Spectrum Management
Part 3

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Renaissance of radio

One hundred years after its invention, radio is entering a new era. The development of communication and computer technologies and their convergence generate applications that were hard even to imagine a few years ago. Radio has become indispensable to the functioning of our society. Areas in which the radio waves have become invaluable are numerous. National defence, disaster warning, public safety, air-traffic control, and weather forecasts, are but a few examples.

The 1969 moon landing, the most spectacular illustration of the conquest of space by humans, would never have been possible without the radio. Remote-sensing satellites are irreplaceable in discovering natural resources of the Earth and in monitoring the climatic changes.

> *Radio astronomy has opened new windows on the universe and contributed to a better understanding of nature. Radio and television broadcasting have become the main source of everyday information for most people. There are more radio receivers than telephones worldwide. The 1996 Olympic Games, for instance, were watched by some two billion people.*

Radio and television play a principal role in meeting information needs of illiterate people unable to read: about two-thirds of the world's population. Non-communication applications of radio waves have become indispensable too, as evidenced by millions of household microwave ovens in daily use. Many industrial processes and scientific experiments have been improved, or even made possible, by the ingenious usage of radio waves.

Radio became crucial for security and economy, nationally and worldwide, like the nervous system in a living organism. The uses of radio waves create businesses. In spite of economic fluctuations, the telecommunication sector alone has been one of the most profitable industries, after pharmaceuticals and diversified financials.[1] In the United States alone, radiocommunication equipment shipped in 1991 is said to have reached USD 55 billion. In 1994, a cellular operator in the United Kingdom made a yearly profit of GBP 350 million.

As a whole, the economic impact of the use of radio is estimated at about 2 per cent of the gross domestic product. One can argue whether or not it is sufficient to describe the impact of the spectrum use on the society in economic terms only. Certainly, it would be an unacceptable oversimplification to judge the value of the nervous system in the human organism based on its weight alone, which is less than two per cent of the total weight of the body.

[1] *ITU: World Telecommunication Development Report (1998).*

At any rate, it is widely accepted that the convergence of wireless telecommunications and information technologies will be a major engine of economic growth and improvement of the standard of living in the next decades. A recent publication of the European Community[②] is the best evidence of this fact. The enormous impact of radio on our lives continues to increase, although we still do not fully realize all the consequences of that development.

Examples of applications of radio waves that could change our lives significantly in the next century

One of them is the global positioning system (GPS). It is a space-based navigation, positioning and time-transfer system completed in 1993 and offering unsurpassed accuracy, reliability and availability. Now open for civilian applications at no cost, it was developed for military purposes for over USD 10 billion.

GPS is American; its Russian equivalent is known as GLONASS (global navigation satellite system). With a handheld receiver, you can determine your position with an accuracy of 30 m or so. If you have special equipment, software, and access to the decryption key, that accuracy may be much greater. In 1997, this type of receiver was priced at some USD 250, and a year later a two-chip GPS receiver was available at 25 dollars.

The operating principle is remarkably simple, and refers to the ancient art of navigation when our ancestors followed the stars in the sky. The difference is that GPS uses man-made "talking stars" – a constellation of 24 satellites. Each satellite carries a precise on-board atomic clock. The exact position of each satellite is monitored by the GPS master control station that also maintains a GPS time standard which, in turn, is synchronized with coordinated universal time.

The data on current satellite positions and time, updated periodically, are uploaded to each satellite to be broadcast continuously in a coded form. A GPS receiver extracts the data, and compares its own time with the time sent by a satellite. The difference between the two times and the velocity of the radio wave are used to calculate the distance from the satellite to the receiver. The satellite clocks are exact to a billionth of a second (which corresponds to a 0.3-m distance uncertainty), but the receiver's clock is simple, to keep its weight and cost low. It introduces an unknown time offset, or error. Thus, to calculate its longitude, latitude, altitude, and the time offset – the four unknown variables – a GPS receiver must use data from at least four satellites. For this purpose, the satellites orbit in a formation that ensures that every point on the planet is always in radio contact with at least four satellites.

The precise signals from the GPS satellites create a worldwide time and frequency reference, easily accessible from any point on Earth, for the first time in history.[③] These signals are used to synchronize various processes and networks, including telecommunication and power supply networks. However, this is only a part of the benefits offered. GPS provides a unique address for each point on Earth, instantly available in electronic form, setting a new standard for locations and distances.

The applications of the GPS appear to be virtually unlimited. They enable drivers, mariners and pilots to navigate safely and efficiently in all weather conditions, day and night, and to save fuel by travelling the most efficient route at optimal speed. They provide data for mapping and surveying tasks, as well as for laying roads, bridges, foundations and utilities, quickly and precisely.

[②] *Green Paper on Radio Spectrum Policy in the Context of European Community policies such as Telecommunications, Broadcasting, Transport and R&D; Commission of the European Communities, Brussels, 9/12/1998 [COM(1998)596).*

[③] *Martin K. E.: Powerful connections, GPS World, March 1996, pages 20-36.*

Once gathered, GPS data can automatically be transferred to a geographic information system. According to some predictions, GPS receivers may become as ubiquitous as watches, and GPS coordinates may eventually replace a street address to define the location of a home or a business. GPS has created new industries. The worldwide GPS market, estimated at USD 3 billion in 1997, is expected to grow to 8 billion by the year 2000, according to a report by Forbes.④

The second example is the satellite communication services. Several constellations of low-orbiting satellites are planned, and have so far absorbed about USD 8 billion. Among them is the *Teledesic* system, whose tests started in 1998 (see *ITU News*, No. 6/98, pages 22-26).

It will provide affordable two-way communication services such as broadband Internet access, videoconferencing, high-quality voice, and other digital data exchange, offering access speeds of up to 2000 times faster than today's standard analogue modems.

> *The Teledesic network is designed to support millions of simultaneous users at any time, offering the same services everywhere on the planet: in London, in the middle of the Gobi desert, or in the Amazonian jungle. Privately funded, and costing USD 9 billion, this network will be in service in 2002. Originally, it was planned as a constellation of 840 satellites in 21polar orbits, some 700 km above the Earth. Later, the number of satellites was reduced to 288.*

The significance of these new communication systems cannot be overestimated. Information exchange for a multitude of computer applications become increasingly essential to economic development, education, health care, public services, and to many other activities. However, the "information gap" is growing and most of the world does not have access to even the most basic telephone service. Even where this basic service is available, most of the networks over which it is provided are antiquated and inappropriate for computer communications. Inadequate telecommunication facilities block computer applications. The cost and time required to upgrade these facilities through conventional or fibre-optic lines would be prohibitive for much of the world.

The new satellite systems create complete telecommunication infrastructure in the sky, accessible from any place, 24 hours a day. They are capable of providing the needed services at a low cost, regardless of distance or location. Because satellites in polar orbits move in relation to the Earth, the cost of continuous coverage of anyone point on Earth is the same as the cost of covering all points on the Earth's surface.

These systems radically transform the economics of telecommunications and enable leap-frogging earlier stages of telecommunication technology development to gain immediate access to the most advanced information infrastructure. The value of such systems lies in the number of people getting access to advanced communication services and who otherwise would never have such access.

Spectrum scarcity

Due to the laws of nature, various applications of radio waves can interfere with each other and nullify the benefits they offer, if incorrectly designed or operated. To avoid such interference, each application requires some amount of radio frequency spectrum for exclusive use, unless special arrangements are made. We use interchangeably the terms "radio waves", "radio frequency spectrum" and "spectrum", that have the same meaning in the context of this article.

④ *Hemisphere Report, Forbes (22 September 1997).*

The capacity that can be provided by any communication system to any single user, or to any group of users, is ultimately limited by the spectrum available to that system. The number of radio systems in operation worldwide is enormous and continues to increase. Liberalization and deregulation trends encourage the introduction of new services and new technologies, which generates demand for radio frequencies without precedence.

The International Telecommunication Union (ITU) has recorded more frequency assignments in the last few years than during the whole previous history of radio.

Most of the suitable frequencies have already been occupied and, within the existing arrangements, the demand exceeds what can be assigned further. In some frequency bands and geographical regions there is no place for new radio stations. Spectrum scarcity is observed in VHF/UHF frequency bands if the population density exceeds 200 people per square kilometre and the gross national product is USD 10 000 per capita per annum, according to some experts. Similarly, the geostationary satellite orbit becomes congested and there may be no place for new satellites in some areas. That scarcity hampers further development of telecommunications. The issue is critical for the future of services and applications, and deserves serious consideration.

The scarcity of radio spectrum is not a new problem. It was the United States Secretary of Commerce, Herbert Hoover, who first declared: "there is no more spectrum available." The year was 1925. In the meantime, a multitude of applications of radio waves have been invented and successfully implemented. Is the spectrum congestion real? If so, is there any way to solve the problem? Is the spectrum/orbit scarcity due to the law of nature or, perhaps, due to our own mismanagement?

The problem of shortage of radio frequencies was repeatedly raised at international conferences and at other occasions. This would indicate that the spectrum shortage has a periodic or chaotic character. Today, we are seeking new solutions to an old problem that depends largely on the progress in science and technology, on development mechanisms, and on a mixture of competition and cooperation.

To solve spectrum scarcity and orbit congestion problems, numerous conferences and symposia gather thousands of experts every year. In particular, ITU holds a World Radiocommunication Conference every two years or so (the next one is planned for the spring of 2000).

The seriousness of spectrum scarcity is evidenced by the number and calibre of international organizations who participate in these events.

Apart from ITU, other specialized agencies of the United Nations include: the International Civil Aviation Organization (ICAO), the International Maritime Organization (IMO), the World Meteorological Organization (WMO), the World Health Organization (WHO), the World Trade Organization (WTO) and the World Bank.

In Europe we can count, among others, the European Commission (EC), the European Conference of Postal and Telecommunications Administrations (CEPT), the European Radiocommunications Committee (ERC), the European Radiocommunications Office (ERO) and URSI.

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