

# Offshore telecommunications

Technological advances accompany the move into deeper waters and the pre-salt

The technological advances in drilling of offshore production wells, progressively deeper and further from shore, have been pioneered by Petrobras – as demonstrated by the Pre-Salt. This scenario has created a major challenge for the companies specialized in this field, where reliable telecommunications with ever more advanced characteristics have become paramount. The distances involved generally mean that communication by radio is impracticable and satellite transmission has generally become the main way to link the platform to shore, or even to other platforms or supply vessels.

The days have long passed when satellite communication was a luxury. Today it is an undeniable necessity for platforms, FPSOs and all types of service and support vessels. In this scenario, many new demands have arisen. Some examples include the use of management programs such as CRM, Lotus Notes, ERP and also specific programs for on-board processes and equipment. There is a growing need to communicate remotely with sophisticated equipment on the platforms, for remote trouble-shooting or to install software or firmware upgrades. Today's wireline and log-while-you-drill applications need to transmit data in real time to onshore data rooms. Remote monitoring and telemetry control are applications that are used frequently, as well as fleet and equipment tracking. Even individual containers can be fitted with satellite tracking modems.

Signals transmitted by satellites tend to be at a low level, as they are designed to cover a large geographical area with the same beam. Applications that need large amounts of bandwidth, such as broadband data transfer, almost always require stabilized tracking antennas. The use of smaller, omni-directional antennas tends to be restricted to low data-rate applications such as satellite phones and fleet tracking. One limiting factor in all satellite applications is the need to have an unobstructed line-of-sight view of the satellite at all times.

Satellite transmissions have a relatively high cost, which is directly proportional to the bandwidth used. For this reason, the users normally artificially limit the use of bandwidth onboard, creating an unsatisfied demand. In other words, if satellite bandwidth became freely available at a significantly lower price, the users would move towards using more sophisticated programs onboard platforms.

The table below shows some of the technological advances that have occurred over the relatively short period since commercial satellite transmissions went mainstream. These advances generally increased the amount of data that could be transmitted for the same cost.

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## Geo-stationary satellites

Communications satellites that we could label as conventional are orbiting earth in a ring called the Clark Belt and which is at an average height of 35,786km above the Earth's surface and exactly above the line of the Equator.

An international organization called the ITU (International Telecommunications Union) is responsible for

the distribution of the satellites in the Clark Belt. Initially, the distribution was made with a spacing of 5 degrees, meaning a total of 72 orbital positions were made available. This spacing was chosen, based on the interference caused on adjacent satellites by equipment transmitting spurious emissions out of the main beam.

The distribution of orbital positions by country is a high-level diplomatic matter. Generally, countries are

## Technological advances that improved satellite use efficiencies

**Reed Solomon/Viterbi** – encoding developed for video transmissions from space-craft in the '60's and later adapted for satellite modems

**DAMA** – Demand-Assigned Multiple Access is not a new Idea, but its application in large scale to satellite transmissions was a significant mark in the improvement in the efficient use of space segment. A pool, or cloud, of satellite bandwidth is made available to a group of users, Who can apply for use of all or part of it in a sequential mode.

**TURBO CODEC** – probabilistic processing applied in satellite modems dramatically increased the throughput

**TDMA** – Time Division Multiple Access and other types of multiple Access, such as CDMA, FDMA, SDMA and WDMA came to market at different time points. All of them allow significant increases in satellite useage, basically dividing the transmissions into tiny time intervals (time slots, in the case of TDMA) measured in milli-seconds and interlacing the data packets from different applications or users in the same space segment

**MPEG-2, MPEG-4** – the compacting of data or video streams using these norms allows a major increase in data transmission capacity.

**QPSK, 8PSK, 16APSK, 32APSK** – greater sophistication in satellite modems has allowed the use of more efficient modulation methods. The increase in throughput as one moves towards the 16APSK and 32APSK modulations is great, but when used on their own, the stability of the satellite links reduces and negates part of the advantages they bring to the table. Other technologies help maintain stable transmissions at high modulations. One method is to automatically reduce the modulation and/or FEC on a terminal that is suffering from atmospheric interference. In this case, the link remains stable, but the data throughput drops until the interference lessens.

**TCP/IP Acceleration** – a specific problem of transmitting IP data via satellite is that the return signal has to travel over 64.000km and takes nearly a second to do so. The encoder takes this to mean that the data packets are being lost and retransmits them. This can happen several times before the "OK" signal comes back. This results in extremely slow data transmissions. Practically all IP data sent over a satellite these days uses IP acceleration to overcome this problem.

**Carrier-in-Carrier** – researchers discovered that, under the right conditions, it is possible to concatenate the transmission and reception signals of a satellite link in the same bandwidth. It would seem that this would double the amount of data sent, but that is not the case, as a significant overhead is created, due to the need to send instructions back and forth between the controllers. Logically, the same applies to the majority of the processes listed here

**DVB-S2** – this new norm for video and data transmission includes a number of different technologies under the same norm. This makes it extremely efficient and the use of DVB-S2 can halve the bandwidth required for broadcasting a TV channel

**ACM Flex-ACM Adaptive** – Adaptive Code Modulation is one of the Technologies used in the DVB-S2 norm. It works well in networks with 100 or more VSAT's and allows individual stations to automatically reduce the modulation when there is atmospheric interference. This means that the whole network does not suffer because of one part. Flex-ACM and adaptive ACM use a pool of bandwidth that individual earth stations can draw on, and spread the loss evenly over the network. These methods allow the link budget to be run with a much lower safety factor

**Group QOS** – is a new concept, where the service supplier sells to the customer a packet which is made up of multiple small pieces. Each piece corresponds to exactly what a specific program or application requires. A customer could ask for a service that would allow him 10 positions with Lotus Notes, 5 with CRP, 3 with ERP, as well as 20 voice lines and an occasional-use video-conference channel and internet for 20 users. The service supplier does not sell a package of X kbps, but a package where He guarantees that all of the customers' applications will work whenever He requires them. This increases the efficiency of the use of the TDMA hub and allows the customer to pay a lower price, as he will not be charged for times that applications do not operate. And above all, the service reliability for the end-user will be greater.



allotted positions that are close to their geographical position.

In the 90s, worldwide demand obliged the ITU to perform a new study, based on which the orbital spacing was reduced to 2 degrees, increasing the number of available positions to 180.

This change required much stricter control of spurious emissions, and RF equipment manufacturers had to improve their manufacturing methods to meet these new requirements. Antennas needed to be a more perfect paraboloid shape and they need to be more rigid, so that gusts of wind do not deform them.

The situation today is that there are some orbital positions available, but at the same time there is a lack of space segment availability in some areas. The table explains the reasons:

#### **Why is there a lack of satellite bandwidth?**

##### **Demand in specific areas**

- The Iraq war is consuming bandwidth at a rate never seen before

- Africa is developing rapidly, culturally and technologically. The lack of terrestrial infrastructure means that the need for satellite is growing rapidly

#### **Lack of Available Frequencies**

- Satellites use radio waves and consequently end up in a dispute with all the other forms of radio transmission. The quantity of data a satellite can transmit is directly proportional to the available frequency spectrum. Today, in several areas, there are not any new frequencies available to increase available capacity.

Presently 4 main frequency bands are used for satellite transmissions and a further 2 are starting to be used. The table shows the bands and their frequency ranges.

#### **Mobile satellite systems**

For mobile applications at sea and on land, there a series of specifically designed satellite systems, allowing small antennas and equipment. However, this area is being challenged more and more by the "traditional" satellite services, because of the advances in robotic stabilized tracking antennas. Today these antennas allow reliable broadband services to operate in moving vehicles, ships, trains and planes.

The systems that were specifically developed for mobility applications include:

**Inmarsat** – was founded in 1979, in the early days of the use of satellites for commercial communications – as a non-profit organization representing the interests of the majority of the major countries – to provide a reliable method of communicating to and from vessels on the high seas, anywhere on the World's oceans. The initial Inmarsat services were only telephone services, but when fax became popular, they introduced facsimile transmission. The rate, however, was only 2.4kbps, while the regular fax speed was 9.6kbps. The organization grew, moved through several generations of more capable satellites, and today offers a wide range of services from a hand-held sat-phone to a full-up mobile communications centre the size of a laptop computer. These systems can handle multiple simultaneous voice calls, broadband internet and real-time video streaming. These units are in constant use by the reporters covering the Iraq war. Inmarsat coverage is practically worldwide, with the notable exception of the polar regions.

**Iridium, Globalstar and Thuraya** – These 3 systems operate constellations of LEO (Low Earth Orbit) satellites. These satellites do not stay stationary in relation to the Earth's surface and cross the skies at high velocity, in different directions at a typical height of 700km. Each system has to operate a large number of

## Radio frequency bands

**L band – 1 to 2 GHz** Inmarsat, GPS, Iridium, GSM  
Virtually immune to rain fade. L-band transmissions tend to be very stable, but there is only a small amount of spectrum in the band, so this band tends to concentrate S at-phone and other low-bandwidth applications

**S band – 2 to 4 GHz** Used for Radars

**C band 4 to 8 GHz** Most traditional satellite frequencies  
Large antennas. Rain fade is minimal. Good geographical coverage

**X band – 8 to 12 GHz** Mainly for Military Use

**Ku band – 12 to 18 GHz** Very popular satellite band. Used by the majority of VSAT hubs.  
Smaller antennas. More powerful beams, but with smaller geographical coverage. Rain fade is significant

**K band – 18 to 26.5 GHz**

**Ka band – 26.5 to 40 GHz** The future of satellite communications  
Very small antennas and beams. Very high power in beam. Large amount of bandwidth available (13.5GHz). Civil and military use. Rain fade a major issue but beam power can be increased to minimize this as a problem.

**Q band – 30 to 50 GHz** State of the art for satellite communications  
Everything said about Ka band applies with more force. 20GHz of bandwidth is an incentive to overcome the limitations of this frequency band

**U band – 40 to 60 GHz**

**V band – 50 to 75 GHz**

**E band – 60 to 90 GHz**

**W band – 75 to 110 GHz**

**F band – 90 to 140 GHz**

**D band – 110 to 170 GHz**

satellites in order to have 24 x 7 global coverage. And they do cover 100% of the Earth's surface, including the polar regions.

The need to hand-off the signal from one satellite to another, without losing the signal, has proved to be the major limiting factor for these systems. The problem is only partially resolved, and all of these systems operate at low data rates due to this problem. The main uses are portable sat-phones and low data-rate transmissions.



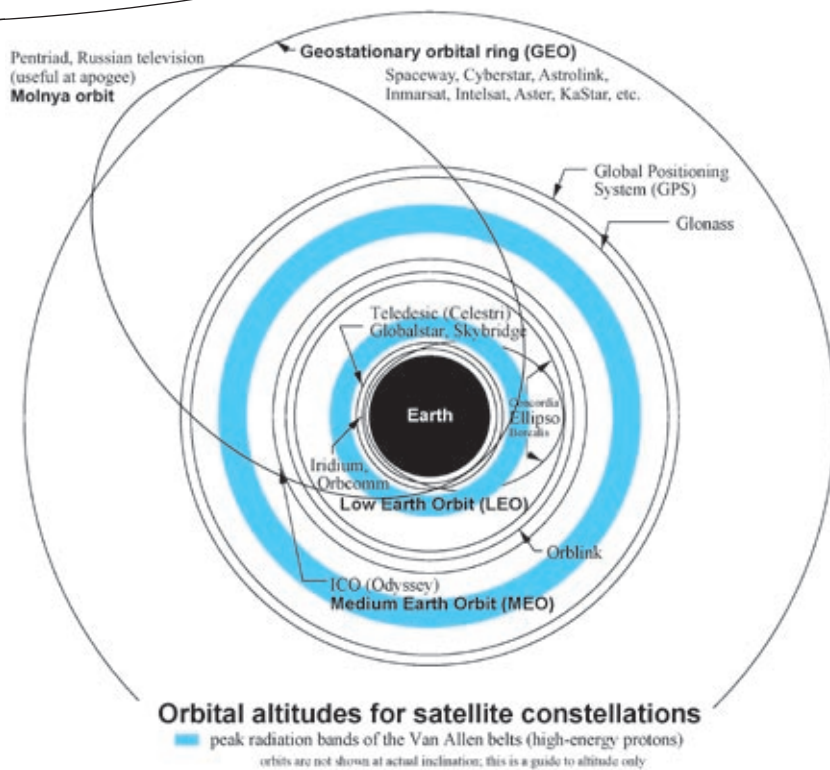
Photo: Stefferson Faria, Petrobras Agency

The advantage is that the telephones are portable – the size of old cellular phones – and the call costs sometimes beat cell phones on a roaming plan.

### A new system to revolutionize the market

An Australian company called O3b has developed a new satellite system which promises to revolutionize the satellite telecommunications market by offering gigabit bandwidths and low prices. The system uses MEO satellites (Medium Earth Orbit) at a typical altitude of 8,063km. They analysed the main problem of LEO and MEO satellites – namely the hand-off from one satellite to the other – and came up with an extraordinary solution. It is easy to picture this, imaging Olympic relay athletes handing over the baton. They all run in the same direction and the runner who is waiting for the baton accelerates to the same speed as the retiring athlete, allowing a very efficient hand-off. Imagine the chaos that would ensue if the athletes all ran in different directions, but had to cross each other's paths at a specific point in time and space to hand-off the baton. O3b applied this analogy to MEO satellites and created a system where all the satellites would orbit the Equator, but at a much lower orbit than the geostationary satellites.

Using this idea, they managed to create a very efficient form of hand-off which allows gigabit data rates. The method uses two tracking antennas – which only have to track in one circular path – in each earth station. One antenna follows



the active satellite and the other picks up the "incoming" one, leaving a significant time period for the hand-off.

Having all the satellites circling the Equator has a further advantage, where the number of satellites required is much less than for the other systems. O3b will initially use 8 satellites and later move on to 16, compared to 64 for some other systems. But there are "no free lunches" and there is a downside – the service is limited to the geographical area which can be seen from a ring, 8,063km above the equator. The upside is that the major part of the Earth's population is situated in this coverage area.

The service promises to bring cheap broadband to the masses, competing with the cost of fibre, and going where fibre never will.

LEO and MEO satellites have an advantage in relation to geostationary satellite – the transit time. The "ping" time of a high-quality geostationary satellite service will run around 800ms, while O3b should achieve 125ms. This comes close to the time achieved in commercial fibre optic services. Logically fibre transmits at the speed of light. The reason that the transit times get close to that offered by O3b is that the routers and other equipment slow down the signals.

For the Offshore industry, the arrival of the O3b service could change the IT paradigm. The repressed demand will be set free and bandwidth-thirsty applications will abound, allowing for more

efficient use of the very expensive offshore drilling and production resources.

### Antennas for use offshore

In 1978, Comsat was contracted by the US Navy to create a worldwide satellite communications systems focussed on the oceans. The Marisat service was formed and this later morphed into the Inmarsat organization. One of the Comsat engineers saw the need for stabilized antennas and started a company to manufacture these in California. The company he founded in 1978 is now called Cobham SeaTel and is the largest worldwide manufacturer of stabilized antennas.

The early antennas – from 1979 to 1993 – used gyros for stabilization. This method basically used

2 or 4 heavy discs spinning at around 3000 rpm. The motors to which the discs were attached were supported in gimbals and the movement of the antenna base away from level (in relation to the Earth's magnetic field) caused them to swivel and apply a force to bring the antenna back to the base point.

The next generation of antennas – still in use today – uses a real-time active stabilization system using positive feedback. This system measures the outputs of accelerometers in different planes and drives the motors with an equal and opposite acceleration force. Additional sensors measure the level plane in relation to Earth's gravitational field and measure the azimuth pointing direction. Modern antennas can point to better than 0.1 degrees and maintain that in adverse sea states and with high-speed vessels.

Even so, a beam spread even that small signifies a large area 35,000 km away and a further method must be used to maintain the antenna accurately pointed. This method is based on measuring the received signal, then moving the antenna or feed slightly and comparing the signal – always ending up pointing at the strongest signal.

There are several manufacturers of stabilized tracking antennas today, in addition to Cobham SeaTel. These include Schlumberger, who purchased the DMS factory in Scotland, Orbit from Israel and a newcomer, KNS from Korea. ■