Maritime Satellite Communications (January 2018)

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Abstract

The maritime market for satellite services is one of the fastest growing segments of satellite industry today. It is also the only market, where satellites enjoy a near monopoly on the high seas.
Maritime communications will experience major changes during the next two decades. The evolution of e-Navigation requires higher digital data exchange capacities. New connectivity solutions for the crew will also increase bandwidth needs. It is tricky to predict the future, especially in the maritime communications market.
What will be the future demands?
Which technologies will be available?
How will the regulatory bodies think in the future?
Within this paper, an overview of Satellite Communications (SATCOM) technology is presented. Future demands for maritime satellite communications, will be also spotlighted.

Index Terms

Autonomous ship, big data wave, Maritime Satellite Communications.

Introduction to Satellite Technology
This section of the report provides an overview of satellite communications technology, capabilities, and common uses.

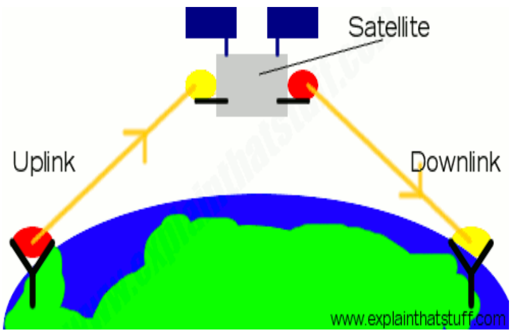
Over the last 50 or more years, satellites have been used to provide a variety of voice, data, navigation, and video services [1]. With the delivery of services from space, there are unique technology concerns that must be considered when evaluating satellite as a telecommunications platform.

These concerns include communication channel limitations (such as capacity limitations, latency, and jitter), weather interference, terrestrial blockage, and sun interference.

The industry has used various techniques to minimize the impacts of these impairments. Nevertheless, many of these impairments cannot be overcome because they are simply the result of the satellite's distance from the earth, the laws of physics, and other factors outside the control of the satellite operator.

While satellite technology plays an important role for certain applications, satellite technology cannot approach the quality, capacity and utility of terrestrial-based technology when providing fixed location broadband services.

Uses of Satellites
Since the 1950s, satellites have been utilized to provide communications links in areas and situations where wireline technologies were not available and were not feasible to construct.
Most communications satellites act as a relay from one point on the earth to one or more other locations or can be intersatellite communications.



Point to point communications is between two fixed locations on earth.
Broadcast communications is between a fixed location and multiple locations.

The information being relayed across a satellite link could be voice, broadband data, and/or video.

Benefits of Satellite

Communication satellites are used in fixed or mobile wireless communications to receive and transmit radio signals from an orbiting satellite to another terrestrial location. Satellite connectivity has the power to drive communications advances across a broad range of industries and geographies.

Global Coverage

Today, satellite communication can deliver a terrestrial-grade experience with voice, video, and data that can be accessed anywhere in the world. Ubiquitous coverage can be obtained with a global network of multiple satellites all tying into one central network management system.

Reliability

Satellite networks are dependable, providing constant connectivity even when terrestrial networks fail. With satellite networks, enterprises can maintain business continuity with built-in redundancy and automatic back-up service.

Security

Satellite networks already constitute a private network. By adding encryption technology satellite can provide a more secure connection than terrestrial networks, making it an ideal solution for government, military and enterprise VPN (virtual private network) solutions.

Scalability

The modularity of VSAT systems allows for quick time-to-market and fast upgrades. VSAT remotes can be deployed rapidly and new remote locations are easily added to a network where limited terrestrial infrastructure exists simply by configuring bandwidth to the site and having ground equipment installed.

Fast Deployment

Satellite technology is an ideal solution for quick deployment, immune to the challenges posed by difficult terrain, remote locations, harsh weather, and terrestrial obstacles. In this rapidly expanding market, satellite allows a service provider to get to market quickly and efficiently and provide immediate connectivity in disaster and emergency relief scenarios.

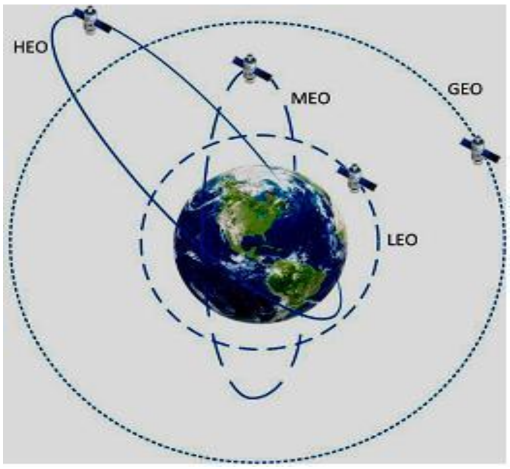
Cost Savings

Satellite technology can deliver a communications infrastructure to areas where terrestrial alternatives are unavailable, unreliable or simply too expensive. Satellite allows service providers to insure scalability, profitability and maintain low operating expenses, all while overcoming a lack **of** existing infrastructure.

Satellite Orbits

Satellite orbits can be classified into three main types:

- GEostationary Orbits (GEO)
- Low Earth Orbits (LEO)
- Medium Earth Orbits (MEO)
- High Elliptical Orbit (HEO)



MEO is mainly utilized for navigation services such as GPS and Galileo, while geostationary and LEO orbits are used for point-to-point and point-to-multipoint satellite communications.

Geostationary satellite technologies were an early enabler of global real-time communications. Because geostationary satellites orbit the earth at the same speed as the earth's rotation, the satellites appear to be stationary above the earth. To accomplish this, they are placed into orbit more than 22,000 miles

above the equator. At this distance, geostationary satellite beams have a direct line of sight to large portions of the earth.
Since geostationary satellites are positioned over one spot on the equator, the ground station antenna needs to point to only one location to receive the information being transmitted.
Geostationary satellites are effective in delivering certain types of signals to multiple locations simultaneously, such as is the case with broadcast television.
Nevertheless, there is very high latency in the communications delivered over geostationary satellites, since the radio signal must travel over 44,000 miles (round trip).

Satellite Orbits

To increase the quality of communications signals, MEO and LEO satellites have been used. Because LEO and MEO satellites orbit between a few hundred and a few thousand miles above the earth, they introduce much less latency than geostationary satellites.
At these lower altitudes, LEO and MEO satellites orbit the earth rapidly. From a fixed point on the earth, these satellites appear to move across the sky quickly; therefore, many satellites are required to ensure that a subscriber always has a satellite in view.
Because of the number of satellites and the intercommunication between satellites and the earth-based devices, LEO systems require sophisticated systems to maintain and hand-off service connections between the orbiting satellites. For example, the service provider Iridium utilizes a constellation of 66 LEO satellites.
These systems, when used to provide voice or data to fixed locations on earth, have proven to be complex and expensive to deploy and operate.

Frequency Bands
There are various radio frequency bands [2] that communication and military satellites operate within:
L-Band (1-2 GHz)
Being a relatively low frequency, L-band is easier to process, requiring less sophisticated and less expensive RF equipment, and due to a wider beam width, the pointing accuracy of the antenna does not have to be as accurate as the higher bands. Only a small portion (1.3-1.7GHz) of L-Band is allocated to satellite communications on Inmarsat. Inmarsat uses L-band for their Fleet Broadband, Inmarsat-B and C. The older Inmarsat A and B antennas were typically 1 meter in diameter, but, with the launch of more powerful satellites and the use of steerable spot beams, the new Fleet broadband antennas are down to less than 30cm (12 inches). L-Band is also used for low earth orbit satellites, military satellites, and terrestrial wireless connections like GSM mobile phones. It is also used as an intermediate frequency for satellite TV where the Ku or Ka band signals are down-converted to L-Band at the antenna LNB, to make it easier to transport from the antenna to the below deck, or indoor equipment. Since there is not much bandwidth available in L-band, it is a costly commodity.
C band
Uplink 5.925-6.425 GHz
Downlink 3.7-4.2 GHz
The C band is primarily used for voice and data communications as well as backhauling. Because of its weaker power it requires a larger antenna, usually above

1.8m (6ft). However, due to the lower frequency range, it performs better under adverse weather conditions on the ground.

X band

Uplink 7.9- 8.4 GHz

Downlink 7.25 – 7.75 GHz

The X band is used mainly for military communications and Wideband Global SATCOM (WGS) systems. With relatively few satellites in orbit in this band, there is a wider separation between adjacent satellites, making it ideal for Comms-on-the Move (COTM) applications. This band is less susceptible to rain fade than the Ku Band due to the lower frequency range, resulting in a higher performance level under adverse weather conditions.

Ku band

Uplink 14 GHz

Downlink 10.9-12.75 GHz

Ku band is used typically for consumer direct-to-home access, distance learning applications, retail and enterprise connectivity. The antenna sizes, ranging from 0.9m -1.2m (~3ft), are much smaller than C band because the higher frequency means that higher gain can be achieved with small antenna sizes than C-band. Networks in this band are more susceptible to rain fade, especially in tropical areas.

Ka band

Uplink 26.5-40GHz

Downlink 18-20 GHZ

The Ka band is primarily used for two-way consumer broadband and military networks. Ka band dishes can be much smaller and typically range from 60cm-1.2m (2' to 4') in diameter. Transmission power is much greater compared to the C, X or Ku band beams. Due to the higher frequencies of this band, it can be more vulnerable to signal quality problems caused by rain fade.

The higher you go in frequency, the more bandwidth is available, but the equipment needs to be more sophisticated.

The Evolving Technology of Maritime Satellite Communications

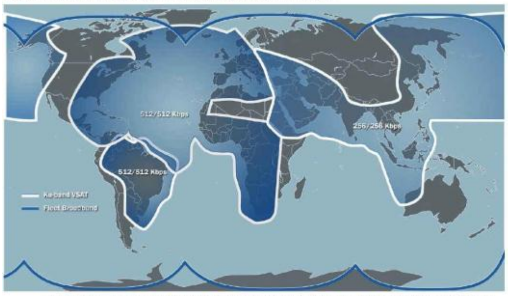
The oldest version of global maritime satellite communications, first offered by Inmarsat in the early 1980s, consists of low-frequency L-band service delivered by special Mobile Satellite Service (MSS) satellites. Even though it was designed for mobile use, L-band service initially required huge antennas to receive signals from early power-starved satellites. Over time, as new generations of satellites were launched, the size of the equipment was reduced, but the budget demands of L-band service were not.

In an effort to make data use affordable for mariners, satellite service providers began adapting terrestrial Very Small Aperture Terminal (VSAT) satellite technology, delivered by Fixed Satellite Service (FSS) for the maritime market. Thus, the first generation of standard maritime VSAT products, characterized by faster speeds and lower airtime costs than L-band solutions, but with the disadvantage of larger antennas and regional service. Indeed, the size and cost of 1-meter maritime VSAT antennas has limited the use of this technology. Originally designed for land use, standard TDMA VSAT systems require very large antennas typically in domes a minimum of 1.3 m (50") diameter by 1.5 m (59") height to operate in the marine environment, making them difficult and expensive to install on all but the largest vessels.

Main characteristics of these services:

- MSS is pay as you go, smaller equipment, and smaller domes. MSS uses L band. Inmarsat and Iridium both offer MSS.
- VSAT uses a larger dome, requires a bit more significant commitment when it comes to installation, you pay a fixed monthly contract for unlimited use. VSAT uses Ku band (and C band).
- VSAT, Iridium and Inmarsat offer global coverage. Iridium is completely global because it includes the Polar Regions, which no other service does.

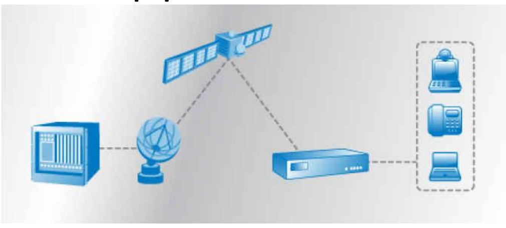
Legacy solutions require two discrete services to provide global coverage



Legacy services are shown on this combined coverage map of a leading L-band and Ku-band service combination. The Inmarsat FleetBroadband service provides coverage of the full world outside of the arctic regions. VSAT service is available only on a regional basis in the northern hemisphere and around the major continents.

VSAT Network

Network Equipment



A network typically consists of a larger earth station, commonly referred to as a teleport, with hub equipment at one end and a Very Small Aperture Terminal (VSAT) antenna with remote equipment at the other end.

The network equipment can be divided into two sets of equipment connected by a pair of cables:

Outdoor Unit (ODU)

An ODU is the equipment located outside of a building and includes the satellite antenna or dish, a Low Noise Block converter (LNB), and a Block-Up-Converter (BUC).

The LNB converter amplifies the received signal and down converts the satellite signal to the L band (950 MHz to 1550 MHz), while the BUC amplifies the uplink transmission when the antenna is transmitting.

Indoor Unit (IDU)

The IDU equipment at the teleport usually consists of a rack-mounted hub system and networking equipment connected to terrestrial networks, like the PSTN or Internet backbone. There is also a device that converts between satellite and IP protocols for local LAN applications such as PCs, voice calls and video conferencing.

At the remote location, a router connects to a small VSAT antenna receiving the IP transmission from the hub over the satellite and converts it into real applications like Internet, VoIP and data.

Network Topologies

Network topologies define how remote locations connect to each other and to the hub. The link over the satellite from the hub to the remote is called the outbound or downlink transmission, whereas the link from the remote to the hub is referred to as inbound or uplink.

Satellite networks are primarily configured in one of these topologies:

- Star Networks
- Mesh Networks
- Hybrid Networks
- Point to Point Connectivity

Value chain of satellite communications

Equipment Vendors

Equipment vendors are generally distinguished between pure antenna manufacturers and satellite equipment manufacturers that produce indoor or outdoor ground equipment including antennas, LNBs, BUCs, hubs, routers, software and network management systems.

Satellite Operators

Satellite operators are responsible for the planning and cost of the construction and launch of satellite into space. They own and manage a constellation of satellites and determine coverage and geographic areas. Satellite operators lease this bandwidth to service providers, government entities, television broadcasters, enterprises and sometimes direct to the end consumer.

Service Providers/ Network Operators

Service providers, sometimes known as network operators, are telecommunication companies or specialized satellite service companies who sell a full service package to the end customer. They lease capacity from satellite operators, purchase and operate the network equipment and the antenna, and are responsible for the installation and maintenance of the network.

Customers
Customers are the enterprises, organizations and consumers who use satellite communication services. Governments or large corporate customers may operate as their own service provider by managing the equipment directly and leasing bandwidth from satellite operators. Individuals and smaller enterprises typically work with service providers who manage the equipment and connections.

Applications
Always-on, high-speed connectivity is needed for a variety of applications. Whether broadcasting radio to consumers or multi-casting data for enterprise networks, satellite can support all of a user’s networking requirements, including:

- VoIP/VPN
- email/internet
- Video/Data
- Broadcasting

Satellite Service Providers and Organizations
The following is a summary of the primary providers and organizations.

International Telecommunications Satellite Organization (ITSO)
Previously known by the acronym, "INTELSAT", resulted from the efforts of a group of nations to join the United States in 1964 to establish a global communications satellite system. he International Telecommunications Satellite Organization is an intergovernmental organization that incorporates the principle set forth in Resolution 1721 (XVI) of the General Assembly of the United Nations, which establishes that communication by means of satellites should be available to the nations of the world as soon as practicable on a global and non-discriminatory basis. It also incorporates the principle embedded in the "Outer Space Treaty," which states that outer space shall be used for the benefit and in the interest of all countries.

Inmarsat (ISAT)
ISAT is a British satellite telecommunications company, offering global mobile services. It provides telephone and data services to users worldwide, via portable or mobile terminals which communicate with ground stations through twelve geostationary telecommunications satellites.
The present company originates from the International Maritime Satellite Organization (INMARSAT), a non-profit intergovernmental organization established in 1979 at the behest of the International Maritime Organization (IMO) - the United Nations' maritime body - and pursuant to the Convention on the International Maritime Satellite Organization, signed by 28 countries in 1976.
In April 1999, INMARSAT was succeeded by the International Mobile Satellite Organization (IMSO) as an intergovernmental regulatory body for satellite communications, while INMARSAT's operational unit was separated and became the UK-based company Inmarsat Ltd. The IMSO and Inmarsat Ltd. signed an agreement imposing public safety obligations on the new company.
Inmarsat was the first international satellite organization that was privatized.

Eutelsat
The European Telecommunications Satellite Organization (Eutelsat) was originally set up in 1977 by 17 European countries as an intergovernmental organization (IGO). Its role was to develop and operate a satellite-based telecommunications infrastructure for Europe.
EUTELSAT's assets, liabilities and operational activities were transferred to

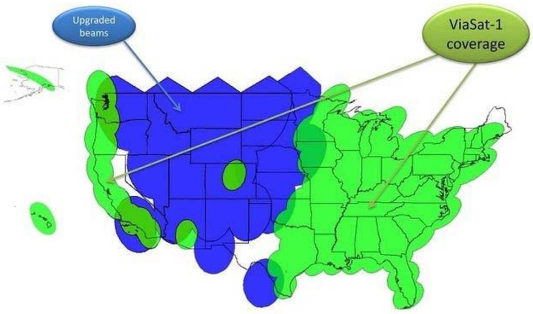
a private company called Eutelsat S.A. established for this purpose in July 2001.
Eutelsat S.A. is a French satellite operator, providing coverage over the entire European continent, the Middle East, Africa, Asia and the America. It is one of the world's three leading satellite operators in terms of revenues

Hughes Network Systems

Hughes Network Systems, LLC (Hughes) is a wholly owned subsidiary of EchoStar Corporation. In North America, the Hughes system includes the *SPACEWAY 3* and the recently launched *EchoStar 17* Ka-band geostationary satellites.

ViaSat

ViaSat delivers geostationary satellite service to residential consumers, businesses, government entities, and the military, and offers fixed and mobile services over ViaSat-1, which ViaSat claims to be the highest bandwidth capacity satellite.
In 2009, ViaSat acquired WildBlue and continues to market WildBlue's data and voice service to consumers.
Exede, a high-speed Internet offering, is delivered over a combination of the ViaSat-1 satellite and older WildBlue satellites.



The ViaSat-1 coverage area is prioritized to areas with high population.

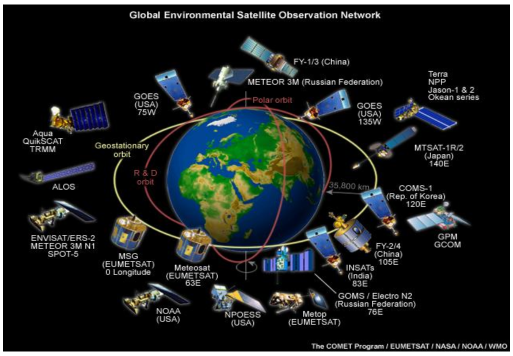
The lower data capacity on WildBlue satellites caused ViaSat to suspend new installations in many areas over the past several years.

Iridium Satellite

Iridium is a LEO satellite communications provider originally formed as a Motorola spinoff. The Iridium network consists of a constellation of 66 satellites. In 1999, Iridium World Communications filed for bankruptcy as a result of high infrastructure costs and low subscriber penetration. Iridium's network was purchased in 2000 for $25 million (the Iridium network originally cost approximately $5 billion), and the company was restructured as Iridium Satellite. Iridium has a major program underway for its next-generation network, Iridium NEXT.

Globalstar

Globalstar is another LEO provider of mobile satellite voice and data services. The company filed for bankruptcy in 2002 and emerged from bankruptcy in 2004. Globalstar appears to be looking to repurpose the spectrum currently used for satellite into terrestrial wireless spectrum because it has asked the FCC to convert 80 percent of its spectrum to "Wi-Fi type" service and has been testing with Amazon.



Services

Both geostationary and LEO service providers offer voice service. Due to the shorter distance that must be traveled by the radio waves, LEO networks have much lower latency than geostationary networks. LEO providers have focused on providing mobile voice services for industries that operate in remote locations such as maritime, aviation, mining, oil and some remote emergency services.

The Iridium and Globalstar packages range from $25 to $265 per month depending on the number of minutes included in the package. The geostationary providers market their voice packages to residential and business consumers. These packages normally range from $20 to $30 per month with unlimited minutes. Competitive satellite broadband services in the United States are currently only provided by geostationary providers. LEO satellite providers focus on mobile voice services and only provide low rate data services for specialized applications.

The broadband packages vary both by the broadband speed delivered and the monthly data allowance. When comparing satellite broadband service offerings to landline based offerings, all of the satellite limitations must be considered. The satellite quality, performance, and reliability are not comparable to a modern landline system.

Current landline providers offer 150 GB to 250 GB of data use per month. Standard satellite offerings provide a significantly lower monthly data allowance than what is considered acceptable to the users. With these low monthly data usage allowances, users would quickly exhaust their monthly allocations with streaming video or other high-bandwidth applications

Industry Regulation

The transmission of services via satellite is coordinated with the International Telecommunications Union (ITU).

In the USA the transmission of energy or communications or signals by space or earth stations is under, and in accordance with, an appropriate authorization granted by the Federal Communications Commission (FCC).

Orbital separation of between two and three degrees is common for geostationary satellites. Because of this physical separation, there is a limit on the number of satellites that can be placed into orbit.

There has been pressure for tighter regulations to ensure that the allocated slots are actually being used.

Frequency Utilization

To increase capacity, satellite providers must add more satellites, i.e. spatial diversity, or add more spectrums, i.e. frequency diversity.

Band	Frequency
VHF	138–152 MHz
P	0.230–1.00 GHz
UHF	0.430–1.30 GHz
L	1.53–2.7 GHz
S	2.7–3.5 GHz
C	Downlink 3.7–4.2 GHz Uplink 5.925–6.425 GHz
X	Downlink 7.25–7.745 GHz Uplink 7.9–8.395 GHz
Ku (US)	Downlink FSS 11.7–12.2 GHz Downlink DBS 12.2–12.7 GHz Uplink FSS 14–14.5 GHz Uplink DBS 17.3–17.8 GHz
Ka	18–31 GHz
Q	40–47 GHz
V	50–58.2 GHz
W	59–64 GHz

Satellite Life Cycle

Satellites require active maneuvering to maintain their orbits. Satellite maneuvers consume the satellite's onboard fuel. As the fuel supply of a satellite dwindles, the operator must plan to decommission the satellite. The FCC requires that geostationary satellites launched after March, 2002 be disposed of at a specific altitude, referred to as the graveyard orbit.

This requirement keeps the geostationary orbit clear of non-operating satellites. After most of their fuel has been spent, some geostationary satellites are placed into inclined orbits to prolong their useful lives. When in an inclined orbit, the satellite is allowed to drift north and south, which requires less fuel to maintain the satellite.

Since a satellite in an inclined orbit is no longer stationary, earth based ground stations must be able to track the satellite; therefore, satellites in inclined orbits are generally only used for military, aircraft, maritime, and other commercial applications.25 LEO communication satellites are typically either actively de-orbited or allowed to have their orbit decay before re-entry into the atmosphere.

If the satellite is large enough that it would not be completely consumed during re-entry, the operator maneuvers it to a predetermined impact area. NASA's Orbital Debris Mitigation Standard Practices contains guidelines for the disposal of satellites to limit the amount of debris released.

Satellite Communication Impairments

Latency

Latency is a measurement of the delay that occurs from the time a signal is sent to the time when it is received. In two-way communication systems, round trip latency is considered since each end must send and receive responses.

Satellite signals travel near the speed of light. Even at this speed, latency is an impairment to satellite communication due to the large distance the signals must travel.

Given that a signal must travel from a ground station to the satellite and back, in addition to normally experienced communications processing delays, the total delay for one-way communication between two ground stations is between 250ms and 300ms.

For two-way communications, as when one satellite customer communicates with another satellite customer, the round-trip time would typically be between 500ms and 600ms. This "double-hop" scenario is likely for people who have satellite as their only communications option because they often live in close proximity with others that are served by satellite.

Unacceptable communication delays would be experienced when calling a neighbor, friend, or local business that also uses satellite service, even though the two customers may be geographically close. Since this latency is primarily caused by laws of physics, there is no way to avoid it.

Voice and many data services are time-sensitive, or isochronous, in nature. Because of this characteristic, interactive voice and data communications are degraded when utilizing geostationary satellites.

Specifically, latency limits subscribers from using some real-time applications, Virtual Private Networking (VPN) and online applications (such as Google Docs).

A transmission over a satellite requires about ¼ of a second to travel from the sender to the receiver, due to the physical distance between the satellite and earth. TCP/IP relies on a complex system of queries and responses to determine an appropriate rate at which to send data. Too fast and the transmission overloads one or more links inside the network. Too slow, and the link is not used efficiently.

While the physics that limit signal speed cannot be altered, technical improvements, such as protocol acceleration and information caching, reduce the number of times communication must occur between the earth-based systems and the satellite thus minimizing the effects of latency.

Despite these many improvements, latency for the new generation of satellite-delivered broadband remains high. LEO satellites have been deployed to help minimize latency problems, but this technology requires a sophisticated constellation of satellites and complex customer equipment and is even more expensive than geostationary satellites.

Terrestrial Blockage

Since geostationary satellites orbit the earth over the equator, subscribers at the equator point their satellite dishes nearly straight up to communicate with the satellite. As a subscriber's distance from the equator increases, the elevation of the dish relative to the horizon decreases. Therefore, the likelihood of an object obscuring the direct view of a satellite also increases as the subscriber's distance from the equator increases. Thus, terrestrial blockage can be significant issue.

Weather Interference

Weather can also affect the reliability of satellite communications. The frequencies used by satellite systems are susceptible to weather degradation. Transmission errors can be caused by heavy rain and the accumulation of ice or snow on dishes.

Weather interference occurs more severely as a subscriber's distance from the equator increases, since the signals must travel a greater distance through the atmosphere before reaching the satellite.

To mitigate weather effects, satellite providers have implemented adaptive power control and more robust modulation techniques; however, weather interference problems persist.

Sun Interference

Twice a year the sun crosses behind each geostationary satellite as it is viewed from the ground station. During these periods in the Spring and Fall, the alignment of thermal noise from the sun with the satellite signals causes a temporary loss of signal. The duration of the outage depends on the satellite ground station location, satellite orbital location, size of the antenna, and the signal frequency. Many publicly available calculators predict solar outages.

Voice over Satellite Concerns

The use of satellite communications for voice services creates Quality of Service (QoS) challenges. There are both quantitative and qualitative parameters that can be evaluated for satellite-based voice services.

Packet loss, traffic prioritization, compression technologies and bandwidth all contribute to the overall quality of a satellite Internet Protocol (IP) call. The primary QoS measurements are latency and jitter, of which latency is the primary barrier to quality satellite-based voice communications.

Packet loss or packet corruption also causes degradation of voice quality. Therefore, if packets are lost due to congestion, weather interference, or other issues, the voice quality will suffer greatly.

Customer Premises Equipment

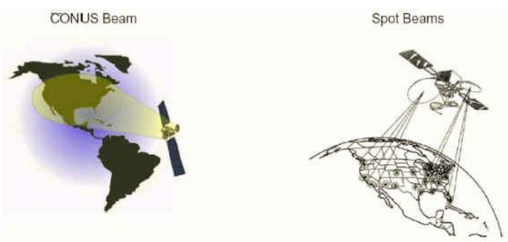
Satellite voice Customer Premises Equipment (CPE) has made great strides over the last decade. Earlier satellite phone models were large, briefcase-sized consoles, while newer models are much smaller.

Even so, a typical satellite phone in use today is approximately twice the weight and five times as thick as an iPhone. Unlike smart phones, satellite phones today do not support Internet Access or other data plans.

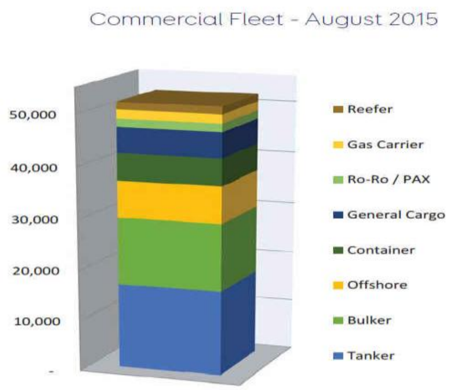
Moreover, the cost of a satellite phone typically ranges from \$499 to \$899 depending upon battery life, size and other factors.

Spot beams VS CONUS beam

Since both orbital slots and additional spectrum are scarce commodities, satellite manufacturers have started to use spot beams as a form of spatial diversity. Rather than one large CONUS beam, spot beams are targeted to specific coverage areas. Spot beams enable large-scale frequency re-use, which allows subscribers to be served more efficiently and directs capacity to where it is needed most.



The maritime market challenges



Gross Tone

The shipping market has traditionally been cyclical in nature [3]. It is increasingly difficult for ship operators to predict demand for world seaborne trade, together with structural changes in the global economy taking place.

It is likely that conditions will become even more challenging in shipping in the future, and in response operators need to fundamentally change the way that they approach their businesses.

A recent satellite communications roundtable, organized by the industry publication *Maritime Reporter & Engineering News*, focused on the business reasons that commercial maritime operations are turning to broadband connectivity.

If you're Connected, You're Competitive

There is little dispute that broadband connectivity will increasingly be a catalyst that will drive profitability for commercial maritime operations.

The emerging data needs of the maritime market include:

- Improving vessel operational efficiency by providing real-time weather and current forecasts to the ship and feeding back vessel performance data to shore
- Automating delivery of electronic charts and software updates
- Running IP-based applications, including accessing centralized databases for logistics, ERP, regulatory compliance, and administrative tasks
- Providing remote IT management, and remote support of engineering tasks and ship maintenance
- Enabling video conferencing for applications like telemedicine, security breaches, accident reconstruction, e-Learning, or emergency repairs
- Offering communications services for crew member calling and Internet café access

E-navigation

E-navigation is an International Maritime Organization (IMO) project that is underway and looking at a future digital concept for the maritime sector [4].

Work to date [5], has identified possible future developments in:

- improved, harmonized and user-friendly bridge design with improved reliability, resilience and integrity of bridge equipment and navigation information together with integration and presentation of information in graphical displays such as that received via communication equipment;
- Improved reliability and resilience of on-board Position, Navigation and Timing (PNT) systems;
- Improved shore-based services with means for standardized and automated ship-to-shore reporting,
- Improved access to relevant information for Search and Rescue (SAR), and
- Improved communication of VTS (Vessel Traffic System) information.

Arctic communication

The Arctic is a new and relatively unexplored area for the future maritime communications market.

The Arctic comprises the latitudes above 60°N except for the area of sea between southern Greenland and northern Norway which is warmed by the Gulf Stream and remains ice free. The Arctic is currently experiencing a warmer climate which is slowly reducing the permanent ice cover and making more of the area accessible to shipping.

With the limited availability of other communications options at sea, satellites will play a major role.

Possible future high level architectures are investigated towards their advantages and challenges.

Autonomous Ships

Unmanned merchant ships on intercontinental voyages are an attractive future application as the world is facing a shortage of seafaring personnel while the number of ships is growing.

For unmanned operation the ship will need to be equipped with advanced sensor systems to detect and avoid obstacles, a positioning and navigation system to determine and control exact location, speed and course as well as route, and the engine also requires advanced on board control.

With every sensor reporting data it is conceivable that a vessel could generate up to 60GB of data per day.

A reliable communication link with robust communication architecture might be achievable with a satellite service in a future autonomous ship scenario.

It is likely that, as more equipment on board begins to generate data, more of the processing of that data will take place on board— a trend that will run alongside and support greater automation and autonomy. The rise of these Smart Ships will see the amount of data it will be necessary to transmit fall dramatically, bringing it well within manageable levels.

Big Data wave

With these developments in mind, it is perhaps understandable that at the moment Big Data is too often seen as an IT wave [3].

But Big Data, is actually a business transformation wave and its real value to shipping and maritime will be realized when it is applied cross-business and includes commercial and enterprise datasets.

There is an urgent requirement for shipping to view itself in the context of the wider logistics channel and identify where operators can add value as part of new, smart, data-enabled supply and value chains.

Smart Ships are just one part of the equation: they require integration with Smart Ports and the growing number of Smart Cities—Hamburg being a good example.

But the level of co-ordination, data sharing and interaction that will be required in the future has to be underpinned by enterprise- grade connectivity.

Fortunately the maritime industry is entering a new age of enhanced connectivity with previously unheard of levels of bandwidth on offer via the launch of high-throughput satellite networks.

Shipping will see a revolution not just in bandwidth but in the flexibility of service delivery and major changes in the connectivity ecosystem bringing in new stakeholders and suppliers offering innovative new applications and services.

Cyber security and cyber resilience

Cyber security and cyber resilience has to become a priority.

Cyber resilience is not an IT risk, it is an inevitable downside risk of the industry's increasing dependence on technology, and it has to be managed by boards, and a culture of cyber awareness embedded throughout organizations across the sector. It's essential that ship operators acknowledge the fact that cyber attacks now target users rather than infrastructure.

As the 2015 Crew Connectivity survey demonstrated, crews at least are a highly-IT literate workforce, so the opportunity to harness that capacity and leverage it across organizations is clear.

Research Key findings

In April 2015 Intelsat, the leading provider of satellite services worldwide, commissioned Futurenautics Research [3], a leading provider of maritime research and insight, to undertake a survey of ship operators and crew within the maritime market.

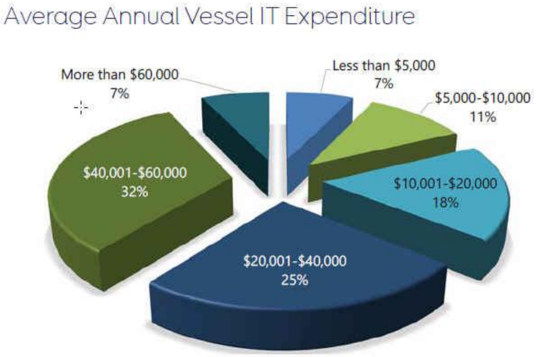
The objective of the survey was to understand the satellite service implications arising from the maritime market's current and future deployment of software applications at sea and ashore.

The survey provides insight into the range of satellite solutions and applications currently deployed and future predicted trends in bandwidth, satellite and application solutions deployment.

The key findings are presented in the next session.

Annual IT Expenditure

The average annual IT expenditure per vessel across all respondent companies was $23,947 with the majority of companies interviewed (58%) spending between $10,000 and $50,000 annually per vessel on IT.



Distribution of Satellite Communications Systems

Inmarsat FleetBroadband was the most commonly fitted satellite communication solution across respondents' fleets. 82% of the fleets within the survey had Inmarsat Fleet- Broadband terminals fitted.

VSAT solutions were present in 57% of fleets now making them the second most common satellite solution fi tted in the commercial maritime sector.

Only VSAT solutions were exclusively used 100% of the time as the primary data solution on-board.

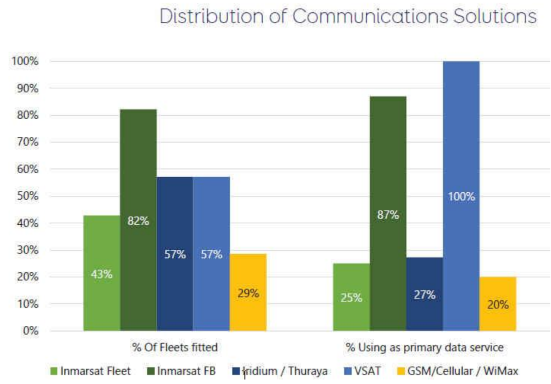
The average expenditure on L-Band solutions ranged from $50 to $3,500 USD/month. The majority of expenditure was in the range $0-$250 USD/month for those back-up systems such as Iridium and Thuraya.

Inmarsat Fleet and FleetBroadband expenditure was concentrated around the $750-$1,500 USD/month range.

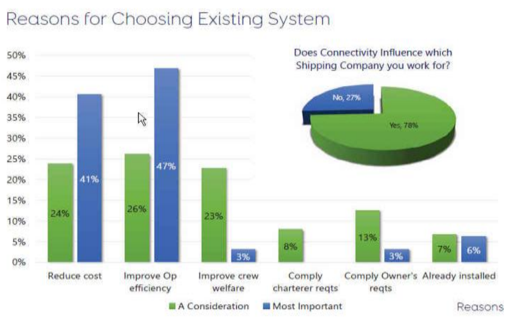
Average expenditure for VSAT varied according to the type of solution fitted. Regional/mini-VSAT installations were in the range of $750-$1,000/vessel/month.

Typically, Ku-Band system expenditure was around the $2,750-$3,500/vessel/month range – with just over half the fleets spending in this range.

All VSAT units were used as the primary data device both deep sea and in port/coastal waters.



Reasons for choosing existing satellite solutions



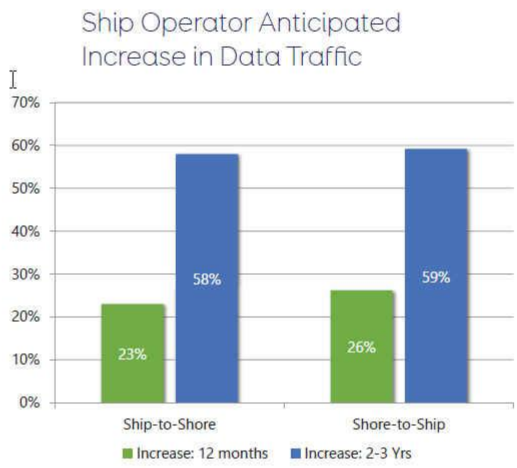
Operational efficiency is the most important reason for choosing a particular communications solution—for the first time more important than cost reduction. It potentially marks a very important shift in mind-set from a focus on fitting solutions to reduce cost, to understanding that they can deliver value across the business and drive competitive advantage.

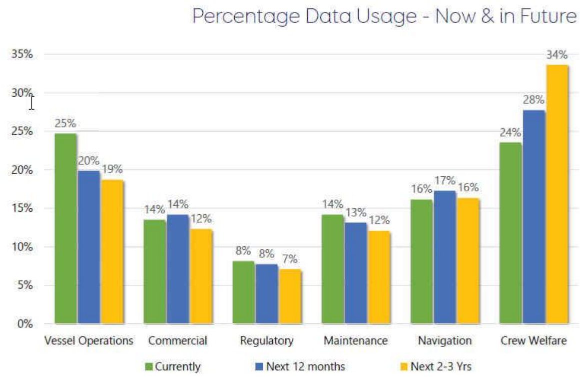
Crew welfare, so frequently cited in the past as a primary reason for fitting VSAT, was only chosen by 3% of respondents as the most important reason for fitting.

This is in stark contrast to the requirements of crew. 72% of crew thought that the level of connectivity provided on board was a factor in choosing which ship operator they worked for. Of that 72% of respondents 78% said that it was a strong or very strong influence on which contract they decided to take.

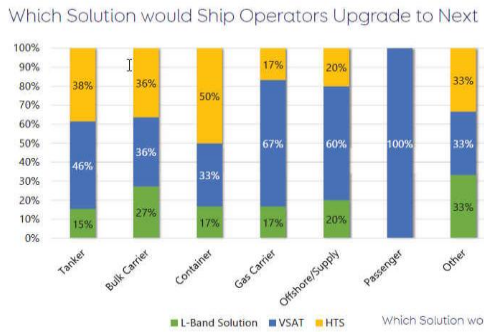
Data Growth

On average ship operators believe that ship-to-shore data traffic would increase by nearly 60% over the next 2-3 years.





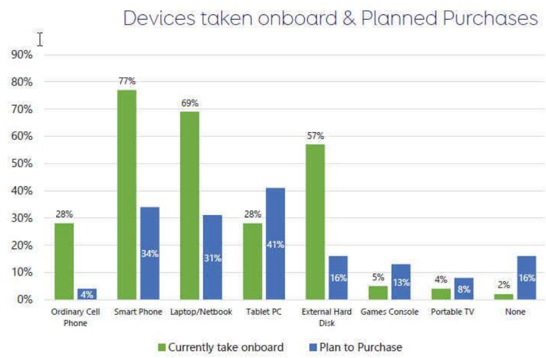
Satellite solution upgrade path



Respondents overwhelmingly thought that VSAT and next generation VSAT solutions (Intelsat EPIC, Inmarsat GX etc.) would be the most suitable solution for their fleet's future data requirements. When asked which solution they would upgrade to next and for which vessel type, only 18% of respondents choose an L-Band solution.

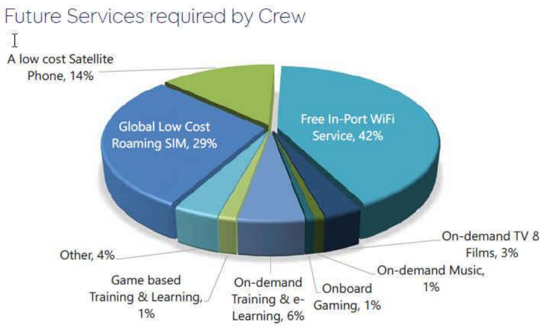
There has been a significant shift in perception and acceptance of VSAT and HTS services by all sectors of the maritime market.

Future Crew requirements

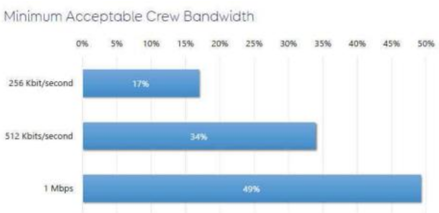


On average, crew takes 3 devices on-board. The most popular devices are Smartphone, laptops and external hard drives.

The future service most wanted by crew was free in-port Wi-Fi.



Internet access is still the most demanded service with 73% of respondents believing that adequate crew Internet service could only be achieved with bandwidth of 512kbps or above, putting it well outside existing L-Band capabilities.



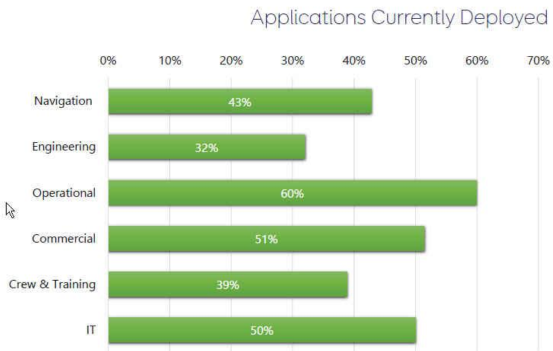
Current Software Deployment

Operational applications (HSEQ, Safety Management, cargo management, crew management and tracking/ positioning) are the most commonly deployed group of applications today, followed by commercial applications such as ERP, E-Procurement, E-Docs and risk/performance management systems.

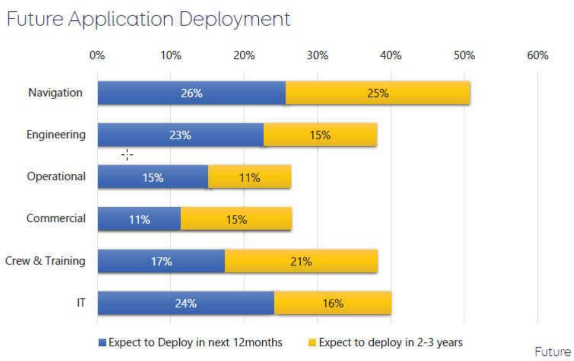
Operational and commercial applications were seen to deliver the most value to ship operators whilst IT/Network applications delivered most cost saving.

Only 23% of respondent companies used any form of cloud based applications despite wide proliferation of supplier companies providing cloud based versions of their software solutions.

Half of the ship operator respondents indicated that they did undertake some form of data analytics on the data collected from their on-board sensors and applications. IT/ Network analytics and operational data were the most common analytics undertaken.



Future Software Deployment



The most significant growth in applications over the next 3 years is to come from Navigation and IT as well as Engineering and Crew/Training applications.

The most widely deployed navigation applications in 3 years will be ECDIS, Back of Bridge, e-Publications, weather-routing and navigation data collection.

Data/cyber-security, remote IT diagnostics and network optimization solutions will be the most commonly deployed IT/Networking applications in 3 years.

Environment Control Areas (ECA's) will be a driver for deployment of engineering applications—specifically emissions monitoring and gathering and analysis of main engine sensor data will lead to adoption of CBM.

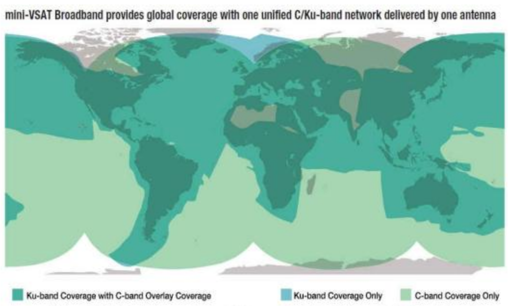
Growth in crew application deployment will be focused on online training and content services.

Attributes of the Ideal Maritime SATCOM Solution

With broadband connectivity providing benefits for every aspect of the commercial maritime operation today – from vessel operations to crew morale – the ideal satellite communications solution must provide:

•Fast data speeds with high quality, low latency service
•Terminals with small, light, easily installed antennas
•Affordable airtime rates
•Global coverage
•Reliability and simplicity
•Anytime, anywhere, one-call support

KVH mini-VSAT Broadband[sm] service and KVH's compatible TracPhone® V-series onboard terminals, is an example of such a solution [6].



KVH's mini-VSAT Broadband network is the world's first global C/Ku-band VSAT network, with truly global coverage outside of the arctic regions, including all world shipping lanes, fishing grounds, and major oil fields. The C-band overlay service also provides redundant coverage in all Ku-band regions, a big benefit since C-band is not susceptible to rain fade.

Conclusion

Industries everywhere are being disrupted and re-shaped by technology and service innovation. In shipping technology innovation and adoption has traditionally been driven by regulation and compliance, moving at the pace of the slowest. But, just as the Internet has permeated every aspect of business and personal communications on shore, it will at sea.

Today's mariners are responding to changes in regulations, technology, and business practices that require a constant connection to shore-side offices and home. Whether to download navigational charts and weather reports, upload vessel operational data, video conference with the main office, or access centralized company databases, mariners need to be online in order to conduct business and stay in touch no matter where they may be located.

Satellite-based communication networks limitations remain a constraint on broadband deployment. But the old days of developing IT strategies optimized to avoid expensive satellite data connections are obsolete. Ambitious startups are launching large fleets of small, interconnected satellites and developing cutting-edge new technology and analytics. The number of earth-gazing satellites has nearly doubled in 2014 alone. It is these startups that are changing how we use Big Data in business here on earth.

In the next few years, a reasonably priced broadband connectivity at sea – delivered by a new generation of maritime satellite communications technology - will allow offshore networks to connect to the 21st century.

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