JOURNAL OF MARITIME RESEARCH

Vol XX. No. III (2023) pp 12–18

ISSN: 1697-4840, www.jmr.unican.es

Basic Characteristics for Development of Antenna Systems for Mobile Satellite Communications (MSC)

Dimov Stojce Ilcev[1,*]

ARTICLE INFO

Article history:
Received 22 May 2023;
in revised from 24 Jun 2023;
accepted 16 Jul 2023.

Keywords:
MSC, SES, AES, GES, VDV, MES, MMSC, LMSC, AMSC, MSA, GNSS, LGA, G/T. EIRP, GEO, LEO, VSAT, Mechanical and Electrical Characteristics, Basic Relations, Bandwidth, Gain.

ABSTRACT

More then one century ago was developed first radio and used onboard ship for communication and safety purposes. Namely, Mobile Satellite Communication (MSC) systems were conceived for the transmission and receiving of telegraphy and telephony signals via mobile antenna at first from ships, and then from cars, trains and aircraft. The consideration of antenna transmission is inevitable, especially in MSC systems, where their propagation characteristics are much affected by different and changeable local environments during movement of mobile and differ greatly from those observed in fixed satellite systems. To create adequate antenna hardware design for MSC systems, engineers have to consider all related factors in order to realize full mechanical and transmission potentials. This article describes evolution and development of mobile antenna systems, classification and types, and characteristics of MSC for Ship Earth Station (SES) and Aircraft Earth Station (AES).

1. Introduction.

The antenna system used for any mobile satellite communication platform is one of the critical and least important parts of the Mobile Satellite Communication (MSC) network. The mobile satellite antenna platform is the interface between the satellite equipment and the external environment to connect ships, land vehicles (road and rail) and aircraft with customers via Ground Earth Stations (GES) or Gateways. Thus all global MSC systems require antennas at the transmitter and receiver to operate properly.

In essence, a satellite antenna enables transmission of Voice, Data and Video (VDV) to a Mobile Earth Station (MES) or receiving data from mobiles regardless of the different positions on the surface of the globe of the two MSC stations. The other satellite stations can be a shore office connected via GES terminals or other mobile stations. All satellites used in MSC networks make use of a beam, which is a pattern of electromagnetic waves transmitted by the satellite. The MES antenna transmission via satellite transponders has a defined pattern and the beam can be wide or narrow covering a large or small area on Earth.

The antenna systems onboard MES terminals are stationary due to the constant movement of the mobile when it is in motion and therefore require the dish to be movable in all dimensions. The dish itself is hidden from view by the radome cover but viewed up close they are sophisticated pieces of equipment with motors and and gears that allow the antenna to maintain a lock on the satellite in all but the most severe conditions. This can be overcome by making use of mobile antenna systems with automatic pointing a satellite dish in relation to azimuth and elevation in the direction of the satellite. The goal of both of these directions for the satellite is to optimize the signal strength so that MES antenna has the best signal and can use the satellite service uninterrupted.

Mobile antenna positioning or tuning is very important aspect for getting standard broadcast signals from a satellite. Thus, the mobile satellite antenna must be automatically pointed at a precise angle to get the strongest possible signal. If the mobile

[1]University of Johannesburg, Johannesburg, South Africa.
[*]Corresponding author: Dimov Stojce Ilcev. E-mail Address: ilcev@uj.ac.za.

antenna position is adjusted manually, it became too difficult to align it at the optimum position.

2. Evolution of Antenna Systems for placeMobile Radio communications.

The Russian professor of physics Alexander Stepanovich Popov designed his first world's radio receiver in 1895 with antenna in the shape of wire mounted on a balloon in the air and transmitter with a lightning conductor as an antenna, including a metal filings coherer and a detector element with telegraph relay and a bell. Soon later, Marconi started commercially to deploy radio and antenna equipment on board different merchant ships and to establish his own company for the production of maritime radio and antenna equipment.

Figure 1: Communication, Navigation (GNSS) and Broadband Shipborne Antennas.

Source: Author.

Since the initial use of mobile radio, more than 100 years ago, was for long distance wireless communications at LF and the first shipboard antenna were all made of haphazard lengths of wire strung as high as possible above the ship's topside, evidently the thinking was that the longer and higher the wire, the better the results should be. After those different kinds of wire and whip antennas were developed for MF/HF/VHF Maritime Mobile Satellite Communications (MMSC), Land Mobile Satellite Communications (LMSC) for personal and vehicle communication and Aeronautical Mobile Satellite Communications (AMSC).

3. Classification & Types of Mobile Satellite Antennas (MSA).

The general classifications of MSA in connection with the service operators and providers are performed on the following shipborne major types: satellite communications antennas, integrated GPS and GLONASS Satellite Navigation Antennas (GNSS) and satellite broadband (multimedia) antenna systems shown in **Figure 1.** In **Figure 2** are shown vehicle borne satellite communicator, GNSS and broadband antenna systems, which can be installed onboard road and rail vehicles.

However, the fundamental classification of MSA systems, according to gain values and technical characteristics, falls into three major groups as follows: Low-Gain Omnidirectional Antennas; Medium-Gain Directional Antennas and High-Gain Directional Aperture Antennas.

4. Antennas Requirements and Technical Characteristics.

This section describes important general requirements for mobile antenna solutions used in MSC systems for maritime, land (road and rail) and aeronautical applications, including antennas for personal handheld terminals. At any rate, the mobile antenna has to be compact, flexible and lightweight and perform with good mechanical and electrical characteristics, especially for heavy mobiles such as ships and aircraft, owing to the special conditions of installation and the influence of changeable environmental conditions.

4.1. Mechanical Characteristics.

Mobile antennas have to satisfy the requirements of mechanical characteristics in relation to construction strength and easy installation. In fact, easy installation and appropriate physical shape are very important requirements in addition to compactness and lightweight. In the case of shipborne antennas, the installation requirements are not as severe compared to that of aircraft and cars because even in small ships there is a comfortable space to install an antenna set.

Figure 2: Communication, GNSS and Broadband Vehicleborne Antennas.

Source: Author.

Figure 3: Communication, Navigation (GNSS) and Broadband Airborne Antennas.

Source: Author.

Otherwise, the only problem is because all types of ships satellite antennas are sometimes under huge stress from vibration and sloping caused by strong winds, ship's rolling and pitch or is subject to corrosion by sea salt. Owing to these problems, a ship's satellite antenna has to be well protected by plastic radome and properly mounted on a strong mast, specially designed for a certain size of antenna.

In the case of road vehicles, especially small cars and buses, low profile and lightweight equipment is required. The big haulage trucks and locomotives have much space for installation of antennas, but still they need to be aerodynamically in shape. The requirements are the same for aircraft, although more severe conditions are required to satisfy avionic standards. Low air drag is one of the most important requirements for aircraft antennas. Vehicles utilizes smaller antenna, while aircraft utilize more aerodynamic sizes of antenna. In **Figure 3** are shown airborne communication, GNSS (GPS and GLONASS and broadband antenna systems.

4.2. Electrical Characteristics.

Sometimes, the mechanical construction of antenna is perfect because of some functional or electrical characteristics; however, designers of antenna have to keep in mind that the compact design of antenna has two major disadvantages in electrical characteristics, such as low-gain and wide beam coverage. The gain is closely related to the beam width and a Low-Gain Antenna (LGA) should have a wide beam width. As the gain of antenna is theoretically determined by its physical dimensions, reducing the size of antenna means decreasing its gain.

Because of low-gain and limited electric power supply, it is very difficult for mobile antennas to have enough receiving capability known as a Ratio of System Gain to System Noise Temperature (G/T) and transmission power known as an Effective or Equivalent Isotropically Radiated Power (EIRP). These disadvantages of Mobile Earth Station (MES) can be compensated by a satellite that has a large antenna and HPA with enough electrical power.

A powerful satellite with high G/T and EIRP performance should permit the fabrication of MES with compact and lightweight antennas. The next disadvantage is that a wide beam antenna is likely to transmit undesired signals to and receive them from an undesired direction, which will cause interference in and from other systems. The wide beam is also responsible for several fading effects, such as that from sea surface reflections in MMSC and AMSC and multipath fading in Land MSC (LMSC) and so, a compact mobile antenna system is required to prevent fading and interference.

Accordingly, it is inevitable for mobile antennas not to have enough performance, such as gain, radiation power and receiving capability because of their small physical dimensions. Without consideration of this, the requirements of transmitting and receiving performance of mobile antennas mainly depend on the satellite transmission capability. The first and second generations of Inmarsat satellites have a global beam and the third generation has spot and global beams to provide global coverage.

The regional or domestic Mobile Satellite Systems (MSS), such as AMSC, MSAT and Optus have spot beams. The spot gives higher satellite capacity than global beams although there are basically no big differences between requirements for mobile antennas in the global system, such as Inmarsat or the mentioned regional systems.

5. Basic Relations of Antennas.

The basic relations of antenna systems are very important parameters to easily understand the mode of antenna functions in two-way (duplex) satellite transmission systems, such as MES transceiving antennas. Moreover, these characteristics of MES antenna systems are needed for link budget calculations and for good satellite up and downlink design, which can provide reliable and acceptable quality satellite communications. At this point, this implies that the signal transmitted via the MES transmitting (Tx) antenna must reach the receiving (Rx) antenna of other MES or Land Earth Stations (LES) at a carrier level sufficiently above the unwanted signals generated by various unavoidable sources of noise and interference.

5.1. Frequency and Bandwidth.

In almost all present and forthcoming MSC systems using Geostationary Earth Orbit (GEO) satellites, the L-band 1.6/1.5 GHz is used for a link between the satellite and MES. The required frequency bandwidth in L-band MSS is about 8% to cover transmitting and receiving channels. Otherwise, in using a narrow-band antenna, such as an omnidirectional patch antenna, some efforts have to be made to widen the bandwidth. The S and L-band are allocated in WARC-92 for the Big Low Earth Orbit (LEO) Iridium and Globalstar MSC systems, which require frequency bandwidths of about 5%.

5.2. Gain and Directivity.

The required antenna gain is determined by a link budget, which can be calculated by taking into consideration the required channel quality and the satellite capability. The channels are expressed as C/N_o and depend on the G/T and EIRP values of the satellite and MES. Thus, in the abandoned Inmarsat-P system and forthcoming ICO system, medium gains of 7 to 16 dBi are required for voice and HSD channels using a transmission speed of about 24 Kb/s. In the case of present systems such as AMSC or MSAT, Optus and similar systems using GEO constellation, a medium gain between 8 to 15 dBi is required for voice and HSD channels of 24 Kb/s.

On the other hand, in the case of the present Inmarsat-A and B MES, a comparative High-Gain Antenna (HGA) of minimum 24 dBi is required, due to the difference in satellite capabilities. Meanwhile, Low Gain Antenna (LGA) of about 0 to 4 dBi are used in the Inmarsat-C and other similar omnidirectional systems to provide (Low Speed Data (LSD) of only about 600 to 1,200 b/s.

The GPS system has adopted LGA because of the extremely low data rate of 50 b/s from the satellites. Because they have the same type of LGA system, it is possible to integrate Inmarsat-C MES with the GPS receiver. There are no exact definitions to differentiate between characteristics of Low, Medium and High-gain antenna systems, except by the gain quantum, shape of the antenna and type of service. However, in the present and upcoming L-band MSC applications, classification of L-Band MES antenna systems by their receiving and service capabilities is illustrated in **Table 1.**

Table 1: Classification of L-Band Antenna Systems in MSC.

Type of Antenna	Gain Class	Typical Gain dBi	Typical G/T dBK]	Typical Antenna (Dimension)	Typical MSC Services
Omnidirectional	Low	0 – 4	–27 to –23	Quadrifilar Drooping-dipole Patch	LSD (Messages) Ship (Inmarsat-C) Vehicles & Aircraft
Semidirectional (Only in Azimuth)	Medium	4 – 8 8 – 16	–23 to –18 –18 to –10	Array (2–4 elements) Helical, Patch SBF (0,4m Φ) Phased Array (20 elements)	Voice/HSD Ship (Inmarsat-M) Vehicles Aircraft (Inmarsat-Aero)
Directional	High	17 – 20 20 – 24	– 8 to –6 –4	Dish (0,8m Φ) Dish (1m Φ)	Voice/HSD Ship (Inmarsat-A, B)

Source: Author.

The ideal antenna gain can be defined with an isotropic (hypothetical) antenna, which has an isotropic radiation pattern without any losses and therefore radiates power in all directions in uniform intensities. Thus, if input power (P_{in}) is put into an isotropic antenna, the power flux-density per ideal unit area (P_{id}) at distance (r) from the antenna is given by the following relation:

$$P_{id} = P_{in}/4\pi r^2 [W/m^2] \quad (1)$$

However, if radiated power density is P (θ, Φ)/r^2 in directions (θ = angle between the considered direction and the one in which maximum power is radiated, known as boresight; and Φ = phase) at distance (r) from the antenna under elevation, the gain of the antenna can be defined by the following equations:

$$G(\theta,\Phi) = P(\theta,\Phi)/r^2/P_{id} = P(\theta,\Phi)/r^2/P_{in}/4\pi r^2 = 4\pi P(\theta,\Phi)/P_{in} = P(\theta,\Phi)/P_{in}/4\pi \ [dBi] \quad (2)$$

The above-defined gain is called an absolute gain or directive gain, which is determined only by the directivity (radiation pattern) of the antenna without taking account of any losses in the antenna system, such as impedance mismatch loss or spillover loss. Thus, if direction is not specified and the gain is not given a function of (θ, Φ), it is assumed to be maximum gain. There is a general relationship between absolute gain and the physical dimensions of the antenna and this is given by the equation as follows:

$$G = 4\pi/\lambda^2 \ \eta a \quad (3)$$

where η = aperture efficiency and a = physical aperture, which will denote the effective aperture of the antenna. According to the above relation it can be realized that compact antennas with small apertures must have low gain. If an antenna aperture is a dish a known diameter (d), can be written in normal and in decibel expression as follows:

$$G = (\pi d/\lambda)^2 \ \eta = 10.log\eta \ (\pi d/\lambda)^2 \ [dBi] \quad (4)$$

Thus, it can be calculated that the gain in the Inmarsat shipborne antenna with a diameter of d = 1 m operated at 1.5 GHz is about 21 dBi. The directivity of the antenna D(θ, Φ) does not include dissipative losses and is defined as the ratio of P(θ, Φ) to the power per unit solid angle from an isotropic antenna radiation, the same total antenna radiated power (P_r). The antenna directivity can be expressed by:

$$D(\theta,\Phi) = P(\theta,\Phi)/P_r/4\pi \quad (5)$$

The definition of antenna directivity does not take the efficiency of an antenna into account because ($P_r/4\pi$) is related to the actual power launched into space. The ratio of G(θ, Φ) to D(θ, Φ) is termed the radiation efficiency of the antenna.

6. Designs of Antennas for MMSC.

The new developed MMSC systems and equipment have introduced modern complexities into the design of shipboard antennas. The direct line-of-sight between antenna and satellite requires the antenna to "see" from horizon to overhead (zenith – 90^o) in elevation and 360^o in azimuth angle, with total hemispherical coverage. In fact, this is fulfilled in the case of transceiver antenna through the use of tracking rotatable, high-gain antennas often installed in pairs on board ship to attain full coverage, irrespective of blockage in the form of the funnel, musts, stacks and other objects.

The ship platform itself imposes even more stringent requirements. Therefore, in spite of constant vibrating, pitching, rolling and yawing during bad weather conditions, the MSC antenna's narrow radiation beam must be pointed accurately from any position on the high seas. Otherwise, the situation regarding land or aero antenna is less complicated.

Figure 4: Inmarsat-FB, Global Xpress and TVRO Shipborne Antennas.

Source: Author.

As the 1970s dawned, optimism and enthusiasm about satellite communications was so great with ideas to virtually replace HF radio in the Navy with the new Fltsatcom military mobile satellite system for Navy, Ground and Air Forces. However, the first real global MSC system was the US Marisat military satellite network, which employed SES and L-band antenna systems similar to ceased Inmarsat-A and B satellite terminals. The new generations of Inmarsat Inmarsat-FB (FleetBroadband), Fleet One and Global Xpress Shipborne Antennas are illustrated in **Figure 4.**

1. Inmarsat-FB MSA – The FleetBroadband (FB) was launched by Inmarsat sometimes in 2007 providing high-speed Internet connectivity, crew IP solutions in parallel with E-mail, Web, data, Virtual Private Network (VPN) and voice calling at sea. It enables tracking and telemetry functionality, so shippers on shore have all the information they need about voyage, Estimated Time of Arrival (ETA), cargo operations, real-time engine data for maintenance, drilling data for improving production or position data for fleet tracking and management and so on. There are two satellite terminal types defined and type-approved for the FB maritime service utilizing Inmarsat-4 satellite constellation at L-band, referred to as Class 8 (High Gain Antenna “FB500”) and Class 9 (Low Gain Antenna “FB250” and “FB 150”) satellite terminals. The key difference between Class 8 and Class 9 is the antenna. Therefore, for each type of FB terminal Inmarsat defines:

1. The air interface at the output of the terminal’s antenna;
2. The mandatory features and service types for each class of user terminal; and
3. The performance requirements of the user terminal.

The Sailor 500 FB transceiver uses the TT-3052A antenna, which is a maritime Broadband Global Area Network (BGAN) antenna that complies with Inmarsat’s Class 8 definition for ship antenna shown in **Figure 4 (Left).** This antenna is larger and provides more bandwidth than the TT-3050A used for the Sailor 250 FB system.

This antenna contains all functions for satellite tracking including a GPS system. A single coaxial cable carries all RF communication, supply voltage and modem connection between the antenna and the terminal. Manufacturers must meet all of these requirements in order to obtain Type Approval antennas. The definition of other equipment features such as physical connections, user interfaces, firewalling, routing control etc is determined by each manufacturer according to specific market-driven needs. Because of the possibility of different physical interfaces on terminals from different antenna manufacturers users should pay particular attention to the installation guidelines for different terminal configurations and features.

2. Inmarsat-GX MSA – The Global Xpress (GX) is the newest Inmarsat standard that is using the last constellation of Inmarsat-5 satellites at Ka-band RF, which Cobham Sailor 100 GX satellite reflector antenna with radome is illustrated in **Figure 4 (Middle).** This light and compact light and compact antenna is an advanced 3-axis stabilized tracking system designed for the Inmarsat GX satellite network. It is a direct development from the immensely successful SAILOR 900 VSAT antenna systems, which have created a new industry standard through innovative design and reliable operation. The GX antenna features advanced Tracking Receiver technology that enables it to verify the right satellite in less than a second. It uses a single cable between satellite antenna known as Above Deck Equipment (ADE) and transceiver with peripherals known as Below Deck Equipment (BDE) for RF, power and data, while advanced features such as Automatic Azimuth Calibration and Automatic Cable Calibration significantly reduce installation time further.

Figure 5: Land Vehicular VSAT Road and Rail Antennas and TVRO Vehicle borne Antenna.

Source: Author.

This GX antenna provides reliable access to the full range of high throughput satellite broadband services for maritime business applications, ships operations and crew welfare, including passenger multimedia services. The technical specifications of ADE are as follows: Antenna pedestal is 3-axis stabilized tracking with integrated GPS Rx; Antenna reflector system is reflector/sub-reflector including ring focus; Transmit Gain is 47.5 dBi at 29.5 GHz (excl. radome); Receive Gain is 44.0 dBi at 19.7 GHz (excl. radome); System G/T is 20.1 dB/K at 19.7 GHz, at ≥10° elevation (ε) and clear sky (incl. radome); Block Up Converter (BUC) has output power is 5 W GX BUC; EIRP ≥53.5 dBW (incl. radome) is MAX. 36.0 dBW/40KHz; Low Noise Block (LNB) GX Ka is single band LNB; Tracking Receiver Internal is “all band/modulation type” including e.g. power, DVB-S2, GSC and modem RSSI; Polarization is Circular Cross-Pol (Inmarsat GX, TX: RHCP, RX: LHCP); Elevation Range is -25° to +125°; Azimuth Range is Unlimited (Rotary Joint); Ship motion (angular) is Roll +/-30°, Pitch +/-15°, Yaw +/-10°; Ship, turning rate and acceleration is 15°/S2 and 15°/S2; ADE motion is linear accelerations +/-2.5 g max any direction; Satellite acquisition is automatic with or without Gyro/GPS Compass input; Humidity tolerance is 100%; Rain/IP class considers EN60945 Exposed / IPX6; Wind tolerance is about 80 kt for operational and 110 kt for survival conditions; Ice survival tolerance is 25 mm/1”; Solar radiation is 1120 W/m2 to MIL-STD-810F 505.4; Compass safe distance is 1 m/40” to EN60945; Dimensions (over all) Height: H 150 cm/58.9” - Diameter: Ø 130 cm / 51.3” and Weight is 126 Kg/ 276 lbs.

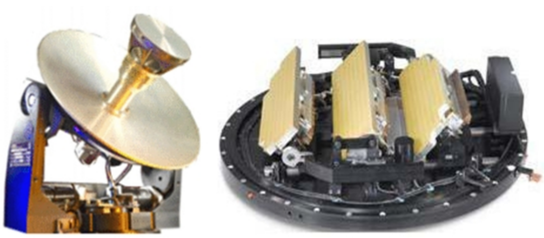
3. TVRO Antenna – Inmarsat GEO satellite operator provides stabilized ships antennas that deliver high-quality TV reception or TV Receive-Only (TVRO) systems suitable for any region of the world. This TV antenna can be installed onboard any type and size of merchant ships, sea rigs or platforms, fishing boats and luxury cruise vessels, which are designed to withstand the harshest marine conditions and to continue working in even the heaviest seas on the globe. Inmarsat has designed four types of shipborne stabilized TVRO antenna, such as metricconverterProductID0.6 metres0.6 metres ST 24 model, 1.2 metres 5004 model, 1.25 metres t130W in 66.5” radome and 1.5 metres 6004 in 76” radome. The last 6004 type of TV antenna is illustrated in **Figure 4 (Right),** which total weight is approximately 159 kg and DAC 2202 is a control unit.

7. Designs of Antennas for LMSC.

The vehicleborne satellite antenna system for LMSC provides communications, broadband and TVRO transmission of multimedia information such as audio and video images, voice and data by the integration of satellite communication, microwave-band transmission, wireless LAN, Internet, mobile public network as well as audio and video compression. These antennas are serving road vehicles and rail wagons with Satcom On-The-Move (SOTM) systems via Inmarsat and other GEO satellite constellations. However, the special vehicleborne satellite antenna system can quickly establish satellite broadband and TV transmissions

1. KVH Land Vehicular mini-VSAT Antenna - The TracPhone V3-IP radome antenna units of KVH producer are mini-VSAT Broadband communications system for road vehicles on the move shown in **Figure 5 (Left).** This antenna delivers a seamless and consistent Internet access with antennas that are smaller and lighter than traditional VSAT antennas. These VSAT systems consist of an antenna and Integrated CommBox Modem (ICM) that connect to a land-based hub via a Ku-band GEO satellite constellation. The ground Hub is managed by a Network Operations Center (NOC) then provides the link to the Internet and the terrestrial telephone network.

Figure 6: VSAT and TVRO Airborne Antennas.



Source: Author.

The antenna transmits RF energy that is potentially harmful. Whenever the system is in use it is necessary to make sure everyone stays more than 11 m (36 feet) away from the radome antenna. However, no hazard exists directly below the antenna. Both antennas may accept an external GPS input as a backup to the antenna's internal GPS. In this sense, it will be more secure to connect a backup GPS and prevent a loss of service if the antenna's internal GPS fails. The specifications of this antenna are: Service Coverage Areas are Seamless Worldwide; RX receive/TX transmit RF band is 11.7-12.75 GHz/14.0-14.5 GHz; Antenna gain is 31.0 dBi (RX-band, min); Transmit power (BUC) 3 W max for V3-IP; Elevation range is 7.5° to 75°; Azimuth range is 720° rotation max; Maximum Download Speed is about 2 Mb/s and Maximum Upload Speed is 128 Kb/s; Antenna Dish Diameter is 36.8 cm (14.5"); Antenna Diameter x Height/Weight is 9.4 cm (D) x 44.7 cm (h)/11.3 kg (15.5" (D) x 17.6" (h)/ 25 lbs).

2. Orbit Rail Low-profile VSAT Antenna – The Orbit RailTRx antennas are supporting a variety of stabilized train antenna system configurations in Ku and Ka-bands. As a common platform, it is designed to accommodate the current and future needs of the train market. As such, these elliptic antennas are an optimal solution for the evolving rail satellite broadband communications needs of inter-city, regional and high-speed trains. The RailTRx antenna product line comprises series of RailTRx 2-300 features a low profile high gain Ku-band antenna, shown in **Figure 5 (Middle)**. The values of 2-300 antennas are: RF Ku-band for Tx is 13.75 to 14.50 and for Rx is 10,95 to 12.75 GHz; G/T is 13.5 dB/K^o; EIRP 44 dBW; Travel Azimuth is 360^o; Elevation is +5 to +50; Antenna diameter is105.8 cm (41.6 in); Height is 48.8 cm (19.2 in); and Weight is 96 kg (211 lbs).

3. KVH Vehicular TVRO Antenna – The KVH manufacturer of vehicular TV antennas for road and rail applications has designed TracVision RV1 radome antenna shown in **Figure 5 (Right).** This satellite antenna is High Definition TV (HDTV) compatible, DVB-S2 acquisition and provides excellent performance and reliability for passengers in family cars, buses and rail wagons with hundreds of channels of satellite TV entertainment in no time. In addition, high performance TV antenna tracking with advanced algorithms provides crystal-clear television picture in extreme conditions. Antenna Unit Diameter x Height & Weight for RV1 are 34.3 cm x 33.7 cm (13.5" x 13.3") & 3.6 kg (8 lbs); and for A9 are 81 cm x 12.7 cm (32" x 5") & 22.5 kg (49.5 lbs).

8. Designs of Antennas for AMSC.

The DVB-RCS VSAT satellite technology is developed more than three decades ago and is taking big role in MSC systems and for Satellite Aeronauticak Broadband (SAB) applications. This service is providing broadcast, broadband, multimedia and very fast Internet with IPTV via GEO satellites using different antenna solutions. The antenna serves just for transceiving facilities or can be integrated with IPTV reception. In general, the new VSAT broadcasting service provides digital Voice, Dataq and Video over IP (VDVoIP). There is also possibility to install onboard aircraft just antenna for receiving TV (TVRO) transmissions.

1. VSAT Ku-band AL-1614 Tx/Rx Antenna – This avionics DVB-RCS Tx/Rx antenna based upon a proven concept implemented on various applications of Orbit Technology Group is used over the last 15 years, which antenna without radome is illustrated in **Figure 6 (Left)**.

This antenna is based on modular sub-assemblies such as follows: ACE, Gear/Motor/Encoder Assembly and RF Front End, which are designed, tested and proven to meet all necessary airborne environmental conditions. It provides access to satellite broadband networks anywhere, anytime under any weather condition while passengers are in the air, and has become essential. It is one of the first innovative stabilized VSAT Ku-band antenna solutions. Comprising a compact yet efficient dual reflector antenna with an RF front end delivering optimal nonstop quality connectivity with the selected satellite. The components of this antenna are assembled and integrated for this specific application in order to meet the required compact system design of Airborne Ku-band AL-1614 Tx/Rx Antenna. The antenna unit complies with ARINC, ETSI and FCC satellite regulations and provides the following key benefits and features: it is efficient "Dual Reflector" of antenna system, high EIRP of > 44 dBW, G/T is >9.5dB/°K and the minimum dynamic tracking error meets aeronautic standard RTCA 160D, provides the typical data rate of 3 Mb/s in reception and 512 KB/s in transmission, typical Eb/No is 6dB and RF bands of antenna are for Tx 14.00 - 14.50 GHz and for Rx 10.95 to 12.75 GHz.

4. Breakthrough Receiving Broadband Antenna for ASB – The P&L International Inc. designed the next generation of airborne ASB Antenna Systems known as ZipPhaser-Air aviation antenna for all size aircraft broadband capability onboard commercial airlines that need capability to connect over the Ocean Regions, which is illustrated in **Figure 6 (Right)**. This antenna system being proposed offers the highest technology phase array capability for DSB TV broadcasting onboard entertainment applications. The antenna system would install on the aircraft with a small low profile footprint and radome with and astounding low weight. The modem router uses an iDirect X5 Evolution and the antenna controller is included. The infrastructure on the aircraft can be wired or WiFi wireless the choice is the of the airlines operator. The X5 router and HUB provide automatic antenna beam switching capability as the aircraft moves from one region to the next providing seamless transition for transatlantic flights. The TV broadcasting network Ground Stations are located in placecountry-regionItaly, placeStateFlorida, placecountry-regionSingapore and placeStateHawaii. Moreover, the broadcasting satellite network is made up of a combination of Intelsat and Telesat Ku-band satellite transponders that downlink to the teleports infrastructures. Installation of this antenna would be simple with minimum effects to the aircraft. Today instant and uniterrupted airborne communications is a must globaly employing the breakthrough technology. However, the ZipPhaser-Air aviation antenna systems is the only low profile, 2-way Ku-band antenna system for all type of aircraft. Based on a unique flat panel technology, this antenna system has been especially designed to meet airlines expectation to provide reliable connectivity and global coverage at unprecedented speed and quality.

Conclusions

The design and configuration of MSA needs to be compact and lightweight especially for LMSC systems. On the other hand, the physical characteristics for MMSC and AMSC applications may be quite different, but both have to be designed compact for harsh environments and very extreme operating temperatures. These requirements will be difficult to achieve because the compact antenna has two major electrical disadvantages such as low gain and wide beam coverage, and because directional antenna has very heavy components for satellite tracking and getting satellite in the focus. However, a new generation of powerful satellites with high EIRP and G/T performances should permit the design of compact and lightweight MSA platforms.

In such a way new physical shapes and less weight are very important requirements in connection with compactness and lightweight, what will permit easier installation and maintenance. Shipborne antennas still have very big dimension especially those integrated in Inmarsat Standard FB and new Global Xpress. The new Inmarsat antenna for FleetBroadband is getting smaller dimension and can be employed for communication s and multimedia transmissions. The Swift64 airborne antenna is well suited for large jumbo jets, which installation requirements are not as limited compared to very small aircraft and helicopters. On the other hand, new aeronautical SwiftBroadband can be installed even on small jets with reduced space on fuselage. However, a phased array MSA is considered to be the best prototype for large aircraft and helicopters because of its very low profile, convenient mechanical strength and easy installation.

References.

[1] Evans B.G., "Satellite Communication Systems", IEE, London, 1991.

[2] Fujimoto K. & James J.R. "Mobile Antenna Systems Handbook", Artech House, Boston, 1994.

[3] Gallagher B. "Never Beyond Reach", Book, Inmarsat, London, 1989.

[4] Group of Authors, "Antenna Design", Peter Peregrinus, London, 1986.

[5] Canadian Marconi, "CMA-2102 Aero Satcom High-Gain Antenna", Canadian Marconi, Ville St-Laurent, 1997

[6] Imarsat, "Inmarsat Aeronautical Services Reference Manual", Inmarsat, London, 1995.

[7] Huurdeman A.A., "Guide to Telecommunications Transmission Systems", Artech House, Boston-London, 1997.

[8] Ilcev D. S. "Global placeMobile Satellite Communications for Maritime, Land and Aeronautical Applications", Theory Volune 1 & Applications, Volume 2, Springer, Boston, 2016 / 2017.

[9] Law P.E., "Shipboard antennas", Artech House, Washington, 1983.

[10] Maral G. at al, "Satellite Communications Systems", John Wiley, Chichester, 1994.

[11] Ohmory S., Wakana. H & Kawase S. "Mobile Satellite Communications", Artech House, Boston, 1998.

[12] Cobham, "Sailor 500 FB Transceiver TT-3052A Antenna", Cobham SATCOM Maritime, Lyngby, Denmark, 2020.

13] Inmarsat, "Inmarsat-GX Global Xpress Antenna System", Inmarsat Inc, London, 2015,

[14] KVH, "KVH Land Vehicular mini-VSAT Antenna", KVH Industries, Middlletown, US, 2017.

[15] Orbit, "Orbit Rail Low-profile VSAT Antenna", Orbit Communication Systems Ltd. Netanya, Israel, 22010.

[16] KVH, "KVH Vehicular TVRO Antenna", KVH Industries, Middlletown, US, 2022.

[17] KVH, "VSAT Ku-band AL-1614 Tx/Rx Antenna", KVH Industries, Middlletown, US, 2012.

[18] P&L International, "Aircraft TVRO Solutions", Weddington, NC, 2015.