THE DEVELOPMENT OF A CONFIGURATION MANAGEMENT APPROACH FOR THE OPERATIONAL PHASE OF THE NATO SEASPARROW PROJECT

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THESIS

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NATO SEASPARROW PROJECT

by

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June 1972

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ABSTRACT

This Thesis develops a configuration management approach for use during the operational phase of the NATO SEASPARROW Surface Missile System project. A brief description of the concepts and techniques of configuration management as well as the background of the NATO SEASPARROW project are presented to familiarize the reader with the subject matter.

The sub-alternatives and constraints in the areas of organizational form, authority constraints, and change control measures are enumerated and evaluated against the goals of the members of the consortium and the requirements of sound configuration management. System alternatives and constraints are then synthesized from the sets of sub-alternatives to provide a final set of cohesive, viable alternatives.

From an evaluation of these system alternatives, the recommended solution is selected. An implementation plan is presented for the selected alternative.

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ACKNOWLEDGEMENTS

The author's wish to express their appreciation for the guidance and inspiration provided by Professor Melvin B. Kline in the preparation of this thesis; and further for his vigorous and imaginative direction throughout their participation in the Systems Acquisition Management Curriculum. Appreciation is also expressed to Captain T. A. Ward, USN, the NATO SEASPARROW Project Mananager, the NATO SEASPARROW Project Staff, and the national representatives, all of whom provided assistance and encouragement in the preparation of this thesis. Special appreciation is extended to Mr. Howard T. Pritchard of the Project Staff.

I. INTRODUCTION

A. PURPOSE

The purpose of this thesis is to present a development of alternative approaches to the configuration management issues surrounding the NATO SEASPARROW Surface Missile System during the system's operational phase. From these alternatives a recommended approach to the configuration management question will be presented.

B. BACKGROUND

The NATO SEASPARROW Project is a NATO (NORTH ATLANTIC TREATY ORGANIZATION) sponsored multinational consortium. The member nations have formed this consortium for the express purpose of designing, developing, and producing a shipboard, point-defense, surface-to-air missile system utilizing the existing United States SPARROW air-to-air missile.

Configuration management is the management of change. It provides the method for orderly and effective management of system design configuration through control of plans and specifications, and for control of hardware configuration through a regulated system of change review, approval, and implementation. Configuration management is relatively new as a distinct management discipline with practices reflecting formalized configuration management first appearing in the early 1950's.[1]

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[1]Engoron, Edward J. and Jackson, Albert L., Jr., "Uniform Policy and Guidance Established for Configuration Management," Defense Industrial Bulletin, p. 1 v. 5, no. 1 January 1969.

Before 1962 these configuration management procedures were restricted to "controlling changes to production hardware via the approval of engineering change proposals."[2]

The role of configuration management in the world of complex weapon systems is emphasized when the dynamic nature of these systems is observed. The re-designs, changes, and modifications that occur to a system as it evolves through its life cycle, from concept development to operational use, are normally numerous and extensive. To provide for proper logistic support maintenance, design modifications, and re-procurement actions, the changes to a system must be effectively controlled and recorded.[3] This thesis addresses the configuration management function during the operational phase, the time span from system delivery to the user until obsolescence, of one specific system. The concepts discussed will, however, have a certain degree of commonalty with other multinational endeavors concerning configuration management. For definitions of terms used in this thesis, which are peculiar to the fields of configuration management and systems acquisition, the reader is referred to the glossary in Appendix A.

C. APPROACH TO THE PROBLEM

The approach used to achieve the objective of this thesis is to develop sets of sub-alternatives and constraints which are discussed in detail. From these sub-alternatives and constraints, three alternative

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[2]Samaras, Thomas T., and Czerwinski, Frank L., Fundamentals of Configuration Management, pp. 279-281, Wiley-Interscience, New York, New York, 1971.

[3]Ibid., p. 2

system approaches are synthesized, evaluated against the objectives of the plan, and the recommended approach is selected.

D. SYNOPSIS OF THESIS STRUCTURE

Chapter II provides a comprehensive look at the concepts and current practices of configuration management in general, together with specific interpretations and applications in the United State Navy. Basic Department of Defense and United States Navy configuration management documents as well as those affecting the NATO SEASPARROW Project are reviewed.

The background of the NATO SEASPARROW Project is described in Chapter III. The management organization is discussed in detail, as is the existing configuration management plan being used during the development and production phases. It is the intent of the authors to provide a basis for understanding of the unique environment which surrounds this particular configuration management application. After reviewing the project history with appropriate emphasis on the configuration management aspects, the chapter concludes by summarizing the current status of the project.

The statement of problem, expressed in terms of the objectives of the nations forming the NATO SEASPARROW consortium is presented in Chapter IV.

Chapter V is a development and discussion of the objectives to be attained by the configuration management approach proposed by this thesis.

Chapter VI delineates and discusses the advantages and disadvantages of the sub-alternatives and constraints in the categories or organizational form, authority constraints, change control measures, and actual administration of the configuration management system.

In Chapter VII, three configuration management system alternative approaches are developed for use during the operational phase of the project. The alternatives are evaluated against the objectives developed in Chapter V and a recommended configuration management approach is selected.

In Chapter VIII, an implementation plan is presented for the selected alternative. The organization, flow of change proposals, and the responsibilities of the organizational units and personnel are enumerated.

II. CONFIGURATION MANAGEMENT - AN OVERVIEW

As noted in the introduction, configuration management, as a distinct management discipline, is of relatively recent origin. The basic functions of configuration management, however, are not new. These basic functions may be categorized as identifying and documenting changes as they occur, facilitating the control of changes, and maintaining the status of change actions.[4]

A. THE NEED FOR CONFIGURATION MANAGEMENT

The functions of configuration management have long been performed in the development and production of weapon systems.[5] It has always been necessary for the contractor to know how a product was configured so that it could be duplicated in production and for the customer to know how it was configured so he could be sure that he was getting what he contracted for, could support it logistically and could evaluate the potential impact of changes. While this concept of configuration management is generally valid after a system enters production and becomes operational, the present day concept of configuration management is much more encompassing. Currently, configuration management in the Department of Defense is concerned with a system throughout its entire life cycle, which covers the time span as a system evolves from concept formulation to engineering development, then into production, and

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[4]Engoron, and Jackson, "Uniform Policy and Guidance Established for Configuration Management," Defense Industrial Bulletin, p. 1

[5]Samaras and Czerwinski, Fundamentals of Configuration Management, p. 2.

finally on to the operation phase. Section C of this chapter gives a description of the system life cycle.

As a system evolves through the life cycle, its physical and functional characteristics also evolve. Changes are continually being made to achieve the desired or improved performance of the components, to correct deficiencies in the system design, to reduce cost and weight of equipments, to improve system effectiveness, and to update specifications. Change is a necessary and vital fact of life for every system. It is assumed by the authors that for small systems the number of changes are normally small, that the complexity is not great and that these changes can be easily managed. When systems become significantly larger the changes increase in number and in complexity.[6] As this occurrs, change must be managed or chaos will result.[7] The discipline of configuration management, as it is known today, has been developed to manage the evolution of change in a system during its life cycle.

B. DEFINITION OF CONFIGURATION MANAGEMENT

Configuration management, as defined by NAVMAT Instruction 4130.1, is,

> "a discipline applying technical and adminstrative direction and surveillance to (1) properly identify functional and physical characteristics of an item, (2) control identification and changes to the characteristics, and (3) record change processing and implementation status throughout the life cycle of the item."[8]

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[6] Ibid., p. 2

[7] Ibid, p. 2

[8] NAVMAT Instruction 4130.1, Configuration Management, A Policy and Guidance Manual, p. I-1 Department of the Navy Headquarters Naval Material Command, Washington, D.C. September 14, 1967.

Samaras and Czerwinski base their definition of configuration management on their concept of "progressive definitization" which states that,

> "the configuration of a product is derived during development, determined during design, established during production and maintained during operational support."[9]

Their definition of configuration management is,

> "the art of organizing and controlling planning, design, development and hardware operations by means of uniform configuration control, identification and accounting of a product."[10]

Figure 1 shows the major facets and interfaces of configuration management.

C. THE SYSTEM LIFE CYCLE

The system life cycle is the idealized step-by-step evolutionary process through which any major system should flow. This cycle has been formalized by the Department of Defense in a series of phases or efforts. Figure 2 depicts the life cycle phases as currently defined in a RDT&E pamphlet.[11]

During the conceptual phase the military, technical and economic bases for an acquisition program are established. This phase includes threat and mission analysis as well as evaluation of the technical feasibility, cost estimates, schedule feasibility, and risk and trade-off analysis of the proposed project. The result of this phase

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[9] Samaras and Czerwinski, Fundamentals of Configuration Management, p. 3.

[10] Ibid, p. 7.

[11] Research and Development in The Department of Defense....A Management Overview, Office of the Director of Defense Research and Engineering, Washington, D.C. pp. 34-41, November 1971.

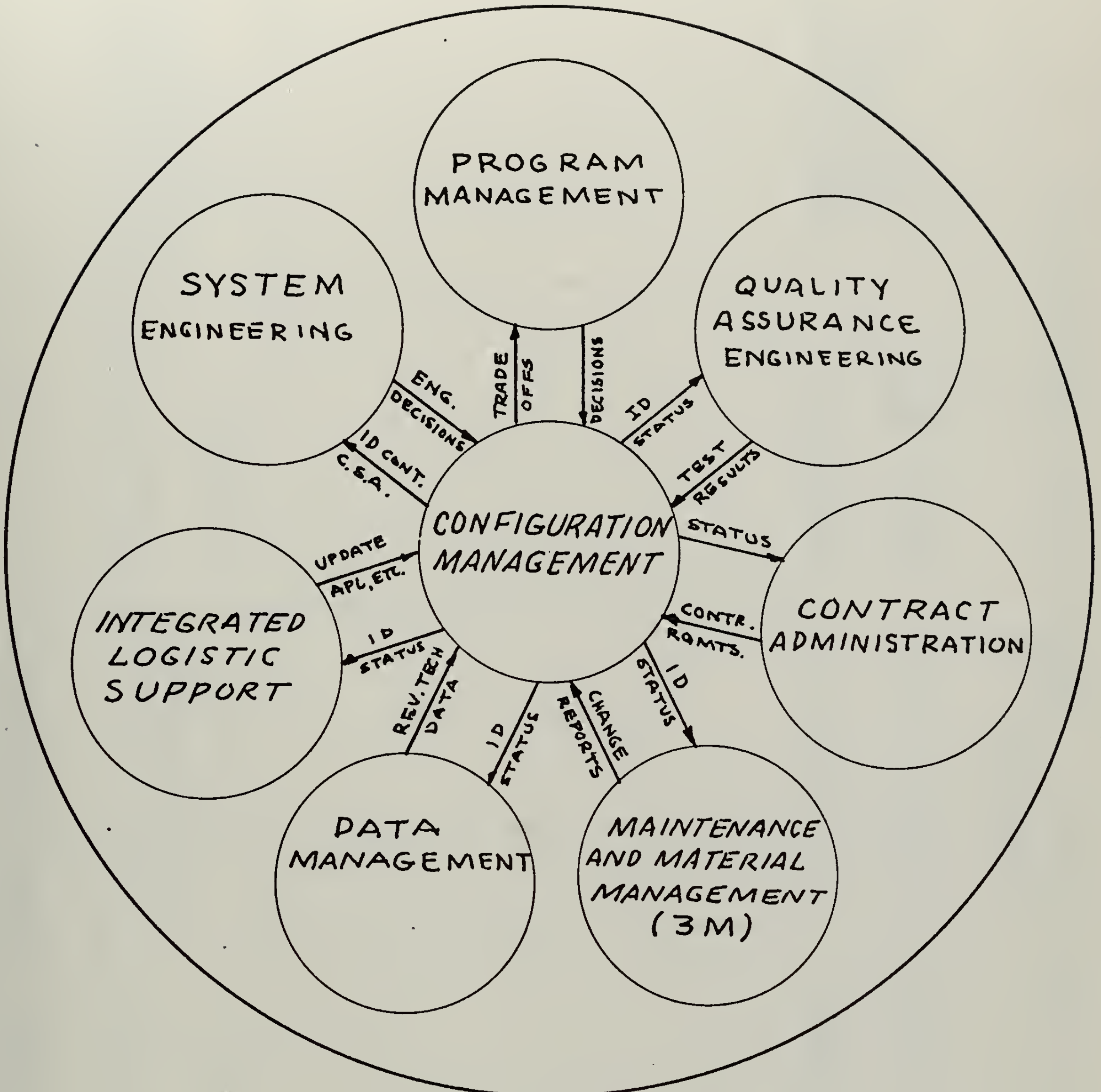

FIGURE 1
MAJOR FACETS AND INTERFACES
OF CONFIGURATION MANAGEMENT

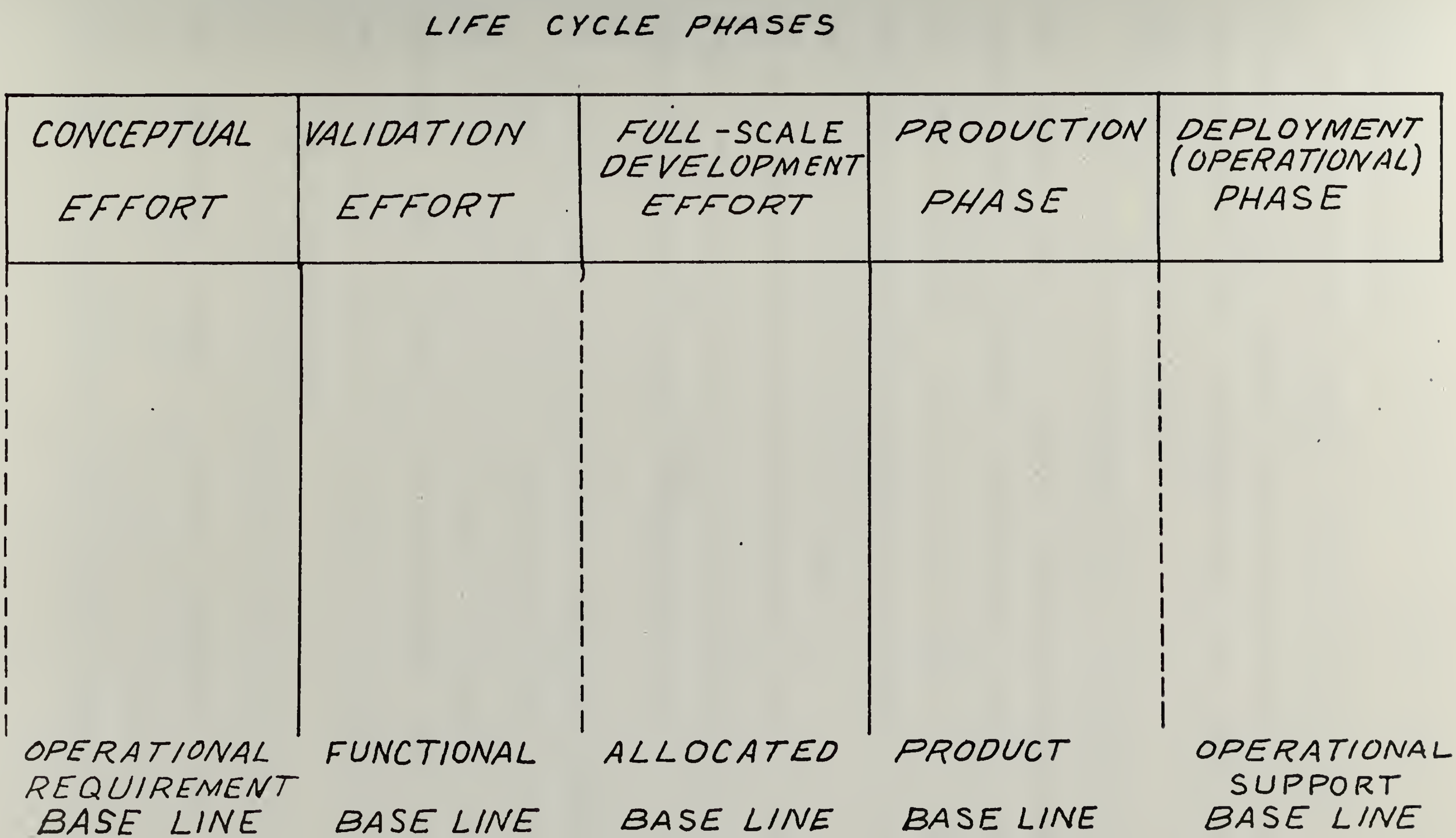

FIGURE 2
SYSTEM LIFE CYCLE / BASE LINE INTERFACE

includes cost, schedule, and operational parameters which have been evaluated and approved.

The validation phase develops, through extensive analysis and some hareware development, the major program characteristics including the technical aspects, cost, and schedule and further validates the operational need of the project.

During the full scale development effort. the system hardware and all necessary items for its support, including training equipment support equipment, operational and maintenance manuals are designed, fabricated, and tested. The result of this effort is a hardware model (prototype) of the system components and the documentation needed to produce the system and to facilitate support.

The production phase includes the production of the system, its training equipment, spares and associated equipments as well as the actual deployment of the system to operational units.

D. PRINCIPAL CONCEPTS AND OBJECTIVES OF CONFIGURATION MANAGEMENT

Common to both the official Department of Defense and the Samaras and Czerwinski definitions of configuration management are the concepts of control, status accounting, and identification. These three concepts, and their related objectives, are essential to configuration management.

1. Configuration Control

Configuration control consists of the systematic procedures by which configuration changes are proposed, evaluated, coordinated and approved for incorporation. Its objective is to insure the smooth functioning of the engineering change proposal preparation, evaluation,

approval and implementation.[12] Briefly, an engineering change proposal is a document which proposes a change to a configuration item in accordance with applicable instructions. It includes such items as a description of the change, its justification, and the effect the change is estimated to have on schedule.[13] A configuration item is a component which satisfies an end use function and is designated as a configuration item by the government. During development and initial production, configuration items are only those specification items directly referenced in a contract. During operational use, any repairable item designated for separate procurement is a configuration item.[14]

2. Configuration Status Accounting

Configuration status accounting, the second conept, is the bookkeeping process which records the configuration item configuration at a baseline and all changes made from that baseline as the system evolves toward the next baseline. Briefly, a baseline is a reference configuration established at a specified point in the system life cycle. Baseline management is more fully explained in Section E of this chapter. The objective of configuration status accounting is to provide the user with accurate, up-to-date information on the configuration status of all configuration items entering operational status. The configuration

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[12] Samaras and Czerwinski, Fundamentals of Configuration Management, p. 11.

[13] Department of Defense Military Standard MIL-STD-480 Configuration Control Engineering Changes, Deviations and Waivers, p. 15.

[14] Naval Material Command Instruction 4130.1, Configuration Management - A Policy and Guidance Manual, 14 September 1967, p. viii.

status accounting technique establishes a record system which enables the user to determine (1) where a product is located or installed, (2) the identification of selected product items by serial number and (3) current modification status.[15]

3. Configuration Identification

Configuration identification, the third concept, is embodied in the technical drawings, publications and related documents that describe the configuration item at each baseline of its development. The objective of configuration identification includes the accumulation and correlation of the approved technical, descriptive documentation required for engineering development, fabrication, test acceptance, operation, maintenance, and logistic support of a weapon system. The establishment and maintenance of the precise identity of each element throughout the system life cycle is facilitated by the use of standardized Department of Defense identification methods.[16] A principal tool utilized in establishing configuration identification is the configuration audit. The audit is used at predetermined points in the life cycle to verify such items as the design specifications, drawings, and manuals against the physical item to insure their congruence.

E. BASELINE MANAGEMENT

The primary vehicle used to achieve configuration management is the concept of baseline management. A baseline is a reference point

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[15] Samaras and Czerwinski, Fundamentals of Configuration Management, p. 13.

[16] TR-133 Configuration Management Handbook, p. 3-1 Naval Ship Missile Systems Engineering Station Port Huneneme, California, 6 May 1970.

which serves as a point of departure for new effort or change. Configuration baselines describe the physical and functional characteristics of the system at specific points in time. When baselines are supplemented with the documentation of all changes made up to any point in time subsequent to that baseline, the exact configuration of the item can be established for that point in time. Figure 2 compares the life cycle phases with the configuration baseline requirements as specified in NAVMATINST 4130.1.[17]

1. Operational Requirements Baseline

The first baseline established is the operational requirements baseline. This baseline is required only on "major"[18] warfare or support area systems. It consists of a general identification of the capabilities needed, information on the operational concept that could lead to intelligent evaluation of trade-offs and alternatives, and the relationships between the needed capabilities and those of other Navy agencies. The source of this information is the General Operational Requirement or Tentative Specific Operational Requirement.[19] The reader is refered to the glossary for the definition of these information sources.

2. Functional Baseline

The functional baseline is mandatory for all Navy material requirements. This baseline serves throughout the system life cycle as

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[17] NAVMAT Instruction 4130.1, Configuration Management, A Policy and Guidance Manual.

[18] Research and Development in the Department of Defense....A Management Overview, Office of the Director of Defense Research and Engineering, Washington, D.C. pp. 34-41, November 1971.

[19] NAVMAT Instruction 4130.1, Configuration Management A Policy and Guidance Manual, III-9

a description of the system's required functional characteristics, description, operational concept, performance constraints, compatibility criteria, related Department of Defense requirements, performance interface, and key configuration elements. The source for the information in the functional baseline is the Specific Operational Requirement and the Technical Development Plan.[20]

3. Allocated Baseline

The allocated baseline is also optional and may be required due to the complexity of an item at its lower level work breakdown structure. When used, this baseline governs the development of selected configuration items that are a part of a higher level item.[21]

4. Product Baseline

The product baseline is a mandatory Navy requirement. This baseline prescribes the necessary "build to", or form, fit, and function requirements for a configuration item and the acceptance test for those requirements. The product baseline identifies the current system specification, the current specification tree, the master configuration listing, the functional/physical configuration descriptions, the physical and functional interfaces, the configuration audit results, and associated changes and revisions. The reader is referred to the glossary for definitions of these terms. The sources are vast and include the specifications, drawings, parts lists, audit reviews, contract change proposals, configuration control board reports, and logistic support plans.[22] The configuration control board is the configuration change

[20] Ibid., p. III-11

[21] Ibid., p. III-17

[22] Ibid., p. III-23

review authority which evaluates engineering change proposals and approves them for adoption.

5. Operational Support Baseline

The final baseline is the operational support baseline which is an extension in time of the product baseline. It is normally developed for Navy items for which prior baselines were not established due to the items not having been developed specifically for the Navy. Such items are normally off-the-shelf type items utilized in industry and commerce. This baseline may also be desired when there has been a substantial change in the product baseline after a number of years in service.[23]

F. CONFIRUATION MANAGEMENT DOCUMENTS IN THE UNITED STATES NAVY

The present configuration management program was established in the Navy in 1968 with the issuance of Department of Defense Directive 5010.10. "Configuration Management" and Department of Defense Instruction 5010.21 "Configuration Management Implementation Guidance," These documents defined the scope of configuration management and criteria which had been established and were supported by a group of new Military Standards (MIL-STD).

1. MIL-STD-480

The primary configuration management document is MIL-STD-480. This document provides:

> "(a) requirements for maintaining configuration control of configuration items.
> (b) requirements for the preparation and submission of proposed engineering changes, deviations and waivers.

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[23] Ibid., p. III-29

(c) requirements for submitting the technical, fiscal and logistic supporting information necessary to define the impact of a proposed engineering change.
(d) instructions for submitting the information necessary to maintain the configuration identification in a current status."[24]

MIL-STD-480 also categorizes the types of engineering change proposals into two classes. A Class I engineering change is described as an engineering change which affects the functional or allocated baselines, the product configuration baseline as contractually specified, or the technical requirements contained in the product baseline. A change is also considered a Class I change if it affects contract fee, incentives, cost schedules and guarantees on deliveries, government furnished equipment, safety, test programs, support equipment compatibilities retrofits, interchangeability, or electromagnetic characteristics. An engineering change which does not fall within the definition of a Class I change is considered a Class II change. The change criteria, which specify the justification for change, are also delineated in MIL-STD-480.

MIL-STD-481 performs the same function as MIL-STD-480 for contracts involving the procurement of multi-application items or items for which the prescribed detail design was not developed by the contractor.

2. MIL-STD-482

To assure the use of uniform status accounting management information throughout the Department of Defense and defense industry, MIL-STD-482 prescribes the standard status accounting data elements to be used on all Department of Defense contracts.

[24]MIL-STD-480, Configuration Control - Engineering Changes, Deviations and Waivers, p. 1, Department of Defense, Washington, D.C., October 30, 1968.

3. NAVMAT Instruction 4130.1

NAVMAT Instruction 4130.1 implements current policy issued from the Department of Defense as well as reflecting Navy policy and guidance.[25] This manual defines the policy, relationships, responsibilities, and procedures to be used in configuration management throughout the Navy.

4. NAVORD Instruction 4130.10

NAVORD Instruction 4130.10 establishes the NAVORD configuration control board and states the policy, authority, and procedures for the functioning of the board.[26] A single configuration control board has been established within NAVORD for review and approval of all Class I engineering change proposals affecting systems within NAVORD cognizance. Figure 3 shows the functional flow of an engineering change proposal through the NAVORD configuration control board. This flow is prescribed in order to insure the thorough evaluation of all engineering change proposals as to their impact on performance, cost and schedule.

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[25] NAVMAT Instruction 4130.1, Configuration Management - A Policy and Guidance Manual, Department of the Navy Headquarters Naval Material Command, 14 September 1967

[26] NAVORD Instruction 4130.10, "Naval Ordnance Systems Command Configuration Control Board; establishment of," Naval Ordnance Systems Command, Washington, D.C. p. 1, 22 September 1971.

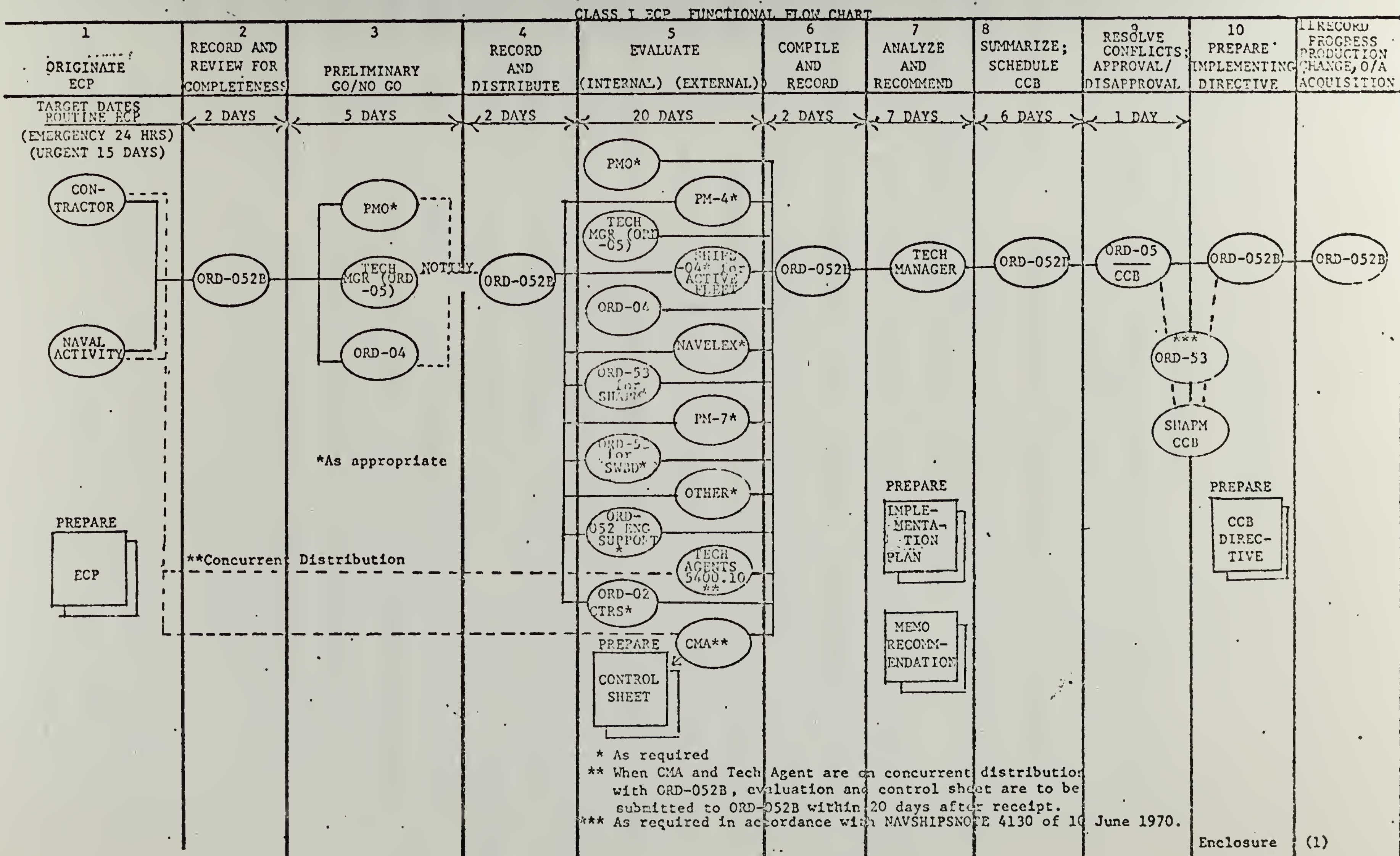


Figure 3. Flow of a ECP Through the NAVORD CCB.

III. BACKGROUND

A. ORIGIN OF THE NATO SEASPARROW PROJECT

In 1966 the NATO Naval Armaments Group approved a United States proposal that NATO develop a lightweight surface-to-air missile system for small warships. The system was to be designed to accommodate the existing United States SPARROW air-to-air missile and to be designated the "NATO SEASPARROW SURFACE MISSILE SYSTEM (NSSMS)."

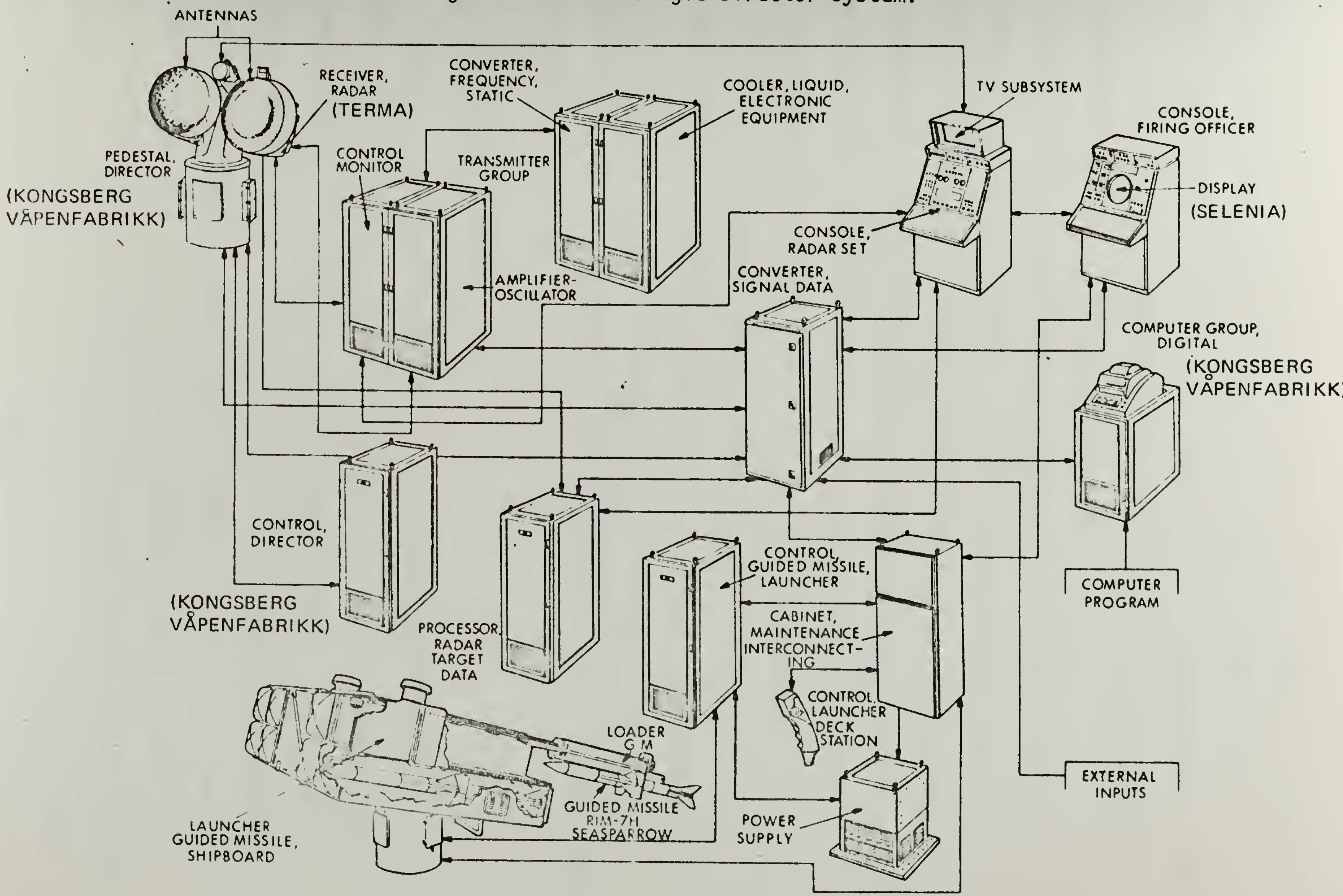
A planning group was established which included members from France, Italy, Norway and the United States; observers from Canada, the Federal Republic of Germany, the Netherlands; and an unofficial observer from Denmark. The chairman of the planning group was from the United States.

The first meeting of the planning group in early 1967 produced preliminary agreement on the nature of the threat, the cost-sharing formula and management approach, and partial agreement on the technical approach.

The starting point for the technical approach was the SPARROW air-to-air missile (AIM-7E). The SPARROW missile is a relatively lightweight, short-range, and highly accurate weapon, utilizing semi-active radar homing guidance with an all-weather capability. To further enhance its appeal, it was the least expensive guided missile in production with the desired attributes. Figure 4, illustrates the components and interfaces for a NATO SEASPARROW Surface Missile Systems, single direction system.

The use of the SPARROW missile against the threat established by the consortium required the development of a shipboard launcher and fire-control system capable of carrying a number of missiles in ready

Figure 4. NSSMS Single Director System.



service stowage, aiming and firing them in a short interval, and guiding them to the point target. Lightness of weight, low cost, ease of installation, and small crew size were all desired to be consistent with the system's ability to cope with the specified threat and to permit installation on a wide variety of naval ships.

At this point of the technical development, the first major configuration change was proposed. All of the member nations, with the exception of the United States, desired a modification to the warm-up time required by the SPARROW Missile. A modification to the missile was proposed which would reduce the warm-up time. The United States Navy considered the modification to be an unnecessary addition to missile cost and complexity; but, in the face of a strong stand by the other nations, it yielded the point in order to avoid a stalemate. The occurrence and handling of this situation is an example of the nature of the configuration management problem facing the project throughout its existence.

B. THE RAYTHEON APPROACH

Concurrent with the development of the NATO SEASPARROW System, the United States was developing a similar system called the Advanced Point Defense System which also utilized the SPARROW Missile. The Raytheon Company, the development contractor for both the SPARROW Missile and the Advanced Point Defense System, was also involved with the development of the technical approach for the NATO SEASPARROW Project. Through the adoption of the "Raytheon approach" to the system description, the Raytheon Company had gained unofficial recognition as the likely prime contractor for the NATO SEASPARROW system development.

In early 1968, a Memorandum of Understanding was agreed upon by the planning group and was submitted to the member nations for their governments approval. At this time, France withdrew from the project and Denmark asked to join as a full-fledged member. The Raytheon Company was selected for the contract definition phase and as the prime development contractor.

C. DEVELOPMENT OF THE MANAGEMENT PLAN

In mid-June 1968, the NATO SEASPARROW Project Office (NSPO) was activated, and in July the first meeting of the NATO SEASPARROW Project Steering Committee (NSPSC) was held. The NATO SEASPARROW Project Office and the NATO SEASPARROW Project Steering Committee were provided for in the Memorandum of Understanding (MOU) as follows:

> "Control, coordinate, and monitor through the NATO SEASPARROW Project Office, all aspects of the cooperative efforts of the participating governments involved in the planning, development and production of the NSSMS."[27]

The Memorandum of Understanding divides the project into two basic stages: the development stage and the production stage. The break between the stages is to be determined by the steering committee as the system progresses.

The NATO SEASPARROW Project Steering Committee is composed of one member from each of the participating governments. Each member of the steering committee is responsible for the coordination necessary with the appropriate authorities of his own country.

The NATO SEASPARROW Project Steering Committee is chartered to meet at least once every three months and holds additional meetings as request by any member. The chairman is selected yearly by the members.

[27] Memorandum of Understanding, 6 June, 1968, NATO SEASPARROW Surface Missile System.

Decisions of the NATO SEASPARROW Project Steering Committee must be made by <u>unanimous</u> vote on the following subjects:

1. Decisions calling for approval of total cost estimates of the development stage.
2. Decisions calling for approval of prime development contract and prime directed production contract and changes thereto.
3. Decisions calling for approval of major schedule changes.
4. Decisions calling for approval of fundamental configuration and configuration changes of the NATO SEASPARROW Surface Missile System and sub-systems as set forth in the NATO SEASPARROW performance and compatability requirements.

When timely agreement cannot be reached, the matter is referred by each member without delay to his higher government authority. All other decision of the steering committee are made by the vote of all members, the vote of each member being weighed in proportion to the financial share of the member's country in the cooperative project. The NATO SEASPARROW Project Steering Committee is also responsible for issuing such instructions, consistent with the Memorandum of Understanding,[28] as might be required for system management.

The NATO SEASPARROW Project Office (NSPO), which serves as the executive staff of the NATO SEASPARROW Project Steering Committee is established in Washington, D.C. The staff is headed by a Project Manager who is designated by the United States. Each participating government furnishes staff personnel for the NATO SEASPARROW Project Office in approximately the same proportion as the financial share of its government.

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[28] Memorandum of Understanding, 6 June, 1968, NATO SEASPARROW Surface Missile System.

The organization, mode of operation, duties, and responsibilities of the project office are established by the NATO SEASPARROW Project Steering Committee. The project manager is responsible for the management of the activities of the project office, consistent with the assignments and directions of the steering committee and with the Memorandum of Understanding.

D. SELECTION OF THE PRIME CONTRACTOR

During the contract definition phase, it became apparent to the steering committee[29] that a competitive approach to contracting for the NATO SEASPARROW System would be required to bring about an acceptable proposal. During this period there developed a rapport among the representatives of the member nations which opened lines of communications and established mutual respects which have prevailed throughout the project.

The Request for Proposal (RFP) for the Engineering Development (ED) phase of the project was prepared and reviewed within the United States Naval Ordnance Systems Command to expedite the completion of the final document.

Upon evaluation of the three bids received the engineering development contract was awarded to the Equipment Systems Division of the Raytheon Company. The contract called for the production of three prototype models, plus a production run to be released upon successful completion of tests on the prototypes.

[29]NATO SEASPARROW Project Office, History of the NATO SEASPARRO Surface Missile System, September 1970, p.II-8.

E. PRESENT STATUS OF THE PROJECT

In late 1969, the government of the Netherlands indicated that it desired to join the NATO SEASPARROW Surface Missile System consortium. In early 1970, the Royal Canadian Navy indicated a desire to purchase certain components of the NATO SEASPARROW Surface Missile System but did not desire to join the consortium as a full-fledged member. The steering committee developed acceptable arrangements for each of these nations, and in February of 1970 the requests were approved. This action brought the project membership to its present status which includes[30] the United States, Norway, Belgium, Italy, Denmark and The Netherlands as full fledged members. In addition, Canada is purchasing individual system components without being a full member.

In March 1972, the first SEASPARROW system was installed on the USS DOWNS, DE-1043.

F. CONFIGURATION MANAGEMENT BACKGROUND OF THE NATO SEASPARROW PROJECT

The configuration management plan developed for use during the design, development, and production phases of the NATO SEASPARROW Project is set forth in Section "K" of the contract between the project and the Equipment Systems Division of Raytheon Company.

This plan utilizes the format presented in MIL-STD-480 for all engineering change proposals. The approval authority for engineering changes proposals has been subdivided between Class I and Class II changes, the engineering change proposals area of impact, and the phase of development or production. Each of these areas has been assigned to

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[30] History of the NATO SEASPARROW SMS Project, NSPO, Washington, D.C., September 1970.

either the contractor, the NATO SEASPARROW Project Office or the NATO SEASPARROW Project Steering Committee for final approval authority. This distribution is illustrated in Table I.

All engineering change proposals (Class I and II) are forwarded to the Defense Contract Audit Agency representative by the prime contractor. The Defense Contractor Audit Agency representative then forwards those engineering change proposals to the NATO SEASPARROW Project Office where contractor approved engineering change proposals are recorded, decisions are made on those within the cognizance of the project office, and those requiring steering committee action are reviewed and forwarded to the member nations for consideration at the next meeting of the steering committee.

All such changes received by the United States representatives are then processed through the standard NAVORD engineering change proposal procedures as established by NAVORD Instruction 4140.10, as described in Chapter II.

Table 1. ECP Review and Approval Authority.

CLASS OF CHANGE	CHANGE IMPACT	RANK	APPROVAL AUTHORITY		
			PRIOR TO CE SPEC. SUBMISSION	FOLLOWING CE SPEC PRIOR TO FACI	FOLLOWING FACI
Class I	Contract Cost	1	NSPSC	NSPSC	NSPSC
and Major	Delivery Schedule	2	NSPSC	NSPSC	NSPSC
Waivers or	Performance Spec	3	NSPSC	NSPSC	NSPSC
Deviations	CRP*/GFP** Inter-face	4	NSPO	NSPO	NSPO
in Deliverable	CE*** Specifica-tions	5	Contractor	Contractor	NSPO
Items	Acceptance Test Specifications and Procedures	6	Contractor	Contractor	NSPO
	Drawings, Specs., Etc.	7	Contractor	Contractor	NSPO
Class II	Drawings, Specs., Etc. (Limited to updating and error correction)		Contractor	Contractor	NSPO

*(CFP) Contractor Furnished Property
**(GFP) Government Furnished Property
***(CE) Configuration Element, same as configuration item.

IV. STATEMENT OF THE PROBLEM

A. NATIONAL OBJECTIVES

There are certain national objectives implicit in the forming of a multinational consortium such as the NATO SEASPARROW Project. These objectives, briefly stated, are:

1) to obtain a shopisticated weapon system which an individual nation might not have the technical, fiscal, and/or managerial resources to produce individually.
2) to improve the national technological base by designing and producing some of the major sub-systems with its own industry.
3) to reduce the foreign exchange cost of purchasing a similar system outright.
4) to obtain a standardized weapon to facilitate logistic support and employment tactics.
5) to promote the integration of European industry.[31]

B. NATURE OF NATO MULTINATIONAL PROJECTS.

As will be discussed further in Chapter VI, most NATO projects have previously been thought of as ad hoc efforts, efforts created for the sole purpose of purchasing or developing, and subsequently producing a specific system. It has become apparent that continuing responsibility in the area of logistic support is necessary to insure the operational

[31] Behrman, Jock, N., International Production Consortia: Lessons Learned From NATO Experience, p. 3, U.S. Department of State Publication 8593, August 1971.

success of the system.[32] The support costs of such systems can be large as exemplified by the NATO HAWK, Missile System which experienced yearly logistic support cost of one-tenth its original purchase price, plus a modernization program at the end of ten years of operation the cost of which equaled the original purchase price. Thus, during a ten year period; ownership cost was double the original purchase price.[33]

C. SOURCES OF LOGISTIC SUPPORT

The supply source for spare parts in most systems is the producing contractor. In the case of the NATO SEASPARROW however, the separate sub-systems have been manufactured by sub-contractors located in each of the member nations. This arrangement was intended primarily to reduce the effect of the project on the balance of payments of the member countries during the production phase. The impact of this arrangement during the operational phase will be a degree of built-in interdependence among the member nations for support parts. In order to meet this problem, and situations similar to it arising from other NATO projects, NATO has established a supply agency. However, this agency must still rely on the original producers for parts.

D. SUMMARY OF THE PROBLEM

Essential to the idea of maintaining effective logistic support on a system-wide basis are the fundamental concepts of configuration management. Effective configuration management will reduce the number

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[32] Behrman, Jack N., International Production Consortia: Lessons Learned from NATO Experience, p. 9.

[33] Ibid., p. 21.

of different configurations and through the mechanism of configuration status accounting enable logistics planners to more accurately plan for system needs.

It is the authors' contention that member nations should continue active participation in the project further into the system life-cycle, satisfying objectives similar to those which brought the consortium together and deriving the benefits of system configuration management. The problem, then, is to develop a plan which will provide the mechanism for this continued participation, while being acceptable to all member nations. The objectives for such a configuration management plan are discussed and summarized in the next chapter.

V. OBJECTIVES

A. INTRODUCTION

It is assumed that, the dynamic nature of the configuration of a deployed missile system requires the implementation of some form of Configuration Management. It is the common consensus among those involved in Configuration Management that given a sysetm with a high degree of complexity containing numerous components or sub-systems, changes are a fact of life. It should not be inferred by this remark that changes are undesirable. Changes are a necessity to correct production design and fabrication discrepancies, and, later in the life cycle, to make added improvements in the system's performance, reliability, maintainability, or availability. This leads to a major underlying assumption of the authors that configuration management efforts for the NATO SEASPARROW will not be termined after production but will be continued in some form through the operational phase.

Given this underlying assumption, it is a realistic extension to make provisions for a configuration management plan covering this phase. This chapter sets forth the objectives for such a plan.

B. SYSTEM-WIDE IMPLEMENTATION OF CHANGE.

The first plan objective, and the three that follow it, are all concerned with the function of configuration control. The thrust of the first objective is directed at the ability of the configuration management organization to implement approved changes on a system-wide basis. The number of participants, while not large, adds complexily to this problem. The plan must make adequate provision for the multinationa

nature of the project and maintain uniform or differing approved configurations through implementation of changes to all SEASPARROW systems. The emphasis placed by the authors here is intended to be on the full range of all systems, <u>not</u> on the procurement, distribution, and installation details relating to a specific change, which is addressed in objective 4. Stated in brief, objective one is as follows:

1. The plan shall provide for implementation of approved changes on a system-wide basis.

C. FLEXIBILITY AND EFFICIENCY

The authors feel that the plan should be designed to be flexible and not require substantial revision or modification for each different situation which might arise. The amount of administrative effort related to each change should not be excessive; duplication of effort should be kept to an absolute minimum, and eliminated entirely, if possible. Changes should be processed without undue delay. Without compromising the other objectives, the organization should maintain a degree of flexibility and should handle changes in an efficient manner. Formally stated, objective two follows:

2. The plan shall be flexible enough to respond to differing situations and to implement changes without undue administrative delay.

D. REVIEW AND APPROVAL MECHANISM

A unique characteristic of NATO SEASPARROW is the project's multinational nature. This partnership arrangement provides distinct advantages which will be fully discussed in Chapter VI. Partnership agreements, especially when the partners are active participants as

opposed to being limited partners interested only in a dollar return on investment, add a degree of complexity to any plan. Procedures must be established which permit the partners to interact on the subject of determining operational system configuration. Specifically, the plan should provide a mechanism for the review of all proposed changes. The review process should consider the actual necessity for the change, the impact of the change on the system and the systems with which it interfaces, and cost and schedule implications, as well as other factors that might be relevant. In certain cases where changes are not being implemented on a system-wide basis, the review should also consider the impact and implications of maintaining systems to a non-uniform configuration.

It is common in configuration management that a change be approved by an appropriate authority prior to implementation. The mechanism for review and approval of proposed changes in the multinational environment requires unanimity on the part of all member nations. This objective is addressed to the most complex question in any configuration management plan, the question of overall system authority and control, and is designated objective three.

3. The plan shall provide a mechanism for the full review and approval of all proposed changes.

E. PROCUREMENT AND INSTALLATION OF CHANGES

Given changes that have passed the review and approval processes, procedures should be established to implement each change either throughout the system or to nations participating in that specific change. This objective relates primarily to the selection of an organizational form, the interactions between customer and contractor,

and the administration of change kit distribution and special technical support. Formally stated, objective four is as follows:

4. The plan shall provide for the procurement and installation of approved changes.

F. CONFORM TO UNITED STATES DIRECTIVES

In the NATO SEASPARROW Project, strict conformance with many key United States Navy directives on configuration management has been the rule since the inception of the project. Documents specifically cited are Naval Material Command Instruction 4130.1, the document which sets forth the criteria on which the prime contractor, Raytheon Company, established its configuration management plan: MIL-STD-480 which establishes procedures for handling ECP's, waivers, and deviations; and MIL-STD-490 which details procedures for preparation of specifications.

It is appropriate that deviations from established United States procedures be made when required by the nature of the system. In summary objective five is:

5. The plan should conform to current United States Navy and Department of Defense policies and procedures, as agreed on by the member nations.

G. BUDGETARY CONSTRAINTS

The requirements of this sytem must adhere to established fiscal constraints. The fiscal contraints will not only impact any proposed change to the system but will also affect the nature and size of the control and review organizational form slected. Fiscal constraints also bound decisions concerning selection of appropriate organizations to perform status accounting and audit functions.

Consideration of this objective is intended to apply not only to upper limit bounds on spending but also to the fiscal management policies for the Configuration Management organization. Key areas for consideration are (1) the method or formula for sharing of the costs for the configuration management system as well as for the procurement of specific changes, (2) the level and method by which changes will be funded in advance, (3) the fiscal control area, i.e., the establishment of specific dollar thresholds for authorized spending by elements of the organization, and (4) a consideration of the balance of payments policy with appropriate thresholds.

Summarizing, objective six is:

6. The plan must realistically adhere to cost and budgetary constraints and must establish an effective configuration management fiscal management policy.

H. PROVIDE FOR SUPPORT FUNCTIONS

The software support functions of Configuration Status Accounting and Auditing are a cornerstone of configuration management. These add visibility and provide the mechanism for management control of system configuration. Provision for the installation of these functions are essential in any configuration management plan. The organization and procedures established must satisfactorily perform these support functions whil remaining flexible enough to respond to the particular needs of a multinational system. The corresponding objective follows:

7. The plan must adequately provide for the performance of the functions of configuration status accounting and auditing.

I. EXCHANGE OF INFORMATION

The configuration management plan must provide for an effective method for circulation of technical data and certain operational information to include: (1) observed problem areas, (2) corrective actions taken, (3) information on safety practices and hazardous situations, and (4) information in designated operational areas.

A system which provides the nechanism for, and firmly advocates, free communication between all member nations should (1) enhance the ability of the system to correct deficiencies, (2) serve as an aid in the implementation of changes, and (3) provide an initiative to maintain system integrity. In summary, objective eight states:

> 8. The configuration management plan should provide for effective exchange of technical operating information.

J. ACCEPTABILITY

In any multinational endeavor, the consent and approval of each partner is essential to the success of the system. Without the full approval and support of each member nation, the integrity of the system is subject to degradation and possible disuse.

This objective, given the basic assumption of joint participation in some configuration management scheme, is perhaps the most important. Without it, the most elaborate, well-prepared plan will fall short of full success. In conclusion, objective nine is:

> 9. The general approach and details of the configuration management plan must be acceptable to all member nations.

The nine primary objectives stated have been structured to account for actual constraints, the multinational nature of the system, and

fundamentally, the need of a complex weapons system for some form of configuration management. The objectives are summarized in Table II.

Table II. Summary of Configuration Management Objectives for the NATO SEASPARROW Surface Missile System Operational Phase.

The configuration mangement plan shall:

1. Provide for implementation of approved changes on a system-wide basis.
2. Be flexible enough to respond to differing situations and implement changes efficiently.
3. Provide an effective control mechanism for the review and approval of proposed changes.
4. Provide for the procurement and installation of approved changes.
5. Conform to current policies and procedures, as appropriate
6. a) Adhere to cost and budgetary constraints, and
   b) Establish an effective configuration management fiscal management policy.
7. Provide for the performance of the functions of configuration status accounting and audit.
8. Provide for effective information exchanges.
9. Be acceptable to all member nations.

VI. ENUMERATION AND DISCUSSION OF SUB-ALTERNATIVES AND CONSTRAINTS

A. INTRODUCTION

The purpose of this chapter is to enumerate and discuss in detail the sub-sets of alternatives in the development of a configuration management plan for the operational phase of the NATO SEASPARROW. The sub-sets considered are:

- Organizational Forms
- Authority Constraints
- Change Control Measures

The range of alternatives and constraints presented have been developed from historical information on other NATO projects, general information on organizational forms, and the application of generally accepted management principles.

Also presented are the various alternatives available for the administrative functions of procurement and installation of changes and configuration status accounting. These two administrative areas represent basic plan implementation details fundamental to any configuration management plan. While they must support the overall approach synthesized from the sub-sets of alternatives above, they are virtually independent and can be effectively individually optimized for inclusion in the final alternative mix. These administrative alternatives have been extracted from current configuration management procedures. The justification for the range of alternatives considered is provided in the appropriate section.

The configuration audit function has been provided for in the production contract which provides for the Defense Contract Administration Service to conduct the First Article Configuration Inspection (FACI) audit. No future requirements for system audits can be envisioned by the authors at this time. Due to these circumstances, consideration of alternatives for the audit function are not deemed necessary.

B. HISTORICAL INFORMATION ON ORGANIZATIONAL FORMS

During the past fifteen years numerous multinational projects have been sponsored by NATO. The organizational structures utilizing have varied greatly among the projects. Four major projects, having different organizational forms and authority relationships, will be examined. The projects described will assist the reader in becoming familiar with the multinational environment as well as assisting in establishing the range of alternatives available. The projects are:

- NATO Air Defense Gound Environment (NADGE) Project
- HAWK ground-to-air Missle
- STARFIGHTER all-purpose military aircraft
- SIDEWINDER air-to-air Missile

1. NADGE Project

The NADGE organization is an industrial consortium composed of major sub-system contractors and headed by a United States company which provided the management leadership. This industrial consortium was matched with a government group having corresponding responsibilities but not headed by a United States representative. Contracts were made directly between the participating governments and the industrial consortium. Under this arrangement each nation was able to tailor the

system it purchased to its own requirements. Each nation was further responsible for obtaining logistic support for its own system configuration.[34]

2. HAWK Project

The HAWK Project had an organization with an industrial consortium similar to the NADGE Project, but with no United States company in the consortium. Instead, the NATO consortium contracted separately with a United States company to supply the required technical resources to the member companies. Again, as in NADGE, a counterpart government organization with similar responsibilities to the industrial consortium had been established.[35]

3. STARFIGHTER Project

The organization used for the production of the STARFIGHTER aircraft did not involve the use of a multinational industrial consortium. Four different groups of companies, one group in each of the participating nations, were formed with each national group having a separate contract with the United States licensor of the system. A multinational governmental counterpart was established similar to the NADGE and HAWK groups to coordinate the overall project.[36] Each country has subsequently developed its own maintenance and logistic support facilities for the STARFIGHTER.[37]

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[34]Behrman, Jack N., "Multinational Production Consortia: Lessons from NATO Experience," p. 15, U.S. Department of State Publication 8593, August 1971.

[35]Ibid., p. 15.

[36]Ibid., p. 15

[37]Ibid., p. 21

4. SIDEWINDER Project

In the case of SIDEWINDER, a single company in West Germany was the prime contractor. This contractor received technical data and managerial assistance from the United States licensor. The governments of the consortium created a single management agency which contracted for the consortium with the West German prime contractor.[38] The prime contractor obtained the contracts for repairing and supporting the SIDEWINDER Missiles for all members of the consortium.[39]

5. NATO SEASPARROW Project

While the NATO SEASPARROW Project has been unique from its inception, in that all members of the consortium participated in the design and development of the system as well as its production, the project has pronounced similarities to the above mentioned systems as it approaches its operational phase. These similarities are rooted in the fact that each member nation will have achieved its primary goals for joining the consortium once the system has been delivered. Each member will have a sophisticated weapon system operational on its ships, the foreign exchange cost will have been minimized, the technological base of its industries will have been widened, and a standard set of operational tactics developed. During the development and production phases of the project, the configuration management organization was not formally specified. It did, nowever, follow the overall management structure of the project on an informal basis. Since, in the opinion of the authors, the primary goals of the member nations in the consortium

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[38]Ibid., p. 15

[39]Ibid., p. 21

have been achieved, the need to continue using the originally agreed upon management organization has greatly decreased. It is further considered reasonable, at this point in the project life cycle, that a new management organizational form may be adopted to meet the needs of the operational phase without jeapordizing the original goals of the member nations.

C. ORGANIZATIONAL FORM ALTERNATIVES

Based on the assumption in this thesis that a basic change in the organization of the NATO SEASPARROW Project could not be ruled out during the operational phase the following alternatives to the configuration management organization are considered:

1. Maintain Existing Organization

This alternative provides for the continued use of the present configuration management organization utilizing the NATO SEASPARROW Project Steering Committee and the Nato SEASPARROW Project Office headed by a project manager.

2. Single Management Group

This alternative reduces the number of management groups to one, headed by the project manager, conducting direct liaison with both the contractor and the respective governments.

3. Multiple Consortia

This alternative disbands the existing consortium in favor of smaller multiple consortia oriented toward meeting the operational phase needs of smaller groups of like-thinking nations with regard to performance and logistic support.

4. Disband the Consortium

This alternative provides for disbanding the existing consortium in favor of each nation managing its own system and arranging for its logistic support through the prime contractor and/or directly with the sub-contractors as well as the prime contractor. Developing an alternative prime contractor in one or all of the member nations is not considered a economically viable alternative by the authors, due to the complexity of the system and high tooling and technology transfer costs.

D. DISCUSSION OF ALTERNATIVES FOR ORGANIZATIONAL FORMS

It is assumed that some modification of the organizational form of the NATO SEASPARROW project can reasonably be expected as the system's production phase is completed. The level of effort required for the acquisition management functions will continually decrease from this time.[40] The magnitude and number of kay decisions which were handled by the consortium through the steering committee/project office organization will decrease, and the bulk of the management effort will focus attention on engineering change proposals and details relating to delivery, acceptance, and logistic support.[41]

Under organizational forms, the first alternative discussed is that of status quo. The steering committee/project office structure would remain. The obvious primary advantages are maintaining the viability of a proven structure and eliminating the need for a considerable reorganization effort. The manning levels and composition of both the

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[40] Interview with NAVORD personnel attached to Naval Ship Missile System Engineering Station, Port Hueneme, California, May 1972.

[41] Ibid

project office and the steering committee could be modified downward in the number and the rank of the staff to reflect the reduced tempo of operations. The current organization is acceptable to all member nations and has achieved considerable success in resolving difficult problems in the project to date.[42]

Given the relative simplicity of the system hardware (in the realm of advanced weaponry), and with the relatively low number of anticipated changes, this two-level organization may not be required to administer the system.[43] Maintaining this organization structure could result in fairly trivial decision being resolved at a high level. This is considered by the authors to be not only time-consuming but costly. While the steering committee meets only once every three months, and in fact has met in full session only thirteen times since the inception of the project in 1966,[44] there are definite time and economic costs associated with these meetings.

The second alternative eliminates one of the management echelons referred to in alternative one. Basically, this alternative calls for the removal of the steering committee from the configuration management decision process. The responsibility and authority would be distributed

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[42]Interview with NATO SEASPARROW Project Office Staff and National Representatives, Washington, D.C., March 1972.

[43]The budget estimate for changes for the first operational year is only $800,000. This figure is considerably less than the amount authorized for changes in the first year of Tartar program.

[44]Interview with NATO SEASPARROW Project Office Staff and National Representatives, Washington, D.C., March 1972.

between the project office and a representative for each nation within each functional replacement for that nation's steering committee and is not to be confused with a national representative resident on the project staff. Each representative would provide the principal liaison between the project office and the functional material commands of each nation. The function of a national representative physically located in the project office is addressed in the concluding chapter.

Using the project office as the basis for a single level organization has the distinct advantage of maintaining existing working relationships to the greatest extent. The project office will be performing many configuration management related functions prior to the installation of a formalized plan. With the removal of the steering committee from the configuration management decision process, control guidelines and decision criteria would have to be restructured. In summary, the fundamental premise behind this alternative is that the project office would receive the sanction of the participating nations to perform the configuration management function for all NATO SEASPARROW systems within specified limits.

The next two alternatives call for a disestablishment of the existing consortium. The first of these calls for the establishment of multiple smaller consortia. This would permit the grouping together of nations having similar objectives in the area of configuration management. Nations having similar plans for making significant modifications and continuing engineering efforts might form one consortium which could be described as "performance-oriented." Others interested only in keeping their system configurations operational and having effective support and exchange of technical information could form a "logistics-oriented"

consortium. The nature of the consortia formed would be a function of the funding available, the emphasis on the threat and total defense posture of each nation, the actions of other nations and their degree of committment, and the state-of-the-art.

The simplest application of this alternative would be the formation of a European consortium,[45] of "logistics-oriented" nations to maintain existing lines of logistics support, while the United States, representing a "performance-oriented" nation, would establish new sources of logistic support for changes and modifications not supported by the original manufacturer. This arrangement would permit a separation of those nations interested in supporting an existing configuration and those having the objective of continuing to improve the system through development efforts.

It is not the intent of this approach to foster the formation of vast numbers of individual or overlapping consortia but rather to group together the nations with nearly congruent system philosophies to allow each member nation to better meet its needs and to maximize its configuration management benefits. Much of the overall control of the system could be lost in the exercise of this alternative but many of the benefits of mutual support would remain.

In the final alternative, each nation would be responsible for arranging its own logistic support. The configuration management function would be performed for United States systems in accordance with current Department of Defense directives. It is likely that change kits

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[45]European Consortium would consist of Norway, Belgium, Netherlands, Denmark and Italy.

and drawings would be made available to system owners on a cash sale basis and that the Naval Ship Missile System Engineering Station could, on a contract or similar basis, maintain the status of the configuration of foreign systems.[46]

This alternative has advantages for both the United States and the other nations. There would be no outside factors to be considered when making decisions on future configuration changes. The United States would be entirely free to modify the system as per its own desires. This configuration freedom would be common to all system owners. Other nations could purchase the changes they desired from the United States, if they were made available, and would be free to determine their system configuration.

This alternative is not unlike former NATO projects where a buyer-seller relationship existed.[47] The overall configuration management of all NATO SEASPARROW systems taken as an entity would be significantly reduced. The cost to all participants would be greater. The United States would bear the full cost of the development of a change if no other nation purchased it. For other nations, the logistics cost would increase due to their inability to pool all parts with the United States Even those nations participating in an informal configuration management effort through the purchase of kits and drawings would experience some difficulty in maintaining continuity. In the past, not all changes have been made available to foreign system owners and gaps created in

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[46]Interview with NAVORD personnel attached to Naval Ship Missile System Engineering Station, Port Hueneme, California, May 1972.

[47]Behrman, Jack N., International Production Consortia: Lessons Learned from NATO Experience, p.23.

documentation have significantly reduced the effectiveness of this method of configuration management. It is not suprising that a nation is reluctant to implement a change when it cannot evaluate the full impact that change may have on its systems. This is often the case under the existing "buyer-seller" relations which exist in weapon systems sold by the United States to other nations. Often, for various reasons, some changes are not made available to these customer nations. The result is gaps in the number sequence of changes. Technical personnel question the effect of the "missing" changes on new changes being offered for implementation.[48]

Information on technical problems is not shared on a system-wide basis. The motivation to maintain system configuration, submit reports, and exchange useful information is substantially less than in a formal organization with more rigid configuration control.

The advantages and disadvantages of the preceding alternatives on organizational form are summarized in Table III.

E. AUTHORITY CONSTRAINTS

The configuration management organization form selected and the extent of authority vested in that form are closely related.[49] The extent of authority vested in any organization plays a large part in determining the effectiveness of that organization. The management principals of delegation of authority and extraction of responsibility commensurate with the authority delegated hold true for multinational

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[48]Interview with NAVORD personnel attached to Naval Ship Missile System Engineering Station, Port Hueneme, California, May 1972.

[49]Cleland, David I. and King, William R., Systems Analysis an Project Management, p. 6, McGraw-Hill, New York, New York, 1968.

Table III. Organizational Form Alternatives - Advantages and Disadvantages.

ADVANTAGES	DISADVANTAGES
ALTERNATIVE 1 - Continue Present Dual Management Group Organization.	
• Proven Structure • Reorganization Not Required • Acceptable to all Members • Maintain Existing Relationships	• Large Manpower Requirements • Trivial Decisions moved to High Levels • Slow to Respond at High Level • High Cost to Keep Both Groups
ALTERNATIVE 2 - Consolidate to One Management Group.	
• Reduced Manpower Requirements • Maintain Relationships • P.O. Famil. with additional Duties • Potential of Rapid Response on Higher Level	• Restructure Guidelines • Restructure Decision Criteria • Some Reorganization Required
ALTERNATIVE 3 - Disband Existing Consortium in Favor of Smaller Multiple Consortia.	
• Permit Grouping of "Like-Thinking" Nations on CM • Preserve Mutual Support • Maximize use of Existing Support Channels • Greater Configuration Freedom	• Much Overall System Control Lost • More Costly Than Single Consortium due to Duplication of Effort • High Reorganization Cost
ALTERNATIVE 4 - Disband Existing Consortium, Each Nation Provide Its Own Logistic Support.	
• Maximum Configuration Freedom • Services of Various U.S. Navy Agencies Available to Other Nations • Low Management Cost	• Proliferation of Configurations • High Support Cost • Difficult to Exchange Information • Reduced Validity of Exchanged Information

organizations just as for any other management organization. However, it is the opinion of the authors that the decision on how the authority is to be limited becomes much more complicated when the number of "bosses" management must report to increases from one to six as in the case of the NATO SEASPARROW project.

The basic question of authority limitation is the degree to which a participating nation will let an international group manage the configuration of its operational system. In a multinational endeavor, the various users may have significantly different attitudes on modifying the configuration of their operational systems, even though their o objectives in establishing the initial system configuration were identical. The individual nations may not share the ideal that uniform system configuration and rigid central configuration control throughout the consortium are consistent with their own objectives. This would be especially true if change cost considerations did not appear to the participating nations to yield corresponding improvements.

With these considerations in mind, it is reasonable to assume that the member nations will insist upon the limitation of the configuration management authority vested in the configuration management organization.

The constraints presented here in the broad category of authority limitation measures may be used individually or in combination to achieve the desired authority limitations for the appropriate organizational form.

1. Cost Constraints

Cost limitations may be sub-divided into two categories: cost per individual change and cost per time period. Exceeding a particular cost boundary in the case of a proposed change would place the approval

decision at a higher level of authority, or perhaps to further review and vote by all participating nations.

2. Area of Impact Constraints

The area in which a change impacts such as cost, performance, schedule, or interface, may serve as a method of limiting configuration management authority.

3. Components of Sub-Systems Constraints

Components or sub-systems affected by the change may be utilized as a limiting factor. This method would allow some components to be subject to lesser configuration control than others.

Specific alternatives consisting of a mix of the three limiting constraints presented here will not be developed in this chapter but will be included in the synthesis of the overall alternatives in the following chapter.

F. DISCUSSION OF AUTHORITY CONSTRAINTS

These constraints primarily address the question of the extent of the ability of the organizational form selected to change the system.

This first constraint, cost,is the most straight-forward. By agreement of the consortium, cost limitations could be established on a per change or per year basis. Within this boundary, a control organization, for example the project office, could unilaterally implement a change throughout the system. These cost limitations would, determine the nature of changes to be made by the control organization(s). At one extreme, if the consortium desired to severely limit the ability of the project office to make changes, the monetary ceilings would be placed at a few hundred dollars unit cost per change per system or a given

number of thousands of dollars per system per year. This would restrict the project office to the most basic engineering "fixes" to correct production discrepancies. Examples of the type of change envisioned here are, replacement of minor components or software changes to update maintenance procedures or technical manuals. With a higher dollar ceiling, the project office would have the flexibility to continue more expansive engineering efforts which could result in the replacement of, or modification to, major sub-systems. A representative example might be a launcher modification which would enable the system to fire another missile or a modification to the missile to counteract an enemy countermeasure.

The impact of a proposed change could also be used to regulate the authority of the controlling organization. A proposed change which would require the removal of operational systems from a ready status for a prolonged period of time or produce significant interface changes with related systems might be examples of impact boundaries which would cause decisions to be moved to higher authority levels or to a vote situation. The consortium might conclude that any change which modified the actual performance specifications of the missile be referred to all participants.

The final area which could be used to limit authority would be a hardware breakdown of sub-systems authroized, or not authorized, for change modifications.. For technical or support reasons, power supplies or switchboards might be placed outside the change authority.

It is likely that the authority to make changes would be limited to some combination of the previously stated constraints. Examples of such constraints are:

- Changes to the overall system might be dollar limited (cost).
- A restriction on removing systems for prolonged periods from operational use (an area of impact-operational schedule).
- A restriction on modification to the Launcher (sub-system).

It is conceivable that a change could be bounded in all major constraint areas.

The preceeding constraints for limitations of authority with the advantages and disadvantages of each are summarized in Table IV.

G. ALTERNATIVES FOR CHANGE CONTROL MEASURES

The basic right to exercise authority and to implement decisions in a consortium comes from the agreement (Memorandum of Understanding) between the member nations when the consortium is formed. Additional guidelines and procedures, supplemental to this basic agreement, must be developed to ensure that changes which have been reviewed and approved are implemented throughout the system. While total control of change is a principal purpose of configuration management, in this section we refer specifically to the implementation of those changes which have been formally approved and those which have been formally rejected by the configuration management organization.

The difficulty in developing agreements among the member nations is significant on the question of what measure should be utilized to motivate some future dissenting member to conform to the decision of the configuration management authority. While each nation is cognizant of

Table IV. Authority Constraints - Advantages and Disadvantages.

ADVANTAGES	DISADVANTAGES
1. COST CONSTRAINTS	
• Highly Definite	• Potentially Difficult to Achieve Agreement On
• Easily Modified	
• Does Not Require Judgment Decision	
2. IMPACT AREA CONSTRAINTS	
• Variable Configuration Management Control on Different Parts of the System	• Trivial Decision Pushed to High Levels
	• May Require Judgment Decision
3. COMPONENTS OR SUB-SYSTEM CONSTRAINTS	
• Variable Configuration Management Control on Different Parts of the System	• Trivial Decisions Pushed to High Levels

the benefits of maintaining a uniform configuration, or of deviating from the uniform configuration in only a manner approved by the configuration management authority, it tends to be hesitant in approving harsh sanctions which may be used against it.

The question of dissent can be split into two areas. First, are those nations that desire a change which the others do not want (Case I) and, second, those that do not want a change which the majority wants (Case II). Therefore, the alternatives must be presented in two groups, those aimed at motivating individual nations to avoid unilateral changes and those designed to encourage dissenting members to accept a change desired by the majority.

The alternatives presented here are restricted to the logistic support area, as it is this area which is of greatest concern to the nations during the operational phase of the project and it is in this area that the configuration management organization will play the greatest role.

1. <u>Case I Alternatives</u>

The alternatives for motivating an individual nation to avoid unilateral change, are:

a. Accept Right to Vary Configuration

The consortium would, under this alternative, accept the right of the dissenting member to make unilateral changes regardless of the effects this has on the other members. Under this option the consortium may provide logistic support for the non-standard configuration or may leave it to the individual member to provide for its own unique support requirements.

b. Reject Right to Vary Configuration

The consortium would, under this alternative, reject the concept that each nation can make the final decision on its own configuration. Under this alternative any nation deviating from the standard without the approval of the consortium would be subject to losing some or all of the logistic benefits provided by the consortium.

2. Case II Alternatives

There are three alternatives designed to motivate a dissenting member to accept a change desired by the others, Case II. The first two have an element of motivation, while the third accepts the dissent. The three alternatives are oriented toward the area of logistic support and are:

a. Formal Approval

Under this alternative the project office would support through the NATO SEASPARROW configuration management organization only those changes which have been formally approved by the configuration management authority.

b. Advanced Funding

This alernative would require a sinking fund or other monetary advance to the configuration management control organization by all participants from which all approved changes would be funded.

c. Support all Configurations

Under this alternative the consortium would accept the right of the individual participant to reject the change and would provide lgoistic support for different configurations.

H. DISCUSSION OF ALTERNATIVES FOR CHANGE CONTROL MEASURES

It may be extremely difficult to arrive at an ironclad policy to control the implementation of changes. It is more likely that a policy would be developed including elements of all three alternatives which could be applied on a case basis. Such a policy should not be viewed as a mechanism for consuring those not conforming to approved configurations.

The first alternative, to support only approved configurations, does imply a removal of support for non-approved configurations. For practical reasons, this is not likely to occur. In cases of differing configurations, where the former configuration was not being maintained by the configuration management organization, existing stocks of components could be furnished the dissenter. On an as-available basis, the configuration management organization could support the dissenter. The emphasis, however, would be placed on maintaining approved configurations. The responsibility for the support of a non-approved configuration would rest with the system owner.

The requiring of a "changes fund" in which all member nations participate may have validity in its own right without using it as a motivating factor to implement change. To be used as a motivating factor any change approved by the consortium would be funded by each nation, according to a predetermined cost-sharing formula, whether it actually decided to install the change or not. Since most changes are to improve performance or reliability it would be highly unlikely for a nation to fail to install such a change once it was funded. It would be possible to remove the motivation aspect, by drawing from the fund only for those nations implementing the change.

In the last alternative, the configuration management organization would recognize the need to support the participants' system, regardless of their configuration status. While this alternative would provide the maximum degree of freedom to the respective nations, it would severely degrade the authority behind decisions of the configuration management organization.

The preceeding change control measure alternatives with their advantages and disadvantages are summarized in Table V.

I. PROCUREMENT AND INSTALLATION OF CHANGES

The procurement and installation of changes involves furnishing plans, instructions, and material for the accomplishment of changes to the NATO SEASPARROW equipments in service or in stock for use as repair parts. This is restricted to the procurement of the necessary parts, documentation to make up the kits, and the distribution of the kits to the installing activity. It does not involve the actual design of the change kits to be provided.

1. Alternatives

The alternatives for providing this effort are:

a. Utilize Existing NAVORD Organization

Under this alternative the project would utilize the existing NAVORD Surface Missile System Ordnance Alteration organization. This organization is established by NAVORD Instruction 8000.6 of 24 Jan 1968. This instruction tasks the Naval Ship Missile Systems Engineering Station (NSMSES) and Naval Ammunition Depot (NAD), Crane, with the task of providing ordnance alternation kits (ORDALTS) for the Navy's surface missile systems. Contracts would be let as necessary to procure items not available through normal supply channels.

Table V. Change Control Measure Alternative - Advantages and Disadvantages.

ADVANTAGES	DISADVANTAGES
CASE I - AVOIDANCE OF UNILATERAL CHANGE	
ALTERNATIVE 1 - Accept Right to Change, Provide Varying Degree of Support.	
• Provide Flexability	• Allows Proliferation of Configurations • Commonalty of parts quickly lost • Motivates members to purchase not Desired Changes
ALTERNATIVE 2 - Reject Right to Change, Provide Varying Degrees of Support Loss.	
• Provide Strong Motivation for Conformaty	• A Clearly Negative Attitude • Does Not Promote Future Cooperation
CASE II - PROMOTION OF ACCEPTANCE OF A APPROVED CHANGE	
ALTERNATIVE 1 - Provide Support For Only Duly Approved Configurations.	
• Allows Desenter to Use-Up Existing Stocks of "Old" parts. • Desenter may "Catch Up" His System by Installing Changes Later	• May Cause "Drop-Outs" From The Consortium
ALTERNATIVE 2 - Require Sinking Fund for Changes	
• Insures Funding of Changes • Provides Strong Motivation for Installation of changes	• Difficult to Gain Agreement on Site of Fund • Adds Substantial Cost to to System
ALTERNATIVE 3 - Provide Support for all Configurations.	
• All Nations Assured of Continued Support Regardless of Configuration	• Potentially Spiraling Support Cost

b. Contract to Prime Contractor

Under this alternative the project would contract with the prime contractor to assemble and distribute the change kits as well as design the kits.

c. Contract to Separate Contractor

This alternative provides for the project to contract with a separate firm to coordinate the preparation and distribution of the kits. For example, Vitro Corporation provides such a service for various NAVORD organizational components.

d. Perform Within Project

Under this alternative the project would establish an organ organization within the NATO SEASPARROW configuration management organization to perform the procurement and installation of change functions.

J. CONFIGURATION STATUS ACCOUNTING ALTERNATIVES

The function of configuration status accounting involves recording the data which identifies Engineering Change Proposals (ECP's) and their approval and implementation status.

The configuration status accounting effort with NAVORD for the Surface Missile System (SMS) program is established by NAVORD Instruction 4130.1 of 5 March 1968. This instruction provides for Naval Ship Missile Systems Engineering Station to collect, record and process surface missile systems engineering change data and prepare listings for both United States and foreign applicability.

The Strategic Systems Project Alterations (SPALT) program provides the policies, controls and procedures for configuration control an

configuration status accounting for the Fleet Ballistic Missile system is a multinational program involving the United States and the United Kingdom.

The configuration status accounting for the Strategic Systems Project Alternations program, together with all the associated computer and reporting software is provided by an independent software firm. The Strategic Systems Project Alteration program is, due to the nature of its application, a very sophisticated status accounting system.

1. Alternatives

The alternatives for the performance of the configuration status accounting functions are:

a. Utilize Existing NAVORD Organization

This alternative provides for the project to utilize the existing configuration status accounting organization established by NAVORD.

b. Contract to Software Firm

Under this alternative a contract would be made with an independent software company as was done for the Strategic Systems Project Alterations program.

c. Perform Within Project

This alternative provides for the project to develop a configuration status accounting organization within the SEASPARROW project.

K. CONCLUSION

The sets of sub-alternatives presented in this chapter have included representative approaches to each of the major equestions addressed

While each of the sub-alternatives have been discussed and their advantages and disadvantages enumerated, no attempt has been made to evaluate them. This has been done deliverately to avoid the possibility of sub-optimization at the expense of the system solution. In Chapter VII three system configuration management approaches are developed with a mix of sub-alternatives and limitation criteria which can be utilized together to form a comprehensive solution.

Table VI summarizes the sets of sub-alternatives and criteria presented in this chapter.

Table VI. Summary of Sub-Alternative Sets and Constraints

ALTERNATIVES				
ORGANIZATIONAL FORM	1 CONTINUE EXISTING TWO GROUP ORG.	2 REDUCE TO ONLY ONE MANAGEMENT GROUP	3 ESTIMATE MULTIPLE CONSORTIA	4 MANAGEMENT BY INDIVIDUAL NATIONS
CHANGE CONTROL				
CASE I	1 ACCEPT RIGHT FOR UNILATERAL CHANGE, FLEXIBLE LOGISTIC SUPPORT	2 REJECT RIGHT OF UNILATERAL CHANGE, REDUCTION IN SUPPORT		
CASE II	1 SUPPORT ONLY "CURRENT" CONFIGURATIONS	2 PRE-PAID SINKING FUND TO COVER CHANGE EXP.	3 SUPPORT ALL CONFIGS CURRENT AND OUTDATED	
CONSTRAINTS				
AUTHORITY CONSTRAINTS	1 COST CONSTRAINTS	2 AREA OF IMPACT	3 COMPONENT OR SUB-SYSTEM	
ADMINISTRATIVE ALTERNATIVES				
PROCUREMENT AND INSTL. OF CHANGES	1 UTILIZE EXISTING NAVORD SMS ORG.	2 CONTRACT WITH PRIME TO PERFORM	3 CONTRACT TO SEPARATE FIRM	3 PERFORM WITHIN PROJECT ORG.
CONFIGURATION STATUS ACCOUNTING	1 UTILIZE EXISTING NAVORD CSA ORG.	2 CONTRACT TO INDEP SOFTWARE FIRM	3 DEVELOP A CSA ORG IN SEASPARROW	

VII. DEVELOPMENT OF ALTERNATIVE SYSTEM APPROACHES AND SELECTION OF RECOMMENDED APPROACH

A. INTRODUCTION

This chapter combines different organizational forms, authority constraints, and implementation measures into three system approaches to the configuration management plan for the operational phase of NATO SEASPARROW, each developed by the authors to satisfy the objectives of Chapter V. Each system approach is synthesized from the elements mentioned in the preceding chapter and is then discussed on its own merits. The system alternatives are compared relative to one another and a selection of a recommended approach is made.

The three alternatives are designed to cover principal courses of action available to the consortium. The first alternative relates to the situation where the existing organizational form is maintained, and the member nations strictly control the allocation of funds to the configuration management effort. The second alternative treats the case of a single management group, the project office, with a greater degree of centralized configuration control. The final alternative addresses the situation of minimal centralized configuration control and disestablishment of the steering committee. This last alternative approaches the buyer-seller relationship discussed earler as being present in other NATO projects, but retains a greater degree of interaction between participants. The number and degree of changes is assumed to be the same, regardless of the alternative selected; i.e., the alternative with a more complex organizational form and more rigid controls will <u>not</u> cause an increase in the number of changes.

B. ALTERNATIVE ONE - MAINTAIN CURRENT ORGANIZATIONAL FORM

This alternative maintains the steering committee and its relationship with the project office. The steering committee would continue to meet on a regular basis and would directly address the issues of configuration management policy and logistic support.

This organizational form has in the past proved quite satisfactory. The current project manager and the national representatives on the project staff interviewed in March, 1972 stated that the organization worked well and that there was a continuing high degree of cooperation. Rather than establish a new organizational structure by eliminating the steering committee it might be wise to make use of the established good working relationships and lines of communication.

Continuing the development of this alternative, in the area of authority constraints on the project office, it is assumed that the steering committee would establish a relatively low ceiling on project office spending without specific authorization of the steering committee. Any change within the project office's spending level which would impact system performance, schedule, or sub-system interfaces to any significant degree would require review and approval of the steering committee. Criteria for degree of significance of proposed changes would be developed by the steering committee for use by the project office. The steering committee would determine the feasibility of maintaining differing configurations and closely control configuration of the entire system. Members not desiring to make a change or desiring to pursue a separate path through a series of changes would be supported on a not-to-interfere basis, with primary consideration given to configurations approved by the steering committee.

The expression "not-to-interfere basis" refers to actions that the authors assume the project office could take in behalf of nations with non-approved configurations. These actions include arranging for support of earlier configurations and arranging for transfer of components made obsolete in one system, to a system owner maintaining an earlier configuration.

This alternative retains a large amount of control at the steering committee level. While it is envisioned that changes would be funded by participants in advance, only the more trivial changes or changes specifically designated by the steering committee would be implemented by the project office. A rigid configuration control policy is assumed; one which would maintain a uniform configuration to the greatest possible degree and, when necessary, carefully control differing configurations.

This rigid policy should yield benefits for all participants, especially in the area of logistic support. This alternative should be conducive to good information exchange of technical and non-technical data since the organizational form requires continuing interaction between the member nations.

It is assumed that this control organization would implement mutually agreeable changes meeting the criteria for change justification as specified in MIL-STD-480 which, briefly stated, is to make changes which correct deficiencies, effect substantial life cycle cost savings, or make significant improvements in the system's effectiveness.

C. ALTERNATIVE TWO - CENTRALIZE CONFIGURATION CONTROL IN PROJECT OFFICE

The second alternative eliminates the two level organization of the steering committee and the project office, and places the responsibility

for configuration management primarily with the project office. The consortium would remove the steering committee from the configuration management decision process after discussing the details of configuration management plan implementation. Liaison with each participating nation would be made through a designated representative in each functional material command. The steering committee would again become involved in a future modernization effort requiring a large increase in expenditures and a new contract. It is assumed that this alternative, through the elimination of an entire echelon of authority, would increase the flexibility of the organization and increase the ability of the organization to implement changes in an expeditious manner.

The expenditure constraints envisioned for the project office are substantially more liberal than those of alternative one. The project office would receive its initial guidance from the steering committee. The project office would have the authority to review, approve, and implement all changes consistent with the policy established by the steering committee. It is assumed that this policy would provide for affecting all changes necessary to maintain the system in current operational status and make improvements as practical within cost constraints. It is further assumed that such a policy would preclude the project office from directing any major re-design or re-engineering effort which exceeded the established ceiling funding level. This alternative again assumes advance funding of change costs on an annual basis. The formula for cost-sharing and the details for administering the changes would be discussed and agreed upon by the steering committee prior to its removal.

With the centralization of change authority it would be essential that the project manager ensure that each member nation was kept informed on the status of changes.

In the area of impact constraints, the project office would be restricted from authorizing or procurring changes which caused significant increases in operating cost or removal of the system from operational status for a prolonged period of time. Once again the degree of significance of a change would be specified by the steering committee. The steering committee might further see fit to limit changes specifically on certain components or sub-systems.

This second alternative provides for rigid configuration control and active participation by member nations. The benefits of rigid control should again be available to all participants. As in alternative one, the project office would assist those nations with differing, non-approved configurations, in maintaining adequate logistic support on a not-to-interfere basis.

D. ALTERNATIVE THREE - MINIMAL CENTRALIZED CONTROL WITH A SINGLE LEVEL ORGANIZATION

The final alternative assumes a single level organizational form composed of the project office, as in alternative two. In this alternative no firm configuration management policy is established prior to the dissolution of the steering committee, with the exception that the nations agree to continue to exchange data and participate actively in maintaining system configuration.

A major difference between this alternative and the previous two is the lack of advance funding of changes. This lack of advance funding, it is assumed, would seriously reduce the ability of the

organization to control and implement change on a system-wide basis. What is envisioned here is a return, to some degree, to the buyer-seller relationship of other NATO projects. It would differ from this relationship in that the consortium would be maintained to permit participants to continue their interaction with the project office on the subject of change and to facilitate the transfer of technical and non-technical data. This method permits the nations to interact with the change authority prior to procurring and implementing the change. The project office would coordinate engineering change proposals. This permits an understanding of the reason for the change and an appreciation of the effects of maintaining differing configurations. It places the responsibility on the project office to solicit all member nations on each proposed change or group of proposed changes and requires each individual nation to respond, positively or negatively, to the solicitation. When the solicitation is completed, the change could then be procurred. This alternative significantly reduces the flexibility of the organization and inhibits its ability to implement changes expeditiously on a system-wide basis. The ability of the organization to control system configuration would be greatly reduced.

This alternative does, however, have some positive points. If implemented, the level of interaction of nations on proposed changes and technical data would be substantially higher than the current system of direct sale of change kits to system owners.[50] It would allow sharing of costs related to a specific change or group of changes.

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[50]Interview with NAVORD personnel attached to Naval Ship Missile System Engineering Station, Port Hueneme, California, May 1972.

As in the previous alternatives, it is assumed that the project office would assist in the coordination of logistic support of non-approved configurations on a not-to-interfere basis. The essential elements of these alternatives are summarized in Table VII.

E. COMPARISON OF ALTERNATIVES

The ability of each of the preceding alternatives to attain the objectives for the configuration management plan outlined in Chapter V will be discussed.

It is felt that both alternatives one and two, the single and double level organization, satisfy the first objective to maintain control of system configuration. It is not felt that the organizational form is as critical a factor as the method for funding changes. In both alternatives one and two, changes are advance funded at some level according to predetermined policy. The disposition of these funds is also agreed upon. The major difference between the first two alternatives lies in the degree of centralization of control over the changes fund. In alternative three, where each nation must respond to the subsequently fund each desired change, it is felt that control over system configuration would be, at best, marginal.

Under the objective of configuration management organization flexibility, alternative two is deemed the most desirable. It is assumed that the flexibility of the organization and the efficiency with which changes are implemented is a function of centralization of control. Control in alternative two is highly centralized in the form of the project office. In alternative one, control is some what dispersed. The fact that the steering committee is not in session continually

TABLE VII. Summary of Characteristics of Major Alternatives

	ALTERNATIVE ONE	ALTERNATIVE TWO	ALTERNATIVE THREE
Organization Form	Two Level: • Steering Committee • Project Office	One Level: • Project Office	One Level: • Project Office
Primary Control.	• Steering Committee	• Project Office	• Project Office
Degree of Control	• Rigid to Moderate	• Rigid to Moderate	• Moderate to Slight
Authority Constraints on Project Office	• Low Dollar Ceiling • Any and/or all areas of impact specified by steering Committee	• Liberal Dollar Ceiling • Not to undertake major redesign or re-engineering efforts	• No Direct Constraints placed by consortium, each change or change package offered separately
Funding	• In Advance (Yearly) • Control of funds rests with steering committee	• In Advance (Yearly) • Control of funds rests with project office.	• Each change/change package procurred separately. No combining of funds.
Logistic Support of Non-approved Configurations	• On a not-to-interfere basis	• On a not-to-interfere basis	• On a not-to-interfere basis
Change Justification	• Any mutually agreed upon change meeting MIL-STD-480	• Correct deficiencies • Effect substantial life-cycle cost savings	• Any change meeting requirements of MIL-STD-480

increases the likelihood that administrative delays in change implementation would occur. Alternative three is a widely decentralized organization, with each member nation reviewing and weighing the impact of each change or group of changes prior to participating. It is reasonable to assume that, given the increased number of administrative interactions that would occur per change and the requirement to confer in advance with each nation on proposed changes, the efficiency and flexibility of alternative three is far less than that of alternative two or one.

The third major objective requires an effective review and approval mechanism. It is felt that while alternative two may nandle review and approval somewhat more efficiently than alternative one, both alternatives can attain the objective to a high degree. It should be noted that the question addressed here is review and approval on a system-wide basis. The word review is used here in a broad sense and is not limited to the technical review by an engineering group. Both alternatives one and two would have established procedures for review and approval of proposed changes leading to implementation. Alternative three's mechanism for review and approval is splintered and diverse. The approval of a change is indicated by a nation's willingness to implement that change. It is felt that unanimous approval or disapproval would probably be the rule in alternatives one and two, while in alternative three delays and the substantially more complicated administration process of individual soliciation and response would seriously hamper accord on any proposed change.

The details relating to the initial procurement and installation of approved changes can be administered equally well by all three alternative

forms. Simply, this is because the project office and its functions in this particular area are common to all three alternatives. This objective refers specifically to the procurement and distribution of approved change materials and is regarded as an essential part of the configuration management plan. Similarly, the next two objectives; conformance to policy and directives, and adherence to budgetary constraints can be met by all three alternatives. The conformance to policy refers primarily to MIL-STD-480, the document which established procedures for engineering change proposals. This military standard has been used consistently since the inception of the project and no deviation from the details contained therein is seen in any of the three forms, in the area of cost constraints each alternative form is viable. The costs of maintaining the steering committee active in alternative one for configuration management decision making may set this alternative at a greater cost than the other two, but this cost is not felt to be significant.

In the discussion of the next two objectives, the alternatives are similarly grouped. It is felt alternatives one and two will be substantially more effective than alternative three, in the support functions of configuration status accounting and operational configuration audit (if held), as well as for the exchange of technical and non-technical data. Alternatives one and two do not have the dispersion of configuration management control of alternative three. In both alternatives one and two there is an established configuration management policy fully formulated and funded in advance. It is assumed that the more rigid organizational procedures which serve to approve and implement change will also enhance the support functions and information exchange.

The last major objective, and one of the most important, refers to the acceptability of the planned approach. The authors have approached this objective from the standpoint that member nations may be reluctant to accept a plan requiring an extensive level of continuing participation and funding. The most acceptable alternative by this criterion is seen as number three. This alternative provides the mechanism whereby a nation can participate in an individual change, or an interrelated series of changes, if it desires to do so without any prior committment. Further, each nation would have complete flexibility to determine its own system configurations. There would be no advance funding requirement and payment would be required only for those changes actually procurred.

Alternatives one and two are viewed as less acceptable because of the requirement to fund changes for some period in advance and to accept the change control authority of the steering committee or the project office.

A summary listing of these alternatives with each objective is given in Table VIII. This table compares the alternatives and reflects the degree to which the authors feel the alternatives satisfy the objectives of the plan.

F. SELECTION OF RECOMMENDED ALTERNATIVE

While it does represent an improvement over the current system of distributing changes to other nations and does have a number of positive factors in the crucial acceptability area, the authors have eliminated alternative three for the following reasons:

Table VIII. Summary of Evaluation of System Alternatives.

OBJECTIVES	Degree to Which Alternative Can Obtain Objective		
	Attain to Substantial Extent	Attain Adequately	Attain Marginally
Ability to Control System Configuration	ONE TWO		THREE
Flexibility of Control	TWO	ONE	THREE
Review and Approval	ONE TWO		THREE
Procurement and Installation	ONE TWO THREE		
Conformation to Directives	ONE TWO THREE		
Cost Constraints	ONE TWO THREE		
Configuration Status Accounting and Audit	ONE TWO	THREE	
Exchange of Data	ONE TWO	THREE	
Acceptability	THREE	TWO ONE	

- the plan would not take advantage of the spirit of cooperation and cohesiveness of the current project.
- the plan is particularly weak in the control and implementation of change areas
- the funding and procuring of approved changes is for less efficient than alternatives one or two.

Alternatives one and two have many similarities. Both can effectively maintain control of system configuration through their fairly rigid organization forms and the advance funding of changes on a yearly basis. Both alternatives envision satisfactory review and approval mechanisms. In the areas of conforming to current policies, budgetary constraints, status accounting, and exchange of data, their capabilities are similar.

The fundamental difference between alternatives one and two is in the organizational form and the distribution of authority over that form. In alternative one the authority is vested primarily in the steering committee, while in alternative two the project office has full authority for mangement of system configuration within specified boundaries. Based on the level of anticipated changes for the NATO SEASPARROW for the first year (less than $1.0 Million),[51] it is felt that the type and number of changes is such that it is well within the capability of the project office to administer. Further, assuming a decreasing number of changes in following years the need for an active steering committee seems questionable. Neither the cost or degree of change appears, in the opinion of the authors, to warrant the active

[51] Interview with NATO SEASPARROW Project Office Staff and National Representatives, Washington, D.C., March 1972.

participation of the steering committee in configuration management. It is felt, however, that full active participation of all member n nations should be continued to maintain effective system configurations and to provide for appropriate logistic support. Keeping these considerations in mind, alternative two is the approach recommended by the authors. The details relating to the implementation of this plan are included in the following Chapter.

VIII. IMPLEMENTATION PLAN

A. INTRODUCTION

The recommended configuration management approach has been defined in broad terms in the previous chapter. In this chapter the specific organizational structure, relationships, and responsibilities necessary to implement the recommended approach are presented. The format used is similar to the configuration management plan for surface missile systems as prepared by the Naval Ship Missile Systems Engineering Station at Port Hueneme, California. The format has been modified to accomodate the multinational nature of the NATO SEASPARROW Surface Missile System and to reflect the time span the configuration management plan is intended to cover, i.e., from the delivery of the first production system through the completion of the system's life cycle.

B. ORGANIZATION

The proposed removal of the NATO SEASPARROW Project Steering Committee from the configuration management decision making process calls for a restructuring of the project management authority relationships. Under this organizational form, the project office is directly responsible to the national governments of the consortium for configuration management. Figure 5 depicts the authority relationships envisioned by the authors for the operational phase configuration management organization. Due to the relatively small size of the NATO SEASPARROW Project, when compared to other major acquisition projects involving substantially greater cost, it is considered feasible by the authors to combine many of the configuration management functions so that fewer

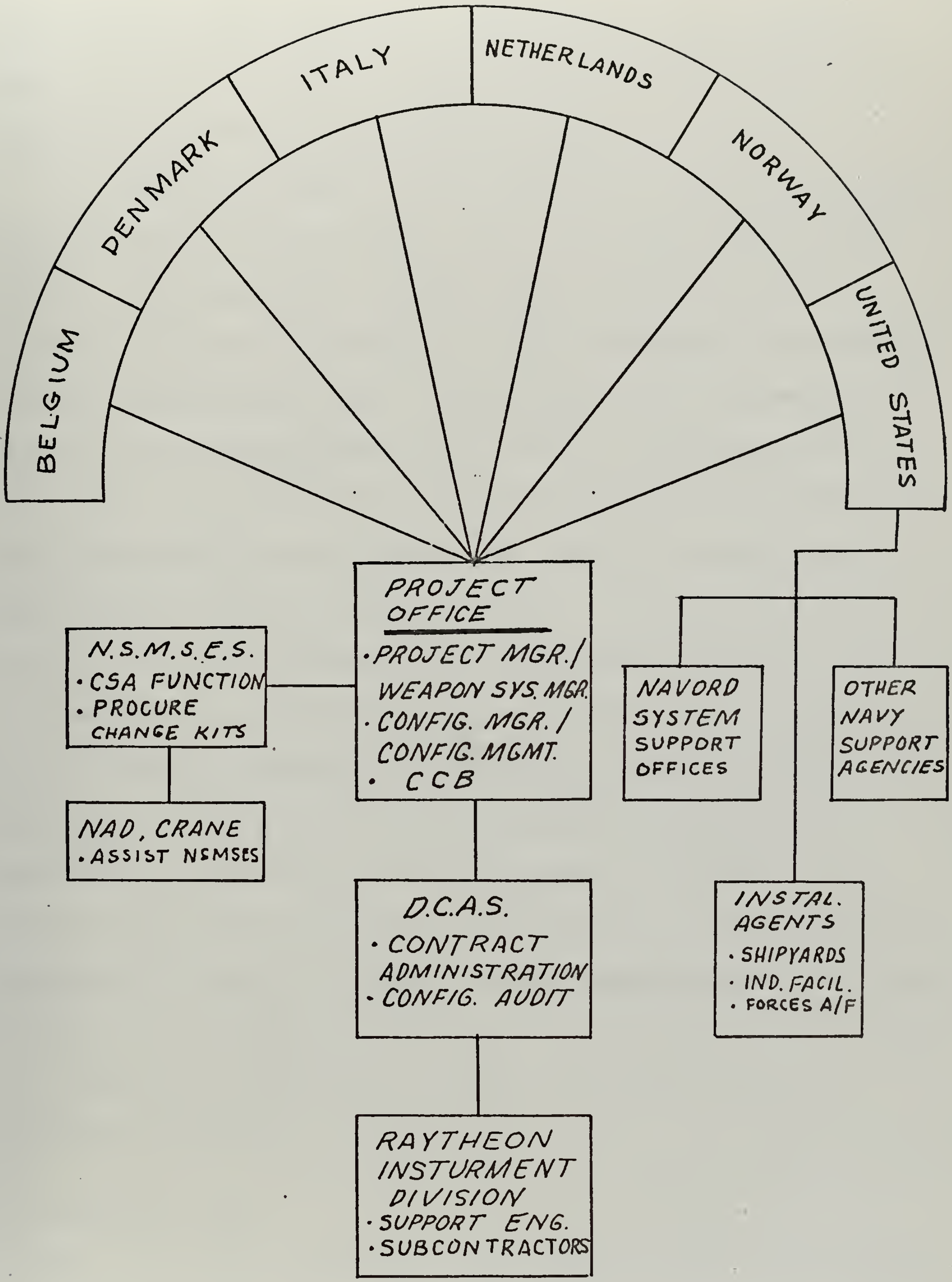


FIGURE 5
CONFIGURATION FUNCTIONAL AUTHORITY FLOW

organizational units are required. The functions to be performed by each organizational unit are listed within the "box" representing that organizational unit on the organizational chart.

As illustrated in Figure 5, the project office derives its authority from the nations of the consortium and is responsible solely to those nations. The implementation of this organizational form can be accomplished through the execution of a new memorandum of understanding to cover the operational phase. The new memorandum should either deactivate the NATO SEASPARROW Project Steering Committee or diminish their role in the configuration management decision process until some future time when it may be required again, such as to manage a major modernization of the NATO SEASPARROW system. It is also felt by the authors that the new memorandum should restructure the project office by broadening its commitment authority sufficiently for it to perform its configuration management mission efficiently and effectively and to remove it from a production-oriented management environment to an operational and maintenance oriented management environment. It is further believed that this could be accomplished by assigning national representatives from the functional material commands which have primary interest in maintenance and operations instead of production. The flow of a engineering change proposal through the review process is illustrated in Figure 6.

C. RESPONSIBILITIES

The configuration management responsibilities of the organizational units and the roles each assumes, as envisioned by the authors, are presented in this section.

FIGURE 6-A ECP FLOW

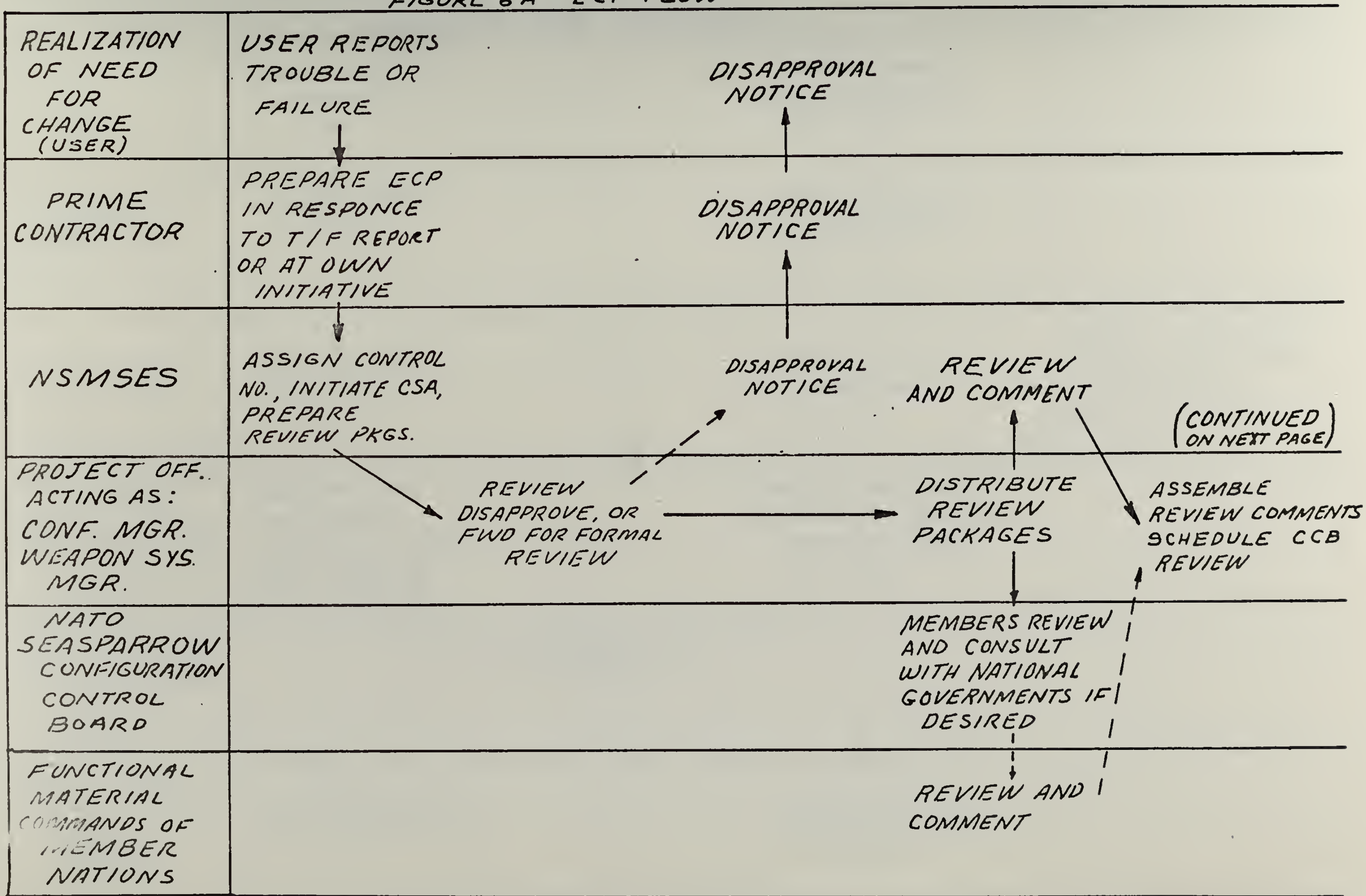
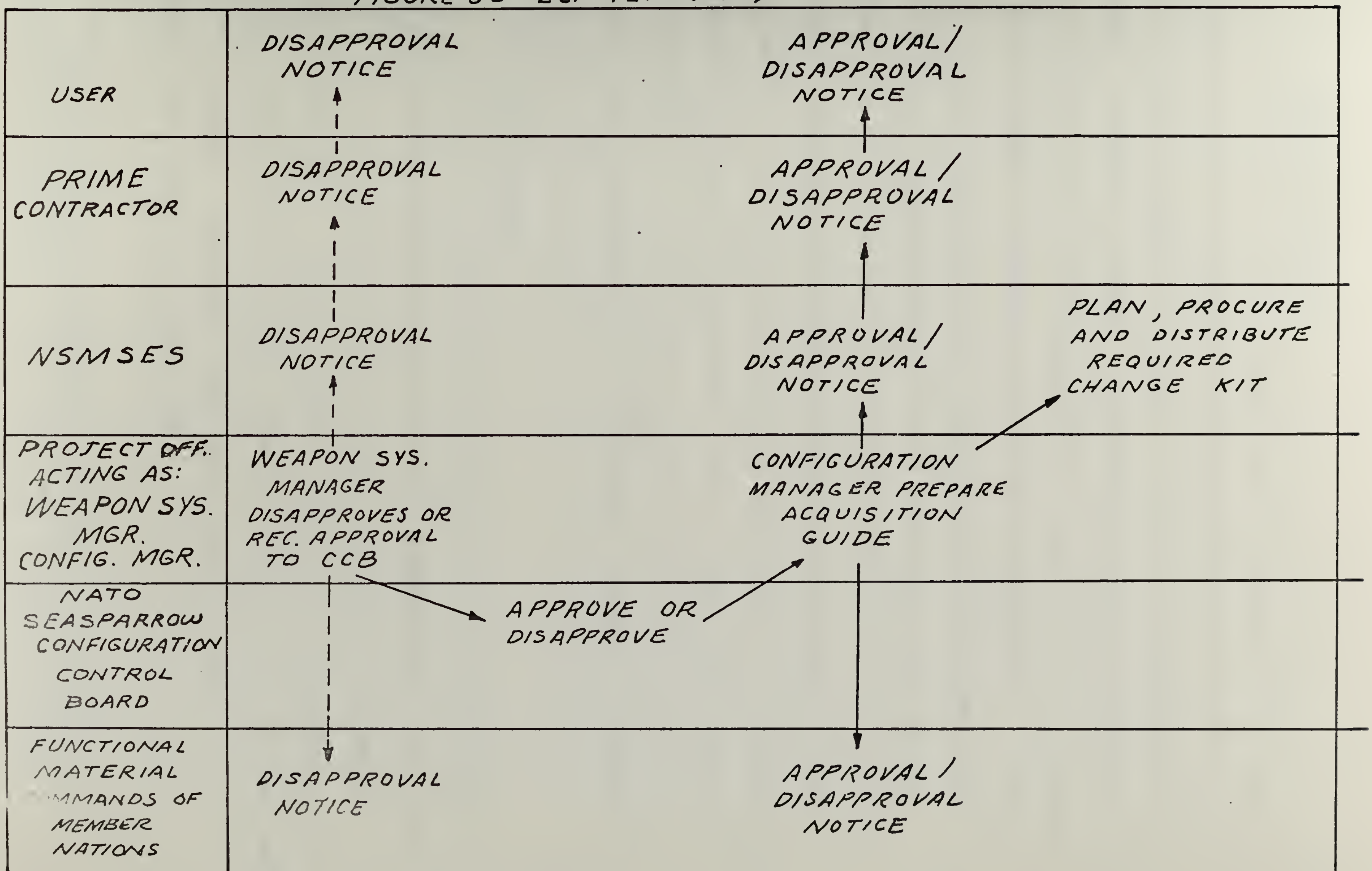


FIGURE 6-B ECP FLOW (CONT.)



1. National Governments

Each member of the consortium would be responsible for assigning a capable national representative to the project office from its functional material command to represent its interest in the project or to arrange, by separate agreement, for some other nation to represent it.[52] The individual nations are responsible for establishing and maintaining a NATO SEASPARROW information center for the dissemination of information from the project office or its agents to the users and for the collection of feedback information to be transmitted to the project office, its agents, and the other nations. They should also provide a channel within their respective functional material commands for the consideration of configuration management questions which are beyond the authority constraints of the project office. Finally, each nation will be responsible for complying with the fiscal obligations decided upon by the steering committee prior to its removal from the configuration management decision process.

2. Project Manager

The project manager will be responsible for the establishment of the configuration management organization, the operation of the project office and its relationship with the other configuration management organizational units. He will establish configuration management policy for the project office within the framework provided in the new Memorandum of Understanding. The project manager will exercise control over all change actions involving project funds.

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[52] Such an arrangement now exists in the project office where the representative of the Royal Netherlands Navy represents both the Netherlands and Belgium.

The project manager would also serve as the chariman of the NATO SEASPARROW Configuration Control Board. The national representative would sit as members of the configuration control board for the purpose of evaluating and taking final approval action on all engineering change proposals within their authority to approve. Engineering changes beyond the scope of the NATO SEASPARROW Configuration Control Board's authority would be forwarded to the material commands of the respective nations with the comments and recommendations of the board. In addition, it would be the responsibility of the board to notify the functional material commands of each nation of any system interface problem arising from the board's actions and for recommending remedies to be taken by the member nations to correct those interface problems.

3. Configuration Manager

The configuration manager is envisioned by the authors as the full time configuration management team member in the project office. He will perform the combined functions of configuration manager and configuration management agent with the exception of being chairman of the configuration control board, a function performed by the project manager.

In the role of configuration manager he would be responsible for making recommendations for the approval or disapproval of engineering change proposals to the configuration control board and for providing the secretariat service for the configuration control board. The secretariat assures the smooth flow of engineering change proposals from inception through final approval and implementation or disapproval. It would also be the responsibility of the configuration manager to accept configuration audits for new systems and change kits.

In the role of configuration management agent he would be responsible for the preparation of change review packages and the administration of implementation of configuration control board approved changes. He would also be responsible for developing special purpose configuration management plans for unique situations arising in the project and for coordinating the configuration status accounting effort. He furnishes information to supporting agencies such as the Naval Ship Missile System Engineering Station for logistic and engineering support purposes.

4. Defense Contract Administration Service

During the development and production phases of the NATO SEASPARROW Surface Missile System, the Defense Contract Administration Service has served as the contract administrator for the project. Since the production contract has a substantial time to run and will be administered by the administration service until completion, it is recommended that they also administer the operational phase engineering support contract discussed later in this section.

The configuration management responsibilities of the Defense Contract Administration Service include interpreting the configuration management contract requirements for the contractor and ascertaining if the requirements are being met. They represent the project office during configuration audits, inspections, reviews, and acceptance trials, as well as the monitoring of the contractor's configuration accounting system to assure the tracking and accomplishment of approved changes. Finally, they coordinate the submission of contractor originated engineering change proposals and submit comments and recommendations on these to the secretariat.

5. Prime Contractor

The configuration management requirements are normally negotiated and written into the production contract. In the case of the NATO SEASPARROW Project the production contract provided for configuration management only through the end of production.

It is recommended that a separate contract for continued support engineering be negotiated with the prime contractor for the operational phase. The responsibilities of the contractor should include the sustaining engineering effort required to support the NATO SEASPARROW system throughout the operational phase. This effort should include the continued search for improvements by the prime and subcontractors, the preparation of engineering change proposals for those improvments, and the corrective engineering required to correct problems or failures encountered by the operational user.[53]

6. Naval Ship Missile System Engineering Station

The Naval Ship Missile System Engineering Station at Port Hueneme, California is the configuration status accouting agent for United States Navy surface missile systems and is uniquely qualified for handling the configuration status accounting function for the NATO SEASPARROW Surface Missile System. The Naval Ship Missile Systems Engineering Station would be responsible for coordinating through the national representatives the collection of the status of change implementation on each installed system including all components in stock as spare parts as well as on any other equipments affecting the status accounting operation.

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[53]An existing system for reporting equipment problems and failures on a multinational project is the Fleet Ballistic Missile Weapon System Trouble and Failure Report Program, Strategic Systems Project Office Instruction 3100.1C, 1 May 1969.

On a periodic basis Naval Ship Missile Systems Engineering Station would be responsible for issuing summary data on each system to all member nations. It would be responsible, together with the Naval Ammunition Depot, Crane, for the procurement, assembly, and issuance of change kits to the respective nations. Figure 7 shows the organization of the Naval Ship Missile Systems Engineering Station.

D. CONCLUSIONS

The above implementation plan is a recommended approach to be used for the preparation, evaluation and installation of, and accounting for engineering changes during the operational phase of the NATO SEASPARROW Project.

In addition to the configuration management plan used within the system, it is most likely that each nation will have some form of formal configuration control apparatus of its own. It is envisioned that some countries, including the United States, will insist upon reviewing some if not all of the engineering change proposals through their existing organizations. Such reviews may somewhat delay the decision process but cannot be anything but helpful to the NATO SEASPARROW Project Configuration Control Board in providing a greater insight into the implications of the change being considered.

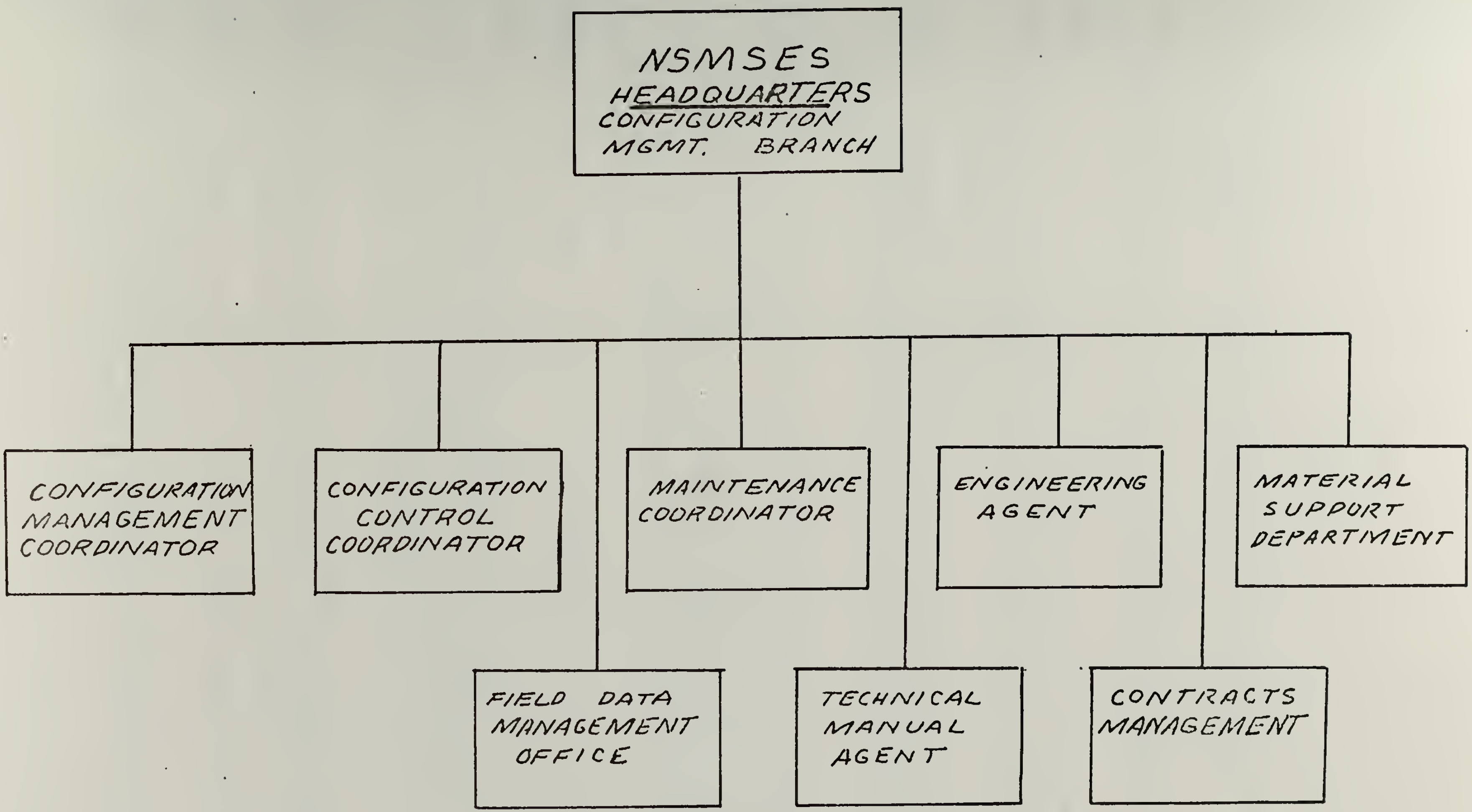

FIGURE 7

NAVAL SHIP MISSILE SYSTEMS ENGINEERING STATION ORGANIZATION

APPENDIX A

GLOSSARY

ACQUISITION PHASE, the period between the end of the definition phase and the delivery of the last equipment to the customer.

ALLOCATED BASELINE, an allocated configuration identification which is an optional baseline initially approved by the customer

AUDIT, to inspect records and procedures.

BASELINE, an approved reference point for control of future changes to a product's performance, construction, and design. Mainly specifications and drawings.

BASELINE MANAGEMENT, developing and administrating the necessary characteristics of a Navy material item at designated points in its life cycle through the use of configuration identification and engineering control.

CHANGE, within the context of configuration control, a formally recognized revision to a specified and documented Navy material requirement. Includes design changes, engineering changes, field changes, technical change orders, changes in specifications or other related requirements - type documents, waivers, deviations, alterations, amendments, improvement, modifications, and other similar types of change actions.

CHANGE CONTROL BOARD, the same as configuration control board.

CHANGE IDENTIFICATION NUMBER, a number assigned to a data package defining an equipment engineering change. It is used to control, sequence, and account for production, implementation, and retrofit actions related to the change. The CIN includes the CI number, company code identification number, ECP number, ECP type code, ECP revision code, and ECP correction code.

CLASS I CHANGE, a change affecting the contract specification, price, weight, delivery schedule, reliability, performance, interchangeability, interface with other products, safety, RFI, or GSE.

CLASS II CHANGE, any change not falling within the Class I change definition given above.

COMPONENT, a part, subassembly, assembly, or combination of these items joined together to perform a function.

DOCUMENT, the collective term for specifications, drawings, parts lists, standards, and report.

ENGINEERING CHANGE PROPOSAL (ECP), a document that proposes change to a Navy material item in accordance with applicable bulletins, regulations, standards, and other directives. Includes design change proposals, engineering change proposals, proposed engineering orders, proposed field changes, proposed change orders, value engineering change proposals, requests for waivers and deviations, alteration improvement proposals, material improvement proposals, and other similar modification proposals, change-type documents.

ENGINEERING DATA, specifications, drawings, parts and wire lists.

EQUIPMENT, an item designed and built to perform a specific function as a self-contained unit or to perform a function in conjunction with other units. It is the same as a product.

FIRST ARTICLE CONFIGURATION INSPECTION, a formal review of the as-built configuration of an equipment against its documentation to establish the product configuration baseline for the CI. Formal approval of Phase II of the detail specification occurs during FACI.

FORM, FIT, AND FUNCTION, the physical and functional characteristics of a CI as an entity, but not covering characteristics of the elements making up the CI.

FUNCTIONAL BASELINE, the functional configuration identification initially approved by the customer. (See FCI.)

GENERAL OPERATIONAL REQUIREMENT (GOR), a document which describes a long term (5 years) operational need or characteristic for a weapon system.

INTERFACE, a common boundary between two or more items. This boundary may be electrical, mechanical, functional, or contractual.

KIT, a collection of carefully identified and controlled items used to build a module, printed circuit board, subassembly, or assembly. Kit items are usually kept in a plastic box or plastic bag and labeled.

LIFE CYCLE, the period covering the design, development, manufacture, operation, maintenance, logistics support, and repair of an equipment.

MODIFICATION, a change to an equipment and spares allowed only after the contract has been revised.

OPERATIONAL, applies to actual use of a product.

PERFORMANCE, the functional or operating characteristics of an equipment; for example, measurement range, accuracy, stability, linearity, and reliability.

PHYSICAL CHARACTERISTICS, quantitative and qualitative material descriptions of an item; for example, form, fit, dimensions, finishes, and composition. Tolerances for each characteristic are also given.

PHYSICAL CONFIGURATION AUDIT, a formal examination of the as-built configuration of an equipment against its documentation to establish the initial product configuration identification.

PRIVATELY DEVELOPED ITEM, an item completely developed at the company's expense and offered to the customer as a production item. Customer control of the configuration is usually restricted to the item's form, fit, and function.

PRODUCT BASELINE, the product configuration identification initially approved by the customer.

PRODUCT CONFIGURATION BASELINE, a CI baseline defined by an approved Part II of the detailed equipment specification, which is established by completion of FACI.

PRODUCTION BASELINE, a company baseline that precedes the customer product baseline.

SPECIFIC OPERATIONAL REQUIREMENT (SOR), a document which describes operational or performance characteristics needed to fulfill a near-term operational requirement for a system.

SPECIFICATION, a document, primarily used for procurement (purchase of an item from a vendor or subcontractor), that describes the major technical requirements for an item and the procedure for determining the requirements have been met. Key sources of specifications are the Federal Government, the military, and industry.

SPECIFICATION TREE, a drawing showing the indentured relationships among specifications independent of the assembly or installation relationships of the items specified. The tree shows the dependency of specifications on other specifications.

STANDARD, a document designed for recurring use. It specifies engineering and technical limitations and applications for an item, process, or engineering practice. A standard gives general requirements and does not describe how something shall be done. Key types of standards are federal, military, and industrial.

SUBASSEMBLY, two or more parts that form a portion of an assembly replaceable as a whole but having a part or parts that are individually replaceable.

SUBCONTRACTOR, one who performs a subtask for the company that has the equipment contract.

SUBSYSTEM, a major functional subassembly or group of items that is essential to operational completeness of a system.

SUPPORT EQUIPMENT, equipment required to make the CI operational in its intended environment; for example, ground equipment or computer programs.

SYSTEM, a composite of subsystems, assemblies (or sets), skills, and techniques capable of performing and/or supporting an operational (or non-operational) role. A complete system includes related facilities, items, material, services, and personnel required for its operation to the degree that it can be considered a self-sufficient item in its intended operational (or non-operational) and/or support environment.

FUNCTIONAL AREA, a distinct group of system performance requirements which, together with all such groupings, forms the next lower level breakdown of the system on the basis of function.

SYSTEMS ENGINEERING, the application of scientific and engineering efforts to (a) transform an operational need into a description of system performance.

SYSTEM SPECIFICATION, a general specification containing technical and mission requirements for the system as a whole and apportioning these requirements to subsystems or equipments for meeting mission goals. It also defines interfaces between the different items.

TECHNICAL DEVELOPMENT PLAN, a complete description of the effort required to fulfill a need, including identification of high risk areas, functional diagrams, equipment configuration, gross solutions to system requirements, and funding schedules.

TECHNICAL MANUAL, a type of technical order which contains instructions designed to meet the needs of personnel engaged in operating, maintaining, servicing, overhauling, installing, or inspecting the equipment.

TENTATIVE SPECIFIC OPERATIONAL REQUIREMENT (TSOR), a preliminary specific operational requirement.

TRACEABILITY, the ability to determine the origin and date of manufacture of a part assembled into a product or to determine which serial numbered product contains a part from an identifiable lot.

TRADE-OFF, an evaluation of a design change to determine its importance in regard to benefits versus disadvantages (higher cost, delays, and so on).

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DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*
Naval Postgraduate School
Monterey, California 93940

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
The Development of a Configuration Management Approach for the Operational Phase of the NATO SEASPARROW Project.

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

5. AUTHOR(S) *(First name, middle initial, last name)*
Richard Paul Genet and Brian Robert Leonard

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
June 1972	109	38

8a. CONTRACT OR GRANT NO.

b. PROJECT NO.

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Naval Postgraduate School
Monterey, California 93940

13. ABSTRACT

This Thesis develops a configuration management approach for use during the operational phase of the NATO SEASPARROW Surface Missile System project. A brief description of the concepts and techniques of configuration management as well as the background of the NATO SEASPARROW project are presented to familiarize the reader with the subject matter.

The sub-alternatives and constraints in the areas of organizational form, authority constraints, and change control measures are enumerated and evaluted against the goals of the members of the consortium and the requirements of sound configuration management. System alternatives and constraints are then synthesized from the sets of sub-alternatives to provide a final set of cohesive, viable, alternatives.

From an evaluation of these system alternatives, the recommended solution is selected. An implementation plan is presented for the selected alternative.

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Change Control Change Management Configuration Control Configuration Management Multinational Consortium NATO SEASPARROW						

DD FORM 1 NOV 65 1473 (BACK)

S/N 0101-807-6821

Security Classification

A-31409

Thesis 136267
G2596 Genet
c.1 The development of a
configuration management
approach for the opera-
tional phase of the NATO
SEASPARROW project.