UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

August 31, 1984

RESOURCES, COMMUNITY, AND ECONOMIC DEVELOPMENT DIVISION

B-216299

The Honorable Jack Brooks
Chairman, Committee on
Government Operations
House of Representatives

Dear Mr. Chairman:

Subject: Reasons for Lack of Replacement for Failed Weather Satellite (GAO/RCED-84-198)

Your August 1, 1984, letter expressed concern over the recent failure of one of the two main U.S. weather satellites. You asked that we conduct an immediate investigation of why the United States does not have a satellite to replace the one that failed. In addition, you asked that we follow up with a review of National Oceanic and Atmospheric Administration (NOAA) policies, plans, and procurement procedures concerning the weather satellite program.

In accordance with your request, this report provides the results of our inquiries on the lack of a replacement satellite. In a subsequent review, we will examine more thoroughly NOAA's policies and practices with respect to its overall planning and procurement of civilian meteorological satellites.

Our review showed that

--NOAA does not have a replacement satellite for the one that recently failed because it expected the satellites to last longer than they actually did;

--because of increased contractor costs and NOAA's expectation that the Office of Management and Budget would not approve additional funds for a replacement satellite, NOAA may not be able to maintain a two-satellite system for the remainder of the decade;

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--NOAA has moved the remaining fully operational satellite to a central location over the United States and has taken other steps to help compensate for the loss of weather information until a replacement satellite can be launched in 1986; and

--NOAA's procurement plans for the next generation of weather satellites, to be deployed in the 1990's, will, according to NOAA officials, provide greater assurance of a continuous, two-satellite system than has been the case in the past.

OBJECTIVE, SCOPE, AND METHODOLOGY

The objective of our review was to determine NOAA's plans for assuring a continuously operating weather satellite system and the reasons for the lack of a replacement satellite.

Our work during this assignment was done at NOAA, Department of Commerce, and National Aeronautics and Space Administration (NASA) headquarters; at NOAA's satellite control center and budget offices in Suitland, Maryland; and at NASA's Goddard Space Flight Center in Greenbelt, Maryland. NOAA is an agency of the Department of Commerce.

To obtain information on planning for the weather satellite system and the steps being taken to help alleviate the present situation, we met with NOAA's Assistant Administrator for the National Environmental Satellite, Data, and Information Service; the chief of the service's systems planning and development staff; and their personnel. We also met with NASA officials responsible for the weather satellite programs and with representatives of the Department of Commerce Inspector General's office to discuss the results of their recent review of coordination between NOAA and NASA in operating the weather satellite program. To obtain information on the budgetary decisions that affected the planning and procurement of the weather satellites, we met with the chief of the NOAA Satellite Service's budget and finance unit; the chief, Business and Environmental Programs Division of the Department of Commerce's Budget Office; and the Office of Management and Budget examiner responsible for NOAA programs. We also talked to the director, NASA systems, Hughes Aircraft Company, to obtain information on the accuracy of the projected satellite lifetimes. Our work was performed between August 7 and August 24, 1984 and was done in accordance with generally accepted government auditing standards.

WEATHER SATELLITE PROGRAM

NOAA and NASA share responsibility for weather satellites. NOAA operates the satellite systems; determines overall program

requirements; approves project operating plans; monitors performance of the systems; and disseminates and preserves data, forecasts, and analyses. NASA develops advanced satellite technology; designs, engineers, and procures spacecraft; selects and procures launch vehicles; launches the satellites; and monitors the satellites during their initial phases in orbit.

U.S. weather satellite systems were first authorized in 1961 when the Congress directed the Department of Commerce to establish a satellite system that would continuously observe and report on worldwide environmental conditions. The system is designed to maintain four weather satellites in orbit--two geostationary operational environmental satellites (GOES) and two polar orbiters.

The two GOES satellites are intended to continually view North and South America and the Atlantic and Pacific oceans as the satellites orbit above the equator at the same rate at which the earth turns. The information the GOES satellites provide includes cloud motion and wind data, precipitation estimates, and frost data. The two polar-orbiting satellites each circle the earth twice daily to provide global coverage of cloud patterns, surface temperatures, atmospheric humidity, and other environmental data.

NOAA's National Weather Service, the primary user of weather satellite data, uses the data to issue warnings about hurricanes, tornadoes, and severe storms; to gather environmental data for daily weather forecasts; and for research.

On July 29, 1984, GOES-5[1]--which had provided coverage of the Atlantic Ocean and eastern United States--failed, after almost 3 years of operation.[2] A replacement for this satellite is scheduled to be available in 1986, when satellites now on order will be ready for launch.

The following table shows the life span of each of the six GOES satellites launched to date.

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[1]Geostationary satellites are initially given alphabetical designations. After being launched, they are referred to numerically. For example, GOES-E was designated GOES-5 after it was launched.

[2]See enc. I for a description of the technical problems resulting in the failure.

Life Spans of GOES Satellites

Satellite[a]	Became operational	Failed	Operating life	Cause of failure
GOES-1 (EAST)[b]	1/08/76		Still operational[c]	
GOES-2 (EAST)	8/15/77	1/26/79	1 year, 5 months	Bulb
GOES-3 (WEST)	7/13/78	3/05/81	2 years, 8 months	Bulb
GOES-4 (WEST)	10/15/80	11/26/82	2 years, 1 month	Power system
GOES-5 (EAST)	8/05/81	7/29/84	3 years	Bulb
GOES-6 (WEST)	6/01/83		Still operating[d]	

[a] GOES-1, -2, and -3 were manufactured by Ford; GOES-4, -5, and -6 were manufactured by Hughes Aircraft Company.

[b] GOES satellites are placed in geostationary orbit over the equator at 135° W longitude (GOES - WEST) and 75° W longitude (GOES - EAST).

[c] None of the failures or other technical problems with GOES-1 have been serious enough to completely disable the satellite. GOES-1 was nevertheless taken out of service in late 1977 but is still capable of operating in a limited capacity.

[d] Major modifications were made to GOES-6 to help correct the bulb failure (see enc. I).

NOAA has had to compensate for the loss of certain GOES satellites in the past. When GOES-2 failed in January 1979, for example, NOAA used experimental satellites[3] to provide eastern

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[3]These satellites manufactured by Ford were synchronous meteorological satellites, designated SMS-1 and SMS-2, which were prototypes of the current GOES satellite.

coverage until August 1981. In addition, when GOES-4 failed in November 1982, NOAA used GOES-1, which was partially operational, to provide coverage for the western area until June 1983.

WHY THERE IS ONLY ONE FULLY OPERATIONAL GEOSTATIONARY WEATHER SATELLITE

In 1977, technical experts at NOAA and NASA projected that the current generation of satellites (GOES-4, -5, and -6) would have a 5-year life span. Because NOAA's goal is to maintain two GOES satellites in orbit at all times, it bought three such satellites (GOES-4, -5, and -6) from the Hughes Aircraft Company in 1977 to provide satellite coverage from 1980 to 1986. These satellites, in combination with GOES satellites already in orbit and satellites to be procured in the future, were intended to provide uninterrupted, two-satellite coverage. NOAA's procurement plans anticipated that GOES-4, -5, and -6 would each operate for 5 years. This expectation was overly optimistic. GOES-4 operated for 2 years, 1 month; GOES-5 lasted about 3 years. GOES-6, the only remaining fully operational geostationary satellite, became operational in June 1983.

NOAA officials said that a satellite replacement schedule involved trade-offs between costs and the need for a continuously operating two-satellite system. In 1977 when NOAA purchased GOES-4, -5, and -6, it was aware that the replacement schedule it developed for the GOES program involved certain risks. For budgetary and other reasons, however, NOAA decided to use a 5-year life span for planning the procurement for satellite coverage in the 1980's.

In a letter dated May 19, 1977, responding to a request from NASA's Deputy Associate Administrator, Office of Space Science and Applications, for information regarding NOAA's planning, the Director of NOAA's Satellite Service said:

> "The five year lifetime stated in the GOES D, E and F [-4, -5, and -6] RFP [request for proposal] resulted from the judgment of technical experts of GSFC [Goddard Space Flight Center] and NESS [National Environmental Satellite Service[4]] regarding the current state of the art which can reasonably be expected with respect to the sensors and supporting spacecraft sub-systems required on the GOES program. . . .The main concern at present is with regard to the VISSR/VAS and SEM [weather and other environmental] sensors. Indeed we don't even have a strong indication

[4]The predecessor organization to the National Environmental Satellite, Data, and Information Service.

that five year lifetime can be achieved with the current sensors. We already have had some partial failures of these sensors on the three spacecraft launched so far, and we have more than two years to go before the first set of sensors will have been in operation for five years. In summary, we are somewhat dubious about the projected five year lifetime but feel it is an important, and hopefully achievable, objective in order to constrain system costs to a reasonable level. Our budgeting is based on this premise."

Balanced against doubts about the operating lives of the GOES satellites, however, was the fact that GOES-1 was still operating in November 1977, when NOAA purchased GOES-4, -5, and -6. Also, Hughes Aircraft Company had indicated its confidence in the satellites' longevity by making recovery of the full contract price conditional on each of these satellites operating for 7 years.

ACTIONS TAKEN TO MEET WEATHER FORECASTING NEEDS

Forced to operate with just one GOES satellite, NOAA moved the West Coast satellite (GOES-6) eastward. This movement will provide satellite coverage of the continental United States but not of the eastern Atlantic or western Pacific oceans.[5] Other possible steps are being reviewed by NOAA and NASA at this time, including using the partially operational GOES-1 to provide limited coverage of such areas as the Pacific Ocean. Further, NOAA plans to obtain supplemental weather data from European and Japanese satellites. The experimental satellites (SMS-1 and SMS-2) that NOAA used to provide coverage when earlier satellites failed were deactivated in January 1981 and August 1982, respectively.

Two satellites being manufactured by the Hughes Aircraft Company are expected to be delivered in time for May 1986 and August 1986 launches. Representatives of NOAA and NASA plan to meet with Hughes officials on September 5, 1984, to discuss the possibilities of accelerating the delivery of the first of these replacement satellites. NOAA officials said, however, that they do not expect the delivery schedule to be accelerated by more than several months.

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[5]See enc. II for a description of satellite coverage.

INCREASED COSTS AND BUDGETARY CONSTRAINTS MAY AFFECT FUTURE PROGRAM CONTINUITY

Operation of a two-GOES system may be interrupted again during the 1980's because increased contractor costs and budgetary constraints precluded NOAA from purchasing a back-up satellite.

In February 1981 NOAA announced its plans to purchase three GOES satellites to provide service in the latter part of the 1980's. NOAA also obtained budget authority for about $111 million, an amount it considered sufficient to buy the three satellites. Hughes Aircraft Company (according to NASA the only manufacturer interested in building the type of satellite specified by NOAA) wanted about $32 million more than NOAA had budgeted. After several months of unsuccessful negotiations with Hughes and consideration of other procurement options, NOAA decided to buy two satellites instead of three in order to remain within the budget.

NOAA's decision to buy two satellites from Hughes was based on (1) a concern that making design changes to permit seeking alternative sources for the satellites would add about 2 years to the procurement schedule and result in an interruption of satellite service and (2) NOAA's belief that the Office of Management and Budget would not approve additional funds for the third satellite. NOAA officials told us that just before this decision was made the administration had proposed cutting the Department of Commerce's fiscal year 1982 budget by about $380 million and the prospects of getting additional funds at that time for the GOES satellite were not very good and, therefore, they did not request such funds. An Office of Management and Budget official told us that, at this time, he is not sure whether NOAA would have received such funds if they had been requested.

In July 1982 the Office of Management and Budget approved NOAA's procurement plan; a letter contract to procure the two satellites from Hughes Aircraft Company was signed on July 15, 1982. The contract had a target price of $100 million and included an option to purchase a third satellite for a negotiated amount not to exceed $49.6 million. This 1-year option, if it had been exercised, would have provided a satellite for launch in August 1987.

PROCUREMENT PLANS MAY FACILITATE
BETTER SATELLITE COVERAGE
IN THE FUTURE

NOAA officials said that their procurement plans for the GOES satellite system for the 1990's, called GOES-NEXT, will increase the likelihood of continuous two-satellite coverage. On June 29, 1984, NASA issued a contract solicitation for GOES-NEXT. According to the solicitation, NOAA will contract to buy three satellites and have an option to buy two additional satellites. The option to purchase two additional satellites, which would be available in the early 1990's, would, according to NOAA officials, provide more back-up in case of satellite failures than has been the case in the past. The 1984 Department of Commerce budget request approved by the Office of Management and Budget included funds to initiate the procurement of the three satellites. NOAA said that its fiscal year 1986 budget request includes funds to buy the two additional satellites. This budget request is currently being reviewed by the Department of Commerce.

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In summary, NOAA's procurement practices and policies have been based on expected satellite lifetimes that were in excess of those actually being realized. In NOAA's view, budgetary constraints also played a role in limiting the number of satellites purchased and did not allow for back-up satellites.

Sincerely yours,

J. Dexter Peach
Director

ENCLOSURE I

WHY GOES-5 FAILED

GOES-5 failed on July 29, 1984, after operating for 3 years (the expected operational life was 5 years) because a tungsten filament bulb did not last as long as expected. This bulb, called an encoder lamp, tells technicians on the ground the direction in which the satellite's mirror is pointing. The mirror scans the earth and creates images of cloud patterns. When the encoder lamp burns out, the direction of the mirror is not known and imaging capabilities are lost. Problems with the encoder lamp were first noted on GOES-2, which was launched on June 16, 1977, and on GOES-3, launched June 16, 1978. The problem, however, was not recognized in time to modify the follow-on satellite--GOES-4. The encoder bulb's operational voltage was lowered in GOES-5, however, to increase the life of the bulb. With respect to GOES-6, which was launched on April 28, 1983, major modifications to correct the problem were made, at an estimated cost of $700,000.

Both NOAA and NASA officials believe the changes made on GOES-6 may increase its operational life by at least one year. NOAA and NASA officials said that additional changes and modifications will be made on the satellites that are currently being manufactured by Hughes Aircraft Company. These satellites, known as GOES-G and -H, are expected to be ready for launch in 1986.

ENCLOSURE II

COVERAGE PROVIDED BY A ONE-GOES SYSTEM VERSUS A TWO-GOES SYSTEM

GOES-5 provided coverage of the eastern United States and the Atlantic Ocean. When it failed in July 1984, NOAA moved its other satellite, GOES-6, east, to partially compensate for the loss. The maps on the next page show the coverage for a one- and two-satellite system.

The following is NOAA's analysis of how the loss of a GOES satellite affects weather data collection.

> "Though at first glance the difference in coverage may not appear significant, the reduction in certain data is considerable. The inner circles within the stippled areas, for example, denote the areas in which cloud-drift winds may be accurately computed. Since these winds are extracted only over tropical ocean areas, the two-GOES system provides about twice the coverage of one-GOES. These data go directly into the National Weather Service computer data base for use in numerical weather prediction. This probably is the most critical loss in a one-GOES system.
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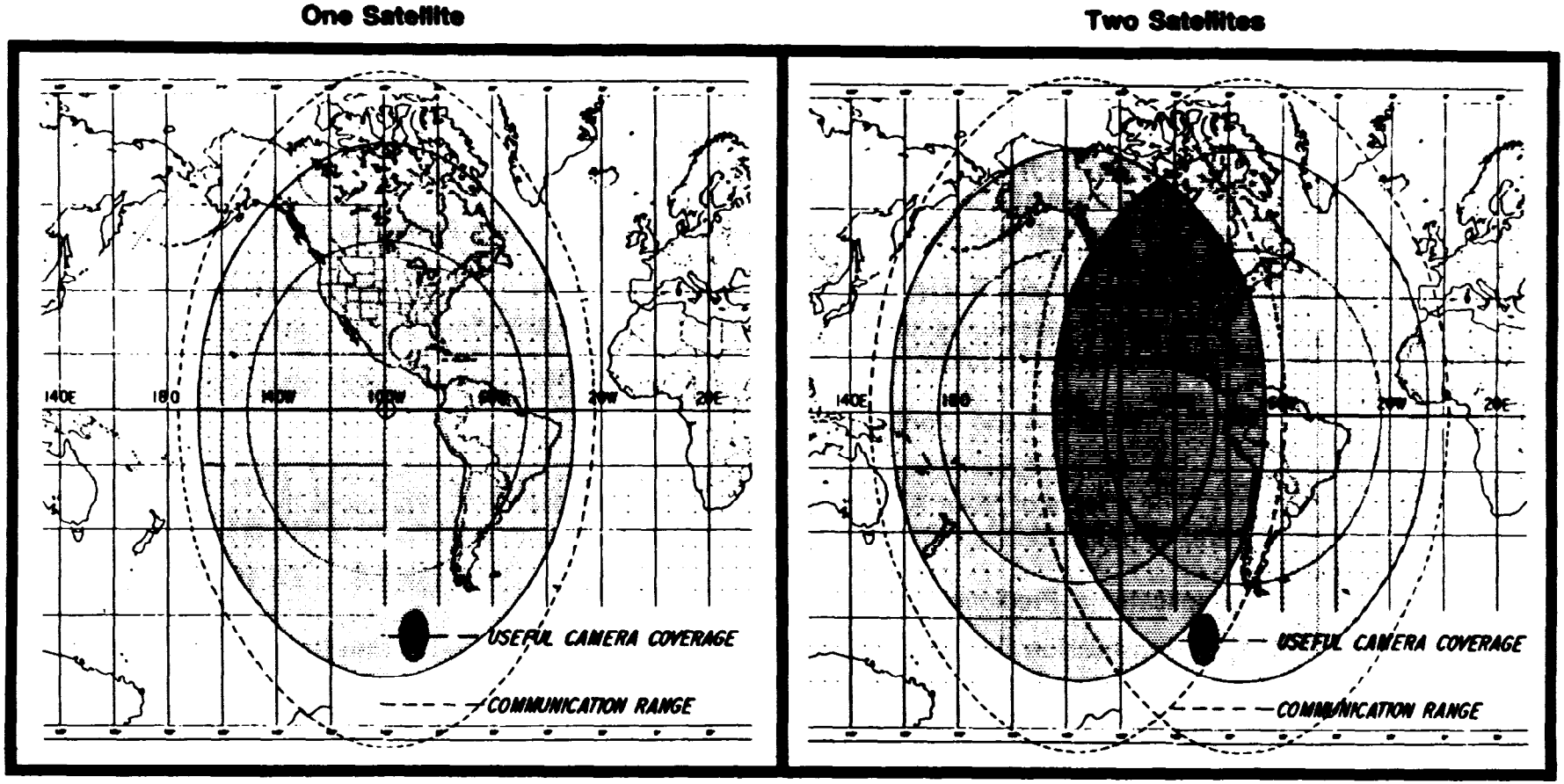
> "Because of the large overlap, the loss of cloud imagery coverage with one-GOES is only about one-third. The north Pacific Ocean area suffers the most serious loss. Storms crossing this area often move into and across the United States. The earlier view afforded by two-GOES coverage provides an additional day or two of storm warning."

GOES Geographic Coverage



Source: NOAA satellite programs briefing, January 1984.

ENCLOSURE II