ITU News No. 6/98, p. 22 - 26

Internet in the Sky: Tests have Started...

Ryszard Struzak[1]

Overview

The first commercial non-geostationary satellite operating at centimetre waves was successfully launched on 25 February 1998. Named T1 (for Teledesic 1), it was placed into low-Earth orbit (LEO) for testing purposes. The full-scale system will offer bandwidth-on-demand services including universal broadband access to Internet and two-way interactive communications with aeroplanes in air and ships at sea and in fact anywhere, anytime, beginning in the year 2002. Data rates are up to 64 Mbps for standard terminals and up to 622 Mbps for high data rate terminals. Other similar projects follow.

TEXT

Marvels of Technology

We have no control over the pace of innovation. Every day we see new ideas, new products, new applications, and new services. The innovation process develops following its own rules, pushed by the ingenuity of individuals, competition, and market demand. It has been so since the dawn of human civilisation. 2200 years ago or so, ancient Greeks and Romans described the seven most extraordinary man-made structures of their times as ‘Seven Wonders of the World’. These were the pyramids of Egypt; the Hanging Gardens of Babylon; the Phidias' statue of Zeus at Olympia; the temple of Artemis at Ephesus; the tomb of King Mausolus at Halicarnassus; the Colossus of Rhodes; and the lighthouse at Alexandria.

Because of primitive transportation and communication means, the world of ancient Greeks and Romans was limited to the Mediterranean region, embracing only a small part of Europe, Africa and Asia. If they had known more about distant regions, the list would be different, and other marvels would be included, such as the Great Wall, a line of fortifications extending about 2,5 thousand kilometres across northern China.

If they were today, their list of Seven Wonders of the World would certainly contain Low-Earth Orbiting (LEO) global satellite systems such as Teledesic and others. These are the most complex structures ever conceived by a human being and also ones of the biggest, both in terms of the number of elements and in terms of geometric size that extend beyond the Earth's dimensions. What all of them, ancient and contemporary, have in common is a combination of extraordinary talents, resources and efforts necessary for their implementation. What is a difference is the economic and social impact. These communication systems are changing profoundly the ways we live and do business. They create Global Information Infrastructure (GII), induce Information Revolution and are opening a new era of Global Information Society. No other man made structure had such a profound impact on the society, worldwide. "The GII will be the key to economic growth for national and international economies", said Vice President Al Gore.

The Space Age

The GII has been possible thanks to developments in many areas of science and technology, especially those related to the space. All agree that ‘Space Age’ began 4 October 1957 when the Soviet Union launched the first artificial Earth satellite, Sputnik 1. Sputnik 1 was about 60 cm in diameter and weighed 80 kg. It orbited the Earth in 96.2 minutes and collected and transmitted data concerning cosmic rays, meteoroids, and the physics of upper atmosphere. After 57 days the satellite re-entered the atmosphere and burned up. It was also the first LEO satellite, although that term did not exist at that time.

---

[1] The opinions expressed in this paper are the author's personal views and do not engage ITU or and other entity. First published in Global Communications Asia '98, pages 156-158.

That demonstration of capabilities of military technology of the Soviet Union was soon repeated by the USA and used, among others, for communication applications. In 1963, the Space Conference of International Telecommunication Union (ITU) recognised the Satellite Services and made the necessary allocations of the spectrum. Two years later, in 1965, ‘Early Bird’ satellite was put into orbit by the Communications Satellite Corporation (COMSAT) to relay telephone messages and television programs between Europe and the United States. It was the beginning of the era of commercial communication services via satellite.

Geostationary Satellite Systems

In the early years of the space communications, the geostationary satellite orbit (GSO) attracted the greatest attention. The satellite Orbit Conference, held in two sessions in 1985 and 1988, drew up Plans and Procedures relating to the use of the geostationary satellite orbit. Satellites at that orbit at an altitude of approximately 35,900 kilometres above the equator travels at a speed matching that of Earth's rotation and remain stationary in relation to the Earth. The main benefit of that technology is that it eliminates the necessity of tracking antenna systems.

There are two drawbacks inherent to the geostationary satellite technology, however. The first is a propagation delay. Radio waves travel 300 000 km per second and with that speed it takes 0.24 second to pass from point A to point B via geostationary satellite, no matter how close or how distant the points are on the Earth. For real-time and interactive applications such delay may be unacceptable.

The second drawback is that geostationary satellites cannot serve every area on the Earth surface. There are regions far away from the equator in the North and in the South, as well as regions where the geostationary orbit is obstructed by mountains and terrain irregularities that cannot be reached from the geostationary orbit.

True Global Systems: Problems

To reduce the delay, satellites have to be located at lower orbits, closer to the Earth. At such orbits they move relative to the Earth. In addition to solving the delay issue, low polar orbits solve also the accessibility problem, as satellites on such obits pass over every point on the globe.

However, two major problems are inherent to that technology. Firstly, as the satellites are moving relative to the earth, tracking antenna systems are required to communicate with them. Thanks to the progress in science and technology, the expensive mechanical tracking systems can now be replaced by electronically steered tracking antennas. Such electronic antenna systems with no moving parts may be less expensive and more practical especially at high frequencies where antenna dimensions are small.

Secondly, as LEO satellites are in move, they can be contacted from any point fixed on the Earth for only short periods (say 20 minutes) when the satellite is visible before it passes over the horizon to reappear again in a next cycle. To assure a continuing connection, a number of ‘cooperating’ satellites are thus necessary. In such an arrangement each satellite carries the connection successively one after another. For a continuous service at one point on the Earth a constellation of satellites is needed. But, as the whole constellation moves above the Earth's, a continuous coverage of a single point means a continuous potential service coverage of the whole Earth's surface (The word ‘potential’ indicates here that satellites may be switched off over some points or regions).

The idea to use a constellation of LEO satellites for a commercial global telecommunication system was presented before the ITU Members at the World Radiocommunication Conference, Geneva 1995 (WRC '95). It was the Teledesic system, the first and only system at that time to plan such a service at centimetre waves.

Although nobody denied the boldness of the idea, many did not really believe that it was feasible. There were many unsolved problems at that time. Practical experience was lacking in the inter-satellite communication and traffic switching on the orbit, in the network synchronisation threatened by the Doppler effect, in propagation effects at centimetric waves, in spectrum resources management, and in other areas.

But main difficulties were associated with regulatory problems rather than with technical issues [Struzak 97 S]. Technical difficulties are objective and well defined, whereas regulatory problems are ill defined, involve unpredictable factors, subjective human judgements and conflicts of interests. A global service from a constellation of LEO satellites was unprecedented and there was no frequency band allocated for such an application. The interest groups associated with the geostationary satellite technology did not want to resign from the spectrum resources allocated earlier exclusively to their applications and to share it with newcomers. It could put their business in jeopardy. A strong opposition from the geostationary-satellite lobby has been neutralised at WRC '95 with the support from developing countries. Two years later, at the World Radiocommunication Conference, Geneva 1997 (WRC '97) nobody raised doubts about feasibility of the concept and Teledesic finally cleared its regulatory approval. The conference opened definitively the sky for non-GEO satellite systems [Albuquerque 98, Smith 98].

Competition

A number of competitors joined Teledesic in the rush for a huge market of 10-20 million users worldwide at early years of the next century. The amount of various space systems submitted to the ITU for notification started to increase exceedingly, see Figure 1.

Many analysts do not believe that the market will be large enough to accommodate all these systems. A number of the submissions are suspected to be so called ‘paper satellites’ that never will really be implemented. Among major projects of LEO global systems discussed at the occasion of WRC '97 were Celestri of Motorola, and Skybridge of Alcatel, in addition to Teledesic. Table 1 lists basic characteristics of these systems; further details can be found on the Web: http://www.alcatel.com (Alcatel), http://www.mot.com (Motorola) and http://www.teledesic.com (Teledesic LLC); for detailed comparison of these and other system, see for instance [Montgomery 97].

In the meantime the regulatory negotiations continue in the ITU and also in the framework of the World Trade Organization. These complement similar negotiations concerning the future Global Mobile Personal Communication Services (GMPCS). A GMPCS Memorandum of Understanding has been prepared to lower or eliminate the non-technical barriers to those applications [GMPCS MoU 97].

T1 Satellite

Just a few months after WRC '97, Orbital Sciences Corporation announced that it successfully launched Teledesic LLC's T1 satellite, the world's first commercial centimetre-band LEO satellite, on February 25. Its air-launch Pegasus system for the deployment of small satellites into low-Earth orbit has enabled the company to conduct operations from five separate launch sites, four in the US and one in Europe. For the first time a space launch vehicle has provided such operational flexibility, according to the company. Pegasus is carried aloft by the company-owned L-1011 ‘Stargazer’ carrier aircraft to a point approximately 40 000 feet over open ocean areas, where it is released and then free-falls in a horizontal position for five seconds before igniting its first stage rocket motor.

The launch of T1 satellite originated from Vandenberg Air Force Base, California where the ‘Stargazer’ took off and flew off the California coast to a pre-determined location over the Pacific Ocean, company reports. Here, the Pegasus rocket carrying the satellite was released at approximately 11 p.m. local time. After 10 minutes or so, Pegasus delivered the T1 satellite into the planned orbit at an altitude of approximately 565 kilometres, inclined at 97.7 degrees.

The T1 satellite (previously called the Broadband Advanced Technology, or BATSAT satellite) is an experimental satellite designed and built by an Orbital, Teledesic and Boeing team. Orbital provided the satellite bus and Boeing supplied the payload. Teledesic is using the satellite to test atmospheric effects, power and transmission systems, ‘rain fade’ adaptability and GPS synchronisation. However, the Teledesic experimental satellite will not be alone for long. One may expect other companies to follow it soon.

ITU News No. 6/98, p. 22 - 26

The Net in the Sky

The T1 satellite launch is part of ongoing developmental effort to build global, broadband 'Internet-in-the-Sky' network, which was licensed by the US Federal Communications Commission last year and will be followed by other projects. Teledesic plans begin launching in 2001, and to have the complete constellation of 288 satellites in orbit by the year 2002. Its system is designed to create the world's network providing affordable, worldwide, 'fibre-like' access to telecommunications services, such as linking enterprise computing networks, broadband Internet access, videoconferencing and other digital services. The Teledesic Network is designed to support millions of simultaneous users. Communications with aeroplanes, vessels and vehicles in move seem exciting, but its greatest impact will result from offering to rural and not-served areas a full access to global ultra-modern telecommunication infrastructure [Daggatt 95, 97, Struzak 97/B]. Of similar importance will be satisfying the communication needs in disaster situations: immediate access to world communication networks everywhere and anytime [Farell 98, Zimmermann 98].

Only few years ago, at Buenos Aires Telecommunication Development Conference in 1994, Vice President Al Gore said: "Constellations of hundreds of satellites in low earth orbit may soon provide telephone or data services to any point on the globe. Such systems could make universal service both practical and affordable." and continued: "[We] now have at hand the technological breakthroughs and economic means to bring all the communities of the world together. We now can at least create a planetary information network that transmits messages and images with the speed of light from the largest city to the smallest village on every continent. [...] And it will greatly promote the ability of nations to cooperate with each other..." Today we witness it coming true.

References

Albuquerque J., Hayden T.: WRC-97 Completes Regulatory Framework Enabling Non-GSO FSS Systems in 2x500 MHz of Ka-Band; Global Communications Asia '98

Daggatt R.: A global, broadband Internet-in-the-sky: The Teledesic Network; Global Communications Interactive '97,

Daggatt R.: Satellites for a developing world; Scientific American, September 1995

Farell G.: Saving the lives of those who save lives; Global Communications Africa '98

Montgomery J., Broadband satellite systems stand ready to bring multi-megabit data rates worldwide. Byte, Nov. 1997

GMPCS MoU Arrangements; ITU News 10/97

Smith R.: WRC '97: A milestone in the development of Global Communication systems; Global Communications Africa '98,

Struzak R.: Building information infrastructure in rural areas; Global Communications Asia '97

Struzak R.: Spectrum management for wireless services of the 21st century; Global Communications Interactive '97

Zimmermann H., Oh Ei Sun: A beacon in time of distress; Global Communications Africa '98

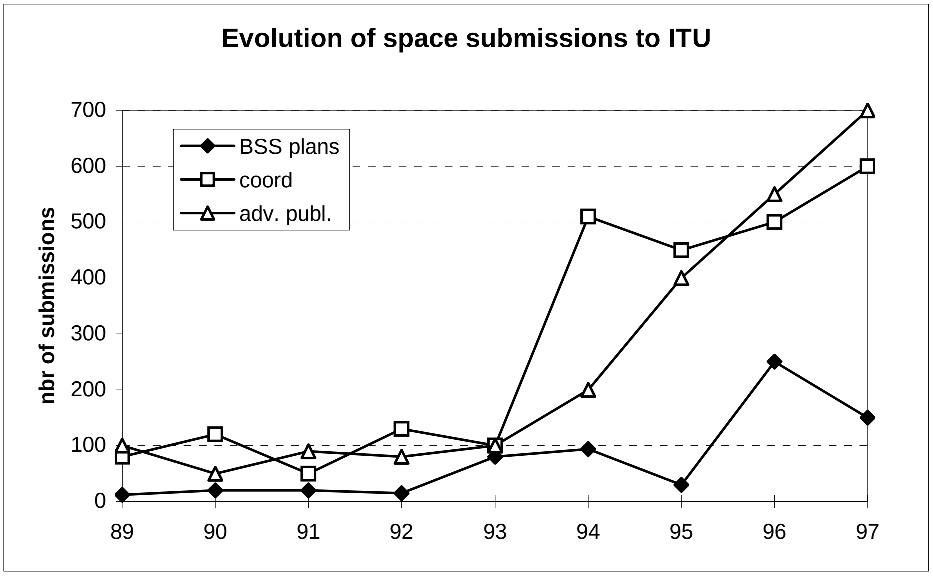

Figure 1. Number of space systems submitted for notification by ITU in the years 1989-1997 (Source: ITU).

Table 1. Major LEO 20/30 GHz satellite system

System	**Celestri**	**Teledesic**	**Skybridge**
Company	Motorola	Teledesic LLC	Alcatel
No. of satellites	63 LEOs + 9 GEOs	288 LEOs	64 LEOs
Altitude (km)	1400	1375	1457
Data throughput (Mbps)	Up to 155	Up to 64 (Standard Terminal) Up to 622 (High Rate Terminal)	Up to 60 (residential) Up to n x 60 (business)
Intersatellite links	Yes	Yes	No
System cost (billions)	$13	$9	$3.5
Operation starts	2002	2002	2001