

WEAPONS SYSTEMS DEVELOPMENT

IN THE AIR FORCE

by

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Faculty Advisor of the Thesis

May 15, 1958

Professor L.F. Hamilton  
Secretary of the Faculty  
Massachusetts Institute of Technology  
Cambridge 39, Massachusetts

Dear Professor Hamilton:

In accordance with the requirements for graduation, I herewith submit a thesis entitled "Weapons Systems Development in the Air Force."

I wish to express my appreciation to those members of the Faculty and the United States Air Force who gave their time to provide the information which made this thesis possible. I particularly wish to thank my thesis advisor for his provocative ideas and assistance which were not only invaluable to the completion of this paper, but which also have stimulated my desire for continued study within this area.

Sincerely yours,

Signature redacted

Charles J. Henry

## ABSTRACT

This thesis deals with the problem of control of Air Force weapons development. In the past few years and particularly since the launching of Sputnik I the Air Force weapons development system has come under criticism from many quarters.

These criticisms are generally pointed in some manner at the implied failure of Air Force development to attain two goals:

- 1) The maximization of long-run weapons development by selection of weapon systems for operational development which will give us weapon supremacy at any future date.
- 2) Developing adequate weapons in the shortest possible time - that is with minimum lead times.

The method of approach used in this paper was to first bring out the major criticisms of the present Air Force development system; secondly to outline the present organizational structure and procedures; thirdly, to analyze the system in light of the major criticisms; and last to reach some conclusions about the primary weaknesses in the present development structure. ✓

The conclusions reached were as follows:

- 1) Less emphasis should be placed on "paper" studies of weapons systems proposals and more effort concentrated on testing of prototypes.
- 2) Rotation practices should be revised so that officers may make permanent careers within the field of research and development in order to promote more know-how and management continuity within the development field.
- 3) Less emphasis should be placed on review and coordination efforts at all levels of the development structure. Valuable lead time is wasted throughout development because of the constant review and revision practices at each level.

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GLOSSARY OF ABBREVIATIONS

AMC	Air Material Command
ARDC	Air Research and Development Command
EMR	Executive Management Responsibility
ICBM	Intercontinental Ballistic Missile
R & D	Research and Development
R & E	Research and Engineering
WSPG	Weapon Systems Phasing Group
WSPO	Weapon Systems Project Office

## Chapter 1

### Introduction

#### The Problem

The United States is now engaged in a limited arms race which is currently costing the government almost 40 billion dollars per year. Bearing a major part of the operational responsibility for the United States position in this race is the United States Air Force since within its mission lies the role of development and maintenance of most of the present United States strategic weapons.

In this era it is not enough to have weapons of sufficient power operational at the present moment. It is equally important to the security of the United States that development be constantly underway on new weapons which will pose an adequate deterrent to any Soviet intentions of aggression at any future date. Thus, our present survival may well depend upon development decisions made five or ten years ago.

Although considerable attention had been given to development procedures and policies of the Air Force as well as the other services by various investigating committees of both Congress and the services, it wasn't until the recent launching of Sputnik I by the Soviets that general doubts were raised as to the

ability of our development programs to compete with those of the Soviet Union. A glance at the following comparison of the weapons progress of the United States and Russia certainly gives added impetus to these doubts.

	U.S.	U.S.S.R.
First nuclear detonation	1945	1949
First thermonuclear detonation	1952	1953
Operational intercontinental jet bomber	1955	1955
Earth satellite	1958	1957
Operational intercontinental ballistic missile	?1960?	1958

Whether it has been a lack of funds or something is amiss with the weapons development system as it is presently set up, there is little doubt that something is alarmingly wrong with the way we are handling the development program.

Since development of a majority of our strategic weapons falls within the responsibilities of the United States Air Force, this service has come under particularly close scrutiny in this area in recent years and especially within the last few months. It is the area of weapons systems development in the Air Force with which this paper is concerned.

The main object of this thesis is to find out what is wrong with weapon system development in the Air Force and what should be done about it. This chapter will attempt to explain the major criticisms which have recently been made in this area.



Chapter II is concerned with how the development organization within the Air Force functions. Chapter III contains an analysis of the criticisms made in light of the present organizational structure, procedures and policy. The last chapter deals with what can be done to improve the present set up.

### Criticisms of the Present Air Force Procedure

Within the area of weapons systems development it can be said that the Air Force has two prime objectives:

- 1) To choose for future development those weapons which, as far as technology allows, will best enable the Air Force to carry out its mission at any future date. Within this area its basic concern in today's arms race is to develop those weapons which will maximize its strategic destructive potential, at any time. This in essence means that ample attention should be given to long range development plans as well as immediate short run operational requirements.
- 2) After selection of which weapons systems to build, its main goal is to develop them as fast and efficiently as possible with such priorities that it may be assured that at all times there will be weapons in being adequate to cope with any Soviet threat.

That these goals are not being sufficiently met has been pointed out by the cases of the development of our ICBM and our intercontinental jet bomber, the B-52.

In 1947 the Air Force had underway a development study on its MX-774 long range ballistic missile. At that time it cancelled its study contract with Consolidated Vultee and in its place concentrated efforts on the slower air-breathing "Snark" and "Navaho" missiles.

The reason given by the Air Force for this decision was that the "Snark" and the "Navaho" missiles would become operational at an earlier date than the ICBM. The ballistic missile project was not reactivated until 1951 and did not receive a high priority until 1954. The irony of this whole situation was that neither the "Snark" nor the "Navaho" ever became major components of the Air Force's strategic arsenal, but we now are behind the Soviets in ICBM development due to the decision to develop those two missiles at that time.

The lead time problem has been the most publicized short-coming in the Air Force development program. A prime example of this was the development our first intercontinental jet bomber as compared to a similar development by the Soviets of the Bison bomber. Development of the B-52 essentially began in 1947 when the Air Force initiated its original development studies. The aircraft became operational in 1955. In comparison, the Soviets began development of their Bison in 1950 and had the first aircraft in inventory by 1955. Similar examples have been pointed out in other comparable weapon development programs.

As a result of many investigations concerned with the

Air Force and overall weapons development many criticisms have been brought forth. While the following list does not include all of these, the major issues are either included or implied:

- 1) There are too many reviewing staffs and committees at each level concerned with research and development control.
- 2) There is not a high level group concerned specifically with the eventual adoption of radical new weapons systems.
- 3) Too many decisions on weapon programming are made at the Air Force level instead of in the Department of Defense thus leading to unnecessary duplication in weapons development by the services.
- 4) There is too much emphasis on development of weapon systems which will be operational within the near future as opposed to those that won't be ready for inventory for many years.
- 5) Too much planning and coordinating is done before development is allowed to begin.
- 6) Not enough funds are being allocated to basic research programs.
- 7) Air Force policies discourage prime contractors from capital investment, and the use of efficient production and development techniques.
- 8) Red tape and unnecessary review delays weapon programming decisions.
- 9) Roles and missions of the Air Force and the other branches of the service are so defined that they cause duplication and excessive competition for development rights.
- 10) Rapid rotation of officers and men in development areas breeds the continuity of control and procedure as well as depriving

development groups of an adequate number of technically competent personnel.

11) Renegotiation procedures used for all Air Force (as well as other services) cost-plus-fixed-fee contracts are costly to industry and detrimental to any incentive for expansion and reinvestment in long life equipment.

The validity of those criticisms will be dealt with (Chapter 111) following a discussion of the Air Force organization and procedures.

## Chapter 11

### The Air Force Development Organization

#### Role of the Office of the Secretary of Defense in R&D

In the years since World War II, our whole national security program has been altered considerably. In 1947 (National Security Act of 1947) the Air Force was made into a separate agency and all three services were placed under the "general supervision" of a Secretary of Defense. In 1949 by Congressional legislation (National Security Act of 1949) and again in 1953 by executive order (Reorganization Plan 6) the powers of the Secretary of Defense were broadened. He was given direct control over the three services. The responsibility for integrating research, development, procurement and in general coordinating all plans and phases of activities of the three services was put in his hands. Administration of the three services was to remain within their own control and Congress still allocates funds directly to the services. The Secretary of Defense may approve or disapprove service obligation of these funds, but may not transfer the appropriated funds among the services.

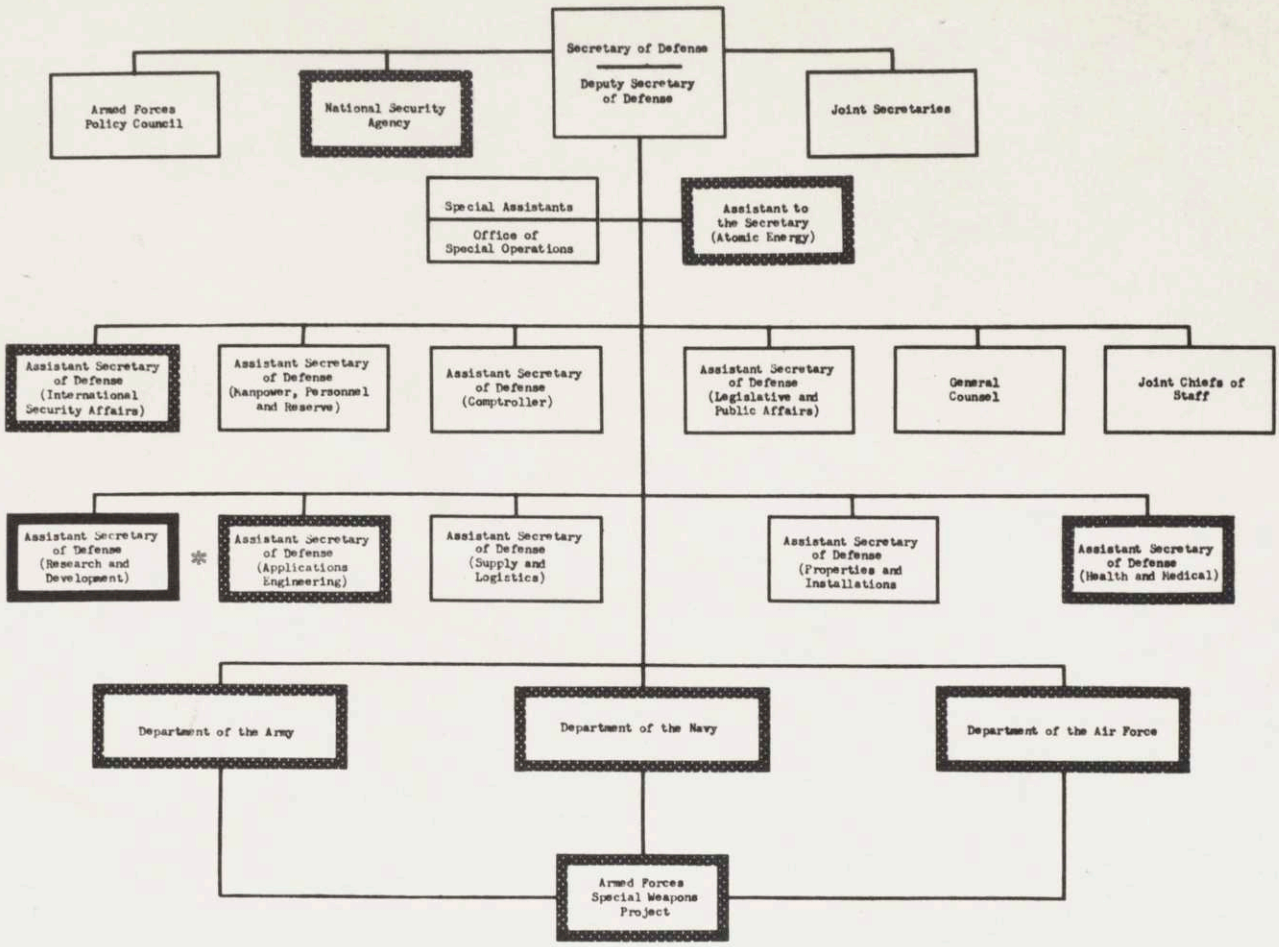
The Secretary of Defense has eight Assistant Secretaries to aid him in coordination and review within areas of related activities. At present, the Assistant Secretaries are in the Defense Department: Manpower and Personnel, International and Security Affairs, Comptrollers, Legislative and Public Affairs, Health and Medical, Properties and Installations, Supply and Logistics and Research and Engineering. The primary responsi-

bility for guidance of the Defense research and development effort lies with the Assistant Secretary of Defense (Research and Engineering). While few of the other Assistant Secretaries of Defense actually participate in the planning and/or review of the development activities carried out by the three services as does the Assistant Secretary of Defense (R&E), they nevertheless formulate policies which alternately influence these activities. An example is the budgeting control activities of the Assistant Secretary of Defense (Comptroller) which affect the funds available for research and development.

Prior to 1953 the only organization within the Defense Department directly concerned with coordination of the research and development programs was the Research and Development Board. Although this board has some success in decreasing duplication and coordinating the research activities of the three services, the Board lacked the necessary authority to initiate research in radically new areas of potential development. Moreover, extended expansion of all phases of research soon made the Board's intricate organization of sub-committees and panels an ineffective and cumbersome system with which to attempt to guide the over-all complex R&D activities of the Department.

In 1953 the Rockefeller Committee on the Department of Defense Organization urged the Board's dissolution. That same year the Committee's recommendation resulted in all responsibility for military R&D being placed directly in the Office of the Secretary of Defense. All authorities of the Research and Devel-

DEPARTMENT OF DEFENSE



(For Chart Code, see page 20.)

\* Now Assistant Secretary of Defense (R&E)  
 Defense Department Organization

opment Board were placed in the newly created offices of the Assistant Secretaries of Research and Development and Applications Engineering.

One vital assumption made in creating these posts was the theory that even top-level control of the broad R&D function should be split. Thus, the Assistant Secretary for R&D had the broad responsibility for the plans, policies and programs of research and development and the Assistant Secretary for Applications Engineering had the responsibility for determining the reliability, simplicity, economy and suitability for production of the weapons contemplated for development and/or eventual inventory.

In the years 1953 to 1957 cooperation between the Assistant Secretaries for R&D and Application Engineering was excellent; nevertheless, the system itself was cumbersome. Officials of the Air Force in charge of various phases of R&D discovered that their actions were directly subject to review by the offices of both of these Assistant Secretaries of Defense. Not only was coordination difficult, but also the time required for review and approval of the R&D functions was longer than would have been necessary if all of the functions were under the auspices of a single authority. Consequently, the organization of the two Secretaries gradually were integrated until in 1957 the two offices were replaced by a single authority, the Assistant Secretary of Defense (Research and Engineering).



His primary functions are as follows:

- 1) Coordination of the exchange of R&D information among the services.
- 2) Development of overall R&D policy (not encroaching upon each service's administration of its R&D program).
- 3) Elimination of duplication among the R&D programs of the three services.
- 4) Review of all development and research plans with authority to cancel any project by withholding the right to obligate funds.

In order to carry out these tasks the organization of this office has been set up with three main functioning groups:

- 1) the Research and Development Policy Council, 2) the Coordinating committees and 3) Technical Advisory Panels.

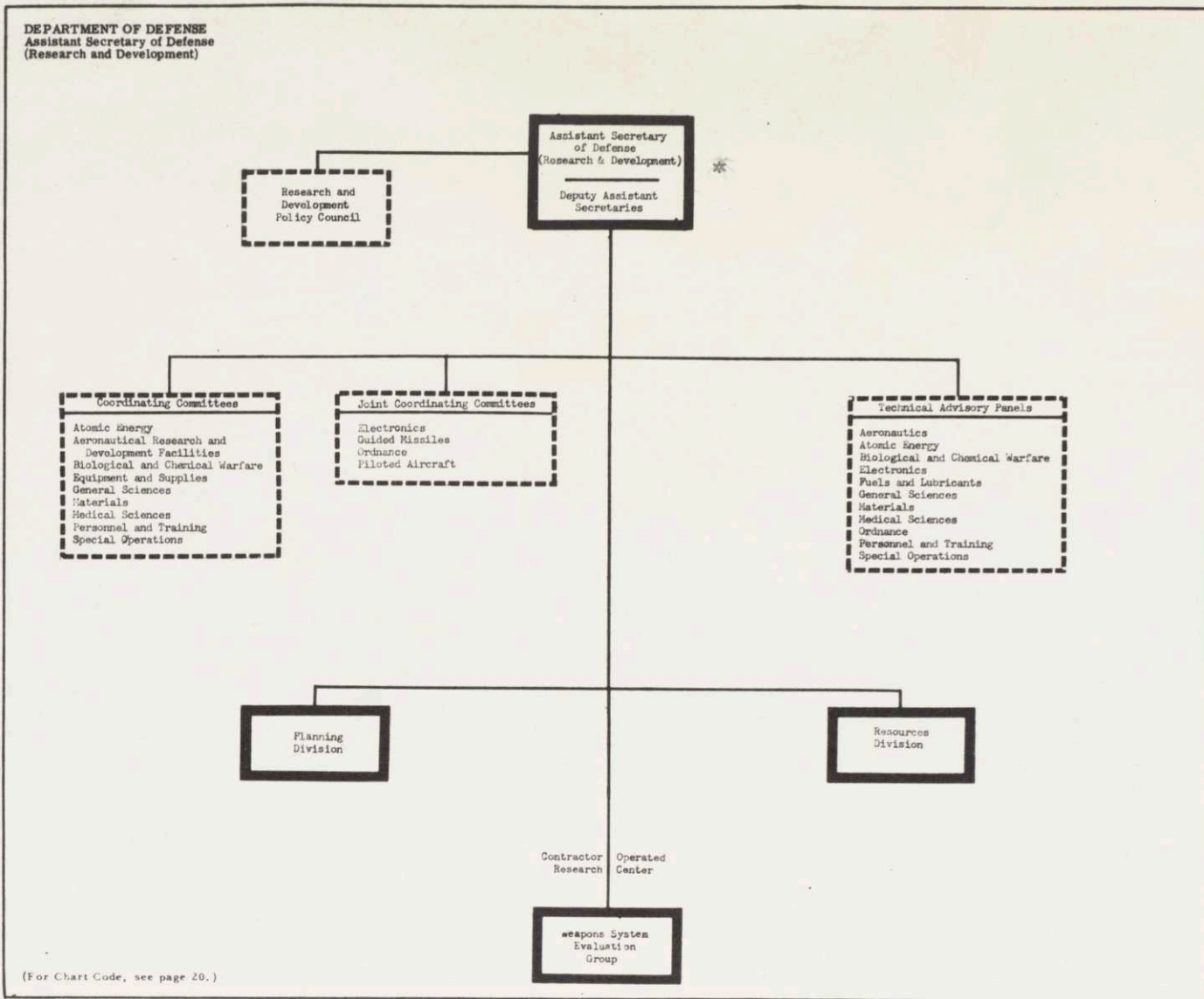
The Research and Development Policy Council is composed of the Assistant Secretary (R&E) who is the chairman, his various deputies, the Assistant Secretaries of each military department having control over R&D and the senior military officer from each department in command of R&D.

The duties of the Council are to review the policies of each service in regard to R&D and to evaluate their advisability in relation to overall strategic plans.

The Coordinating Committees have been established in

DEPARTMENT OF DEFENSE  
 Assistant Secretary of Defense  
 (Research and Development)

\* Now Assistant Secretary of Defense (R&E)  
 Office of the Assistant Secretary of Defense (R&E)



(For Chart Code, see page 20.)

specific areas of research. Consisting of a representative from each of the three military departments and the office of the Assistant Secretary of Defense (R&E), the function of these committees is to coordinate R&D within their areas in the three services. These committees are also confined to review of department plans in their activities. Technical Advisory panels are established in areas of technical concepts and are composed mostly of civilian scientists and administrators who are experts in their various fields. These panels report their findings to the appropriate coordinating committees. The value of having these civilian advisory panels at this level cannot be underestimated in that they provide a sound contact for advice from the civilian research and development community. Budgetary Control of R&D in the services is also handled by the Assistant Secretary of Defense (R&E). As previously stated, funds are appropriated to each military service by Congress and may not be transferred among those departments, the obligation of these funds is subject to the approval of the Secretary of Defense. It is the prerogative of the Assistant Secretary of Defense (R&E) to recommend the withholding of funds from any specific development program.

The Assistant Secretary of Defense (R&E) also exercises extensive control over the preparation of each fiscal year's budget proposal.

The preparation of a budget proposal takes approximately eighteen months. It is the responsibility of the Research and

Development Policy Council to establish the general "guide lines" for the Research and Development budget before work is begun on it. The Committee then reviews the budget proposal about 6 to 12 months before it is submitted to Congress. After appropriations have been made it is this same Committee which must approve each department's obligations of funds for its development and research programs. Overall coordination for budget planning is carried out by the Assistant Secretary of Defense (Comptroller).

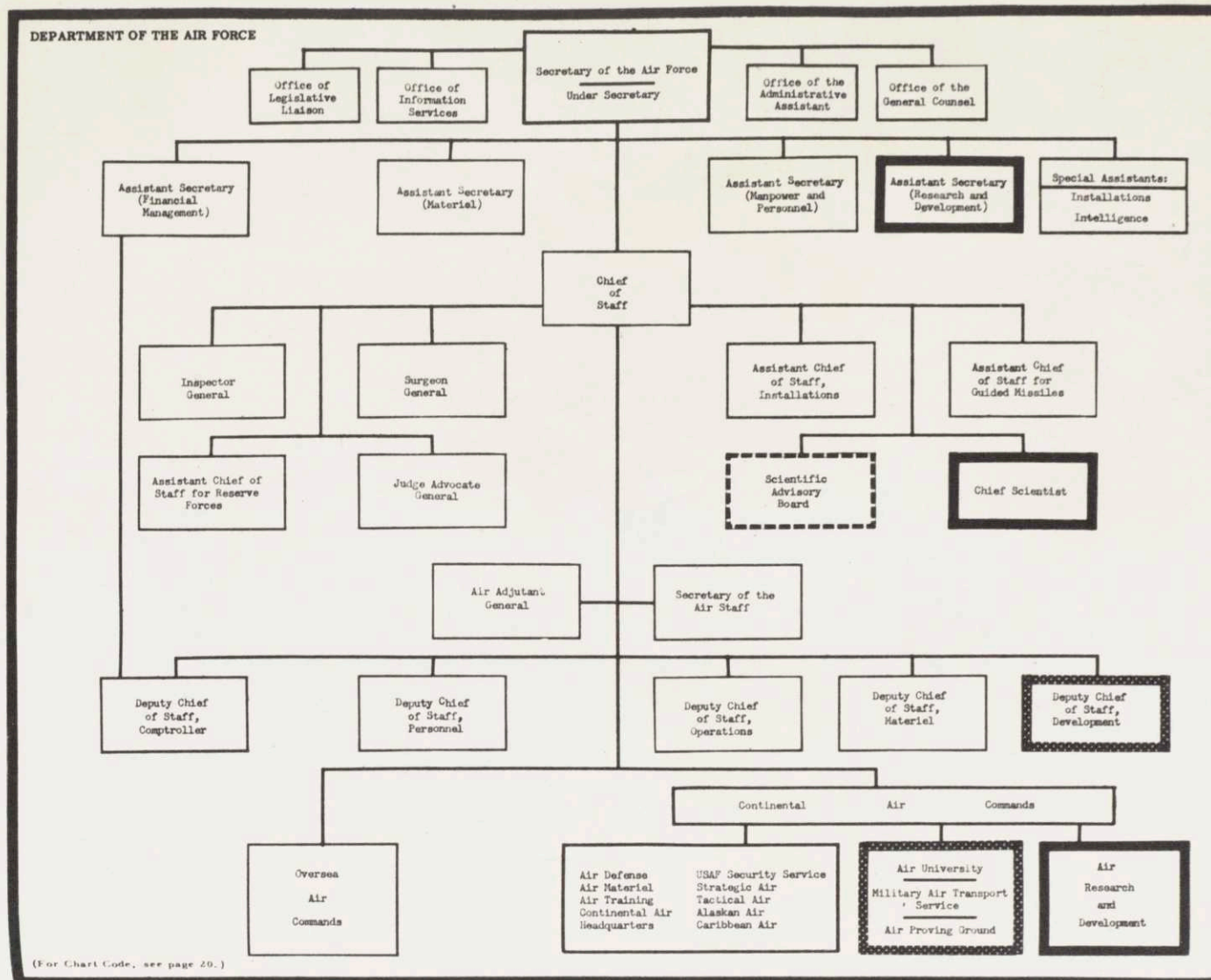
USAF Organization for Planning and Control of Development Activities

The primary responsibility for research and development within the Air Force is in one command, the Air Research and Development Command; however, the Air Force also has a vertical chain of command down through the organization extending from the Assistant Secretary of the Air Force (R&D) to the ARDC with full R&D responsibility at each level. Moreover, the Air Force also maintains various panels and boards at all levels for studies of weapon systems development.

The Assistant Secretary of the Air Force (R&D) has the responsibility for supervising all matter concerned with the formulation, execution and review of development plans, policies and their procedures. He is also responsible for qualitative determination of the requirements of the Air Force.

The Assistant Secretary of the Air Force (R&D) and the Chief of Staff receive information from the Air Force Scientific

Air Force Organization Chart



Advisory Board and the Chief Scientist about probable avenues of development and present and future program possibilities.

The Chief Scientist is responsible for recommendations in general policy and plans for overall Air Force Research and Development.

The Scientific Advisory Board consists of both civilian and military personnel drawn from the various special fields of development of interest to the Air Force. The Board is headed by a civilian and has the following responsibilities:

1. To advise on program emphasis.
2. To report when research on any particular system has reached the stage where it is ready for application.
3. To review long-range research and development plans.
4. To advise the Air Force on the adequacy of the R&D facilities.
5. To make various general reports on the level of R&D activities within the Air Force.

The Deputy Chief of Staff, Development is responsible for the overall development of new and improved weapon and supporting systems and the determination of requirements for new systems. Operational planning and coordination must necessarily take place at the Headquarters, ARDC. The Deputy Chief of Staff, Development also monitors the implementation of recommendations of the Scientific Advisory Board.

Within the Staff of the DCS/D are several offices

concerned with the possible areas of weapons development and their effect upon long range Air Force planning. These offices under the auspices of the Director of Development planning, the Director of Research and Development and the Director of Requirements which evaluate long range estimates of research, development and weapon needs of the Air Force.

Subject to routine approval, the office of the DCS/D holds the responsibility for final evaluation of weapons systems proposals and their initiation into development projects, as well as review authority over all ARDC functions.

#### Organization of the Air Research and Development Command

The Air Force spends approximately \$600 million on applied and basic research and development each year. Ninety-eight per cent of these funds are programmed through the ARDC which is an organization unique in the military history of the United States in that it is presently the largest R&D organization within the Federal government. All ARDC programs are planned and directed from Headquarters, ARDC. This Headquarters is organized into four areas of responsibility: (1) Western Development (2) Research and Development, (3) Weapons Systems and (4) Resources.

(1) The Western Development Command is concerned with development of all components of complete weapon systems inclu-

ding ground support units.

(2) The Deputy Commander Research and Development is concerned with overall administration of the research, development and engineering services.

(3) The Deputy Commander for Weapons Systems is responsible for the control and management of weapons system projects subject to the approval of USAF.

(4) The control of all logistics, supply, finance and personnel activities required for support of the ARDC mission is exercised by the Deputy Commander for Resources.

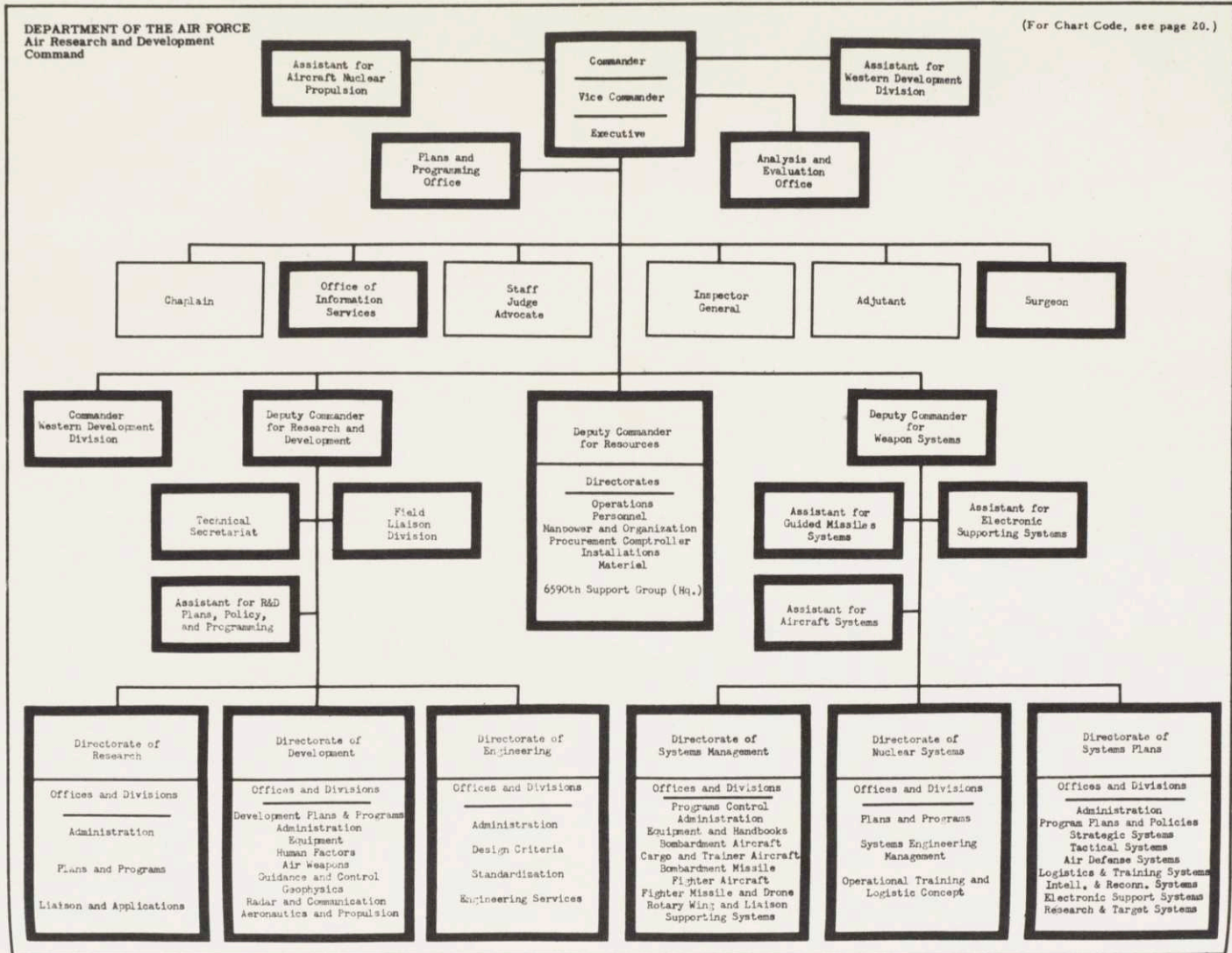
The Deputy Commander for Weapon Systems is also responsible for all long-range planning and programming of weapons system development within ARDC. He may initiate and evaluate studies for new weapon systems and has the added responsibility for evaluation and integration of adequate financial plans for weapon systems development. His office serves as an initial evaluation point for all industry proposals for new weapon systems. It also furnishes approval to AMC on engineering matters which apply to any weapon system.

Within the office of the Deputy Commander for Weapons Systems are three subsidiary commanders established to carry out his various functions. These are under the control of the Directorate of System Management, the Directorate of Nuclear Systems and the Directorate of Systems Plans.

The Directorate of Systems Management has authority



Air Research and Development Command



over the development of all air borne and supporting weapons systems after the issuance of the Development Directive to ARDC. His responsibilities are discharged through Weapon Systems Project Office which utilize necessary support from all command centers.

The Directorate of Nuclear Systems is in charge of all development of nuclear-powered aircraft.

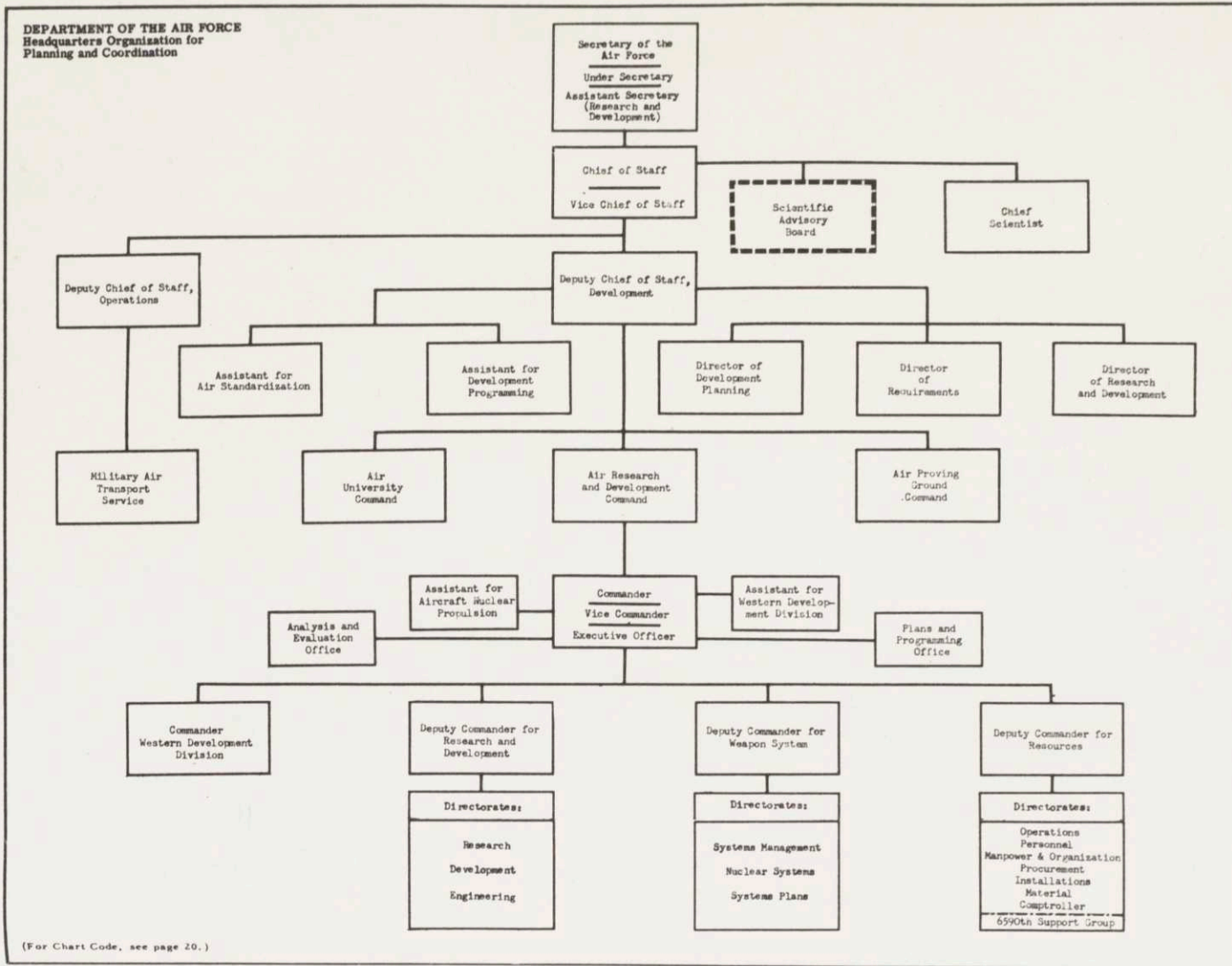
The Directorate of Systems Plans discharges most of the planning activities within the office of the Deputy Commander for Weapons Systems. Long-range weapons system planning and programming, evaluation of new proposals from industry, coordination with all planning agencies within USAF in evaluation of possible future weapons systems are carried out in their office. General design and exploratory studies are also carried on (or often contracted to private research groups) by this office.

#### Initiation of New Weapon Systems Development

Most initial proposals for the study of a weapon possibility came from within the ARDC organization though occasionally such as in the case of the Boeing jet tanker a source will be an Air Force contractor.

All such proposals are processed through Headquarters, USAF, and emerge under the title of Development Planning Objective. This document which states the expected performance,

Air Force Development Structure



general requirements and uses of the weapon system, is sent to the headquarters of the Air Research and Development Command. There it undergoes a brief study by the office of the Deputy Commander for Weapon Systems and then is forwarded to one of the eleven ARDC research centers for an evaluation study of its feasibility. A study contract may be signed with a civilian company to aid in this evaluation of the weapon system proposal.

After the determination of feasibility has been made the results are processed back to the office of DCS/D where the specific requirements for the weapons system are drafted. This draft is then circulated among 20 to 30 USAF offices which evaluate it and make suggestions for modifications. If the modifications are accepted then the draft may be recirculated. After this process is complete the draft becomes known as a General Operational Requirement.

The Directorate of Systems Development in ARDC then prepares what is known as a Development Plan which is submitted to the approval of the Air Force Secretary's Civilian Review Board and final review by the Assistant Secretary of Defense (R&E). If development of the weapon system is approved Headquarters USAF issues a Development Directive to start the actual design and development. This Directive is forwarded to the Directorate of Systems Management within the ARDC and the actual development begun either within the authority of an existing project or as a separate project. From this point management

control is executed by the Weapon Systems Project Office.

Executive Management Responsibility for Weapon System Programs

The responsibility for control and coordination within weapon system programs lies at divisional level in Weapon System Project Offices (WSPO). At present there are nineteen such project offices. Many of these offices have control of one weapon system such as a specific aircraft and its components. Others have control of weapon systems of a group of related projects such as the F-102/106 series. The remaining offices have authority in complete areas of technical development. For instance there is a WSPO for each of the following: strategic missiles, tactical missiles, tankers and guided air rockets.

Within each WSPO is at least one Weapon System Phasing Group for each weapon system which is under the authority of that particular office. These WSPG's include representatives of all major Air Force agencies concerned with the present development or future procurement and operational aspects of the weapon system with which they are concerned. At minimum this includes planners from ARDC, AMC, training commands, facility agencies and the prospective operational units.

The chairman of each WSPG is the chief of the WSPO for that program. Meetings of these groups are periodical. It is the responsibility of the chairman to call the meetings whenever he deems it necessary.

The WSPG's are essentially problem identifying groups. The problems involved may range over the weapon system's entire prospectus from present development to foreseeable operational difficulties. The WSPG's are not command groups. When a group finds a lag in planning, progress or decision-making, the WSPG chief, who is chairman of that group, reports this to the appropriate authority and requests action.

A problem of long standing within this particular area of the development structure has been the determination of where ARDC authority ends and that of AMC begins. Under the plan just implemented in March of 1958 the Executive Management Responsibility (EMR) will be given specifically to ARDC or AMC depending upon the stage of development of the particular weapon system. Now the chairman of each WSPG will have responsibility to the ARDC until such time that Headquarters USAF indicates that the weapon system is to be put into inventory. At this time the EMR for the project will pass into the hands of the AMC. The chairman of the WSPG will go with the program from responsibility to ARDC to that of the AMC.

Although this somewhat unique solution to coordination difficulties is untried as yet, there is optimism within both ARDC and AMC that this new arrangement will greatly facilitate decision-making in areas where it has been lagging in time element and effectiveness.

Also operating within the Weapon System Project Offices are Equipment Management Groups. Each of these groups is responsible for a particular class of sub-systems or equipment not supplied by prime contractors such as firecontrol and testing equipment. The groups assimilate information on development, capabilities and availability of the equipment and then make recommendations or requests for decisions and implementation as do the WSPG's.

#### Procedure for Selection of Prime Contractors for Weapons Systems

Once a Development Directive for a major weapon system has been issued immediate action is taken to let development contracts. All contracting for final development and production of weapon systems is carried out under direction of the Air Material Command.

In 1956 the USAF initiated negotiation procedures for prime contracts to replace the design competition method. To date this procedure has been attempted on one project, the WS-110, a chemical bomber. The Air Force estimates this will cut from one to one and a half years of lead time from this program.

Under the new procedure Headquarters USAF notifies the Source Selection Board of the need for a specific type of weapon system capable of specified tasks. The Board, consisting of representatives of the ARDC, AMC and the potential using command, then sets up a list of possible prime contractors. It

then screens this list and eliminates those companies which do not have the capabilities to design and produce such a system. The Board then notifies the remaining companies of their decision and asks for management proposals.

The proposals are then scored with a point system against a long list of criteria. Various weights are given to each consideration. Technical details of the proposed plan, the company's cost analysis, the ability of the personnel within the company in terms of their experience, the availability of supplies, who the sub-contractors would be and the location of the sub-contractors are the most important criteria considered. Considerable negotiation and consequent revision of the proposals will take place during this phase.

After the final proposals are submitted and scored at least two of the top potential contractors are selected. The Board then recommends these selected contractors to the commanders of ARDC, AMC and the using command. Not less than two of these top contractors are picked for the award of technical development contracts.

In the following period of development the Air Force continually evaluates the programs of the competing contractors. When the point is reached where the Source Selection Board feels that competition is no longer justified, they select a team of experts to investigate the progress of each contractor. From



this evaluation one or more of the contractors are selected as the production source of the weapon system.

### The Cost Plus Concept

Although there are many various types of contracts available for use by the Air Force in contracting for R&D and primary production the main type of contract is let on a fixed-fee-plus-cost- basis.

Legislation is now in effect that allows all the military departments to let R&D contracts at a fixed fee of up to 15% of the cost; however, the Air Force (as well as the other services) has cut this figure down to 3% to 4% in most cases by service regulations which disallow reimbursement of some of the cost which would normally be redeemable under standard overall government contracting regulations.

## Chapter III

### Analysis of Air Force Weapon Systems Development Problems

#### Basic Problems

As mentioned earlier the Air Force has two prime objectives in its development programing: that is it must choose for development those weapons which will maximize its long-run capabilities and it must then attempt to see that those weapons reach the production stages as quickly as possible.

The following discussion is pointed at the factors which have negatively effected the maximization of these objectives.

#### The Problem of Long-Run Maximization of Weapon Capabilities

##### 1. New Weapon Systems

Numerous authorities in the military development field have underscored the lack of top level consideration given to the development of radical new weapon systems. Dr. Lloyd Berkner in a report to a Congressional Committee on Government Operation<sup>1</sup> presented a strong case for civilian control of research and development. Pointing to the accomplishments of the OSRD during World War II, Dr. Berkner told the Committee that military de-

<sup>1</sup> Organization Administration of the Military Research and Development Programs, Twenty-Fourth Intermediate Report of the Committee on Government Operations, House Report No.2618, 83rd Congress, Second Session.

velopment would function better under the control of a top level civilian agency since military leaders were inclined to put more emphasis on immediate maximum readiness than on long range weapon development.

In 1955 a sub-committee of the Hoover Commission also presented doubts as to whether or not the military departments could be relied on for the initiation of such projects. It further stated that a standing committee should be created to initiate new projects from within the office of the Assistant Secretary of Defense (R&E).

A close look at Air Force development activities seems to indicate that it is quite aware of the importance of radical new weapon systems development. The Scientific Advisory Board, various staffs within the offices of the DCS/D and the Assistant Secretary of the Air Force (R&D), the Chief Scientist, and the many agencies within ARDC have among their duties responsibility for selection, evaluation and review of plans for new weapons possibilities. If anything it would seem that the Air Force has too many people concerned with this aspect of development. The difficulty seems not be in the lack of interested groups in this area, but rather in the profuse number of groups which must review and process these proposals for radical new weapons.

This argument is borne out in part by the observations of Burton Klein,<sup>2</sup> a man with long experience in the Air Force's

<sup>2</sup> Klein, Burton, "A Radical Proposal for R&D", Fortune, May, 1958.

Rand Project. Mr. Klein claims there is too much control in the area of R&D and in particular of new weapons development. He points out that the OSRD which is looked upon as an exemplary model of coordinated research effort by many experts was anything but that. He argues that actually the operations of the OSRD were not closely coordinated, but instead were carried out under highly decentralized control. Individual project leaders were allowed to a great extent to decide on their own just exactly what paths they wished to pursue. Therefore, states Mr. Klein, the splendid record of the OSRD points up the fact that what we need is less control of development within the services rather than more, if we expect to regain our weapons lead.

This argument hits particularly hard at the way in which the Air Force is handling its new weapons proposals. It implies that the Air Force in its anxiety to develop adequate weapons has actually crippled efforts to develop new weapon systems by too much burdensome control, coordination and review. Rather than create an other group within the Air Force to handle top level coordination of these efforts, it would thus seem that the Air Force would improve its situation in this respect by cutting down on the number of groups and commands with coordinating and reviewing authority.

## 2. Effect of Budget Fluctuation on Development

It takes eighteen months to prepare a budget. Within R&D the budget is obsolete before it even gets to the approval of

the Assistant Secretary of Defense (R&E). After it gains his approval it will be constantly changed and revised by various authorities within the Executive Branch of the government as well as within Congress. By the time funds are allocated by Congress, there is little resemblance between the budget proposals submitted by the ARDC and the money made available. Not only has the budget itself been changed, but also conditions within ARDC have undergone constant alteration.

Therefore, when the budget level for R&D in the Air Force drops or rises each year, the funds available must constantly be reallocated over the existing and newly initiated projects. Of course, this is a continuous process within the ARDC as well as throughout the Air Force.

The point is that the Air Force must constantly reassess its allocations to various projects, very often with budget cuts in mind. To do this programs are given priorities according to the value of their projects. The Air Force then attempts to spread decreases in funds over its overall program, slicing more off low priority projects than those of higher priorities. Unfortunately the top priority programs are usually those farthest along in the development cycle. Therefore, those programs which are just getting underway or are in the earlier stages of development tend to have their progress slowed even more in "tight" budget years. There are also the difficulties of starting new projects in years when R&D funds are at relatively low levels.

Often initial development of the weapons systems may be virtually postponed until a later date when more funds become available.

The chances that Congressional control or the long involved processes of making a budget will change to any degree within the immediate future are small. Thus it seems that the Air Force will have to continue to live with the difficulties described above. What can be altered is the emphasis given to nearly operational weapons systems relative to those priorities given to basic research and new weapons development programs.

### 3. Effects of Inter-Service Competition on Long-Run Air Force Development

As pointed out in Chapter II the Assistant Secretary of Defense (R&E) has final review authority over all military weapon systems development although he may not transfer funds for R&D from one service to another. In recent years this has left the services fairly free to administer and direct their own development programs. The result has been that as we have entered the era of guided missiles there has been a great amount of dual development of similar weapons systems by the three services.

Although many arguments have been voiced against duplication, there are areas of development where little has been done to subdue this tendency. One recent example is the develop-

ment of intermediate range ballistic missiles (IRBM). All three services were allowed development rights in this area.

Proponents of duplication within R&D areas point to the development of the IRBM as example of what competition between the services can do. There is no doubt of the success of those programs. The United States Air Force and Army have both developed very capable missiles in this field while the ICBM program, which was put in Air Force hands alone, is still far from producing an operational missile. It is argued that this is indicative of what can happen when inter service competition is allowed; however, there are other aspects to this situation.

Very few experts in the field of military development will argue with the idea that each service will push its development programs harder if it is in competition with the other services. The difficulty is that this same competition shifts the emphasis of program development. When the services are competitive only within restricted areas such as they are today, they will sacrifice funds which would have been allocated to development of other possibly more important projects in order to win that particular competition.

This is true since their further use of that particular weapon may depend on whether or not they are successful in its development.

This situation can be extremely dangerous within the

Air Force where there is already a decided emphasis on short-run development goals in a situation where lead times vary from four to eight years.

#### 4. Short-Run vs. Long-Run Development Goals

Air Force planners have been accused frequently of placing emphasis on maximum immediate readiness rather than long-run readiness over the foreseeable future. These accusers, including Dr. Berkner and J. Sterling Livingston, have pointed out that the background of the military officers tend to make them think in terms of immediate results. This tendency, they say, is aggravated with the fact that there is constant pressure exerted by Congress upon the Air Force as well as the other services to show immediate results from their weapon development programs. Members of Congressional Committees invariably ask just what are the immediate results from present basic research efforts as well as newly initiated development programs. These questions are not easily answered. It is fortunate in this respect that the membership of Congressional committees is as stable as it is. After long service on these committees, Congressmen usually tend to change their attitude toward R&D needs.

If the Air Force is to stand accused of a lack of long-run weapons development planning, it must at least be said in its favor that it has attempted to overcome this deficiency by setting up numerous panels to study long range weapon devel-



opment. The Air Force Scientific Advisory Board, which is composed of some 60 officers and civilian scientists, has as one of its primary duties the review and recommendation of future weapon needs. Concrete proposals for weapons developments are also considered by this Board in terms of long-run development. Various programming and planning groups of the ARDC are constantly reviewing these problems as are various other ad hoc committees and panels within the Air Force.

In this attempt of the Air Force to regulate closely long term development planning may lie the key to one of the basic weaknesses of the development system. The fact is that as the frontiers of science advance ~~if it becomes~~ increasingly difficult to determine what our future weapons may be or, indeed, which ones of these will be the most effective. Basis research is the most difficult to regulate, but the course of initial development is also becoming harder to predict. Yet at the same time the Air Force is attempting to impose even more controls and guidance over the direction of initial development.

The net result of all this guidance may well be an actual hindrance to the initiation of the most lucrative weapons development. It is hard to judge the future performance of a weapons system by paper studies. Perhaps we might actually advance farther and faster by actual testing and less thinking and conjecturing about what future performance might be.

If this argument is true (and there is much evidence

to support it<sup>3</sup>) then present trends are going in a reverse direction from what is really needed.

### The Lead Time Problem

#### 1. Effect of Rotation Policies

The Air Force is currently following a practice of rapid rotation of officers at all levels of command. Thus an Air Force career officer may only spend ten years or less during his active duty tour working in his primary career field. It is worth noting that since the creation of the ARDC it has had two commanders with no previous experience in the research and development field as a result of this policy.

While this practice has brought excellent results in certain areas of command where technical knowledge is not required for administrative decision, within the field of Research and Development it is of primary importance that even high ranking administrators have adequate technical knowledge in order to cope with weapon development decisions.

The ARDC and higher level development offices within the Air Force are forced as a result of this rotation system to maintain a large number of staffs and study groups to evaluate and assimilate scientific and technical reports in order that the line organization can effectively make decisions. While

<sup>3</sup> Klein, op. cit.

it is not argued that all such staffs and committees could be greatly reduced, it does appear that the processing of a many technical reports through their hands might be avoided if the various commanders were life long career men in military R&D. It also seems likely that much of the routine processing and everyday information flow would be handled more smoothly and efficiently by men who had advanced through the R&D organization. Difficulties have arisen particularly in the lower levels of the organization. One chairman of a WSEG said that the continuity of decision making and follow up was constantly hampered by the rotation of officers into and out of the group. One WSEG found half of its membership changed between meetings. Complaints from industrial sources are often centered on the fact that they are constantly dealing with officers unfamiliar with their duties. Consequently, contracts negotiation and later coordination and review efforts slow the progress of the whole project.

## 2. Cost-Plus-Fixed-Fee Contracting

As pointed out in Chapter II, the main type of contract used by the Air Force in dealing with prime contractors is this type of agreement.

In many quarters the cost-plus-fixed-fee contracts are being criticized as wasteful not only in terms of money but in effort applied to the programs. Dr. Sterling Livingston in a recent article on Weapons Development<sup>4</sup> pointed out that present

<sup>4</sup> "Decision Making in Weapon Development," Harvard Business Review, January-February 1958

fixed-fee contracts for development or production were encouraging companies to attack their jobs on a mass engineering basis. Also many companies were using extra labor wherever possible and thereby raising their profits. Thus under present policies it seem that contractors have an incentive not to introduce modern efficient machinery. Dr. Livingston cites as an example the case of the contractor who would reduce his total costs on an operation from \$1000 to \$100 by installing automatic machinery; however, in doing so he would also reduce his profits from, say, \$100 to \$10 per unit. To make matters worse, if he had invested the money, his interest expense would be disallowed under the terms of his contract. These temptations that confront the manufacturers may well be great enough to cause many of them to increase their costs and consequently their lead times.

As an alternative method, Dr. Livingston gives the idea of determining profit upon a basis of percentage of total assets employed rather than actual cost. This he claims would provide a more reasonable basis for computing profit and would encourage companies to invest more in research and development facilities and production equipment. This in turn would increase the capabilities of the aircraft industry as a whole. Though there might be pitfalls in this approach and a certain amount of difficulty attached to obtaining the necessary cost figures, and the total effects upon cost and lead time from the weaknesses of the present type of fixed fee contracts cannot be accurately

estimated, investigation into this problem is undoubtedly warranted.

### 3. Review and Coordination

In Chapter II the procedure generally used by the Air Force for getting a weapon system proposal to the final development stage was outlined. This procedure usually takes approximately five years or over one half of the time necessary to get a weapon system to the production stage. In their effort to plan systematically for the development of the system, the Air Force planners attempt to foresee the performance characteristics of every component of the weapon system and to predict the end results. This in the opinion of the author is probably the greatest single weakness in the Air Force development program.

No matter how much planning is done, swift technological changes and unforeseeable circumstances will call for eventual revision of most of the original paper performance characteristics. The OS-58 Supersonic bomber, for instance, does not have anywhere near the same control devices, electronic equipment or even the same engines that the original plans called for several years ago. Moreover less than one fourth of the aircraft developed since the end of World War II have ended up with engines not intentionally programmed for them.

Attempting to determine the requirements and speci-

fications of a weapon system from the start is just too elaborate and wasteful in terms of lead time. A better policy would be to get the proposed weapons to the test stage as quickly as possible, find out what they will do and then make the required changes. It might be argued that this would prove too expensive, but experience says otherwise. The cost of bringing a weapons proposal to test is a small fraction of the total development costs. For instance the cost of building an experimental jet engine might be as low as \$30,000 but to complete the engine's development would cost somewhere between \$50 million and \$100 million dollars.

If there is any place where the Air Force can make drastic cuts in its lead time, it is in the area of initial development and review procedures.

## Chapter IV

### Conclusions

#### Overall Effect of Armed Services Missions on Development

Before drawing any conclusions about the present situation in Air Force development, it is worth while to consider the importance of the roles and missions assigned to all three of the services.

Originally the evolution of the Army, Navy and later the Air Force was based upon the concept of locomotion. That is, the Army traveled on the ground, the Navy traveled by sea and the Air Force traveled by air. Until World War II this concept of division by means of travel was quite useful and organizationally sound since the weapons used by the services were closely connected to their mode of transportation. During World War II the usefulness of such a system of organization became questionable as aircraft were used by the Navy and the Army began to rely on rockets and extensive air support. Weapon developments are now approaching the stage where all three services are relying upon guided missiles as their basic weapon. Classification of roles and missions is becoming more difficult since the potential use of guided atomic missiles is primarily against industrial centers and military concentrations. The masses of armies and fleets of the Navy are no longer practical. Manned combat aircraft are fast becoming obsolete. With this new age of atomic guided missile the services are finding it more diffi-

cult to justify their separate roles.

Thus it is not surprising to find the Army, Navy and the Air Force all attempting to gain leadership in guided missiles as well as in other fields. Moreover, this struggle for weapons is not likely to subside. The Secretary of Defense has introduced stop-gap measures by limiting the range of the Army's missiles and requesting it to confine its development to ground-to-air, and ground-to-ground missiles, but this is only a temporary solution to the basic problem of assignment of logical missions to the services. If duplication is accepted as a thing to avoid, since dual effort is tremendously encouraged and overlapping in research and development is unavoidable.

Each service pushes weapon development in every area without regard for developments in the other services. Each service also attempts to gain control over as many weapon systems as possible in order to provide insurance against future budget cuts.

Until the situation is established with stronger control from higher in the Defense Organization and the whole organizational set up of the service is altered this situation will probably exist.

Of course there are authorities that advocate continued duplication within the Defense Department and claim the roles and



missions of the services should overlap to some degree in order to foster healthy competitive research. It is, however, the opinion of as many, if not more, people intimately acquainted with the Defense program that the present situation of duplication is detrimental to an efficient Defense program despite isolated cases where inter-service rivalry has speeded weapons development.

This is a controversial area and authorities with much more knowledge of the subject than this author disagree radically in their approaches to the solutions of this problem. The only thing upon which there is fairly general agreement is the fact that there is something wrong - in particular with Air Force and other services' weapons systems development and in general with the present assignment of missions to the services.

### Conclusions

In the Introduction several criticisms were mentioned in relation to the way the Air Force is presently carrying out its development role. The suggested corrections for these are even more numerous and it was not the purpose of this thesis to consider all solutions or aspects of this problem; however, it was its purpose to consider the more important problems involved.

Assuming that the present set up of the Defense organization will remain essentially the same, three major weaknesses

will continue to plague the Air Force programming:

1) There is too much evaluation put into weapon possibilities before any prototype testing is done. This effects the development programming in two ways: first, it makes the task of selection of weapons for operational development a more risky business since paper studies can never foresee all the operational difficulties that actual testing will uncover; secondly, these evaluation studies add greatly to the lead times of the programs.

2) Until the rotation policies of the Air Force are revised, in the areas of R&D so that officers acquainted with the field are retained there during their careers, the whole Air Force research and development organization will suffer, particularly at the lower levels of command concerned with actual project administration.

3) There is too much emphasis on review and coordinating efforts of all levels of the development structure. As pointed out in Chapter III it takes approximately five years to even get a development proposal to the stage where actual operational design can be started. This is partly due to the Air Force policy of emphasizing paper studies of entire weapon systems, rather than immediate prototype testing, but much of this time is spent in needless review by various staffs, groups and committees. In its effort to control efficiently the whole development program, the Air Force has actually created a situation whereby the management efforts often hinder development efforts. This

"over control" hits particularly hard in areas related to basic research as well as development programs.

Two other areas in the R&D program have come under considerable criticism. The Air Force would do well to re-evaluate its policies in these particular situations:

1) A study should be made of present contracting procedures. The fact that the Source Selection Board is now limiting the manufacturers which can compete for development contracts without benefit of bidding may in the long run tend to destroy competition in the aircraft industry. As it is now only two companies, Boeing and Convair, are considered capable of heavy bomber development.

2) Investigation of the effects of the cost-plus-fixed-fee contracts upon manufacturers incentive and their re-investment policies. Complaints about these contracts are heard from every aircraft contractor. It may well be that the solution of this problem may lie with the adoption of J. Sterling Livingston's proposal of a type of contract with profits based on assets employed.

If the Air Force will take steps to correct the previously mentioned deficiencies, it will be a long way toward speeding up its development programs and accomplishing better selection of future weapons for development.

Of course, broader solutions to these problems have

been suggested by many authorities. Unification detachment of R&D from military control and top level coordination of development within the office of the Secretary of Defense are examples of plans brought forth. It may well be that the best solution not only for the Air Force but for the whole Defense development situation may lie in one of these proposals. One thing is certain, our very survival may depend on what decisions are made in the next few years in Air Force weapon development.

APPENDIX

Specific Recommendations for Organizational Changes

Specific Recommendations For Organizational Changes

The conclusions and recommendations stated in the final chapter point to two changes in the Air Force development program which cannot be made by policy decisions alone. The first of these proposed changes is to get prototypes of weapon systems built and tested as rapidly as possible rather than attempting to conduct extensive feasibility studies. The second is to minimize time consuming reviews carried out during the span of every Air Force development project.

A minute analysis of the organizational changes necessary to accomplish the above could only be done over a period of years of study and familiarization with the entire Air Force development program; however, major alterations which could be made to implement the above changes are apparent after examination of the basic workings ( Chpt. II ) of the structure.

The following recommendations are not meant to be all inclusive or necessarily representative of the best ultimate approach to the problems, but they are indicative of what must be done if the Air Force lead times are to be significantly shortened and advanced weapons introduced for final development as quickly as possible.

1) Elimination of specific detailed review of every major weapon proposal by the Office of the Assistant Secretary of Defense (R&E). would cut months from pre-development lead times. This Office is attempting to do too much when it tries to review all of the technical aspects of these proposals. This review generally consists of digging into facts and data already carefully considered at lower levels. Performance and capabilities can readily be understood by all the reviewing authorities within this Office without the extensive review now carried on.

2) Review of drafts of weapon proposals by the potential operating commands, the Office of the Assistant Secretary of the Air Force (R&D), the Directors of R & D, Requirements and Development Planning, the Analysis and Evaluation Office of ARDC and other minor reviewing staffs should be abolished.

3) To replace the control exercised by the above named boards and offices over the initial development programs, the following organizational changes are suggested.

a) A single agency within the Office of the Deputy Chief of Staff, Development should be created to consider initial development proposals. This agency would review the technical aspects of the

weapons proposals and then make recommendations to the DCS/D. He would then either give his approval or not. If he did, then a Directive would be issued calling for prototype development, if he did not then the proposal could be returned to Office of the Deputy Commander for Weapon Development for further study, modification and possible eventual recirculation.

b) Another agency within the Office of the DCS/D would be responsible for evaluation of the results of prototype testing. The recommendations from these tests ( and other studies at research level) could then pass review up the line to the Office of the Assistant Secretary of Defense ( R & E).

If review were limited to the above agencies and offices an estimated three years could possibly be cut from present lead times.

4) In order to give adequate emphasis to prototype control and development three general types of R & D would have to be recognized by the Air Force: basic research, prototype and initial development research, and weapon systems development for inventory. This emphasis on prototype testing could be put into the organization by the creation of a Directorate of Prototype Testing and Development.



This Directorate under the supervision of the Deputy Commander for Weapons Systems would then be responsible for evaluation and testing of prototypes as well as the initiation of new development proposals.

The proposals for major revisions mentioned above are, of course, over-simplified to a very great degree. The revisions to the present budgetary policies would be enormous, but not insurmountable nor prohibitive. The testing facilities of the Air Force and industry would have to be expanded to some degree, but most of these facilities are already available. The point is that these revisions or some similar to them must be enacted if the Air Force development program can ever hope to compete with comparable programs within the Soviet Union.

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