U. S. GENERAL ACCOUNTING OFFICE

STAFF STUDY

THE SAFEGUARD BALLISTIC MISSILE DEFENSE SYSTEM

Department of the Army

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C O N T E N T S

SAFEGUARD BALLISTIC MISSILE DEFENSE SYSTEM

As a part of a continuing evaluation of major weapon system acquisitions, the General Accounting Office has reviewed the Army's practices and procedures in the SAFEGUARD ballistic missile defense program for preparing the Selected Acquisition Report, testing and evaluating system effectiveness, and measuring cost, schedule, and technical progress.

SYSTEM DESCRIPTION AND STATUS

The SAFEGUARD was originally planned to be a 12-site program. The system is comprised of (1) Spartan missiles for intercepts beyond the atmosphere, (2) Sprint missiles for intercepts within the atmosphere, (3) Perimeter Acquisition Radars for detecting and tracking targets, (4) Missile Site Radars for tracking at closer ranges and launching and guiding the two missiles, and (5) a Ballistic Missile Defense Center for operational command and control utilizing a data processor subsystem by which man would control the system.

On May 26, 1972, the President signed the Treaty on the Limitation of Anti-Ballistic Missile Systems which received Senate ratification on August 3, 1972. The Treaty limits SAFEGUARD deployment to two sites, places constraints on the configurations of the two sites, and limits the type of ballistic missile defense research and development programs which may be undertaken. Before the Treaty the approved SAFEGUARD program had consisted of a Ballistic Missile Defense Center at Colorado Springs, Colorado; deployment sites at Grand Forks, North Dakota, and Malmstrom, Montana; and advanced preparation for sites at Whiteman, Missouri, and Warren, Wyoming. (See ch. 1)

Coming events

As a result of the Treaty, the Secretary of Defense on May 26, 1972, directed that the following actions be immediately implemented in the SAFEGUARD program: (1) initiate planning to cancel the 12-site program, (2) suspend construction of the Malmstrom site and begin planning for dismantling, (3) suspend all future work for the remaining sites, (4) continue deployment of the Grand Forks site, and (5) initiate planning to deploy an anti-ballistic missile defense of the National Command Authority at Washington, D.C.

On July 10, 1972, the Army Chief of Staff directed that a ballistic missile defense system design review be made of the SAFEGUARD and related development programs to include an analysis of design, development, production, logistic support, construction, and related cost considerations. A separate study was initiated at the direction of the Secretary of the Army for the purpose of providing recommendations in the areas of responsibilities, organizations, and procedures for managing the Army's ballistic missile defense programs. The total impact of the Treaty on the SAFEGUARD program will not be known until these studies are completed and approved.

Following is a listing of milestone events related to the site at Grand Forks, North Dakota, where deployment is continuing.

January 1973	Complete construction of the Missile Site Radar facility
April 1973	Initiate Perimeter Acquisition Radar and data processor interface tests
June 1973	Initiate Perimeter Acquisition Radar engineering tests
September 1973	Complete construction of the Ballistic Missile Defense Center facility
October 1974	Readiness date for the Perimeter Acquisition Radar and the Missile Site Radar

(See ch 1)

Cost

Because of the difficulties in making either a one-or a two-site estimate as of June 30, 1972, a Selected Acquisition Report was not prepared, but a short narrative status report was issued which contained a brief discussion on cost, schedule, and technical performance of the acquisition. Our examination therefore covered a limited review of the March 31, 1972, Selected Acquisition Report and available status data as of the Treaty date.

As of May 26, 1972, the cost to acquire four SAFEGUARD sites was $7.973 billion which represented an increase of $1.789 billion from the $6.184 billion three-site estimate shown in the June 30, 1971, Selected Acquisition Report.[1] The increase was attributed to $199 million for economic changes, $417 million for schedule changes, $225 million for support changes, $856 million for quantity changes, $74 million for estimating changes, and $18 million for engineering changes.

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[1]As of December 31, 1972, the program acquisition cost had been reduced to $5.516 billion, primarily due to the reduction in deployment from four sites to one.

Provision for inflation was incorporated into the program estimate based on computations made in accordance with instructions issued by the Department of the Army which provided for estimating inflation by using specified percentages by appropriation type. Current and projected economic cost growth as of May 26, 1972, totals $790 million.

In reviewing the basis for the $7.973 billion four-site estimate, we observed that (1) the inflation estimate for the production effort was understated by about $24 million, (2) the Army estimate for production was about $125 million lower than estimated by the production contractor, and (3) the contingency estimate for construction changes at the first tactical site was about $50 million lower than the estimate provided by the construction contractor to support claims which have not been adjudicated or validated to date.

As of June 30, 1972, a total of $4.932 billion had been appropriated for the SAFEGUARD program of which $4.267 billion had been obligated and $3.277 billion expended. This status data covers the Research, Development, Test, and Evaluation (R, D, T & E); Procurement; and Military Construction (MCA) appropriations. (See ch. 2)

Contract data

The SAFEGUARD system is being developed under two cost-plus-incentive-fee type contracts and one cost-plus-fixed-fee contract. For the two cost-plus-incentive-fee type contracts, there is no incentive on cost. The incentives are on schedule and performance. As of June 30, 1972, the definitized value of the three development contracts totaled $1.457 billion.

The principal production contract is a cost-plus-fixed-fee contract and is negotiated annually. As of June 30, 1972, the definitized value of the contract totaled $1.690 billion. The contract has been partially terminated as a result of the Treaty limiting the deployment of Anti-Ballistic Missile Systems. There is no provision for economic escalation in either the production contract or the three development contracts.

The construction contract for the first tactical site, where the SAFEGUARD is to be deployed, is an advertised fixed price contract, and its definitized value totaled $153.4 million as of June 30, 1972. The construction contract for the second tactical site is a negotiated fixed price contract with provisions for economic escalation. As of June 30, 1972, the definitized value of the contract totaled $161.8 million. The contract, however, is in the process of being terminated because of the Treaty.

For the eight contracts listed in the contractor cost section of the June 30, 1972, Selected Acquisition Report, there were a total of 414 definitized changes and 443 undefinitized changes. The undefinitized changes were estimated to cost $46.9 million.

Performance

The Selected Acquisition Reports showed that the SAFEGUARD system performance requirements had not changed since June 30, 1971. The more significant performance requirements have not changed since the development estimate was prepared in March 1969. Required performance, however, has not been tested for certain system components, but the Selected

Acquisition Reports show that performance tested to date has met design requirements. (See ch 2)

Program milestones

Significant schedule changes occurred between the June 30, 1971, and March 31, 1972, Selected Acquisition Reports for the second and third tactical sites. The Treaty, however, eliminated these sites from the program. The Treaty did not affect the October 1974 equipment readiness date for the one remaining tactical site at Grand Forks. (See ch 2)

Relationship to other systems

A prototype demonstration program is currently being conducted on a Site Defense system which is planned to be used for augmenting SAFEGUARD if the Soviet threat continues to grow. The program concept envisions the addition of smaller radars, modified Sprint interceptors, and commercial data processors. Advanced development of this program was initiated in fiscal year 1971, but it has not been designated as a major acquisition for Selected Acquisition Report purposes. Several advanced ballistic missile defense programs are also included in the Army's overall research and development effort. The SAFEGUARD, Site Defense, and the advanced research programs are being considered in the system design review.

Selected acquisition reporting

Although not required by the Department of Defense instruction for preparation of the Selected Acquisition Report, the report, in our opinion, could be made more effective as a management tool and as a means for keeping the Congress informed if it (1) included estimated costs for all

items and services applicable to the SAFEGUARD system, (2) provided more information showing the actual time-phased progress of the acquisition in terms of cost, schedule, and technical performance, and (3) disclosed significant differences between Army and contractor estimates.

As of May 26, 1972, estimated costs totaling $2.466 billion applicable to the SAFEGUARD system were not being reported in the Selected Acquisition Reports. They include costs of warheads, test range support, family housing, training, and other support items. Current Department of Defense instructions do not require such cost to be included. Also, the Selected Acquisition Report does not provide the Congress with an assessment of program progress on a time-phased basis showing where the acquisition stands in relation to where it was expected to stand for the same amount of time and resources expended. In addition, the Selected Acquisition Report did not identify about $175 million in differences between Army and contractor estimates for production and construction which may indicate that future program cost could increase.

TEST AND EVALUATION PROGRAM

The SAFEGUARD test and evaluation program includes the essential elements of engineering, acceptance, and operational suitability testing, but the effectiveness of the program has been impaired to some extent because the SAFEGUARD system is being developed, produced, and deployed concurrently which is a departure from the more desirable phased acquisition process. To a great extent, however, this situation was dictated by the operational readiness dates required to meet the developing threat. When

engineering testing is not completed before large-scale production commitments are made, necessary design changes discovered by testing must be incorporated into production hardware, and the risks of costly modifications after deployment are increased.

The effectiveness of the SAFEGUARD test program has been impaired to some extent because of the complexity of the system and the major test limitations and constraints such as the Nuclear Test Ban Treaty and the infinite number of possible attack conditions. These limitations, however, are recognized in the test plans, and computerized simulations are being used to obtain data that cannot be obtained through live tests. Consequently, SAFEGUARD system effectiveness is being determined by a combination of test programs, computerized simulations, and engineering analyses.

Despite the high degree of concurrency the test plans prepared contained many of the essential elements of good test planning and test results were being evaluated and reported to intermediate and higher levels of the SAFEGUARD organization in a timely manner. Most of the test reports were highly technical in nature and did not specifically provide a direct correlation between test and evaluation results and the performance/design specifications established for the system and its subsystems. A periodic summary report which correlates the test and evaluation results to the performance/design specifications would, in our opinion, improve overall visibility into the technical progress of the system and provide better assessments of such progress to decision makers within the Army and Department of Defense.

The test and evaluation reports showed that there are several critical areas which, if not resolved, could degrade system effectiveness, but none of these are considered critical enough by the Army to preclude deployment of the system. These problems are known to SAFEGUARD management and efforts, including additional testing, are being directed toward corrective action. For the most part, the test and evaluation reports, including the annual assessment pursuant to the President's direction, indicate that technical achievements on the system are progressing satisfactorily.

The SAFEGUARD program has already passed most of the key decision points encountered in a phased, acquisition process, but the Site Defense program which was initiated in fiscal year 1971 affords the opportunity of applying the basic concepts of this process and incorporating the testing practices stipulated by recent Department of Defense directives. (See ch 3)

PROGRESS MEASUREMENT

Although a considerable amount of status data was being provided to the SAFEGUARD System Manager through various reporting media, these did not provide information that would disclose where the SAFEGUARD acquisition stood in relation to where it was expected to stand at a given point in time in terms of cost, schedule, and technical performance. The System Manager over the past several years has emphasized the need for establishing a management information system that would integrate cost, schedule, and technical performance data and provide him with an overall, periodic assessment of program progress.

Implementing actions directed by the System Manager include the following: (1) development and use of a single project work breakdown structure, (2) establishment of cost, schedule, and technical performance baselines, (3) implementation of contractor performance measurement criteria, and (4) development of a system for integrating these elements into a performance report covering the total program.

These actions have progressed to the point where the program participants, except for the development contractor, are using the SAFEGUARD project summary work breakdown structure for management reporting and control purposes. Cost, schedule, and technical performance baselines are being prepared, controlled, and monitored according to the work breakdown structure; and contractor performance measurement criteria have been applied to the internal management control systems of the prime production contractor and three of its four major subcontractors.

Revised procedures were issued in July and August 1972 to strengthen the cost estimating function, and extensive use is being made of parametric cost estimates to assist SAFEGUARD management in evaluating the validity and credibility of program estimates. Remaining actions to be completed involve primarily the integration of cost, schedule, and technical performance data and issuance of a periodic performance report containing an assessment of program progress. One crucial problem area which has not been resolved concerns the means to be used for integrating technical performance with cost and schedule data.

At two of the production contractor's facilities, we found that the information provided to the Army generally depicted the progress of the work completed against that which was expected to be completed for the same amount of time and resources expended. Although the systems did not provide for the routine reporting of technical progress, technical problems which impact cost or schedule are reflected in the reports and are assessed on an exception basis.

We also found that the contract work breakdown structure was properly integrated with the contractor's internal management control system. The integrated system was structured to define tasks to be performed; provided for assignment of organizational responsibility at each level of the work breakdown structure; established time-phased cost and schedule baselines for authorized work; provided for the accumulation of actual costs by work packages and organizational elements; allowed for comparison of work accomplished with that planned; and provided controls over changes to cost and schedule baselines.

The overall progress measurement system being implemented for the SAFEGUARD acquisition should, in our opinion, provide better visibility of program progress than has been available in the past. When completed, however, the system will not provide in-depth visibility into the time-phased progress of the SAFEGUARD acquisition primarily because the development contract data cannot be completely integrated with the production and construction data. The effectiveness of the system will also be impaired unless a method for integrating technical performance with cost and schedule goals is established.

While the Treaty on the Limitation of Anti-Ballistic Missile Systems has significantly reduced the future SAFEGUARD effort, the progress measurement system being implemented for the SAFEGUARD acquisition can be used for the Site Defense program in managing and controlling that program as it progresses through the phases of the acquisition process. (See ch. 4)

Matters for Consideration

The Treaty on the Limitation of Anti-Ballistic Missile Systems, signed by the President on May 26, 1972, and ratified by the Senate on August 3, 1972, has significantly altered the direction of the Army's ballistic missile defense program. The overall impact of the Treaty on the future of the ballistic missile defense program has been reviewed by the Army. Appropriate recommendations have been made to, and are being considered by, the Office of the Secretary of Defense. The results of these reviews would be of interest to the Congress for consideration during the 1974 authorization and appropriation hearings.

The signing of the Treaty resulted in the cessation of work at three sites and in several contract terminations. The Army's preliminary estimate of the sunk (nonrecoverable) costs for the equipment and facilities not required for a one-site SAFEGUARD deployment totals approximately $500 million. However, this does not take into account the use which may be made of residual facilities, hardware and material. For example, the Army has informed us that the Air Force is actively considering the use of the Malmstrom Perimeter Acquisition Radar hardware. Such use would reduce the cost of the lost effort. The Congress may wish to inquire into the status of the terminations.

As a result of the Treaty the Army has significantly reduced its plans for a multimillion dollar training facility. In addition, we have been informed that Army management organization for the ballistic missile defense program is being streamlined, resulting in major personnel reductions.

Agency Review

A draft of this staff study was reviewed by Army officials associated with the management of this program and comments were coordinated at the Headquarters level. The Army's comments are incorporated, as appropriate. As far as we know there are no residual differences in fact.

CHAPTER 1

INTRODUCTION

As a part of our continuing evaluation of major weapon system acquisitions, the General Accounting Office has reviewed the practices and procedures used in the SAFEGUARD ballistic missile defense program for measuring cost, schedule, and technical progress of the acquisition; testing and evaluating the effectiveness of the software and hardware components of the system; and preparing the Selected Acquisition Report of March 31, 1972.

DESCRIPTION OF THE SYSTEM

The SAFEGUARD ballistic missile defense system is a large, complex assembly of men and hardware which must operate together in order to counter the threat for which it was designed. The basic hardware components are two radar subsystems, two missile subsystems, and a data processor subsystem. Operational command and control of the entire defense system will be accomplished through a Ballistic Missile Defense Center.

One of the radars, the Perimeter Acquisition Radar, will be used for early detection of incoming warheads. The other radar, the Missile Site Radar, will be used to track warheads at closer ranges and to launch and guide the two defensive missiles to intercept the incoming target. The Spartan missile will be used for intercepting enemy warheads above the atmosphere, and the Sprint missile will be used for closer range intercepts. The data processing systems consist of both the computer hardware and the software programs necessary to operate the system.

HISTORY OF THE PROGRAM

The Department of Defense and Department of the Army have conducted for over 16 years an extensive research, development, and test program to develop a ballistic missile defense capability. As early as 1962, Nike-Zeus missiles, predecessors of the present SAFEGUARD system missiles, were developed and tested for intercepting intercontinental missile warheads.

In September 1967 the Secretary of Defense announced the decision to begin deployment of the SENTINEL system which was oriented primarily against a threat from Communist China. A 1969 study disclosed that the Chinese intercontinental ballistic missile program had slipped but that the Russian intercontinental ballistic missile program had not leveled off as expected and was becoming a dangerous threat.

In view of the changing threat from the Soviet Union, the President made the decision in March 1969 to initiate deployment of a SAFEGUARD ballistic missile defense system which was substantially different in configuration and purpose from the previously approved SENTINEL system. The President announced that plans for expanding the deployment to a full 12-site program would be determined based on a periodic analysis of the threat.

The President established three primary defense objectives for the SAFEGUARD system: (1) protect our land-based retaliatory forces against a direct attack by the Soviet Union, (2) defend the American people against the kind of nuclear attack which Communist China is likely to be able to mount within the decade, and (3) protect against the possibility of accidental attacks from any source.

Prior to the signing of the Treaty on the Limitation of Anti-Ballistic Missile Systems on May 26, 1972, the approved SAFEGUARD program consisted of a Ballistic Missile Defense Center at Colorado Springs, Colorado; deployment sites at Grand Forks, North Dakota, and Malmstrom, Montana; and advanced preparation for sites at Whiteman, Missouri, and Warren, Wyoming. As of June 30, 1972, a total of $4.932 billion had been provided in the R, D, T & E, Procurement and MCA appropriations for this effort of which $4.267 billion had been obligated and $3.277 billion expended.

As a result of the Treaty, the Secretary of Defense directed, on May 26, 1972, that the following actions be immediately implemented in the SAFEGUARD program:

(1) initiate planning to cancel the 12-site program,

(2) suspend construction of the Malmstrom site and begin planning for dismantling,

(3) suspend all future work for the remaining sites,

(4) continue deployment of the Grand Forks site, and

(5) initiate planning to deploy an anti-ballistic missile defense of the National Command Authority at Washington, D.C.

The System Manager is also responsible for conducting a prototype demonstration program on a Site Defense system which is planned to be used for augmenting the SAFEGUARD system if the Soviet threat continues to grow. Advanced development of this program was initiated in fiscal year 1971, however, it has not been designated as a major acquisition for Selected Acquisition Report purposes. The program concept envisions the addition of smaller radars, modified Sprint interceptors, and commercial data processors.

SYSTEM MANAGEMENT

The SAFEGUARD management organization comprises the SAFEGUARD System

Office, Rosslyn, Virginia, and its subordinate organization; the SAFEGUARD System Command, Huntsville, Alabama, and the SAFEGUARD System Evaluation Agency, White Sands, New Mexico. These activities report to the SAFEGUARD System Manager who reports directly to the Army Chief of Staff and functions as an element of the Office of the Chief of Staff. The System Manager has the mission of assuring the timely, effective deployment of the SAFEGUARD system.

The SAFEGUARD System Command is responsible for system acquisition and the SAFEGUARD System Evaluation Agency for independent system evaluation within the SAFEGUARD system organization. In addition, the Corps of Engineers has established a Huntsville Division for accomplishing the construction effort, the Army Materiel Command has established the SAFEGUARD Logistics Command for logisitics support, and the Army Strategic Communications Command has established the SAFEGUARD Communications Agency for managing the communications program.

The Western Electric Company, Inc., New York, New York, is the prime contractor for overall development and production for the SAFEGUARD program and has assigned the development work to Bell Telephone Laboratories, Inc., a subsidiary company, and to other major subcontractors.

INTEGRATED MANAGEMENT CONCEPT

Integrated management is a concept established by the Department of the Army which concentrates in the SAFEGUARD System Manager full responsibility for all aspects of the SAFEGUARD program.

The primary mechanisms used by the System Manager for controlling, directing, and coordinating the program are the various plans and documents comprising the SAFEGUARD system master plan. The master plan is used by the System Manager for approving major concepts and program actions,

documenting actions for necessary approval from higher authority, reviewing various program activities, and developing standardized procedures including a uniform and formal planning process.

SCOPE OF REVIEW

Information on the SAFEGUARD program was obtained by reviewing plans, reports, correspondence, and other records at the contractor plants, the system program office, intermediate and higher commands of the Department of the Army and the Office of the Secretary of Defense. We also interviewed appropriate agency officials.

We evaluated management policies and the procedures and controls related to the decisionmaking process, but we did not make detailed analyses of audits of the basic data supporting program documents. Further, we made no attempt to (1) assess the validity of the military threat or the technology, (2) develop technological approaches, or (3) involve ourselves in decisions while they were being made.

CHAPTER 2

WEAPON SYSTEM STATUS

As a part of the actions taken after the Treaty on the Limitation of Anti-Ballistic Missile Systems was signed, the Army Chief of Staff directed that a ballistic missile defense system design review be made of the SAFEGUARD system and related development programs to include an analysis of design, development, production, logistical support, construction, and related cost considerations. At the direction of the Secretary of the Army, a separate study was initiated for the purpose of providing recommendations in the areas of responsibilities, organizations, and procedures for managing the Army's ballistic missile defense programs.

Because of the difficulties in making either a one- or two-site estimate as of June 30, 1972, the Assistant Secretary of Defense (Comptroller) decided that a Selected Acquisition Report would not be prepared and directed that a short narrative status report be prepared instead. The report issued discussed cost, schedule, and technical performance but pointed out that program acquisition costs would not be available until completion of the system design review. However, the Army's preliminary estimate of the sunk (unrecoverable) costs for the equipment and facilities not required for a one-site SAFEGUARD deployment totals approximately $700 million. However, this does not take into account the use which may be made of residual facilities, hardware and material. For example, the Army has informed us that the Air Force is actively considering the use of the Malmstrom Perimeter Acquisition Radar hardware. Such use would reduce the cost of the lost effort.

The total impact of the Treaty on the SAFEGUARD program will not be known until completion and approval of the system design review; therefore, we made a limited review of the cost, schedule, and technical performance data reported in the March 31, 1972, Selected Acquisition Report and available status data as of the Treaty date. Our examination of this data was directed toward (1) determining the basis for significant changes since our review of the June 30, 1971, Selected Acquisition Report and (2) evaluating improvements and continuing shortfalls in the reporting system.

COMING EVENTS

January 1973	Complete construction of Missile Site Radar facility at first tactical site
April 1973	Initiate Perimeter Acquisition Radar and data processor interface tests at first tactical site
June 1973	Initiate Perimeter Acquisition Radar engineering tests at first tactical site
September 1973	Complete construction of the Ballistic Missile Defense Center facility
October 1974	Perimeter Acquisition Radar and Missile Site Radar readiness date for the first tactical site

SYSTEM COST EXPERIENCE

The March 31, 1972, Selected Acquisition Report showed an estimated cost of $7.975 billion for acquiring four SAFEGUARD sites. As of May 26, 1972, the four-site estimate had decreased to $7.973 billion and consisted of $2.506 billion for development, $4.171 billion for production, and $1.296 billion for construction. The $7.973 billion four-site program estimate represents an increase of $1.789 billion from the $6.184 billion three-site estimate shown in the June 30, 1971, Selected Acquisition Report.

Reported cost increases

The cost increases of $1.789 billion was attributable to the following factors.

	Estimated increase (in millions)
Economic changes (inflation)	$ 199
Schedule changes (Stretchout)	417
Support changes	225
Quantity changes (one additional site)	856
Estimating changes	74
Engineering changes	18
Total increase	$1,789

Economic changes

The increase of $199 million for economic changes consisted of $42 million for development, $78 million for production, and $79 million for construction. Inflation costs were based on computations made in accordance with instructions issued by the Department of the Army in October 1971 which provided for estimating inflation by using specified percentages by appropriation type.

Total economic cost growth (including projected inflation) reported in the SAR covering the period May 1969 (2-site deployment) to May 1972 (4-site deployment) is about $799 million.

Schedule changes

The increase of $417 million for schedule changes comprised $406 million for retaining management, engineering, and production capabilities over a longer period because of the stretched-out deployment schedule for the third tactical site and $11 million for added repair parts for a longer period of deployment for the first three sites.

Support changes

The increase of $225 million for support changes comprised $199 million for added reliability and on-site tests and $26 million for community support.

Quantity changes

The increase of $856 million for quantity changes was attributable primarily to the addition of the fourth tactical site to the program estimate. This increase consisted of (1) $753 million for design, construction, hardware, and repair parts for the fourth site; (2) $54 million for missile reliability and maintainability hardware; (3) $38 million for advanced preparation planning for a National Command Authority site; (4) $8 million for additional spare parts for the first three sites; and (5) $3 million for miscellaneous design and engineering support.

Estimating changes

The increase of $74 million for estimating changes comprised 41 revisions to previous estimates. Two primary changes were increases of $42 million for revised construction estimates for the first three sites and $21 million for contingency costs applicable to the construction contract for the first site.

Engineering changes

The increase of $18 million for engineering changes represented increases of (1) $13 million for changes to data processing equipment, (2) $3 million for other hardware changes, and (3) $2 million for test planning.

Funding experience

Through fiscal year 1972, $4.932 billion had been appropriated for the SAFEGUARD system but available funding had been reduced to $4.739 billion

by reprogramming actions of $193 million. Of the available funding, $4.267 billion had been obligated and $3.277 billion had been expended.

Observation on data supporting the program estimate

In reviewing the basis for the program estimate of $7.073 billion, we observed that the (1) inflation estimate for the production effort was understated by about $24 million, (2) Army estimate for production was about $125 million lower than estimated by the production contractor, and (3) contingency estimate for construction changes at the first tactical site was about $50 million lower than the estimate provided by the construction contractor.

We observed that the fiscal year 1972 portion of the production estimate was adjusted to conform with the amount of funds authorized by the Congress, and, as part of the adjustment, SAFEGUARD officials omitted about $24 million by not applying the inflation index to the adjusted estimate. Officials of the SAFEGUARD System Office told us that an evaluation made during budget considerations showed that the fiscal year 1972 program could be executed within the funds authorized by the Congress without the added allowance for inflation.

We also observed that the production estimate shown in the Selected Acquisition Report was about $125 million less than the January 1972 contractor estimate for the same effort. In explanation, SAFEGUARD System Command officials told us that the $125 million reduction to the contractor's estimate was based primarily on engineering judgment, past experience, and prior negotiations with the contractor.

The construction estimate contained an amount for contract changes

which was $50 million less than estimated by the contractor. Corps of Engineers officials said that past experience had shown the contractor estimates for this effort were too high, and for this reason, the Corps estimate was considered sufficient to cover the costs of contract changes.

SYSTEM SCHEDULE EXPERIENCE

Significant schedule changes occurred between the June 30, 1971, and March 31, 1972, Selected Acquisition Reports for the second and third tactical sites. The Treaty, however, eliminated these sites from the program. The Treaty did not affect the October 1974 equipment readiness date for the one remaining tactical site at Grand Forks.

SYSTEM PERFORMANCE EXPERIENCE

The Selected Acquisition Reports showed that the SAFEGUARD system performance requirements had not changed since June 30, 1971. The most significant performance requirements have not changed since the development estimate was prepared in March 1969.

Required performance, however, has not been tested for certain system components, but the Selected Acquisition Reports show that performance tested to date has met design requirements. A detailed discussion of the test and evaluation program for the SAFEGUARD system is contained in Chapter 3 of this report.

SELECTED ACQUISITION REPORTING

Although not required by the Department of Defense instruction for preparation of the Selected Acquisition Report, we believe the report could be made more effective as a management tool and as a means for keeping the Congress informed by (1) including estimated costs for all items and services applicable to the SAFEGUARD system; (2) providing more

information showing the actual time-phased progress of the acquisition in terms of cost, schedule, and technical performance; and (3) disclosing significant differences between Army and contractor estimates which may indicate that future program cost could increase.

By definition, the Department of Defense instruction for the Selected Acquisition Report does not provide for including estimated costs for certain items and services such as warheads, test targets, test range support, family housing, hospitalization, training, and other Army-wide support. The estimated cost of these items and services was $1.500 billion at May 26, 1972. In addition, there are $957 million in operating costs which were directly appropriated for the SAFEGUARD program in the Operation and Maintenance and Military Personnel appropriations.

Although the Army informed us that such costs are regularly disclosed in various statements and reports it has furnished to the Congress, we believe that if these types of costs were included in Selected Acquisition Reports, as a general practice, it would provide the Congress with better visibility of a weapons system program.

While the Selected Acquisition Reports have contained information on the status of the SAFEGUARD program, they provide very little information on the time-phased progress of the acquisition in terms of cost, schedule, and technical performance. The reports, in our opinion, would be more effective as a management tool and as a means for keeping Congress informed if they provided an assessment of program progress on a time-phased basis showing where the acquisition stands in relation to where it was expected to stand for the same amount of time and resources expended. A detailed discussion of the method used by SAFEGUARD management to

measure progress of the acquisition is provided in Chapter 4 of this report.

The Selected Acquisition Report did not identify about $175 million in differences between Army and contractor estimates for the production and construction. Although we are not questioning the judgment applied in arriving at the lower Army estimates for this effort, we believe that when significant differences such as these occur, disclosure should be made in the Selected Acquisition Report that a potential does exist for program cost increases.

CHAPTER 3

TEST AND EVALUATION

The SAFEGUARD test and evaluation program includes the essential elements of engineering, acceptance, and operational suitability testing, but the effectiveness of the program has been impaired to some extent because the SAFEGUARD system is being developed, produced, and deployed concurrently. Normal testing practices could not be followed in the SAFEGUARD program because of system complexity and test limitations such as the Nuclear Test Ban Treaty and the infinite number of possible attack conditions. However, system effectiveness is being determined by a combination of test programs, computerized simulations, and engineering analyses. While the current test and evaluation results indicate successful technical progress, the reports do not provide a direct correlation between test and evaluation results and the system performance/design specifications.

IMPORTANCE OF TEST AND EVALUATION IN ACQUIRING MAJOR WEAPON SYSTEMS

A phased, life-cycle acquisition process is prescribed by the Department of Defense for use in acquiring today's multibillion dollar weapon systems. The five separate phases of this sequential process are: (1) concept formulation, (2) validation and ratification, (3) full-scale development, (4) production, and (5) deployment. To minimize the risk of fielding an unsatisfactory weapon, certain prerequisites should be met before a weapon system is advanced to each succeeding phase of the cycle.

Complete and valid test data are necessary for making sound decisions concerning the suitability of advancing a weapon to the next phase in its life cycle. It is through test and evaluation that management is provided with vital information about the workability, acceptability, and utility of a major weapon system. This information must be made available to management at key points in the acquisition cycle in order for risk to be ascertained and minimized.

To provide such information, test programs must, as a minimum, provide for the (1) formulation of test objectives to satisfy the mission objectives of the weapon, (2) development of test plans to accomplish test objectives, (3) implementation of testing on the basis of test plans, (4) evaluation of test results and preparation of test reports, and (5) utilization of test results when making key management decisions.

Since May 1970, the Department of Defense has increasingly emphasized test and evaluation activities and has instituted a number of concepts to be followed in testing practices. The current emphasis is on the need for more hardware proofing through the use of prototypes in the development of a system, the need for performing early testing and evaluation, and the determination of operational suitability prior to large-scale production commitments. Increased efforts are also being made to assess technical uncertainty and to control the progressive commitments of resources to programs.

REVIEW METHOD

There are three basic categories of test and evaluation required during a weapon's life cycle:

Engineering testing to physically demonstrate, before a system is accepted for production, that it will perform as intended.

Acceptance testing to demonstrate that the state and quality of the weapon system fulfill legal and/or other special requirements agreed to by the supplier and the customer.

Operational suitability testing to demonstrate that the weapon system, the operating personnel, and the tactical operations can work together to accomplish an established combat mission.

Each of these has a distinct place in the phased, life-cycle acquisition process.

To reinforce and emphasize certain ideal concepts, we formulated a model (see appendix II) to depict the role of testing and evaluation in the acquisition cycle. Our model shows the acquisition phases, the critical decision points, testing criteria, responsible parties, and the three basic testing categories. The model was compared with the practices employed in the SAFEGUARD test and evaluation program for development of test plans, implementation of testing, and evaluation and timely reporting of test results.

Because of the number of agencies involved and the magnitude of test plans required to implement the SAFEGUARD test and evaluation program, time did not permit a comprehensive review of all test planning functions or test plans. On a selective basis, however, we did examine some of the more important functions involved in this process and the resultant plans.

TEST AND EVALUATION METHODOLOGY

System effectiveness is defined as the capability of a weapon to meet the threat for which it was designed and is the goal toward which all testing and evaluation activities should be directed.

Effectiveness of the SAFEGUARD system, however, cannot be determined by testing alone because of its complexity and the major constraints under which it is being tested. Consequently, assessment of system effectiveness is being accomplished through a combination of computerized simulations, engineering analyses, and actual tests.

Computerized simulations are being conducted by the weapon system contractor and the SAFEGUARD System Evaluation Agency to provide information to verify that the performance and design specifications are adequate, identify the important functions or parameters which need careful testing, predict test results prior to testing, and support engineering analyses. Simulation is the only realistic method available to exercise the total system and evaluate its design response short of a nuclear encounter.

The weapon system contractor and the System Evaluation Agency have responsibility for conducting three major evaluation programs for assessing system effectiveness. The contractor's evaluation effort involves the use of simulation models to predict performance and includes comparisons of actual test data with simulated results to provide a continuous assessment of system performance and to define additional test requirements.

The SAFEGUARD System Evaluation Agency is analyzing data from simulations and from the various test programs in order to provide the System Manager with a continuing, independent evaluation of the critical aspects of the system's development and deployment. This agency also is responsible for determining, on a continuing basis, the level of operational effectiveness of the SAFEGUARD deployment.

SAFEGUARD test planning requires that all testing be directed toward the assessment of system effectiveness by using analysis and simulation to define the necessary test requirements and determine the adequacy of test results. The objective of the various tests to be conducted is to accumulate necessary data to: (1) determine if design values are actually achieved, (2) validate simulations, (3) reduce the uncertainty in the important functions or parameters identified by analysis and simulation, and (4) determine the level of operational capability.

TEST AND EVALUATION PROGRAM

Control over the test and evaluation program is being maintained through a coordinated test plan which serves as the basis for preparation of the many supporting test plans required for the development, production, site activation, and operational phases of the system.

As the top level SAFEGUARD test document, the coordinated test plan identifies 60 separate test programs to be carried out, assigns test responsibility to the participating agencies, and provides planning guidance for conducting the programs. It also contains a succinct summary of program test objectives, items to be tested, operations to be performed, data to be gathered, and applicable test locations, equipment, and schedules. The agencies responsible for the programs are required to identify the test data requirements, prepare and coordinate the supporting test plans, conduct the testing, and evaluate and document the test results.

In addition to having responsibility for system acquisition, the SAFEGUARD System Command is responsible for coordinating and monitoring the test and evaluation requirements contained in the coordinated test plan. Stanford Research Institute is under contract to assist in this effort by reviewing test requirements, plans, schedules, programs, results, and interfaces between test and simulation for the purpose of identifying and recommending corrective actions for test voids, data gaps, or test duplications. Stanford Research Institute also makes a continuous review of the coordinated test plan to assure that test programs are being directed toward system effectiveness.

Development of test plans

In order to separate important areas of testing and to divide organizational responsibilities, the SAFEGUARD System Command categorized test programs according to test phase as follows:

Development phase
Development acceptance tests

Production phase
Product quality assurance tests
Production verification tests
Maintenance evaluation tests

Site activation phase
Technical verification tests
Operational acceptance tests

Operational phase
Performance verification tests
Service life evaluation tests

The general objectives of the tests to be conducted under each category are set out in appendix III. Not included in the above are test programs required to complete SAFEGUARD testing such as lethality and vulnerability and hardening which because of their special nature are being handled separately. Except for the operational phase, most of the supporting test plans have been prepared.

On a selective basis we examined a number of second, third, and lower level test plans and observed that they generally contained the more important features of a test plan, including test objectives to be accomplished, time frame for their accomplishment, operations to be performed, testing constraints involved, test targets required, and data to be gathered. We also found that test plans for the early portion of the development phase required that testing, to the extent possible, be directed toward proving design/performance characteristics.

The primary development test plan, for example, stated that the objective of the Sprint missile ground and flight tests was to determine whether the missile and its ground support and launch equipment would perform in accordance with the design/performance specifications and SAFEGUARD system requirements. The test plan also provided that this objective was to apply to the development ground tests, development flight tests at White Sands Missile Range, and subsystem integration tests at the Kwajalein Missile Range. The objective of this plan was further defined in third, fourth, and lower level test plans prepared by the Sprint subcontractor.

In the more advanced stages of the development testing, such as the subsystem integration tests at Kwajalein, test plan objectives were oriented more toward factors such as concept verification, target function, and intercept function in order to gather data necessary for verification of the simulation models used in the overall system evaluation programs. Although the primary objective of the subsystem integration tests is not directed toward proving design/performance characteristics, the data obtained through the live tests assist in this determination.

Because testing of the SAFEGUARD system cannot be accomplished until installation is completed at the tactical site, increased emphasis has been placed on the product assurance program during the production phase. The implementing plans, therefore, require that a high level of

confidence be achieved in the areas of quality, reliability, and maintainability. The weapon system contractor required each of the major subcontractors to prepare and implement product assurance plans directed toward achieving this high level of confidence.

In addition to the required product assurance program, the System Manager directed that a special reliability plan be prepared and implemented on the Sprint and Spartan subsystems. The objectives of this special test program are to (1) verify that the Sprint and Spartan subsystem reliability is not significantly degraded during production and deployment, (2) verify that production hardware will perform its intended function for specified periods of time under prescribed environments, (3) identify and evaluate factors contributing to reliability degradation, and (4) determine corrective actions.

The site activation and operational test phases of the system are scheduled to begin in 1973 and 1974, respectively. We verified that test plans had either been or were being prepared for these phases. The site activation phase test plans are directed toward determining whether the installed equipment meets specifications, the user can operate the system in a deployed state, and the system performs satisfactorily for an extended period of time. The operational phase test plans are directed toward determining the level of operational effectiveness.

Except in a few areas, Stanford Research Institute reports showed that the test plans for the SAFEGUARD system were technically adequate. For those areas identified as being deficient, we found that additional

test plans were available covering the areas but had not been provided to Stanford Research Institute for review. SAFEGUARD System Command officials told us that the plans would be furnished in the immediate future.

Implementation of testing

A complete determination of system effectiveness cannot be made by testing alone because of the following testing limitations and constraints: (1) the Nuclear Test Ban Treaty prevents generation of an actual nuclear environment for testing, (2) the infinite number of intercept conditions, if tested, would require excessive time and funds, (3) safety considerations and international relations preclude subjecting the system to many stressing conditions, and (4) a complete prototype SAFEGUARD system will not be available for testing before deployment at the first tactical site.

The subsystem integration tests currently being conducted at the Kwajalein Missile Range, for example, will not provide a true test of the total operation of the system for several reasons, including the following: (1) it is impractical to provide an actual threat which is commensurate with the designed threat (2) the adequacy of intercept planning cannot be completely tested in a black-out free environment, (3) the test facility does not include the Perimeter Acquisition Radar, (4) an exact replica of the tactical software will probably never be tested at this facility, and (5) the expense associated with a single live test imposes a limit on the number and variety of tests which can

be conducted. Because of these constraints, the function of this test facility is not so much to conduct tests representative of tactical system operation as to validate the capability of the system to perform certain critical functions.

In addition to these major testing constraints, there is a significant overlap (see appendix IV) in the test schedules for engineering, acceptance, and operational suitability testing because the SAFEGUARD system is being developed, produced, and deployed concurrently. This is a departure from the phased, life-cycle acquisition process, but the Department of the Army exempted the SAFEGUARD system from this process because of its size, complexity, and urgent deployment need. In requesting the exemption, SAFEGUARD management advised that a great deal of concurrency was necessary in order to meet the initial operational capability dates.

We observed, however, that controls were established to consider testing results before an item was released to production. Before each major assembly or subsystem was released, a critical design review was required to determine whether necessary testing had been conducted to indicate that an item would perform as specified. These reviews were attended by representatives from development, production, user, and evaluation organizations. When an item did not appear to meet specifications, pre-release conditions were specified which the contractor was required to satisfy before production release was made.

Decisions reached in the critical design reviews were documented in formal reports signed by the contractor and appropriate Government personnel. Because of the large number of individual reports issued, we examined only the final reports issued for the two missile subsystems, the two radar subsystems, and the command and control facility and found that these items were released to production with no major restrictions. Although engineering tests had not been completed, we were told that these reports represented a technical consensus that testing conducted indicated a reasonable expectation that the items would perform as required when produced and deployed.

Evaluation and reporting of test results

Evaluation and reporting of SAFEGUARD test results involve a number of Government and contractor activities and many different reporting techniques. Each of the activities responsible for a test program is required to evaluate, document, and report test results. The overall SAFEGUARD test reporting objectives are to provide (1) the System Manager and participating agencies a report presenting the status and results of all the test programs, (2) the means for periodic review of test accomplishments versus test plans, and (3) the means for identifying and recording significant accomplishments and results in testing the system and its components.

To accomplish these objectives, a consolidated quarterly test report, organized by the four SAFEGUARD testing phases and the applicable test

programs, is prepared and distributed to the System Manager and each program participant. The report contains a succinct summary of the (1) test and evaluation results; (2) test objectives compared with test results; (3) cost and schedule impacts resulting from test failures; (4) status of all test programs, supporting plans, and studies; (5) actions taken to change test plans and schedules; and (6) significant actions planned for the next quarter.

We examined the reporting techniques being used for selected tests and observed that the results were submitted in a timely manner for review and evaluation. The subsystem integration tests by the weapon system contractor at Kwajalein, for example, are reported to the SAFEGUARD System Command by maintaining telephone contact during mission countdown, a 4-hour post mission report, a 48-hour post mission report, and a 30-day final mission report.

We also observed that the reports contained the more important features of a test report including a brief description of the test objectives, the degree of success in meeting the objectives, subsystem performance and intercept parameters, miss distances if applicable, and any anomalies or failures. The SAFEGUARD System Command provides the System Manager with 24-hour and 72-hour post mission reports describing the test results. These reports contain generally the same information as reported by the contractor. A copy of the contractor's 30-day final mission report is also furnished to the System Manager.

The results of the subsystem integration tests are also reported to the System Manager by the SAFEGUARD System Evaluation Agency through (1) a contingency plan submitted 10 days before the test, (2) a 10-hour quick look report, (3) a 48-hour post mission report, (4) a 14-day post mission report, and (5) a 45-day summary report. The purpose of the contingency plan is to advise the SAFEGUARD organization of actions to be taken in the event that some or all of the test objectives are not achieved. The other reports contain information showing the specific test objectives, success in meeting the test objectives, assessment of any problem areas, and recommended changes, if warranted, to the test program or schedule.

In addition to evaluating and reporting the results of individual tests, the weapon system contractor also provides the SAFEGUARD System Command reports on its system evaluation program, including periodic analysis memoranda, monthly progress reports, and a comprehensive annual evaluation report. These documents include narrative assessments and data on simulation development, system performance evaluation, test requirements, and data analysis. The annual report contains an overall assessment of total SAFEGUARD system performance in meeting its defense objectives. The evaluation results are provided to the System Manager through both reports and briefings.

The SAFEGUARD System Evaluation Agency also provides the System Manager with single topic evaluation reports and quarterly evaluation reports which summarize the evaluation activity during the quarter.

These reports provide information covering the adequacy of areas such as design, development, and testing of hardware and software; system effectiveness; system maintainability and reliability; command and control functions; scheduling impacts; and system safety considerations. Also at monthly briefings, the System Evaluation Agency brings to the attention of the System Manager specific results of its evaluation efforts, including an identification of hardware or software items which would degrade the system during an engagement. One instance was observed in which the SAFEGUARD System Evaluation Agency identified a durability problem with the antenna cartridge of the Missile Site Radar and after the matter was brought to the attention of the System Manager, the weapon system contractor was directed to make additional tests which led to corrective design changes.

The various Government and contractor test and evaluation reports provided assessments of technical accomplishments and highlighted problem areas requiring resolution to prevent degradation in system performance. We observed, however, that most of the reports were highly technical in nature and did not specifically provide a direct correlation between test and evaluation results and the performance/design specifications established for the system and its subsystems. We discussed this matter with SAFEGUARD System Command officials who stated that there was no single document which summarized demonstrated system performance data and compared it to the performance/design specifications. The

officials stated that such a document was not needed for their use but could be useful for higher levels within the Army and Department of Defense.

The test and evaluation reports showed that there are several critical areas which, if not resolved, could degrade system effectiveness, but none of these were considered critical enough by the Army to preclude deployme These problems are known to SAFEGUARD management and efforts, including additional testing, are being directed toward corrective action. For the most part, the test and evaluation reports, including the annual assessment pursuant to the President's direction, indicate that technical achievements on the system are progressing satisfactorily.

CONCLUSIONS AND RECOMMENDATIONS

Although the SAFEGUARD test and evaluation program provides for the conduct of engineering, acceptance, and operational suitability testing, the tests are being conducted on a concurrent basis which has lessened the effectiveness of the test program. To a great extent, however, this situation was dictated by the operational readiness dates required to meet the developing threat. When engineering testing is not completed before large-scale production commitments are made, necessary design changes discovered by testing must be incorporated into production hardware, and the risks of costly modifications after deployment are increased.

The effectiveness of the SAFEGUARD test program has also been impaired to some extent because of the major testing limitations and constraints under which the system is being tested. These limitations, however,

are recognized in the test plans, and computerized simulations are being used to obtain data that cannot be obtained through live tests.

Despite the high degree of concurrency in tests being performed during the development, production, and deployment phases of the SAFEGUARD system, the test plans prepared contained many of the essential elements of good test planning and test results were being evaluated and reported to intermediate and higher levels of the SAFEGUARD organization in a timely manner. But because of the concurrency in system acquisition, the major limitations and constraints on conducting tests, and the heavy reliance upon simulations and engineering evaluations, we believe that a periodic summary report which correlates the test and evaluation results to the performance/design specifications would improve overall visibility into the technical progress of the system and provide better assessments of such progress to decision makers within the Army and Department of Defense.

The SAFEGUARD program has already passed most of the key decision points in the phased, life-cycle acquisition process, but the Site Defense program initiated in fiscal year 1971 affords the opportunity to apply the basic concepts of this process and to incorporate testing practices stipulated by recent Department of Defense directives. To insure the most efficient and economical acquisition for the Site Defense program, we recommend that the System Manager take appropriate steps to assure that the basic concepts of the phased, life-cycle process are followed in that program and that appropriate test and evaluation be completed prior to large-scale production commitments.

We also suggest that consideration be given to the formulation of a periodic summary report which compares the test and evaluation results to the system and subsystem performance/design specifications for informing higher command levels of the progress being achieved toward meeting these specifications.

CHAPTER 4

PROGRESS MEASUREMENT

Efforts are currently being made by the SAFEGUARD system organization to implement a progress measurement system for the SAFEGUARD program designed to integrate firm, time-phased goals for cost, schedule, and technical performance and provide a report showing a measurement of actual accomplishments against these goals. When fully operational, however, the system being implemented will not furnish in-depth visibility into the overall progress of the acquisition because the new system does not provide for the complete integration of the development effort with the production and construction efforts. But it should provide better visibility of program progress than has been available in the past, and it should be useful in managing the Site Defense program which was initiated in fiscal year 1971 to augment SAFEGUARD.

IMPORTANCE OF PROGRESS MEASUREMENT

Because of the complexity, size, urgency, and dollar value of modern weapons, it is essential that total program visibility be maintained during all phases of the acquisition cycle. To obtain such visibility, a technique must be used which provides current, accurate information showing where the time-phased progress of an acquisition stands in relation to where it was expected to stand at a given point in time in terms of cost, schedule, and technical performance.

Without such information, an accurate determination cannot be made whether an acquisition is being accomplished at a cost higher or lower

than was planned, proceeding in accordance with established schedules, or meeting its technical performance requirements. Conversely, when integrated cost, schedule, and technical performance data are reported regularly on a summarized basis and compared to firm, time-phased goals for these elements, early warning signs of impending cost overruns, schedule slippages, and performance degradations should be detected in sufficient time to initiate corrective action.

PROGRESS MEASUREMENT MODEL

Before discussing the results of our evaluation, it is necessary to briefly comment on the essential elements required to measure the progress of a major weapon system acquisition and the review approach we used to examine this subject. We first identified the elements that should be contained in such a system and formulated a model (see appendix V) depicting the continuous role that progress measurement should have during the acquisition life cycle.

An effective progress measurement system should contain the following three elements:

-- a uniform method for defining, collecting, reporting, and correlating management data.

-- a method for establishing firm, time-phased goals for each major element of the acquisition.

-- a technique for the continuous comparison of actual work accomplished with that planned.

Because of the extensive amount of data generated in the development and production of a major weapon system, a uniform approach must be

used for collecting, reporting, and reviewing the data. Use of work breakdown structures provide a consistent framework for defining and assigning work, establishing and maintaining a data base, and controlling and reporting progress. The work breakdown structure is a tool for subdividing a total weapon system into its component parts which can be displayed to show their relationship to each other and to the total acquisition.

If progress measurement is to be meaningful, it is important that realistic cost, schedule, and technical performance goals for the weapon be developed and agreed to by the Government and contractor activities involved, and that controls be designed to prevent undisciplined changes to these goals. It is also important that these goals be divided and assigned to each element of the work breakdown structure.

The continuous analysis of work actually accomplished versus that planned can provide early warning signs of impending problems in time for corrective actions. Major problems causing unfavorable variances may already be known to management, but a performance measurement system documents the cost impacts on a systematic, routine basis. It will also assist in identifying and tracing smaller variances to their source before a major cost impact results.

EMPHASIS BY DEPARTMENT OF DEFENSE ON PROGRESS MEASUREMENT SYSTEMS

The Department of Defense has taken a number of major steps to improve various aspects of its weapon system acquisition process includ-

ing the control and reporting of program progress; use of a single, realistic work breakdown structure; and use of contractor program control systems. Department of Defense Instruction 7000.2, for example, was promulgated by the Assistant Secretary of Defense (Comptroller) on December 22, 1967. It is intended to provide the criteria for contractor reporting of valid and up-to-date data for measuring progress against cost, schedule, and technical plans.

The Secretary of the Army in an October 1969 memorandum to the Deputy Secretary of Defense cited this instruction as an improvement in the control and reporting of program progress. By analyzing the monthly variances reported by the contractor, the Secretary stated that a project manager would be able to detect impending cost overruns at an earlier stage in their development and in time to select among alternative courses of action.

The Army Materiel Command is currently taking action to apply the same criteria prescribed for contractors to management control systems of subordinate commands performing substantial work on major weapons. The implementing instructions stated that it was reasonable and consistent to want assurance that the management of the Government portion of a project met the same standards that were required of contractors.

REVIEW METHOD

The above discussed criteria for a progress measurement system together with pertinent instructions issued by the Department of Defense were compared to the actual practices and procedures used by SAFEGUARD management to assess program progress. Our review objective was to

determine whether SAFEGUARD management methods included a technique for measuring progress of the acquisition so that at any point in time a determination could be made as to where the acquisition stood in relation to where it was expected to stand for the same amount of time and resources expended.

PROGRESS MEASUREMENT SYSTEM FOR THE SAFEGUARD ACQUISITION

The System Manager over the past several years has emphasized the need for establishing a management information system that would integrate cost, schedule, and technical performance data and provide him with an overall, periodic assessment of program progress.

Implementing actions directed by the System Manager include: (1) development and use of a single project work breakdown structure, (2) establishment of cost, schedule, and technical performance baselines, (3) implementation of contractor performance measurement criteria, and (4) development of a system for integrating these elements into a performance report covering the total program. The current status of these actions and our evaluation follow.

Development of a work breakdown structure

A revised work breakdown structure was developed (see appendix VI) because the one in use did not conform with prescribed Department of Defense directives and did not allow the necessary flexibility to gather and correlate data for the diverse segments of the SAFEGUARD

program. Also, there was no correlation of the existing structure between development, production, construction, and site activation activities and functions. The System Manager instructed that the revised structure be used as the basis of allocating resources and monitoring and controlling cost, schedule, and technical performance of the work assigned to each program activity.

All Government and defense contractor activities converted to the revised structure except the contractor responsible for the development work. Consequently, the prime development contract effort is not totally integrated with the production, construction, and deployment efforts being conducted by other program participants. The development contractor opposed restructuring the research and development effort, which has been underway for a number of years, to conform to the revised work breakdown structure. After considering a number of problems cited by the contractor, the System Manager waived the requirement for applying the structure to the prime development contract.

The System Manager's decision followed a review and analysis which led to the conclusion that an arbitrary correlation between elements of the development program and the production Work Breakdown Structure would serve as a useful working substitute for integration at the major subsystem level.

Establishment of cost, schedule, and technical baselines

The SAFEGUARD organization has established procedures for the preparation, approval, and control of program cost, schedule, and technical performance baselines. A discussion of the procedures and practices used in establishing and maintaining these baselines follow.

In a prior review, we identified several procedural problems related to preparing, documenting, reviewing, and approving program cost estimates. As a result, SAFEGUARD management issued detailed guidelines in July and August 1972, setting forth policies, procedures and responsibilities for initiating, preparing, documenting, reviewing, and approving cost estimates used in the management process. This formalization of cost estimating procedures complemented cost analysis procedures, including the independent validation of cost estimates, implemented in August 1970. At the time of our review, an estimate had not been prepared pursuant to these new procedures.

Prior to March 1972, cost baselines for the SAFEGUARD program had not been established so that a direct correlation could be made to the project work breakdown structure elements without a significant amount of cost prorations between elements. Cost baselines are now, however, being established in accordance with the work breakdown structure and will be used as a basis for assessing program progress. In addition, more extensive use is being made of cost analysis to validate the program estimates.

SAFEGUARD schedule baselines were established based on the coordinated requirements of all program participants. Detailed schedule requirements are maintained by a computer which produces monthly printouts for coordination with and review by all program activities. A quarterly status report showing a graphic summary of total schedule status is also provided. The schedule system provides a logical and correlative sequence of milestones ranging from key to minor with the former being controlled by the System Manager. The schedule baselines are relatable to the work breakdown structure and a formal procedure is followed in making changes, including immediate notification to the System Manager of any event that could cause a major slippage.

The technical performance requirements for the SAFEGUARD system and its major subsystems were prepared by the development activity, independently evaluated by the various program participants, and approved by the System Manager. The approved requirements are documented in various technical plans and are structured in accordance with the project work breakdown structure. Changes to these requirements are controlled, coordinated, and approved through a configuration management program with final approval being made by the System Manager.

Implementation of contractor performance measurement criteria

The performance measurement criteria contained in Department of Defense Instruction 7000.2 have been applied to management control systems of the prime production contractor and three of its four major subcontractors. The fourth subcontractor was exempted because the estimated cost to implement the criteria was prohibitive as compared to the number of items to be delivered. The systems established by the contractors have either been approved or recommended for approval, and surveillance of the systems is being accomplished and reported monthly.

The performance measurement data applicable to the production effort, including that reported by the subcontractors, is reviewed and analyzed by the prime contractor and reported to the SAFEGUARD System Command in consolidated monthly and quarterly reports. These reports contain progress measurement assessments of work package and contract line items in terms of cost and schedule. At quarterly meetings between the prime contractor and the SAFEGUARD System Command, the overall

production progress is reviewed and any negative variances are analyzed for corrective measures.

We reviewed the performance measurement systems at two of the prime contractors' facilities and found, except for technical progress, that the information provided to the SAFEGUARD System Command generally depicted the progress of work completed against that which was expected to be completed for the same amount of time and resources expended. Although the systems did not provide for the routine reporting of technical progress, technical problems which impact cost or schedule are reflected in the reports and are assessed on an exception basis.

At the production contractor's facilities we found that the contract work breakdown structure was properly integrated with the contractor's internal management control system. The integrated system was structured to define tasks to be performed; provided for assignment of organizational responsibility at each level of the work breakdown structure; established time-phased cost and schedule baselines for authorized work; provided for the accumulation of actual costs by work packages and organizational elements; allowed for comparison of work accomplished with that planned; and provided controls over changes to cost and schedule baselines.

Almost 3 years were spent in attempting to apply the criteria to the development effort, but the responsible contractor strongly opposed making any major changes in its internal management system because of the disruptive effect on its operations. Consequently, the data reported by its management control system cannot be completely integrated in the

project work breakdown structure. During this period, however, the contractor did accept some of the lesser requirements but refused to accept the more important ones, particularly those designed to relate schedules to auditable costs.

As presently structured, the development contractor's management control system does not provide for a documented assessment of work accomplished with that planned. Progress assessments by the contractor therefore, rely heavily on subjective judgments of its managers and supervisors. However, the contractor and the System Manager have developed a working substitute which, the Army informed us, is proving useful. No further actions are planned to require the contractor to apply the prescribed criteria to its management control system.

Although firm-fixed price construction contracts are exempted from application of Department of Defense Instruction 7000.2 criteria, the Corps of Engineers uses a system which provides for close monitoring of construction progress. The System Manager is provided monthly progress reports on the construction effort which show the current cost estimate and the percent of completion compared with that planned to be completed within the same time period. Also, the cost data reported can be integrated into the project work breakdown structure by program elements.

Technique for integrating cost, schedule, and technical performance

Plans call for the completion of a computerized system which will serve as a central data bank for collecting, integrating, and reporting of cost, schedule, and technical performance data by the project work breakdown structure for the total SAFEGUARD program. A monitor has been appointed for each of the major subsystems to assure that this data is available and relatable to at least the second level of the work breakdown structure. Prior to this time, no single individual was responsible for integration of the data from the development, production, site activation, and other functional areas.

A management information center is being completed where program cost, schedule, and technical performance data will be summarized and displayed for review by the System Manager and the various agencies responsible for conducting the program. Plans also call for the preparation of a cost performance report which will integrate and provide an overall assessment of the progress of the program in terms of cost, schedule, and technical performance. At the time of our review, however, the content and format of the report had not been determined.

One crucial problem area which has not been resolved concerns the integration of technical performance into this system. The performance/design specifications can be related to the third level of the project work breakdown structure, but at the time of our review, there was not an overall report showing the technical progress being made against these goals. SAFEGUARD System Office officials told us, however, that they were in the process of devising a means to relate cost and schedule to technical performance goals.

Before the above discussed actions were taken, the System Manager was provided a vast amount of status data through reports and briefings. We examined the more important status reports and briefings identified for us by SAFEGUARD management. The data in these documents contained valuable information on the program, but, for the most part, emphasized the management by exception technique and did not provide the System Manager with progress assessment data concerning how well any element of the program was progressing in terms of previously assigned cost, schedule, and technical performance goals. Also, cost, schedule, and technical data were generally reported as separate entities rather than being integrated for progress measurement purposes.

PROGRESS MEASUREMENT SYSTEM FOR THE SITE DEFENSE PROGRAM

SAFEGUARD System Office officials told us that actions are being taken to implement a progress measurement system for the Site Defense program which was initiated in fiscal year 1971 to augment SAFEGUARD. They stated that some of the problems encountered in establishing a performance measurement system for the SAFEGUARD program would not be encountered on the Site Defense program because it is smaller and less complicated and implementation actions were initiated at the start of the program. Management of the Site Defense program will use the existing SAFEGUARD management control systems and procedures.

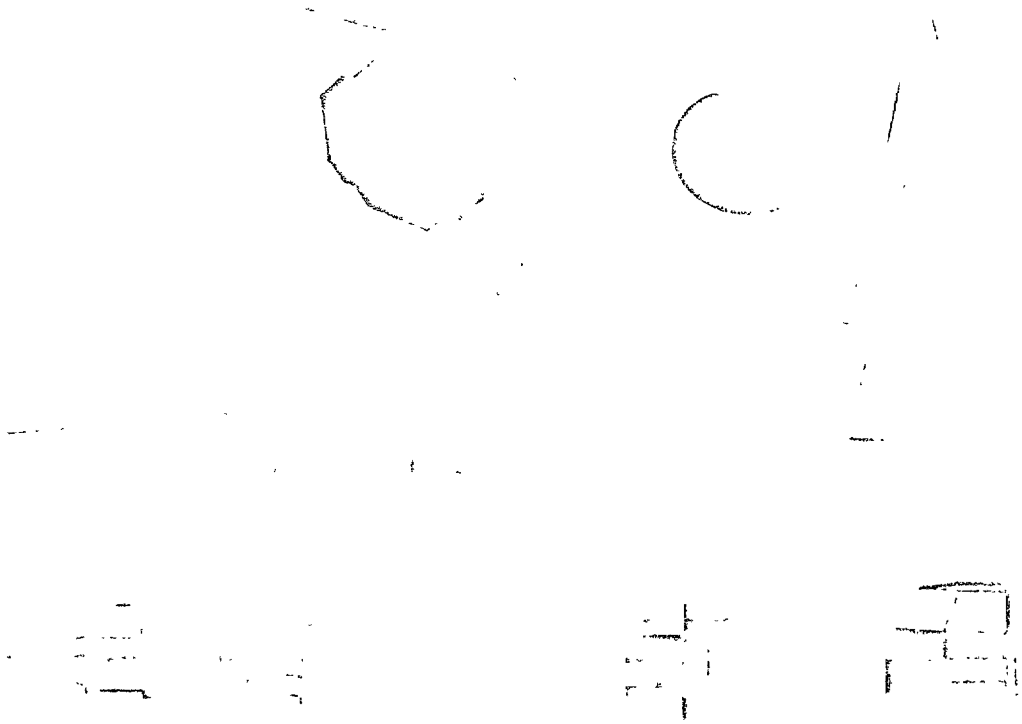
CONCLUSIONS AND RECOMMENDATIONS

Although a considerable amount of status data is provided to the SAFEGUARD System Manager through various reporting media,

the System Manager has not been provided with information that disclosed where the SAFEGUARD acquisition stood in relation to where it was expected to stand at a given point in time in terms of cost, schedule, and technical performance. Actions, however, are being taken to implement a system which will integrate firm, time-phased goals for cost, schedule, and technical performance and provide a report showing a measurement of actual accomplishments against these goals.

The system being implemented, however, will not provide in-depth visibility into the overall progress of the SAFEGUARD acquisition primarily because the development contract cannot be completely integrated with the production and construction efforts. The effectiveness of the progress measurement system will also be impaired unless a method for integrating technical performance with cost and schedule goals is established. In our opinion, however, the data which should be generated by the envisioned system will be an improvement over data provided to the System Manager in the past.

While the Treaty on the Limitation of Anti-Ballistic Missile Systems has significantly reduced the future SAFEGUARD effort, we recommend that actions continue toward perfecting the performance measurement system because it can be applied to the site Defense Program.



TEST MODEL FOR ACQUISITION CYCLE

ACQUISITION PHASE	CONCEPT FORMULATION	VALIDATION AND RATIFICATION	FULL SCALE DEVELOPMENT	PRODUCTION: INITIAL	PRODUCTION: FULL SCALE	DEPLOYMENT
DEFENSE SYSTEMS ACQUISITION REVIEW COUNCIL (DSARC)	DSARC I	DSARC II	DSARC III			
TESTING CRITERIA	DETERMINE WHETHER: 1. MISSION AND PERFORMANCE ENVELOPES HAVE BEEN ADEQUATELY DESIGNED AND BASED ON MILITARY OBJECTIVES, 2. ACTUAL ENGINEERING DESIGN AND COMPONENT TESTING HAS BEEN DONE TO DEMONSTRATE THAT TECHNICAL RISKS HAVE BEEN ELIMINATED OR REDUCED TO AN ACCEPTABLE LEVEL, 3. PRACTICAL TRADE-OFFS BETWEEN REQUIREMENTS AND ENGINEERING DESIGN HAVE BEEN MADE, AND 4. REAL PROOFING OF CRITICAL COMPONENTS HAS BEEN UTILIZED TO THE GREATEST EXTENT POSSIBLE THROUGH ENGINEERING TESTING.	DETERMINE WHETHER 1. DESIGNS AND ENGINEERING FOR THE WEAPON SYSTEM HAVE BEEN VALIDATED, AND 2. TECHNICAL AND ECONOMIC BASIS FOR ENTERING FULL-SCALE DEVELOPMENT HAVE BEEN VALIDATED THROUGH DEVELOPMENT OR FABRICATION OF MODELS OR PROTOTYPES WHERE FEASIBLE.	DETERMINE WHETHER: 1. STABILIZED DESIGN AND PERFORMANCE REQUIREMENTS HAVE BEEN ACHIEVED, 2. HARDWARE HAS BEEN PROVEN THROUGH TESTING; 3. ENGINEERING TESTING HAS BEEN COMPLETED, 4. A SYSTEM ACCEPTABLE FOR PRODUCTION, INCLUDING ALL COMPONENTS AND SUBSYSTEMS, HAS BEEN DEVELOPED, AND 5. OPERATIONAL SUITABILITY HAS BEEN REVIEWED WITH A PROTOTYPE OR AT LEAST A MOCK-UP.	DETERMINE WHETHER: 1. *PRODUCIBILITY* HAS BEEN VERIFIED; 2. COMPLETE AND ADEQUATE DOCUMENTATION HAS BEEN PROVIDED; 3. SUFFICIENT QUANTITIES TO PERMIT TEST AND EVALUATION AND TO CORRECT DESIGN DEFECTS WHICH EFFECT PRODUCTION HAVE BEEN PROVIDED; AND 4. OPERATIONAL SUITABILITY OF A PRODUCTION ARTICLE HAS BEEN TESTED.	DETERMINE WHETHER: 1. CONFIGURATION OF THE WEAPON SYSTEM HAS BEEN FIRMLY ESTABLISHED; 2. ACCEPTANCE TESTING AND CERTIFICATION OF COMPONENT SUBSYSTEMS, AND COMPLETE SYSTEMS HAVE BEEN PROVIDED, AND, 3. COMPLETED SYSTEM HAS ACHIEVED PERFORMANCE GOALS AS CONTRACTED.	DETERMINE WHETHER: 1. USER HAS ACCEPTED A WEAPON SYSTEM WITH THE DESIRED CAPABILITY; 2. USER HAS VERIFIED IF THE WEAPON, MEN, AND TACTICS WILL PERFORM IN THE MANNER INTENDED THROUGH OPERATIONAL SUITABILITY TESTING AND 3. MAINTAINABILITY AND RELIABILITY STANDARDS HAVE BEEN ACHIEVED.
RESPONSIBLE PARTIES PRIMARY ▲ SECONDARY ○ MONITOR ⊗	DEVELOPER ▲ USER ○	DEVELOPER ▲ CONTRACTOR ○ USER ⊗	CONTRACTOR ▲ DEVELOPER ○ USER ⊗	DEVELOPER ▲ USER ○ CONTRACTOR ⊗	CONTRACTOR ▲ DEVELOPER ○ USER ⊗	USER ▲ DEVELOPER ○ CONTRACTOR ⊗

BASIC TESTING CATEGORIES

- ENGINEERING TESTING ←→
- ACCEPTANCE TESTING ←→
- OPERATIONAL SUITABILITY TESTING ←- - -→

APPENDIX III

SAFEGUARD TESTING PHASES AND CATEGORIES

Development Phase:

Development Acceptance Tests [1]
These tests are those necessary to develop the system hardware and software and to furnish data for establishing confidence that the subsequent deployment can meet design objectives.

Production Phase:

Product Quality Assurance Tests [2]
These are tests and inspections for quality assurance of hardware produced under the production contract. These tests and inspections are performed at the factory to assure the quality of a specific hardware item or a specific lot of an item.

Production Verification Tests [2]
These tests are performed on samples of the production output in order to determine whether the production environment has degraded the characteristics designed into the product. Included in this category is the testing required to qualify new producers or new manufacturing processes.

Maintenance Evaluation Tests [2]
These tests are to determine the adequacy of procedures, tools, test equipment, and personnel skills required to maintain and operate the deployed system.

Site Activation Phase:

Technical Verification Tests [2]
These tests on demonstrations are accomplished on-site to fulfill requirements to demonstrate that installed hardware, software, technical facilities, and support facilities meet specifications. Within each test program under this category, selected tests designated as Contractor Demonstration Tests will be monitored in detail as part of the Government acceptance of the system.

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1 Engineering testing

2 Acceptance testing

Operational Acceptance Tests [1]

The user determines by these tests that military personnel can operate the SAFEGUARD system and that the system performs at a specified level for an extended period of time. These tests will be used to determine the satisfactory interface of hardware, software, personnel, communications, procedures, logistics, and facilities.

Operational Phase:

Performance Verification Tests [1]

These tests are for verifying the continued operational capability of the SAFEGUARD system during its lifetime. In these tests, the system, complexes, and sites will be operated under tactical conditions using simulated threats provided by computer programs and satellites of opportunity.

Service Life Evaluation Tests [1]

These tests are to verify projected equipment life and to detect degradation trends as the basis for decisions on subsequent production and modification efforts to maintain system effectiveness. Several Government activities will conduct these tests.

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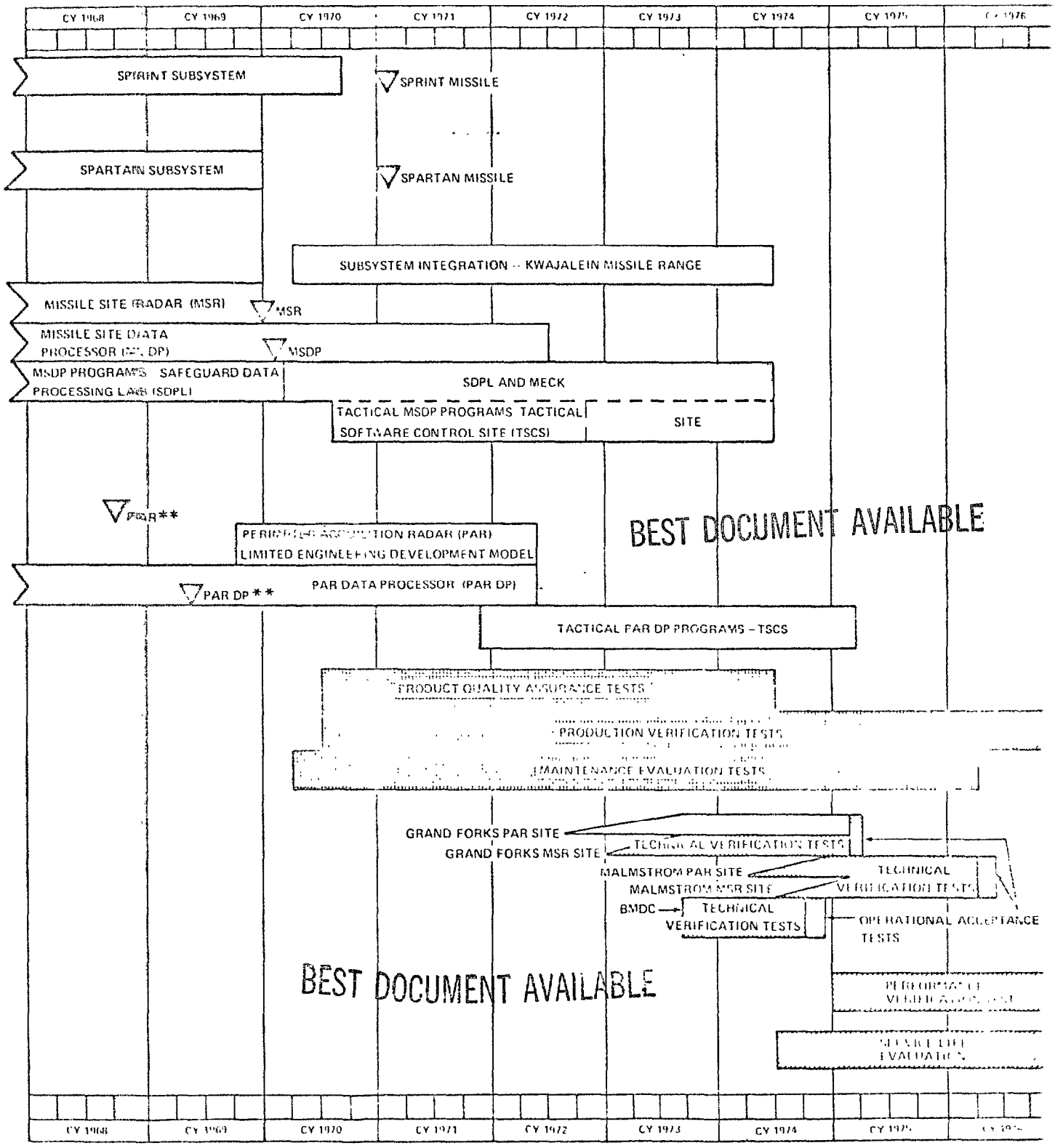
[1] Operational suitability testing

TEST SCHEDULE SUMMARY*

(AS OF APRIL 1972)



DEVELOPMENT TESTS

PRODUCTION TESTS

SITE ACTIVATION TESTS

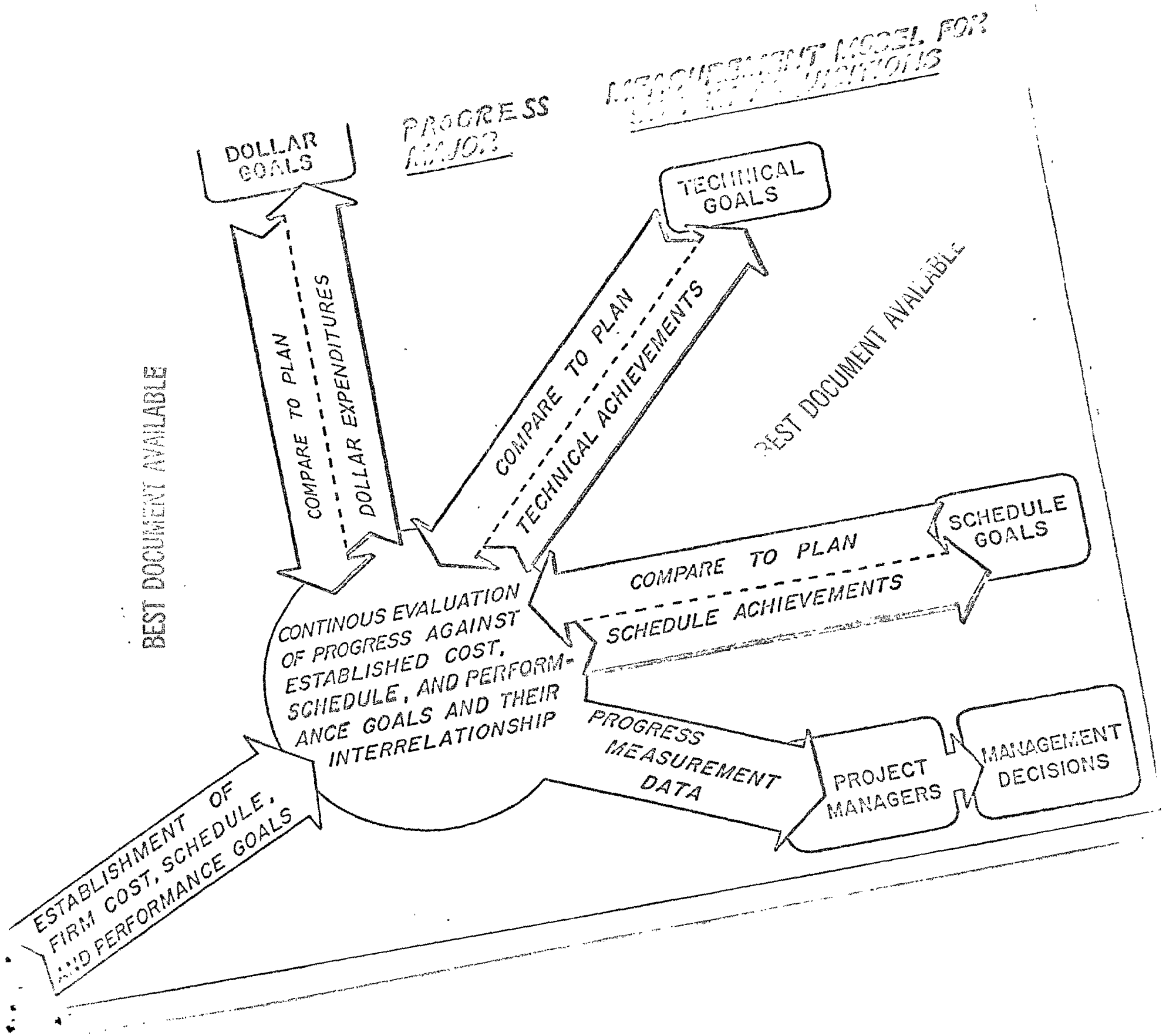
OPERATIONAL TESTS

SIGNIFICANT PRODUCTION START

** PROTOTYPE PRODUCTION START

* EXCLUDES THE DEVELOPMENT TEST SCHEDULE FOR SPRINT AND SPARTAN WARHEAD SECTIONS

APPENDIX V


MANAGEMENT MODEL FOR
PROGRESS
MAJOR
DOLLAR GOALS
TECHNICAL GOALS
COMPARE TO PLAN
DOLLAR EXPENDITURES
COMPARE TO PLAN
TECHNICAL ACHIEVEMENTS
BEST DOCUMENT AVAILABLE
SCHEDULE GOALS
COMPARE TO PLAN
SCHEDULE ACHIEVEMENTS
CONTINOUS EVALUATION OF PROGRESS AGAINST ESTABLISHED COST, SCHEDULE, AND PERFORMANCE GOALS AND THEIR INTERRELATIONSHIP
PROGRESS MEASUREMENT DATA
PROJECT MANAGERS
MANAGEMENT DECISIONS
ESTABLISHMENT OF FIRM COST, SCHEDULE, AND PERFORMANCE GOALS
BEST DOCUMENT AVAILABLE

APPENDIX VI

SAFEGUARD PROJECT SUMMARY WBS BLOCK DIAGRAM
(THROUGH 3RD LEVEL FOR HARDWARE & THROUGH 2ND LEVEL FOR NON-HARDWARE SUBSYSTEMS)