# New Satellites for Personal

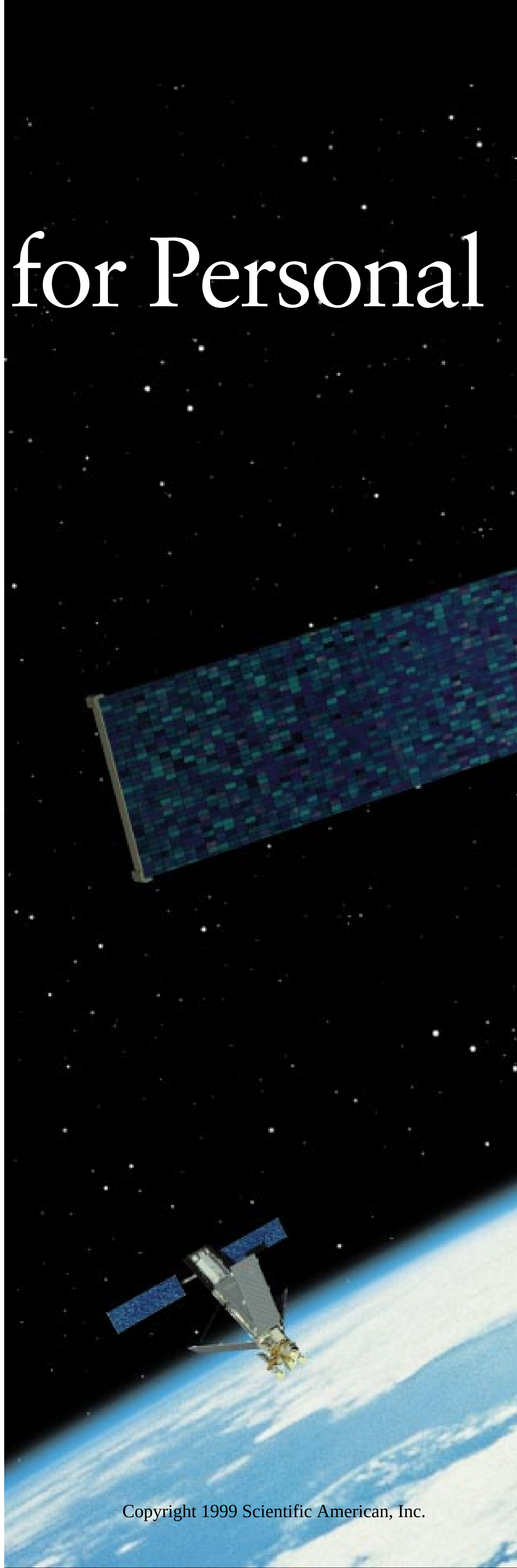
by John V. Evans

Since the first commercial model was launched into orbit in 1965, the communications satellite has become a linchpin of global communications. From modest beginnings—that first satellite could handle only 240 voice circuits at a time—the technology has blossomed to the extent that satellites now carry about one third of the voice traffic between countries and essentially all the television signals between countries.

Much of the voice traffic handled by satellites, however, is to countries that have no access to fiber-optic cables, which are the preferred medium for carrying telephone calls. Because large communications satellites are typically put into geostationary orbits, where they are roughly 36,000 kilometers (22,300 miles) above the same spot on Earth at all times, it takes a quarter of a second for signals to travel to and from the satellite, delaying the responses received during a conversation. Although not all users find this delay irritating, communications satellites are increasingly being used to carry television signals and data rather than voice traffic.

All of that is about to change. In November 1998 the first of a completely new type of satellite communications system began operation. Called Iridium, it is a network of 66 satellites, each capable of handling as many as 1,100 simultaneous calls. Iridium and the other networks expected to follow will provide cellular telephone service via satellite. Among other unique characteristics, these new systems will be based on a relatively large number of satellites in orbits considerably lower than geostationary ones; they will therefore introduce less delay into telephone conversations. A second type of system will be designed primarily for handling data, such as connections to the Internet. Over the next six or seven years, three to five of the voice-type systems and possibly upward of a dozen of the data-oriented satellite systems could go into operation.

How fast and big this market may grow is difficult if not impossible to say. Nevertheless, several groups have already invested billions in projects that are well along. The technical challenges and risks are significant; some of the enterprises, for example, would be unthinkable if not for the availability of a new generation of powerful communications satellites capable not only of amplifying and retransmitting

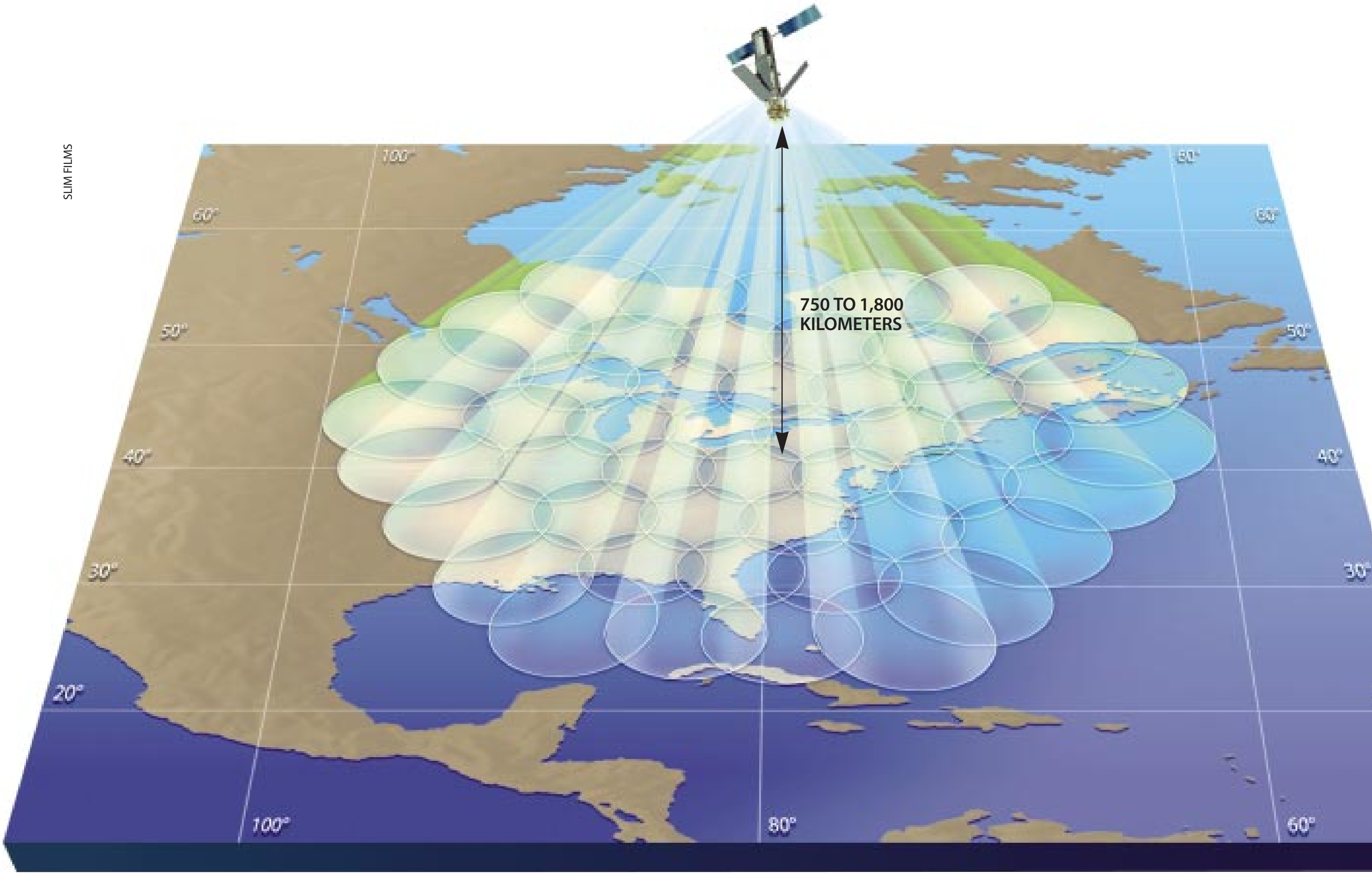


SLIM FILMS

COMMUNICATIONS SATELLITES shown here are typical of a new generation of craft capable of switching and routing calls. Visible in this scene are two of the Iridium system's 66 satellites, which are in low-Earth orbits.

*Fleets of satellites will soon make it possible to reach someone anywhere on Earth, using nothing more than a small handset*

# Communications




SPOT BEAMS of an Iridium satellite each cover a "cell" on Earth perhaps 150 kilometers across. A cluster of four dozen of these relatively narrow beams provides coverage of a larger region—the eastern U.S., say. Use of the narrow beams is necessary because the signals from the handheld telephones are weak, placing most of the burden of connection on the satellite.

signals but also switching and routing them. In addition, some of the proposed systems will operate at very high frequencies in radio bands not previously used for satellite communications.

### Satellites as Base Stations

The new personal communications satellite systems are striving to incorporate the advantages of both satellite and cellular systems into a single global network. In these new systems the satellites will be, in effect, orbiting cellular base stations, with which the handheld or mobile phones will communicate directly. Moreover, like conventional satellite systems, the new networks will be capable of serving large areas—including ones where no service is currently available.

Advantages such as these will be achievable only with some rather sophisticated technologies, however. One of the fundamental challenges results from the fact that a handheld phone can be equipped only with a very small antenna. It is impossible to design such an antenna so that it beams signals in a highly directional manner. Moreover, because the phones are held against the head when they are in use, the transmitted power must be kept below about one watt to allay concerns about the possible effects of radio-frequency radiation on biological tissue, such as the brain. (Low-power operation is also necessary to avoid draining the batteries too quickly.)

What these factors mean is that the signal transmitted from the phone is rather weak and that to "hear" it in geostationary orbit would require an antenna with a diameter of about 10 to 12 meters. Deploying such a huge antenna in space will be difficult, to say the least. To get around the need for such large dishes, the first of the new personal communications satellite systems have put satellites in orbits much closer to Earth. Because the required signal power falls with the square of the distance, bringing the orbit down from 36,000 kilometers to 10,000 kilometers, for example, causes a 13-fold increase in the strength of the signal received from the handheld phone. Such an increase permits the antenna on the lower-orbit satellite to be about the same size—two to three meters—as those now used on geostationary satellites.

Of course, there is a trade-off. In geostationary orbit, each satellite "sees" about a quarter of Earth, so only three or four satellites are needed for global coverage. At 10,000 kilometers, on the other hand, a satellite would have an orbital period of about six hours and would see less of Earth's surface. In fact, a fleet of about a dozen or more equally spaced satellites would be necessary to cover the planet.

In addition, because the signal from the handheld phone is weak, the entire burden of completing the link is placed on the satellite. The hookup can be achieved only if the satellite employs very narrow, searchlightlike spot beams on the order of one degree or so, each covering a "cell" on Earth perhaps 150 kilometers across. Many of these beams must be employed to provide coverage of the intended service area.

In general, satellites must orbit either above or below the Van Allen radiation belt, whose energetic ionized particles would damage solar cells and perhaps other solid-state components. Thus, satellite altitudes must be above about 10,000 kilometers or below about 1,500 kilometers. For the latter option, however, the orbital period is roughly 100 minutes, and about 50 or more satellites are required to cover the globe, because each one sees only a small part. (Imagine trying to take a picture of an elephant from one meter away.) The high- and low-orbit choices have become known as intermediate circular orbit and low-Earth orbit.

### Targeting Business Travelers


The designs of the announced satellite cellular phone systems differ considerably, reflecting different assumptions about the customers who might be attracted. The largest groups of potential users are two types of business travelers: those from the developed world who do business often in less developed countries, where the local phone service may be unreliable, and those who need mobile communications in their own countries but who travel beyond the reach of terrestrial cellular systems. Other potential markets include people living in very rural areas, where there is currently no service at all, and law-enforcement, fire, public-safety and other government officials who need access to a communications network that would survive a regional disaster, such as an earthquake or flood.

Many different global systems have been proposed, but only five appear to have some promise of being fielded. Four of them are U.S.-based and have received licenses from the Federal Communications Commission; the fifth is an enterprise spun off from the International Mobile Satellite Organization (Inmarsat), a treaty organization similar to Intelsat. The four U.S.-based projects are Iridium, which was constructed by Motorola with Lockheed Martin, Raytheon and other contractors; Globalstar, a joint effort in which Loral Space and Communications (a satellite manufacturer) and Qualcomm (a maker of cellular equipment) are the principal partners; ECCO, a proposal put forth by Constellation Communications in Reston, Va.; and Ellipso, to be built by Mobile Communications Holdings in Washington, D.C. In addition, several regional systems are being developed that will employ geostationary satellites and primarily serve Third World countries.

Deregulation of the telecommunications industry in various developed countries is speeding delivery of new services and prompting the investment of enormous amounts of capital in new facilities. A key factor in this activity is the explosion in the use of the Internet, which is expected to grow from 50 million households in 1998 to perhaps 150 million by 2000, representing a market of more than $10 billion. Corporate use of the Internet may grow even more spectacularly. Increasingly, corporations are using the Internet to create their own semiprivate "intranets." Some observers believe this market could expand from the less than $1 billion spent in 1996 to more than $30 billion by 2000.

To serve these markets, many new satellite systems are planned. Because of the congestion on the frequencies currently used for fixed (as distinct from mobile) satellite services, these systems will operate in a higher range of frequencies, known as Ka-band. The choice of Ka-band is driven largely by the absence of a suitable alternative; recent developments have made it almost impossible to secure orbital locations for satellites that would operate in other bands without interfering with neighboring satellites. Worldwide there are now believed to be more than 50 proposed Ka-band projects requiring approximately 170 geostationary-orbit locations. Most of these proposals appear to be for national or regional systems, and not much has been published about them thus far.

### Data and Multimedia Services

A total of six U.S. systems have received licenses from the FCC to offer global service, although none has progressed beyond the design stage. One of the systems would be based on low-Earth-orbit satellites, the other five on constellations of geostationary-orbit spacecraft. In some sense, these projects are more risky than the voice-oriented satellite projects described earlier because the demand is less certain. This fact may aggravate the problem of raising capital—leaving the field open to those companies best able to commence their projects with their own resources. Those most committed at present, in terms of money spent on design studies, appear to be Lockheed Martin, Motorola and Teledesic.

In addition, success in a consumer market is believed to depend on terminals that cost less than about $1,000. These terminals will combine a small satellite dish antenna and a two-way radio, which may be mounted on the dish, with an indoor component that interfaces with the computer. Achieving such a low cost will most likely require the mass production of a million or more terminals, which is hardly a certainty. If, somehow, the price of the terminals can be brought down to this level, then satellites may take on another role—that of providing "last-mile" connections to homes and businesses for broadband data, multimedia and related services, because existing telephone lines do not afford this kind of data rate (although efforts are under way to change this situation).

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The development of the fleets of satellites described here will affect some of us profoundly. By 2000 it will be possible to call home from essentially anywhere on the planet using a handheld terminal similar to one of today's cellular phones. For better or worse, we need never be out of touch, no matter where we are.

Besides the obvious benefits to commerce and tourism, universal service will become possible, at least for those who can afford it, in countries where none now exists. Within a decade, it will probably be possible to live in a remote area and yet be connected to the worlds of commerce and entertainment via the Internet and other sources of multimedia at rates high enough to support movies-on-demand. The world will soon be a place where not just communications but also torrents of information will be available just about everywhere. Whether this world will seem smaller, larger or more interesting will probably depend on your point of view. SA

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