REPORT TO THE JOINT COMMITTEE ON ATOMIC ENERGY CONGRESS OF THE UNITED STATES

19

Army's Evaluation Of Alternative Designs For Providing Computer Capabilities Needed For SAFEGUARD Antiballistic Missile System B-164250

Department of the Army

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-164250

Dear Mr. Chairman:

During the executive hearing on the SAFEGUARD antiballistic missile (ABM) system held February 16, 1970, we told you that our work in process included an examination into (1) the Army's role in certain contractor-initiated design changes and make-or-buy decisions for components of the SENTINEL ABM's data processing subsystem--the command and control computer which links the system's radars and interceptor missiles--and (2) the impact of the decisions on cost-effective acquisition of the greater data processing capabilities needed for SAFEGUARD.

The results of our examination are discussed briefly in the following paragraphs and are detailed in the summary which follows. The report is not intended as a General Accounting Office evaluation of the management of the overall ABM program or of the ABM system's military effectiveness.

To eliminate the need for assigning a national security classification, we have deleted from the summary certain information which, according to the Army, warrants a SECRET classification. We are separately forwarding for your use a listing entitled "Classified Information Deleted from Report on Army's Evaluation of Alternative Designs for Providing Computer Capabilities Needed for SAFEGUARD Antiballistic Missile System" (B-164250).

Our examination indicated that the Army project office--because of an insufficient number of competent technical personnel--had not made critical and independent evaluations of the rationale and support for, or available alternatives to, the proposal of the system's prime contractor to change memory components from a film design to a slower core design. It appears, however, that the Army's acceptance

of the prime contractor's proposals did not have any adverse effect on the ABM system's capability to meet the lesser threat for which the SENTINEL program was authorized. Because of the rapidity of later advancements in memory technology, we were unable to make any conclusions on the decision's effect on the system's cost or its potential for growth to meet SAFEGUARD defense objectives. (See p. 5 of summary.)

It should be noted, however, that further changes in the data processing subsystem have been recommended by the National Academy of Sciences Advisory Committee. Although the recommended changes in the subsystem have not been adopted by the Army for the approved segment of the ABM program, the changes may be applicable to the future program and may have a significant impact on the cost and effectiveness of the program. (See p. 19 of summary.)

We found that the Army had not been required to participate, and had not participated, in the prime contractor's decision to make rather than buy certain components of the processors. In addition, the Army had not been required to review, and had not reviewed, the cost and other considerations supporting the decision.

Our examination into the circumstances of the prime contractor's decision indicated, however, a reasonable basis for the decision. The original manufacturing plans provided that the processors be manufactured mainly by the prime contractor. The prime contractor later considered modifying its make-or-buy program because of the advantages of retaining in the ABM program the experience of the subcontractor who had designed and developed the processors. Accordingly the subcontractor was requested to submit a price proposal to assemble, wire, and test the processors and to fabricate certain of their components. The subcontractor's proposal was rejected, however, because it was determined to be not economically competitive. The records of the system's prime contractor showed that the estimated buy costs exceeded the estimated make costs. (See p. 24 of summary.)

B-164250

This report is also being sent today to the Vice Chairman of your Committee.

Sincerely yours,

Acting Comptroller General
of the United States

The Honorable John O. Pastore, Chairman
Joint Committee on Atomic Energy
Congress of the United States

Content

ABBREVIATIONS

ABM	Antiballistic missile
MSR	Missile Site Radar
PAR	Perimeter Acquisition Radar
ICBM	Intercontinental ballistic missile

SUMMARY OF INFORMATION ON GENERAL ACCOUNTING OFFICE EXAMINATION INTO ARMY'S EVALUATION OF ALTERNATIVE DESIGNS FOR PROVIDING COMPUTER CAPABILITIES NEEDED FOR SAFEGUARD ANTIBALLISTIC MISSILE SYSTEM

DESCRIPTION OF DATA PROCESSING SUBSYSTEM

The data processing subsystem controls the entire operation of the antiballistic missile (ABM) system. Each radar site has its own data processor serving as the automated command and control link between the sensors (radar) and the reactors (interceptor missiles) and is subject to only certain command decisions and to some human intervention.

The data processor's command and control of the radars and SPARTAN[1] missile in the area defense concept is illustrated on page 2. The Perimeter Acquisition Radar (PAR) or long-range radar detects and tracks the incoming object and provides data to its data processor--which identifies the object as an incoming target, computes the probable point of intercept, and provides the target data to the appropriate Missile Site Radar's (MSR's) data processor. When additional target data are ordered and obtained from its own radar, the MSR's data processor plans the interception; readies, launches, and guides the SPARTAN missile; and arms and detonates the SPARTAN's warhead.

Computer programs tell the data processors how to handle and act on data provided by the radars. These instructions are designed in advance to attempt to provide for every conceivable attack situation and are stored in the data processor's memory components.

The data processor's major components and their interface with each other and other ABM system elements are schematically illustrated on page 3. Processing is done in the Central Logic and Control component which consists primarily of (1) two types of memory units--program storage units

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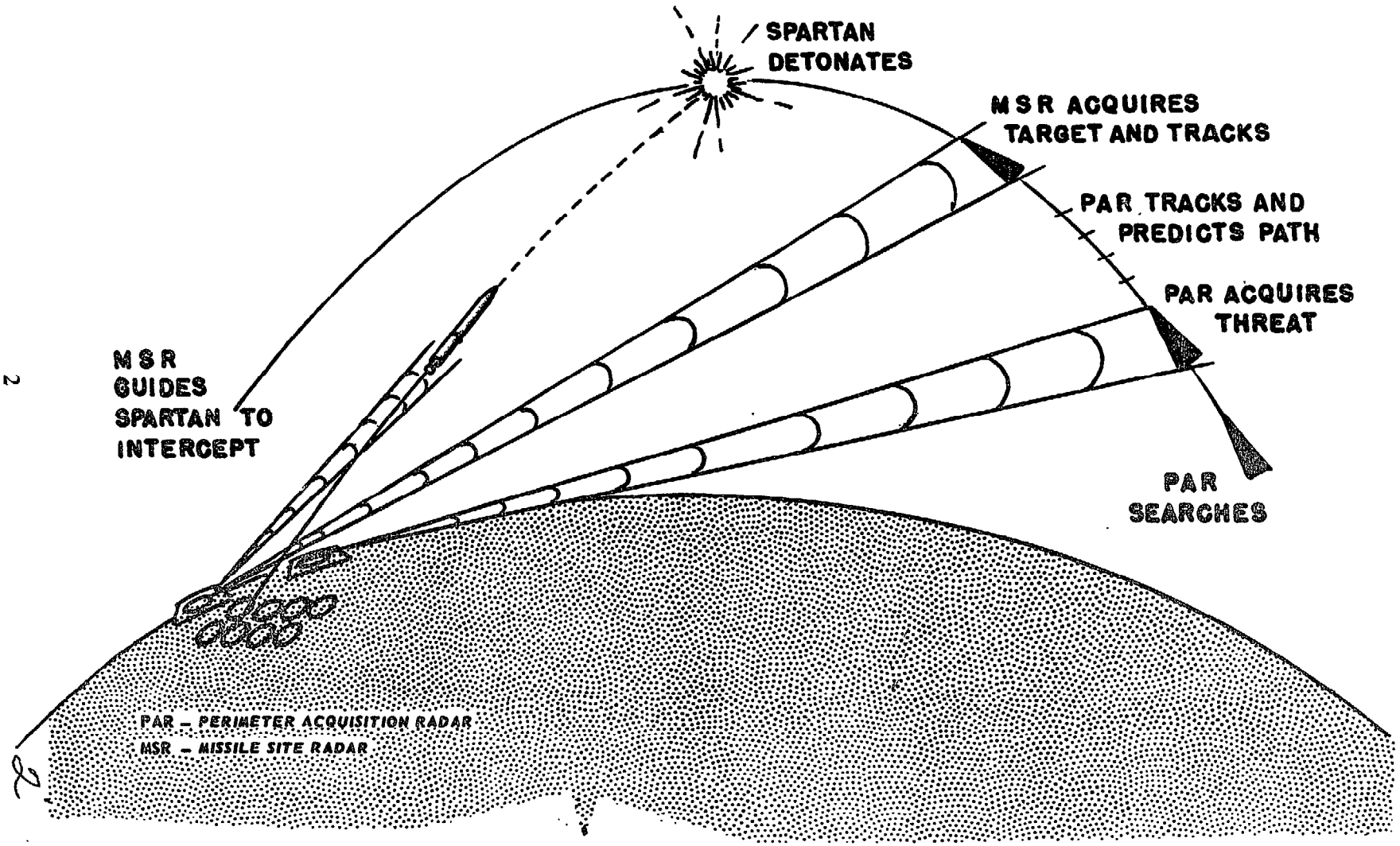
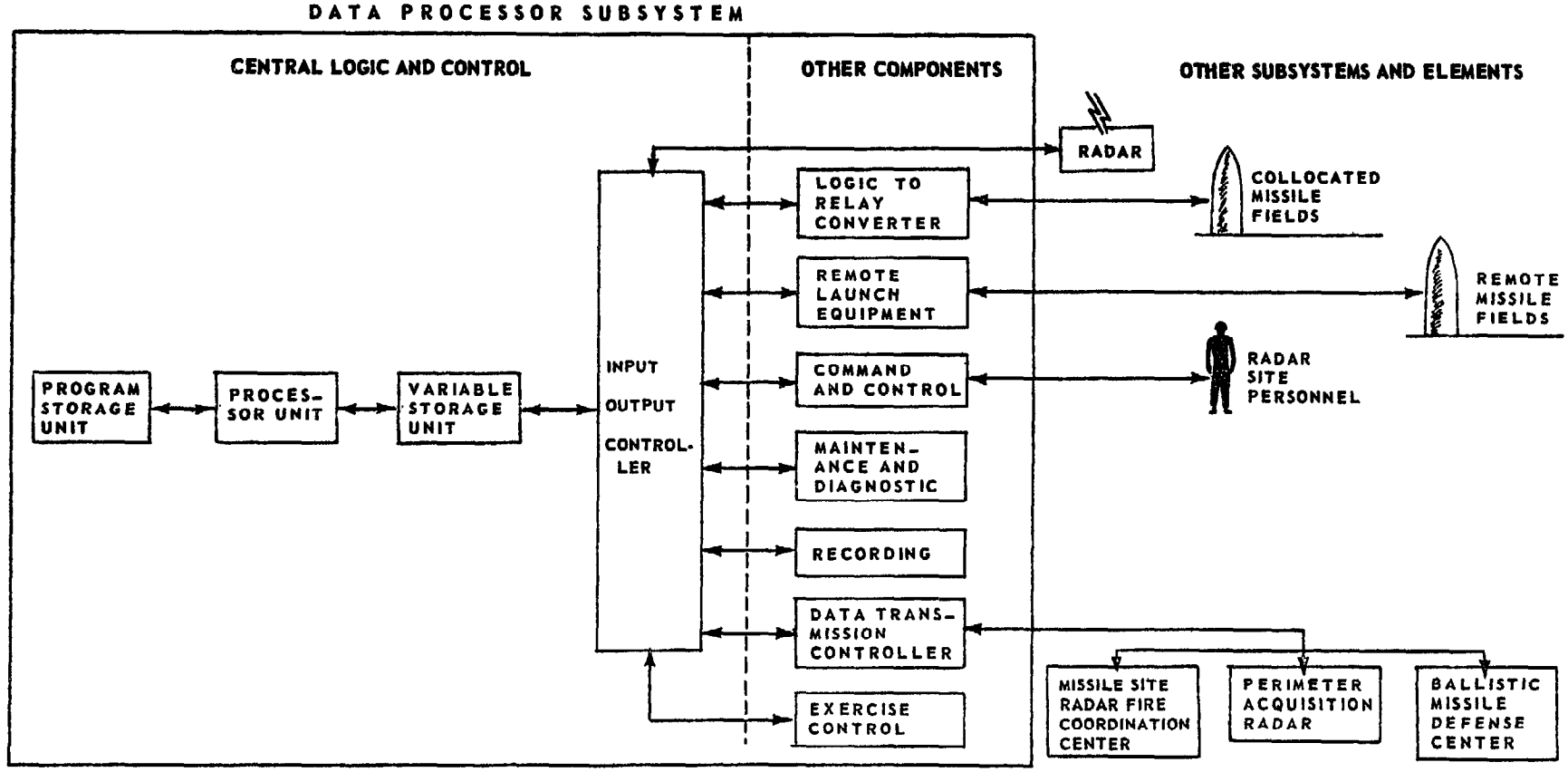
[1]The SPRINT missile is used in the terminal defense situation against enemy missiles which elude the SPARTAN.

CONCEPT OF AREA DEFENSE



MAJOR COMPONENTS OF A MISSILE SITE RADAR DATA PROCESSOR AND INTERFACE WITH OTHER ABM SYSTEM ELEMENTS 1/



LOGIC TO RELAY CONVERTER – Provides the communication link between the data processing subsystem and the collocated SPRINT and SPARTAN missile launch equipment.

REMOTE LAUNCH EQUIPMENT – Provides the communication link between the data processing subsystem and the launch equipment of missiles remote from the radar site.

COMMAND AND CONTROL – Provides the communication link between the data processing subsystem and radar site personnel.

MAINTENANCE AND DIAGNOSTIC – Provides maintenance information on the data processing subsystem and the radar.

RECORDING – Provides for the storage, recording, playback, and readout of informational data.

DATA TRANSMISSION CONTROLLER – Provides the external communication link that connects the data processing subsystem with other radar sites and higher command authority--Fire Coordination Centers and the Ballistic Missile Defense Center.

EXERCISE CONTROL – Provides for operational testing of the data processing system through simulated tactical exercises.

1/ The PAR data processor has the same components and interface as the MSR data processor except for the Remote Launch Equipment and the Logic to Relay Converter.

containing the computer programs and variable storage units containing raw and processed data, (2) processor units performing the arithmetic and logic analysis of data in accordance with the preset programs, and (3) input-output controller units for transmitting instructions and status data to the other data processor components and, in turn, to the other elements of the ABM system.

The preset program instructions are read from the program storage unit into the processor at its request. In executing the instructions, the processor sends requests for new or updated data to the radar through the variable storage unit and the input-output controller. A notification to the processor is placed in variable storage when the data are received and are available for analysis and processing.

The subcomponents of the Central Logic and Control are being designed so that the number of processor and memory units can be varied to satisfy the throughput[1] and storage requirements of the various radar sites to provide for system growth. The resulting combination of these units is referred to as a multiprocessor system.

According to Army officials, the maximum throughput of a multiprocessor configuration is determined by the number and internal operating speed of the processors and by the time required for the processors to locate and obtain data from the memory units. Slower memories can decrease the output of the processors by requiring them to wait for requested data. Increases in the number of program and variable storage units provide greater storage capacities but do not provide greater memory operating speed. Although additional memory units can provide greater processor output, greater memory speed is a factor in achieving the Central Logic and Control's maximum throughput capacity.

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[1]Throughput refers to the output of the processors and is usually expressed in terms of the average number of instructions that can be executed in 1 second.

DECISION TO CHANGE PERFORMANCE AND DESIGN REQUIREMENTS FOR DATA PROCESSOR'S MEMORY COMPONENTS

The performance requirements for the NIKE-X system's Multifunction Array Radar's data processor called for a throughput capability of 30 million instructions a second. According to the prime contractor,[1] Bell Telephone Laboratories, a review of the state of the art in 1964 showed that commercially available computers could not provide the throughput and reliability required. To meet these requirements, the development plan called for faster processors and memories in a multiprocessor configuration.

The throughput capability was to be achieved by using eight processors for each site, by developing processors having average processing rates of 4 million instructions a second for each processor, and by developing random access

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[1]The prime contractor is the Western Electric Company. Western Electric is a wholly owned subsidiary of the American Telephone and Telegraph Company. Bell Telephone Laboratories' capital stock is owned jointly and equally by those companies. Contracts are written between the Government and Western, and Western then authorizes Bell to do certain parts of the work. Bell acts for Western as the technical director of research, design, and development.

Bell's technical direction relates primarily to (1) all research and development, (2) design requirements and testing, (3) technical discussions with customers, and (4) design and configuration control. With respect to research and development contracts, Western's responsibilities involve primarily (1) administrative and financial matters relating to the contracts and (2) fabrication of hardware.

storage units having speeds of 200 nanoseconds.[1] According to the prime contractor, a thin film memory design was chosen because, among the memory designs then considered suitable for meeting the 200-nanosecond speed requirement, (1) its technology was in an advanced state, (2) it was capable of high reliability, and (3) its design was susceptible to upgrading.

Because of its experience in film memories and in the development of computer systems for NIKE-ZEUS--the predecessor ABM system--the Univac Division of Sperry Rand Corporation was chosen by Bell in 1964 to develop for the NIKE-X system a type of thin film memory, called coupled film, having a 200-nanosecond speed. Univac demonstrated the capability to meet the 200-nanosecond speed specification for coupled film during an acceptance test in January 1967.

Univac's experience in fabricating the coupled film showed that this design would be very expensive. In June 1966 Bell authorized Univac to study the feasibility of

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[1]One nanosecond is equivalent to one billionth of a second. For the variable storage unit, the 200 nanoseconds represented the time required by the memory unit to respond to a processor's request for data. It covers the cycle referred to as read and restore; i.e., locating a word in storage, reading the word into a storage register for transfer out of the storage unit, and restoring the word to its storage location. The 200 nanoseconds also represented the time required to update stored data in a cycle referred to as clear and write; i.e., locating a word in storage, clearing or erasing the word from that location, and placing a new word in the storage location.

For the program storage unit, the objective of 200 nanoseconds represented the time required by the memory unit to make stored instructions available for reading by the processor. The nondestruct design of the program storage unit eliminated the need to restore the words to their storage locations.

replacing coupled film with less expensive 200-nanosecond mated film.[1] According to an Army report, Univac later demonstrated to Bell and Army representatives that 200-nanosecond mated film was feasible.

According to the Army, the effort to check out data processing software required a more rapid delivery of memory units than could be provided in the development contract for coupled film. To obtain the additional memory units, Bell, in December 1966, solicited proposals for five variable memory units having cycle times of 700 nanoseconds or better.

These memories were to be used to supplement the 200-nanosecond coupled-film memories in applications where lesser speeds could be tolerated. Lockheed Electronics Company quoted on two commercial (nonmilitarized) models: a 650-nanosecond core memory at a fixed unit price of $70,596 and a 500-nanosecond core memory at a fixed unit price of $83,226.

In March 1967 Bell awarded subcontract 304561 to Lockheed for the five 500-nanosecond core variable memory systems needed to check out software for the data processing subsystem.

Meanwhile, according to the Army, Univac realized that a slower memory unit might be used and proposed a 500-nanosecond mated-film memory. In February 1967 Bell directed Univac to start design and development of the slower militarized mated film, to terminate all work on the coupled-film program storage units, and not to start new fabrication

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[1] The basic concept of the coupled-film design was to deposit spots of magnetic material on two separate plates. Sensing wires were placed between the two plates. The two plates then were assembled and aligned so that the deposited spots formed coupled cells. Mated film consists of a multilayer deposited magnetic element built upon a single substrate. Both the magnetic elements and the sensing conductors are produced by deposition. According to Univac officials, Univac's mated film is planned for use in the Navy's S-3A aircraft avionics program.

of coupled-film variable storage units. The Army approved the mated-film development in April 1967.

In April 1967 the Army directed Bell to study an ABM deployment for thin area defense and for limited terminal defense of MINUTEMAN sites--referred to as the 1-67 deployment. Limited protection for MINUTEMAN sites was defined in July 1967 as a high confidence that a number of MINUTEMAN missiles would survive a Russian intercontinental ballistic missile (ICBM) attack on their silos. In a subsequent operational model--the 2-67 deployment--the defense was to be expanded to provide greater protection, including more protection of the ABM system's radars.

For the 1-67 deployment, primary emphasis was to be placed on cost-effective growth of the MINUTEMAN terminal defense. Bell reported that, by using a 500-nanosecond instead of a 200-nanosecond memory, the lesser threat could be met and significant cost savings could be realized. According to Bell, the use of a core design to achieve a 500-nanosecond speed would be less expensive than the mated-film design being developed by Univac.

In August 1967 Bell issued a specification for militarized core memory for the program storage and variable storage units. Bell requested seven contractors, including Lockheed and Univac, to propose a firm fixed price for 15 (five program and 10 variable) 500-nanosecond core memory units.

On September 8, 1967, the Government project office told Bell that it understood that Bell was trying to save money by specifying a 500-nanosecond memory on the basis that the thin area defense planned for the 1-67 deployment would not require the faster 200-nanosecond memory. The project office advised Bell that the existing specification of a 200-nanosecond memory speed would be required for the 2-67 deployment and requested justification for a 500-nanosecond memory. The project office asked whether the 500-nanosecond memory could handle a threat greater than that postulated for the 1-67 deployment and whether the use of both 200- and 500-nanosecond memories in the same data processor was the most cost-effective approach.

Bell replied by message dated September 13, 1967, that the matter of the most cost-effective memory was being restudied; that the 500-nanosecond memory would satisfy the 1-67 requirements; and that, if more capacity were required for later growth, faster memory could be added compatibly with the slower memory.

A project office official informed us that the Government had not made an independent study to evaluate Bell's position. We were told that the project office staff had discussed and analyzed the problem with Bell officials and had concluded that Bell's position was valid. On September 19, 1967, the project office changed the approved requirement from 200 nanoseconds to the slower memory speed of 500 nanoseconds.

As stated on page 5, the approved processor throughput requirement for each NIKE-X deployment site was 30 million instructions a second, or 4 million instructions a second for each processor. In September 1967 the requirement was reduced from 4 million to 1.6 million instructions a second because, according to SAFEGUARD System Office officials, processors having the higher speed would not be available in time for early deployment of a thin defense. Shortly thereafter Bell reported that substituting the slower memory units for the 200-nanosecond units would reduce the processor's throughput and that the approved requirement had been reduced further to 1.3 million instructions a second.

On September 22, 1967, Lockheed responded to Bell's request for quotation for fifteen 500-nanosecond core memory units and proposed a fixed price of about $1.4 million. According to a Bell memorandum, the other six contractors solicited had replied that they were not in a position to make a fixed-price proposal on Bell's specification.

In a response dated September 22, 1967, Univac, in declining to bid on the core proposal, stated that mated film had advantages over core memory, such as (1) potential for greater speed, (2) lower power requirement, (3) higher packaging density for each memory rack, (4) greater long-term reliability, and (5) application of low-cost, mass-produced, automated techniques. Univac contended that these

advantages outweighed any initial cost advantages of core memory. Since there may have been other factors which have not been brought to our attention, we cannot comment on the validity of Univac's statements.

A project office official told us that the core proposal and the mated-film alternative had been compared by Army and Bell officials at a meeting on October 11, 1967, and that, on this basis, Lockheed had been selected as the source for the 500-nanosecond memory units. In November 1967 Bell directed Univac to stop further development and notified Lockheed that it had been selected to manufacture the core units. A subcontract amendment terminating the mated-film development effort was approved by the project office in October 1968.

A project office official told us that the only documentation of the October 11 meeting was a Bell memorandum dated November 1, 1967. The memorandum showed that Bell had specified a mean-time-between-failure reliability rate[1]

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[1] The Army requires that the operation of the ABM's data processing equipment be guaranteed on a continuous basis for 24 hours a day. To ensure the continuous operation of the data processing equipment, the very highest reliability possible within the state of the art of component development is required to meet the long mean-time-between-failure requirement. This requirement specifies the average number of operating hours that a component will operate before the occurrence of a known system failure. Army officials informed us that the mean-time-between-failure specification for the core memory modules being furnished by Lockheed was 5,000 hours and was required for the Central Logic and Control system to meet its availability and reliability specification.

During a meeting held on December 4, 1968, between Bell and Lockheed representatives, it was stated that a component provided by one of the component vendors did not meet Bell's specifications and that this had resulted in a memory system mean time between failure of only 3,900 hours. In June 1970 we asked Bell for the mean-time-between-failure rate of the core memory units as reported by Lockheed and for the supporting documentation. We asked also whether Bell agreed or disagreed with Lockheed's reliability estimates. On December 28, 1970, Bell replied that Lockheed had reported a mean time between failure of 5,000 hours on the basis of nominal failure rates for the component parts in the design. Bell concurred in Lockheed's estimate. Bell, however, furnished no supporting documentation.

of 5,000 hours but that Lockheed's memory unit, as proposed, had a mean-time-between-failure reliability rate of 1,200 to 1,500 hours. Lockheed later increased its proposed price for the 15 memory units from about $1.4 million to about $2.2 million to provide for the 5,000-hour reliability requirement.

According to the memorandum on the October 11 meeting, core was selected over mated-film memory on the basis of Bell's representations that core would cost less. We found no evidence that the Army had independently, or in participation with Bell, compared the technical features and the expected costs of the core design with the mated-film design or with other alternatives.

We were told that the project office evaluations had been limited to desk reviews of Bell's findings and to discussions with Bell personnel, that the reviews had been premised on the competence and reliability of Bell personnel, and that detailed independent evaluations had not been made because adequate technical staff and facilities had not been available to the project office. The project office official explained that, during 1967 and 1968, the data processing technical staff comprised three people and that, at the time of our inquiry in May 1970, it comprised seven people.

Subsequent to Bell's November 1967 direction to terminate Government-funded effort, Univac independently continued developing mated film and, on March 21, 1968, submitted an unsolicited fixed-price proposal to Bell for 250-nanosecond mated-film memory for the SENTINEL system. Univac contended that mated film would:

1. Decrease size. Thirty-two thousand 68-bit words could be placed in one rack. (A rack of core memory consisted of 16,000 words.) This reduced the rack and space requirements for the memory by one half and reduced line length between the processors and the memories.

2. Increase processor throughput. Throughput would be about 20 percent greater than a 500-nanosecond memory due to the faster memory's higher supply rate.

3. Lower cost. Savings would result from the reduced number of racks, interface switching units, and space requirements for the memory and from the reduced number of processors because of the increase in throughput.

In August 1968 Bell told Univac that its proposal had been rejected because the units were of commercial quality and would not meet the requirements for militarized equipment of the highest possible reliability. Bell expressed interest, however, in the greater speed and increased packing density offered. In later meetings Bell and Univac officials explored the possibility of using 250-nanosecond mated film in the SENTINEL system.

By letter dated December 20, 1968, the executive director of Bell's SENTINEL Design Division furnished to the project office a memorandum dated December 11, 1968, entitled "Study of UNIVAC Unsolicited Proposal for Mated Film Memories." Bell reported that (1) the mated-film memory appeared to be technically feasible to produce with adequate reliability and margins, (2) the cost per bit[1] of the 250-nanosecond memory would be essentially the same as that of the core memory, and (3) by putting twice as much memory in one rack,[2] the reduction in the number of racks permitted by the increased packaging density would result in savings of about $27 million less development costs (approximate net savings of about $20 million) for acquisition of the number of memory units required for the then-planned SENTINEL deployment.

Univac officials told us that the greater packaging density and the resultant reduction in the number of racks referred to by Bell in its letter of December 20, 1968, were the same as Univac's September 1967 proposals. In

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[1]A bit is a computer term for one discrete information position.

[2]Lockheed's core memories had a storage capacity of 16,384 words, whereas Univac's proposed mated-film memories had twice this storage capacity.

addition to proposing the cost benefits, Univac stated in its September 1967 response that the 500-nanosecond mated-film memory could be easily upgraded to a 200-nanosecond cycle time. Univac stated also that it had demonstrated to the Government and to Bell representatives that mated-film memory at a speed of 200 nanoseconds was feasible and that, prior to September 1967, Univac had successfully demonstrated a 250-nanosecond mated-film memory in laboratory tests.

Bell advised, however, that it did not appear possible to take advantage of Univac's mated-film proposal since the design change at that time would have delayed the then-present schedules for the SENTINEL program by 14 months. Bell concluded that, if substantial schedule changes were made, such development might be reconsidered.

In March 1969 the President announced the planned deployment of the SAFEGUARD system, which provided for a 15-month delay in the readiness date for the first site. In April 1969 the project office replied to Bell's letter of December 20, 1968, and concurred in Bell's findings. The project office informed Bell that efforts to meet ABM's evolving requirements indicated the need for a larger computer and possible further delays in schedule. Bell was directed to consider Univac's proposal, together with other advanced-type memories, for possible use in meeting the requirements.

Agency and contractor comments

As requested by the Joint Committee on Atomic Energy, a classified draft of this report was released to the Secretary of Defense on March 26, 1971, for comment and declassification. On April 1, 1971, the Army provided copies to Western Electric Company, the prime contractor, for comment.

By letter dated April 29, 1971, the Deputy Assistant Secretary of the Army (Research and Development) furnished the Army's comments on the draft of this report. (See app. I.) Western furnished its comments by letter dated April 22, 1971. (See app. II.) Corrections and suggested clarifications have been appropriately recognized in the preceding sections of the report. The more significant comments are summarized and discussed below.

1. In regard to the Army's participation in the decision to use the slower core memory, the Army stated that:

> "*** Government representatives were constantly aware of both the alternatives being considered by the contractor and the consequences of those alternatives. The extent of Government participation in the final decision to utilize the 500 nanosecond core memory is consistent with the broad responsibility and extensive capability which the Government requires of the Weapon System Contractor.
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> "*** Alternatives to the Data Processing System memory were under continuous review and consideration by the NIKE-X Project Office with regard to both cost and system effectiveness. The Project Office had considered the use of plated wire, coupled film, mated film, and core memories, and Government personnel agreed with *** [Bell's] recommendation to use 500 nanosecond core memories only after assuring themselves that it was in all important regards the most advantageous approach in terms of cost, efficiency, and reliability.

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"*** while the Government must supervise, review, and evaluate the proposals and recommendations of the prime contractor in the development of the program, the Government has neither the facilities nor the staff to duplicate completely the *** [weapon system contractor's] efforts. Between the extremes of complete Government in-house capability, on the one hand, and unreasonable abdication of Government responsibility, on the other hand, lies the middle ground upon which effective Government management must rest. Qualified Government personnel must remain aware and fully informed of the prime contractor's activities and must evaluate and review any contractor proposal or recommendation which, if acted upon, would significantly affect cost, schedule, system integrity, or system performance. It is considered that the Government adequately performed this required management function."

We recognize that the technical expertise required to design and develop a weapon system as complex as ABM makes critical and independent evaluations difficult and necessitates a large degree of reliance on a prime contractor's technical advice. The Army acknowledged that it must review and evaluate contractor proposals or recommendations which would significantly affect cost, schedule, system integrity, or system performance.

During our review we asked the Army for its memorandum of the meeting with Bell officials which led to the memory change decision. The Army could not provide such documentation but did furnish Bell's memorandum of the meeting, which stated, in essence, that core had been chosen because it cost less than mated- or couple-film memory. (See p. 11.) This memorandum did not refer to the extent that the Army had participated in this decision. The Army informed us that detailed independent evaluations had not been made because of the unavailability of adequate technical staff and facilities.

Since the Government's review and evaluation were limited to desk reviews and discussions with contractor personnel (see p. 11), we do not agree with the Army's contention that an adequate review was made in this instance. In our opinion, the memory design change described in this report involved the types of system design, cost, and growth potential issue that require critical Government assessment of a contractor's proposal by in-house staff and/or, where appropriate, by technical advisory groups to ensure that the technical advice does not become, in effect, technical decisionmaking and that the Government makes the important program decisions.

2. With respect to the advantages of mated film proposed by UNIVAC in its September 1967 response to the core proposal (see p. 9), the Army stated that:

> "*** The reliability of the thin film memory has not been proven in a production model data processor. Some members of the technical community are aware of the inherent effects of aging on thin film memory. These effects could reduce the reliability of the memory. In addition, neither Univac nor any other known computer vendor has delivered large computers designed upon thin film memory concepts. The trends have been toward using core or integrated circuit memory."

It appears that the Army was referring to current information on the state of the art and the producibility of the memory design--especially the trends toward the use of integrated-circuit memory--rather than to information available at the time of the decision.

As far as the current technology and applications are concerned, the magnetic film design has been produced for use in military systems where there is a need for high reliability, long life, and extreme environmental applications; e.g., the Navy has selected mated film for use in the S-3A aircraft avionics program. The available documentation indicates that, in the 1967 time frame, when the design changes were being considered, core and film were the prime alternatives for use in ABM's data processing subsystem.

In September 1967 Univac proposed a mated-film alternative having characteristics that seemed to offer significant advantages. About 6 months later Univac submitted an unsolicited proposal for a faster mated-film memory having similar characteristics. After a visit to Univac's facilities, Bell personnel substantially validated Univac's claims, added that the mated-film design appeared to be producible and reliable, and estimated a material savings if the mated-film design were used in SENTINEL. As previously explained, we believe that these circumstances should have prompted the Army to more critically and independently evaluate the mated-film alternative.

3. Western stated that:

> "*** statements by Univac officials are reported suggesting that the mated film proposal made by Univac in 1968 was substantially similar to its 1967 proposal. [See pp. 12 and 13.] In fact, the 1967 proposal was technically inadequate. Univac's 1968 proposal reflected further independent development of a new memory of different characteristics. Also, the estimate of potential cost savings from this later proposal was predicated on the much larger number of sites in the SENTINEL deployment, and could not have been realized in the much smaller SAFEGUARD deployment even if otherwise feasible."

It appears that the basic characteristics or advantages of mated film were its greater packaging density and the related reduction in the number of racks, which resulted primarily in the $27 million savings for SENTINEL estimated by Bell in 1968. Greater packaging density was also one of the major characteristics for mated film proposed by Univac in 1967. With respect to the technical adequacy of Univac's original proposal, the documentation furnished to us showed that the reason for choosing the core rather than the film design was Bell's representations that the core memory would cost less. (See p. 11.)

The estimate of $27 million in savings was based on the SENTINEL deployment plan. (See p. 12.)

The reduction in the number of racks, however, also should result in savings for the SAFEGUARD deployment. We agree that, under the present plans, the amount of savings for SAFEGUARD would be less because of the fewer number of sites at this time. With respect to possible modifications to SAFEGUARD, however, Bell stated in its SAFEGUARD Growth Study (see p. 22) that the possible alternative of using multiple radars instead of one radar would tend to increase the memory requirement. This, we believe, would correspondingly increase the savings resulting from the greater packaging density.

CHANGES TO DATA PROCESSING CONFIGURATION RECOMMENDED BY NATIONAL ACADEMY OF SCIENCES ADVISORY COMMITTEE

The shift from the SENTINEL to the SAFEGUARD deployment resulted in significant upgrading of the requirements for the data processing subsystem. The ABM objectives shifted from thin area defense against the unsophisticated Chinese threat to terminal defense of the MINUTEMAN sites against a more massive and sophisticated Russian threat.

To meet SAFEGUARD's greater defense objectives, the requirement for a Central Logic and Control having throughput capability of approximately 6.5 million instructions a second (a five-processor multiprocessing system) for the 1-68 SENTINEL Chinese deployment was increased to about 13 million instructions a second (a 10-processor multiprocessing system) for the Russian threat. The requirements for program and data storage capacity also were substantially increased.

On the basis of the data processing performance and design specifications, maximum sizing is 10 processors, 16 program storage units, and 16 variable storage units (10-16-16). The point at which an additional processor will not increase throughput in proportion to the additional processor's capabilities and cost has not yet been demonstrated.

According to the prime contractor, the Central Logic and Control has a design limit of 15 processors and production of configurations containing more than 10 processors will require modification to the interfaces between the processor units and the various other units of the Central Logic and Control.

Four processors are installed and operating as a multiprocessor Central Logic and Control at the prototype MSR located at Kwajalein Missile Range. No more processors will be added to this test site. The first 10-processor Central Logic and Control is scheduled to be installed at the SAFEGUARD Tactical Software Control Site at Whippany, New Jersey, in February 1972 for use in the development of software for the tactical sites.

The National Academy of Sciences Advisory Committee on the NIKE-X Data Processing System, at a meeting held in April 1969 with representatives of the SAFEGUARD organization, the Advanced Ballistic Missile Defense Agency, and the prime contractor, discussed the results of its review of the data processing plans for SAFEGUARD. According to the advisory committee's report on this meeting, the Army's plans called for continued development of the existing multiprocessor Central Logic and Control and--due to the uncertainty of achieving the desired performance by this approach--for concurrent parallel development of alternatives.

The advisory committee's position was that the data processing system must be made to accommodate changing requirements--handling more complex threats and more demanding radars--and that commercial systems probably could better meet these requirements than the complex software needed for the present Central Logic and Control.

For SAFEGUARD Phase 1 deployment at two MINUTEMAN sites, the advisory committee recommended commercially available computers as the prime candidates instead of the hardware being developed for the existing Central Logic and Control approach. The existing multiprocessor configuration for the Central Logic and Control would continue in development as a backup system.

The advisory committee reasoned, in essence, that commercial data processors currently, or soon to be, available could handle the traffic projected at the busiest centers with one or two central processors instead of the 10 to 15 processors needed for the current multiprocessor approach. The advisory committee questioned the feasibility and efficiency of the complex software system needed to handle many processors.

The SAFEGUARD System Manager and the prime contractor concluded that the adoption of the advisory committee's recommendations could endanger SAFEGUARD's scheduled readiness dates, particularly for Phase 1. Therefore, according to a SAFEGUARD system design review, it was concluded (1) that planning for Phase 1 should be pursued by employing the current Central Logic and Control multiprocessor approach and that production planning and software development must

proceed as required to support all options of Phase 2,[1] (2) that continuous review of the program should be maintained to determine whether modification of this course of action would be required, and (3) that studies should be continued, on an expanded basis, of alternative approaches involving later generation commercial hardware and software.

In May 1969 the Director, Defense Research and Engineering, and the SAFEGUARD System Manager requested that a review of the status of the SAFEGUARD data processing system be performed by the Office of the Director, Defense Research and Engineering. According to a Defense memorandum, the major conclusion reached during this study was that the primary system should be the current hardware to meet the Phase 1 schedules. The memorandum stated, however, that the advisory committee was likely correct in its judgment that very large commercially available computers would become the best candidates in the long run for operational ABM systems. Accordingly the memorandum stated that the SAFEGUARD project office should:

1. Study means for introducing commercial data processing into SAFEGUARD, including the remote possibility of use in Phase 1.

2. Initiate software development to use higher order languages and other techniques to facilitate transfer from the prime contractor's machines to other processors.

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[1]Under Phase 2 there are three optional deployments which can be implemented individually or in combination. Phase 2a provides for deployment at other MINUTEMAN sites and at the National Command Authority at Washington, D.C., to provide confidence that a number of MINUTEMAN missiles will survive. Other Phase 2 options provide for expansion to 12 sites for additional defense objectives, including (1) increased protection of the strategic bomber force against Russian-submarine-launched ballistic missiles and fractional orbital bombardment systems and (2) area defense against a Chinese ICBM attack.

In August 1969 the Director, Defense Research and Engineering, directed the prime contractor to study the growth of the SAFEGUARD deployment that would be necessary to ensure that a number of MINUTEMAN missiles would survive an attack by an evolving Russian counterforce capability. In its report dated December 31, 1969, and entitled "SAFEGUARD Growth Study," Bell estimated a throughput requirement of 25 million instructions a second on the basis of an assumed need for the capabilities of the data processing subsystem to equal the full capabilities of the MSR.

The study found that obtaining 25 million instructions a second by using SAFEGUARD Central Logic and Control hardware was possible but would require either (1) upgrading the component with faster memories, incorporating other improvements, and providing configurations of 15 processors or (2) using two cooperating SAFEGUARD Central Logic and Control configurations. The study concluded that, in comparison with alternative data processing implementations, the extension of the present SAFEGUARD Central Logic and Control technology would result in clearly exorbitant costs.

As of June 1971 the Army planned to use the present Central Logic and Control for SAFEGUARD data processing hardware but studies were being made of alternatives for possible use if the growth threat exceeded the capacity of the Central Logic and Control.

Contractor comments

Western stated that:

> "On pages 20-24, the draft provides data selected from the report of the NAS [National Academy of Sciences] Advisory Committee. The selected data may give the impression that commercial data processing systems could be used more readily in SAFEGUARD than was actually envisioned in the NAS report. NAS recognized that no available commercial data processors meet SAFEGUARD requirements and that the use of commercial data processors would require a combination of computer reengineering, radar redesign, or modifying the overall SAFEGUARD objectives or deployment plan."

As stated in this report, the advisory committee's position was essentially that (1) the computers being developed for the multiprocessor concept involved complex software of questionable feasibility and (2) very large computers currently, or soon to be, available could better handle the projected threat. The prime contractor was technically correct in pointing out that a commercial computer could not be used in its on-the-shelf configuration and that some degree of engineering modification would be needed to achieve a specified SAFEGUARD configuration.

It seems reasonable to assume, however, that this type of additional effort would not be significant when compared with the alternative of continued development under the present multiprocessor concept which, as stated in the SAFEGUARD Growth Study, involved clearly exorbitant costs.

PRIME CONTRACTOR'S DECISION TO MANUFACTURE PROCESSORS IN-HOUSE

Under its research and development subcontract, Univac's responsibilities included the design and development of processors and the fabrication of breadboard models. The processors were fabricated by Western and were shipped to Univac for checkout and debugging. Under the production program Univac had no responsibility for the manufacture of processors; the processors were to be manufactured mainly by Western.

The decision to utilize Lockheed's core memory rather than Univac's film memory left Univac without a specific hardware allocation in the SENTINEL production program. On December 5, 1967, Bell told Western that, because Univac had designed and developed the processor, it would be desirable to have Univac's engineering design support during design and deployment of the SENTINEL system.

Bell told Western also that engineering design effort alone might not be sufficient to ensure the availability of Univac's best designers and, consequently, suggested that Univac be given complete responsibility, including manufacturing, for the processor. Bell suggested that the responsibility would enlist Univac's self-interest and would better ensure the availability of Univac's employees for the SENTINEL program. Bell stated, however, that it would not expect Western to take this action if Univac were not economically competitive.

On December 28, 1967, Western began discussions with Univac. On May 1, 1968, Western requested Univac to submit a proposal in connection with the processors. Western's request did not concern complete manufacturing responsibility for the processors but, rather, was limited to (1) wiring, assembling, and testing 101 processors, (2) manufacturing 9,000 multilayer boards, (3) manufacturing 10,500 access frames, and (4) manufacturing 2,220 analog racks.[1] At that

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[1]Multilayer boards and access frames are components of the processor. The analog rack is used to house such components as power supplies and test equipment.

time Western's manufacturing plans provided for processor wiring, assembling, and testing in its Burlington shops; for either making or buying the multilayer boards and analog racks; and for buying access frames.

Western told us that, in its opinion, wiring, assembling, and testing 101 processors would have satisfied Bell's objective of giving Univac a significant and continuing role in the SENTINEL and SAFEGUARD programs. Western said that the requirements for access frames, multilayer boards, and analog racks had been included to create a procurement package which would (1) be attractive to Univac, (2) have the least adverse economic effect on the program, (3) be acceptable to the Government, and (4) respond to Bell's request. Western said that Univac had not been requested to submit a proposal for complete manufacture of processors because Univac was not qualified to make digital racks. The racks were made previously by Western.

On May 24, 1968, Univac submitted the following cost-plus-a-fixed-fee proposal.

Processors	$ 4,456,444
Access frames	7,136,500
Multilayer boards	2,609,000
Analog racks	8,234,600
Total	$22,436,544

The proposed amounts for processors did not include (1) the cost of equipment to be furnished to Univac by Western, (2) transportation of logic chassis and digital racks from Western to Univac, (3) Univac's expense for handling the Western-furnished equipment, logic chassis, and digital racks, and (4) Western's expense for supervising and monitoring Univac's work. Adjusted for these items, Western's estimated cost of placing the work with Univac was as follows:

Processors	$ 6,171,168
Access frames	7,136,500
Multilayer boards	2,609,000
Analog racks	8,234,600
Total	$24,151,268

In its evaluation of Univac's proposal, Western compared (1) the proposed costs for assembling, wiring, and testing the processors with the estimated costs for doing the work in-house and (2) the proposed costs for multilayer boards, access frames, and analog racks with proposals from other potential suppliers. These comparisons showed that Univac's cost of $24.2 million ($6.2 million for processors) would be about $4.5 million higher than Western's estimated cost of $19.7 million ($3.4 million for processors). On that basis Western concluded that Univac was not competitive and, on June 21, 1968, notified Univac that its proposal had been rejected.

We examined Western's cost estimates, Univac's proposal, and proposals from Western's other potential suppliers. We found that the difference of about $4.5 million computed by Western had been based on a comparison of Univac's proposed price for the components with Western's estimated cost to wire, assemble, and test the processors and with the average prices quoted to Western by other sources to manufacture the other components.

Our examination showed that the Army project office had not been required to review, and had not reviewed, the costs and other considerations supporting Western's decision to reject Univac's proposal. Western officials informed us that the Government's review and approval usually were not requested until a supply source had been selected and that Western's negotiations with Univac represented preliminary evaluations of Univac as a potential manufacturing source. In this case, however, it appears that a review by the Army project office would not have resulted in a reversal or a significant modification of Western's decision.

APPENDIXES

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, D.C. 20310

29 April 1971

Dear Mr. Bailey:

This is in response to your letter of March 26, 1971, to the Secretary of Defense concerning your review of the Data Processing Subsystem for the SAFEGUARD System. Please find enclosed the Army comments to GAO Draft Report, "Examination Into Army's Evaluation of Certain Contractor-Initiated Design Changes and Make-or-Buy Decision for Components of Data Processing Subsystem of SAFEGUARD Antiballistic Missile System," (Code 67029), dated 26 March 1971, (OSD Case #3257).

The Army comments are generally addressed to clarification and explanation of portions of the draft report. However, I think that the comment concerning Army participation in the decision to utilize the slower core memory is particularly important. Although the decision to use the core memory is now more than three and one-half years old, a review of circumstances leading up to the decision indicates that Government representatives were constantly aware of both the alternatives being considered by the contractor and the consequences of those alternatives. The extent of Government participation in the final decision to utilize the 500 nanosecond core memory is consistent with the broad responsibility and extensive capability which the Government requires of the Weapon System Contractor.

The General Accounting Office is authorized to distribute copies of this report to the Congress in accordance with DOD Directive 5200.1. It is requested that this reply, with comments, be published as an appendix to the final report.

Charles L. Poor
Deputy Assistant Secretary of the Army
(Research and Development)

Mr. Charles M. Bailey
Director, Defense Division
U.S. General Accounting Office
Washington, D. C. 20548

APPENDIX I

SPECIFIC COMMENTS ON GAO DRAFT REPORT
RE SAFEGUARD DATA PROCESSING SUBSYSTEM
DATED 26 MARCH 1971

GAO STATEMENTS [Page 1, lines 22-27,] [See GAO note, p. 37.]

(Reference Page 1, lines 15-19, of the GAO letter forwarding the Report to Congress)
"Our examination indicated that the Army project office--because of an insufficient number of competent technical personnel--did not make critical and independent evaluations of the rationale and support for, or available alternatives to, the system prime contractor's proposal to change memory components from a film design to a slower core design."

[Page 9, lines 7-9,]
(Reference Page 9, lines 12 and 13, of the GAO Report)
"A Project Office official informed us that the Government did not make an independent study to evaluate BTL's position."

[Page 11, lines 9-13,]
(Reference Page 12, lines 3-6, of the GAO Report)
"We found no evidence that the Army had independently, or in participation with BTL, compared the technical features and the expected costs of the core design vs. the mated film design or other alternatives."

ARMY COMMENT

The GAO statements relate to the Army participation in the decision to change from a 200 nanosecond film to a 500 nanosecond core memory. At all times during the evolution of the change to a 500 nanosecond core memory, key Government personnel at the Project Office were aware that improvements in the Data Processing System were being considered by BTL. Government and BTL personnel were in frequent contact with each other discussing the status of memory considerations. Alternatives to the Data Processing System memory were under continuous review and consideration by the NIKE-X Project Office with regard to both cost and system effectiveness. The Project Office had considered the use of plated wire, coupled film, mated film, and core memories, and Government personnel agreed with BTL's recommendation to use 500 nanosecond core memories only after assuring themselves that it was in all important regards the most advantageous approach in terms of cost, efficiency, and reliability.

An integral aspect of the NIKE-X/SENTINEL/SAFEGUARD development has been the utilization of a prime Weapons System Contractor (WSC), Western Electric Company (WECo) and its associate, Bell Telephone Laboratories (BTL). It is the function of the WSC to provide system engineering and technical direction, including developing, testing, integrating, producing, and deploying the weapons system. The Department of Defense recognizes that such a prime contractor occupies a highly influential position both in determining basic

ARMY COMMENT (Continued)

concepts of a system and in supervising their execution by other contractors. Realistically, while the Government must supervise, review, and evaluate the proposals and recommendations of the prime contractor in the development of the program, the Government has neither the facilities nor the staff to duplicate completely the WSC's efforts. Between the extremes of complete Government in-house capability, on the one hand, and unreasonable abdication of Government responsibility, on the other hand, lies the middle ground upon which effective Government management must rest. Qualified Government personnel must remain aware and fully informed of the prime contractor's activities and must evaluate and review any contractor proposal or recommendation which, if acted upon, would significantly affect cost, schedule, system integrity, or system performance. It is considered that the Government adequately performed this required management function.

[Page 2, lines 15-19,]

GAO STATEMENT (Ref. Page 2, last line, and Page 3, lines 1 and 2, of the GAO letter forwarding the Report to Congress)

"We found that the Army did not participate in or review the cost and other considerations supporting the prime contractor's decision."

ARMY COMMENT

It is not clear whether this statement is intended to be critical; however, it is easily construed as implying that the Army failed to perform a required task. The contractor's action in issuance of a Request for Quotation and the subsequent rejection of the proposal was within the normal prerogatives inherent to a prime contractor responsible for total system integration and management. As noted and explained in the last paragraph of the GAO Report, beginning at page 22, the Army was not required to review this type of contractor decision.

Because the above quoted statement could be misconstrued easily, it is recommended that it be deleted.

[Page 8, lines 3-6 and 13-15,]

GAO STATEMENT (Ref. Page 8, lines 8-11, of the GAO Report)

"In April 1967 the Army directed Bell to study an ABM deployment for thin area defense and limited terminal defense of MINUTEMAN sites--referred to as the 1-67 deployment. Primary emphasis was to be placed on cost-effective growth of the MINUTEMAN terminal defense."

ARMY COMMENT

This statement could be construed as implying that the 1-67 study was primarily aimed only at evaluating MINUTEMAN terminal defense. This was not the case; rather, both the CPR and MINUTEMAN defense were primary considerations in that study. Later a CPR defense portion of the study was used as a basis for the decision for deployment of the SENTINEL system.

[Page 9, lines 18-27,]

GAO STATEMENT (Ref. Page 9, line 21, Page 10, line 1-7, GAO Report)

"In September 1967 the requirement was reduced from 4 million to 1.6 million instructions per second, according to SAFEGUARD System Office officials processors with the higher speed would not be available in time for early deployment of a thin defense. Shortly thereafter, BTL reported that substituting the slower memory units for the 200 nanosecond units would reduce the processor throughput and the approved requirement was further reduced to 1.3 million instructions per second."

ARMY COMMENT

The GAO statement could be construed as implying that the basic design of the processor was changed to effect the reduction in throughput. The reduction in throughput was accomplished by changing the memory from 200 nanoseconds to 500 nanoseconds. The slower memory was selected because the I-67 System Studies showed that a slower memory was the most cost effective approach with the reduced threat. Choosing the slower memory resulted in only a 20% decrease in throughput at a substantial cost savings.

[Page 9, lines 34-40 and page 10, lines 1-4,]
GAO STATEMENT (Ref. Page 10, line 13-18, GAO Report)

"In a response dated 22 September 1967, UNIVAC, in declining to bid on the core proposal, stated that mated film had advantages over core memory such as: (1) potential for greater speed, (2) lower power requirements, (3) higher packaging density per memory rack, (4) greater long-term reliability and (5) application of low cost, mass production automated techniques. UNIVAC contended that these advantages outweighed any initial cost advantages of core memory. Since there may have been other factors which have not been brought to our attention, we cannot comment on the validity of UNIVAC's statements."

ARMY COMMENT

It should be noted that there were other considerations in the response to the points made by UNIVAC. The reliability of the thin film memory has not been proven in a production model data processor. Some members of the technical community are aware of the inherent effects of aging on thin film memory. These effects could reduce the reliability of the memory. In addition, neither UNIVAC nor any other known computer vendor has delivered large computers designed upon thin film memory concepts. The trends have been toward using core or integrated circuit memory.

[Page 10, lines 15-18, and page 11, lines 1-6,]

GAO STATEMENT (Ref. Page 11, lines 3-10, GAO Report)

"A Project Office official told us that the only documentation of the 11 Oct 67 meeting was a BTL memorandum dated 1 Nov 67. The memorandum showed that BTL had specified a level of reliability of 5000 hours mean-time-between-failure but Lockheed's memory unit as proposed had a mean-time-between-failure reliability rate of 1200 to 1500 hours. Lockheed later increased its proposed price for 15 memory units from $1.4 million to about $2.2 million to provide for the 5000 hours reliability requirement."

ARMY COMMENT

The GAO statement could be construed as implying that the escalation in cost required to achieve the indicated higher memory reliability is excessive and more than that initially proposed by the subcontractor. Therefore, the following estimated vs. actual cost per bit for the higher reliability militarized and the non-militarized systems, indicates that the cost is as anticipated in the referenced BTL memorandum dated 1 Nov 67. This data indicated that cost estimate data used by the Government and BTL to make memory choice was reasonable. The BTL memorandum estimated the cost for the R&D commercial core memories systems to be 8 cents per bit. This was the estimated cost per bit for a non-militarized, non-high reliable (R&D 16,000 word 500 nanosecond) system. The actual cost per bit for the first ten R&D 16,000 word 500 nanosecond systems delivered was 7.84 cents. Delivery of these units began in May 1969.

The BTL memorandum also estimated the cost for the fully militarized R&D systems in small lots, with high reliability components to be 11 cents per bit. The actual cost for the first 20 fully militarized systems (16,000 dual 8,000 words) delivered for R&D use, was an average of 10.89 cents per bit. The delivery of the first militarized systems began in September 1969.

[Page 13, lines 16-26,]

GAO STATEMENT (Ref. Page 14, line 7-15, GAO Report)

"In March 1969 the President announced the planned deployment of the SAFEGUARD ABM system which provided for a 15 month delay in the readiness date for the first site. In April 1969 the Project Office replied to BTL's letter of 20 Dec 68 and concurred with BTL's findings. The Project Office informed BTL that efforts to meet the ABM's evolving requirements indicated the need for a larger computer and possibly further delays in schedule. BTL was directed to consider UNIVAC's proposal, together with other advanced type memories, for possible use in meeting the requirements."

ARMY COMMENT

During the April 1969 thru April 1970 timeframe, the Weapon System Contractor made detailed studies and analysis of SAFEGUARD Data Processing System size vs. threat. A summary of these studies and analysis is contained in a Memorandum for File signed by Mr. T. H. Crowley presented to SAFSCOM on 14 April 1970. This memo documented the results of a SAFEGUARD data processing growth study. One of several alternatives considered to increase the throughput of the Central Logic and Control was to include a faster memory. This option remains open if the need arises. In the text of the BTL studies, several memories were considered, including a faster core, based on the present core memory; a magnetic film, similar to those first considered for SAFEGUARD; and integrated circuit memories. All segments of industry at the time of the report felt that the most promising high speed memory during the next decade would be an integrated circuit memory. The BTL conclusions in the study were that if a memory change does come about in the future, studies will be concentrated on the integrated circuit memories rather than either core or magnetic film.

GAO note: Page number references in this appendix have been changed to correspond to the pages of this report.

APPENDIX II

Arthur P. Clow
Executive Vice President

Western Electric

April 22, 1971

MR. C. M. BAILEY, Director
Defense Division
United States General Accounting Office
Washington, D. C. 20548

Dear Mr. Bailey:

In accordance with the request in your letter of March 26, 1971 to the Secretary of Defense, I enclose the comments of Western Electric Company, Incorporated, to GAO Draft Report of March 1971 on Army's evaluation of (a) a contractor-initiated design change and (b) a proposal to subcontract certain components of the data processing subsystem of the SAFEGUARD antiballistic missile system. I trust that you will make these comments available to the Joint Committee on Atomic Energy along with your report and that you will consider it in the development of your final report.

We thank you for the opportunity to comment on the draft report.

Very truly yours,

Arthur P. Clow

Enc.

195 Broadway, New York, New York 10007 / 212 571-5761

Comments of
Western Electric Company, Incorporated to GAO Draft Report of March 1971 on Army's evaluation of (a) a contractor-initiated design change and (b) a proposal to subcontract certain components of the data processing subsystem of the SAFEGUARD antiballistic missile system.

April 22, 1971

CONTENTS

GAO note: These comments were omitted because they included classified information which is being forwarded separately to the Chairman, Joint Committee on Atomic Energy, and because the other unclassified corrections are recognized in the body of the report.

Summary Statement of Position of Western Electric

It appears that no particular criticism of the prime contractor in the performance of the ABM Program, or of its Associate, Bell Telephone Laboratories, is stated or reflected in the GAO draft report or its cover letter.

Our comments, therefore, are limited to a summary statement and some specific comments designed to correct certain inaccuracies found in the draft and to amplify upon the draft in several places, where we felt misleading inferences might otherwise be drawn.

[Pages 1 and 2] [See GAO note, p. 44.]

With regard to the first of the matters discussed, the 1967 decision to use core memory in the data processing subsystem, the draft, on page 1/of its cover letter, makes it clear that the ABM system's **capability** to realize program objectives was not adversely affected.

The draft indicates that the decision to use core memory was motivated by the desire to save money since the use of core memory would be less expensive than the mated film design. Equally important to the decision were the significant technical risks surrounding the mated film memory development which were not present with core memories. The Army and Bell Laboratories could proceed with assurance that 500 nanosecond core memories of the requisite characteristics could be produced in the required quantities on schedule. This was not the case for film memories. When changes in system requirements were made that permitted use of core memory, the decision was basically clear.

[Pages 12 and 13]

In a footnote on page 14 of the draft, statements by Univac officials are reported suggesting that the mated film proposal made by Univac in 1968 was substantially similar to its 1967 proposal. In fact, the 1967 proposal was technically inadequate. Univac's 1968 proposal reflected further independent development of a new memory of different characteristics. Also, the estimate of potential cost savings from this later proposal was predicated on the much larger number of sites in the SENTINEL deployment, and could not have been realized in the much smaller SAFEGUARD deployment even if otherwise feasible.

[Pages 19-22,]

On pages 15-19, the draft provides data selected from the report of the NAS Advisory Committee. The selected data may give the impression that commercial data processing systems could be used more readily in SAFEGUARD than was actually envisioned in the NAS report. NAS recognized that no available commercial data processors meet SAFEGUARD requirements and that the use of commercial data processors would require a combination of computer reengineering, radar redesign, or modifying the overall SAFEGUARD objectives or deployment plan.

With regard to the second of the two principal matters discussed, the review in 1968 of a proposal to subcontract certain work on components of the data processing subsystem of the ABM system, the draft, in its concluding portion is to the point that Western's determination was sound and appropriate and that an independent review by the Army would not have reversed or significantly modified Western's decision.

Western's determination is characterized in the title and the cover letter to the draft (though not in the draft discussion itself) as a "make-buy decision". It is more correct, however, to characterize it in the way used in the draft discussion, namely, as an evaluation of a proposal to subcontract certain components of the data processing subsystem. It was merely a second look at a decision dating back as far as 1963, and incorporated in approved make-buy programs since that time, to assemble, wire and test the processors in-house, utilizing in part purchased components. The second look confirmed the original decision.

On page 5, in a footnote, the draft states: "Western's responsibilities involve primarily (1) administrative and financial matters relating to the contracts and (2) fabrication of hardware." This summary is accurate as to Western's R&D contracts administered through its Associate, Bell Telephone Laboratories. With regard to production contracts, Western's responsibilities include (1) management of the overall project, (2) engineering administration, (3) technical assistance to subcontractors on manufacturing processes, (4) product control of subcontractors, (5) financial control relating to the contract, (6) fabrication of hardware, (7) installation and test, and (8) coordination of all phases of the project to meet established schedules.

SPECIFIC COMMENTS

The Contractor-Initiated Design Change to Core Memory

Page 8 - Concerning the decision to use a core memory design instead of a mated film design, the GAO draft report omits mention of a major factor. The technological development and production base for core memories was firmly established and in being during the 1966-1969 interval. This was not the case for large coupled film or mated film memories. Hence, the Army and Bell Laboratories could proceed into the SENTINEL and SAFEGUARD production programs with assurance that 500 nanosecond core memories of the requisite characteristics could be produced in the required quantities on the required schedule. This was not the case for film memories. In the absence of a large manufacturing base and extensive field experience with film memories of comparable size, the adoption of film memories for the production program would have introduced a significant risk of encountering technical or production difficulties so severe as to impact on project schedules. Film memories were attractive in the 200-nanosecond speed region, where core memories were not available, and showed promise as an eventual competitor for core in the 500-nanosecond speed region.

[Page 11, last paragraph to page 13, first paragraph,]

Page 12, last paragraph to page 13, last paragraph and page 14, footnote - It should be noted that the 250-nanosecond mated film memory referred to here (Univac's unsolicited proposal in 1968) was not the same as the 500-nanosecond mated film memory referred to on pages 8 and 10 (Univac's mated film proposal in 1967). Univac's unsolicited proposal was for a new memory of different characteristics than those previously developed by Univac.

[Page 12, lines 25-26,]

Page 14, line 1 - The $27 million saving estimated in the "Study of Univac Unsolicited Proposal for Mated Film Memories" (1968) was based on a SENTINEL deployment of 6 PAR sites, 17 MSR sites and a BMDC, which was estimated to require 344 racks of Lockheed core memory at the various sites. This compares to 107 racks of Lockheed core required for the 2 PAR sites, 3 MSR sites and BMDC presently authorized for SAFEGUARD. It is evident that neither the estimated $27 million saving nor the estimated $20 million dollar net saving can be construed as applying to SAFEGUARD.

The NAS Advisory Committee Report

[Page 20, paragraph 3]

Page 16, paragraph 3 - Concerning proposed use of commercial data processing systems for use in ABM systems, the draft report fails to observe that no commercial data processor available for procurement meets the availability and reliability objectives, the environmental criteria and the throughput requirements of SAFEGUARD. Thus, adoption of a commercial data processor would require some combination of:

a) Reengineering a commercial data processor.

b) Redesigning other SAFEGUARD components (and in particular the MSR and PAR buildings), and/or

c) Modifying the overall objectives or the overall deployment plan for SAFEGUARD.

Thus, the NAS Advisory Committee's recommendation was not for direct substitution of a commercial computer in place of the CLC to meet the existing requirements. Rather, it was the committee's opinion that changes of types (b) and (c) above might be required in any event to meet changing system requirements, and it was the committee's opinion that such changes could be accommodated more easily with a commercial data processor than with the CLC.

The Subcontract Proposal

[Page 24, paragraph 2, second sentence]

Page 20, second sentence - Bell Laboratories did not tell Western that Univac's engineering design support was "necessary", but rather that it was desirable; hence, Bell Laboratories' statement that it would not expect Western to give Univac a production responsibility if Univac were not economically competitive.

[Page 24, paragraph 4, third sentence]

Page 20, last paragraph, states, "WECo's request did not concern complete manufacturing responsibility for the processors but, rather, was limited to (1) wiring, assembling, and testing 101 processors, (2) manufacturing 9,000 multilayer boards, (3) manufacturing 10,500 access frames, and (4) manufacturing 2,220 analog racks." Concerning any implication that Western did not fully

implement the request made by Bell Laboratories stated in the preceding paragraph, it was not economical to have all components for a processor manufactured by Univac. Many manufactured or purchased articles, which are common to other units besides processors, are included in the wired, assembled, and tested end item. We believe the scope of work for the Univac proposal filled Bell Laboratories' request.

GAO note: Page number references in this appendix have been changed to correspond to the pages of this report.