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## A Practical System for Regional Mobile Satellite Services

Randall Glein, Denis Levenson, and Dean Olmstead

Hughes Aircraft Company  
 Bldg. S64, MS B433  
 P.O. Box 80002  
 Los Angeles, CA 90009, USA  
 Telephone: (310) 364-6808  
 Fax: (310) 364-5545

### ABSTRACT

The Regional Mobile Satellite (MSAT) concept proposes a worldwide, interconnected mobile satellite service (MSS) network in which MSAT-type satellites provide the space segment services to separate regions (i.e., one or a few countries). Using this concept, mobile communications users across entire continents can now be served by a handful of regionally controlled satellites in geostationary earth orbit (GEO). All requirements, including handheld telephone capabilities, can be cost-effectively provided using proven technologies. While other concepts of regional or global mobile communications continue to be explored, the Hughes Regional MSAT system demonstrates the near-term viability of the GEO approach.

### REGIONAL MSAT—A NORTH AMERICAN EXAMPLE

Since the advent of mobile communications, users have enjoyed steadily increasing freedom from the constraints imposed by hard wire. Unfortunately, mobile communication has been limited by the height and range of radio towers. But now, high-power regional mobile satellites eliminate these restrictions.

North America, with its highly developed cellular infrastructure, has become a natural first candidate for a regional mobile satellite system. When its MSAT system is launched in 1994, the team of American Mobile Satellite Corp. (AMSC) and Telesat Mobile, Inc. (TMI) will show how entire continents can be served by the high-power spot beams of GEO satellite systems.

This network architecture consists of two MSAT satellites (Figure 1, Table 1), satellite control facilities, various earth stations, and the end users' mobile and fixed terminals. These components are common to any Regional MSAT system.

The North American system's coverage spans the entire United States, Canada, Mexico, Puerto Rico, the Virgin Islands, and the Caribbean (Figure 2). A user anywhere within this range can place a call from his or her

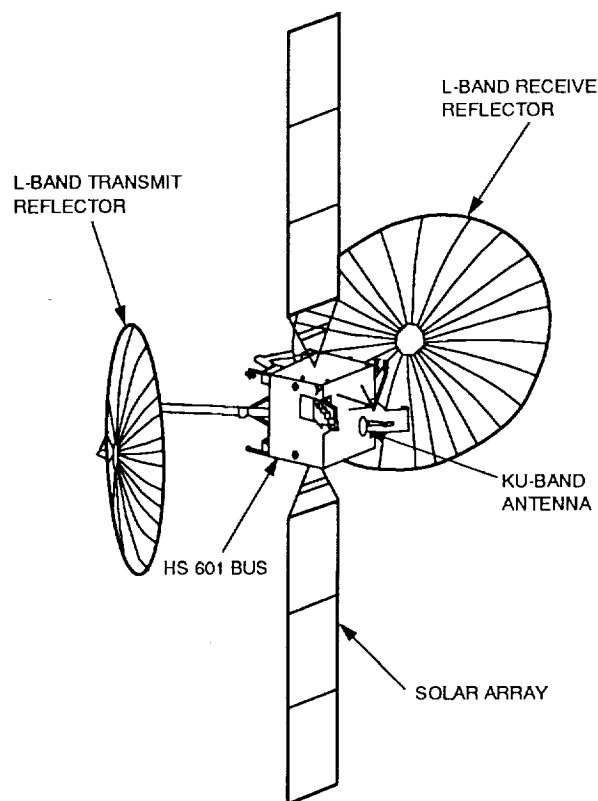
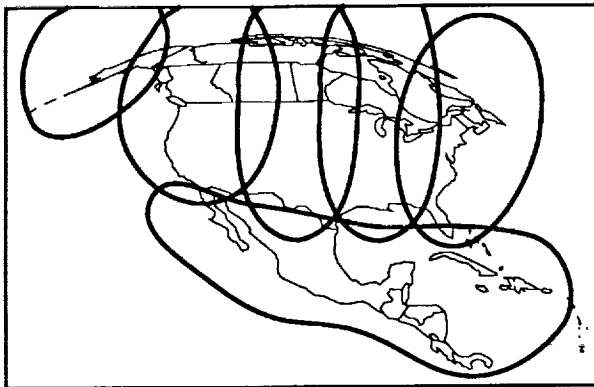


Figure 1. Regional MSAT Satellite

**Table 1. Regional MSAT Space Segment Summary**

Spacecraft bus	HS 601
Dry weight	2500 lb
EOL power	2880 W
L-band antennas	Two 6 x 5 m deployable mesh reflectors
Ku-band antenna	1 m shaped reflector
L-band frequencies	1530 to 1559 MHz, 1631.5 to 1660.5 MHz
L-band AEIRP	56.6 dBW at 18 dB NPR
L-band G/T	2.7 dB/K (CONUS)
Eclipse capability	85%
Service life	12 yrs



**Figure 2. Approximate North American Coverage Pattern**

mobile terminal. A dual-mode handset allows users who are within range of a cellular system to have their calls routed through the land-based cellular network while calls from users outside of their home cell site are automatically routed through the satellite system.

Once the call enters the satellite system, one of two Network Control Centers (NCCs) determines where and how to route the call. The NCC monitors the entire ground network [1], choosing the appropriate private or public gateway, assigning communications channels, and routing the call to achieve the most cost-effective communications link. The NCC can optimize resources and maintain service quality at the same time [2].

The system uses proven technology to accommodate a wide variety of mobile terminals. Its architecture, however, allows new technologies to be easily incorporated as they become available. New services can be implemented with no impact to the quality of the existing service. For example, advances in speech

compression technology, allowing reduced channel spacing, can be incorporated as they occur with minimal impact.

This is how the technology is being put to use in the North American mobile communications market. But the advantages of this system can be applied in regional markets anywhere in the world.

## ADVANTAGES OF A GEOSTATIONARY MSAT ARCHITECTURE

Mobile satellite communications is not just a novel technology application; it is a business opportunity with significant potential for profit. The financial practicality of a Regional MSAT system is one of its most attractive attributes. Though a GEO satellite may cost more per satellite than a medium earth orbit (MEO) or low earth orbit (LEO) satellite, only a single GEO satellite is required to provide complete regional coverage. This translates into system costs dramatically lower than other architectural alternatives [3].

The Regional MSAT offers inherent flexibility and modularity. Using high-power spot beams, it can be tailored to meet the needs of any specific region. This allows the GEO system to be planned and implemented independently of global developments. A Regional MSAT applied in Asia, for example, will have entirely different requirements than a system developed for South America. Yet the two systems can use compatible ground hardware and be interconnected using existing facilities.

The payload design of the Regional MSAT satellite also provides a high degree of flexibility. The design of the hybrid matrix amplification system enables power to be dynamically shared among the various beams. This allows any variation in traffic patterns to be accommodated through real-time allocation of total power among the beams. This approach provides the most efficient use of capacity based on user geography and population density over the life of the system. Additionally, the Regional MSAT provides the ability to tailor coverage by shaping the spot beams to serve only the areas that have the greatest demand. No power is wasted directing coverage beams over unpopulated or unwanted areas.

The system also efficiently uses the frequency spectrum. It employs frequency reuse between nonadjacent beams with sufficient isolation. In addition, with power-limited capacity expected to be roughly 2,000 simultaneous 4.8 kbps voice channels, the total bandwidth requirements allow multiple GEO systems to coexist within the allocated L-band MSS spectrum.

### APPLICATIONS IN A REGIONAL MSAT SYSTEM

A Regional MSAT system can meet a myriad of service demands, from personal communications to industry-specific applications to infrastructure development (Figure 3). It augments existing cellular networks by providing service when users roam outside of their coverage areas and expands them by serving uncovered areas. Thus, the Regional MSAT is inherently appealing to both the cellular roamer and the unserved rural mobile user, two of the largest segments of the satellite mobile communications market. The system meets these users' need for personal, handheld communica-

tions in two distinct ways: the dual-mode handset and the pocket phone.

The handset used in the MSAT system is capable of automatically operating in two modes: As a regular cellular phone linked to the region's cellular infrastructure or as a direct link to the satellite. This dual-mode handset increases versatility and ease of user operations. When users are within a cell site, the mobile earth terminal (MET) directs the call to the cellular system. When outside of a cell, the call is routed through the L-band transceiver in the MET. This function is autonomous and transparent to the user.

One model of the dual-mode phone will also have the capability of being a handheld portable cellular phone (Figure 4). When inside a cell site, the handset for this model can be detached and used as a normal portable cellular telephone.

Now imagine that a handset can be disconnected from the MET and operated when the user is beyond the reach of a terrestrial cell site. This is the Regional MSAT pocket phone concept. With the pocket phone, satellite transmission and reception is conducted via a cordless

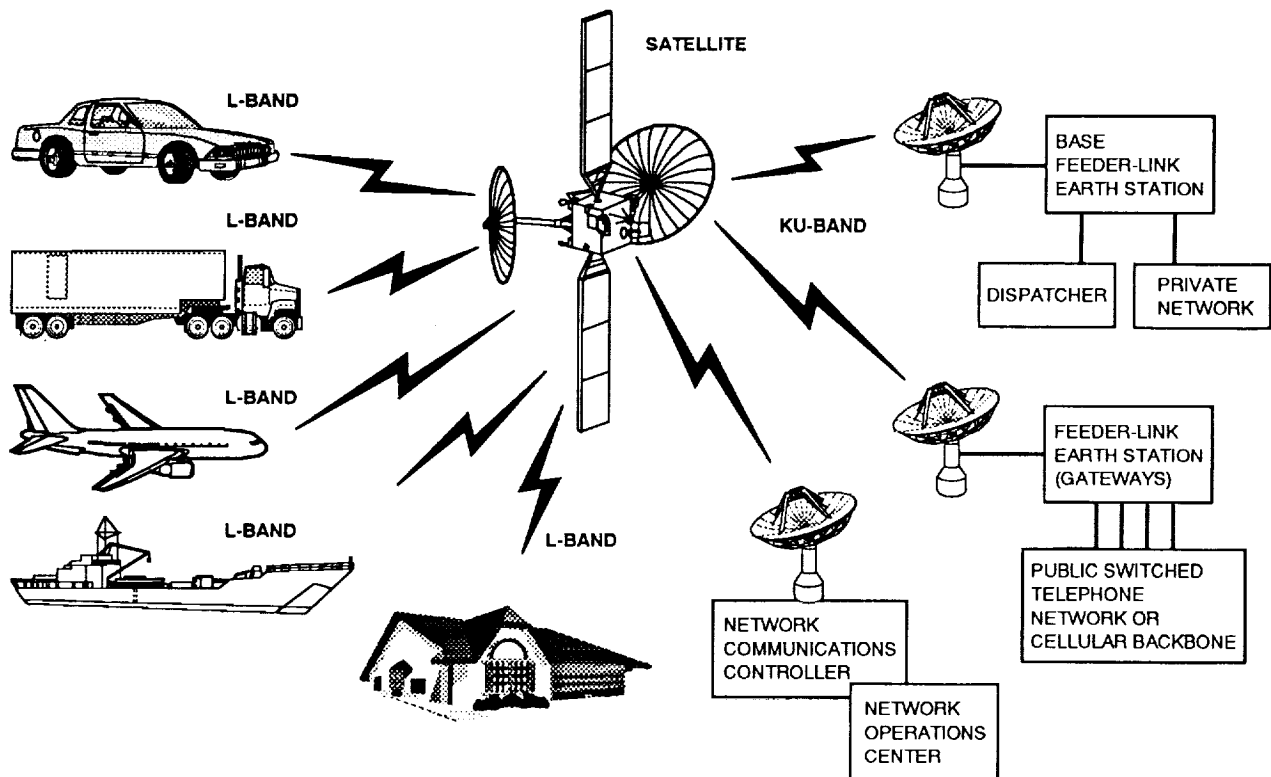
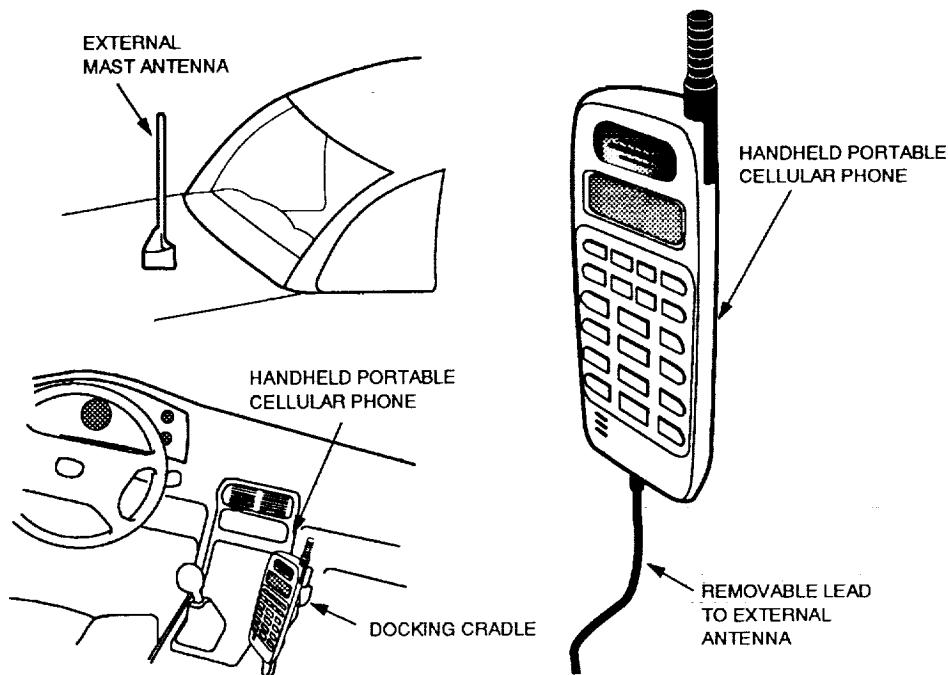


Figure 3. Regional MSAT System



**Figure 4. Multimode Phone**

connection between the handset and the MET. Users need only stay within range of their MET "base station" to complete their links to the satellite, a position they are most likely to be in if they are beyond the reach of cellular communications. These capabilities give a Regional MSAT system the ability to meet the variety of personal communications needs seen in the market today, and in the foreseeable future.

Regional MSAT applications reach well beyond personal voice communications. One of the largest applications in the North American system is for the trucking industry. The MSAT system allows each vehicle to be in constant contact with a home base, customer, or destination. This is especially useful for just-in-time deliveries, in-route itinerary changes, and roadside emergencies. Mobile terminals can be equipped with Global Positioning Service (GPS) or RS-232 ports to allow voice, digital data, and positioning services to be provided. Similar applications exist for the airline and rail industries, where reliable logistical communications are essential while in route and many passenger telecommunications services are being increasingly demanded.

The system's architecture also accommodates private networks. Users can implement a virtual private network if they need that level of autonomy in their service. Users demanding a

truly private network can operate their own gateway and ground station infrastructure including a dedicated link to the satellite. Both types of services are very attractive to private sector organizations that have large numbers of users, as well as government and public sector organizations such as the police, public utilities, and agencies responsible for developing a country's natural resources.

In areas where the traditional land-based communications infrastructure is still in development, a Regional MSAT system provides excellent access into rural areas that even fixed satellite services (FSS) cannot economically serve. When the cost of building an infrastructure is prohibitive, FSS-provided thin route services can be cost-effective, except when service demands are extremely low. In this case, MSS provides a cost advantage over even FSS-delivered telephone service.

### **REGIONAL MOBILE SATELLITE SYSTEM ECONOMICS**

To assess the business viability for a regional MSS system, we must understand the economics from the perspective of both purchasing and providing service. In its initial form, the MSAT system in North America will

provide mobile terminals for under \$2,000 each and offer voice service rates that are competitive with existing cellular roaming charges. Over time, as the subscriber base expands, these costs are likely to decrease and become affordable to more customers, thus increasing demand for mobile satellite capacity. The introduction of Regional MSAT systems around the world will expand the market for space segment, terrestrial network, and subscriber hardware, which will translate into further cost reductions to the ultimate consumers of the services.

For the service provider, the economics revolve around the start-up capital expenses, the revenues derived from subscribers, and to a lesser extent, the annual operating expenses required to run the business. From an organizational standpoint, the MSAT architecture allows various degrees of vertical integration. For example, independent service providers can provide the interface between the space segment provider and the mobile users. The space segment provider may be a wholesaler of satellite capacity, or may directly serve end users, large or small.

The following economic analysis takes the perspective of a space segment provider who provides retail services directly to mobile communicators.

Capital expenses of \$400M are assumed, which includes one high-power satellite, a launch vehicle, launch insurance, and supporting ground infrastructure such as a telemetry and command facility and mobile communications network control functions. These expenses are all incurred during a three-year construction period before satellite launch.

The annual operational expenses are broken down into two categories. First is a variable expense for marketing that is based on \$300 for each subscriber added to the system plus a fixed percentage (10%) of revenues that is designated for general promotion and marketing of the various mobile services. The second category is a fixed expense equal to 20% of the original capital expenses per year to account for other operating, general, and administrative expenses. These assumptions are based on, but not identical to, the cellular business model of reference [5].

Revenues are generated on an individual subscriber basis over the twelve-year satellite life,

where the average subscriber is assumed to spend \$100 per month on mobile services, which could include voice, data, or a combination. This amount is assumed to include usage and monthly access fees that may be charged.

The number of subscribers is assumed to increase linearly to a maximum level of 400,000 users, based on the assumptions of 10,000 minutes per channel per month, a power-limited system capacity of 2,000 simultaneous channels, and average usage of 50 minutes per subscriber per month. This maximum level of subscribers is achieved in the fifth year of operations after launch. The analysis also includes a 2% subscriber churn rate per month, which is the monthly turnover of subscribers who drop the service. This impacts both revenues and marketing expenses.

Finally, it is also assumed that the system provider captures only 80% of the total revenues. The remaining revenue, in addition to the new subscriber marketing expenses described above, is distributed among other independent service providers for their role in signing up new subscribers and administering billing services.

The result, on a pre-tax basis, is an internal rate of return to the system provider of approximately 20%. Assuming a capital cost of 15%, this scenario results in a net present value (NPV) of roughly \$135M. Financing is not included, thus the returns may be understated because potential leverage effects resulting from debt financing are not accounted for. Additionally, this scenario results in a payback period on the capital investment in just over 5 years after launch. Note also that this analysis assumes launch of only one spacecraft, which eliminates opportunity for growth after achieving system capacity, thus limiting financial returns which could be experienced by accommodating more users.

The business risk of this system is low, based on the population that can be covered from a single GEO satellite. With a capacity of 400,000 users, this type of system need be adopted only by a small percentage of the population. For instance, in a region of one billion people, a penetration rate of only 0.04% will fill the system, whereas a region with 250 million people will need to be adopted by 0.16% of the

population. These figures seem more than plausible even when the predicted availability of cellular capacity is used to limit the addressable market size.

This economic analysis is not intended to represent the only way to implement a regional mobile satellite business, but to demonstrate that a Regional MSAT system in geostationary orbit offers the potential for lucrative returns to investors. In addition, the revenue of \$100 per subscriber per month can be interpreted as \$50 in access fees and an average of only \$1.00 per minute of usage, which is significantly below those rates expected with alternative system architectures.

## CONCLUSIONS

The mobile communications market is one of the fastest growing segments of the global economy. Technology that exists today is fully capable of supporting mobile communications for entire geographic areas. Through a GEO satellite system, MSAT developers can tailor an open systems architecture to meet the unique needs of a specific region's mobile communications users. In time, as new technologies become economically viable, a Regional MSAT system can evolve, eventually providing direct-to-handheld global communications coverage. With virtually unlimited applications available today at a cost-effective rate, the Regional MSAT provides a practical—and affordable—choice for introducing mobile voice and data services to regional mobile satellite service markets around the world.

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