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HISTORY OF MOBILE RADIO AND SATELLITE COMMUNICATIONS

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The safety of navigation through all past ages has been a primary preoccupation for all seamen and shipping owners. Distress and disasters at sea caused by the blind forces of Mother Nature or by human factors have occurred during the course of many centuries on ships and in the life of seafarers. For many centuries, seafarers sailed without incoming information about trip, navigation and weather conditions at sea. At that time, only audio and visual transfers of information from point to point were used. However, no earlier than the end of the 19th century, were developed new disciplines, such as the transmission of news and information via wire initially, then by radio (wireless) and latterly, via modern satellite and stratospheric platform communications systems. The facts about airplanes and land vehicles are well determined and clear because these transport mediums have more reliable environments and routes than ships. After a disaster with airplane, train, truck or bus it is much easier to find out their positions and to provide alert, search and assistance. With the exception of safety demands, an important question is the utilization and development of new mobile radio and satellite communications and navigation systems for commercial and social utilization at sea, on land and in the air.

Introduction

Communication satellites provide the bridges for a number of new, specialized markets in commercial and private telecommunications and make ties between nations [1—11]. In the course of more than 40 years they have obtained global links in the public and private Terrestrial Telecommunication Network (TTN). Soon after Mobile Satellite Communications (MSC) and Navigation came to serve navy, ground and air forces worldwide and for of economic reasons, they also provided commercial MSC.

For 30 years, MSC system was used, particularly because ocean-going vessels have become dependent for their commercial and safety communications on Mobile Satellite Services (MSS). Although, aircraft and land vehicles started before merchant ships, due to many unsuccessful experiments and projects they have had to follow the evident lead of Inmarsat maritime MSC service and engineering. Thus, the modified ship's Mobile Earth Stations (MES) are today implemented on land (road or railway) vehicles and aircraft for all civil and military applications, including remote or rural locations and industrial onshore and offshore installations.

The GPS, DGPS, GLONASS and other new satellite navigation and determination systems provide precise positioning data for vessels and aircraft and also serve land navigation and fleet vehicle management. Because of the need for new, enhanced services, these systems will be augmented with satellite communications and ground surveillance facilities.

At the end of this race a new mobile satellite revolution is coming, whereby anyone can carry a personal handheld telephone using simultaneously satellite or cellular/dual systems at sea, in the car, in the air, on the street, in rural areas, in the desert, that is to say everywhere and in all positions. These integrated systems will soon be implemented, with new stratospheric platform wireless systems using aircraft or airships.

Overview

The word *communications* is derived from the Latin phrase "*communication*", which stands for the social process of information exchange and covers the human need for direct contact and mutual understanding. The word "*telecommunications*" means to convey and exchange information at a distance (*tele*) by the medium of electrical signals.

In general, telecommunications are the conveyance of intelligence in some form of signal, sign, sound or electronic means from one point to a distant second point. In ancient times, that intelligence was communicated with the aid of audible callings or oral shouting, fire and visible vapor or smokes and image signals. We have come a very long way since the first human audio and visual communications, in case you had forgotten, used during many millennia. In the meantime, simple and primitive kinds of mutual communications between individuals or groups of people were invented. Hence, as impressive as this achievement was, the development of more sophisticated and reliable communications and so, wire and radio, had to wait a couple of centuries more.

The invention of the telegraph in 1844 and the telephone in 1876 harnessed the forces of electricity to allow the voice to be heard beyond shouting distance for the first time. The British physicist M. Faraday and the Russian academic E. H. Lenz made experiments with electric and magnetic phenomenon and formulized a theory of electromagnetic induction at the same time.

The British physicist James C. Maxwell published in 1873 his classical theory of electromagnetic waves radiation, proving mathematically explanation that electromagnetic waves travel through space with a speed precisely equal to that of light. Following this experiments, the German physicist Heinrich Rudolf Hertz during 1886 experimentally proved Maxwell's theoretical equations.

He demonstrated that HF oscillations produce a resonant effect at a very small distance away from the source and that this phenomenon was the result of electromagnetic waves. Thus, it is after Hertz that the new discipline of Radio technology is sourced and after whom the frequency and its measuring unit (Hz) are named.

An English physician, Sir Oliver J. Lodge using the ideas of others, realized that the EM resonator was very insensitive and he invented a "coherer". A much better coherer was built and devised by a Parisian professor, Edouard Branly, in 1890. He put metal filings (shut in a glass tubule) between two electrodes and so a great number of fine contacts were created. This coherer suffered from one disadvantage, it needed to be "Shaken before use". Owing to imperceptible electric discharges, it always got "baked" and blocked.

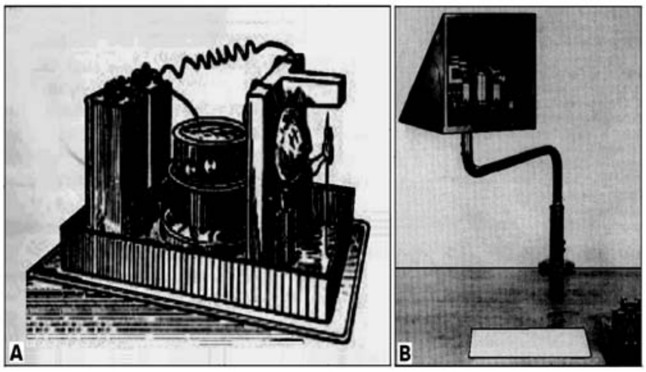

Fig. 1. Popov's radio receiver (*a*) and ship's Morse sender (*b*)

The Russian professor of physics Aleksandar S. Popov in 1894 successfully realized the first practical experiments with EM waves for the transmission of radio signals. In the same year, he succeeded in making a reliable generator of EM waves, when the receiving or detecting systems in common use still were not at all satisfactory. Accordingly, using the inventions of his predecessors and on the basis of proper experiments, professor Popov elaborated the construction of the world's first radio receiver with a wire-shaped antenna system in the air attached to a balloon, see Fig. 1*a*. In 1895, Popov improved Branly's receiver by the insertion of choke coils on each side of the relay to protect the coherer and also by replacing the spark gap with a vertical antenna insulated at its upper end and connected to the ground through the coherer. In Addition, he then mounted a small bell in serial connection with the coherer's relay anchor, whose ringing effected automatic destabilization and successive unblocked function of the receiver system.

On 7 May 1895, professor Popov demonstrated his new invented apparatus to the members of the Russian Physic-Chemical Society as follows: a lightning conductor as an antenna, a metal filings coherer and detector element with telegraph relay and a bell. The relay was used to activate the bell, which is announcing the occurrence of transmitting signals and in this way serving as a decoherer (tapper) to prepare the receiver to detect the next signals.

This was the first telegraph station in the world, which could work without any wires. In May the same year, he reported sending and receiving radio signals across a 550 m distance. Soon, instead of a bell he contrived to use a clock mechanism to realize direct, fast destabilization of metal filings in the coherer upon receipt of the signals.

In December 1895, he announced the success of a regular radio connection and on 21 March, 1896 at the St. Petersburg University, he demonstrated it in public. Finally, on 24 May 1896 Popov installed a pencil instead of the bell and sent the first wireless message in the world the distance of 250 m between two buildings, conveying the name "GENRICH GERZ" (the name of Hertz in Russian) by Morse code using his homemade transmitter and receiver.

In March, 1897, Popov equipped a coastal radio station at Kronstadt and the Russian Navy cruiser Africa with his wireless apparatus and in summer, 1897, Popov started to make experiments at sea, using radios on board ships before the entire world. In 1898, he succeeded in relaying information at a distance of 9 km and in 1899, a distance of 45 km between the island of Gogland and the city of Kotka in Finland. With all his inventions Popov made advances on the discoveries of Hertz and Branly and created the groundwork for the development of maritime radio.

In 1895, a few months later than Popov, a young Italian experimenter, Guglielmo Marconi, started to use radio and was the first to put EM theory into practical application. By the next year, he had sent Morse code messages at a distance of 2 miles. Moving to England to obtain patents on his equipment, he demonstrated radio reception over 8 miles. In 1897, he exhibited the use of two-way radio between ship and shore and, according to Western literature practically started the use of maritime radio. By the same year, G. Marconi succeeded as a businessman in getting his wireless telegraphy transmissions officially patented for the first time in the world.

The owners of the Dublin Daily Express in Ireland invited Marconi to conduct wireless reports of the Kingston Regatta of July 1898 from the steamer ship Flying Huntress, the first ship equipped with a commercial wireless system. Using an antenna hung from a kite to increase the effective height of his masts and a LF of 313 kHz at 10 kW of power, on 12 December 1901 Marconi crackled out the first wireless message to span an ocean in the form of Morse code; three dots forming the letter "s". This telegraph signal was sent from Newfoundland in Canada and received in Cornwall on the west coast of England.

Unlike Popov, Marconi was a good businessman and was able to turn his research into a financial and manufacturing empire. In the Fig. 1(*b*) is illustrated Sailor first used Morse Ship's Sender for transmitting distress alert messages and later for commercial ship to shore and vice versa direction at the turn of the 20 century.

In 1900, R. Fessenden made the first transmission of voice via radio in the USA, Fleming in 1904 discovered the diode valve, while their countryman and pioneer Lee de Forest developed and used a triode valve, which made it possible to use radio not only for radiotelegraphy but for telephony (voice) communications. As early as 1907, he installed a triode valve mobile radio on a ferryboat operating on the Hudson River near New York City.

Development of fixed and mobile radio communications

The very impressive development of mobile radio for maritime at first and later for aero applications initiated mobile distress and safety radio. Once the principles of radio were understood mobile radio has been a matter of the steady development of technology to extend communications accessibility, coverage and reliability by reducing the size, cost and power consumption of radio equipment and improving efficiency. With further innovations an age-old barrier between ships and shore was eliminated and possibility to communicate with mobile radios independent of space and time were created. These early radio devices were primitive by today's standards, incorporating spark transmitters, which blasted their signals across almost the entire radio spectrum. It is supposed that the first vessel to have a Ship Radio Station (SRS) was the American liner St. Paul, equipped in 1899. The next one, early in the following year was the German vessel s/s Kaiser Wilhelm der Grosse.

Thereafter, mobile radio spread rapidly throughout the shipping and safety business. By 1899, however, A. S. Popov had been the first in the world who successfully carried out demonstrations of mobile wireless telegraphy communications at a distance of 20 miles between warships of the Black Sea fleet. The first recorded use of radio for saving life at sea occurred early in March 1899.

The lightship on the Goodwin Sands Berlin in 1903, where some of the basic principles for the use of radiotelegraphy at sea were established. In the subsequent Berlin Conference near Dover on the south coast of England was fitted with one of the first seaborne Marconi SRS and used it to report to the Coastal Radio Station (CRS) that the German steamer Elbe had run aground.

The first distress signal was CQD (Come Quick Distress), used from 1904 only on British ships equipped with Marconi devices. After the collision of two passenger ships, the British s/s Republic and the Italian s/s Florida, running in thick fog in the early hours of 23 January 1909, the radio officer on board the s/s Republic sent for the first time in history the distress signal: "CQD MKC (call sign of s/s Republic), CQD MKC, CQD MKC" and text: "Republic rammed by unknown steamship, 26 miles southwest of Nantucket, badly in need of assistance".

After the catastrophe of the White Star liner s/s Titanic in the early hours of 15 April 1912, the UK proposal for a distress signal was the already established CQD, the USA proposed the NC of International signal codex and Germany preferred SOE. By 1912, there were 327 established CRS and 1,924 SRS available for public, commercial and safety use. Use of radio at sea became very attractive and indispensable, creating an immediate need for enforcement of the rules and regulations under international radio coordination. Because of this, the first Preliminary Radio Conference was held in of 1906, two radio frequencies, 500 and 1000 kHz were earmarked for correspondence. This conference also established a standard for International distress signals in radiotelegraphy, SOS.

The radiotelephony distress signal MAYDAY was adopted in 1927 at Hanover. The name of this signal derives from the French phrase "M'aidez", which means, "Help me". The first international SOLAS (Safety of Life at Sea) Convention was adopted during 1914 in London, partly as a result of the Titanic disaster. It stipulated Morse telegraphy on 500 kHz and battery-operated backup radio unit. Ships carrying more than 50 passengers were required to carry radio devices with a range of at least 100 Nm and larger ships had to maintain continuous radio watch with a minimum of 3 radio officers.

At the Conference in Washington in 1927 the Regulations were established as a supplement to bring into force three safety calls in radiotelegraphy for distress, urgency and security, SOS, XXX and TTT, respectively. These three signals were obligatory only on 500 kHz, with a silence period of 3 minutes after every 15th and 45th minute.

At that time was also introduced the use of radiotelephony at sea and, soon after that, the first radiotelephone communications between s/s America and coastal radio station Deal Beach, New Jersey in the USA, was realized. Then, at the Conference in Madrid radio stations call signs and frequencies were determined, the International Telecommunications Union (ITU) was established and Radio Regulations (RR) adopted.

At the Conference in Atlantic City in 1947 a supplementary ITU RR was adopted and a new radiotelephony distress frequency on 2,182 kHz accepted, instead of the old one on 1,650 kHz, with silence periods of 3 minutes after every 00th and 30th minute. Three telephone safety calls were previously used for distress, urgency and security such as: MAYDAY, PANPAN and SECURITE, respectively, on 2,182 kHz and more recently, on 156.8 MHz (16 VHF channel). Finally, the new era of transistors commenced and later on the period of revolutionary integrated circuits started after 1957. In the meantime, was the change to frequency instead amplitude modulation with a new ARQ system for use in maritime radio telex services.

Evolution of satellite communications

The first known annotation about devices resembling rockets is said to have been used by Archytus of Tarentumin, who invented in 426 B.C. a steam-driven reaction jet rocket engine that flew a wooden pigeon around his room. Devices similar to rockets were also used in China during the year 1232. In the meantime, human space travel had to wait almost a millennium, until Sir Isaac Newton's time, when we understood gravity and how a projectile launched at the right speed could go into Earth orbit.

Finally, the twentieth century came with its great progress and the historical age of radio and space communications began to unfold. Russian scientist Konstantin Tsiolkovsky (1857—1935) published a scientific book on virtually every aspect of space rocketing. He propounded the theoretical basis of liquid propelled rockets, put forward ideas for multi-stage launchers and manned space vehicles, space walks by astronauts and a large platform system that could be assembled in space for normal human habitation.

A little later, the American Robert H. Goddard launched in 1926 the first liquid propelled engine rocket.

At the same time, between the two World wars, many Russian and former USSR scientists and military constructors used the great experience of Tsiolkovsky to design many models of rockets and to build the first reactive weapons, particularly rockets called "Katyusha", which one Soviet Red Army used against German troops at the beginning of the great Patriotic War (Second World War).

Towards the end of the Second World War, many military constructors including Verner fon Broun in Germany started with experiments to use their series V1 and V2 rockets to attack targets in England. After that, in October 1945, the British radar expert and writer of science fiction books Arthur C. Clarke proposed that only three communications satellites in Geostationary Earth Orbit (GEO) could provide global coverage for TV broadcasting.

The work on rocket techniques in Russia and the former USSR was much extended after the Homeland War. The satellite era began when the Soviet Union shocked the globe with the launch of the first artificial satellite, Sputnik I, on 4 October 1957, shown in Fig. 2(*a*).

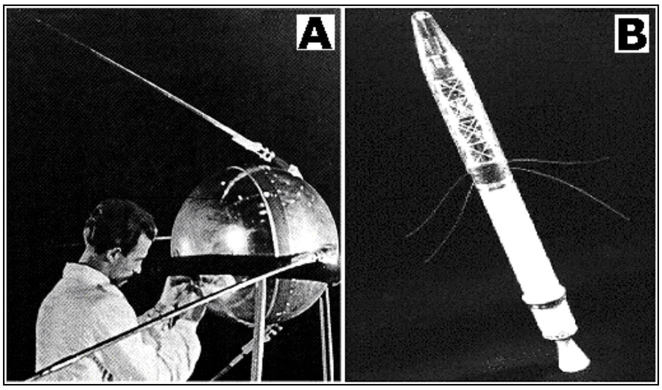

Fig. 2. Sputnik I (*a*) and Explorer I (*b*)

This launch marked the beginning of the use of artificial Earth satellites to extend and enhance the horizon for radiocommunications, navigation, weather monitoring and remote sensing and signified the announcement of the great space race and the development of satellite communications. That was soon followed on 31 January 1958 by the launch of US satellite, Explorer I, illustrated in Fig. 2(*b*) and so, the development of satellite communications and navigation and the space race began. The most significant progress in space technology was on 12 April 1961, when Yuri Gagarin, officer of the former USSR Air Forces lifted off aboard the Vostok I spaceship from Bailout Cosmodrome and made the first historical manned orbital flight in space.

Active communication satellites

After the launch of Sputnik I, a sustained effort by the USA to catch up with the USSR was started. This was reflected in the first active communications satellite named SCORE launched on 18 December 1958 by the US Air Force. The second satellite, Courier, was launched on 4 October 1960 in High-inclined Elliptical Orbit (HEO) with its perigee at about 900 km and its apogee at about 1,350 km using solar cells and a frequency of 2 GHz.

The maximum emission length was between 10 and 15 min for every successive passage. The third such satellite was Telstar I designed by Bell Telephone Laboratories experts and launched by NASA on the 10 July 1962 in HEO configuration with its perigee at about 100 km and apogee at about 6,000 km, see Fig. 3(*a*).

The plane of the orbit was inclined at about 45º to the equator and the duration of the orbit was about 2.5 h. Because of the rotation of the Earth, the track of the satellite as seen from the Earth stations appeared to be different on every successive orbit. Thus, over the next two years, Telstar I was joined by Relay I, Telstar II and Relay II. All of these satellites had the same problem, they were visible to widely separated LES for only a few short daily periods, so numbers of LES were needed to provide full-time service.

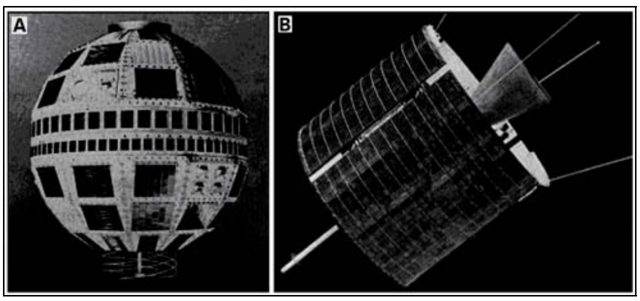

Fig. 3. Telstar I (*a*) and Intelsat I (*b*)

On the other hand, GEO satellites can be seen 24 hours a day from approximately 40% of the Earth's surface, providing direct and continuous links between large numbers of widely separated locations. The World's first GEO satellite Syncom I was launched by NASA on 14 February 1963, which presented a prerequisite for the development of MSC systems. This satellite failed during launch but Syncom II and III were successfully placed in orbit on 26 July 1963 and 19 July 1964, respectively. Both satellites used the military band of 7.360 GHz for the uplink and 1.815 GHz for the downlink.

Using FM or PSK mode, the transponder could support two carriers at a time for full duplex operation. Syncom II was used for direct TV transmission from the Tokyo Olympic Games in August 1964. These spacecraft continued successfully in the trial service until some time after 1965 and they marked the end of the experimental period.

Technically, all these initial satellites were being used primarily for Fixed Satellite Service (FSS) experimental communications, which were used only to relay signals from Fixed Earth Stations (FES) at several locations around the world. Hence, one FES was actually located aboard large transport vessel the USNS Kingsport, home-ported in Honolulu, Hawaii. The ship had been modified by the US Navy to carry a 9.1 m parabolic antenna system for tracking the Syncom satellites.

The antenna dish was protected, like present mobile antennas today, from the marine environment by an inflatable Dacron plastic radome, requiring access to the 3-axis antenna through an air lock within the ship. Otherwise, the Kingsport ship terminal was the world's first true MES and could be considered the first Ship Earth Station (SES).

The ITU authorized special frequencies for Syncom communication experiments at around 1.8 GHz for the downlink (space to Earth) and around 7.3 GHz for the uplink (Earth to space). Namely, this project and trial was an unqualified success proving only the practically results of the GEO system for satellite communications but, because of the large size of the Kingsport SES antenna, some experts in the 1960s concluded that MSC at sea would never really be practical. However, it was clear that the potential to provide a high quality line-of-sight path from any ship to the land and vice versa via the satellite communications transponder existed at this time.

Intelsat was founded in August 1964 as a global FSS operator. The first commercial GEO satellite was Early Bird (renamed as Intelsat I) developed by Comsat for Intelsat, see Fig. 3(*b*). It was launched on 6 April 1965 and remained active until 1969. Routing operations between the US and Europe began on 28 June 1965, a date that should be recognized as the birthday of commercial FSS.

The satellite system had 2×25 MHz width transponder bands, the first with 2 Rx uplinks (centered at 6.301 GHz for Europe and 6.390 GHz for the USA) and the second 2 Tx downlinks (centered at 4.081 GHz for

Europe and 4.161 GHz for the USA), with maximum transmission power of 10 W for each Tx. This GEO satellite system used several LES located within the USA and Europe and so, the modern era of satellite communications had begun.

In the meantime, considerable progress in satellite communications had been made by the former USSR, the first of which the Molniya I (Lightning) satellite was launched at the same time as Intelsat I on 25 April 1965. These satellites were put into an HEO, very different to those used by the early experiments and were used for voice, Fax and video transmission from central FES near Moscow to a large number of relatively small receive only stations.

In other words, that time became the era of development of the international and regional FSS with the launch of many communications spacecraft in the USSR, USA, UK, France, Italy, China, Japan, Canada and other countries.

At first all satellites were put in GEO but later HEO and Polar Earth Orbits (PEO) were proposed, because such orbits would be particularly suitable for use with MES at high latitudes. The next step was the development of MSC for maritime and later for land and aeronautical applications. The last step has to be the development of the Non-GEO systems of Little and Big Low Earth Orbits (LEO), HEO and other GEO constellations for new MSS for personal and other applications.

Early progress in mobile satellite communications and navigation

The first successful experiments were carried out in aeronautical MSC. The Pan Am airlines and NASA program in 1964 succeeded in achieving aeronautical satellite links using the Syncom III GEO spacecraft. The frequencies used for experiments were the VHF band (117.9 to 136 MHz), which had been allocated for Aeronautical MSC (AMSC).

The first satellite navigation system, called Transit was developed by the US Navy and become operational in 1964. The great majority of the satellite navigation receivers has worked with this system since 1967 and has already attracted about 100,000 mobile and fixed users worldwide. The former USSR equivalent of the Transit was the Cicada system developed almost at the same time.

Furthermore, following the first AMSC unsuccessful trials and experiments, the Radiocommunications Subcommittee of the Intergovernmental Maritime Consultative Organization (IMCO), as early as 1966 discussed the applicability of a MSC system to improve maritime radiocommunications. This led to further discussions at the 1967 ITU WARC for the Maritime MSC (MMSC), where it was recommended that detailed plan and study be undertaken of the operational requirements and technical aspects of systems by the IMCO and CCIR administrations.

A little bit later, the International Civil Aviation Organization (ICAO) performed a similar role to that of IMCO (described earlier) by the fostering of interest in AMSS for Air Traffic Control (ATC) purposes. The majority of early work was carried out by the Applications of Space Technology to the Requirement of Aviation (Astra) technical panel. This panel considered the operational requirements for and the design of, suitable systems and much time was spent considering the choice of frequency band. At the 1971 WARC, 2 x 14 MHz of spectrum, contiguous with the MMSC spectrum, was allocated at L-band for safety use. Hence, the work of the Astra panel led to the definition of the Aerosat project, which aimed to provide an independent and near global AMSC, navigation and surveillance system for ATC and Airline Operational Control (AOC) purposes.

The Aerosat project unfortunately failed because, whereas both the ICAO authority and world airline companies of the International Air Transport Association (IATA) agreed on the operational benefits to be provided by such a system, there was complete disagreement concerning the scale, the form and also potential cost to the airlines. Finally, around 1969, the project failed for economic reasons.

The first experiment with Land MSC (LMSC) started in 1970 with the MUSAT regional satellite program in Canada for the North American continent. However, in the meantime, it appeared that the costs would be too high for individual countries and that some sort of international cooperation was necessary to make MSS globally available.

In 1971, the ICAO recommended an international program of research, development and system evaluation. Before all, the L-band was allocated for Distress and Safety satellite communications and 2×4 MHz of frequency spectrum for MMSS and AMSS needs, by the WARC held in 1971. According to the recommendations, Canada, FAA of USA and ESA signed a memorandum of understanding in 1974 to develop the Aerosat system, which would be operated in the VHF and L-bands.

Although, Aerosat was scheduled to be launched in 1979, the program was cancelled in 1982 because of financial problems.

The first truly global MSC system was begun with the launch of the three Marisat satellites in 1976 by Comsat General. Marisat was a GEO spacecraft containing a hybrid payload: one transponder for US Navy

ship's terminals operating on a government UHF frequency band and another one for commercial merchant fleets utilizing newly-allocated MMSC frequencies.
The first official mobile satellite telephone call in the world was established between vessel-oil platform "Deep Sea Explorer", which was operated close to the coast of Madagascar and the Phillips Petroleum Company in Bartlesville, Oklahoma, USA on 9 July 1976, using AOR CES infrastructure and GEO of the Marisat mobile satellite system.

The IMCO convened an international conference in 1973 to consider the establishment of an international organization to operate the MMSC system. The International Conference met in London two years later to set up the structure of the International Maritime Satellite (Inmarsat) organization.

The Inmarsat Convention and operating agreements were finalized in 1976 and opened for signature by states wishing to participate. On 16 July 1979 these agreements entered into force and were signed by 29 countries. Thus, the Inmarsat system officially went into operation on 1 February 1982 with worldwide maritime services in the Pacific, Atlantic and Indian Ocean regions, using only Inmarsat-A SES at first. Moreover, the Marecs-1 B2A satellite system was developed by 9 European states in 1984 and launched experimental MCS system Prodat serving all mobile applications.

In the meantime, the ex-USSR satellite organization Intersputnik developed the following mobile systems: the Volna (Wave) Network; the Morya Network and the Gals Network.

The Volna MSC system served to connect maritime and aeronautical MES terminals via space segment constellation to LES and ground-based telecommunication facilities for former USSR ships and aircraft. This MSS consists in communications payloads carried by the spacecraft Gorizont and Raduga. The Volna Network provided radio and TV service for mobile stations on UHF frequency bands between 335—399/240—328 MHz.

On the other hand, the Volna Network provided service uplink/downlink on L-band between 1636—1644/1535—1542 MHz for MMSS and also on L-band 1645—1660/1543/158 MHz for AMSS applications, while feeder link used 6/3 GHz uplink/downlink bands for both MSS applications.

In 1989 the former Soviet Union expanded its MMSS with the Morya MSC Network, using existing ex-Soviet communication satellites series Morya for carrying the MSC payload. Namely, the Morya Network provided MMSS on two 2.5 MHz wide frequency uplink/downlink bands centered on 1637.25/1535.75 MHz (service link) and 6084.0/3758.3 MHz (feeder link).

Piggybacked on the former Soviet Union's Raduga spacecraft, named Gals (Tack), a special telecommunications payload was serving as satellite links for the former USSR (today Russia) military forces. Thus, this Network will operate using the X-band spectrum for up linking (7.9 to 8.4 GHz) and down linking (7.25 to 7.75 GHz), for defense maritime, land and aeronautical applications.

The Intersputnik provided those three MSS using communication transponders in payloads carried by its GEO spacecraft Gorizont (Horizon), Raduga (Rainbow) and Morya (Seamen).

In 1985, the Cospas-Sarsat satellite system for Search and Rescue (SAR) was declared operational. Three years later the international Cospas-Sarsat Program Agreement was signed by Canada, France, USA and the former USSR. In 1992, the Global Maritime Distress and Safety System (GMDSS), developed by the International Maritime Organization (IMO), began its operational phase.

Hence, in February 1999, the GMDSS became fully operational as an integration of Radio MF/HF/VHF (DSC), Inmarsat and Cospas-Sarsat LEOSAR and GEOSAR systems.

The Transit system was switched off in 1996 to 2000 after more than 30 years of successful and reliable service. By then, the US Department of Defense was fully converted to the new Global Positioning System known as GPS.

However, the GPS service could not have the market to itself, the ex-Soviet Union developed a similar system called Global Navigation Satellite System (GLONASS) in 1988. While both, the Transit or Cicada system provides intermittent two-dimensional (latitude and longitude when altitude is known) position fixes every 90 minutes on average and was best suited to marine navigation, the GPS or GLONASS system provides continuous position and speed in all three dimensions, equally effective for navigation and tracking at sea, on land and in the air.

The USA Federal Communications Commission (FCC) is encouraging toward private development of the Radio Determination Satellite System (RDSS), which would combine positioning fixing with short messaging.

In 1985, Inmarsat developed the Standard-C system and later examined the feasibility of adding navigational capability. Although, the ESA satellite navigation concept, called Navsat, dates back to the 1980s, the proposed project has received relatively little attention and even less financial support. Since 1988, the USbased Company Qualcomm has established the OmniTRACS service for mobile messaging and tracking. Soon after, Eutelsat promoted a very similar system named EuroTRACS integrated with GPS and the Emsat communications system.

At the beginning of this millennium approved by ICAO were developed and became operational three regional Satellite Augmentation Systems (SAS) for Communications, Navigation and Surveillance (CNS): the US Wide Area Augmentation System (WAAS), the Japanese MTSAT Satellite-based Augmentation System (MSAS) and the European Geostationary Navigation Overlay Service (EGNOS).

Thus, SAS augments the two military GNSS now operating, the US GPS and the Russian GLONASS and make them suitable for safety critical applications such as flying aircraft or navigating ships through narrow channels and port approaches.

Conclusion

The last European Union contribution is the Global Navigation Satellite System (GNSS) as a precursor to a new system known as Galileo. This full GNSS, under development in Europe, is a joint initiative of the EC and the ESA in order to reduce dependency on the GPS service. The target of new the Galileo project is to start with operations at the beginning of next decade and to become completely operational by 2018.

In the meantime, were projected and are under development other 4 Satellite Augmentation Systems (SAS): 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 soon IS Marine Radio will propose to ICAO own project known as African Satellite Augmentation System (ASAS), as an African Project for Africa and Middle East.

The interesting and very prospective projects are developing in Europe, Japan and the USA for new mobile and fixed broadcast, broadband, multimedia and Internet Stratospheric Communication Platforms (SCP) systems powered by fuel or the Sun's energy and manned or unmanned aircraft or airships equipped with transponders and antenna systems at an altitude of about 20—25 km.

The SCP systems are the newest space technique with top digital transmission technologies for fixed and all mobile commercial and military applications, which will include remote and rural solutions as well, employing Voice, Data and Video over IP (VDVoIP) and IPTV service.

At the end of this race a new mobile satellite revolution is coming, whereby anyone can carry a personal handheld telephone using simultaneously satellite or cellular/dual systems at sea, in the car, in the air, on the street, in rural areas, in the desert, that is to say everywhere and in all positions.

These integrated systems will soon be implemented, with new stratospheric platform wireless systems using aircraft or airships. The final target of this race is to do Space more friendly to mankind and eventually to discover our new home.

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