U.S. DEPARTMENT OF COMMERCE
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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Geostationary Satellite Acquisition Strategy Improved, but Store-in-Orbit Approach Needs Re-evaluation

Inspection Report No. OSE-8784-7-0001/March 1997

Office of Systems Evaluation

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EXECUTIVE SUMMARY

The National Oceanic and Atmospheric Administration (NOAA) operates a two-satellite configuration of Geostationary Operational Environmental Satellites (GOES) to monitor weather conditions in the United States and adjacent regions. The National Weather Service uses GOES data to issue advance warnings of severe storms, such as tornados and hurricanes, and to forecast regional weather. NOAA and the National Aeronautics and Space Administration (NASA), its acquisition and development agent, have joint responsibility for the GOES program.

The current series of five satellites, designated as GOES-NEXT, offer significant operational improvements over the prior series. GOES-I and J were successfully deployed in 1994 and 1995 and are now referred to as GOES-8 and 9. The three remaining satellites, GOES-K, L, and M, are to be launched beginning in 1997. GOES-8 and 9 are experiencing reliability problems that have increased the risk of a gap in two-GOES coverage early next decade. To compensate for potential failures, NOAA has accelerated the launch schedule and also plans to accelerate the acquisition of the follow-on series of satellites.

When we started our inspection, NOAA planned to purchase the follow-on series noncompetitively from the current GOES-Next contractor, Space Systems/Loral. However, in response to criticism of this plan, NOAA developed a new acquisition strategy, called the "evolutionary program," for competitively procuring follow-on satellites on a cost-reimbursement basis. To mitigate the risk of a follow-on satellite not being ready in time to fill a coverage gap projected for early next decade, NOAA also proposed to buy one or two stop-gap satellites on a sole source basis from Loral. By the end of our inspection, NOAA had agreed to modify its evolutionary program and stop-gap procurement so they better control costs and risk. Our observations follow:

- **NOAA has agreed to an improved GOES satellite acquisition strategy**. NOAA's evolutionary program and the sole source procurement of stop-gap satellites were problematic. The evolutionary program, with its cost-reimbursement contract and evolutionary requirements, was not focused on controlling growth in cost or requirements. Also, the schedule for awarding the follow-on contract (in 1999) exposed NOAA to a wide coverage gap early next decade that could require the purchase of up to two stop-gap satellites. However, NOAA's plan to purchase the stop-gap satellites noncompetitively was difficult to justify under federal procurement regulations and possibly unnecessary because industry indicated that it could deliver the first follow-on satellite in time, if the procurement was accelerated.

  By the end of our inspection, in response to pressure from the Congress, NASA, the satellite industry, and our office, NOAA agreed to pursue two procurement plans

proposed by NASA that control costs and risks and to accelerate the award of the follow-on contract. NOAA requested NASA to immediately start a competitive procurement of two to four follow-on satellites through a fixed price contract to be awarded in the last quarter of 1997. The satellites will essentially be functionally equivalent to the GOES-Next satellites and will be built using commercially available satellite product-lines. Simultaneously, NOAA will request NASA to enter into an agreement with Loral to procure one stop-gap satellite if needed as insurance against a coverage gap. The procurement will proceed in phases, starting with the purchase of very long lead items--satellite components that take a long time to manufacture--in preparation for satellite fabrication. However, later phases will not be started if a coverage gap seems unlikely. We believe these two procurement plans will meet NOAA's coverage needs, control costs and risks, and promote competition. (See page 6.)

- **Early launch of GOES-K is reasonable, but storing a backup satellite in space may not be a cost-effective policy for the future.** Launching GOES-K in April 1997, two years earlier than planned, is a reasonable contingency for insuring continuity of coverage now that GOES-8 and 9 are experiencing significant reliability problems. However, we do not believe that NOAA and NASA have shown that launching a satellite early for storage in space as a backup is a cost-effective policy for insuring continuity in the future. Although the agencies cite numerous cost and risk advantages to storing satellites in orbit rather than on the ground, we believe NOAA should develop more complete analyses of costs, benefits, risks, and backup alternatives. Also, NOAA should make every effort to preserve GOES-K mission life while it is in a backup mode, including developing firm criteria for when to activate its instruments. (See page 9.)

Our recommendations begin on page 12.

Discussion of NOAA's Response

In the response to our draft report, NOAA essentially agrees with our findings and three of our four recommendations. NOAA disagrees with the importance we placed in our second finding on the likelihood and cost of losing mission life while a satellite is stored in orbit. NOAA also disagrees with the substance of our third recommendation which is to develop a plan for replacing failing GOES in advance of an emergency that considers alternatives besides just store-in-orbit. A discussion of NOAA's response to our draft report starts on page 12. A copy of NOAA's response is included as Attachment 2.

INTRODUCTION

The National Oceanic and Atmospheric Administration (NOAA) operates a two-satellite configuration of Geostationary Operational Environmental Satellites (GOES). GOES are placed in geostationary orbit (22,300 miles above the Equator) so they can constantly view the same region of the Earth. Two GOES, one positioned in the east and the other in the west, are required to fully monitor weather conditions in the United States. When only one satellite is operational, NOAA moves it to a more central location, which sacrifices some monitoring capability.

GOES are equipped with two primary instruments, an *imager*, which takes visible-light and infra-red images of clouds, and a *sounder,* which measures temperature and humidity in the atmosphere. The National Weather Service uses this data to issue advance warnings of severe storms, such as tornados and hurricanes, and to forecast regional weather. GOES has been credited with reducing loss of life and property due to severe storms.

NOAA and the National Aeronautics and Space Administration (NASA), its acquisition and development agent, have joint responsibility for the GOES program. NOAA funds the program, establishes program policy, identifies requirements, oversees contract acquisition and management, and operates the satellites after they are launched and checked out. NASA is responsible for contract acquisition and management, engineering management, and satellite launches and check-out.

The contract for developing GOES-Next, the current series of five satellites, was awarded in 1985 to Ford Aerospace, now Space Systems/Loral. The GOES-Next satellites are lettered GOES I through M until successfully deployed, when their designations are converted to numbers. GOES-I and J were successfully deployed in 1994 and 1995 and are now called GOES-8 and 9. The three remaining satellites, GOES-K, L, and M, are to be launched beginning in 1997.

GOES-8 and 9 are experiencing reliability problems that have increased the risk of a coverage gap early in the next decade. To compensate for potential failures, NOAA has accelerated the launch schedule for GOES-K through M and also plans to accelerate the acquisition of follow-on satellites.

BACKGROUND

A. GOES-Next Development

GOES-Next satellites were developed to improve the quality of weather data acquired by the prior series of GOES. They offer such improvements as independent and simultaneous

imaging and sounding; better resolution, frequency, and reliability of data; and more accurate calibration of weather events. However, GOES-Next development was plagued with delays and cost overruns. In 1991, the General Accounting Office reported that these problems were due largely to the complexity of the satellite design, inadequate program management by both NOAA and NASA, and poor contractor performance.[1]

Development delays threatened two-GOES coverage. In 1991, to avoid a potential no-GOES situation, NOAA borrowed a European geostationary weather satellite until 1994, when GOES-8 became operational.[2] Also, the cost of the GOES-Next program has increased dramatically. The original contract was valued at $276 million for developing the five satellites under a cost-plus-award-fee contract.[3] NASA's latest estimates bring the cost of the GOES-Next series to $1.2 billion, more than four times the negotiated price.

Although the GOES-Next program has had serious problems, GOES-8 and 9 are delivering high-quality weather data. NOAA officials have stated that the quality of soundings and images is within 95 percent of specifications and that scientists are now just beginning to exploit the full capabilities of these instruments and the forecasting information that can be derived from the data they provide.

B. GOES-Next Reliability Problems

There is renewed concern about a gap in two-satellite coverage. Both GOES-8 and 9 have experienced partial failures and are currently relying on redundant instrument motors that could also fail. The motors contain faulty electrical wire coils, or "windings," that cannot handle the extreme temperature variations in orbit. Due to these reliability concerns,[4] NOAA reduced the expected mission life of GOES-8 and 9 from five years to three years. Although the motors for GOES-K, L, and M have been redesigned, NOAA is also shortening the mission life of GOES-K to four years primarily because there is not enough time to complete a full mission life test of the new motor before it is launched. Because of the anticipated reduced lives of these satellites, NOAA has accelerated the launch schedule for GOES-K, L, and M and

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[1] The U.S. General Accounting Office, *Weather Satellites: Actions Needed to Resolve Status of U.S. Geostationary Satellite Program*, July 1991, GAO/NSIAD-91-252.

[2] NOAA borrowed Meteosat-3 from Eumetsat, the European Organization for the Exploitation of Meteorological Satellites. Eumetsat is responsible for weather forecasting and research in Europe.

[3] In a cost-plus-award-fee contract, the government pays for costs incurred by the contractor as well as all or part of the predetermined award fees based on a subjective evaluation of contractor performance.

[4] Mission life was also reduced because past performance indicates that early satellites in a series do not reach their full mission life.

is projecting that the first follow-on satellite will be needed in 2001 instead of 2004.[5]

C. Early GOES-K Launch and Store-in-Space

Because of the problems with GOES-8 and 9, NOAA has decided to launch GOES-K in spring 1997, two years earlier than originally scheduled. GOES-K will be stored in orbit or used immediately depending on the condition of GOES-8 and 9. NASA was studying the possibility of storing GOES-K in a special backup mode that would preserve its mission life by limiting fuel consumption and mechanical wear. This way GOES-K could still serve for its full mission life when it is activated to replace an aging satellite. However, at the conclusion of our field work, NASA was still unsure how much mission life could be preserved because GOES-Next satellites are not designed to operate in this backup mode.

After completing our field work, we have learned that after further study, NOAA and NASA have become more confident that a satellite's mission life can be preserved while it is in the backup mode. We have not reviewed the study's finding. The launch of GOES-K in April 1997 will be the first operational experience with this new life-preserving mode of operation for the GOES-Next satellite series. (See "Discussion of NOAA's Response" on page 12.)

D. The Follow-on Acquisition

In response to NOAA's FY 1995 budget request, the Congress wanted the agency to leverage the high cost and significant technological advancements of the GOES-Next series over more than just five satellites and to minimize the risk of losing two-satellite coverage in the future. Therefore, instead of funding development of a new next-generation of satellites, the Congress urged NOAA to buy additional GOES-Next satellites in an affordable manner and concentrate on increasing their reliability.

NOAA agreed with this approach and intended to buy follow-on satellites that were identical to, or "clones," of the GOES-Next series from the current contractor, Loral. However, special legislation required for a noncompetitive procurement was not passed. Instead, in the FY 1996 appropriation, the Congress urged NOAA to buy these satellites competitively and for a fixed price, if possible.

By this time, NOAA and NASA learned that even if they bought the follow-on satellites from Loral, they would not be identical to the GOES-Next satellites. Parts of the 1985-vintage satellite were obsolete, and many design changes had to be made to adapt replacement parts.

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[5] According to the GOES planning schedule, another condition that would be required for the first follow-on satellite to be needed by 2001 is for the GOES-L launch to fail. NOAA and NASA officials stated that it is accepted policy to plan for such a failure because typically one out of five geostationary satellite launches fails.

These factors changed the definition of what the government was buying. Instead of clones, NOAA would buy satellites that were *functionally equivalent* to the last satellite manufactured in the GOES-Next series (GOES-M).

At the same time, NOAA determined that three or four satellites would be required to cover the period between the last GOES-Next and 2010, when it is estimated that the first next-generation satellite will be ready. Since a new series of satellites takes about 10 years to develop, the exact year the next-generation series will be ready depends on when the Congress starts funding the acquisition.

By April 1996, NOAA's procurement agent, NASA, was urging it to proceed with a competitive procurement. The satellite industry also voiced its concern about a sole source acquisition because a manufacturer other than Loral claimed it could meet NOAA's GOES needs. In response to these pressures, NOAA reevaluated its short- and long-term needs and by June 1996 developed a new acquisition strategy. Since most of its weather data requirements were being met by the GOES-Next satellites, NOAA determined that a major, or "block," change in technology was not needed and that the current instruments would suffice, at least for a while. However, the GOES-Next bus[6] was becoming increasingly obsolete, and better technology is available now. Consequently, NOAA planned to procure two to four modern, more capable buses. Requirements for these buses would be developed and a contract awarded in 1999. The first, and possibly the second, bus would be fitted with the same instruments used now for the GOES-Next mission bought under a separate sole source agreement from the current instrument contractor, ITT. Then, as requirements evolved, more advanced instruments would be developed and installed on later buses. This strategy became known as the *evolutionary program.*

However, if the contract was awarded in 1999, the first evolutionary satellite would not be ready to launch in 2001, the date NOAA projects the first follow-on satellite will be needed. So, as part of the evolutionary program, NOAA proposed buying a *stop-gap* satellite from Loral like the one currently used, with an option to buy a second one in case of an emergency. NOAA argued that only the incumbent contractor could deliver a satellite by 2001 and that NOAA should not assume the risk of using another contractor's unproven satellite in this short time frame.

To procure noncompetitively, government regulations require a Justification for Other than Full and Open Competition. NOAA and NASA jointly developed the justification and forwarded it through NASA channels for approval. If the justification was approved, NASA would advertise the intention to sole source to give industry an opportunity to comment on the

[6] The satellite bus consists of the satellite chassis and support systems for the mission instruments. It does not include the imager and sounder.

acquisition. However, NASA management was not convinced that a noncompetitive procurement was necessary or justified under federal procurement regulations and proposed an alternative plan.

In September, even though five months had elapsed since NOAA was urged to abandon its plans for a sole source procurement, NASA still believed that a bus procured competitively could be built by 2001. However, it would require an *accelerated competitive procurement* to be started immediately. NASA was prepared to release a draft Request For Proposals for industry review in the near future, release a final version by March 1997, and make an accelerated award by the last quarter of 1997. However, NASA believes the current situation warrants extra precautions against a coverage gap. The delay in starting a procurement has made it more difficult for a contractor to deliver a satellite by 2001, and reliability problems with the operational GOES may actually result in a premature failure as projected. Therefore, NASA proposed that at the same time, the government should also enter into an agreement with Loral to begin buying satellite components in case a stop-gap satellite is needed. The continuation of this *phased procurement* would be contingent on the condition of the GOES-Next series at key decision points.

PURPOSE AND SCOPE

Our survey of NOAA satellite programs revealed that the GOES Program Office was planning to significantly change the launch schedule, acquire follow-on satellites on a sole source basis, and substantially upgrade ground systems. The objectives of this inspection were to determine (1) what the best approach is for acquiring the follow-on satellites; (2) whether NOAA had sufficiently justified its proposal to launch GOES-K early as an in-orbit spare; and (3) whether proposed ground system improvements were justified and the plans to implement them will result in high-quality systems. This report covers the follow-on satellite acquisition and the GOES-K launch decision. We will review and report on satellite ground systems in the future.

Our fieldwork was conducted from May to October 1996. We reviewed NOAA and NASA planning documents, including the program plans, satellite and launch services contracts, and status reports. We reviewed procurement-sensitive documentation from industry concerning the availability of launch services and the capabilities of industry to meet GOES mission requirements. We interviewed representatives from NOAA's GOES Program Office and Systems Acquisition Office and NASA's GOES Program Office and General Counsel. We consulted with a former NOAA official who now represents various clients in the space systems community, as well as representatives of two satellite manufacturers. We met with an outside expert in government satellite programs and interviewed a representative of Eumetsat about Meteosat capabilities.

Our work was conducted in accordance with the *Quality Standards for Inspections* issued in March 1993 by the President's Council on Integrity and Efficiency.

OBSERVATIONS AND CONCLUSIONS

I. NOAA has agreed to an improved GOES satellite acquisition strategy

NOAA's evolutionary program and the sole source procurement of stop-gap satellites were problematic. The evolutionary program was not focused on controlling growth in cost or requirements, and the schedule for awarding the contract exposed NOAA to a wide coverage gap early next decade. Similarly, purchasing stop-gap satellites noncompetitively was difficult to justify under federal procurement regulations and possibly unnecessary if the competitive procurement was started immediately so that a follow-on satellite could be delivered sooner. However, by the end of our inspection, in response to pressure, NOAA agreed to pursue two procurement plans proposed by NASA that control costs and risks and accelerate the award of the follow-on contract. We believe these two procurement plans will meet NOAA's coverage needs, control costs and risks, and promote competition.

A. NOAA's Evolutionary Program Did Not Control Costs and Risks

Although NOAA originally wanted to purchase the follow-on series noncompetitively from the current GOES-Next contractor, Space Systems/Loral, by June 1996 it had agreed to abandon its noncompetitive procurement plan and had developed the evolutionary program, which called for a full and open competition for two to four satellites. Recent trends in government satellite acquisitions indicate that a competitive procurement can yield significant cost savings.[7]

However, NOAA's evolutionary program did not go far enough to control costs and risks. NOAA's preliminary plans indicated that the satellites were to be bought on a cost-reimbursement contract, a contracting approach that would introduce a high degree uncertainty in a program that had already quadrupled in cost. This contract type was chosen to allow requirements to evolve as the program progressed. However, uncontrolled requirements growth could lead to unforeseen technical problems and development delays, as happened with GOES-Next. Also, the evolutionary program did not address potential cost savings associated with developing requirements that could be supported by production-line satellite buses.

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[7] For example, NASA recently procured three Tracking and Data Relay Satellites (TDRS) for $480 million in a full and open competition on a fixed price contract. The total bid price was $150 million less than NASA's in-house estimate and $180 million less per satellite than the cost of the prior TDRS (TDRS-7), which was bought on a sole source basis.

Instead, NOAA might have purchased more costly and risky custom-built buses. Finally, NOAA wanted to purchase follow-on buses with additional capacity to handle growth in requirements. However, buying extra capacity initially may not be cost-effective since the first and possibly the second follow-on bus will carry the current instrument suite.

Also, the schedule for awarding the follow-on contract exposed NOAA to a wide coverage gap that could require the purchase of up to two stop-gap satellites from Loral. Due to problems with GOES-8 and 9, NOAA projected that the first follow-on satellite would be needed by 2001. However, in the evolutionary program, NOAA planned to spend almost a year developing requirements (completed in 1997) and almost two years to award the contract (in 1999). Following this schedule, NOAA projected that the first evolutionary (follow-on) satellite would be delivered by 2004, leaving up to a three year coverage gap (2001-04). However, if the process for procuring the follow-on satellites was accelerated, industry could deliver a satellite sooner.

B. NOAA Agreed to a More Controlled Follow-on Acquisition

By the end of our inspection, NOAA had agreed to pursue NASA's plan for acquiring the follow-on satellites. Besides controlling costs and risks, the procurement of the follow-on satellites will be started immediately and the award process accelerated so that the contract can be awarded by October 1997, about two years earlier than NOAA proposed in the evolutionary program. This schedule should leave enough time for the selected contractor to deliver the first follow-on satellite by 2001. This procurement plan controls costs and risks in three ways.

First, requirements will be controlled because the follow-on satellites will essentially be functionally equivalent to GOES-M, the most mature GOES-Next satellite. (GOES-M incorporates improvements to address problems found in the previously launched GOES-Next satellites.) NOAA is considering adding two sets of requirements that go beyond current GOES-Next capabilities. It wants the follow-on satellites to comply with the original 1983 GOES-Next requirements rather than the lesser actual performance of GOES-8 or 9 and to accommodate advanced instruments that NOAA has been researching.[8] To reduce risks and costs, we believe that these requirements should be justified and well-defined and that extra capacity for advanced instruments should not be purchased until they are installed on later buses. Risk of requirements growth may be somewhat mitigated because modern production-line buses may already provide some of this additional capability.

Second, in its recent Requirements Letter to NASA (see attachment), NOAA has indicated that it wishes to use production-line buses for the follow-on series. Even though production-line

[8] A higher resolution sounder, a faster imager, a new lightning mapper, and an enhanced solar environmental monitor.

buses are not specifically designed for the GOES mission, adapting these buses for this purpose should be less risky and less costly than developing custom-built ones. Industry has claimed that production-line buses are more reliable, last longer, can be built more quickly, and provide the benefit of product line improvements to customers. Also, NOAA has indicated that additional bus requirements for accommodating the advanced instruments will be limited to the capabilities of currently available production-line buses. This will help control growth in requirements and costs.

Third, and most important, NOAA will control the cost of the follow-on series by using a fixed price contract. A cost-plus-award-fee contract was used to develop the GOES-Next series because significant research and development was required. However, much less research and development will be needed for the follow-on series because the requirements and the manufacturing processes are well understood. Further, both the Congress and the satellite industry support using fixed price contracts, and government agencies are increasingly using them. By appropriately fashioning these contracts, risk will be transferred to the manufacturer, while still giving the customer insight into the production process and allowing incremental (but controlled) improvements to the original design that come from operational experience. Not only will a fixed price contract control costs, but it is also a substantive commitment to control requirements growth.

C. NOAA Could Not Justify a Sole Source Procurement of Two Stop-Gap Satellites

Because of reliability problems with GOES-8 and 9, NOAA is concerned about a coverage gap in the year 2001, before the first follow-on satellite may be delivered. To mitigate this risk, as part of the evolutionary program, NOAA proposed to buy up to two stop-gap satellites from the current contractor, Loral. However, according to NASA legal experts, NOAA's justification for a sole source procurement, which was based on an "unusual and compelling urgency," was weak and could easily be defeated in court.[9]

In addition, NOAA did not adequately demonstrate that Loral was the only source for a satellite by 2001. Another satellite manufacturer claimed that by that date it could deliver a satellite that surpassed the older GOES-Next capability by performing better, being more reliable, lasting longer, and being easier to operate. Also, Loral had significant obstacles to

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[9] An "unusual and compelling urgency" refers to a section of the *Federal Acquisition Regulation* that permits a government agency to buy from a particular contractor rather than hold a full and open competition, if the agency's need is "of such an *unusual and compelling urgency* [our emphasis] that the Government would be seriously injured [otherwise]." NOAA's case was weak because the need dates for the first and second follow-on satellites were predicated on projections of early failure, rather than actual failures, and these dates were many years away. Usually, a more immediate actual need is required to justify an unusual and compelling urgency. Also, it can be argued that NOAA is partially responsible for the urgency of the situation because it did not move ahead when NASA recommended a competitive procurement in April 1996.

overcome to deliver a satellite by 2001. It had to redesign significant portions of the mid-1980s GOES-Next bus to replace obsolete parts, including 25 percent of the electrical components and at least one major subsystem, the Earth sensor (which is involved in assuring pointing accuracy).[10] Thus, the option for procuring a second stop-gap satellite became even more difficult to justify.

D. NOAA Agreed to a Phased Procurement of One Stop-Gap Satellite

NOAA agreed to pursue the phased procurement NASA recommended as an extra precaution against a coverage gap early next decade. The phased procurement will be contingent on the actual (rather than projected) condition of the GOES-Next satellites and the progress being made in developing the competitively procured follow-on satellites. Though not all the details have been worked out, the general idea is that the procurement would proceed in three phases--buying very long lead items, buying long lead items, and fabricating the satellite. Because of reliability problems with GOES-8 and 9, the purchase of very long lead items may be warranted as soon as the agreement is signed. However, subsequent phases would not be started if GOES-8, 9, or K perform better than projected or if the competitive procurement is on track to deliver a satellite by 2001. NOAA and NASA will have to develop the specific criteria, decision points, and approval process for controlling the phases of the procurement.

Cost estimates for the phased procurement were not developed before our field work ended. However, NASA's preliminary estimates indicate that the first phase--the purchase of very long lead items--will cost $30 to $40 million. If the phased procurement is not completed, the goal is to use some of the very long lead items on the follow-on satellites. Savings from the competitively procured follow-on satellites may offset some of the losses. However, if NOAA had initiated a competitive procurement earlier as recommended by NASA, a phased procurement for stop-gap satellites might not have been necessary.

II. Early launch of GOES-K is reasonable, but storing a backup satellite in space may not be cost-effective in the future

Launching GOES-K in April 1997, two years earlier than planned, is a reasonable contingency for ensuring continuity of coverage now that GOES-8 and 9 are experiencing significant reliability problems. However, we believe that NOAA and NASA have not shown that launching a satellite early for storage in space as a backup is a cost-effective policy for insuring the continuity of two-GOES coverage in the future. Although the agencies cite numerous cost and risk advantages to storing satellites in orbit rather than on the ground, we believe NOAA should develop more complete analyses of costs, benefits, risks, and backup alternatives.

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[10] The important task of aligning satellite data with its true location on Earth.

Also, NOAA should make every effort to preserve GOES-K mission life while it is in a backup mode, including developing firm criteria for when to activate its instruments.

A. Justification for Early Launch

NOAA's plan to launch GOES-K in April 1997, two years earlier than previously scheduled, is a reasonable continency for avoiding a coverage gap early next decade. Based on a five-year mission life, GOES-K was to be launched in 1999 to replace GOES-8. However, NOAA decided an early launch was warranted because of the risk that the instrument motor problems would render GOES-8 or 9 incapable of fulfilling its five-year mission.

Several factors influenced NOAA's decision to launch GOES-K in April 1997. A later launch date in 1997 or 1998 was unavailable because of the large demand by commercial firms for geostationary orbit launches and because the only pad capable of launching the last remaining Atlas-I rocket, which will be used to put GOES-K into space, is undergoing a six-month refurbishment in 1998. Also, the alternative of launching GOES-K in the event of an imminent failure would require the declaration of a national emergency to preempt another launch customer, which would be very disruptive to the commercial satellite business. Even if preemption was used, up to 15 months would be needed to call up a satellite from ground storage and put it into operation.

Therefore, launching GOES-K in April 1997 seems to be a reasonable contingency. However, GOES-K mission life may be lost while it is in a backup mode. To mitigate this loss, we believe NOAA and NASA should make every effort possible to preserve its life, including developing firm criteria for when to activate its instruments.

B. More Analysis Is Needed to Justify a Store-in-Orbit Policy

NOAA and NASA have also been considering plans to routinely store a GOES-Next satellite in orbit as a backup rather than launching one in response to a reliability problem. They claim it is more advantageous to store a satellite in orbit than on the ground, noting that it is less expensive, reduces the risks of human handling, is not susceptible to natural calamities such as earthquakes, and is a more valuable asset as a launched and checked out satellite. (Launch and check-out are the riskiest parts of putting a satellite into operation.) NASA officials have also told us that storing a satellite in orbit would make it easier to manage staffing because NASA would not have to increase and then decrease staff in the event of an emergency launch.

Storing a GOES-Next satellite in orbit may not be as cost-effective and risk-free as NOAA and NASA's preliminary studies claim or be warranted as a contingency for reliability problems. One major obstacle to the store-in-orbit policy is the potential high cost of losing mission life while the satellite serves as a backup. Unless a GOES-Next satellite can be put into a backup

mode of operation that preserves mission life (i.e., limits fuel consumption and mechanical wear), significant costs are incurred for each month of mission life lost. Since each GOES-Next costs about $200 million to build and about $100 million to launch, the cost of each month lost out of a five-year mission life is about $5 million. NOAA claims that "minimum" mission life will be lost. (See "Discussion of NOAA's Response" on page 12.)

Although NASA and NOAA cite numerous cost and risk advantages to storing satellites in orbit rather than on the ground, we believe more complete cost, benefit, and risk analyses are needed. For example, a significant issue that was not addressed is the additional costs to both NOAA and NASA for more capable ground systems and additional operations to manage a three-satellite configuration (instead of two). A comparison of the environmental risks of storing GOES in space (radiation and debris) and on the ground (natural calamity) has also not been fully factored into the risk analysis. Moreover, a major disadvantage of storing a satellite in space is that it cannot be repaired as it could if it was stored on the ground. This situation arose with GOES-K. Had it been in space, the faulty instrument motors detected on GOES-8 and 9 could not have been replaced on GOES-K, which might have significantly reduced its mission life.

Also, in the future, finding a pad for launching a replacement satellite in an emergency may be easier. According to a firm specializing in analysis of the satellite business, demand for launches into geostationary orbits will subside in the future.[11] Further, NOAA needs to explore alternatives for backing up a failing GOES. In case GOES-K cannot be launched in April 1997 and GOES-8 or 9 fails, NOAA is considering alternatives, such as moving the remaining operational GOES-Next satellite to the central United States and supplementing these options with imagery from the remaining sounder. In the future, NOAA should also consider the alternative of borrowing a European weather satellite. (Our preliminary information indicates that the European geostationary weather satellite configuration could have an extra backup satellite after a planned launch in 1997.) Finally, NOAA and NASA should develop better techniques for predicting when a replacement satellite is needed. Currently, NOAA bases the GOES launch schedule on the five-year satellite mission life specified to the satellite manufacturer. NASA has been experimenting with more sophisticated prediction techniques that factor in actual satellite performance.[12]

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[11] The Teal Group Corp. in its *World Space Systems Briefing* projects that demand for commercial geostationary launches will sharply decrease from a peak of about 35 in 1997 to under 10 in 2003 due to the introduction of low earth orbit communication satellite constellations.

[12] For example, the NASA Goddard Space Flight Center study reported by R. Brodhurst in "Reliability Implications of Launching GOES-K Early," April 18, 1996.

RECOMMENDATIONS

NOAA has improved its strategy for acquiring GOES satellites to one that better controls costs and risks. We urge NOAA to complete the purchase of follow-on satellites and the one stop-gap satellite using the procurement plans proposed by NASA and to limit the growth of requirements as proposed in NOAA's Requirements Letter to NASA (see Attachment 1). In addition, NOAA's plan to launch GOES-K two years early seems to be a reasonable contingency for insuring against a GOES-8 or 9 failure. However, because mission life may be lost while a satellite serves as a backup, we believe that NOAA should more fully evaluate alternatives for replacing satellites in the future and make every effort to preserve GOES-K's mission life.

In addition to continuing with the current satellite procurement plans, we recommend that the Under Secretary for Oceans and Atmosphere direct NOAA to:

1. Delay purchasing extra bus capacity for the advanced instruments until they are installed on the later buses, if this is practical.

2. Develop a plan, including criteria, authority, and decision points, within the next thirty days for deciding whether the phased procurement is to continue or stop.

We also recommend that Under Secretary for Oceans and Atmosphere direct NOAA to work with NASA to:

3. Develop a more complete analysis of costs, benefits, risks, and backup alternatives before launching another GOES-Next as an in-orbit backup.

4. Develop a strategy for preserving GOES-K mission life while it is in a backup mode, including establishing firm criteria for when to activate its instruments.

Discussion of NOAA's Response

NOAA essentially agrees with our findings and three of our four recommendations. A copy of NOAA's response to our draft report is included as Attachment 2. We made several editorial changes to our final report that were suggested by NOAA officials in informal communications.

NOAA officials requested to meet with us on February 18, 1997, to discuss our findings and recommendations. At this meeting, they stated that NOAA disagrees with the importance we placed in our second finding on the likelihood and cost of losing mission life while a satellite is stored in orbit. They stated that a study completed after our field work was finished had found that GOES-K would be able to complete its full five-year mission even if it is stored in orbit for

two years.

We have not had an opportunity to review the study's finding. However, store-in-orbit is still considered controversial by the satellite community. The launch of GOES-K in April 1997 will be the first operational experience with this new life-preserving mode of operation for the GOES-Next satellite series. To conserve fuel, GOES-K will be put into a slow spin rather than kept stabilized as it was originally designed to operate. It has been reported that this new mode of operation may jeopardize the satellite's electronic components that are sensitive to thermal changes caused by the spin.

The rest of the February 18 meeting focused on recommendations one and three. At this meeting we clarified our recommendations and, based on our discussion, believed NOAA would change its response to our draft report accordingly. However, NOAA chose not to do so.

Recommendation 1

NOAA has complied with this recommendation, though its response states otherwise. We recommended that NOAA seek cost savings, if practical, by not purchasing more capacity than is needed for the first two follow-on buses. These buses, which will carry the current instrument suite, will need less capacity than the later buses, which are projected to carry additional or more powerful instruments. NOAA has complied with this recommendation because it has specified in the requirements to the satellite industry that less capacity will be needed for the early buses. We explained at the February 18 meeting that by specifying requirements in this way, NOAA was satisfying our recommendation.

Recommendations 2

NOAA concurs. NOAA, in coordination with NASA, is developing a plan that defines the criteria, timing and authority for deciding whether to continue or stop the phased procurement.

Recommendation 3

NOAA disagrees with this recommendation, though its response states otherwise. At the February 18 meeting, we explained that we were recommending NOAA develop a plan for replacing failing GOES in advance of an emergency that considers alternatives besides just store-in-orbit. Therefore, NOAA's response that it will decide about a replacement approach on a case-by-case basis when an emergency occurs, as it did in the decision to store GOES-K in orbit, does not satisfy our recommendation.

The decision to launch GOES-K as an in-orbit spare was based on the particular circumstances at the time GOES-8 and 9 started experiencing reliability problems. The problems with GOES-8 and 9 are serious. The failure of a single back-up motor winding would permanently disable one of two primary instruments on each satellite. If the back-up winding fails on the GOES-9

imager, the satellite would be unable to complete its most important mission--gathering data for advance warning of severe storms. Further, NOAA and NASA have been unable to completely eliminate the heat fluctuations that cause the motor windings to break. The final decision factor was that a remedy was readily available. GOES-K was ready to launch and NOAA had a launch pad reservation in a time of great launch pad demand.

However, much of NOAA's other justification for storing GOES-K and future GOES in orbit was either weak (e.g., on-ground storage is more dangerous than in-orbit storage) or incomplete (e.g., NASA costs for store-in-orbit were not available). Also, conditions peculiar to the GOES-K launch (the heavy demand for launches) will change in the future when more launch pad availability can be expected. Finally, NOAA did not seem to seriously consider alternatives to store-in-orbit until the GOES-K launch was temporarily threatened.

Therefore, we still urge NOAA to develop a more complete analysis of costs, benefits, risks, and backup alternatives for replacing failing GOES in advance of an emergency. By comparing alternatives and preparing for the future, NOAA could develop a cost-effective back-up strategy and not depend on heroic efforts or circumstance to ensure two-satellite coverage.

Recommendation 4. NOAA concurs. NOAA and NASA have developed plans for preserving GOES-K mission life while it is in backup mode. The GOES Special Issues Working Group within NOAA is developing criteria for when to activate GOES-K. The group plans to have a draft version of the criteria at its end of April meeting. The criteria will be based on the condition of GOES-8 and 9. When activation is warranted, GOES-K will be moved from its storage orbit into position to replace either GOES-8 or 9 and then its instruments will be turned-on.

Attachment 1

UNITED STATES DEPARTMENT OF COMMER
Office of the Deputy Under Secretary
for Oceans and Atmosphere
Washington, D.C. 20230

OCT 30 1996

Mr. Martin A. Davis, Code 415
GOES Project Manager
Goddard Space Flight Center
Greenbelt Road
Greenbelt, MD 20771

Dear Mr. Davis:

NOAA has completed their definition of the GOES program requirements which shall be reflected in the GOES-N,O,P,Q spacecraft draft Request for Proposal (RFP) being readied for release by NASA to industry. NOAA understands the purpose of the release is to solicit industry comments.

The image navigation and registration requirements for the Imager and Sounder are as stated in the 1983 NOAA program requirements. That is:

1. Image navigation, 3 sigma values measured at nadir

   56 microradians (day)
   56 microradians (night)

2. Image registration, 3 sigma values measured at nadir

15 minutes	28 microradians (day) 28 microradians (night)
90 minutes	42 microradians (day) 42 microradians (night)
24 hours	112 microradians (day) 112 microradians (night)

The spacecraft design shall accommodate full time operation of the Imager and Sounder instruments, including operating through all eclipse periods.

NOAA requests that capability be provided to accommodate potentially new instrument payloads. For this RFP action, this payload shall include a double-rate Imager, a high-resolution Interferometer Sounder, a Lightning Mapper, and an improved Solar Environmental Monitor. If this advanced instrument payload exceeds the capability currently available from industry's production-line spacecraft busses, then NOAA will re-evaluate this requirement.

Changes in the flight spacecraft design shall be compatible with NOAA's existing ground system, or provisions shall be made in the new spacecraft contract for required ground system changes. The spacecraft contract shall include the costs for proposed ground system changes.

Finally, other requirements are as NOAA/NASA have developed in the draft GOES-N,O,P,Q spacecraft documentation and will be subject to review in the spacecraft RFP requirements review scheduled on November 12, 1996.

Sincerely,

Steven P. Kirkner
GOES Acquisition Manager

cc: SAO - W. Mehuron
SAO GOES Staff
E/OSD - Dittberner
E/OSD - J. Hawkins
E/OSD3 - R. Reynolds
E/SO - G. Davis
E/SO1 - K. Kelly
OM22 - R. Gird
OM - G. Mandt
OM - L. Uccellini
R/E/SE - E. Hildner
GSFC/170 - R. Beck

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
CHIEF FINANCIAL OFFICER/CHIEF ADMINISTRATIVE OFFICER

MAR 13 1997

MEMORANDUM FOR: Frank DeGeorge
Inspector General

FROM: Joseph T. Kammerer for

SUBJECT: Draft Inspection Report, Geostationary Satellite Acquisition Strategy Improved, But Store-in-Orbit Approach Needs Re-evaluation (Report No. OSE-8784-7-XXXX)

Attached is the National Oceanic and Atmospheric Administration's response to the above referenced draft inspection report. We appreciate the opportunity to review and respond to this draft report.

We concur with the majority of the report's findings and recommendations. However, regarding recommendation 1, we do not believe it is practical to "delay purchasing extra bus capacity for the advanced instruments until they are installed on the later buses, . . . " because it has been determined that additional capacity already exists in some commercial buses, or may be available at low costs at contract initiation. Under the fixed-price nature of the GOES N-Q procurement, contractors are free to choose the most cost effective manner to accommodate growth in the instrument complement.

Attachment

NOAA RESPONSE TO OIG DRAFT REPORT: NOAA GEOSTATIONARY SATELLITE ACQUISITION STRATEGY IMPROVED, BUT STORE-IN-ORBIT APPROACH NEEDS RE-EVALUATION (OSE-8784-7-XXXX) dated January 22, 1997

Finding 1: NOAA has agreed to an improved GOES satellite acquisition strategy

NOAA essentially agrees with this finding.

Finding 2: Early launch of GOES-K is reasonable, but storing a backup satellite in space may not be cost-effective in the future

NOAA generally agrees with this finding, however, extensive analyses by NASA and NOAA indicate minimum loss of mission life for 2 years of in-orbit storage followed by 5 years of full operational life. We do not agree that there is a high cost of losing mission life in back up mode.

NOAA's response to the specific recommendations made in the draft report is as follows:

Recommendation 1: Delay purchasing extra bus capacity for the advanced instruments until they are installed on the later buses, if this is practical

NOAA Response: NOAA does not concur with this recommendation and believes this recommendation is not practical. Rather, NOAA's requirements are structured to require the extra bus capacity on the third and fourth buses, assuming the options would be exercised. Under the fixed-price nature of the NOAA GOES N-Q procurement, bidders are free to choose the most cost effective manner to accommodate growth in the instrument complement. Each bidder has the opportunity to decide to design in any needed enhancements (if they do not already exist) beginning with the first or beginning with later busses. The competitive environment is expected to produce the best price.

Recommendation 2: Develop a plan, including criteria, authority, and decision points, within the next 30 days for deciding whether the phased procurement is to continue or stop

NOAA Response: NOAA agrees. A plan is now being developed. NASA comments that the latest draft of the warranty clause allows the decision to be made now to continue with the first two phases. This approach and decision authority has been coordinated between NOAA and NASA.

Recommendation 3: Develop a more complete analysis of costs, benefits, risks, and backup alternatives before launching another GOES-Next as an in-orbit backup.

NOAA Response: As the GOES Program Manager discussed with the OIG staff on the telephone on February 11, 1997, and in their meeting on February 18, 1997, NOAA interprets this statement to mean that the next time (after GOES-K) NOAA might be considering another satellite for a possible store-in-orbit launch, that the specific circumstances at that time be the subject of careful analysis of costs, risks, benefits, and other backup alternatives before making a decision. We agree, and, as was the case for GOES-K, will do this analysis.

Recommendation 4: Develop a strategy for preserving GOES-K mission life while it is in a backup mode, including establishing firm criteria for when to activate its instruments

NOAA Response: NOAA agrees. NASA comments that the first part of this recommendation was accomplished as part of the in-orbit storage review presented on November 25-26, 1996.