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In 1972 the Commission on Government Procurement recommended a new plan for the acquisition of major weapons systems and other major systems which has become the basis for a revised policy in procurement for all executive agencies. The Department of Defense suggested that the NAVSTAR Global Positioning System resembled the Commission's recommendations. Findings/Conclusions: The evolution of the NAVSTAR Program resembled the Commission's recommendations only slightly. The NAVSTAR system did not begin with a statement of mission capability, cost, and time goals stated independently of a specific system solution; did not follow a Secretary of Defense assignment to a service or services for responding to a statement of needs and goals; did not use industry initiative and innovativeness to identify alternative system concepts; and did not maintain competition by exploring rival systems. However, the Office of the Secretary of Defense involvement in the identification and reconciliation of navigational needs was greater than the level of involvement criticized by the Commission. Recommendations: Executive agencies have to understand that under the new acquisition process, mission area deficiencies must be determined and stated independently of any specific system solution. Effort allowed under the technology base requires redefinition so that solutions to mission needs result from competition between alternative solutions. Industry must be given greater flexibility to propose a wide range of alternative solutions to mission area deficiencies in responding to Government requests. (Author/SC)

REPORT TO THE CONGRESS

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

Comparison Of The NAVSTAR Program With The Acquisition Plan Recommended By The Commission On Government Procurement

The Commission on Government Procurement recommended a new plan for acquiring major weapons systems and other major systems which has become the basis for a revised policy in procurement for all executive agencies.

GAO has compared the NAVSTAR Global Positioning System with the Commission's plan and has concluded that the evolution of the NAVSTAR program resembled only slightly the Commission's recommendations.

PSAD-77-50

JAN. 24. 1977

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

B-182956

To the President of the Senate
and the Speaker of the House of Representatives

This report on the NAVSTAR Global Positioning System is one of three reports on our review to determine how closely recent Department of Defense acquisition programs parallel the major system acquisition plan the Commission on Government Procurement recommended.

We made this review at the request of Senator Lawton Chiles, Chairman, Subcommittee on Federal Spending Practices, Efficiency, and Open Government, Senate Committee on Government Operations. As agreed with the Senator's office, we asked the Department of Defense to suggest systems for our review which came closest to the Commission's plan.

The Pershing II and the Shipboard Intermediate Range Combat System are covered in separate reports. Of the three programs, only the Shipboard Intermediate Range Combat System had any significant similarity to the beginning steps of the Commission's plan.

We made our review pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

Copies of this report are being sent to the Director, Office of Management and Budget; and the Secretary of Defense.

Comptroller General
of the United States

Contents

ABBREVIATIONS

ACP	area coordination paper
DOD	Department of Defense
DCP	development concept paper
DSARC	Defense Systems Acquisition Review Council
GAO	General Accounting Office
OSD	Office of the Secretary of Defense
SAMSO	Space and Missile Systems Organization

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

COMPARISON OF THE NAVSTAR PROGRAM WITH THE ACQUISITION PLAN RECOMMENDED BY THE COMMISSION ON GOVERNMENT PROCUREMENT
Department of Defense

D I G E S T

In December 1972 the Commission on Government Procurement recommended a new plan for acquiring major systems. The Commission's recommendations were the basis for an April 5, 1976, Office of Management and Budget circular on major system acquisitions; it prescribed policy for all executive branch agencies.

GAO was asked to compare the beginning steps in the acquisition process of some recent major systems with the Commission's plan. (See p. 1.)

Because Department of Defense officials had indicated that the Commission's intent had been accomplished either formally or informally in some Defense programs, GAO asked Defense to suggest programs which came closest to the recommended procedures.

One suggested program, the NAVSTAR Global Positioning System, is a satellite navigation system which will allow strategic and attack aircraft, ships, submarines, and ground vehicles and troops to ascertain their positions to within 10 meters. NAVSTAR will meet the need for a continuous, all-weather, worldwide system that is difficult for an enemy to jam or destroy. The program cost estimate is $1.2 billion. It does not, however, include procurement costs for equipment the above users must have.

The evolution of the NAVSTAR program resembles only slightly the Commission's recommendations for acquiring a major system. Chief reasons for this conclusion are that the program did not:

--Begin with a statement of mission capability, cost, and time goals stated independently of a specific system solution.

--Follow a Secretary of Defense assignment to a service or services for responding to a statement of needs and goals.

--Use industry initiative and innovativeness to identify alternative system concepts.

--Maintain competition by exploring rival systems. (See p. 10.)

However, the Office of the Secretary of Defense involvement in the identification and reconciliation of navigational needs was greater than the level of involvement criticized by the Commission. (See p. 10.)

It should be noted that:

--Only three of the six pertinent recommendations are suitable for a meaningful comparison; implementation of the other three requires changes in the Federal budgeting process or in the Department of Defense technology base which have not yet been made.

--The NAVSTAR program began before the Commission's report was issued.

--The evolution of the program was consistent with then-existing acquisition regulations. (See p. 10)

GAO presented the results of its review of the three programs during August 24, 1976, hearings before the Subcommittee on Federal Spending Practices, Efficiency, and Open Government. GAO observed that implementation of the Commission's plan as outlined in the Office of Management and Budget circular will require improvements in several areas:

-Executive agencies have to understand that under the new acquisition process, mission

area deficiencies must be determined and stated independently of any specific system solution. This will enable agency heads and the Congress to make decisions based on a clear understanding of the mission deficiency and need for new systems.

--Effort allowed under the technology base requires redefinition so that solutions to mission needs are not dictated by in-house efforts but result from competition between alternative solutions.

--Industry must be given greater flexibility to propose a wide range of alternative solutions to mission area deficiencies in responding to Government requests.

Officials of the Office of the Secretary of Defense and the Air Force agreed generally with the report. Comments of these officials have been incorporated.

CHAPTER 1

INTRODUCTION

Major system acquisitions account for a large portion of Federal expenditures. We reported 1/ in February 1976 that major Federal acquisitions 2/ in process as of June 30, 1975, would cost about $404 billion at completion. About $220 billion is for Department of Defense (DOD) acquisitions, excluding the Army Corps of Engineers.

In December 1972, after about 2-1/2 years of study, the Commission on Government Procurement issued its report containing 149 recommendations for improving Federal procurement. Twelve recommendations were on major system acquisitions. The Office of Federal Procurement Policy, Office of Management and Budget, issued Circular No. A-109, "Major System Acquisitions," on April 5, 1976. It prescribed policy for all executive branch agencies based on the Commission's recommendations.

During July 1975 hearings on major system acquisition reform, the Chairman, Subcommittee on Federal Spending Practices, Efficiency, and Open Government, Senate Committee on Government Operations, asked us to undertake a special study of the "very beginning steps" in the requirements process for some current programs. He asked that we compare the evolution of these programs with the Commission's recommendations.

DOD officials had indicated in congressional hearings that the intent of the Commission's plan had been implemented either formally or informally in some DOD acquisitions. Therefore, with agreement from the Senator's office, we asked the Deputy Secretary of Defense to suggest acquisitions which were managed in a way that most nearly corresponded to the procedures the Commission recommended.

1/"Financial Status of Major Acquisitions, June 30, 1975," PSAD-76-72, dated February 27, 1976.

2/For civil agencies, acquisitions over $25 million were considered major. For DOD, programs with research, development, test, and evaluation costs over $50 million or production costs over $200 million were considered major.

The Office of the Secretary of Defense (OSD) asked each service to suggest systems to be reviewed. The systems selected were (1) the Army's Pershing II missile system, (2) the Navy's Shipboard Intermediate Range Combat System, and (3) the NAVSTAR Global Positioning System, which has a joint service program office with the Air Force as the executive service. The Pershing II and Shipboard Intermediate Range Combat System are the subjects of separate reports.

We presented the results of our review of the three programs during August 24, 1976, hearings before the Subcommittee on Federal Spending Practices, Efficiency, and Open Government. We observed that implementation of the Commission's plan as outlined in the Office of Management and Budget circular will require improvements in several areas:

--Executive agencies have to understand that under the new acquisition process mission area deficiencies must be determined and stated independently of any specific system solution. This will enable agency heads and the Congress to make decisions based on a clear understanding of the mission deficiency and need for new systems.

--Effort allowed under the technology base requires redefinition so that solutions to mission needs are not dictated by in-house efforts but result from competition between alternative solutions.

--Industry must be given greater flexibility to propose a wide range of alternative solutions to mission area deficiencies in responding to Government requests.

SCOPE OF REVIEW

Our review covered only the Commission's first six recommendations. To determine the evolution of the selected programs, we conferred with officials of OSD, military department headquarters, program offices, and selected contractors. We reviewed available correspondence; reports; briefing charts; contracting documents; and planning, programming, and budgeting system documents.

We did not evaluate the conclusions reached or decisions made in the programs' evolution. Rather, we compared the programs with the major system acquisition plan envisioned by the Commission and with the Office of Management and Budget circular on major system acquisitions.

Formal comments were not obtained from DOD on this report. However, OSD and Air Force officials reviewed the report and were generally in agreement with its findings and conclusions. Comments of these officials have been incorporated.

CHAPTER 2

COMMISSION ON GOVERNMENT PROCUREMENT

The Commission on Government Procurement's recommendations on major system acquisitions called for:

--Establishing a common plan for conducting and controlling all acquisition programs. The plan should highlight the key decisions for all involved organizations: the Congress, agency heads, agency components, and the private sector.

--Defining each organization's role so it can exercise proper responsibility and control over acquisition programs.

--Providing the Congress and agency heads with the information needed to make program decisions and commitments.

The plan forms a structure applicable to programs of all agencies. The recommendations were not designed to be applied selectively to the acquisition process but, rather, to be used together to improve the entire acquisition process.

Specific actions called for in the early stages of the process were:

--Agency components (such as the Army, Navy, and Air Force) would submit their perceptions of mission deficiencies to their agency head (such as the Secretary of Defense).

--The agency head would reconcile a perceived need with overall agency mission capabilities and, if there was agreement that a need existed, would (1) set initial cost, time, and capability goals and (2) direct one or more agency components to respond to the need.

--An agency component would establish a program office and solicit proposals from industry for conceptual solutions to the stated need.

--Industry would respond to the solicitation with proposed systems.

--The agency budget request and the congressional authorizations for front-end research and development would be by mission purpose rather than by individual items.

--The agency head would allocate funds to agency components for the proposed systems.

--The agency component would fund selected alternative systems using annual fixed-level funding, after reviewing their progress each year.

--Industry would explore 1/ the selected systems within the established funding goals.

--The agency component would choose systems for competitive demonstration on the basis of this exploration.

--The agency head would specifically approve the competitive demonstration.

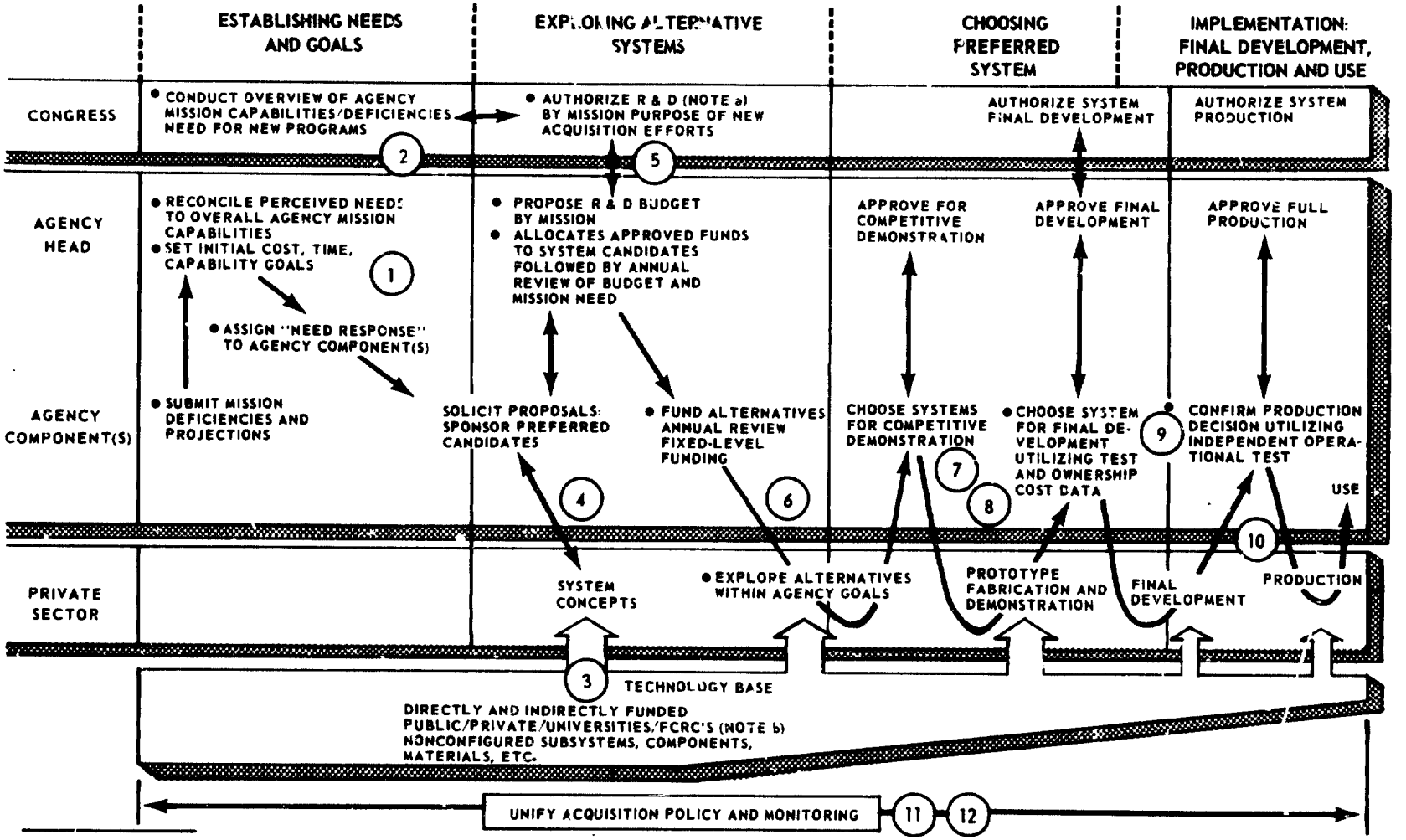
As an exception, agency head approval would be required if the agency component determined it should concentrate development resources on a single system.

The attached chart from the Commission's report shows the interaction of the Congress, agency heads, agency components, and private sector in the recommended major system acquisition plan.

1/As used by the Commission, "exploring alternative systems" includes the study, design, and development effort occuring between agency head direction for a component to respond to a need statement and the selection of systems for competitive demonstration.

MAJOR SYSTEM ACQUISITION

• RECOMMENDED ACTIONS



[a] RESEARCH AND DEVELOPMENT.

[b] FEDERAL CONTRACT RESEARCH CENTERS.

CHAPTER 3

EVOLUTION OF THE NAVSTAR GLOBAL POSITIONING SYSTEM

The NAVSTAR Global Positioning System, comprised of satellites, satellite control stations, monitor sets, and user equipment, will provide precise information on user position and speed. Anticipated users include strategic and attack aircraft, support aircraft, ships, submarines, and ground vehicles and troops. The system will have 24 satellites--8 in each of three 10,900-nautical-mile orbital planes. User equipment will receive and process data from the best four of six to nine satellites available to a user at any time. Six classes of user equipment have been proposed for different user missions, environments, and user vehicle characteristics, such as speed.

Control stations and monitor sets will determine satellite locations and will update the information being transmitted from the satellites. Users will be able to determine their positions within about 10 meters and their velocities on a global basis, 24 hours a day. The system will operate in all weather conditions and will be difficult for an enemy to jam or destroy.

On April 17, 1973, the Deputy Secretary of Defense directed the Air Force to consolidate two prior satellite navigation and positioning programs--the TIMATION and 621B programs of the Navy and Air Force, respectively. The NAVSTAR program then came into being. Appendixes to this report describe existing navigation systems (app. I); DOD efforts to assess its navigation and positioning capability (app. II); and a summary of satellite navigation system efforts, including NAVSTAR (app. III).

THREE-PHASE SYSTEM DEVELOPMENT

The NAVSTAR program has been divided into three phases.

Phase I

Phase 1, concept validation, extends from Defense System Acquisition Review Council (DSARC) I in December 1973 to DSARC II scheduled in March 1978. It now calls for a six-satellite network to demonstrate the feasibility of the system. The number of satellites has been increased from four to six to support Navy fleet ballistic missile testing.

Before using the satellite system, approximately 6 months of "inverted range" testing will take place in mid-1976. During these tests, ground-based satellite transmitters will transmit signals to aircraft to simulate the space-based system. As the six-satellite system is launched, testing will shift to the space-based system; by November 1977 the six-satellite system will be in use.

User equipment will be developed concurrently with satellite development and launching. Two general development models will be built to demonstrate the general requirements and to provide production specifications for the six basic types of user equipment. Based on these models, a prototype of one type of user equipment will be built with a $25,000 cost goal. The equipment will be installed in low-performance aircraft to test utility and maintenance. A third general development model, being developed by the Air Force Avionics Laboratory, will demonstrate maximum antijamming protection.

In addition to the above testing, the program will investigate clock technology, particularly the extremely accurate and highly stable clocks necessary to achieve high-positioning accuracy.

Phase II

Phase II, system test and limited capability, will last from March 1978 through DSARC III in early 1982. During this period, the system is planned to attain precise three-dimensional capability, periodically, and a continuous, two-dimensional capability, with fully operational ground stations. This phase will also include:

1. Initial operational test and evaluation and initial production of the low-cost class of user equipment.

2. Completion of initial operational test and evaluation on the other classes of user equipment.

3. Building satellites.

Phase III

Phase III, full operational capability, extends from 1982 through 1987, during which time the remaining satellites will be built, user equipment will be procured, and the two-dimensional satellite system will be augmented by further launches to provide a precise, three-dimensional capability.

ESTIMATED PROGRAM COST

The cost estimate for the NAVSTAR program is $1.2 billion. It does not, however, include the procurement costs for equipment that users of the system must have.

NAVSTAR Cost estimate

Phase	Cost estimate (millions)
I	$ 288.3
II	516.8
III	394.9
Total	$1,200.0

The most recent planning estimate available for phase I, as of April 1976, shows the following funding requirements for each service.

Cost estimate for Phase I

Service		Cost estimate (millions)
Air Force		
NAVSTAR	$150.5	
Fleet Ballistic Missile Testing	71.9	$222.4
Navy		43.8
Army		22.1
Total		$288.3

NAVSTAR has a requirement to establish a unit production cost goal during phase I which will be updated during the program. The program office plans to use it to support its life-cycle-cost goals. A life-cycle-cost model will be used in making equipment trade-off decisions. If deployed successfully, NAVSTAR would probably be complemented by some type of inertial system. A reduction in other navigation systems might reduce total DOD navigation costs.

CHAPTER 4

COMPARISON OF THE NAVSTAR PROGRAM WITH THE COMMISSION'S ACQUISITION PLAN

The evolution of the NAVSTAR program only slightly resembles the Commission's recommended acquisition plan. Major reasons for this conclusion are that the program did not:

--Begin with a statement of mission capability, cost, and time goals stated independently of a specific system solution.

--Follow a Secretary of Defense assignment of responsibility to a service for responding to a mission deficiency.

--Use industry initiative and innovativeness to identify alternative system concepts.

--Maintain competition by exploring competing systems.

Office of the Secretary of Defense involvement in the identification and reconciliation of navigational needs was, however, greater than the generally low level of involvement criticized by the Commission. Also, the program is maintaining or considering competition for certain subsystems.

It should be noted that:

--Only three recommendations (1, 4, and 6) are suitable for a meaningful comparison. Implementation of recommendations 2, 3, and 5 will require changes in the Federal budgeting process or in the Department of Defense technology base. These changes have not yet been made.

--The NAVSTAR program began before the Commission's report was issued.

--The evolution of the program was consistent with then-existing acquisition regulations.

The following sections present our comparison of the Commission's first six recommendations with the evolution of the NAVSTAR program.

STARTING AND COORDINATING PROGRAMS

"Recommendation 1. Start new system acquisition programs with agency head statements of needs and goals that have been reconciled with overall agency capabilities and resources.

(a) State program needs and goals independently of any system product. Use long-term projections of mission capabilities and deficiencies prepared and coordinated by agency component(s) to set program goals that specify:

(1) Total mission costs within which new systems should be bought and used.

(2) The level of mission capability to be achieved above that of projected inventories and existing systems.

(3) The time period in which the new capability is to be achieved.

(b) Assign responsibility for responding to statements of needs and goals to agency components in such a way that either:

(1) A single agency component is responsible for developing system alternatives when the mission need is clearly the responsibility of one component; or

(2) Competition between agency components is formally recognized with each offering alternative system solutions when the mission responsibilities overlap."

The Commission envisioned that an agency component, such as a military service, would submit long-term projections of mission capabilities and deficiencies to the agency head for review. The agency head would then have these projections reconciled with overall agency resources and capabilities. A major system acquisition program could be started according to recommendation 1 if there was agreement that a deficiency existed. This action was to include a statement of needs and goals which did not call for a specific solution and was to occur before identifying and exploring specific systems and before possible solutions were reduced to a single system. Under the Commission's plan, the Secretary of Defense would assign a service or services the responsibility for responding to a statement of specific needs and goals.

The conceptual study which led to NAVSTAR began about 1964--the year the Air Force and Navy began studying ways to use satellites to improve navigation. The services initiated these efforts rather than the Secretary of Defense. Undoubtedly, they did so with the knowledge that increased navigation and positioning would improve military operations.

DOD documented the needs and goals for navigation and positioning. (See app. II.) These efforts, particularly those involving the Joint Chiefs of Staff and the Director, Defense Research and Engineering, are consistent with that portion of recommendation 1 aimed at preventing a single service from perceiving a mission need and proceeding without Secretary of Defense involvement. Several aspects of these efforts, however, are not similar to the Commission's plan because

--they occurred at a later point in the acquisition process;

--mission needs apparently reflected the projected capability of the Air Force's satellite navigation system under development, rather than a determination of the specific need;

--from the beginning, the services assumed that only a satellite system would fulfill their needs.

Program initiation

In 1964, as a result of navigational capability achieved for submarines by the TRANSIT program (see app. I), the Navy and the Air Force started to explore ways to improve satellite navigational systems. This could be described as exploration of a technological opportunity. The Commission recognized that a program could be prompted by technological opportunities. In these instances, however, under the Commission's plan, the mission need would be questioned. The system idea would evolve freely based on mission goals, not on premature product specifications. The need would be separated from any particular system and goals would be defined independently of the performance, cost, and schedule characteristics of any particular system. Alternative systems, performance requirements, and unit costs would then be explored.

Unlike the Commission's plan, the services pursued satellite solutions without independently establishing mission needs and goals.

Documentation of the mission needs and goals

At different times from about 1966-73, the military services and the Office of the Secretary of Defense documented navigation needs. (See app. II.) This occurred after the Air Force and Navy began developing and advocating separate satellite navigation systems.

In 1966, the LORAN Installation Plan listed navigation characteristics considered essential or desirable by the Joint Chiefs of Staff. A comprehensive review of all navigation systems was made in 1968 to determine the most cost effective solution to navigation deficiencies. The resulting Joint Chiefs of Staff study, which repeated the above-mentioned characteristics, was the basis of the 1971 Joint Chiefs of Staff Master Navigation Plan. This plan was reviewed by the Director, Defense Research and Engineering, who pointed out several problems, including accuracy requirements that seemed to be based on the Air Force's proposed 621B system, rather than on actual operational needs. The plan also assumed that a defense navigation satellite system would be developed. It did not state mission deficiencies independently of a specific system solution as recommended by the Commission.

The Director requested in November 1970 that an area coordination paper (ACP) on navigation be prepared. It was signed on January 10, 1973. One principal conclusion was that navigation requirements need to be reexamined to establish their value. It advocated (1) continuing investigation of systems having the potential, singly or jointly, of meeting long-range DOD navigation needs and (2) a decision on a satellite system within the next few years. The ACP also recognized the need for coordination of DOD navigation development. Shortly after approval of the ACP, the Deputy Secretary of Defense issued a memorandum stating that DOD would proceed to Defense Systems Acquisition Review Council I with a navigation satellite system. It made the Air Force responsible for the effort.

Mission cost goals

The Commission felt that mission cost goals, within which new systems could be bought and used, should be established before alternative system concepts were identified to solve a mission need. DOD has not addressed mission cost goals in this manner. As an example, the 1973 ACP presented costs in terms of navigation system costs with a NAVSTAR system and without a NAVSTAR system. Cost estimates were limited to the classes of navigation equipment which would

be directly affected by the NAVSTAR. LORAN, OMEGA, TRANSIT, and doppler systems (see app. I) would be competitors, while inertial systems would primarily be backup systems.

Assignment of mission needs and goals to agency components

As stated previously, the Air Force and Navy initiated efforts to improve the satellite navigation system. Under the Commission's plan the Secretary of Defense would assign responsibility to a service or services for responding to a statement of needs and goals. In 1973, the Deputy Secretary of Defense directed the Air Force to develop a satellite navigation system by incorporating elements of the Air Force and Navy concepts. This assignment was not the kind envisioned by the Commission, because it specified a specific solution. Also, it occurred at a later point in the acquisition process than recommended by the Commission.

CONGRESSIONAL REVIEW OF NEEDS AND GOALS

> "Recommendation 2. Begin congressional budget proceedings with an annual review by the appropriate committees of agency missions, capabilities, deficiencies, and the needs and goals for new acquisition programs as a basis for reviewing agency budgets."

In accordance with current budgeting procedures, funding for navigation systems has been by project or program rather than by mission area. Thus, funding has been obtained for projects related to 621B and TIMATION and for NAVSTAR, TRANSIT, LORAN C, LORAN D, inertial systems, and others but not for navigation. Budget proceedings have not been started with a mission area presentation. The 1974 Congressional Budget Act requires that starting with fiscal year 1979, the President's budget request will contain descriptive information in terms of national needs, agency missions, and basic programs.

The Commission stated that the Congress cannot effectively review expenditures and the allocation of national resources without clearly understanding the needs and goals for new programs. It continued that the needs and goals for a program are presented to the Congress when a single system is proposed, with cost, schedule, and performance estimates often predicated on insufficient research and development. At this point, the cost to meet a mission need is largely determined by the cost of the new system, not the worth of the new system compared to others.

The Congress should have an early opportunity to (1) understand and debate any agency's mission needs and goals for new acquisitions and (2) discuss the relationship of proposed mission capabilities to current national policy and the allocation of resources in accordance with national priorities.

TECHNOLOGY BASE

> "Recommendation 3. Support the general fields of knowledge that are related to an agency's assigned responsibilities by funding private sector sources and Government in-house technical centers to do:
>
> (a) Basic and applied research.
>
> (b) Proof of concept work.
>
> (c) Exploratory subsystem development.
>
> Restrict subsystem development to less than fully designed hardware until identified as part of a system candidate to meet a specific operational need."

This recommendation is directed toward establishing a broad technology base to support an agency's assigned responsibilities through technology base efforts. The Commission's recommended budgeting process calls for a separate appropriation to finance the technology base. This restructuring of the budget has not been done. Also, current research and development practices allow subsystem development to proceed farther than would be allowed under the Commission's plan.

The early Air Force and Navy development was aimed at independently establishing the workability of the system concept each was pursuing. Some of these efforts fall within the Commission's definition on technology base effort; others go beyond it because fully designed hardware was developed. This happened before the Deputy Secretary of Defense acted in 1973 to centralize control over the space-based navigation system development. Some early developments in the 621B and TIMATION programs are presented below.

In 1968 the Air Force contracted with Hughes Aircraft Company and TRW Systems for a satellite navigation concept and system design study. The information developed from these studies identified certain aspects of satellite navigation

which the Air Force then pursued in its efforts to prove the feasibility of a global-positioning system. Such efforts included (1) a study to predict the total electron content over the entire world, (2) examination of signal wave forms as means to transfer data, and (3) activity to determine optimum frequency and structure of signals; and were undertaken before the concept had been approved for development.

The Air Force also contracted to have ground-based transmitters and airborne receivers or user equipment built to support the concept. Although the equipment was not fully designed for use, the Air Force did pursue the idea of satellite navigation from study and technology to simulated demonstration. Again, this was done before the Deputy Secretary of Defense approved the concept for development.

The Navy's TIMATION efforts were designed to support the satellite navigation concept. The Navy emphasized actual demonstration and carried out tests using technology satellites and user equipment. The most advanced work was the development of space clocks. Now these efforts have been interwoven with the NAVSTAR program to avoid duplicating development of clock technology. An important point is that specific and integral subsystems of a satellite navigation system--satellites and clocks--were being developed before the Secretary of Defense approved a major system acquisition effort.

The efforts identified above are in keeping with the methods used by DOD to establish new systems. A major technology effort is intended to validate a system. Some efforts progressed to the development of specific equipment for satellite navigation. A U.S. Air Force Space and Missile Systems Organization (SAMSO) comment summarizes these efforts:

> "System 621B has systematically progressed from preliminary design and analysis studies for technical feasibility through the completion of receiver breadboard development. The * * *emphasis [was] * * *to establish a solid advocacy base for system acquisition approval* * *."

CREATING NEW SYSTEMS

> "Recommendation 4. Create alternative system candidates by:
>
> (a) Soliciting industry proposals for new systems with a statement of the need (mission deficiency); time, cost, and capability goals; and operating

constraints of the responsible agency and component(s), with each contractor free to propose system technical approach, subsystems, and main design features.

(b) Soliciting system proposals from smaller firms that do not own production facilities if they have:

(1) Personnel experienced in major development and production activities.

(2) Contingent plans for later use of required equipment and facilities.

(c) Sponsoring, for agency funding, the most promising system candidates selected by agency component heads from a review of those proposed, using a team of experts from inside and outside the agency component development organization."

DOD did not solicit proposals for alternative systems from industry to meet its needs and goals for navigation. The Air Force and the Navy developed different concepts (621B and TIMATION) to meet their perceptions of navigation needs and goals. These concepts were developed in-house; industry involvement was limited to specific tasks to support the services' concepts.

Moreover, the method used to develop the NAVSTAR concept resulted in requests for proposals that effectively ruled out smaller firms from being awarded development contracts.

Rationale for the recommendation

According to the Commission, agency components prematurely commit themselves to a system because (1) a predetermined design is often linked to the statement of "need," (2) industry is pressured to propose the kind of system the agency component wants, (3) limited resources are available to explore alternatives, and (4) the services must defend a system before many resources are committed to it. The premature commitments are, according to the Commission, made for a system that reflects design contributions from many public and private organizations. This "design by committee" cuts off real alternatives and results in a complex and not easily managed system.

In an environment of uncertain needs and technology, alternative systems would provide relatively inexpensive

insurance against the possibility that a premature choice may later prove to be poor and costly. Alternative concepts introduce the benefits of competition early in the evolution of a system when the cost to maintain competitors is only a small fraction of that needed for later development and production phases. A wider base of innovative talent can be applied rather than concentrating resources on a single system.

Alternative systems concepts

Alternative system concepts for satisfying navigation needs and goals were not developed or explored. The military services each decided that a satellite navigation system was the best solution. As a result, the Navy was pursuing TIMATION and the Air Force was pursuing the 621B. Neither system would have met all of DOD's navigation requirements--TIMATION would not meet security requirements for signals and 621B required stations in foreign countries. Elements of each were eventually incorporated into NAVSTAR.

The TIMATION and 621B programs cannot be considered alternative systems, as they used the same technical approach with variations in design and did not address the same stated needs. Under NAVSTAR, only one system is being developed.

Solicitation of industry proposals

In April 1973, the Deputy Secretary of Defense directed the Air Force to develop a navigation satellite program. Thus, requests for proposals issued to industry were not intended to produce alternative system concepts, but elements of the satellite system which had been developed in-house.

The requests for proposals did allow for subsystem competition. With NAVSTAR, the requests were functionally oriented and cited only minimal constraints, such as average mission duration and the weight of the satellite.

Relationship with smaller firms

Solicitations were essentially limited to larger firms familiar with satellites, particularly satellite navigation. Before issuing requests for space vehicles, the program office visited 13 aerospace contractors to determine the state of the art and to provide information on the possible development. Small firms, previously uninvolved in satellite technology, were not invited to this meeting.

Program personnel explained some concerns about smaller firms. For example, a small firm's knowledge and capital

reserve usually are less than a larger firm's. Both of these items can be vital if a contractor has an unexpected problem. The Government deals with the prime contractor only. If a small firm has a design proposal and subcontracts with a large firm for production, control of the project is likely to rest with the large firm, with whom the Government has no contractual relationship.

Although the requests for proposals for space vehicles were issued to any interested firm, 13 firms in the satellite industry were favored, as the request was based on input from them. Requests for proposals for user equipment and control systems were limited to contractors familiar with satellite navigation: (1) General Dynamics and Magnavox and (2) TRW and Philco-Ford. These companies had been awarded prior contracts which stated that one of them would be awarded the phase I contract.

The requests for space vehicles resulted in four proposals. Three of the four firms had worked on satellite navigation systems, and the other, which had worked on communication satellites, subcontracted with a firm knowledgeable about 621B.

Source selection committees, composed of personnel from inside and outside the program office, evaluated the proposals. In early 1974, Rockwell International was awarded the space vehicle contract and General Dynamics/Magnavox was awarded the user equipment and control system contracts.

CONGRESSIONAL REVIEW OF SYSTEM EXPLORATION

"Recommendation 5. Finance the exploration of alternative systems by:

(a) Proposing agency development budgets according to mission need to support the exploration of alternative system candidates.

(b) Authorizing and appropriating funds by agency mission area in accordance with review of agency mission needs and goals for new acquisition programs.

(c) Allocating agency development funds to components by mission need to support the most promising system candidates. Monitor components' exploration of alternatives at the agency head level through annual budget and approval reviews using updated mission needs and goals."

The Commission stated that the Congress could better understand where research and development money was spent if it reviewed, authorized, and appropriated funds for studying candidate systems according to mission.

This would segregate funds for (1) maintaining the technology base, (2) exploring alternative solutions to mission needs, and (3) developing the selected systems. All development projects associated with the alternatives to meet each agency mission need would be grouped together.

Previous comments under recommendation 2 apply to this section also. Budget requests, authorizations, and appropriations have not been made by mission area. Accordingly, congressional review of NAVSTAR and the effort leading to NAVSTAR has been by individual item.

Although DOD is not exploring alternatives to the NAVSTAR program, it followed a mission area approach in establishing the program. Within OSD, reviews were made of DOD navigational capability and needs. As a result, the decision made to pursue development and production of NAVSTAR and several other non-space-based systems. These systems are not alternative systems but are complementary to NAVSTAR. Among these are self-contained inertial systems and ground-based OMEGA and LORAN systems which provide backup in case NAVSTAR malfunctions and additional assurance of navigational capability in the event of physical or electronic attack by a sophisticated foe.

Before the NAVSTAR concept was selected in 1973, TIMATION and 621B were reviewed. The best aspects of each were incorporated into NAVSTAR. This selection considered the needs of all the services and was undertaken to avoid obvious duplication.

Early review of navigation needs and capability included the 1966 LORAN Installation Plan, a 1968 Joint Chiefs of Staff study, and numerous efforts of the individual services. (See app. II.) The relationship between military requirements and the systems in existence or being developed was examined in the 1973 ACP. The mission needs and goals identified by the services and the Joint Chiefs of Staff and examined in the ACP were presented in detail in the Joint Chiefs of Staff Master Navigation Plan. Originally prepared from their 1968 study on navigation, this plan stated that only a satellite system could meet the requirements. Despite this restriction, the plan is a mission area approach to determining needs and goals for navigation. It has been updated several times since 1968.

A mission area budget can then be processed. DOD has already begun to think in terms of mission areas and to relate systems to them. Formulating a mission area budget would mean regrouping existing information.

REINSTATING MEANINGFUL COMPETITION

"Recommendation 6. Maintain competition between contractors exploring alternative systems by:

(a) Limiting commitments to each contractor to annual fixed-level awards, subject to annual review of their technical progress by the sponsoring agency component.

(b) Assigning agency representatives with relevant operational experience to advise competing contractors as necessary in developing performance and other requirements for each candidate system as tests and tradeoffs are made.

(c) Concentrating activities of agency development organizations, Government laboratories, and technical management staffs during the private sector competition on monitoring and evaluating contractor development efforts, and participating in those tests critical to determining whether the system candidate should be continued."

Alternatives to NAVSTAR are not being explored. However, several alternatives concerning technological risk and cost for user equipment are being sponsored. In addition, a second source for phase II satellite procurement is now being considered.

The Commission felt that most programs would benefit from competition among contractors which are independently responsible for their systems. This could be aided by challenging industry to use a wider span of technologies for system solutions that are of lower cost and simpler design. Contract incentives for competitors should be directed toward economy and austerity in system design. The Commission also stressed the integrity of contracts, which makes each contractor independent and fully responsible for designing the system contained in the proposals. Ultimately, success or failure of any alternative system should be determined by demonstration.

When the Deputy Secretary of Defense approved NAVSTAR on December 22, 1973, he stated that competitive development

contracts should be used for all user equipment, because continuation of the program beyond phase I depends largely on the development of accurate but inexpensive user equipment.

To meet this request, SAMSO is developing two alternates for manpacks (portable sets) and high dynamics sets for aircraft and helicopters. These will provide competition in those user classes where the potential equipment investment is greatest. The original contract for user equipment was awarded to General Dynamics and Magnavox Research Laboratory. Later, contracts were awarded to Texas Instruments, Inc., for both alternate development efforts in early 1975. Through these contracts, SAMSO hopes to achieve the best and least costly design by insuring active incentive among competitors.

Although only one contractor is developing a satellite for phase I, SAMSO officials have requested approval for a second contractor for phase II. In addition, procurement from two sources through phase III would assure the benefits of competition in the future. The competitive, second-source satellite would not be a copy of the same design and would be compatible with all users. To insure competition, the second contractor would be directed to have only a limited number of subcontractors in common with the original contractor. This competition hopefully would result in lower life-cycle cost.

In other areas, evidence showed no contractor competition. General Dynamics and Magnavox Research Laboratory are developing ground controls, and technological choices for the clock are being made by the Navy.

DESCRIPTION OF EXISTING NAVIGATION SYSTEMS

A brief description of present navigational systems is presented below. Each offers some of the characteristics needed for military purposes, such as global coverage, continuous availability, all-weather operation, and being impervious to enemy countermeasures. After NAVSTAR becomes operational, some of the more specialized systems may remain in use, but some of the more general purpose systems may be phased out.

1. LORAN-C is a system of radio signal transmitting stations used by ships and submarines. User position is determined from the time it takes signals to arrive from different stations. The system covers the North Atlantic, Mediterranean, Norwegian Sea, east coast of America, North and Central Pacific, and Southeast Asia. Accuracy depends on the user's distance from the stations and can be obtained to within 200 meters at 1,600 kilometers. Greater accuracy, to within 70 meters, can be obtained at lesser distances. Continuous, two-dimensional (longitude and latitude) information is provided.

2. LORAN-D is a tactical, short-range version of LORAN-C. It employs portable transmitters and is designed for rapid deployment into an area.

3. OMEGA is a chain of eight stations which transmit very low frequency signals. Use of this kind of signal and high power enable the system to cover the entire world. It provides continuous, all-weather navigation with two-dimensional (longitude and latitude) accuracy of 1 to 2 nautical miles for civil and military aircraft, surface ships, and submarines. The system does not provide altitude data.

4. Bottom navigation uses contour maps of the ocean bottom and a means of determining depth at the user's location. It can be used in all weather conditions and is impervious to enemy countermeasures. Data on system limitations is classified.

5. Inertial systems are self-contained systems which determine position by tracking movement from a known starting or reference point. They work on the principle that a vehicle's movement over the surface of the globe will displace a pendulum pointing at the center of the earth. Positioning becomes less accurate with the passage of time.

APPENDIX I

Because of decreasing accuracy, these systems do not meet all military requirements. However, with a satellite system, such as NAVSTAR, to periodically update the positional information, inertial systems could be used when enemy countermeasures prevent the use of NAVSTAR.

6. Celestial navigation is reliable and provides worldwide coverage in clear weather. It cannot be used to determine altitude and is not continuously available.

7. TRANSIT is the only operational satellite navigation system. It is used primarily by submarines. The system requires a user to obtain several readings at different times from TRANSIT satellites. Satellites are not available continuously, however, and submarines must expose their antennas to obtain navigational readings.

APPENDIX II

DE' RTMENT OF DEFENSE ASSESSMENT OF NAVIGATION AND POSITIONING

Deficiencies in existing or planned navigation systems have been documented numerous times by DOD. Some of these efforts are summarized below.

LORAN INSTALLATION PLAN--1966

DOD needs were stated by the Joint Chiefs of Staff in the 1966 LORAN Installation Plan. It listed several essential and desirable navigation system characteristics, such as improved accuracy, nonsaturability, and continuous availability. DOD defines two areas requiring navigational data: general purpose and objective. An objective area is that specific area in which a crew or unit leader must be able to navigate to a precise position to deliver stores, operate sensors, carry out operational tasks, or transit to terminals. A general purpose or en route area is all area external to the objective areas. The LORAN Installation Plan contained general purpose and objective area accuracy requirements for subsurface, air, ground, and sea operations.

MILITARY AIRLIFT COMMAND--1966

The Military Airlift Command identified deficiencies in global aircraft navigation in a July 1966 required operational capability document. This document described the navigation systems in use as limited in coverage and range. For example, the Navy's TRANSIT program was not compatible with aircraft velocity, and inertial systems were too expensive and not sufficiently accurate.

AEROSPACE CORPORATION MISSION ANALYSIS--1967

A March 1967 mission analysis by Aerospace Corporation presented existing navigation system limitations and a recommendation concerning future systems. Data on limitations of existing systems is classified.

APPENDIX II

JOINT CHIEFS OF STAFF STUDY

In October 1967 the Deputy Secretary of Defense requested that the Joint Chiefs of Staff review all navigation systems in use or being developed to recommend the most cost-effective combination of systems. The resulting study identified a need for worldwide coverage, redundancy, instantaneous response, continuous availability, and ability to resist enemy countermeasures. It included accuracy requirements for en route needs and objective area needs in three dimensions (longitude, latitude, and altitude) for close air support, helicopter assault, mapping, electronic warfare, and bombing missions.

The study found no system or combination of systems available in the 1970-80 period to meet the requirements. It stated that satellite systems appeared to have the most promise of providing continuous, worldwide navigational accuracy.

The study stated that no single system capable of meeting DOD needs existed and that a navigational satellite system and an inertial system were complimentary. The satellite system would provide precise positioning data and in-flight corrections for the inertial system. The inertial system would be self-contained and would be essentially impervious to enemy countermeasures.

MILITARY AIRLIFT COMMAND--1968

On April 9, 1968, a Required Operational Capability Document for a navigation satellite system was issued by the Military Airlift Command. Unlike the previous document, it identified specific needs for all types of users. The new system was to have worldwide, all-weather, and continuous coverage; passive user operation; low vulnerability to jamming; and accuracy of 1 nautical mile for en route needs and 0.01 nautical mile for objective area navigation. The Aerospace Defense Command, the Strategic Air Command, and the Tactical Air Command listed their accuracy requirements.

NAVY REQUIREMENTS--1968

The Navy issued OPNAV Instruction 03530.1A, Navy Navigation Policy, on September 16, 1968. It stated that no navigation system with worldwide coverage was in use or being developed which would accomplish the Navy's specific requirements of all tasks and missions. Taking into

consideration the most likely systems, the Navy presented two types of requirements:

--General purpose, a 1-nautical mile, continuous, all-weather requirement for forces en route to an objective area or in port-to-port or long-range, point-to-point operations.

--Precision, a 0.1- to 0.5-nautical mile, continuous, all-weather requirement to support flight operations and weapons systems.

The Navy also distinguished between essential and desirable characteristics:

--Essential:

--Worldwide coverage.

--All-weather, day and night operation.

--Effective, instantaneous response.

--Nonsaturability.

--No electronic radiation by user.

--Determination of position when user equipment is activated.

--Desirable: 1/

--No foreign bases.

--Easy to maintain, repair, and operate.

--Not limited to line of sight.

--Denies enemy use.

--No environmental propagation limitations.

1/One of the desirable characteristics is classified.

JOINT CHIEFS OF STAFF MASTER NAVIGATION PLAN--1971

The Joint Chiefs of Staff study became the principal reference for the 1971 Joint Chiefs of Staff Master Navigation Plan which called for accuracy of about 18 meters in 3 dimensions and an all-weather, continuous, worldwide system. It supported early implementation of OMEGA, selection of an advanced navigational satellite system for early implementation, support for the development and procurement of a self-contained system, and improvement of the LORAN-C and LORAN-D equipment.

Several issues, such as affect of user equipment on the cost of navigation systems and analysis of the operational requirements, were not resolved by the master plan. Moreover, the accuracy requirement was based on the expected capability of the ongoing Air Force development rather than on actual needs. The plan assumed that a satellite navigation system would be developed and that some of the other systems would be phased out.

SUMMARY OF SATELLITE NAVIGATION EFFORTS

The concept of a satellite navigation and positioning system originated in the 1950s at the Applied Physics Laboratory. By tracking Soviet satellites, the laboratory found that a satellite transmitting radio signals could be used to determine the position of an object on Earth. Radio signals from a satellite could be used to determine the distance from the satellite to the object. If the position of the satellite were known, several of these measurements could be used to compute the position of the object.

NAVY SATELLITE EFFORT--TRANSIT

The Navy became interested in satellite navigation for its fleet ballistic missile submarines, and the TRANSIT system became operational in 1964 as a result. It includes six satellites in low-altitude, subsynchronous orbits which allow submarines to determine their positions within 0.1 nautical mile. The system is worldwide, all-weather, and meets the accuracy needs of submarines. Limitations of the system are classified. The advantages and problems of TRANSIT resulted in further Navy study of space-based navigation. This effort started in 1964 and was called TIMATION.

NAVY SATELLITE EFFORT--TIMATION

The TIMATION program advocated a system of 9 satellites in each of 3 medium altitude orbits, for a total of 27 satellites. The proposed system would give instantaneous position data, would provide worldwide coverage, and would not be affected by the user's velocity. To prove the approach was workable, the Navy explored (1) methods for establishing precise time data 1/ for satellites, (2) the capability of transferring time data for synchronization, and (3) orbital configurations.

1/Precise time data is required. The concept is based on accurate knowledge of the position of satellites, exact time at that position, and the transit time of a signal from that position. Distances from three satellites are required to compute the users' positions.

In 1967, the Navy launched an experimental satellite (TIMATION-I) to demonstrate the feasibility of the system. Receivers were placed on aircraft, trucks, and a boat, and two-dimensional accuracy of 100 meters was obtained. Use of this technique to transfer time was verified to one-millionth of a second.

TIMATION II was launched in 1969. It used two different radio signal frequencies to reduce errors caused by the ionosphere and an improved clock for increased stability and synchronization. Tests demonstrated two-dimensional position accuracy of 50 meters under conditions similar to TIMATION I and instantaneous two-dimensional positioning within 70 meters. The effort demonstrated that the clock was stable and could be synchronized from the ground. Also, time transfer experiments were carried out. The Navy also developed user-related equipment and assembled four tracking systems to monitor the satellites.

AIR FORCE SATELLITE EFFORTS--621B

In 1964, the Air Force Space and Missile Systems Organization (SAMSO) also began work on a satellite navigation system, including studies and laboratory tests to develop a practical system. A 1967 mission analysis by the Aerospace Corporation of El Segundo, California, and SAMSO analyzed satellite navigation for jet aircraft. This was a critical aspect of any new system, since TRANSIT could not provide the desired accuracy for jets. The resulting report, "Improvement in Navigation of High Speed Aircraft," (Oct. 23, 1967), identified satellite navigation as the best approach. Based on an investigation of different navigation systems for tactical fighter command and control, the report concluded that an advanced satellite navigation system was the most cost-effective system. It also stated that accuracy of about 18 meters was achievable with then current technology.

The report discussed regional satellite systems which would be linked together for a continuous, worldwide system. Numerous ground stations, some in foreign countries, would be needed for tracking and control. SAMSO later awarded two contracts of about $500,000 each in May 1968 to TRW Systems and Hughes Aircraft for system formulation and design work. In January 1969 they submitted reports which SAMSO used to finalize a Concept Formulation Package/Technical Development Plan. The plan advocated using a 621B satellite navigation system. This proposal was submitted to the

Air Force Systems Command in April 1969 and was modified following a request by the Command for an Advance Development Plan which did not commit the Air Force to the total system at initial program approval.

During the first half of 1969, SAMSO awarded several study and feasibility contracts in areas, such as optimization of user equipment for cost savings, building breadboard models of receivers and transmitters, integrating 621B into existing aircraft avionics, and the impact of 621B on naval fleet and air operations. From 1969 to 1972, SAMSO made many studies to investigate 621B, including:

--Delay of signals by atmospheric effects.

--Application of 621B to missile and space guidance.

--Financial impact of 621B on procurement and maintenance of DOD navigation equipment.

--621B signal acquisition and tracking.

--Range measuring.

--Signal frequency and structure.

--Design, fabrication, and test of 621B equipment using ground-based transmitters.

--Performance characteristics of signal wave forms.

Single-channel and multichannel receiver tests were made at White Sands Missile Range to confirm performance of the proprosed receivers. These tests used an NC-135 aircraft and two continuous-tracking receivers to determine system performance, equipment design, and effects of environment and atmosphere on radio signals. Results proved that position-fixing to 5 meters and velocity to 0.3 meter per second were attainable. Tests were also carried out using other equipment.

The 621B program thus progressed from a concept to preliminary design and analysis for technical feasibility and demonstration to establish a basis for system acquisition approval.

NAVSTAR PROGRAM

In 1970, the Director, Defense Research and Engineering, recommended that an area coordination paper (ACP) and a development concept paper (DCP) be prepared to resolve the issues remaining in the Joint Chiefs of Staff Master Navigation Plan. (See app. II.) The ACP was to review all navigation systems and relate them to each other according to cost and need; the DCP was to show the merit and cost of a satellite system. This recommendation was supported by the Secretary of Defense and the two papers were prepared.

The Director signed the ACP on January 19, 1973, and it was updated on December 11, 1973. The ACP reviewed the status of navigation development programs and possible answers for future requirements. Its major conclusions were that:

1. Navigation requirements be reexamined to establish their value and to facilitate trade-offs between requirements, design, and cost.

2. The key economic question be answered: Can acquisition costs be offset by reducing the number of navigation systems?

3. A decision be made on whether or not to develop an advanced system, such as NAVSTAR, in the next few years.

4. System options having the potential, singly or jointly, of meeting long-range DOD needs continue to be investigated. Three options were identified: (a) global systems, (b) deployable and mobile systems, and (c) self-contained systems.

5. A navigation focal point be established in the Office of the Secretary of Defense to review DOD efforts and to provide the Deputy Secretary of Defense specific recommendations on new development, cost avoidance, and phasing out of navigation systems.

The DCP which was to show the merit and cost of a satellite system was also signed on January 10, 1973. However, there was disagreement within OSD, and the paper was not officially approved. On April 17, 1973, the Deputy Secretary of Defense designated the Air Force as responsible for a Defense Satellite Navigation Development Program. He instructed the Air Force to undertake the necessary coordination; assign a program manager; and establish a joint Army, Navy, Marine Corps, and Air Force program office which would prepare detailed plans for the system. The Army and Navy were instructed to insure that their elements of the program were directed at establishing a comprehensive and integrated DOD system. The program office was to prepare a DCP for Defense Systems Acquisition Review Council I by July 1973. The program office was established at SAMSO in June 1973. The DCP, which was signed on January 10, 1973, included joint-service requirements and some aspects of TIMATION. Thus, the main task was to consolidate the Air Force and Navy programs.

SAMSO studied the best concept to present to DSARC I and determined potential users. After the classes of user equipment had been determined, contracts for defining the user equipment and the control systems were awarded in June 1973 to (1) General Dynamics and Magnavox Research Laboratories and (2) TRW Systems, Inc., and Philco Ford. In accordance with these contracts, the contract for developing user equipment and control systems would be awarded to one of these teams.

The program office also investigated the state of the art for navigation. Program personnel visited 13 satellite contractors before giving an information briefing on possible development of a global positioning system. Information was also obtained on other aspects of satellite navigation. Studies were made on the capabilities of existing systems; potential cost avoidances resulting from NAVSTAR; and cost, performance, and schedule analyses. The latter were based on various constellations of satellites with different orbits, boosters, satellites, or support facilities.

The DCP continued to be revised as the system changed. DSARC I was rescheduled to October and was finally held on December 13, 1973. In November 1973, the system was named NAVSTAR Global Positioning System to more accurately describe the proposed system and to relieve it of past connotations.

The DCP based its concept of NAVSTAR on the best aspects of TIMATION and 621B. The orbit configuration was patterned after TIMATION's orbit configuration. Unlike 621B, it provided worldwide coverage without foreign ground stations. The satellite signal, however, was based on 621B research. This signal would provide more resistance to enemy countermeasures. The precise clock was to be developed by the Navy. Considerable research on stability and precision of spaceborne clocks was done under TIMATION, and the Navy had overall responsibility for work on time and clock development for DOD. The Council recommended this approach:

--Evolutionary system development.

--4 years to validate the concept--phase I.

--Some operational testing.

--Subsynchronous operational satellites.

--Cost of $150 million to complete phase I.

--Carry over of experimental hardware to system development.

This recommendation was approved by the Deputy Secretary of Defense on December 22, 1973. He indicated that since user equipment costs would be a major factor in program approval beyond phase I, the program should use competitive development contracts for user equipment.

After the first council, SAMSO issued several requests for proposals. The first, issued in January 1974, was for space vehicles. It contained functional specifications, giving contractors flexibility to propose different designs. It cited constraints such as weight--dictated by the launch vehicle--and reliability requirements. The requests also stated that emphasis would be on technical competition rather than on price competition. Four proposals were received in April 1974, and source selection began. The contract was awarded to Rockwell International in June 1974.

Requests for proposals for user equipment and the control system were issued to General Dynamics/Magnavox Research Laboratory and TRW/Philco-Ford in April 1974. These requests contained functional specifications and few constraints. Constraints concerned the size and weight of the

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unit; interfaces with the satellite, such as signal structure and data flow; and the use of a high order computer language to meet changing technology.

Similar to the space vehicle contract, the contracts for the user equipment and control system were the result of source selection based largely on technical competition. General Dynamics/Magnavox Research Laboratory received the contracts for the two segments.

To pursue a somewhat higher risk technology with the opportunity for additional payoffs in the form of lower life-cycle-cost user equipment, SAMSO issued separate requests for proposals for alternate development of the manpack and the high dynamic set in February 1975. Proposals for the high dynamic user equipment were evaluated by one selection committee; those for the manpack unit were evaluated by another. As a result of these separate evaluations, Texas Instruments, Inc. was awarded both contracts. Alternate requests for proposals were not issued for the low-cost user equipment or the control system.

APPENDIX IV

PRINCIPAL OFFICIALS

RESPONSIBLE FOR MATTERS

DISCUSSED IN THIS REPORT

	Tenure of Office	
	From	To
DEPARTMENT OF DEFENSE		
SECRETARY OF DEFENSE:		
Donald H. Rumsfeld	Nov. 1975	Present
William P. Clements, Jr. (acting)	Nov. 1975	Nov. 1975
James R. Schlesinger	July 1973	Nov. 1975
William P. Clements, Jr. (acting)	May 1973	July 1973
Elliot L. Richardson	Jan. 1973	May 1973
Melvin R. Laird	Jan. 1969	Jan. 1973
DEPUTY SECRETARIES OF DEFENSE:		
Robert Ellsworth	Dec. 1975	Present
William P. Clements, Jr.	Jan. 1973	Present
Kenneth Rush	Feb. 1972	Jan. 1973
Vacant	Dec. 1971	Feb. 1972
David Packard	Jan. 1969	Dec. 1971
DIRECTOR, DEFENSE RESEARCH AND ENGINEERING:		
Malcolm R. Currie	June 1973	Present
John S. Foster, Jr.	Oct. 1965	June 1973
SECRETARY OF THE AIR FORCE:		
Thomas C. Reed	Jan. 1976	Present
John L. McLucas	July 1973	Nov. 1975
Robert C. Seamans, Jr.	Feb. 1969	May 1973