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Marisat -A New Commercial Application Of Communications Satellite Technolgy

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MARISAT -- A NEW COMMERCIAL APPLICATION OF COMMUNICATIONS SATELLITE TECHNOLOGY

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ABSTRACT

A new type of commercial satellite communications system called MARISAT is in its final stages of deployment for operational service beginning this year. This system will provide two different communications services by using two different types of communications repeaters on a single satellite. One service is dedicated to U.S. Navy requirements; the second service is the first commercial offering of maritime mobile satellite communications. Through this latter service the quality and reliability of commercial satellite communications will be extended to ships operating on the high seas. This will be the first step in the evolution of an international global maritime satellite communications system.

This paper summarizes the composition and design of the MARISAT System and gives a progress report on the status of its development and deployment.

INTRODUCTION

For over a decade, now, we have seen the success of commercial applications of satellite technology to communications. In the 1960's we had the early development of an international point-to-point commercial satellite communications system (INTELSAT) followed more recently by the deployment of the first domestic point-to-point satellite communications systems. Now, in 1976, we are standing at the threshold of a new commercial use of this technology, namely, communications with small earth stations placed aboard mobile vehicles. The first step will be taken in the form of the MARISAT satellite communications system which is inaugurating service this year. A common satellite will provide service to the United States Navy while at the same time providing the first commercial offering of maritime mobile satellite services to the commercial shipping community. This system represents a major step forward in that it brings to practical commercial reality the use of communications satellites by a large number of small, inexpensive earth stations.

THE MARISAT SYSTEM

The MARISAT System configuration is shown in Figure 1. Three satellites have been procured, one each for emplacement over the Atlantic and Pacific Ocean areas and a third as an on-the-ground spare. Each satellite contains three communications repeaters. One of these operates in the UHF bands and contains one wideband and two narrowband channels exclusively for use by the U.S. Navy. Each of these channels may be activated or deactivated by ground command. In this manner, satellite prime power released from the UHF service is made available to the other communications repeaters. The Navy has contracted for use of all channels in both satellites for the first year with firm options to lease all channels on a yearly basis continuously throughout a three-year period.

Two other repeaters are included for shore-to-ship and ship-to-shore civil maritime communications, respectively. The shore-to-ship repeater translates C-band transmissions received from the earth station at frequencies near 6 GHz to L-band frequencies near 1.5 GHz for relay to commercial ship stations. The L-band output power level can be controlled by ground command consistent with the level of activation of the Navy's UHF repeater.

The ship-to-shore repeater performs the reverse process by translating transmissions received near 1.6 GHz from the ship station back to frequencies near 4 GHz for relay to the earth stations. The 6 and 4 GHz bands are also used for tracking, telemetry and command functions.

The earth stations provide a link to COMSAT General's Control Center in Washington,D.C. as well as the interface for interconnection of the system with the terrestrial telecommunications networks. General spacecraft maintenance and telemetry monitoring will be performed and command instructions will be issued from the COMSAT General Control Center.

The MARISAT System is jointly owned by four communications companies in an organization which has come into force earlier this year called the MARISAT Joint Venture. The ownership interest of the four companies is as shown in Figure 2. In addition to its majority ownership interest, COMSAT General serves as the MARISAT System Manager for the Joint Venture. The elements of the jointly owned system include the satellites and certain of the land based control on communications equipment and facilities. COMSAT General is furnishing, in addition, other facilities for MARISAT use which will be shared with other COMSAT General programs, most notably the COMSTAR domestic satellite system.

The ship terminals required to complete the communications connection between shore stations and ship are furnished separately by each co-owner of the MARISAT System or acquired independently by ship owners and operators.

Communications service will be provided to the two coverage regions depicted in Figure 3. These service coverage regions, which encompass more than 2/3 of the world's major sea lanes, are achieved by selecting satellite positions of $15^{o}W$ and $176.5^{o}E$ longitude. Two shore stations in the United States provide the initial service with the satellites. One of these is at Southbury, Connecticut for service through the Atlantic satellite and the other at Santa Paula, California for service through the Pacific satellite. Figure 4 shows the COMSAT General earth staion and System Control Center arrangement for operation of both the MARISAT and COMSTAR systems. Each of the two earth stations has three antenna systems. One limited-motion 34' antenna is dedicated to COMSTAR. One 42' antenna is assigned exclusively to the MARISAT System. A second 42' antenna, while normally assigned to serve the COMSTAR domestic system, has been designed also to serve MARISAT so that a full back-up capability is available at each earth station for MARISAT use.

Three operating modes are possible depending upon U.S. Government use of the satellite. These are portrayed in Figure 5. The system design permits a commercial communications capacity in the low power mode (the initial mode of operation) of 1 duplex voice and 44 Telex channels. Operation in the medium and high power modes will be possible when the Navy decreases its use of the UHF repeater.

THE MARISAT SATELLITE

The design of the MARISAT spacecraft (see Figure 6) borrows heavily from flight-proven technology of earlier communications satellites. MARISAT employs conventional spin stabilization with a despun antenna farm coupled to three spinning repeaters through a non-contacting coaxial rotary joint. The apogee motor, the FW-5, is the same motor used in the TELESAT and WESTAR series of spacecraft. This motor is undersized, however, for the increased spacecraft weight permissible with the Thor-Delta 2914 and must be augmented by the spacecraft hydrazine propulsion system during transfer orbit in order to achieve synchronous orbit injection.

The spinning portion of the satellite is approximately 85 inches in diameter by 63 inches in length, with an overall length of about 148 inches including the antenna farm (see Figure 6). The spacecraft dry weight is expected to be about 30 pounds below the allowable dry weight of approximately 700 pounds. This will permit the use of additional hydrazine fuel beyond the minimum mission requirement. North-south stationkeeping is not planned. Rather, the initial orbit will be biased such that the inclination of the orbit plane will be maintained within 2.5^{o} of the equatorial plane over a five-year service life.

Electrical power will be derived from fixed solar panels mounted on the cylindrical portion of the spacecraft. The panels are somewhat larger (63 inches by 85 inches) than the TELESAT panels to take full advantage of the eight-foot Delta shroud. Spacecraft power has also been enhanced somewhat through the use of 6.2 cm x 2.2 cm solar cells. Approximately 300 watts of DC prime power will be available at the end of a five-year lifetime. The design includes nickel-cadmium batteries with sufficient capacity to power all satellite subsystems through eclipse.

The telemetry and command system employs two cross-strapped telemetry encoders and beacons which generate separate C-band carriers. Redundant command receivers and digital decoders can decode 160 commands. The ranging function is performed by demodulating the range tone transmissions received from the earth station in the command receiver, and routing the demodulated tones to the telemetry beacon oscillator which is phased modulated by the tone set before retransmission to the earth station. Figure 7 shows the complete spacecraft.

EARTH STATIONS

Two almost identical earth stations have been constructed each having three antenna systems. Figure 8 shows the antenna complex and control building at Santa Paula, California. The basic earth stations, including buildings, utilities, antenna systems, RF equipment as well as the tracking, telemetry and command system, are ready for operational use.

The MARISAT shore station communications equipment (SSCE) has been installed and tested at the earth stations and commercial operations are ready to begin. These earth stations are being connected to the public telecommunications networks on a worldwide basis. Therefore, the system permits near instantaneous communications between ships operating on the high seas and points almost anywhere in the world. The range of communications services includes telex, telephone, data and facsimile.

SHIP TERMINALS

Technical requirements for ship terminals to operate with the MARISAT System have been adopted by the system's co-owners and have been distributed widely throughout the world to interested manufacturers and other entities. Procedures have been published for manufacturers to have their terminal designs type accepted by the MARISAT System Manager for use in the system and the commissioning procedures for each ship station to be checked out with the system prior to entering operation have been issued. Ship terminal performance requirements include an equivalent isotropic radiated power (e.i.r.p.) of 37 dBw and a receive sensitivity of at least -4 dB/ deg. K. This implies use of a steerable antenna of about 4 feet in diameter in combination with a transmitter having a power level on the order of 40 watts along with a transistorized low noise receiver.

A number of companies throughout the world are active in the planning and development of ship equipment for use with MARISAT. The first and largest of such activities was the placement of an order by COMSAT General for 200 ship terminals from Scientific-Atlanta, Inc.

The COMSAT General ship terminal is divided into two major sets of equipment. The set of equipment designed for installation above decks consists principally of a 4 foot steerable parabolic antenna, transistorized transmitter and low-noise receiver, all enclosed in a Fiberglas radome. This equipment without radome is shown in Figure 9. The first group of these terminals have been installed on a wide variety of types of ships around the world. Figure 10 shows a typical installation on a supertanker. The antenna beam, which is approximately 10° in width, is steered automatically in the direction of the satellite.

The rest of the equipment which is designed for installation below decks is contained in the console shown in Figure 11. This console includes the antenna control unit (ACU), all the communications electronics, power supplies, telephone handset and teleprinter.

A close-up view of the comparatively simple antenna control unit is shown in Figure 12. This control is used for initial acquisition of the satellite by the antenna steering system. The antenna steering system establishes a horizontal platform by sensing the vertical direction and correcting for ships' pitch and roll. The operator, using tables of pointing angles, enters initial azimuth and elevation angles in the ACU, the antenna locks-on to an L-band signal radiated by the satellite and from then on the antenna operation is automatic. The ship's gyrocompass is used as a reference for changes in ship's heading. A step track system supplements the antenna stabilization system by correcting for the comparatively slow changes in the position of the ship and the satellite.

Figure 13 shows the simple operating controls and displays in normal use. The ship terminal constantly monitors the control channel it receives from the shore station and responds automatically to shore station instructions to process incoming messages. For ship-to-shore traffic the operator enters information on the type of messages, its priority and destination and pushes a request button. This information is transmitted to the shore station in a fraction of a second and the shore station responds within seconds through the control channel to set-up the desired call. Equally prompt operating arrangements set up calls in the shore-to-ship direction.

SUMMARY

The first commercial satellite system for use in communications between small stations aboard ships and shore based stations is being established this year. This system called MARISAT should revolutionize maritime communications much as the Early Bird System dramatically altered the course of inter-continental communications over a decade ago.

ILLUSTRATIONS

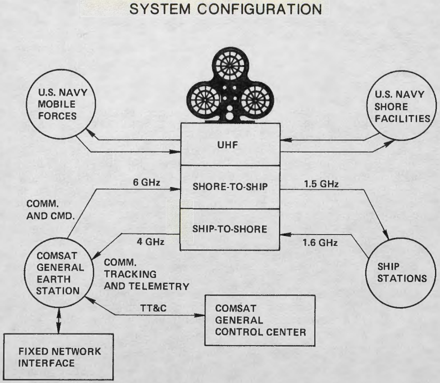

FIGURE 1

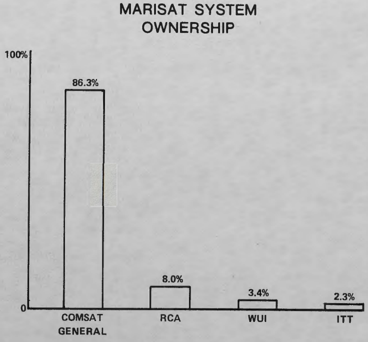

FIGURE 2

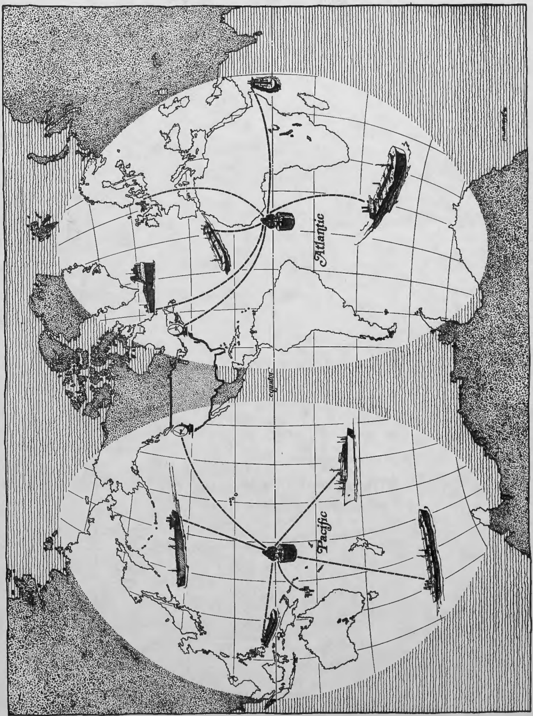

FIGURE 3

COMSAT GENERAL EARTH STATIONS

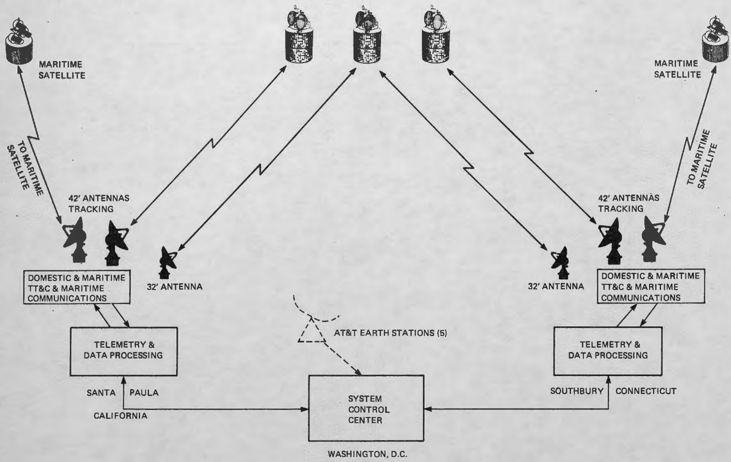

FIGURE 4

MARISAT OPERATING MODES AND COMMUNICATIONS CAPACITY

OPERATING MODE	LOW	MEDIUM	HIGH
U.S. GOVERNMENT USE			
COMMERCIAL DUPLEX CAPACITY	1 VOICE 44 TELEX	5 VOICE* 66 TELEX*	9 VOICE* 110 TELEX*

*OTHER COMBINATIONS ARE POSSIBLE

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FIGURE 5

MARISAT SPACECRAFT EXPLODED VIEW

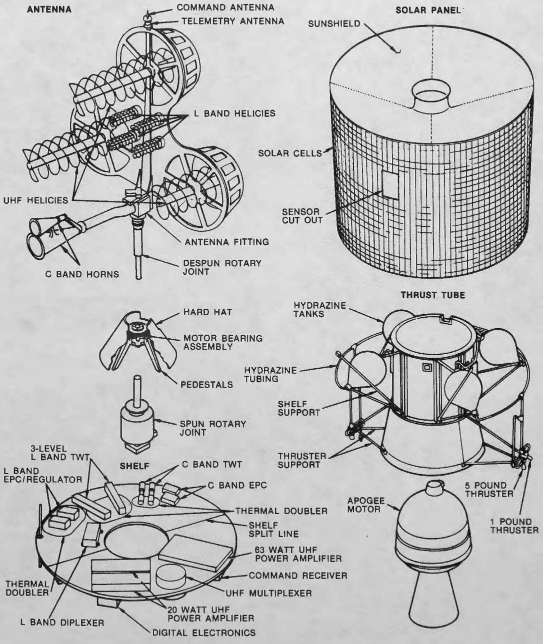

FIGURE 6

FIGURE 7

FIGURE 9

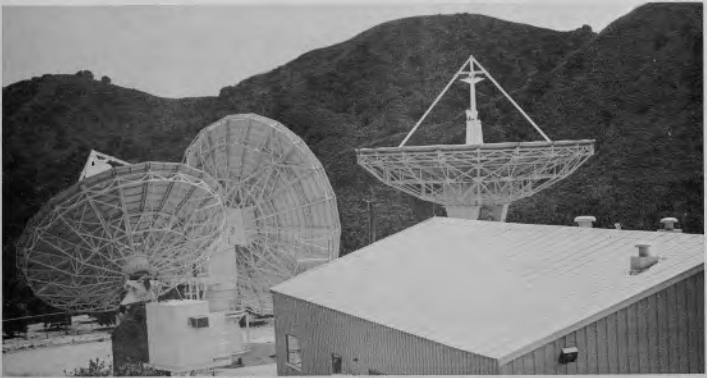

FIGURE 8

FIGURE 10

FIGURE 11

FIGURE 12

FIGURE 13