ΔΟΡΥΦΟΡΙΚΕΣ ΕΠΙΚΟΙΝΩΝΙΕΣ ΣΤΗΝ ΝΑΥΤΙΛΙΑ

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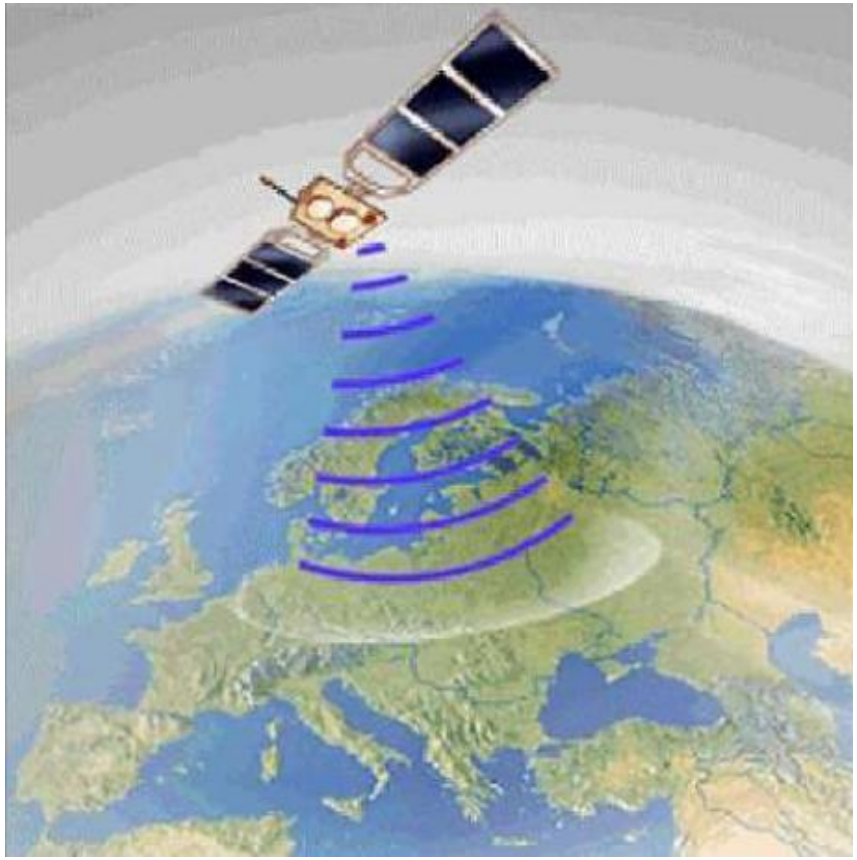
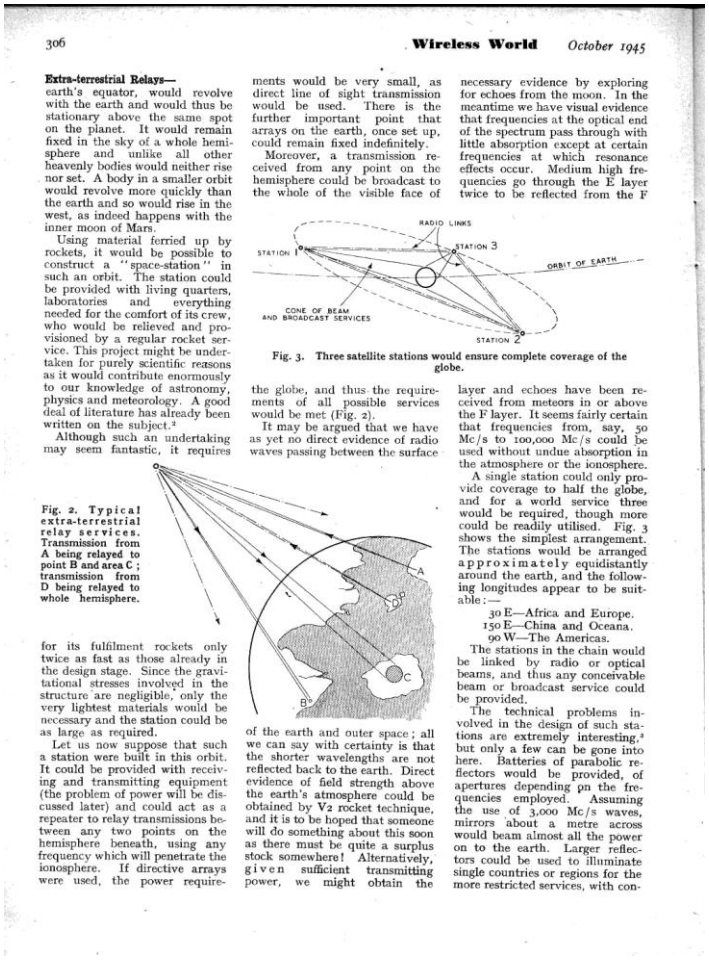
Maritime Satellite Communications

- 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.



Can we predict the future?

- **Sir Arthur C. Clarke's prediction on the future** of geostationary satellite communications, **published in the *Wireless World* magazine in 1945.**
- **Not considered seriously at the time it became a reality within 20 years** with the launching on 1965 April 6th of Intelsat I *Early Bird* the 1st commercial geostationary communication satellite.



306 **Wireless World** *October 1945*

Extra-terrestrial Relays—

earth's equator, would revolve with the earth and would thus be stationary above the same spot on the planet. It would remain fixed in the sky of a whole hemisphere and unlike all other heavenly bodies would neither rise nor set. A body in a smaller orbit would revolve more quickly than the earth and so would rise in the west, as indeed happens with the inner moon of Mars.

Using material ferried up by rockets, it would be possible to construct a "space-station" in such an orbit. The station could be provided with living quarters, laboratories and everything needed for the comfort of its crew, who would be relieved and provisioned by a regular rocket service. This project might be undertaken for purely scientific reasons as it would contribute enormously to our knowledge of astronomy, physics and meteorology. A good deal of literature has already been written on the subject.[2]

Although such an undertaking may seem fantastic, it requires for its fulfilment rockets only twice as fast as those already in the design stage. Since the gravitational stresses involved in the structure are negligible, only the very lightest materials would be necessary and the station could be as large as required.

Let us now suppose that such a station were built in this orbit. It could be provided with receiving and transmitting equipment (the problem of power will be discussed later) and could act as a repeater to relay transmissions between any two points on the hemisphere beneath, using any frequency which will penetrate the ionosphere. If directive arrays were used, the power requirements would be very small, as direct line of sight transmission would be used. There is the further important point that arrays on the earth, once set up, could remain fixed indefinitely.

Moreover, a transmission received from any point on the hemisphere could be broadcast to the whole of the visible face of the globe, and thus the requirements of all possible services would be met (Fig. 2).

It may be argued that we have as yet no direct evidence of radio waves passing between the surface of the earth and outer space; all we can say with certainty is that the shorter wavelengths are not reflected back to the earth. Direct evidence of field strength above the earth's atmosphere could be obtained by V2 rocket technique, and it is to be hoped that someone will do something about this soon as there must be quite a surplus stock somewhere! Alternatively, given sufficient transmitting power, we might obtain the necessary evidence by exploring for echoes from the moon. In the meantime we have visual evidence that frequencies at the optical end of the spectrum pass through with little absorption except at certain frequencies at which resonance effects occur. Medium high frequencies go through the E layer twice to be reflected from the F layer and echoes have been received from meteors in or above the F layer. It seems fairly certain that frequencies from, say, 50 Mc/s to 100,000 Mc/s could be used without undue absorption in the atmosphere or the ionosphere.

Fig. 3. Three satellite stations would ensure complete coverage of the globe.

Fig. 2. Typical extra-terrestrial relay services. Transmission from A being relayed to point B and area C; transmission from D being relayed to whole hemisphere.

A single station could only provide coverage to half the globe, and for a world service three would be required, though more could be readily utilised. Fig. 3 shows the simplest arrangement. The stations would be arranged approximately equidistantly around the earth, and the following longitudes appear to be suitable:—

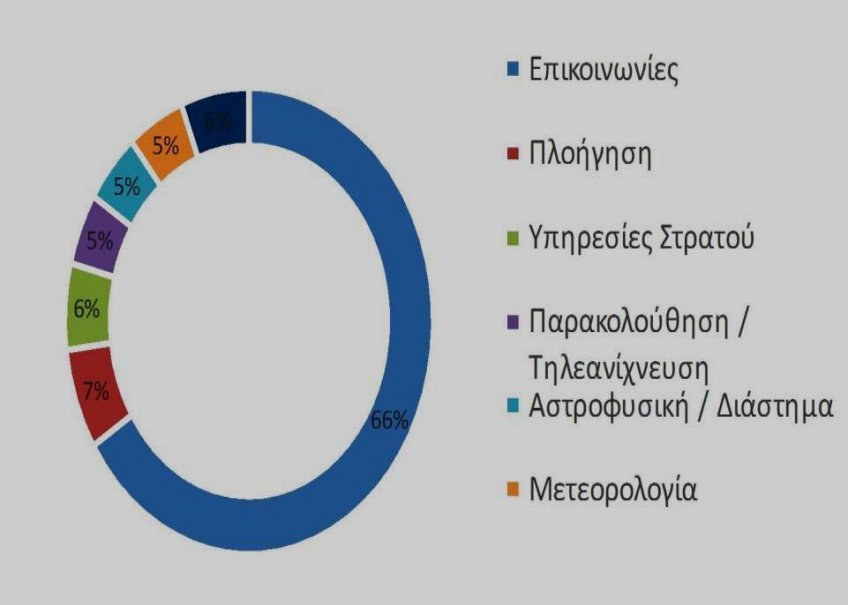
30 E—Africa and Europe.
150 E—China and Oceana.
90 W—The Americas.

The stations in the chain would be linked by radio or optical beams, and thus any conceivable beam or broadcast service could be provided.

The technical problems involved in the design of such stations are extremely interesting,[3] but only a few can be gone into here. Batteries of parabolic reflectors would be provided, of apertures depending on the frequencies employed. Assuming the use of 3,000 Mc/s waves, mirrors about a metre across would beam almost all the power on to the earth. Larger reflectors could be used to illuminate single countries or regions for the more restricted services, with con-

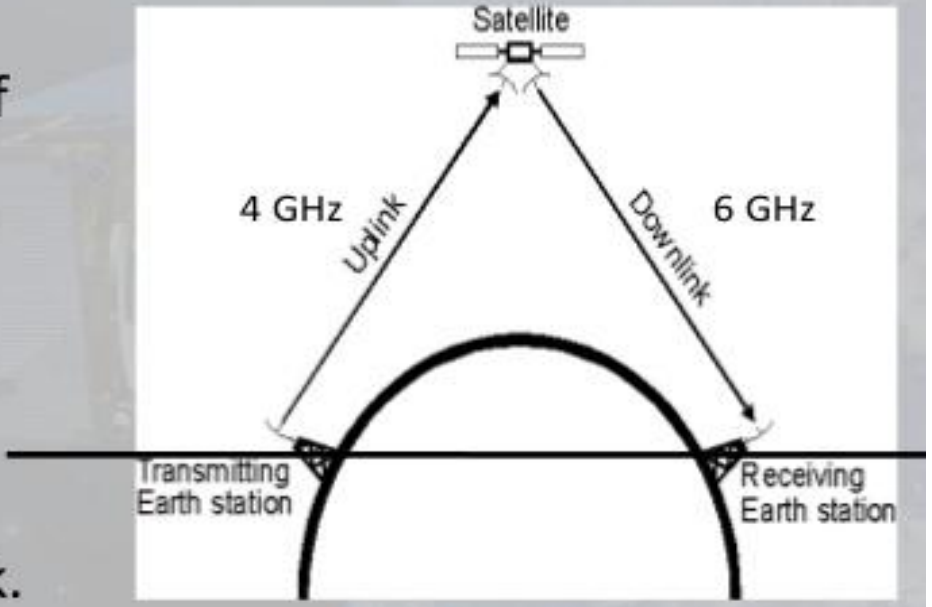
Satellite Uses

- Communications
- Navigation
- Military
- Observation
- Science
- Meteorology



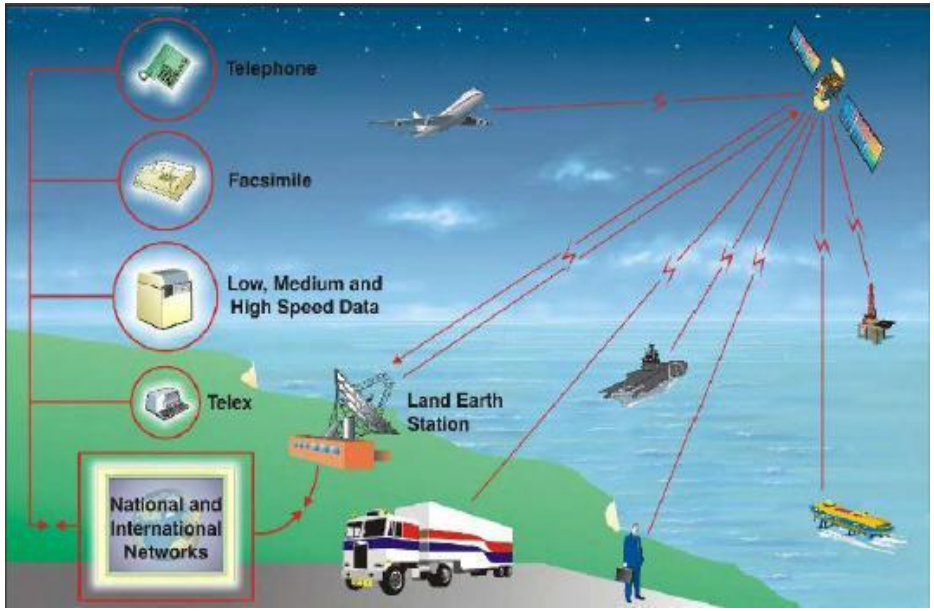
➢HOW SATELLITES WORK :

- A Earth Station sends message in the form of signal in GHz range (Uplink).
- Satellite Receive the signal and after processing by transponder, it retransmit signals back. (Downlink).



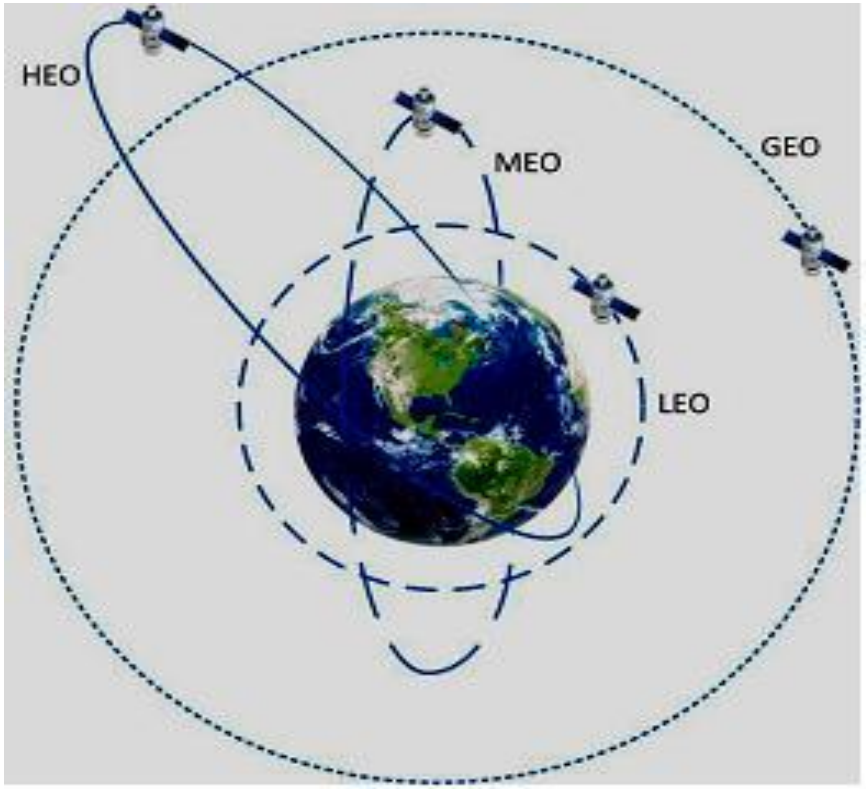
Benefits of Satellite

- Global Coverage
- Reliability
- Security
- Scalability
- Fast Deployment
- Cost Savings



Satellite Orbits

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



Satellite Frequency Bands

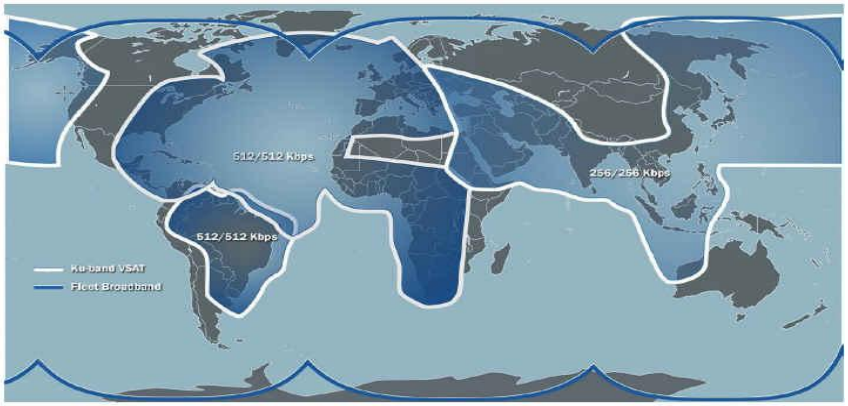
- **L-Band (1-2 GHz)**
  A small portion (1.3-1.7GHz) of L-Band is allocated to satellite communications on Inmarsat.
  Inmarsat uses L-band for their Fleet Broadband, Inmarsat-B and C.
  L-Band is also used for low earth orbit satellites, military satellites, and terrestrial wireless connections like GSM mobile phones.
  Since there is not much bandwidth available in L-band, it is a costly commodity.
- **C band (4-8 GHz)**
  Uplink 5.925-6.425 GHz
  Downlink 3.7-4.2 GHz
  used for voice and data communications as well as backhauling., requires a larger antenna, it performs better under adverse weather conditions on the ground.
- **X band (7-8 GHz)**
  Uplink 7.9- 8.4 GHz
  Downlink 7.25 – 7.75 GHz
  used mainly for military communications and Wideband Global SATCOM (WGS) systems.
- **Ku band (12-18 GHz)**
  Uplink 14 GHz
  Downlink 10.9-12.75 GHz
  used typically for consumer direct-to-home access, distance learning applications, retail and enterprise connectivity. The antenna sizes, are much smaller than C band because the higher frequency. Networks in this band are more susceptible to rain fade, especially in tropical areas.
- **Ka band (26-40 GHz)**
  Uplink 26.5-40GHz
  Downlink 18-20 GHZ
  primarily used for two-way consumer broadband and military networks. Ka band dishes can be much smaller. 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.

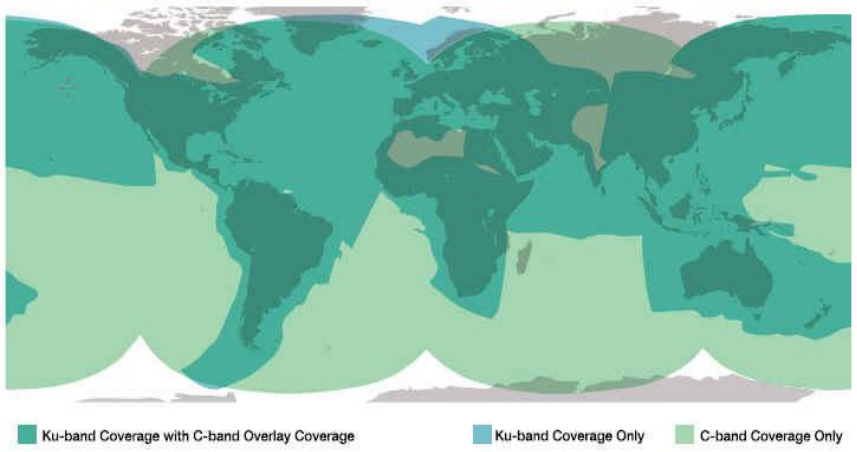
The Evolving Technology of Satellite Communications

- 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.
- 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.
- 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.

Combined coverage map of a leading L-band and Ku-band service combination. *The Inmarsat FleetBroadband (L Band) service provides coverage of the full world outside of the arctic regions. VSAT (Ku band) service is available only on a regional basis in the northern hemisphere and around the major continents.*



mini-VSAT Broadband provides global coverage with one unified C/Ku-band network delivered by one antenna

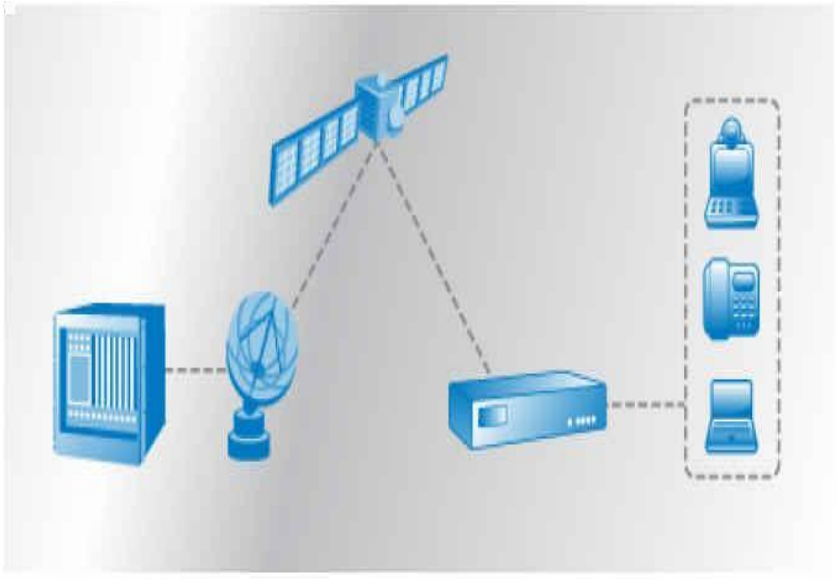


VSAT
Network Equipment

- The network equipment can be divided into two sets of equipment connected by a pair of cables:
- **Outdoor Unit (ODU)**

  includes the satellite antenna or dish, a Low Noise Block converter (LNB), and a Block-Up-Converter (BUC).
- **Indoor Unit (IDU)**

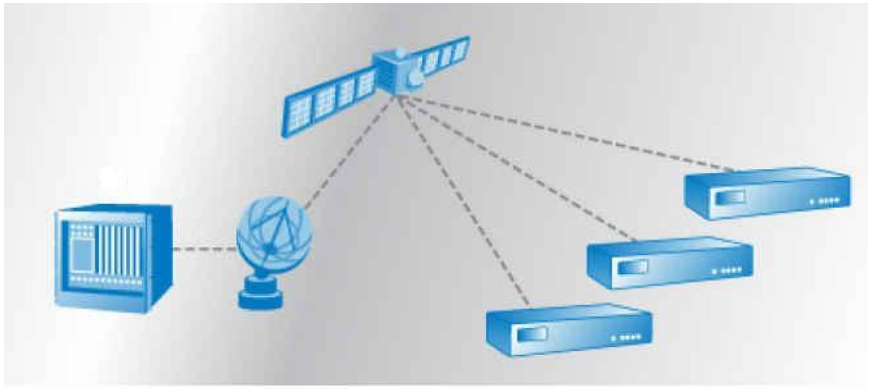
  consists of a rack-mounted hub system and networking equipment connected to terrestrial networks



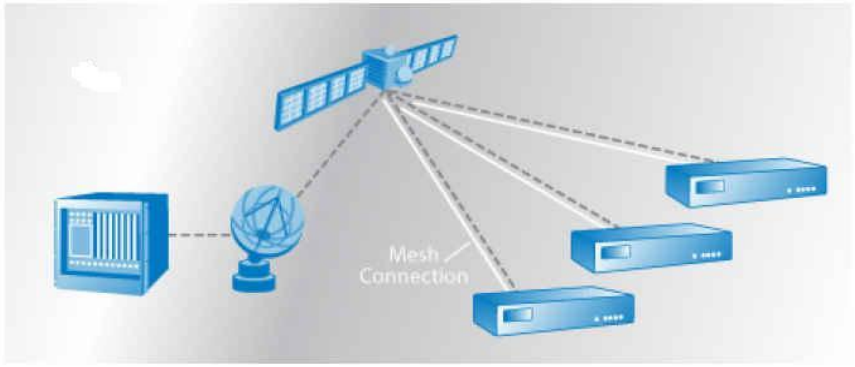
Network Equipment

Satellite Network Topologies

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



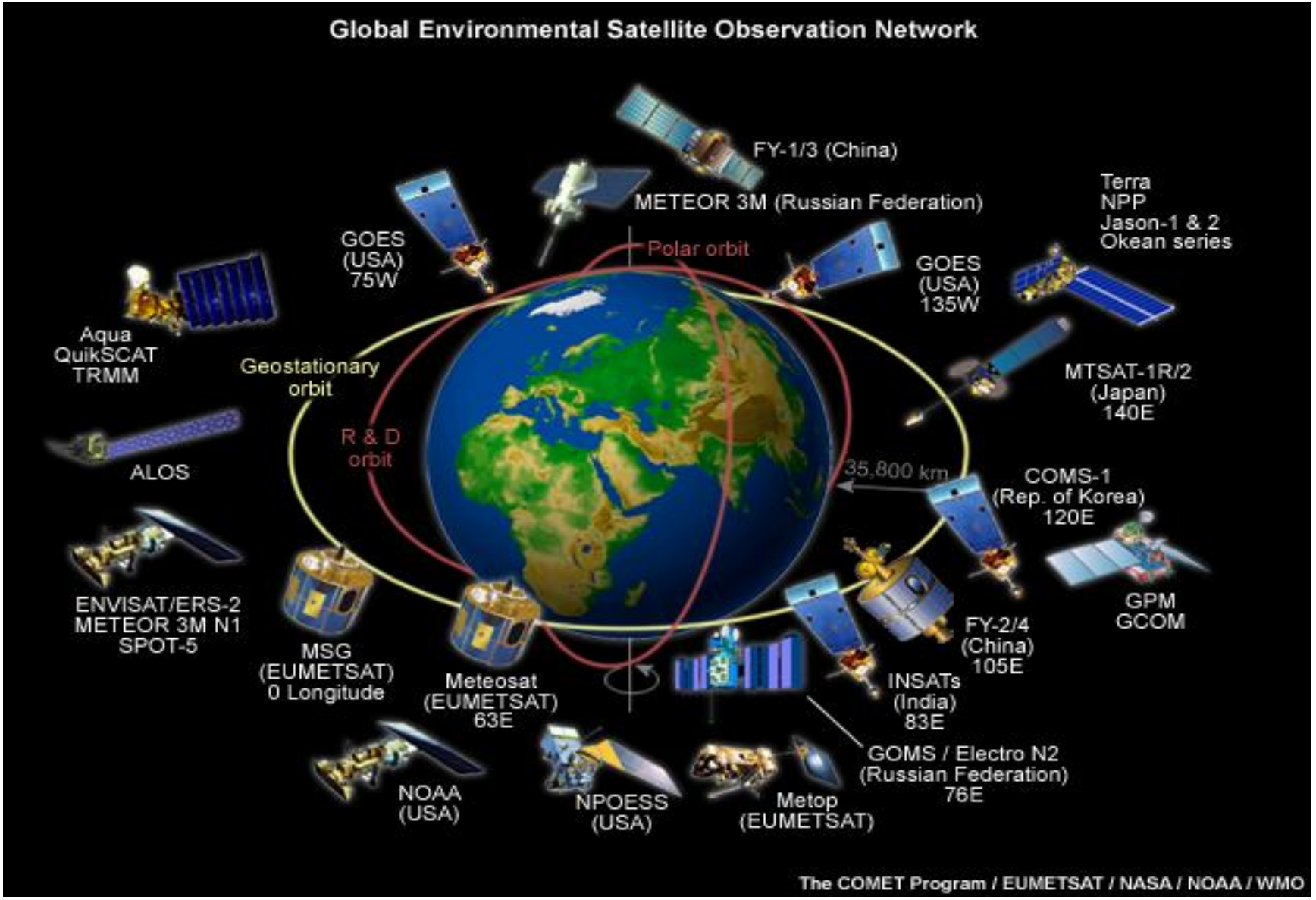
Star Topology



Mesh Topology

Satellite Service Providers and Organizations

- International Telecommunications Satellite Organization (ITSO)
- Inmarsat (ISAT)
- Eutelsat
- Iridium Satellite
- Hughes Network Systems
- ViaSat
- Globalstar

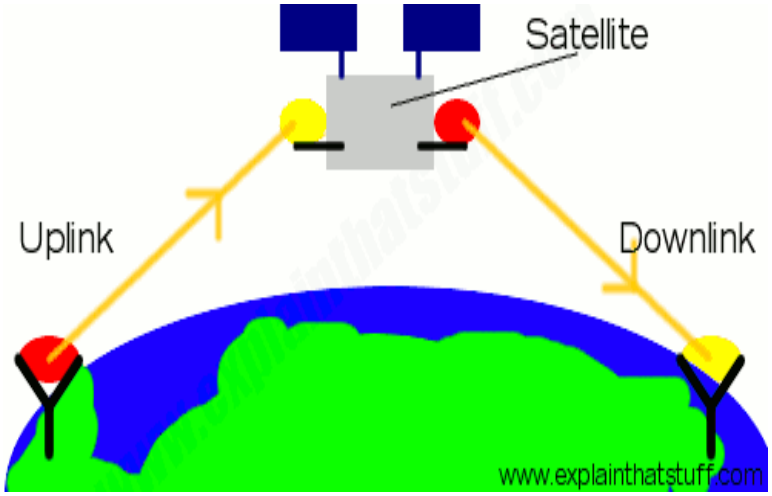

Global Environmental Satellite Observation Network
FY-1/3 (China)
METEOR 3M (Russian Federation)
GOES (USA) 75W
GOES (USA) 135W
Terra
NPP
Jason-1 & 2
Okean series
Polar orbit
Aqua
QuikSCAT
TRMM
Geostationary orbit
R & D orbit
MTSAT-1R/2 (Japan) 140E
ALOS
35,800 km
COMS-1 (Rep. of Korea) 120E
GPM
GCOM
ENVISAT/ERS-2
METEOR 3M N1
SPOT-5
MSG (EUMETSAT) 0 Longitude
Meteosat (EUMETSAT) 63E
FY-2/4 (China) 105E
INSATs (India) 83E
GOMS / Electro N2 (Russian Federation) 76E
NOAA (USA)
NPOESS (USA)
Metop (EUMETSAT)
The COMET Program / EUMETSAT / NASA / NOAA / WMO

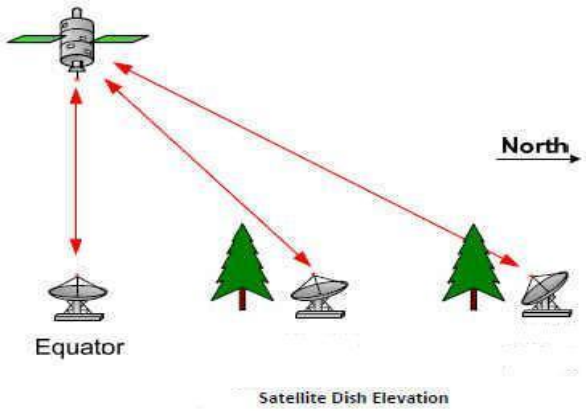
Industry Regulation

- 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.

Satellite Communication Impairments

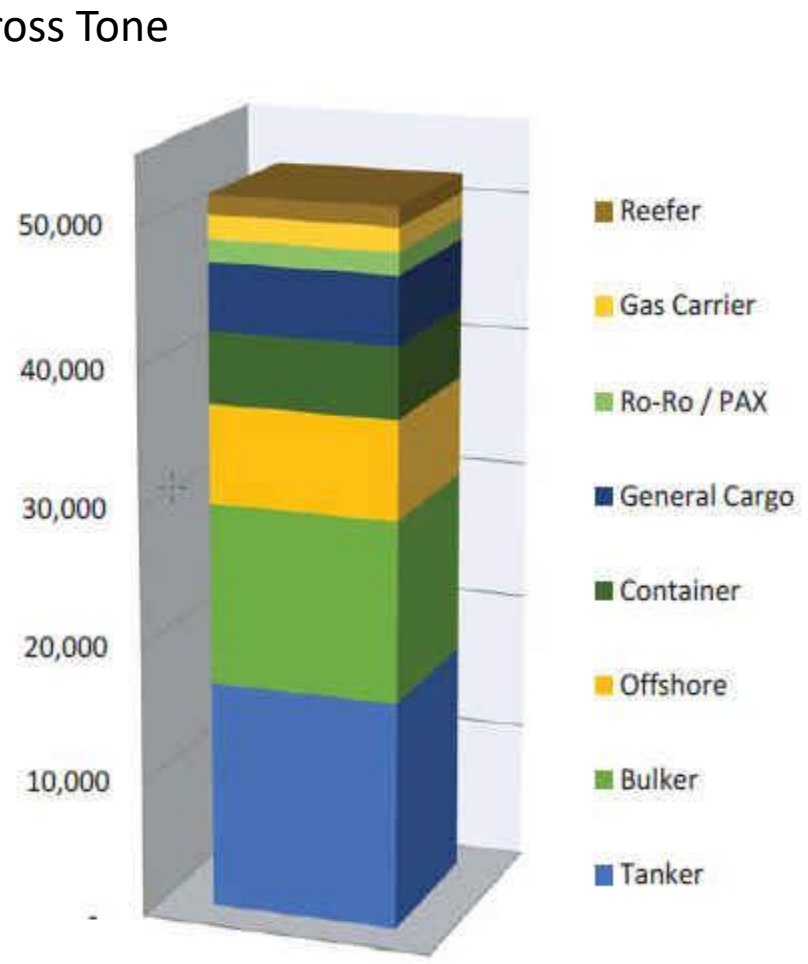
- Latency
- Terrestrial Blockage
- Weather Interference
- Sun Interference
- Broadband/Cost limitations





The maritime market challenges

- 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.
- There is little dispute that broadband connectivity will increasingly be a catalyst that will drive profitability for commercial maritime operations.
- If you're Connected, You're Competitive



The maritime market challenges

E-navigation

- 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)
- Improved communication of VTS (Vessel Traffic System) information.

The maritime market challenges

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.

The maritime market 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.

The maritime market challenges

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.

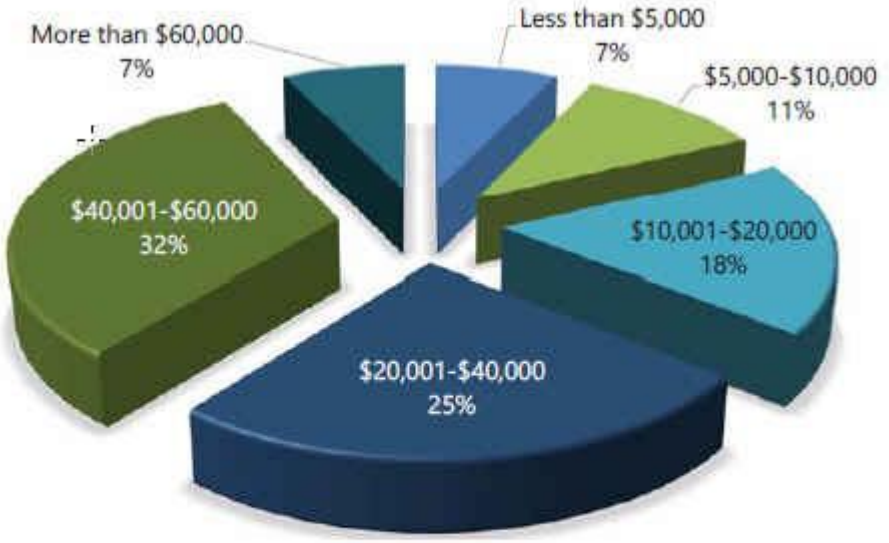
  But Big Data, is actually a business transformation wave and its real value to shipping and maritime will be realized when it is applied cross-business and includes commercial and enterprise datasets.
- Maritime industry is entering a new age of enhanced connectivity with previously unheard of levels 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.

Futurenautics Research

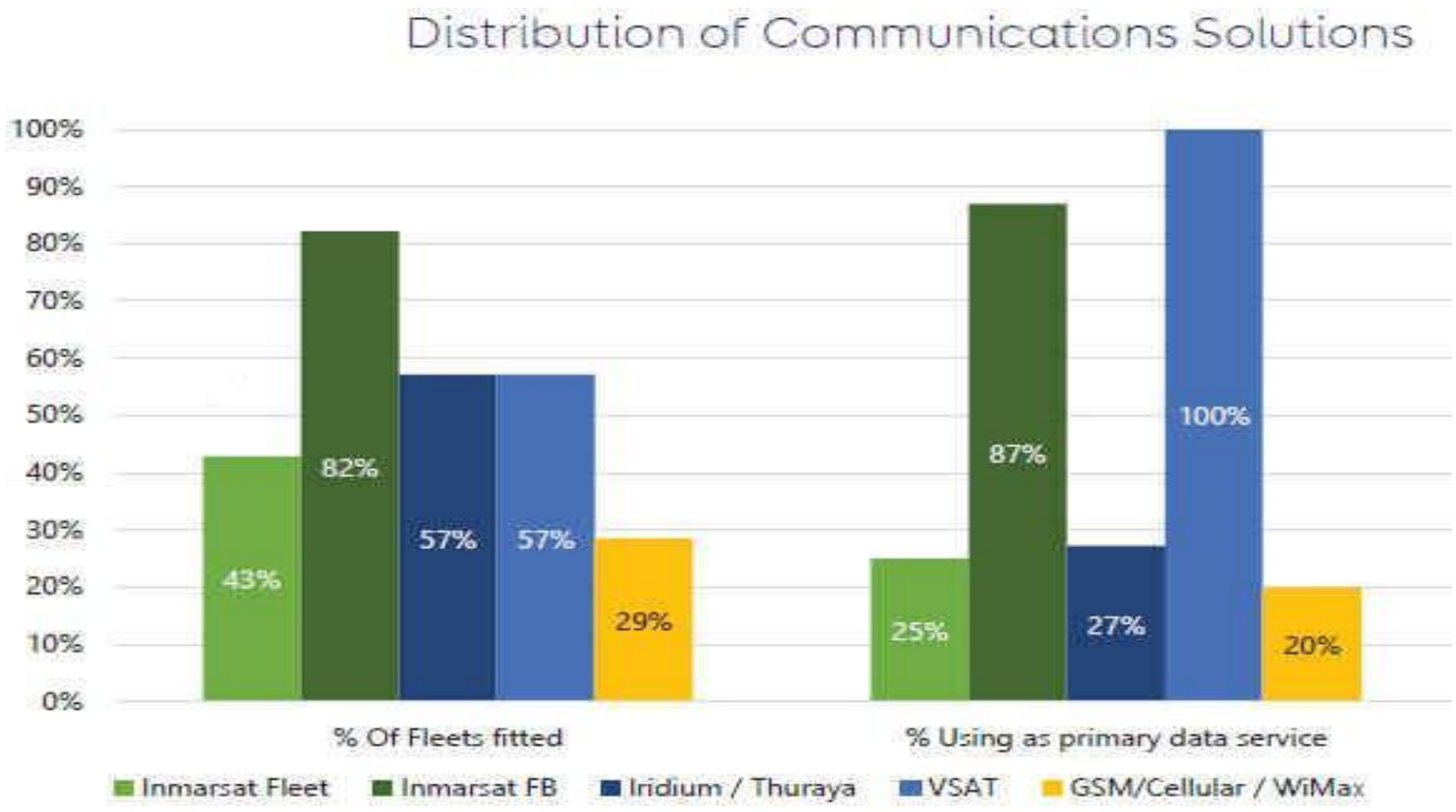
- In April 2015 Intelsat, the leading provider of satellite services worldwide, commissioned Futurenautics Research, a leading provider of maritime research and insight, to undertake a survey of ship operators and crew within the maritime market.
- The objective of the survey was to understand the satellite 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 next.

Annual IT Expenditure

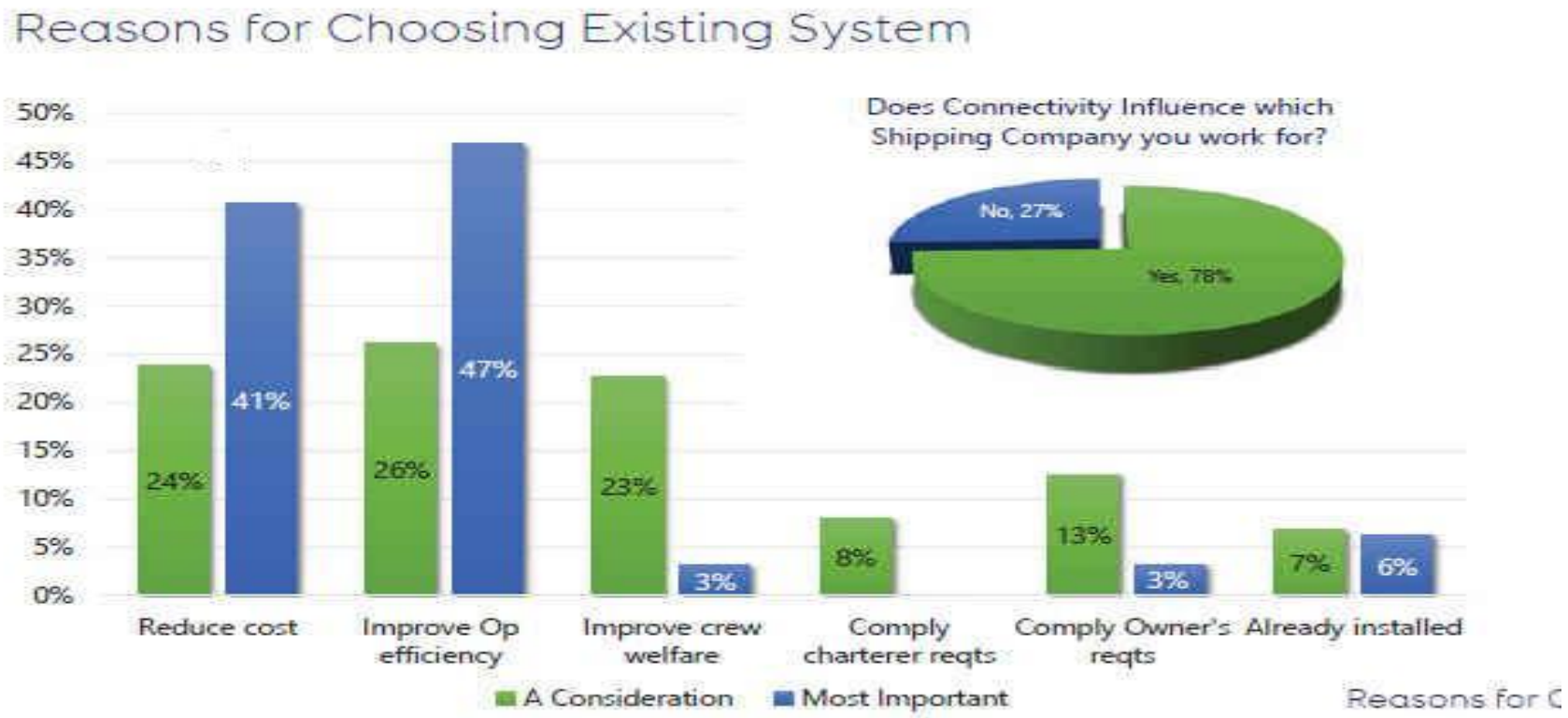


Average Annual Vessel IT Expenditure

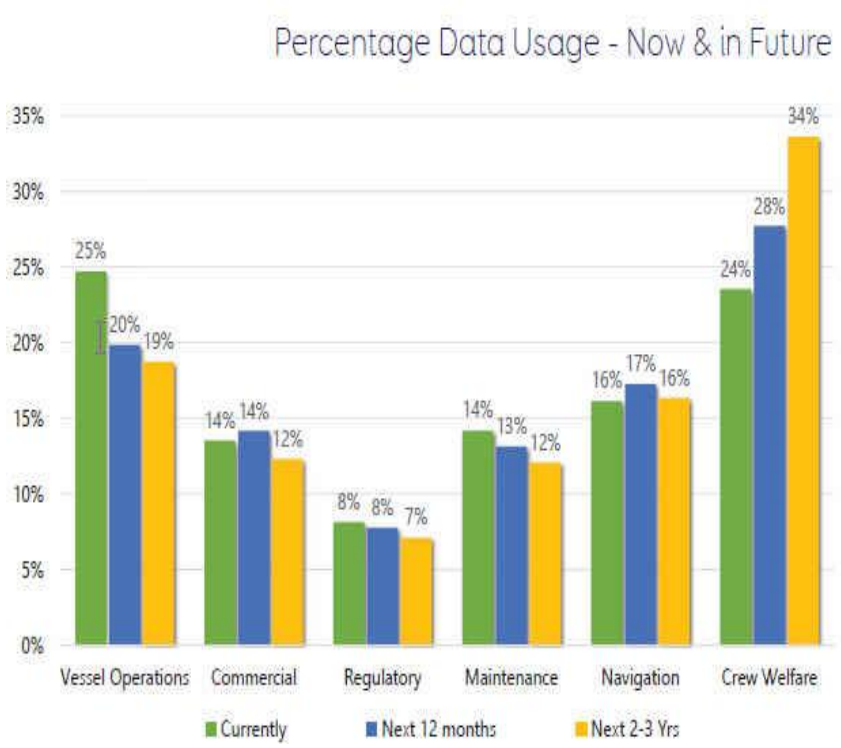
Distribution of Satellite Communications Systems



Reasons for choosing existing satellite solutions

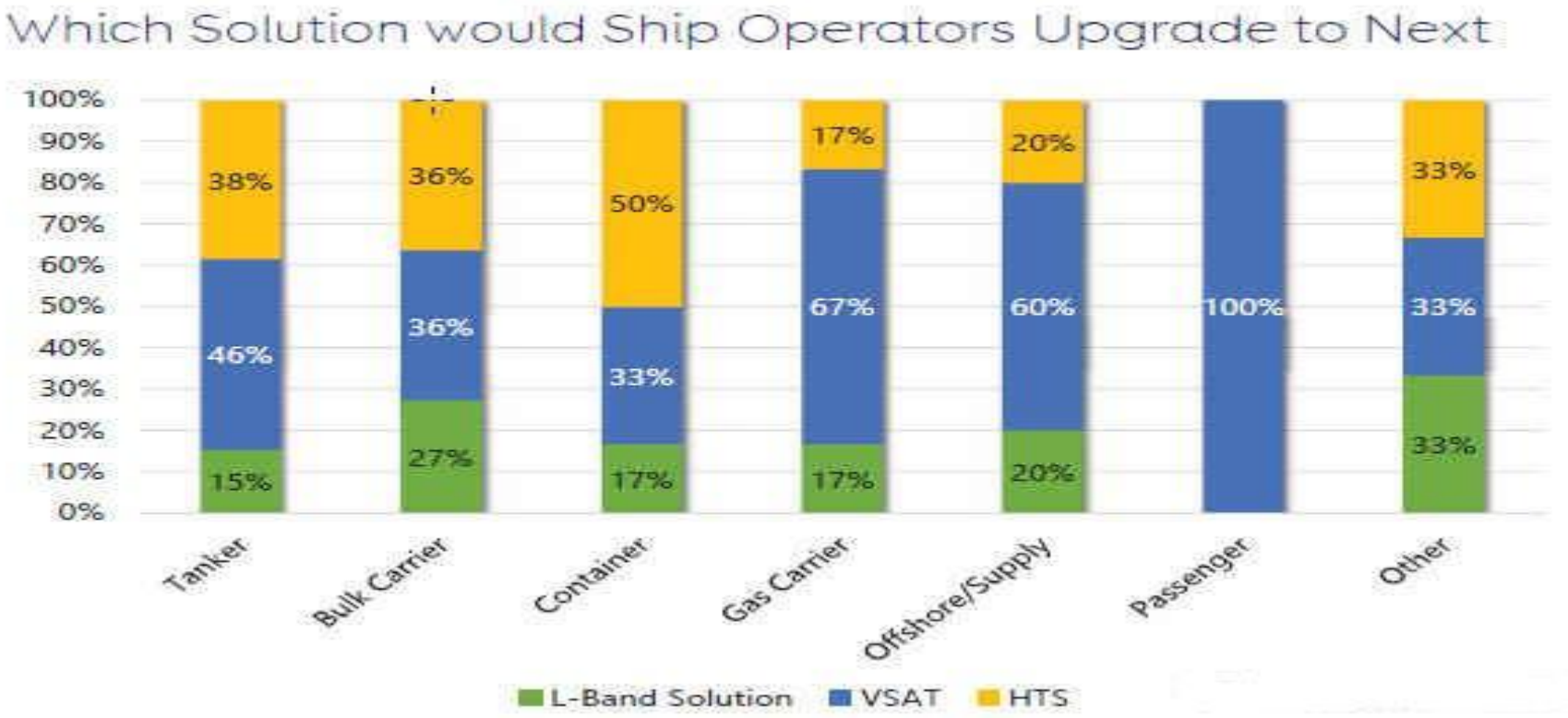


Data Growth

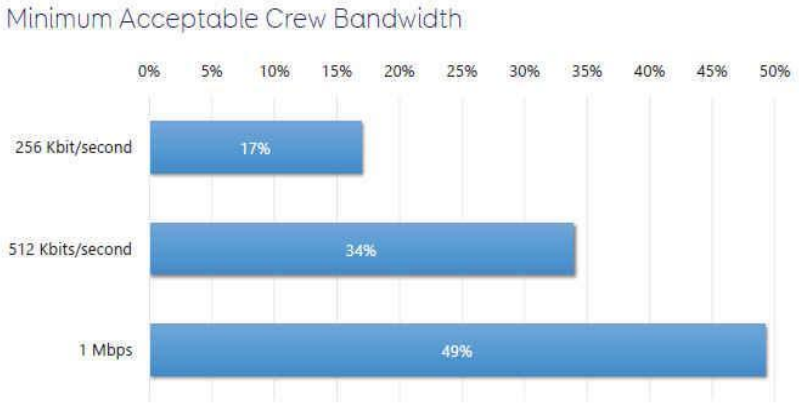

Percentage Data Usage - Now & in Future
35%
30%
25%
20%
15%
10%
5%
0%
25%
20%
19%
14%
14%
12%
8%
8%
7%
14%
13%
12%
16%
17%
16%
24%
28%
34%
Vessel Operations
Commercial
Regulatory
Maintenance
Navigation
Crew Welfare
Currently
Next 12 months
Next 2-3 Yrs

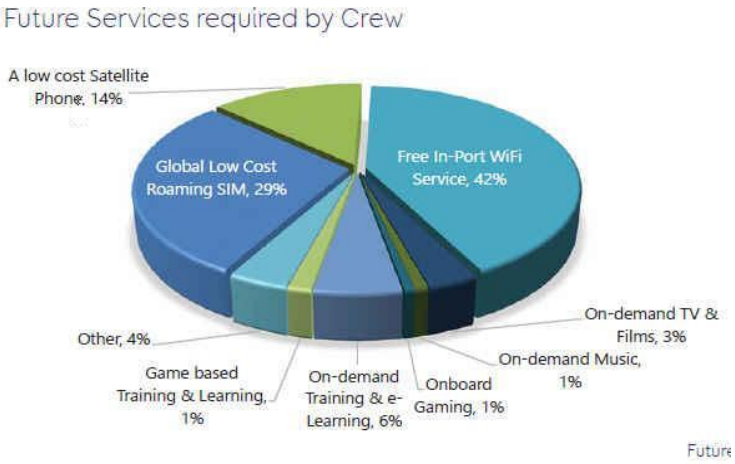

Ship Operator Anticipated Increase in Data Traffic
70%
60%
50%
40%
30%
20%
10%
0%
23%
58%
26%
59%
Ship-to-Shore
Shore-to-Ship
Increase: 12 months
Increase: 2-3 Yrs

Satellite solution upgrade path



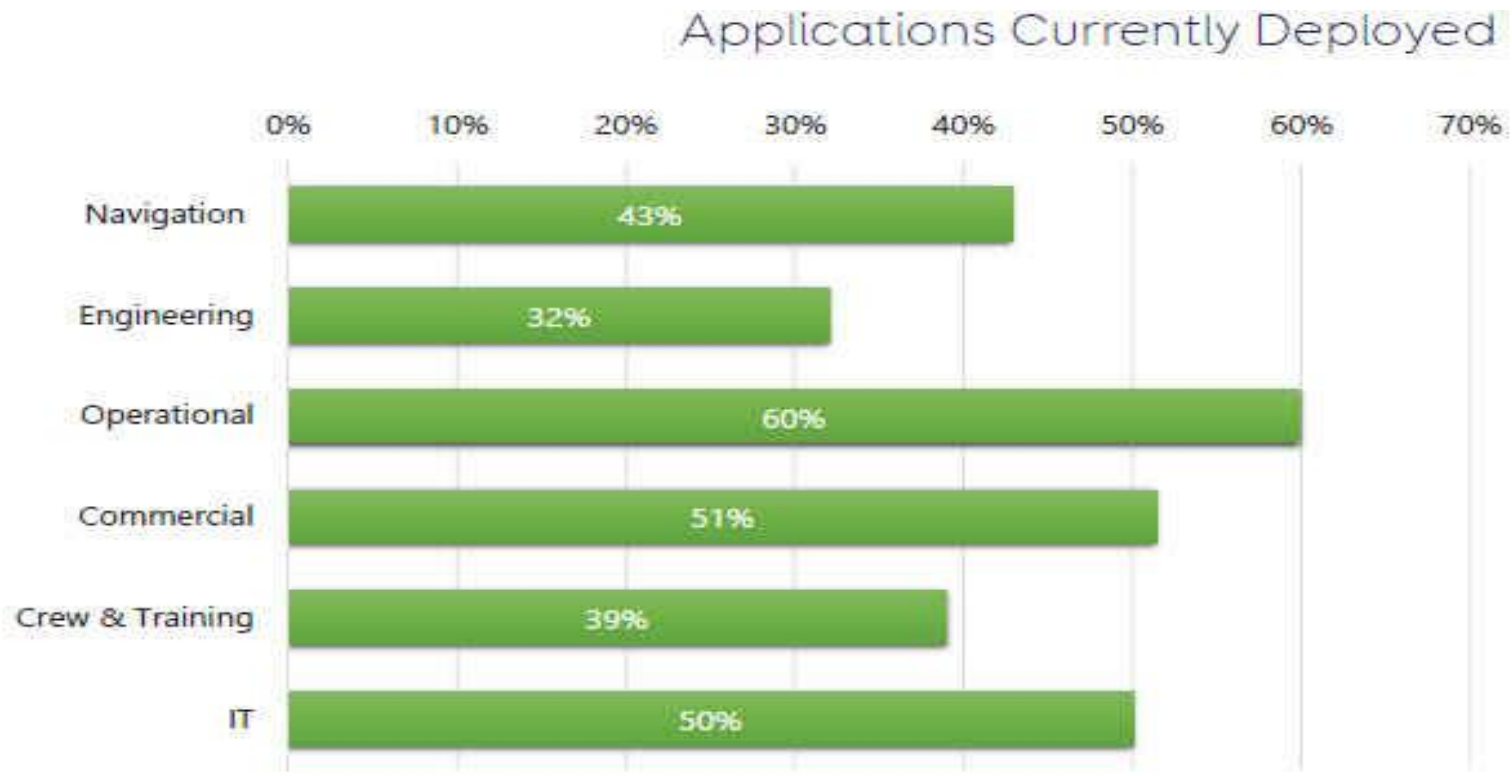
Future Crew requirements



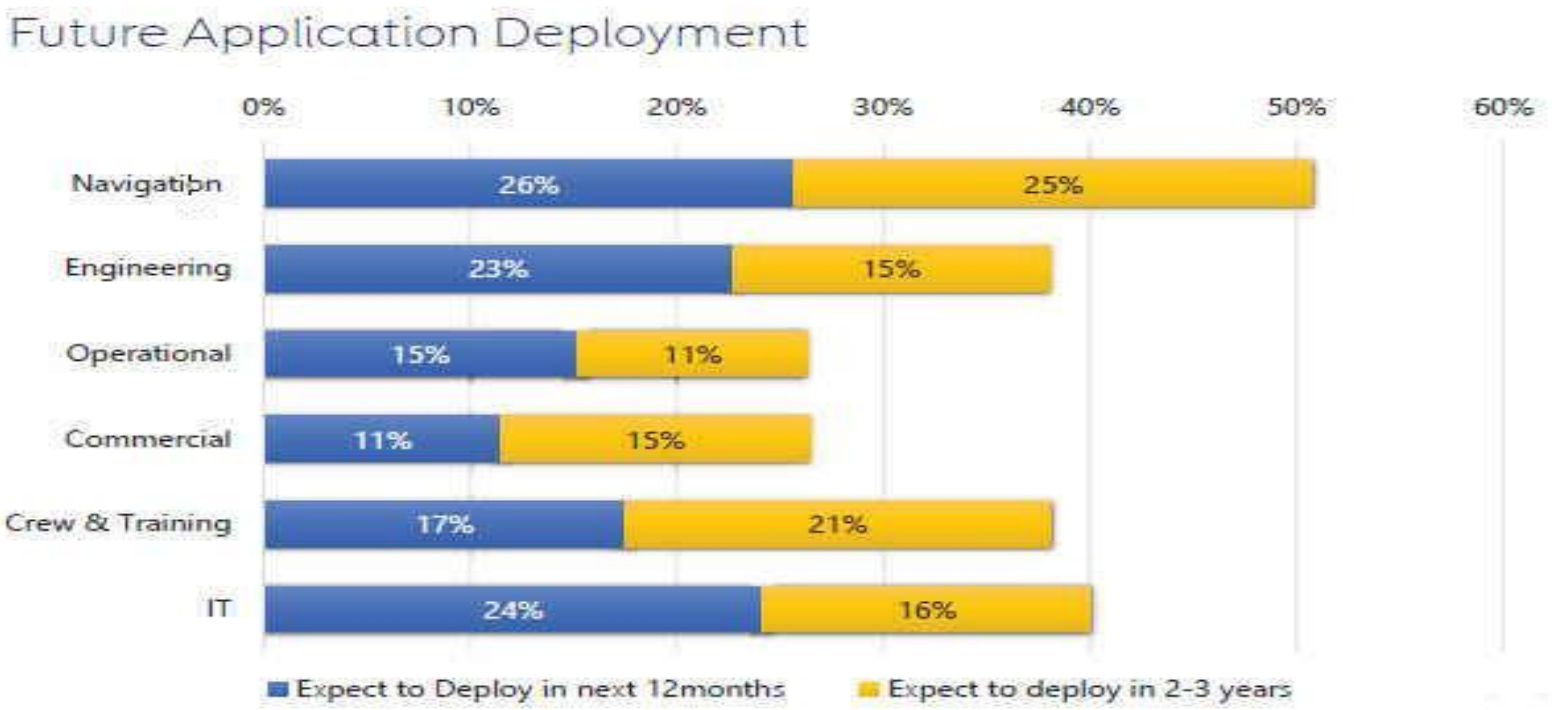


Future

Current Software Deployment



Future Software Deployment



Attributes of the Ideal Maritime SATCOM Solution

- 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

Conclusion

- Industries everywhere are being disrupted and re-shaped by technology and service innovation.
- Today's mariners are responding to changes in regulations, technology, and business practices that require a constant connection to shore-side offices and home.
- 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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