Mobile Satellite Communications (MSC). The heart of the payload is an IF processor that separates all the incoming channels and forwards them to the appropriate beam in both directions: forward (ground-to-ship) and return (ship-to-ground). In fact, global beam covers 1/3 of the Earth between 75° North and South latitudes. Thus, spot beam coverage usually consists in 6 spot beams over determined regions including heavy traffic areas at sea, to meet the demands of increasing maritime transport operations and for enhanced safety and security.
The GNSS signal characteristics are generally based on the ICAO Annex 10 (SARP), IMO and Inmarsat SDM and comply with the Radio Regulations and ITU-R Recommendations. This type of spacecraft has two the following types of satellite links related to the maritime Coast Earth Stations (CES):

1. Forward CES to Satellite Direction – The CES are located throughout the region coverage. Their signals are received by a C-band (Inmarsat), Ku-band or a Ka-band antenna system. Thanks to the very high radio frequency used, the reflector size of the antennas is quite small (1000 mm for C, 500 mm for Ku and 450 mm for Ka-band). The reflector is movable via focusing two electromotors for angles of Azimuth and Elevation, so that it can work with the communications satellite payloads in any of the possible three GEO positions.
Incoming signals are amplified, converted to IF, filtered and routed within the IF processor where they are then up-converted and transmitted in L-band to the Ship Earth Station (SES).
2. Return Satellite to CES Direction – The L-band signal received from all approaching SES terminals are processed in the same way and retransmitted to CES via a C, Ku and Ka-band antenna. The output power of the C, Ku and Ka-band SES transmitters is just 2W thanks to the high gain satellite antenna and convenient frequency band. It is also possible to provide station-to-station satellite channels in either the Ku or Ka-band to enable stations working with different spots in satellite coverage and to communicate with one another. The GNSS satellite channel is also routed to adequate CES on the same two bands for calibration purposes.

1.2. Ground Segment

The MTAS Ground Segment system consists in several CES and System Control Terminal (SCT) located in any corresponding positions. Thus, an important feature of these stations is that they have been built to withstand earthquakes, which also required a special antenna design.
1. Coast Earth Stations (CES) – In order to provide continuous service, even during natural disasters, two CES can be implemented at two different locations separated by about 500 km. The MMSS provided by two CES are in charge of all communication functions through the satellites. Any CES, with a 13 m antenna diameter, transmits and receives signals in the Ku, Ka and C-band. A very high EIRP of 85 dBW and a high G/T ratio of 40 dB/K are achieved in the Ku and Ka-band, respectively and ensure very high availability of the feeder link.
The L-band terminal similar to the SES is used for the system testing and monitoring. About 300 circuits are available simultaneously in both: transmit and receive directions. It also includes dedicated equipment for testing the satellite performance after launch and for permanent monitoring of the traffic system. Top-level management software is provided to configure the overall system and check its status.
2. Ship Earth Stations (SES) – Special part of the MTAS Ground Segment are SES terminals approaching to the entire region including GNSS. It is similar to the Inmarsat standards containing: ADE (Above Deck Equipment) as an antenna and BDE (Below Deck Equipment) as a transceiver with peripheral equipment using L-band. The BDE Voice, Data and Video (VDV) terminals can be used for ship crew and cabin crew including passenger applications. The SES is a ship-mounted radio capable of communications via spacecraft in the MTAS system, providing VDV and Fax two-way service anywhere inside the satellite footprint.
3. Satellite Control Stations (SCS) – The SCS is usually located in the same building as the CES and utilizes an antenna with the same diameter. This station has to control the satellite throughout its operational life in the Network. Two Radio Frequency (RF) bands can be used: S-band in normal operation and Unified S-band (USB) while the satellite is being transferred to its final orbit, or in the event of an emergency when satellite loses its altitude.
Accordingly, in S-band the EIRP is 84 dBW and for security reasons, the EIRP in USB is as high as 104 dBW. An SCS displays the satellite’s status and prepares telecommands to the satellite. Furthermore, the satellite position is measured very accurately (within 10 m) using a trilateral ranging system instead of measuring one signal, which is sent to the satellite then returned to the Earth. On the other hand, the Station sends out two additional signals, which are retransmitted by the satellite to two dedicated ranging stations on the ground, which return the same signals to the SCS via satellite. This technique allows the satellite’s position to be measured in three dimensions. In addition, a dynamic spacecraft simulator is also provided to check telecommands.
4. GNSS System – The GNSS system known as the MTAS consists in a large number of Ground Monitoring Stations (GMS), Ground Control Stations (GCS), CES and few Geostationary Ranging Stations (GRS) to implement a wide triangular observation base for GEO satellite ranging. The GMS terminals are very small autonomous sites housed in a shelter. Each GMS computes its location using GPS and MTAS communication signals over the coverage area.
Any differences between the calculated and real locations are used by the system to correct the satellite data. Data is sent to the GCS via the public network, while the GCS collects all the information from each GMS. Complex software is able to calculate accurately the position and internal times of all GPS and MTAS satellites. The GNSS signal, incorporating the status of the GPS spacecraft and corrections, is calculated and sent to the traffic station known as CES for transmission to MTAS satellites.

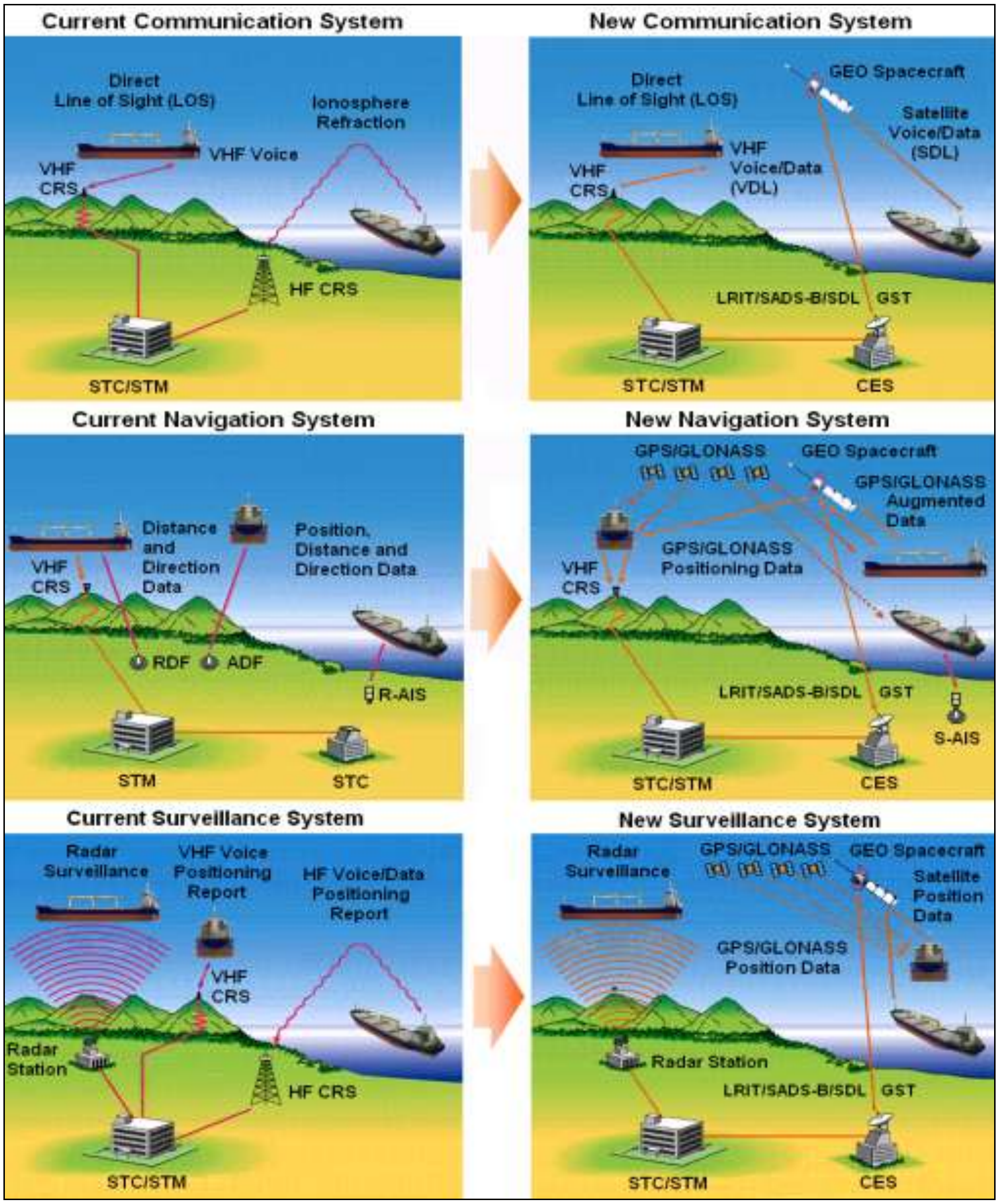

Figure 1. Current and New CNS/MTM System **–** Source: by Ilcev

2. Maritime Mobile Satellite Service (MMSS)

The MMSS functions in frame of the new MTAS infrastructure include the provision of all the mobile maritime communications defined by the IMO, such as new Global Maritime Distress and Safety System (GMDSS), Inmarsat and Cospas-Sarsat systems, including new systems with nomenclatures such as Maritime Commercial Communications (MCC) and Maritime Crew and Passenger Communications (MCPC). In a more general sense, these MSC service solutions could be available for Maritime Traffic Management (MTM), Maritime Traffic Control (MTC) and Maritime Traffic Service (MTS) providers and maritime operators in all ocean regions through data link service providers. Direct access to the MTAS network could also be possible through the implementation of dedicated CES in other states covered by MTAS spacecraft.
The MTAS system for the SES is interoperable with MSC system of the Inmarsat Space and Ground network. It can be connected directly to the navigation bridge GMDSS operator (Master, duty-deck or radio officer) by VDV, Fax, video, GPS augmentation information and Automatic Dependent Surveillance System (ADSS).
The MTAS will not only be capable of handling MTS for ocean going vessels, but will also be offered to the Civil Maritime Community (CMC) in all coastal regions as an infrastructure, which could facilitate the implementation of the future IMO CNS/MTM systems.

The MTAS service provides all ocean going ships with GPS augmentation information to improve safety and security at sea and all navigational performance requirements, namely to find out the response to the demands of IAA, which are essential to the use of GPS or GLONASS for vessels operation as the sole means of navigation. Using previous not augmented system, ship navigation officers know very well where their ship is in space and time, but offshore MTC terminals don't know.

In order to provide all ships and MTC with sufficient GPS augmentation information and satellite surveillance, a certain number and location of GMS will be required. At this point, the number and location of GMS required for each state in the region will depend on the requirements for the level of navigation services and reception of GPS signals. Therefore, the MTAS system needs number of GMS, few GCS and CES for the each region. For this reason, the some regions could implement MTAS with a lower number of GMS than other GSAS regions.

3. Current and New CNS/MTM Mission

The MTM MTAS is a mission of CNS and it will provide three services: MMSS, GNSS and Automatic Dependent Surveillance System (ADSS).

Current communication facilities between ships and MTC are executed by Radio MF/HF voice and telex and VHF voice system; see Communication Subsystem in **Figure 1**. The VHF link between ships on one the hand and Coast Radio Station (CRS) and Traffic Control Centre (TCC) on the other, may have the possibility to be interfered with by high mountainous terrain. The HF link may not be established due to lack of available frequencies, bad propagation, intermediation, unstable wave conditions and to heavy rain or thunderstorms.

Current navigation possibilities for recording and processing Radio Direction Information (RDI) and Radio Direction Distance Information (RDDI) between vessels and Maritime TCC) or MTC centre are performed by ground navigation equipment, such as the Coastal Surveillance Radars, Racons (Radar Beacon) and Passive Radar Reflectors, integrated with VHF CRS facilities, shown in the Navigation Subsystem in **Figure 1**. This subsystem needs more time for ranging and secure navigation at the deep seas, within the cannels and approachings to the ports, using few onboard type of radars and other visual and electronic navigation aids.

In 1948 the world's first harbour surveillance Radar was installed, overlooking the approach of the Port of Liverpool. In fact, the facility was supplemented by the use of portable VHF radio equipment. From this beginning, a wide variety of first MTC for MTM with MTS of vessel traffic has developed. The latter may employ as many as thirteen VHF communication channels and thirty radars linked by a microwave network to one or more TCC terminals. At such centres, computer process and analyze not only the radar signals but a host of other data relevant to the movement of traffic in the port or approaching to ports. Some facilities are to this day quite simple, being limited to the ability of radio system to broadcast routine general information. Today MSC facilities make very simply transfer of navigation data and information via GEO satellites.

The current surveillance utilities for receiving Radar and VHF Voice Position Reports (VPR) and HF Radio Data/PVR between ships and TCC can be detected by Radar and MF/HF/VHF CRS. This subsystem may have similar propagation problems and limited range or when ships are sailing inside of fiords and behind high mountains they cannot be detected by Coastal Radar; see the Surveillance Subsystem in **Figure 1**.

On the contrary, the new CNS/MTM System utilizes the communications satellite and it will eliminate the possibility of interference by very high mountains, see all three CNS Subsystems in **Figure 1**. At this point, satellite voice communications, including a data link, augments a range and improves both the quality and capacity of communications. The Weather (WX) and Navigation Warnings (NX), sailing planning and NAVAREA information may also be directly input to the Navigation Management System (NMS). If the navigation course is free of islands or shallow waters, the GPS Navigation Subsystem data provides a direct approaching line and the surveillance information cannot be interfered with by mountainous terrain. The display on the screen will eliminate misunderstandings between controllers and ship's Masters or Pilots.

3.1. Current Radio and MSC System

The previous Maritime Radio Communications (MRC) system for general international purposes has been operational for near 100 years and recently was replaced by MSC system to enhance ship-to-shore voice and data traffic for both commercial and safety applications. In general, the initial development will have been established by using a service of MRC on MF and HF Morse radiotelegraphy, radio telex and radiotelephony (voice) for maritime medium and long distance communications, respectively. The latter progress was in order to promote advanced maritime short distance commercial, safety, approaching and on scene distress communications on VHF voice frequency band. Finally, global DCS MF/HF/VHF Radio subsystem was developed by IMO in frame of GMDSS system and integrated with Inmarsat and Cospas-Sarsat facilities.

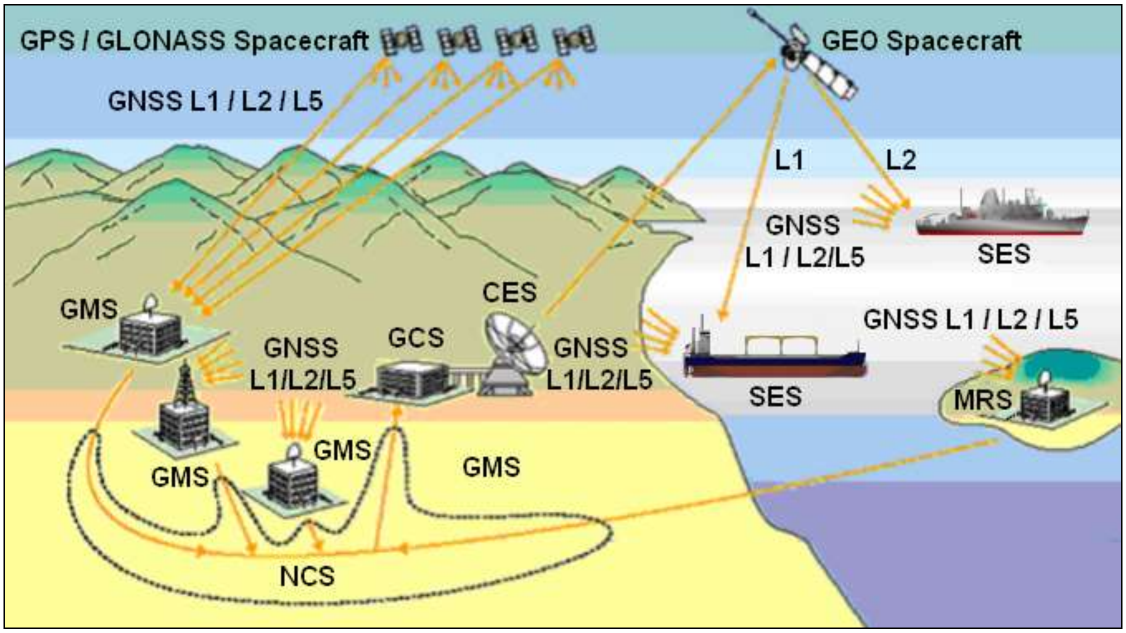

Figure 2. Future MTAS Navigation System **–** Source: by Ilcev

Meanwhile, in order to respond to the significant increase in the volume of communications data that has accompanied the large increases in cargo maritime traffic, periodic communications have moved to the satellite communications low, medium and high speed data link and data transmission has become the core type of maritime communications. The media needs to be divided to reflect this change in communications content, which has seen voice (Tel) communications used mainly for irregular safety and security or even for emergency situations in general. A transmission system based on fundaments new GMDSS digital technology (bit-based) needs to be integrated by the MTAS, to introduce wholesale improvements in Satellite CNS ability and to enhance current system for emergency (distress, safety and security).

Gradually, new MMSS VDV and VDVoIP links have come into use and totally may replace old HF and VHF traditional radio. Because of any emergency and very bad weather conditions ship can be extremely affected, it is necessary to keep them as alternative solutions and to employ again a well-trained Radio Officer on board every oceangoing ship. Namely, SES can be used for communications with corresponding CES via any MATS or Inmarsat GEO satellite for maritime commercial, emergency and social purposes.

3.2. MTAS GNSS

The GPS or GLONASS (GNSS-1) can be used worldwide to control the positions of vessels and to manage maritime traffic. They support vessel’s navigation well in all routing phases, including approaching to the port and mooring utilities. In fact, they have some performance limitations and they cannot consistently provide the highly precise and quite safe information in the stable manner required for wide-area navigation services. To assure safe and efficient sea traffic navigation of civil vessels, GPS and GLONASS performance needs to be augmented with another system that provides IAA essential elements well for sea navigation. The MTAS augmentation solution for GPS/GLONASS can be integrated with adequate Land (LTAS) and Aeronautical Transportation Augmentation System (ATAS) into the US WAAS, Japanese MSAS, European EGNOS, Chinese SNAS, Indian GAGAN and new systems such as ASAS for entire Africa and Middle East. Once in operation, this new state-of-the-art system will assure full navigation services for vessels in all navigation phases within the oceanwide, coastal, approaching and channel waters through MTAS coverage.

The L1/L2 RF band is nominated for the transmission of signals from GNSS spacecraft in ground and air directions, which can be detected by the GMS, GRS and GNSS-1 ship’s receivers. The MTAS GNSS satellite transponder uses the L1 RF band to broadcast GNSS augmentation signals in the direction from CES to SES. The L, Ku or Ka-band is used for unlinking GNSS augmentation data from SES via GEO spacecraft to TCC. The whole ground infrastructure and Communication System is controlled by GCS and Network Control System (NCS). The components of the MTAS navigation system are illustrated in **Figure 2**. To provide GNSS augmentation information, all ground stations, which monitor GNSS signals, are necessary in addition to MTAS. This special navigation infrastructure, which is composed by MTAS, GPS/GLONASS or GNSS wide-area augmentation system and these ground stations, is called the MTAS network.

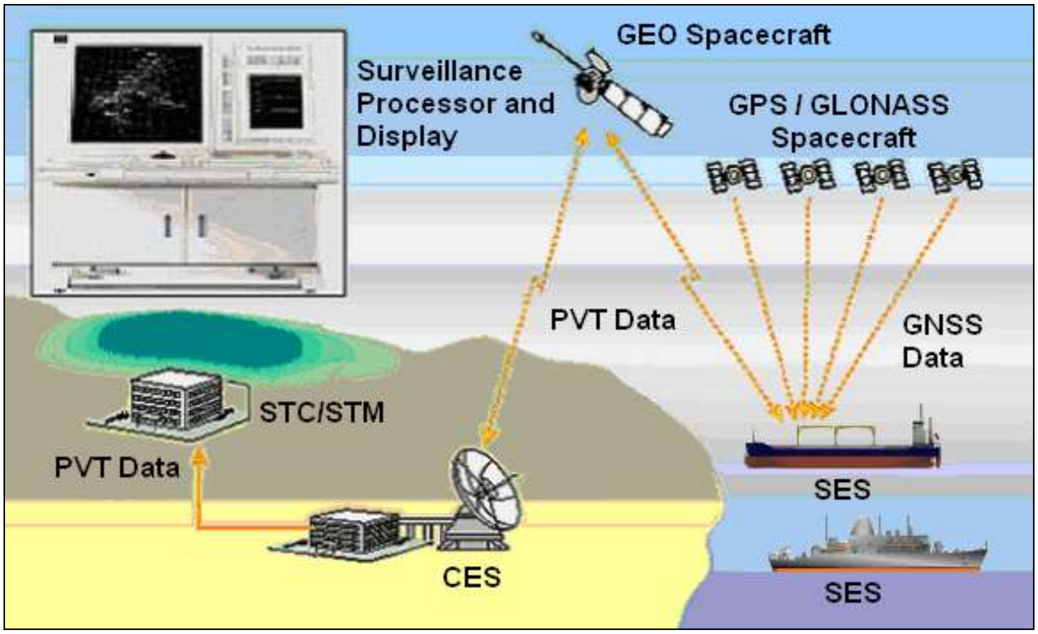

Figure 3. Future MTAS Surveillance System – Source: by Ilcev

3.3. Wide Area Navigation (WANAV) System

The Wide Area Navigation (WANAV) system is a way of calculating own precise position using the Ship Surveillance Satellite Equipment (SSSE) facilities and other installed ship navigation devices to navigate the desired course and to send this position to TCC. In the case of WANAV routes 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 sea routes and has created double tracks. This system enables more secure, safety and economical sea navigation routes.

3.4. MTAS Automatic Dependent Surveillance System (ADSS)

The current radio surveillance system is mainly supported by VHF CRS. Namely, this system enables display of real-time positions of the nearby approaching ships using radar and VHF voice radio equipment. Due to its limitations, the VHF service being used for domestic sea space, channels and coastal waters cannot be provided over the ocean. Meanwhile, out of radar and VHF coverage and range on the oceanic routes, the ship position can be regularly reported by HF radio voice or via data terminals to the HF CRS.
Consequently, the advanced CNS/MTM MTAS system utilizes the ADSS data function, which automatically reports all current ships positions measured by GPS to MTC, as illustrated in **Figure 3**. In this way, the approaching vessels receives positioning data from GPS spacecraft or GPS augmented data via GEO GNSS transponder, as illustrated in **Figure 2**, and sends via CES its current position for recording and processing to the MTC terminal. This service enhances safety and control of vessels in ocean and coastal navigation.
The screen display of satellite ADSS looks just like a pseudo-radar coverage picture showing positions of the ships. The new ADSS system will increase safety and security at sea and reduce ships separation, improve functions and selection of the optimum route with more economical courses. It will also increase the accuracy of each ship position and reduce the workload of both controller and Master or Pilot, which will improve safety. In this sense, ships can be operated in a more efficient manner and furthermore, since the areas where VHF radio does not reach due to the short range, mountainous terrain or bad weather will disappear, small ships, including Pilot boats and helicopters, will be able to obtain any data and safety information on a regular basis. These functions are mandatory to expand the traffic capacity of the entire ocean or coastal regions for all ships and for the optimum navigation and safety route selection under limited space and time restraints.

4. Special Effects of the MTAS System

Special effects of the MTAS system used for secure communications, navigation, ranging, logistics and control of the vessels at sea, in the channels, around the coastal waters and in the port surface ship traffic are Safety Enhancements on Short and Long Ranges, Reduction of Separation Minima, Flexible Sailing Profile Planning and Coastal Movement Guidance and Control.

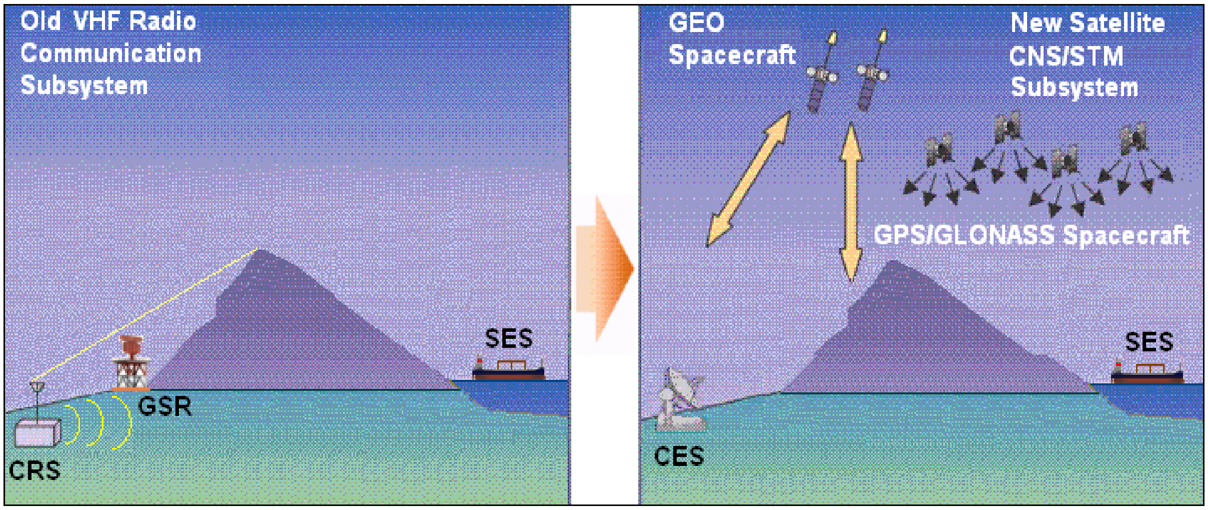

Figure 4. SESR Subsystem – Source: by Ilcev

These effects of the MTAS are very important to improve maritime communication facilities in any phase of sailing, to enable better control of ships, provide flexible and economic trip with optimum routes, to enhance surface guidance and control in port and in any case to improve safety and security at sea and in the ports.

4.1. Safety Enhancements at Short and Long Ranges

A very important effect of the new MTAS system for CNS/MTM is to provide Safety Enhancement at Short Ranges (SESR) via CES, as illustrated in **Figure 4**.
Current radio system for short distances between vessels and CRS is provided by VHF voice or by new DSC VHF voice and data equipment, so the Master or ship's Pilot will have many problems establishing voice bridge radio communications when the ship position is in the shadow of high mountains in coastal waters.
Meanwhile, all vessels sailing in coastal waters or fiords and in ports can receive satellite navigation and communications even at short distances and where there is no navigation and communications coverage due to mountainous terrain. This is very important for safety and secure navigation during bad weather conditions and reduced visibility in channels, approachings and coastal waters, to avoid collisions and disasters.
The MTAS system is also able to provide Safety Enhancement at Long Rangers (SELR) illustrated in **Figure 5.**, by using faded HF radio system or the noise-free satellite system. In such a way, many ships out of VHF range can provide their augmented or not augmented positions to MTC or will be able to receive safety and weather information for secure navigation.

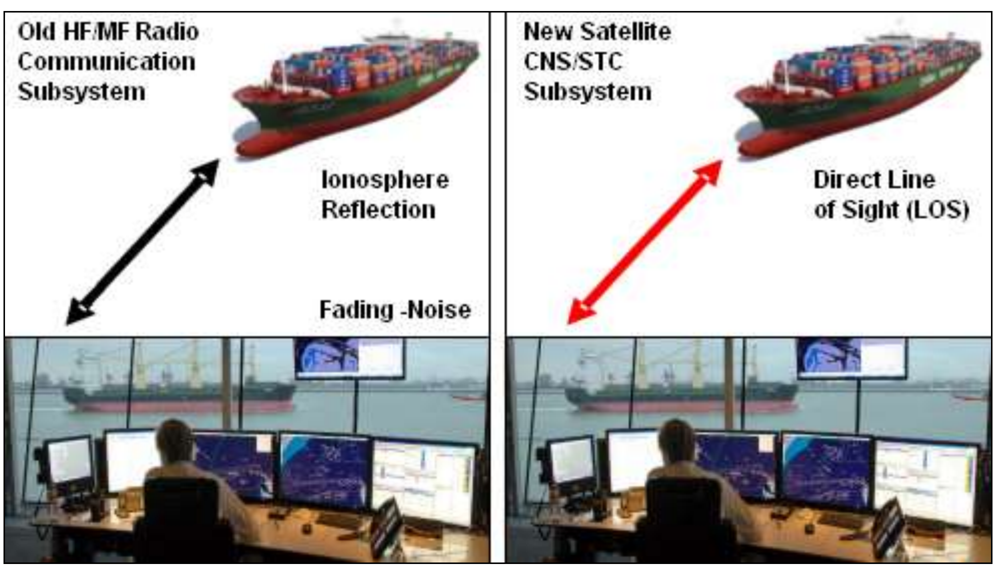

Figure 5. SELR Subsystem – Source: by Ilcev

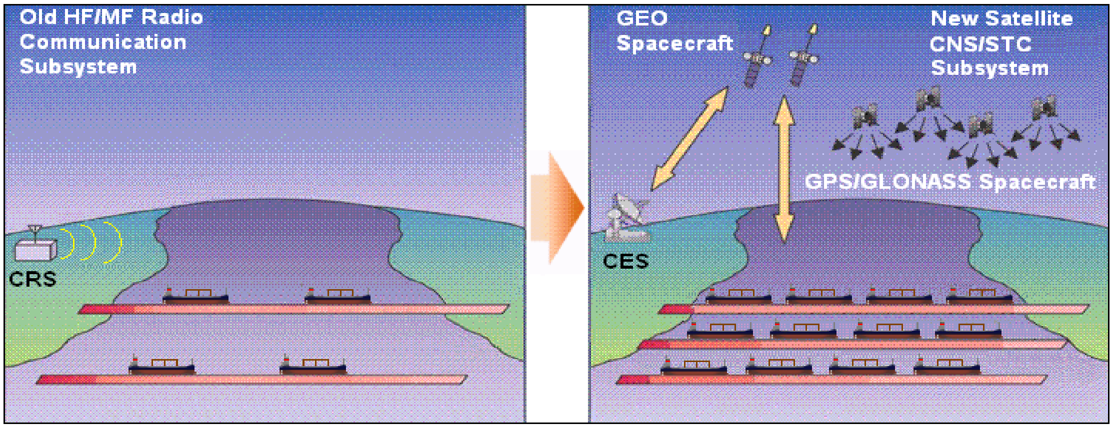

Figure 6. RSM Subsystem – Source: by Ilcev

4.2. Reduction of Separation Minima (RSM)

One of the greatly important MTAS safety navigation effects is the Reduction of Separation Minima (RSM) between ships or other moving object on the sea routes by almost half, as shown in **Figure 6**. The current system has an RSM controlled by conventional VHF or HF Radio system and Radar Control System (RCS), which allows only large distances between vessels. Besides, the new CNS/MTM system controls and ranges greater numbers of vessels for the same sea corridors (channels), which enables minimum secure separations, with a doubled capacity for vessels and enhancements of safety and security. Therefore, a significant RSM for sailing ships will be available with the widespread introduction and implementation worldwide of the new GSAS technologies on the CNS system.

4.3. Flexible Sailing Profile Planning (FSPP)

The next positive effect of MTAS system is Flexible Sailing Profile Planning (FSPP) of shortest or optimal course, shown in **Figure 7.** The current system uses fixed courses of orthodrome, loxodrome and combined navigation by navaids. Thus, the fixed course is controlled by the vessel's on-board navigation instruments only, which is a composite and not the shortest possible route from departure to arrival at the destination port. The FSPP allows the selection of the shortest or optimum course between two ports and several sub points. With thanks to new GSAS technologies on CNS/MTM system FSPP will be available for more economic and efficient sailing operations. This means that the ship's engines will use less fuel by selecting the shortest sailing route of new CNS/MTM system than by selected the fixed courses of current route composition.

4.4. Coastal Movement Guidance and Control (CMGC)

The new Coastal Movement Guidance and Control (CMGC) infrastructure is a special maritime security and control system that enables a port controller at shore to control, guide and monitor all vessels movements in coastal navigation, in the cramped channel strips and fiords, approaching areas to the anchorage and harbours, ship movement in harbours, including land vehicles in port and around the port's coastal environment, even in poor visibility conditions at an approaching to the port. Thus, 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 satellites and by sensors on ground, shown in **Figure 8.**

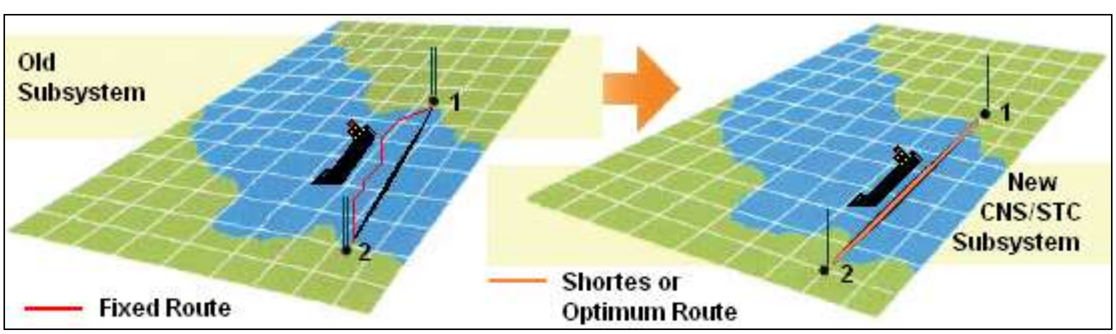

Figure 7. FSPP Subsystem – Source: by Ilcev

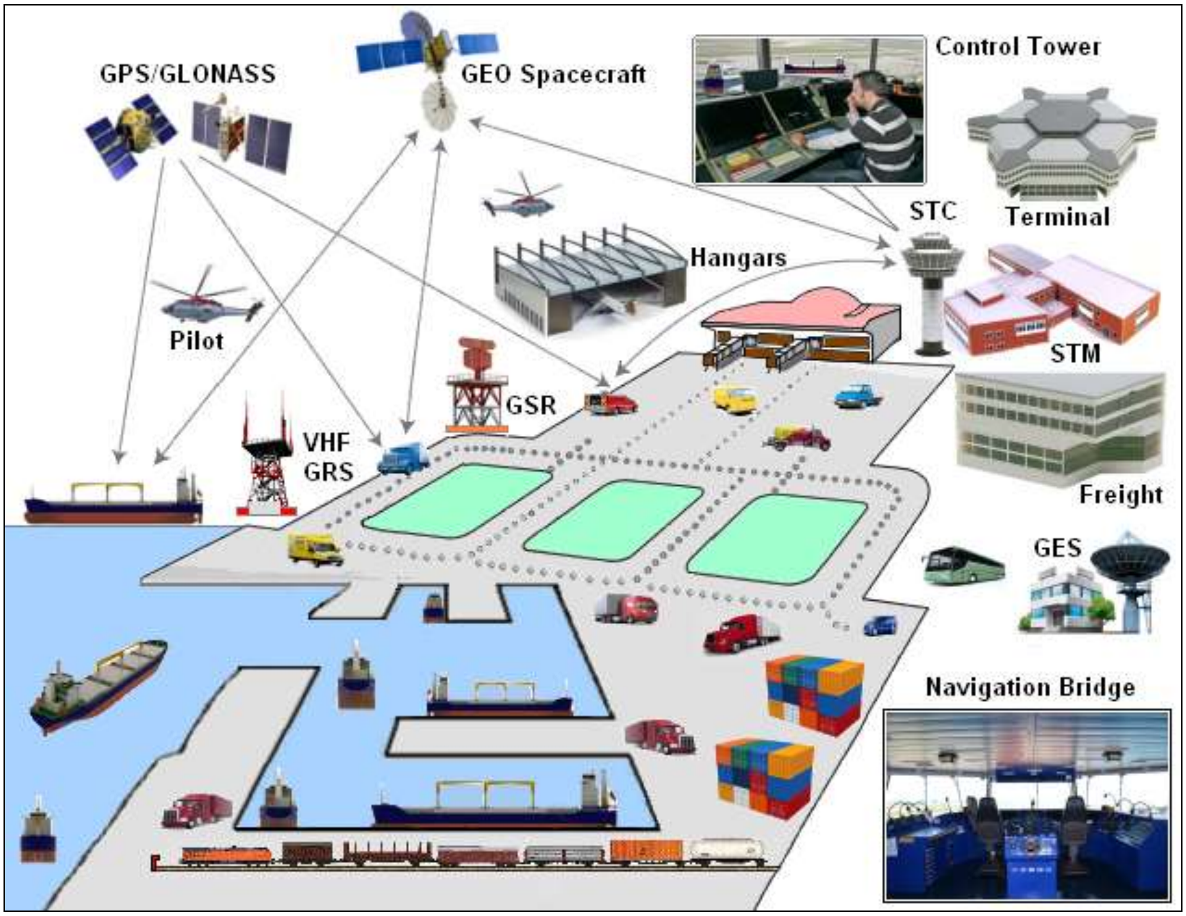

Figure 8. CMGC Subsystem – Source: by Ilcev

The command monitor also displays reported position data of coming or departing vessels and all auxiliary land vehicles (road and railways) moving into the port's surface. This position is measured by GNSS, using data from GPS/GLONASS and GEO satellites. A controller is also able to show the correct ship course to Masters and sea Pilots under bad weather conditions and poor visibility or to give information on routes and separation to other vessels in progress.

The following segments of CMGC illustrated in **Figure 8** are as follows:

1) GNSS Satellite Constellations of the US GPS or Russian GLONASS measures the exact positions of ships approaching to port, in the port or port vehicle's;

2) GEO MSC Satellite Constellations in the Geostationary Orbits are integrated with the GPS positioning data network caring both communication and navigation payloads, In addition to complementing the GPS satellite, it also has the feature of communicating data between the ships or vehicles and the ground facilities, pinpointing the mobile's exact position;

3) Control Tower is the centre for 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 port control tower. The controller performs sea-controlled distance guidance and movements for the vessels and ground-controlled distance vehicles and directions based on this data;

4) Light Guidance System (LGS) is managed by the controller who gives green light or red light guidance whether the ship should proceed or not by pilot in port, respectively;

5) Radar Control Station (RCS) is a part of previous system for MTC of ship movement in the channels, approaching areas, in port and around the port's coastal environment;

6) Very High Frequency (VHF) CRS is a part of RCS and VHF or Digital Selective Call (DSC) VHF Radio communications system;

7) Coast Earth Station (CES) is a main part of satellite communications system between CES terminals and shore telecommunication facilities via GEO satellite constellation;

8) Pilot is small boat or helicopter carrying the special trained man known as a Pilot, who has to proceed the vessel to the anchorage, in port, out of port or through the channels and rivers; and

9) Bridge Instrument of each vessel displays the ship position and course.

5. Conclusion

Several international agencies, especially IMO and ICAO were assessed that US-based GPS and Russian GLONASS military solutions as stand alone-systems for determination of the Position, Velocity and Time (PVT) are unable to meet the present requirements for high-operating IAA. After that were developed new applications for global and local augmentation systems that will provide satellite health data for IAA and corrections for satellite GNSS range errors, and to achieve enhanced safety-of-life operations of vessels in distress and aircraft emergency landed at sea, secure harbour approach and port MTM, including ISPS, contra piracy and robbery and terrorist diversions.
Radio-positioning and time-transfer data from present GPS or GLONASS of GNSS-1 integrated in GSAS and forthcoming GNSS-2, in the moment represented by new European Galileo system, in combination with GEO MSC will enable greater efficiency in the business operations of the transportation and communications systems for commercial and safety solutions including to improve ISPS, particularly by using the time synchronization of the Time Division Multiplex Access (TDMA) solutions and the provision of accurate position data for automatic surveillance systems. Development of new Galileo system as a new GNSS-2 generation and as an alternative technology of GPS and GLONASS systems will utilize digital signals from Geostationary (GEO), Medium (MEO) and/or Low Earth Orbit (LEO) satellite constellations to connect directly with user's handsets or with positioning receivers for all mobile applications. In the proper manner, new satellite technology has to provide a cost-effective of transmitting navigation signals and even to replace some terrestrial infrastructures of stations for high IAA. The navigation data could be integrated into such augmented systems to provide a GNSS-1 and GNSS-2 of GSAS service at low cost of IAA.

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BIOGRAPHIES OF AUTHORS

Prof. Dimov Stojce Ilcev is a research leader and founder of the Space Science Centre (SSC) for research and postgraduate studies at Durban University of Technology (DUT). He has three BSc degrees in Radio, Nautical Science and Maritime Electronics and Communications. He got MSc and PhD in Mobile Satellite Communications and Navigation as well. Prof. Ilcev also holds the certificates for Radio operator 1st class (Morse), for GMDSS 1st class Radio Electronic Operator and Maintainer and for Master Mariner without Limitations. He is author of several books in mobile Radio and Satellite CNS, Space DVB-RCS, Satellite Asset Tracking (SAT), Stratospheric Platform Systems (SCP) for maritime, land (road and railways) and aeronautical applications.