Will Satellites Draw Rings Around the Petroleum Equipment Industry?

Kally Fraser explores satellite technology and its potential for launching a whole new era of operational efficiency for the petroleum equipment industry.

Geosynchronous satellites are in orbit 22,500 miles overhead and provide communications over an entire hemisphere. Courtesy of ORBCOMM.

How can satellites help people in the petroleum industry? To answer this question, it is important to understand what satellites do and how they can be used to improve communications for those who are engaged in managing various petroleum industry activities, such as gasoline sales, inventories, leak detection, fleet operations and maintenance.

For instance, a satellite can constantly communicate the readings of hundreds of tank gauging devices (equipped with transceivers) to the corporate oil company office. Satellite networks can include leak-monitoring devices, tanker truck deliveries and metered sales—virtually any activity that can be electronically recorded and quantified.

Technology evolution

A satellite is a complex, expensive communications device that is launched by rocket and orbits the earth. Fifty years ago, satellites existed only in science-fiction literature. However, extensive military and corporate development and testing was done during and after the Cold War.

Initial customers of the technology were organizations such as the military, shipping companies and communications companies. Applications included network broadcasts, search-and-rescue on the high seas and voice communications. Today, satellite technology is widely available in such forms as direct broadcast TV, handheld global position locators and telephones.

In the mid 1980s, satellite applications were introduced in the exploration and production side of the petroleum industry and gained wide acceptance by 1990. Because they accurately transmit data and voice communications from drilling rigs in remote areas to central offices, satellites have become important tools in offshore and international operations. Pipelines use satellite technology to report flow rates and to operate SCADA (Supervisory Control and Data Acquisition) systems. SCADA systems give the operator of the pipeline the ability to control and monitor product flow and to ensure that the pipeline operates reliably and safely.

On the retail side, satellites transfer data to support point-of-sale (POS) transactions, credit authorizations and inventory management data.

Satellite communications

Satellite systems have two primary components, the space segment and the ground segment. The space segment is the actual hardware in orbit above the earth. Satellites have antennae that point towards the earth and are used to relay information to and from specialized radio transmitters and receivers, known as transceivers, on the ground. The antennae provide coverage for any transceiver located within sight of the antennae.

To visualize the coverage, imagine a powerful flashlight shining down on Earth. If the flashlight is far enough away from the earth, the light can shine on an entire hemisphere of the planet. If, however, the light is close to Earth, the coverage will be more like a spotlight, covering a smaller area, but with a greater intensity. The satellite's antennae act much like the flashlight; any transceivers located within the beam of light can send or receive information from the satellite. The height of the satellite above the earth's surface is critical to determine the cost and performance of the communications system.

Communications satellites provide two-way wireless communications. To communicate with the satellite, a user must have a transceiver that is designed to work on a particular radio frequency or channel.

Radio waves, like light, are part of the electromagnetic spectrum. This spectrum is allocated into channels, based on the frequency of electromagnetic waves, which are measured in cycles per second or hertz.

Satellites generally use multiple channels within a block of the electromagnetic spectrum to send and receive data. With traditional satellites, the antennae must be pointed toward the satellite to ensure a reliable communications link. The satellites and transceivers are designed to work together through the use of specific communications protocols to ensure that the links are reliable. The communications protocols manage the radio spectrum to insure that multiple users can share the scarce resource.

The functionality and cost of satellites is determined by two parameters: first, the height of the satellite in orbit above the earth; and second, the radio frequency at which the satellite system broadcasts and receives. Certain orbits in space and particular radio frequencies are optimum for satellite communications. In space, as on the ground, the real estate for satellites is scarce and expensive. The government regulates how this valuable real estate is parceled out and commercialized.

Satellites may be launched into orbit at distances ranging from 500 to 22,500 miles above the earth.

European Space Agency Ariane 5 rocket launching geosynchronous satellite. Photo by Orbital Graphics, courtesy of ORBCOMM.

Weak links

With the price of oil as low as levels in the 1980s, petroleum companies are searching for ways to achieve consistent margins. Until recently, the cost of satellite communication links was prohibitive for many companies. They, therefore, relied on other data collection solutions that, by themselves, were not totally satisfactory.

For example, all sites cannot be totally automated because of the cost and complexity involved. Therefore, important information may be missing from the total picture. This problem is even more pronounced when the equipment includes both stationary and moving assets (such as tanks and trucks). Even when all assets at all locations can be included in the system, it is difficult to ensure that all of the right information goes to the right person in the right form in a timely and secure fashion.

Regardless of how centralized or decentralized the operation, the management of a retail petroleum distribution and marketing company consists of three basic functions: (1) sales, (2) operations and (3) the "back office," where data collection, analysis and communication take place.

Particularly when operations are spread out over hundreds of square miles, a company can achieve economies of scale and responsive customer service only with fast and efficient data flow to and from the field. Information is most often transmitted manually or by telephone, even in highly computerized systems. However, phone lines in rural areas are sometimes unreliable for data communications.

• The manual method

Employees at service stations can collect tank level data, sales volume and other data by reading the information, then either writing it down on paper forms or entering it into their computer systems. Since no additional investments in communications are required, this method has the lowest initial cost. However, given the person-hours of time and training needed to perform these tasks manually, the actual operation costs can be quite high. In addition, the reliability, completeness and accuracy of the data often suffer. Data collection also tends to be a low priority for field employees as it ties them up in non-revenue generating activities.

• Telephone systems

Many managers use modems to provide the data connection between the office and headquarters. Modems offer a low hardware cost, but the installation and operating expense can be relatively high. Modems often require a second dedicated phone line. Or, they can be configured to share the line with the voice telephone; but this limits the modem's functionality. Most charges include interstate and intrastate long- distance rates.

Satellite under construction. Courtesy ORBCOMM.

GEO satellites

Traditional satellite systems are often known as Very Small Aperture Terminal (VSAT) systems. Another name for VSAT systems is Geosynchronous (GEO) satellites. They provide a reliable method to connect the remote service stations with the central office. Geos are located 22,500 miles from the earth's surface. This technology also supports Wide-Area Networks (WANs). The small dishes seen on top of retail outlets are sure signs of WANs, which contain point-of-sales and inventory systems. GEO systems are relatively expensive to build and to use.

GEO satellites generally orbit along the equator at the same speed as the earth rotates. They are set in a particular longitude that can cover all of North America. Military GEOs have been employed since 1975.

Large aerospace companies, such as Hughes, Loral and Lockheed-Martin, all build GEO satellites for military and commercial applications. In the late 1980s, these companies started the design and development of the satellites that now provide much of the widely available applications. The current generation of satellites has higher power transmitters and more robust communications protocols so that the transceiver on the ground can be much smaller. For example, TV satellite dishes in the 1980s, using older satellite technology, required dishes that were 3.5 to 4.5 feet in diameter.

Contemporary systems that take advantage of the higher power satellite transmitters, such as direct TV, require dishes only 18 inches in diameter.

• Licensing
Making a GEO satellite operational is a major undertaking. First, a company must get federal government permission to use an orbit station or position. This process takes two to six years; and, even then, the company may not receive the desired slot. Frequently, other companies challenge a license application to obtain the most optimal locations in space for their satellites.

Real estate is particularly important in space. Once a company receives a license for a "good" area in space, that company will defend it like gold because areas are limited. Only a few orbital slots cover the entire US. These large areas can contain many satellites. Satellites are highly regulated on both a national and international scale. International treaty implications also affect the processes of both launching and operating satellites.

• Construction
After receiving a GEO license, the company builds the satellite. It is very large—sometimes the size of a school bus—and can take up to two years to assemble and test. Satellites are generally constructed from non-ferrous, very lightweight materials, primarily aluminum composites. The electronics on board must be protected from radiation and the temperature extremes that exist in space. Satellites generally have a central structure to hold the electronics and antennae. This structure has solar panels that fold out from the main structure to generate the electrical power to operate the electronics.

• Launching
The next step is the launch. GEO satellites are launched into space by rockets such as Boeing's Delta and Lockheed-Martin's Titan and Atlas rockets. Other countries offer launch services such as the European Space Agency's Ariane 5, the Russian Proton and the Chinese Long March. The company or

government wishing to launch the satellite must purchase the launch services. Launching a satellite can be a very risky proposition—launch insurance alone can cost as much as $60 million! Satellites weigh thousands of pounds and are very expensive to move into space. A typical GEO launch can cost upwards of $125 million just for the lifting service.

• Maintenance

Although they may have some maintenance problems initially, GEOs generally work flawlessly once they are positioned in orbit. Satellites can remain in space for many years; their life expectancy is difficult to predict. In the 1970s, the satellites used for emergency communications by ships were expected to last about seven years. Yet, some of them still continue to operate today.

• Fueling

GEO satellites are powered by solar panels. These panels are used to generate electricity to operate the electronics and communications systems on board. GEOs typically use compressed nitrogen gas to maintain their position in space.

• Costs

From start to finish, a GEO can cost more than $500 million and require years of preparation before it is fully operational. However, once operational, satellites are extremely profitable.

Iridium low-earth orbit satellite in orbit–note the size of the communications coverage circle. Courtesy of ORBCOMM.

LEO satellites

New lower orbiting satellites have the capacity for global communications and reliable wireless data communications. They operate only 500 miles above the earth; thus, giving them the name Low-Earth Orbit (LEO) satellites. Much cheaper to build and launch than traditional satellites, this latest generation of satellite technology reduces the total cost of ownership for the retail petroleum distribution and marketing industry.

The same efficiencies that drive down the cost and increase the performance of personal computers also apply to LEO satellites. As with computers, LEO satellites can provide more performance in smaller packages.

Unlike VSAT technology, LEO technology does not require aiming an antenna at a particular point in the sky. It is simply enough to place the ground device so that it has a view of the sky. As the LEO satellites move overhead, the satellite network manages the communications between remote sites and the central office for equipment and vehicles that are either mobile or fixed. The result is a communications network that is easy to set up and maintain.

A GEO satellite orbits at the same speed as the planet Earth revolves, so it appears to be stationary relative to a point on the ground. However, a single LEO satellite orbits the earth once every 90 minutes. Multiple LEOs are generally placed in the same orbital plane and are spaced evenly around the earth. Think of a necklace stretched around the planet Earth with eight equally spaced beads, and you will have a picture of a LEO orbital plane. All LEO satellite constellations require multiple planes to provide the full coverage of the planet Earth.

ORBCOMM’s system has 28 LEOs, 3,000 miles apart; every minute, every inch of the planet is covered. This coverage provides a great intensity because the LEOs are only 500 miles above the Earth. Other LEO systems, such as Iridium, are focused on voice communications, and have more than 28 satellites in orbit. For both LEO systems, the communications hardware on the ground is much smaller and less expensive than with GEO systems.

• Licensing
In the early 1990s, the International Telecommunications Union recognized the emerging LEO technologies and reserved selected parts of the electromagnetic spectrum for the projects. The LEO licensing took almost two years to resolve to ensure the resources were apportioned correctly. If the licensing had not occurred, it would have been an effective veto of the emerging technology. LEOs present a unique licensing challenge: since the satellites cover every country on Earth, each country has to enable the communications in their country. In the US, the Federal Communications Commission (FCC) has this responsibility. The US has taken the lead in this new technology, thanks in part to the FCC’s ability to allow provisional licensing schemes.

• Construction
Each LEO is about the size of a desk and has the latest electronics with small, but powerful components. Since multiple satellites are required for LEO systems, satellite manufacturers can built “assembly lines” and standardize components and assembly techniques. Each ORBCOMM satellite, for example, took only a few weeks to assemble. It took ORBCOMM, for instance, less time to build 28 LEO satellites than it typically takes to build one GEO.

€ Launching

One company launched all eight of its LEO satellites on one rocket, the Pegasus, at the end of this July. A Pegasus rocket is carried on the underside of a L1011 Jet Liner, flown out over the Atlantic Ocean and dropped from 40,000 feet. The rocket ignites and, from there, is launched into orbit.

• Communications
LEOs designed for data-only applications, such as ORBCOMM’s, use VHF radio spectrum. One advantage is that hardware is widely available and can be used anywhere. LEOs designed for voice communications need higher frequencies and, therefore, more expensive communications hardware.

• Maintenance
From a satellite standpoint, LEO satellite systems are very robust. Rather than a single satellite that represents a single point of failure, there are many satellites that provide redundancy for the constellation as a whole. The maintenance program for LEOs is to build spare satellites and place them in orbit as satellites fail. From customers’ perspectives, they will not see any degradation of service.

• Fueling

LEOs also generate power from solar panels to operate the communications and electronics. They carry only limited fuel for maneuvering once in the correct path of their orbit.

• Costs

Given that a LEO system only has to communicate with a satellite 500 miles overhead, rather than 22,500 miles overhead, the power needed to reach the satellite is substantially less. Consequently, the transceiver hardware is much cheaper. Data LEO transceivers typically cost around $500; in contrast, a similar piece of GEO hardware costs between $4,000-$5,000. Airtime on the systems for low bandwidth with applications is similar.

Today, retail petroleum marketers can monitor inventories, manage logistics, track deliveries and collect data from more equipment and vehicles than ever before. Therefore, today’s pressing question isn’t “What can be monitored?” but “How and what can be cost-effectively integrated into the entire system?” That’s where satellites come in.

The new satellite technologies provide system integration for many petroleum-equipment applications, including the integration between storage tanks and tanker trucks to reduce the cost of getting crucial data.