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The Honorable Frank E. Moss
Chairman, Committee on Aeronautical
and Space Sciences
United States Senate

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Dear Mr. Chairman:

Your January 16, 1974, letter asked us to obtain cost and other data on both the Department of the Air Force and the joint National Aeronautics and Space Administration (NASA)/National Oceanic and Atmospheric Administration (NOAA) polar orbiting weather satellite programs.

We interviewed officials in NASA, NOAA, the Department of the Air Force and the Office of Management and Budget (OMB). At these meetings they told us of the existence of two classified studies which provided some comparative analyses of the technical characteristics and costs of the NASA and Air Force operational weather satellite systems and the follow-on systems in development.

We then met with your staff on February 13, 1974, and orally presented the information. At that meeting your staff asked us for a written report. We have not independently verified the data; however, we have discussed the matters in this report with the agency officials.

We plan to discuss briefly the history of the NASA/NOAA and Air Force satellite systems, compare the characteristics of both systems, provide cost comparisons of the operational and developmental satellite systems, and furnish information on plans to obtain some measure of commonality of both systems.

HISTORY OF NASA/NOAA PROGRAM

The purpose of the joint NASA/NOAA weather satellite system is to provide systematic, global cloud cover observations and other meteorological observations to increase man's ability to forecast weather conditions. It is also to observe, collect and disseminate comprehensive data and information about the state of the upper and lower atmosphere, the oceans and their resources, inland waters, the earth, the sun, and the space environment. The NASA/NOAA system provides data for weather predictions not only to the United States but also to foreign countries.

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NASA's responsibility is to develop, procure, and launch polar-orbit weather satellites for NOAA. Once the satellite is launched and satisfactorily transmitting data, it becomes NOAA's operational responsibility. NASA launched the first TIROS research and development weather satellite in 1960. A derivation, the TIROS Operational Satellite (TOS) produced by the Radio Corporation of America, became NOAA's first operational weather satellite system. This spinning satellite, among other things, had a television camera that transmitted cloud imagery back to the data receiving station on earth.

NASA also began the NIMBUS experimental satellite program in the early 1960s. General Electric developed this satellite. NIMBUS E is the most recently launched. NIMBUS F, the sixth in this series, is scheduled for launch this summer. These satellites have been test beds for satellite instrumentation. Many of the NIMBUS program developments and improvements were incorporated into the TOS system.

The resulting second generation of operational weather satellites was the improved TIROS Operational Satellite (ITOS). ITOS was first launched in the late 1960s. It is a stabilized satellite compared with the earlier spinning satellite. Four satellites in the ITOS series have been successfully launched by NASA and operated by NOAA. Two others have not been successful, however, as they did not achieve orbit velocity because of launch vehicle failure.

The NASA/NOAA satellites are launched from the Western Test Range, Vandenberg AFB, California. U.S. data receiving stations are at Gilmore, Alaska, and Wallops Island, Virginia. The data received at these stations is relayed to Suitland, Maryland, and to Offutt AFB, Nebraska, for processing. Foreign countries also receive NOAA satellite data via direct readout as the satellite passes over their stations.

NASA is developing TIROS-N, the third generation of the TIROS satellites. TIROS-N will incorporate significant advancements in instrumentation and capabilities compared with the present ITOS. TIROS-N is not expected to become operational until after mid-1977. TIROS-N is to provide greater quality and quantity of input data for numerical weather prediction, a significant factor in long-range weather forecasting. It is planned to use TIROS-N in providing data for the International Global Atmospheric Research Program (GARP). GARP is to (1) increase our understanding of the general circulation of the atmosphere and (2) provide the physical basis for long-range weather prediction, for determination of the feasibility of large-scale climate modification, and for assessment of the consequence to global environmental quality of man's pollution of the atmosphere.

HISTORY OF AIR FORCE PROGRAM

Specific requirements for which the Air Force weather satellite system was developed are classified. In broad terms it is to provide weather information with maximum responsiveness to the military operational decisionmaker.

Air Force research and development on weather satellite systems resulted in the launch of the first operational Block 5 satellite in February 1970. The Radio Corporation of America produces Block 5 satellites and the current series of Air Force operational satellites is Block 5C. With the exception of certain subsystems, the Air Force polar-orbiting system, its mission, and data collected have been declassified.

As with the NASA/NOAA satellites, Air Force satellites are launched from the Western Test Range. Receiving stations at Loring AFB, Maine, and Fairchild AFB, Washington relay data to the Air Force Global Weather Central at Offutt AFB, Nebraska. Direct readout of the data from the Air Force satellite is also possible by properly equipped military mobile weather stations. Since December 1972, when the data being collected was declassified, it has been made routinely available to NOAA. NOAA is considering the cost and the benefit of using this data. Additional capability would have to be added to NOAA's data collection and display systems to use the Air Force data.

The Air Force is developing a follow-on system labeled the Block 5D which is expected to be launched in late 1974 or early 1975. The production contract for Block 5D is with RCA, but Westinghouse produces the sensors that are supplied to the Radio Corporation of America as Government-furnished equipment.

COMPARISON OF NOAA AND AIR FORCE OPERATIONAL SATELLITE SYSTEMS

A significant consideration of management for each system is to provide maximum assurance that there will not be a break in service. According to NOAA and Air Force officials, although the systems have not operated at full capacity at all times, there has been no break in service throughout the history of these two programs.

The NASA/NOAA approach to insure continuous service has been to provide full redundancy of satellite instruments. If all instruments are functioning properly, only one satellite is required in orbit at a time. A failure in performance in one of the instruments is the signal to turn on the backup instruments and prepare another satellite for launch. This rationale has been adopted because it takes about 120 days to prepare and launch a NASA satellite because launch vehicles or launch crews are not in standby readiness.

The Air Force, however, takes a different approach. Each satellite is equipped with only one set of instruments. The Air Force has a requirement for weather data readouts in the early morning and at noon so it must maintain two satellites in orbit at all times. This and the fact that the Air Force has launch vehicles and launch crews readily available and can prepare and launch a new satellite within 30 days provides the rationale behind its approach. The follow-on Block 5D satellite does have selective redundancy in those areas which have given problems, such as tape recorders and attitude control systems.

To provide global coverage with one satellite, NASA places the NOAA satellites in an orbit of about 800 nautical miles contrasted to the lowe orbit of about 450 nautical miles for each of the two Air Force satellite NASA weather satellites are heavier than the Air Force satellites, partly because of instrumentation redundancy. The higher orbit and the heavier satellite require a launch vehicle with greater lift capability than the Air Force satellite. NASA uses a Delta launch vehicle, whereas the Air Force uses a refurbished standard THOR.

The following table compares the prime factors of each system.

NOAA ITOS and Air Force Block 5C Satellites

	NASA/NOAA	Air Force
Coverage	Global	Global
Data requirements	Numerical readings and Cloud imagery	Cloud imagery and nu cal readings
Redundancy of instruments	Full	Limited
Satellite weight	750 pounds	425 pounds
Orbit height	800 nautical miles	450 nautical miles
Expected satellite life	12 months	9 months
Launch vehicle	Delta	THOR
Standby launch vehicle	No	Yes
Standby launch crew	No	Yes
Launch crew	Civilian	Air Force
Backup launch time	120 days	30 days

COST COMPARISON OF OPERATIONAL SYSTEMS

In 1972 the Department of Defense commissioned a study of the Air Force and NOAA polar-orbiting weather satellite systems. The Department of Defense and NOAA personnel completed this study on May 18, 1972, and i sued what is commonly known as the "Duffy Report." This study group (1) pared costs of the Block 5C and ITOS systems and (2) examined the possibility that one system could fulfill the requirements of both the Air For and NOAA. According to NASA, NOAA, OMB, and Air Force officials, the Duffy Report contains the most recent comparison of program costs.

The report showed estimated total costs of $145 million for NASA/NOA compared with $107 million for the Air Force to maintain a weather satellite in orbit for 8 years. The 8-year, one-orbit base was used because t satellites have different expected operational lives and the Air Force pr gram maintains two satellites in orbit versus one for the NASA/NOAA progr The comparative cost data was based on (1) research, development, test, and evaluation costs for each system, (2) production costs for eight sate lites for each system, (3) launch costs necessary to maintain one operational ITOS and one operational Block 5C in orbit at all times over the 8 years, and (4) 8-year support and operational costs.

ITOS has an expected operational life of 12 months and the 8-year NASA/NOAA costs of $145 million include research, development, test, and evaluation costs and production and launch costs for eight satellites plus the estimated annual support and operations cost over 8 years. Block 5C has a 9-month expected operational life and would require more than eight satellites to maintain one orbit for 8 years. The $107 million cost for Block 5C includes research, development, test, and evaluation costs, an extrapolation of the production and launch costs for the eight-Block 5C satellite base to cover 8 years, and the annual support and operations costs for that period. Types of cost and the applicable appropriations follow.

Estimated Comparative Costs to Maintain Block 5C and ITOS Satellites in Orbit for 8 Years

Type of cost	AF	NASA/NOAA	Difference	Percent difference
	(millions)			
Development and production cost	$ 56	$ 65	$ 9	16
Launch cost	18	46	28	156
Support and operations cost	33	34	1	3
Total costs for 8 years (one orbit)	$107	$145	$38	36

Appropriations and Related Dollars

Agency and appropriation	Development and production cost	Launch cost	Support and operations cost
	(millions)		
Air Force:			
Research, development, test, and evaluation	$16	$-	$-
Procurement	40	16	3
Personnel and operations and maintenance	-	2	30
Total	$56	$18	$33
NASA:			
Research and development	$16	$ 4	-
NOAA:			
Satellite operations	49	42	$34
Total	$65	$46	$34

The above table shows the NASA/NOAA launch costs to be two and one-half times that of the Air Force system even though the Air Force wo be required to make the greater number of launches. The lower Air Force costs are attributed to the Air Force use of the THOR missile to launch its satellite, a refurbished surplus launch vehicle, and the already-in-place Air Force launch crews, whereas NASA uses the more expensive Delta launch vehicle and civilian crews. About $400,000 was included in the Air Force estimate for additional costs that would be incurred at the Western Test Range because of the added responsibility of launching weat satellites. This amount paid wages of about 40 people and paid for some tests and checkouts.

The study points out that the estimated launch costs for the Air Force may have been understated because only the cost of refurbishing th surplus THORs was included. The study states that, had the original cos of the boosters been considered, the differences between the costs might tend to level out. The Air Force says its program was designed to take advantage of surplus launch vehicles and thereby hold down new procureme costs.

Another cost difference is in production costs of the NASA/NOAA sat lite which are attributed to NASA's providing redundant instrument packa in each ITOS satellite. According to the study, the two systems would b comparable in cost if adjusted for these two factors; however, no analys was made to support this conclusion.

The Duffy Report concluded that the Air Force had a good, cost-effective project. The study also contained a conclusion, although strongly objected to by the NOAA representative, that the Air Force weat satellite system could fulfill the NOAA data requirements; however, the reverse was not true in that the NOAA system could not fulfill Air Force requirements. The basic conclusion was to keep separate Air Force and NOAA satellite systems because of possible international questions and concern if the Department of Defense took over the operations of the civilian weather satellite program. This is important since foreign cou tries also receive data via NOAA's satellite.

COST COMPARISON OF FUTURE SYSTEMS

As stated earlier, the future NASA/NOAA and Air Force satellite systems are TIROS-N and Block 5D. A contract for producing Block 5D has already been negotiated with the Radio Corporation of America, and the first launch is scheduled for later this year or early next year. The TIROS-N satellite, however, is only now being defined but is expected to be launched in 1977.

The Congress approved procurement funds for TIROS-N in NASA's and NOAA's fiscal year 1973 appropriation. OMB withheld these funds, howeve pending the outcome of the study it requested, entitled "Meteorological Satellite Analytical Study." OMB asked NASA/NOAA and the Air Force to assess the technical feasibility and possible cost savings of a more ful integrated polar-orbiting satellite program. After this study was compl in December 1973, the funds were released.

The baseline (option one) for the OMB study was the proposed technical characteristics and estimated 8-year program costs for the Air Force Block 5D and NOAA's TIROS-N satellite systems. Other options addressed the possibility of fulfilling both agencies' requirements by using either the Air Force or NOAA satellites; a modified version of the Air Force or NOAA satellites; combinations of Air Force and NOAA satellites; or a completely new satellite design.

The study concluded that the total estimated program costs over 8 years, using the baseline systems, would be $306 million ($149 million for the eight Block 5D satellites and $157 million for the four TIROS-N satellites). Types of costs and the applicable appropriations in the estimate follow.

Estimated 8-Year Program Costs For Block 5D and TIROS-N

Type of cost	Block 5D	TIROS-N	Difference	Percent difference
	(millions)			
Development and production cost	$ 79	$ 68	$(11)	-14
Launch cost	13	27	14	108
Support and operations cost	57	62	5	9
Total 8-year cost	$149	$157	$ 8	5

Appropriations and Related Dollars

Agency and appropriation	Development and production cost	Launch cost	Support and operations cost
	(millions)		
Air Force:			
Research, development, test, and evaluation	$27	$ -	$ -
Procurement	52	9	5
Personnel and operations and maintenance	-	4	52
Total	$79	$13	$57
NASA:			
Research and development	$34	$ 6	$ -
NOAA:			
Satellite operations	$34	21	62
Total	$68	$27	$62

The above table shows the total estimated 8-year program development and production costs to be greater for Block 5D than TIROS-N. This compares the cost of eight Block 5D satellites to four TIROS-N satellites. The difference in quantity is because of the Air Force program requirement for maintaining two satellites in orbit at all times compared with one satellite for the NASA/NOAA system. On a per satellite basis, TIROS-N production costs would be greater because of NOAA's requirement for redundancy of instruments. On the other hand, launch costs are greater for the NASA/NOAA program even though the Air Force program requires twice the number of launches. This again is attributed to the Air Force's use of the refurbished THOR launch vehicle and Air Force launch crews versus NASA/NOAA's use of Delta launch vehicles and civilian launch crews.

The Block 5D baseline cost was later revised to about $130 million, primarily because of an estimated saving of about $18 million by using satellite rather than ground communications. A contract has been awarded to the American Satellite Corporation, Germantown, Maryland, for this satellite communication capability. The estimated program costs over 8 years would be $287 million ($130 million for the eight Block 5D satellites and $157 million for the four TIROS-N satellites). The baseline cost of NASA/NOAA TIROS-N also considered ground rather than satellite communications. NOAA says NASA/NOAA baseline costs would decrease if satellite communications are used.

Estimated costs for each of the other options considered ranged from $180 million to $303 million. Although estimated costs of the baseline systems exceeded that of each of the other options, the overall conclusion of the study was to maintain the separate Block 5D and TIROS-N systems because

—data requirements of the two agencies would not be met by other than the baseline system and

—operations of a civilian program by the military could create international complications, particularly with those countries that by agreement have established ground stations to receive data from NOAA's satellites.

FACTORS LEADING TOWARD SOME MEASURE OF COMMONALITY

NOAA expects TIROS-N to provide a major advance in the fields of numerical weather prediction, nontactical aviation and marine services, oceanography, hydrology, and space environmental monitoring. NOAA therefore emphasizes the very high resolution quantitative features of its system while still providing useful cloud cover data. In addition to quantitative measurements, the Department of Defense also expects Block 5D to provide an advance in meeting its more specialized tactical and strategic requirements for rapid visual interpretation of high-resolution, day-and-night image data. Each agency believes adoption of the other's hardware might reduce the degree to which its primary requirements would be met.

NOAA, NASA, the National Security Council, and the State Department believe that military management of a civilian weather data gathering pro gram, particularly in this case with agreements with other countries to provide them data, would create international problems. The State Depart ment headed up a 1973 study for the President and, with the National Security Council, addressed the question of what international problems would be created if the military assumed management responsibility for th civilian aspects of the weather satellite program. The results of this study supported the importance of maintaining civilian management of pres ent civil programs. Under this concept the study supported achieving economies through the use of common components and operations, such as launch crews, launch facilities, satellite shells, and orbital altitude. In addition, all agencies will try to use common instrumentation to the extent possible.

The Air Force and NOAA are drawing up an agreement that would provic the mechanism for working out details related to:

—Maintaining two NOAA satellites using an Air Force satellite-type shell, each with single instrument systems in lower orbits at all times (to provide the same global coverage as provided by the previous higher orbit and redundancy), and

—Launching NOAA satellites using Air Force launch vehicles and laur crews.

As a result NOAA estimated program costs could be reduced by about $26 million to a total estimated cost of about $131 million. Final agree ment is expected to be negotiated by summer 1974. When the agreement is finalized, NOAA will send us a copy.

We do not plan to distribute this report further except for specific requests and then only after you agree or publicly announce its contents.

Sincerely yours,

Elmer B. Staats

Comptroller General
of the United States