

# **From the Sea to the Stars:**

## ***A Chronicle of the U.S. Navy's Space and Space-related Activities, 1944-2009***

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### Communications Moon Relay (CMR) System

On the basis of the initial success of the NRL's Project *PAMOR* experiments (see page 12), the Chief of Naval Operations directed the establishment of the Communications Moon Relay (*CMR*) system in 1956 for transmission of teletype and facsimile messages between Washington, DC, and Hawaii. In the Washington, DC, area, the transmitter was located at the U.S. Naval Radio Station, Annapolis, Maryland, while the receiver was located at Cheltenham, Maryland. The Hawaiian facilities were located at Opana and Wahiawa on the island of Oahu. The Washington, DC, and Hawaii terminals each used two 84-foot-diameter dish antennas—one for transmitting and the other for receiving.

The inaugural test of *CMR* was conducted in January 1960 when the Chief of Naval Operations, Admiral Arleigh Burke, sent a teletype message to the Commander-in-Chief, Pacific Fleet (Admiral Herbert G. Hopwood). The teletype message was followed by two facsimile images: the first, a photo of a "moon maiden," of the centerfold variety; the second, a more appropriate public affairs photograph. A U.S. postage stamp to commemorate the event was issued later in that year.

A *CMR* receiver and 16-ft steerable parabolic dish antenna were installed in USS *Oxford* (AG159) in 1961. The Naval Research Laboratory demonstrated the first shore-to-ship satellite communications relay on 15 December 1961, when ceremonial messages were sent by the Chief of Naval Operations (Admiral G. W. Anderson) to USS *Oxford* from NRL's Stump Neck, Maryland, satellite research facility. The first two-way ship-to-shore satellite communications were conducted when USS *Oxford* was at sea between Buenos Aires and Rio de Janeiro on 30 March 1962.

The Navy's *CMR* system carried operational message traffic between Hawaii and Washington, DC, for half a decade. The ground stations were manned by Navy personnel from four to eight hours daily (that is, from moonrise in Hawaii to moonset in Maryland).

The *CMR* system offered very reliable communications and was resistant to jamming. Curiously, the National Security Agency and the Naval Security Group did not allow encrypted message traffic on the *CMR* link, arguing that anyone could intercept the link because "all the world could hear it"—despite the fact that encrypted messages had been transmitted on the Medium Frequency/High Frequency (MF/HF) broadcasts for years. The principal operational disadvantage of the *CMR* was simply the availability of the moon, which had to be within sight of both of the link terminals. As observed by then-Lieutenant Commander Burton Edelson at the Bureau of Ships, this was only a single-satellite system, and, for reliable 24-hour communications, the Navy would need a constellation of multiple (artificial) satellites.

*CMR* was the only operational satellite communications relay system in the world until the Defense Satellite Communications System (*DSCS*) came on line on 16 June 1966. (The *CMR* capability was disestablished in the mid-1960s, and its antennas were

used in the Technical Research Ship Special Communications (TRSSCOM) System—see page 46.)

### **Origin of the Transit Navigation System**

In July 1957, the Applied Physics Laboratory (APL) of Johns Hopkins University, like the Naval Research Laboratory, established a space exploration study group to look into ways of applying the Laboratory's technical expertise to the field of space research. Although this ad hoc study group never submitted any formal proposals, it did create an area of research interest and specialized knowledge within the Laboratory so that "when an idea that was really good came up, they saw it." That one "really good" idea arose in the autumn of 1957, in the wake of the Soviet Union's launch of its *Sputnik* satellite on 4 October.

The consternation that *Sputnik* had aroused at APL was tempered by the fascination that this Soviet achievement aroused in many members of the Laboratory who, in the words of one senior-level APL official, "thought it was pretty neat." One of those individuals captivated by the *Sputnik* episode was Dr. William Guier, who had joined the Laboratory in 1951. *Sputnik* was launched on a weekend. "The next Monday I came in," remembered Guier, "and to my surprise, no one was listening to it. They kept saying you could get it on twenty megacycles, and I thought someone would be listening, with all the receivers all over this place. So in the early afternoon, I decided I'd see if I could get that thing." He did.

Guier had been working recently in the Research Center with George Weiffenbach, a physicist who had joined APL at about the same time. As part of his experiments in microwave spectroscopy, Weiffenbach had been using a shortwave receiver that could pick up very sensitive radio signals. Around four o'clock that afternoon, Weiffenbach stuck a piece of wire into the antenna connection on his receiver, and he and Guier began listening to the distinctive "beep-beep" signals emanating from *Sputnik*. When Weiffenbach analyzed the tape recordings with the aid of a wave analyzer, the result was "an absolutely gorgeous Doppler shift." In other words, the satellite's signals sounded higher pitched as *Sputnik* came closer to Washington and lower as it went away, just as a bystander would hear the whistle of a freight train change pitch as the train approached and passed.

While waiting for the satellite's next pass over the United States, Guier realized that the slope of the Doppler shift could help him ascertain the distance to *Sputnik*. To compute the satellite's path, he and Weiffenbach used the estimated time of *Sputnik*'s arrival over Washington, as broadcast by a Moscow short-wave radio station that Weiffenbach had serendipitously picked up on his receiver. After listening and recording data for several days, the two physicists discovered they could use a mechanical calculator to predict the satellite's orbit much more accurately than could the elaborate tracking system employed by the Navy's research station in downtown Washington. Unfortunately, *Sputnik-I* stopped sending signals after the first week because its storage batteries were depleted. But Guier took his calculations and began processing them on the Laboratory's recently installed *Univac 1103* digital computer.

Coordination of these joint efforts was aided enormously by the existence of the Technical Committee for Communication Satellites. This committee included representation from such organizations as NASA and Lincoln Laboratory, as well as both administrative and technical representatives of each of the military services. Chairmanship of this group rotated periodically. Monthly meetings were held. Committee members kept a close eye on commercial research with satellite communications. The Technical Committee proved to be an effective mechanism for promoting progress.

Because the 1961 Directive on satellite-systems acquisition was in effect at this time, the Navy did not directly acquire communications satellites during this period, but relied instead on the satellites built by Lincoln Laboratory, private industry, and the Air Force. (The sole exception was an experimental *Lofti* satellite with potential applications in anti-submarine warfare – details to follow on page 53).

The Naval Research Laboratory (NRL) continued its work on satellite communications throughout the 1960s, funded both by BuShips and by the Office of Naval Research to the tune of about \$300,000 each per year. In 1968, Dr. Alan Berman, Director of Research at NRL, established the Satellite Research Branch as a separate organization to consolidate this work. The Branch was placed under the direction of J. Plumer Leiphart, whose contributions to space communications were becoming increasingly recognized. The Branch consisted of small but highly effective task groups, each working, promoting, and advancing its projects as rapidly as technical advances and Navy operational interest in the applications developed. Leiphart and his NRL colleagues felt that this approach was much more productive than the highly organized and extensively programmed way in which the Air Force approached the initiation and administration of its counterpart development project. The benefits of the NRL small task-group approach paid off later when *TacSat-1* was developed.

#### "Spy Ship" Communications (TRSSCOM)

In 1964, the U.S. Navy established the world's first operational ship-shore satellite communications system to provide telecommunications support for Navy Signals Intelligence (SIGINT) surveillance ships that were deployed in several oceans of the world. This communications system was named the "Technical Research-Ship Special Communications System" (TRSSCOM) in keeping with the cover story that these ships were for "technical research" rather than surveillance.

The TRSSCOM System derived from the Communications Moon Relay (CMR) concept (see page 23). To obtain the equipment needed for TRSSCOM, the Naval Research Laboratory disestablished the CMR link between Hawaii and Washington, DC, and the CMR antennas were then installed at Cheltenham, Maryland (for the Second and Sixth Fleets); Wahiawa, Hawaii (Third Fleet); and Okinawa (Seventh Fleet).

The TRSSCOM system went operational with the USS *Oxford* on 25 February 1964. Other "technical research" ships were added as equipment became available: USS *Georgetown*, 1966; USS *Jamestown*, 1968; USS *Liberty*, 1967; USS *Belmont*,

1968; and USS *Valdez*, 1969. *TRSSCOM* provided support to the intelligence collection mission of these ships.

The *TRSSCOM* installation in USS *Liberty* was totally disabled during the Israeli attack on that ship during the Arab-Israeli War of 1967. (The "Technical Research" ships were placed in reserve, and the *TRSSCOM* system was suspended in the fall of 1969, bringing to a close the Navy's first operational satellite communications program.)

### **Navy Plans for Using DSCS Satellites**

After the *Advent* program was canceled in 1962, the Secretary of Defense assigned the newly established Defense Communications Agency to come up with a plan for acquiring a U.S. military communications satellite system.

Congress, in response to the President's "Policy Statement on Communications Satellites," passed legislation in 1963 establishing the Comsat Corporation, a government-controlled for-profit corporation with a charter and exclusive license to pursue commercial satellite communications for the U.S. Considerable debate took place within DoD as to whether the newly established Comsat Corporation should develop the military satellite communications system. It was finally decided that the Air Force, rather than Comsat Corporation, should develop the Defense Satellite Communications System (*DSCS*). The Navy was to be responsible for developing the shipboard terminals, Army for its ground terminals, and the Air Force for the airborne terminals.

The stated purpose of the *DSCS* was to enable military commanders to send "logistic" messages. To a certain extent, this was true, but the *DSCS* system intended to support additional applications that were at least as important as logistics. First, it would be used for command and control of the U.S. strategic forces. Second, it would carry intelligence data from the new satellite systems being developed by the National Reconnaissance Office to the various Intelligence nodes and the National Command Authorities. Third, it would connect the National Command Authorities with the theater Commanders-in-Chief and Commanders of the general purpose forces. Navy and other requirements were added as the development progressed.

*DSCS* became a major component of the Defense Communications System (*DCS*)—the U.S. military communications for worldwide telecommunications among DoD and various government agencies. For many years, the *DCS* relied primarily on the *DSCS* satellites for overseas communications traffic.

### **The DSCS Satellites**

The *DSCS-I* system was designed from the start to be survivable in wartime, including nuclear warfare. The orbit was near-synchronous, selected such that each satellite in the constellation moved about thirty degrees per day; if one was destroyed, another would soon drift into view. There was no command system in the satellite, so no enemy could take control of the system. To provide some jamming resistance, and to make sure there would be enough bandwidth, the Super High Frequency (SHF) communications band was selected. After U.S. negotiations at the International