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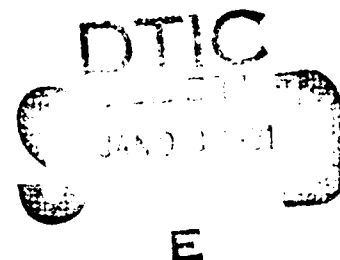
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An Analysis of Weapon System Acquisition Intervals, Past and Present

G. K. Smith, E. T. Friedmann



A Report prepared for the
OFFICE OF THE UNDER SECRETARY OF DEFENSE
FOR RESEARCH AND ENGINEERING and
THE UNITED STATES AIR FORCE

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Critics of weapon system acquisition frequently claim that management process changes during the 1960s and 1970s caused the acquisition cycle to lengthen. A review of three classes of aerospace systems--aircraft, missiles and helicopters--shows that over the past 30 years the time from the beginning of full scale development to delivery of the first operational item has changed only slightly, but average production rates have fallen by half. The planning phase corresponding to today's Phase I (from Milestone I to Milestone II) has nearly doubled, and the introduction of Phase Zero may have added still more time, but evidence on Phase Zero effects is still tenuous. Opportunities for shortening the acquisition cycle time appear to lie mainly in flexible application of the regulations governing approval of the Mission Element Need Statement, and in some cases the Services should be allowed to proceed simultaneously with Phase Zero, and even Phase I, studies while the MENS is being reviewed. 142 pp.

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PREFACE

Defense executives, contractors, and Congressional review agencies have long been concerned with the assumption that the weapons acquisition cycle required an inordinately long time to complete. Such concern was heightened with the appearance in 1976 of Office of Management and Budget (OMB) Circular A-109, which emphasized early and formal approval of mission element need. Since then, many study groups have examined various aspects of the acquisition cycle and have offered suggestions on how to accelerate the planning, development, testing, or production phases. With few exceptions, however, those studies proceeded from the unverified assumption that most phases of the acquisition cycle have been lengthening, and they have devoted attention to ideas for shortening it.

Under sponsorship of the Office of the Under Secretary of Defense for Research and Engineering (OUSDRE), The Rand Corporation in 1979 completed a survey of weapon system acquisition experience during the 1970s. That study included a brief review of acquisition intervals—the extent to which discrete phases of acquisition have been growing longer—limited to military aircraft. The evidence suggested that for the phases of acquisition occurring after the beginning of full-scale development, the only noticeable change was a decline in production rates proportional to the growth in unit cost. However, the limited scope of that study precluded any significant analysis of the acquisition phases that precede full-scale development. At the request of OUSDRE, Rand undertook a follow-on study examining the early phases of acquisition and possible ways to shorten the cycle. The results are presented in this report.

This study drew heavily on earlier unpublished research conducted by Rand for the U.S. Air Force under Project AIR FORCE (Contract F49620-77-C-0023). For the sake of completeness, both the earlier work and the present analysis are reported here under joint sponsorship.

This report should be of interest to Air Force and OSD officials involved in establishing acquisition policy and to researchers who need some knowledge of acquisition intervals for past systems. The appendixes contain an extensive compilation of basic data that may be useful in future studies.

SUMMARY

During the past two decades, several layers of management and several formal review milestones have been added to the organization and procedures for managing weapon system acquisition. Critics of the process frequently assume that these changes have caused the overall acquisition cycle to lengthen and that the delays have undesirably lessened the timeliness and value of the final product. This report addresses three questions, two analytical and one prescriptive: (1) Has the overall acquisition cycle really lengthened significantly during the past few decades, and if so what phases of the cycle have been most affected? (2) Do changes in the length of the acquisition cycle, or any phase of it, derive directly from previous changes in OSD organization or procedures? and (3) Regardless of past trends or events, are there practical ways to reduce the length of the present acquisition cycle without undesirably altering program outcomes?

For the historical review, three classes of aerospace systems were examined: aircraft, missiles (excluding long-range surface-to-surface ballistic missiles), and helicopters. These are the only kinds of systems that have been developed in significant numbers more or less continuously over several postwar decades and that have been subject to the full panoply of decision review and ratification processes. Because of sparseness of data on the early milestones of many systems, the principal effort was devoted to aircraft systems.

To evaluate historical trends in acquisition intervals, an attempt was made to determine six major milestone dates for each historical system:

1. Issuance of a formal, Service-level requirement for the system.
2. Start of demonstration and validation analysis (equivalent to today's Milestone I);
3. Start of full-scale engineering development (equivalent to today's Milestone II);
4. First flight (or equivalent test) of the initial development model;
5. Delivery to the user of the first fully operational system (the first production item after the development lot); and
6. Delivery of the 200th operational unit.

The central phase of the acquisition cycle has remained fairly unchanged and the early and late phases have been lengthening. The time from beginning of full-scale development to first flight has remained remarkably constant over a period of three decades, and the additional time required to deliver the first operational item has changed only slightly. The largest change during the hardware development and production phase has been a steady reduction in average production rate, which has fallen by half over the period. This drop in production rate appears to be closely linked to the increase in average unit price; any change in this trend can occur only through a reduction in unit cost or an increase in investment rate.

The greatest change appears to have been before the beginning of full-scale hardware development. The phase corresponding to today's Phase I (from Milestone I to Milestone II) has nearly doubled over the past 30 years. That seems to

be a long-term trend, and there is no direct evidence that the management changes introduced during the past ten years caused any significant increase in the trend. In fact, the largest changes were apparently at the beginning of the 1960s.

The addition of a Phase Zero is the only change in management organization and procedures that can be even tenuously linked to an increase in acquisition intervals. During the 1950s and 1960s the preparation and approval of a formal requirement for the system were largely concurrent with Phase I, whereas today's policy calls for that process to be completed (ending in an approved Mission Element Needs Statement) and Phase Zero studies conducted before Phase I starts. The rather short span of experience with the MENS and Phase Zero studies precludes any firm conclusions about their effect on decision time. If the decision process is administered according to the letter of the directives, with each phase being completed before the next starts, then it seems likely that the introduction of the MENS, together with Phase Zero studies, may add another year or two to the historical trend. In that case, the total decision time preceding the start of full-scale development will have increased by a factor of two to three since the early 1950s. However, the actual administration of the decision process is likely to be somewhat flexible, and more experience must be obtained before we draw any firm conclusions regarding the effects of the MENS and Phase Zero.

Increases in the duration of the demonstration and validation phase (at least, increases of the size noted herein) should not automatically be deemed undesirable. Projects undertaken in the 1960s exhibited relatively larger cost growth, schedule slip, and performance shortfalls than similar programs of the 1970s, and in comparable ways the 1960s were "better" than the 1950s. Some of the time growth identified in this analysis appears to be linked to observed improvements in the ability of defense managers to produce systems that come closer to predicted cost, schedule, and performance than was the case in earlier years. Furthermore, delays in the initial decision phase will not necessarily translate into the delivery of a "less modern" system. Many elements of technology are continually changing, and designs are updated and refined throughout the initial decision phase, so the quality of the delivered product may well be improving as time goes by. An extended initial decision phase will ordinarily cause a slippage in initial operational capability dates, but if a delay occurs the system may be able to take advantage of new knowledge and could well be a more effective weapon when fielded.

There are several possible approaches to shortening the pre-Milestone II decision time. If the letter of the current directives is to be strictly observed, with MENS approval required before Phase Zero, then opportunities lie mainly in the area of streamlining budget procedures. Gaps of a year or more could occur because the necessary study funds were not budgeted before MENS approval, thus requiring another budget cycle before funds can be made available. To cope with this problem it may be appropriate to establish a "revolving fund." Once a MENS is approved, work could promptly start on the ensuing studies using money from the fund, and then later when the regular project appropriations have been provided by Congress, the "advanced" money could be repaid to the fund. Such a procedure would probably require the establishment of a specific budget line item for the revolving fund. Otherwise, the process would require no change in policy or procedure and could save over a year in some cases.

A more functional approach to reducing front-end decision time would be to

administer the process with more flexibility than is suggested by the regulations and directives. As long as it is OSD policy to use the MENS as a screening mechanism for all projects, with the intent of approving a MENS only for those projects that have high assurance of being carried through the full acquisition cycle, the review process will be lengthy. However, there is a wide variation among projects in terms of perceived urgency of operational need and in the degree of consensus that exists regarding the major issues surrounding the project. Under some conditions it would seem appropriate to permit the Services to proceed with Phase Zero studies on the basis of a draft MENS, and require final MENS approval only as a necessary condition for a DSARC I (or in some cases even DSARC II) review.

This suggestion does not imply a reversion to the days when programs were started with inadequate attention to long range consequences and were difficult to cancel after they accumulated momentum and broad political support. Although a small step back from the present formal policy, such a measure seems necessary if decision times are to be significantly reduced. Furthermore, the approach suggested here leaves intact many opportunities for control that did not exist during the 1950s and 1960s, and it in no way contravenes the letter or the spirit of OMB circular A-109. By having the Service submit a draft MENS before starting Phase Zero studies, the OSD would insure itself of being fully informed and would still have an early opportunity to review both the need for the system and the recommended approach to satisfying that need. Surely it should not be too difficult to cancel, or significantly redirect, a program at that stage.

Such a procedure would almost certainly reduce the front-end decision time (compared with the time required under strict observance of the directives), but it would also entail some additional costs of one kind or another, and may encounter substantial and valid objections from Service, OSD, or OMB authorities. However, without some actions along the general lines suggested here, there seems to be no way to significantly reduce the duration of Phase Zero or Phase I without abandoning essential and useful elements of the systems acquisition review process.

GLOSSARY

ADO	Advanced Development Objective.
AFSC	Air Force Systems Command.
CFP	Concept Formulation Paper.
DCP	Development Concept Paper.
DepSecDef	Deputy Secretary of Defense.
DSARC	Defense System Acquisition Review Council.
DT&E	Development Test and Evaluation.
FSD	Full-scale Development.
GOR	General Operational Requirement.
IOC	Date of Initial Operational Capability.
IOT&E	Initial Operational Test and Evaluation.
LOH	Light Observation Helicopter.
LTV	Ling-Temco-Vought Corporation.
L/C	Letter Contract.
MENS	Mission Element Need Statement.
Milestone Zero	Approval of MENS and authorization of concept exploration phase.
Milestone I	Program review by DSARC to authorize start of demonstration and validation phase.
Milestone II	Program review by DSARC to authorize start of full scale development.
Milestone III	Program review by DSARC to authorize start of rate production.
OMB	Office of Management and Budget.
OSD	Office of the Secretary of Defense.
Phase Zero	Interval between MENS approval and Milestone I.
Phase I	Interval between Milestone I and Milestone II.
RFP	Request for Proposal.
RFQ	Request for Quotation.
SOR	Specific Operational Requirement.
TAC	USAF Tactical Air Command.
TADS/PNVS	Tactical Air Data System/Pilots Night Vision System.

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I. INTRODUCTION

Critics of the defense systems acquisition process frequently complain that it takes far too long to develop a new system and get it to the users. They further argue that such delays have serious consequences, leading to the delivery of outdated equipment and to excessive development costs. Finally, some critics argue that systems can be acquired in significantly less time than is common today, citing examples from earlier years (most often the 1950s) as models of how programs should be conducted.

A central element of this theme is that the management practices and organizations that have evolved during the 1960s and 1970s have introduced unnecessary bureaucratic delays in the acquisition process. In particular, the Defense Systems Acquisition Review Council (DSARC), established in 1969, and OMB Circular A-109, issued in 1976, are often cited as sources of delay, through both the additional layers of management they created and the tendency to prolong the decision process by demanding milestone reviews before the project goes on to a subsequent phase. The strong implication of this theme is that things used to be better before the introduction of these organizations and procedures, and that there is now "slack time" in the system that could be eliminated without incurring unacceptable (or even significant) penalties.

Several studies have addressed this topic during the past few years. The Defense Science Board made it a major theme of their 1977 summer study.¹ Other works worth noting include an Air University thesis,² a study by the Logistics Management Institute,³ and a Concept Issue Paper published by Hq. United States Air Force.⁴ However, with the exception of the Hq. USAF paper, little quantitative evidence has been presented to support the claims of increased acquisition cycle times.

The present study was undertaken with three broad objectives. The first was to review the history of military acquisition programs over the past three decades to determine if acquisition intervals have indeed been growing longer and, if they have, to determine in what part of the acquisition cycle the lengthening has been most pronounced. The second was to see if any such lengthening of intervals could be directly associated with any particular management process or policy. Finally, regardless of the historical trends, we wished to identify any opportunities for significantly shortening the cycle.

¹Report of the Acquisition Cycle Task Force, Defense Science Board 1977 Summer Study, Final report, 15 March 1978.

²Maj. David T. Spencer, *Alternatives for Shortening the Systems Acquisition Cycle: Milestone 0 to DSARC II*, Air Command and Staff College thesis, May 1979.

³William G. Moeller et al., *Accelerating the Decision Process in Major System Acquisition*, Logistics Management Institute, September 1973.

⁴Lt. Col. Jon S. Eckert, *Trends in U.S. Air Force Tactical Fighter Life Cycles*, Concept Issue Paper 80-3, Hq. USAF, April 1980.

THE EVOLUTION OF ACQUISITION POLICY

It is useful to first examine the basic phases of an acquisition cycle and to review the evolution of major policy approaches to management of that cycle. The acquisition cycle is generally thought to consist of three major phases:

1. *The Planning Phase:* Before a new system is committed to full-scale hardware development, there is usually a several-year period of analysis and exploratory development. During that period a mission need is established (the "requirement"), and sometimes a number of alternative solutions (systems) are considered. Critical technical issues are explored through component development programs. As more is learned about the probable cost and performance of the alternatives, attention focuses on the preferred solution, and that design concept is defined in increasing detail. Finally, the merits of the favored system are weighed against the latest evaluation of the threat and, if the system is sufficiently attractive, a commitment is made to develop the system.⁵
2. *The Development Phase:* The full-scale hardware is developed, an initial batch of units is fabricated and tested, and production tooling is installed.
3. *The Production Phase:* Units are produced for delivery to the operating forces.

In practice the distinction between adjacent phases is frequently blurred in various ways, and sometimes there are distinct sub-phases in one or more of the major elements. In fact, it is the management of the transition from one phase to the next that has been a major emphasis of acquisition policy. As we examine how that policy has changed, we find that there have been three broadly different policy sets, roughly corresponding to the 1950s, the 1960s, and the 1970s.

Before the 1960s there was no formal DoD acquisition policy, largely because the Secretary of Defense did not have the authority to enforce such a policy. When the Department of Defense was established in 1947 it was a loose confederation of the three military departments, and the Secretary of Defense could, at most, give some general direction to these departments.⁶ The first Secretary of Defense, James Forrestal, lost no time in recommending that "the statutory authority of the Secretary of Defense should be materially strengthened . . . by making it clear that the Secretary of Defense has the responsibility for exercising direction, authority, and control over the departments of the National Military Establishment."⁷ However, that power was only slowly granted, and throughout the 1950s the individual services generally ran their own acquisition programs with very little interference by OSD. Although several changes were made in the structure of DoD in the intervening years, it was not until 1958 that the Secretary of Defense was given the authority to direct and control the military departments rather than merely to supervise them. The Secretary of Defense became operating head of DoD;

⁵This sequence of reviews and decisions can be compressed into a few months or extended over a decade or more, depending on the perceived urgency of need and the availability of design concepts to satisfy that need adequately and practically.

⁶Charles J. Hitch, "Evolution of the Department of Defense," in Richard Head and Eavin J. Rokke (eds.), *American Defense Policy*, Johns Hopkins Press, Baltimore, 3d ed., p. 347.

⁷*First Report of the Secretary of Defense, 1948*, Washington, D.C., 1948, p. 3.

and although the military departments were still separately organized, they were no longer autonomous.

The McNamara Policies

This authority was not fully exercised until Robert McNamara became Secretary of Defense in 1961. He believed in active management from the top and chose to take a role in all aspects of programs, rather than waiting for problems and conflicts to be brought to his attention.⁸ Many of his reforms, such as the Planning, Programming and Budgeting System (PPBS) and the emphasis on cost effectiveness, acted as means of centralizing power and decisionmaking within the Office of the Secretary of Defense (OSD).

Early in 1964, with the publication of DoD Directive 3200.9, DoD adopted the Air Force procedure of dividing the acquisition cycle into three phases, although not the three outlined above. Instead, there were two planning phases (the Concept Formulation Phase and the Contract Definition Phase), followed by the Acquisition Phase, which included development and production. During the Concept Formulation Phase a decision was made about whether a system was needed. That decision was based primarily on paper cost-effectiveness studies, which estimated the costs and capabilities of the system and were to demonstrate that the required technology was available. During the Contract Definition Phase two or more contractors produced formal proposals for conducting the Acquisition Phase (equivalent to today's Full-Scale Development and Production Phases). Those proposals included design specifications and firm cost and schedule figures. That was also primarily a paper exercise, although contractors usually did some work with hardware in the process of preparing the proposals. Following further studies and analyses, the proposals were the basis for selecting a contractor for development and production.⁹ The intent of the policy was that the firm cost estimates made in the proposals were to be used as the basis for fixed-price contracts, which were thought to provide a better incentive for cost reduction and require less direct government supervision of contractors than the cost reimbursement contracts that had been common previously. (In a cost reimbursement contract, the amount a contractor receives for his work depends in some way on his costs; in a fixed-price contract, the government and the contractor agree on a set price before the contract award.)¹⁰ In some cases, the design, manufacture, testing, and post-production support were contracted for under a single fixed-price contract, a practice known as Total Package Procurement (TPP). This was thought to allow the government greater cost control during all phases with a minimum of government examination of the contractor's cost data. It was also expected to allow greater concurrency of

⁸Alain Enthoven and K. Wayne Smith, *How Much Is Enough?* Harper & Row, New York, 1971, p. 32.

⁹Lt. Col. William F. Brockman, USAF, *Acquisition Strategy for the 1970s*, Air War College, Maxwell Air Force Base, Alabama, 1972, p. 21.

¹⁰Because fixed-price contracts can have escalation clauses or provisions for price renegotiation if the original cost estimates are considerably off target, the distinction between fixed-price and cost reimbursement contracts is not a clear one. For more on the various types of contracts used from 1947 to 1977, see Barry R. Lenk, *Government Procurement Policy: A Survey of Strategies and Techniques*, George Washington University Program in Logistics, Washington, D.C., 1977.

development and production, leading to shorter acquisition times and consequent cost savings.

The Packard Policies

Melvin Laird became Secretary of Defense in January 1969, but it was David Packard, his Deputy Secretary of Defense, who took charge of acquisition policy. By that time it had become clear that many of Secretary McNamara's policies had not been entirely successful. An OSD review of seven major weapon systems in May 1969 found that, on average, costs were 79 percent higher and development time was 32 percent longer than original estimates.¹¹

In the years 1969-1971 Deputy Secretary Packard issued a series of memoranda that made sweeping changes in acquisition policy. Then in 1971 he issued DoD Directive 5000.1, *Acquisition of Major Defense Systems*, which consolidated almost all of the major changes into a single document.

Decision Milestones and DSARC

Deputy Secretary Packard felt that OSD, under Secretary McNamara, had tried to manage the details of each program too closely, without being systematic enough to give OSD adequate control over the programs. He wanted to decentralize management of the day-to-day decisions, but at the same time keep OSD informed of the progress of the programs and in control of them. To achieve this, he chose three points during major programs at which he required approval of the Secretary or Deputy Secretary of Defense before the program could continue:

- Milestone I: The beginning of concept demonstration and validation.
- Milestone II: The beginning of full-scale development.
- Milestone III: The beginning of high-rate production.

These decision points enabled the SECDEF to decide whether to begin development of a program, whether to accept a contractor's proposal and go into full-scale development, and whether to go into production. In addition, cost, performance, and schedule thresholds were to be established for each system. If any of these thresholds were breached, SECDEF review of the program was again required. Except for these reviews, management of the program was to be left to the services.

To help the SECDEF make these decisions, Deputy Secretary Packard created the Defense Systems Acquisition Review Council (DSARC), an advisory group of high-level OSD officials. Its task is to investigate a variety of issues regarding the system in question, and to advise the SECDEF of their findings and recommendations at each of the three milestones noted above. The product of each review is a recommendation, which becomes the SECDEF's primary source of information for milestone decisions. The milestones and DSARC reviews are designed to allow the SECDEF to maintain control of the acquisition process and to keep informed about the systems, while allowing the services to manage their programs without interference between reviews, assuming there are no breaches of program thresholds.

¹¹House of Representatives Committee on Government Operations, *Hearing on Policy Changes in Weapon System Procurement*, September 22-24, 29, and 30, 1970, 91st Cong., 2d Sess., Washington, D.C., 1970, p. 11.

Hardware Tests and Prototyping

During the McNamara years, risk reduction and contractor selection for full-scale development had been based mainly on paper studies. Deputy Secretary Packard believed that these studies had not provided adequate information so he ordered the increased use of hardware testing and prototyping and a corresponding reduction in dependence on paper studies. He also ordered that development-production concurrency was to be kept to a minimum. During the McNamara years, production commitments were often made and production begun before very much testing had been completed. In a number of cases, design problems were discovered only after a substantial amount of production work had been completed. This required expensive retrofits to try to resolve the design problem. Those efforts were not always successful, resulting in increased costs, disappointing performance, and production delays. To reduce the extent of such problems, Deputy Secretary Packard directed that no production work, except for the procurement of certain long lead time components, was to begin until testing had demonstrated the soundness of the design.

Policy Initiatives After Packard

Although Deputy Secretary Packard left OSD in late 1971, the policies he introduced make up the bulk of present OSD acquisition policy. Since then only two substantial changes have been made in OSD policy. In 1973 a directive was issued ordering that each service have an agency, separate and distinct from the developing and using commands, responsible for Operations Testing and Evaluation (OT&E). That change was recommended by the Commission on Government Procurement, which stated that an independent agency would be more effective and objective than the user in conducting OT&E.¹² The directive also emphasized the importance of completing sufficient development and operational testing to provide a valid estimate of operational effectiveness and capability prior to contracting for production.

On April 5, 1976, the newly established Office of Federal Procurement Policy issued Circular A-109, which set a standard policy for all federal acquisition. On January 18, 1977, OSD issued a revised version of DoD Directive 5000.1 to bring DoD acquisition policy into compliance with Circular A-109. The important changes in acquisition policy caused by those directives were in the early part of the acquisition cycle. Before that time the conceptual phase was initiated at the discretion of the individual service and the work was typically performed by advanced planning groups without a formal System Program Office or Program Manager. Normally such work was devoted to a single system with clearly defined operational characteristics. After a substantial investment of time and money, the SECDEF would be asked by the service for a decision on the system at Milestone I. At that point the only real options open to the SECDEF were to approve that particular system or to reject the project. Not only did this allow substantial amounts of money to be spent on a system before OSD reviewed it, but it built up a constituency for the

¹²*Report of the Commission on Government Procurement*, Vol. 2, Washington, D.C., 1972, pp. 164-166.

development of the system, making it difficult to explore the possibility that other systems might perform the same mission better or at lower cost.

Under the A-109 policy revisions, the acquisition cycle begins with a service determination that there is a need for a system to perform a mission. The service then prepares a Mission Element Needs Statement (MENS), which expresses the need in terms of operational requirements rather than performance specifications or characteristics of the system. Since a particular type of system to meet the need is not specified, the exploration of a wider variety of alternative systems should be possible. To give OSD control over this portion of the acquisition cycle, a new Milestone Zero was added. When a service felt it had a mission need, a MENS had to be submitted for SECDEF approval before the exploration of systems could begin. Upon approval of the MENS, a System Program Office was to be established and a Program Manager appointed and given a charter.

It is clear from this brief review that there has been an increase in high level management and review of acquisition programs. The basic question addressed in this report is, Have those changes in policy and management practices had any significant effect on the time required for a system to pass through the entire acquisition cycle?

DATA BASE

To determine with useful precision the existence of historical trends in acquisition cycle duration, it is necessary to examine classes of systems that have been developed in significant numbers more or less continuously over a period of several decades and that have been subject to the full panoply of management processes for decision review and ratification. Few adequate data samples are available. In this study attention was focused on aircraft, with some additional work being done on missiles (excluding long-range surface-to-surface ballistic missiles) and helicopters. Members of the three data sets are listed in Table 1. The period covers three decades, from the late 1940s to the late 1970s.

Data deficiencies made it impossible to include all systems in each class; coverage was dictated by the availability of data. Army and Navy systems are less well represented than Air Force systems, reflecting the existence at Rand of a better data base for Air Force systems.

A listing of the milestones for each system, together with source references and occasional comments on data problems, is contained in Appendix A (aircraft), Appendix B (helicopters), and Appendix C (missiles). A full bibliography of sources is included with each appendix. When several sources agree on a date, all such sources are cited (although we recognize that they all may have copied from the same original source, which may have been wrong). Discrepancies and contradictions are noted in footnotes.

SELECTION OF MILESTONES

The next step was to identify consistent milestones or events in each program, determine the interval between those events, and track the intervals across time

Table 1

DATA SAMPLE				
Aircraft		Helicopters	Missiles	
<u>Fighters</u>	<u>Bombers</u>	AH-1	TM-61	Matador
F3D	B-47	AH-64	SM-64	Navaho
F-84	B-52	SH-3	GAR-1	Falcon
F-86	B-58	CH-3	IM-99A	Bomarc
F-89	B-70	CH-46	GAM-72	Quail
F-94	B-1	CH-47	TM-76B	Mace
F4D		CH-53	GAM-77	Hound Dog
F-100		CH-54	GAM-87	Skybolt
F-101	<u>Attack</u>	UH-43	AGM-69	SRAM
F-102		HH-52	AGM-65	Maverick
F-104	A3D	OH-6		Harpoon
F-105	A-4	OH-23		ALCM/SLCM
F-106	A-5	OH-58		Pershing II
F4H/F-4	A-6	SH-34		
F-111	A-7	TH-55		
F-14	A-10	UH-1		
F-15		UH-2		
F-16		UH-60		
F-18	<u>Transport</u>			
<u>Patrol</u>	C-130			
	C-133			
S-3A	C-135			
P-3	C-141			
	C-5			

so as to reveal any trends. Furthermore, it was clearly desirable to track milestones that correspond to events defined by today's management practices. Unfortunately, the changes in management practice have in turn changed the definition of some milestones, making tracking difficult. We succeeded in tracking six major milestones, as shown in Fig. 1.

1. Issuance of a formal, Service-level requirement for the system.
2. Beginning of Concept Demonstration and Validation (the equivalent of Milestone I today).
3. Beginning of full-scale development (equivalent to Milestone II today).
4. First flight (or equivalent full-scale system test).
5. Initial delivery of the first production unit to the operational forces.
6. Delivery of the 200th operational unit.

To simplify the quantitative analysis and to provide some continuity from one analysis step to the next, we used the six milestones to define five intervals, each beginning or ending with the start of full-scale development (see Fig. 1). A sixth interval was defined as the production phase (first to 200th operational unit delivered).

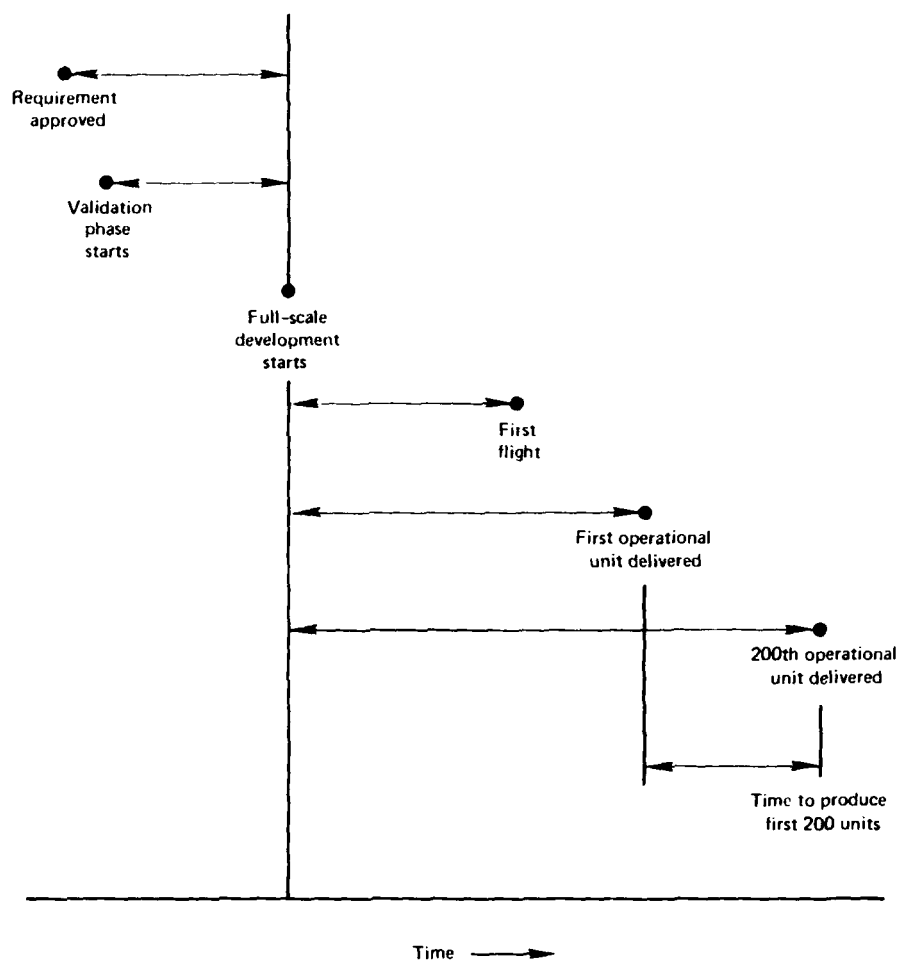


Fig. 1—Milestones tracked and intervals analyzed

The text of this report is devoted to an analysis of each of the six intervals. Section II discusses the planning phase activities, while the full-scale hardware development and production phases are discussed in Section III. Some observations on the overall results of the analysis and suggestions for shortening some elements of the acquisition cycle are discussed in Section IV.

Reviews of historical records of past programs usually can easily identify key dates and events that occurred in the second phase, but the first phase is much less well documented. The documentation requirements of current OSD management practices are overcoming that flaw, but earlier programs were simply not obliged to document key decisions or milestones during the analysis process leading up to the beginning of full-scale development. Hence there is an unfortunate disparity in quality and extent between data displayed in Sections II and III.

II. THE PLANNING PHASE

It is usually not possible to identify the true beginnings of projects clearly because new systems tend to evolve from diffuse activities and interests that gradually accumulate support and focus. The phase of acquisition that starts from those fuzzy beginnings and extends to the beginning of full-scale development has been labeled and organized many ways in the past; we refer to it as the Planning Phase. The objective of this analysis is to determine if there has been any significant change in the length of time required for the pre-development planning tasks. If a significant change has occurred, we will want to know the source of that change and what might be done to reduce the overall time required to reach a firm go-ahead decision.

For each system, we attempted to reconstruct the major events and decisions that occurred before the beginning of full-scale development, but little information was available on program histories during that phase of acquisition. Milestones are few and documentation is sparse. Much of the analysis and decision process occurs within the DoD, and even within a particular Service, and there is little stimulus to record the steps involved in any systematic way. Nevertheless, some distinct milestones must be identified if we are to measure intervals. The two milestones selected for analysis in the present study are described below.

REQUIREMENT FORMULATION

Only one event during the planning phase could be unambiguously identified in the various programs, the issuance of a formal requirement for the system. The date of issuance for the initial Service level formal requirement is shown in Table 2, together with the date at which full-scale development started. The interval between issuance of a formal requirement and the beginning of full-scale development is shown in Fig. 2 as a function of the FSD start date.¹³ Before OMB Circular A-109 and the subsequent initiation of the Mission Element Need Statement (MENS) process in the DoD, the process of issuing a formal requirement for a new weapon system was conducted most unevenly. In some cases a system was truly initiated by the drafting of a requirement document, and the subsequent analysis and development can be traced to that stimulus. But in many other cases the formal requirement was prepared almost as an *afterthought* (sometimes after full-scale development had started) and was clearly issued as a meaningless formality.

Occasionally, no formal, headquarters-level requirement was ever issued; that happened most often with major systems that entered development following the emergence of a consensus at the highest levels of administration. In those instances, formal documentation became a trivial matter. Consequently, we have no historical data that can be directly compared with Phase Zero of today's acquisition cycle and

¹³The date of full-scale development start will be used as the independent variable in many of the trend charts to simplify comparison between one chart and another.

Table 2

PLANNING PHASE INTERVALS

System	Equivalent Milestone I Date	Requirement Issue Date	FSD Start Date	Milestone I to FSD Start (months)	Requirement Date to FSD Start (months)
<u>Aircraft</u>					
F-84	10/44	9/44	1/45	3	4
F-86	5/45	4/45	12/46	19	20
B-47	10/43	11/44	9/48	59	46
F-89	8/45	11/45	10/48	38	35
F-94		10/48	10/48		0
B-52	4/45	11/45	2/51	70	62
F-102	1/49	8/50	9/51	32	13
F-101	1/51	2/51	10/51	9	8
F-100	9/50	1/51	2/52	17	13
F-105	5/52	9/52	9/52	4	0
C-130	1/51	3/51	9/52	20	18
B-58	3/49	12/51	2/53	47	15
F-104	1/53	12/52	7/54	18	19
F-4	10/54		5/55	7	
A-6	5/57		12/57	7	
B-70	11/55	10/54	12/57	25	38
C-141		5/60	4/61		11
F-111	2/60	7/60	12/62	34	29
A-7	12/62		3/64	15	
C-5	5/64	3/64	10/65	17	19
F-14	11/67		2/69	15	
S-3	11/65	12/65	8/69	45	44
F-15	4/65	6/68	12/69	56	18
B-1	4/64	4/65	6/70	74	62
A-10	12/69 ^a	12/66	1/73	37	73
F-16	9/71	2/76	1/75	40	-13
F-18	9/71		1/76	52	
AV-8B	3/76 ^a		7/79	40	

Table 2—continued

System	Equivalent Milestone I Date	Requirement Issue Date	FSD Start Date	Milestone I to FSD Start (months)	Requirement Date to FSD Start (months)
<u>Missiles</u>					
Matador	8/45		6/47	26	
Navaho	4/46		3/52	71	
Falcon	3/47	11/47	3/48	12	4
Bomarc	1/50		1/51	12	
Quail	10/53	3/53	4/55	18	25
Mace		10/54	1/56		15
Hound Dog		3/56	8/57		17
Skybolt	7/57	1/59	2/60	31	13
SRAM	4/63	3/64	10/66	42	31
Maverick	6/66	7/64	7/68	25	48
Harpoon	11/70 ^a		5/73	30	
ALCM/SLCM	2/74 ^a		1/77	35	
Pershing II	1/74 ^a		12/78	59	
<u>Other Systems</u> ^b					
UTTAS/UH-60	5/71 ^a		5/71	0	
TACTAS	5/73 ^a		6/73	1	
EF-111A	10/74 ^a		1/75	3	
CH-53	10/71 ^a		4/75	42	
Aegis(ship)	11/74 ^a		6/76	19	
XM-1	11/72 ^a		11/76	48	
DSCS III	12/74 ^a		12/76	24	
AAH/AH-64	9/72 ^a		12/76	51	
DIVAD Gun	2/77 ^a		1/78	11	
MX	3/76 ^a		12/78	33	
NAVSTAR	12/73 ^a		6/79	54	

^aActual DSARC I review date.

^bThis set includes all other systems that have actually passed through both DSARC I and II reviews. Poor documentation made it impossible to include the helicopters shown in Table 1 in this part of the analysis.

no attempt was made to calculate a trend over time. However, the average duration of the intervals shown in Fig. 2 is 24 months, and the average time required to move from Milestone I to the beginning of full-scale development (see the following section) was 32 months. The obvious conclusion is that in programs starting before the issuance of OMB circular A-109 it was common practice to process the formal requirements document *after* the initiation of what we now would call Phase I studies. In comparison, today's policy clearly calls for those two activities to occur in series. That is, a MENS must be approved before even the Phase Zero studies can begin, and thus today the MENS would typically appear one to two years before Milestone I.

How should we interpret the disparity in timing between the modern MENS and the older requirements document? Clearly the two did not serve identical functions. The MENS addresses only the question of operational need, whereas the typical requirements document of the old days included some degree of system description and performance specification. However, a careful review of many program histories leads to a strong cumulative impression that the equivalent of Phase I studies was frequently initiated on a speculative basis, long before a consensus was forged on overall military need. Indeed, that very practice of "uncontrolled" concept formulation and advanced technology development was one factor leading to the formulation of Circular A-109.

If the requirements formulation is to be completed before start of Phase Zero, as specified in the current regulations, the overall planning phase will inevitably be lengthened. However, some flexibility is usually observed in the application of such regulations, so it is useful to examine our limited experience with Phase Zero.

We reviewed several currently active programs in an attempt to gain some insight into the typical duration of Phase Zero as it is currently being managed. Specifically, dates were sought for the following milestones:

1. Approval for the first formal statement of need for a new capability within the Service. Such a document is frequently issued by an operating command, and constitutes a request by that command addressed to the Service headquarters. It is normally the first identifiable step in the process that leads to the drafting of a MENS and its submission to OSD for approval.
2. MENS approval by OSD.
3. The start of formal Phase Zero studies (normally conducted by contractors) to examine alternative approaches to satisfying the mission need defined in the MENS.
4. Milestone I DSARC review.

Although OMB circular A-109 was issued in 1976, and the implementing versions of DoD Directives 5000.1 and 5000.2 were issued in early 1977, major procedural changes of that sort take some time to become established as routine activities. Furthermore, service action officers kept sparse records when formulating and processing the first few MENS and it proved impossible to assemble any orderly and significant body of data on the actual time intervals involved. Preliminary evidence suggests that it is possible to spend several years moving through this phase (that is, from the first service level approved requirement to Milestone I review), but that may simply reflect the newness of the procedures. For example, the practice of not requesting from Congress the funds needed for Phase Zero studies until the MENS has been approved has sometimes created a "dead time"

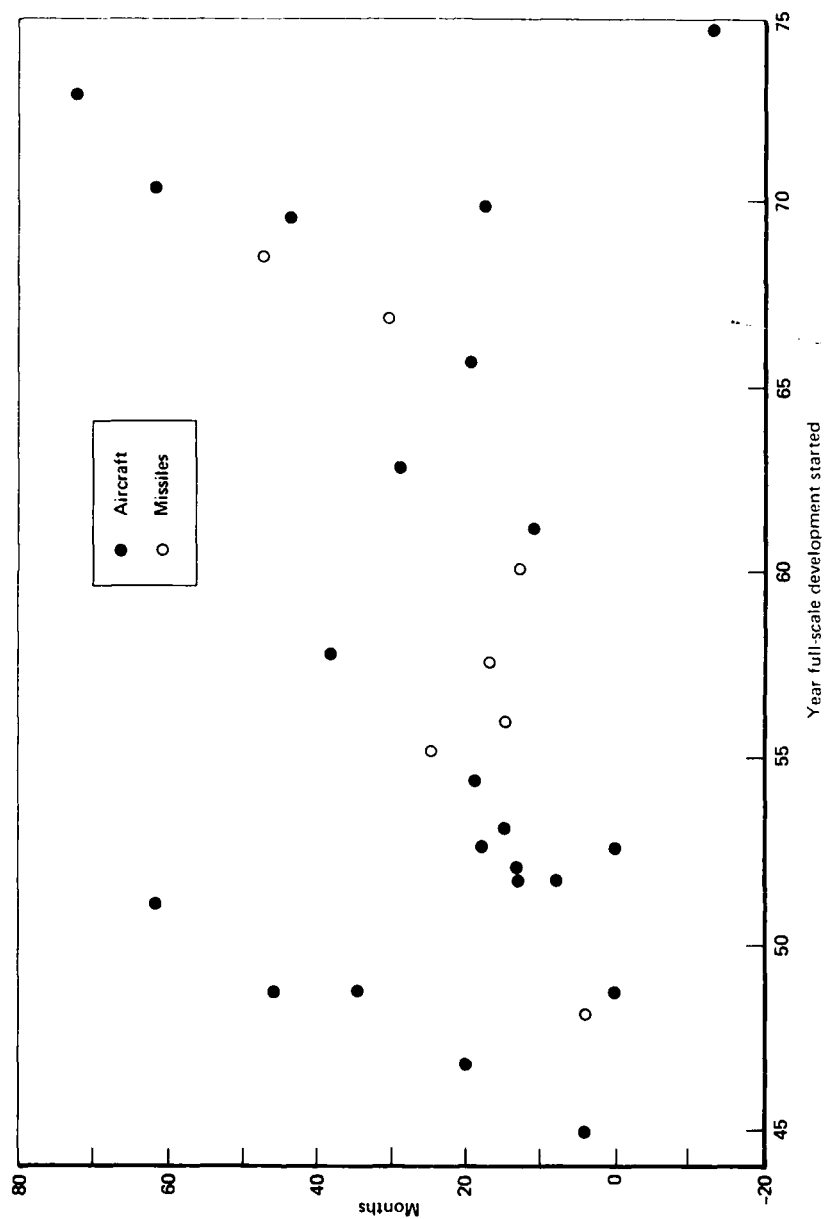


Fig. 2—Interval from formal requirement to FSD

of six to 12 months merely because the budget cycle and the DSARC cycle were not in phase. Such delays do not occur in every case, but they have occurred in some cases. Further experience with the procedures may reduce delays of that type. Section IV contains a further discussion of this subject.

CONCEPT VALIDATION

As noted earlier, the only pre-Milestone II event that could be unambiguously identified and tracked was the issuance of a formal requirement for the system. Other events, such as contracts for funded studies, decision directives from senior officials, etc. were found to be nearly useless for purposes of analysis because of poor documentation. Consequently, we decided to construct a synthetic milestone that would correspond to today's Milestone I review. We examined each program and estimated when the Milestone I review would have occurred if the current DoD management process had been in force when that program was evolving. This imperfect process calls for some difficult judgments, but it seemed the only way to get a milestone that could be consistently applied to the many older programs and that could be compared with current milestones.

For those unfamiliar with the DSARC milestone review, the following excerpts will help to define the timing and intent of the Milestone I review.

Milestone I—Demonstration and Validation. When the DoD Component completes the competitive exploration of alternative system concepts to the point where the selected alternatives warrant system demonstration, the DoD Component Head shall request approval to proceed with the demonstration and validation effort. [DoDD 5000.1, Jan. 18, 1977, Paragraph IV.D.2.]

As a result of the competitive identification and exploration of alternative design concepts, the DoD Component Head may conclude that the demonstration and validation phase should (1) involve several alternatives; (2) be limited to a single system concept; (3) involve alternative subsystems only and not be conducted at the system level; or (4) there should be no demonstration and the program should proceed directly into full-scale engineering development. [DoDD 5000.2, Jan. 18, 1977, Paragraph IV.E.2.]

The dates selected for the equivalent of a Milestone I review are shown in Table 2. For some programs it was very difficult to establish with any confidence when a Milestone I review would have been conducted, so those systems (principally helicopters) are deleted from the table. Conversely, 12 additional systems were introduced—those that actually passed through both a Milestone I and a Milestone II review.¹⁴ Those systems are a mixed lot but constitute most of the 1970s data against which the 1950s and 1960s can be measured.

The duration of Phase I, as plotted in Fig. 3, displays a lot of scatter. However, unlike the requirements data shown earlier, we were able to select an equivalent

¹⁴Of the 80-plus systems that have received some sort of formal DSARC review during the past decade, only 17 have passed through both a Milestone I and a Milestone II review. Of the remainder, over half went directly to a Milestone II with no prior review, a few were canceled or substantially revised after Milestone I, and the others are now proceeding through Phase I.

Milestone I date in a reasonably systematic manner and it should be possible to draw some inferences regarding long-term trends.

We used two approaches to test for a long-term trend. First, we ran a series of linear least-squares regressions on several variants of the data base. Our objective was mainly to see if there had been a cumulative change over the several-decade period. The large amount of scatter and the skewed distribution of the data discouraged use of a higher-order model.

The first test was with the most homogeneous data set that contained a significant number of entries—fighter and attack aircraft. That yielded a positive slope of ten months per decade, with a t-statistic significance probability of 1 percent.¹⁵ Next, we ran a regression with the entire aircraft sample, which yielded a slope of seven months per decade and a significance probability of 9 percent. In a third run, we added the missile systems to the entire aircraft sample, yielding a positive slope of six months per decade with a significance probability of 3 percent.

One interesting feature of the data shown in Fig. 3 is that large strategic systems appear to require exceptionally long planning periods. The four highest points in the 1950 decade represent the B-47, B-52, Navaho, and B-58, and the highest point in the 1970s represents the B-1. If those systems are removed from the sample, the slope of the fitted line becomes 10 months per decade, with a significance probability of less than 1 percent.

Finally, the entire sample shown in Table 2 was pooled. It might be argued that such disparate systems as aircraft, missiles, helicopters, satellites, and tanks should not be included in the same sample. However, we are dealing here with *decision* time, and there is some basis for arguing that in most cases it takes roughly the same length of time to decide on the merits of a major weapon system regardless of type. The regression on the pooled sample yielded a positive slope of four months per decade and a significance probability of 16 percent. Regardless of arguments on the validity of such a pooled sample, the large significance probability would suggest placing little confidence in the results of that regression.

The results of the regression analysis for the somewhat homogeneous sample of aerospace systems are quite strong.¹⁶ The duration of Phase I in a typical program of the 1970s was one to two years longer than that of our estimated "equivalent" Phase I for programs of the 1950s. However, further analysis was needed to learn if that growth was a uniform trend or if it could be related to particular events or changes in management style.

Recognizing that most interest centered on whether the 1970s experience was different from that of earlier times, we divided the data into two sets—systems with

¹⁵In all statistical tests of this type, our null hypothesis is that the slope of the regression line is zero (that there was no change in the interval over time). The significance probability shown is essentially the probability that the null hypothesis could be true, based on a one-tailed statistical test. In the present case there is less than 1 percent chance that the estimated slope would be as large as ten months per decade if the interval had actually not changed over time.

¹⁶The data quoted above were computed using the *end* of the interval (Milestone II) as the independent variable. This may be considered a slightly unorthodox procedure, so the regressions were repeated with the beginning of the interval as the independent variable. Results were identical to the earlier set for the most homogeneous sample (fighter and attack aircraft only). The other variants of the sample yielded roughly comparable values of trend slope but with poorer statistical significance than the initial calculations. This is an example of a situation, noted elsewhere in the report, that seemingly robust statistical results can be changed to a significant degree by small changes in sample or in experiment design.

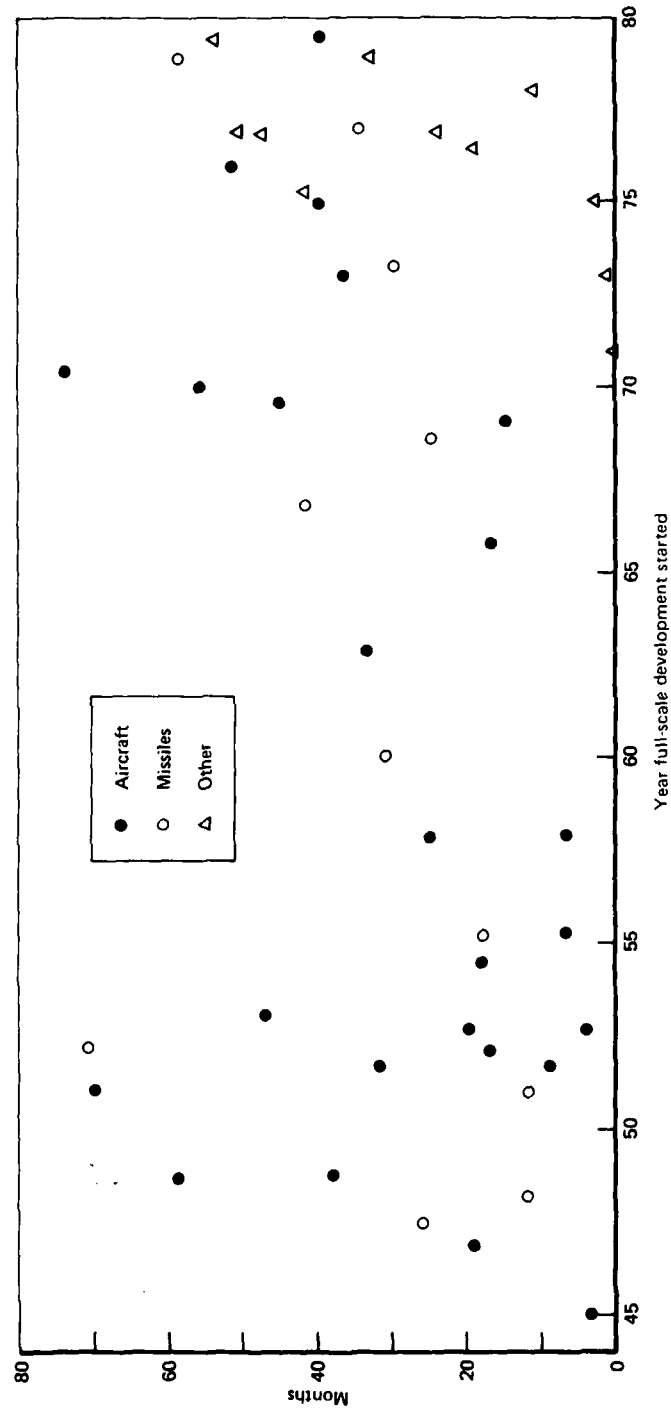


Fig. 3—Duration of concept formulation and validation phase

FSD beginning before or after 1970—and compared the two sets.¹⁷ Again we conducted three separate tests: for aircraft systems only; aircraft plus missiles; and aircraft, missiles, and other 1970s systems together. The results are shown in Table 3.

Table 3
COMPARISON OF PHASE I DURATIONS
(months)

Sample	Time Period			
	Pre-1970	Post-1970	Pre-1960	Post-1960
<u>Aircraft Only</u>				
Sample size	21	5	15	11
Mean phase duration	27	49	25	39
Median duration	19	40	19	40
Standard deviation	19	15	20	18
Significance probability ^a	2%		5%	
<u>Aircraft and Missiles</u>				
Sample size	29	8	20	17
Mean phase duration	27	46	26	38
Median duration	20	40	18	37
Standard deviation	19	16	21	16
Significance probability ^a	0.5%		1%	
<u>All Programs</u>				
Sample size	29	19	20	28
Mean phase duration	27	34	26	33
Median duration	20	37	18	35
Standard deviation	19	21	21	19
Significance probability ^a	10%		5%	

^aBased on the Mann-Whitney test.

Examining different parts of the sample provides different conclusions. If we examine the history of aerospace systems alone, we find that during the 1970s the average duration of Phase I was 70 to 80 percent greater than during the previous two decades. A statistical test yields a very high confidence that the sample distributions are truly different (less than 2 percent chance of incorrectly rejecting the null hypothesis of no difference in phase duration).

When all 1970s programs in our sample are compared with the aircraft and

¹⁷We used the Mann-Whitney nonparametric test to compare the distributions of the two samples because in many of the examples the distributions were badly skewed.

missiles of the 1950s and 1960s (admittedly a mixed sample), we find that the difference in mean phase duration was substantially decreased, and the conclusion that the two sample distributions are different carries a 10 percent chance of being incorrect. However, it can be seen from Table 2 that three of the systems (UH-60, TACTAS, and EF-111A) proceeded through Phase I in three months or less. That is clearly inadequate to conduct normal Phase I studies, so we conclude that those data points must represent largely administrative decisions. Eliminating them from the sample changes the post-1970 mean phase duration from 34 to 40 months (a 50 percent increase over the pre-1970 mean), and the two distributions can be claimed to be different with a significance probability of less than 1 percent.

To test the effect of the major change in acquisition management that occurred in the early 1960s, we moved the division line in our sample, comparing pre-1960 and post 1960 events. Results are shown in Table 3. The results are remarkably similar to those obtained when the sample was split at 1970. For aerospace systems the mean phase duration for the 1960s and 1970s together is about 50 percent greater than that of the 1950s, and the sample distributions can be claimed to be different with a probability of error of not more than 5 percent. Using the entire sample, we find the difference in mean phase duration is reduced to 25 percent, and the significance probability is 5 percent. But when the three exceptional data points of the 1970s (UH-60, TACTAS, and EF-111A) are removed, the mean duration of the later period is 40 percent greater than for the earlier, and the significance probability is less than 1 percent. Clearly, the 1950s were different from the later periods. However, the subsequent growth in Phase I interval appears to be distributed between the 1960s and the 1970s, and we find little evidence that the observed trend toward increasing duration of Phase I can be linked uniquely to management changes made at the beginning of the 1970s.

Finally, we examined the set of systems passing through both Milestones I and II during the 1970s (note (b) in Table 2) to see if any intra-decade trends could be identified. The sample was arranged into chronological order and separated into two equal parts, first according to Milestone I date and then according to Milestone II date, and in each case the two halves were compared. Results are shown in Table 4. The comparison depends on which milestone is used to separate the data set into two parts; one way shows the *early* systems to have taken longer, the other way shows the *later* systems to have taken longer. With that result, statistical tests seemed unnecessary and we conclude that this comparison provides no basis for asserting the existence of any trends within the decade.

When interpreting the data and analysis results presented in this section, one should remember that the data are sparse, widely scattered, and in some cases involve a pooling of diverse kinds of weapon systems. Many factors other than management policies affect the duration of the planning phase. Nevertheless, we believe two conclusions are justified:

1. OMB Circular A-109 clearly changed the role of requirements formulation in the planning phase. Whereas the earlier practice had often been to start concept formulation and exploratory development work before a requirement was issued, present policy calls for an approved requirement before any such work can start. Very preliminary data suggest that this may have added a significant amount of time to the planning phase (measured

Table 4

PHASE I TRENDS IN THE 1970s

Basis of Sample Division	Mean Interval Duration (months)	
	First Half	Second Half
According to DSARC I date	38	28
According to DSARC II date	27	39

in years rather than months), but measurement difficulties render that conclusion highly tentative.

2. There are strong indications that the portion of the planning phase now characterized as Phase I (the interval between Milestones I and II reviews) has been growing at the average rate of 6 to 10 months per decade, and Phase I durations for aerospace system developments in the 1970s appear to average from 50 to 80 percent greater than those of the 1950s. However, it also appears that the major change in Phase I durations occurred between the 1950s and the 1960s and that only a modest additional increase occurred in the 1970s. There is little evidence to suggest that the large changes since the 1950s can be directly and uniquely related to any of the management changes at the beginning of the 1970s.

III. HARDWARE DEVELOPMENT AND PRODUCTION PHASE

After the beginning of full-scale hardware development, the documentation of a program becomes more complete and readily available. In the present study we were able to measure three milestones: first flight, delivery of first operational unit, and delivery of 200th unit. We are interested in learning how long it takes to proceed from the beginning of major hardware development to each of those three milestones. The time required to produce the first 200 operational units was also assessed separately. Results are summarized in Tables 5, 6, and 7.

The fixed-wing aircraft (Table 5) constitute the majority of this sample. In this case, it seemed unreasonable to include dissimilar systems in the same data set when we were measuring the time required to develop, test, and manufacture a system. Although there is no obvious reason why it should take longer to reach a *decision* regarding, say, a helicopter system than an aircraft system, there may well be reasons why the *hardware development* of one class of system would take longer than that for another class. Finally, the interval data for missiles and helicopters were much more sparse and scattered than for aircraft. Therefore, the analysis discussed below is restricted to the sample of aircraft, although milestones for the other systems are recorded in Tables 6 and 7.

Several sources of complexity in the data deserve discussion. The principal one is that some of the aircraft programs started with a prototype phase before the full-scale system development phase. This raises the question of when the "development" interval really started: Was the prototype phase part of the planning process or part of the development process? In general, we prefer to treat prototype development as part of the planning phase (as was done in Section II of this report) because the start of FSD has been widely viewed as the critical decision involving the first commitment of major resources to the program. However, we recognize that such an interpretation is not universally accepted so we show development-phase data for both interpretations. For programs involving a prototype phase Table 5 shows two lines. The first line (with a "P" following the system designation) shows data for the prototype phase in cols. (1) thru (4), and with the subsequent intervals (cols. (5) and (7)) measured from the start of the prototype phase. The second line shows the full-scale system development phase, with subsequent intervals measured from the start of FSD. Sometimes, especially in the earlier programs, full-scale development was started before the prototype had been brought to flight status.

This approach still leaves some difficult decisions to be made because the relationship between a prototype and a subsequent full-scale development program is not always clear. For example, was the F-88 a prototype of the F-101? In this study the lineage between the two designs was not considered to be that direct because different engines were used, there were substantial differences in planform and other design features, and the empty weight of the F-101 was roughly twice that of the F-88. The YF-17, however, was treated as a prototype of the F-18 because the similarity in configuration and size between the two designs was of the same

Table 5

ACQUISITION INTERVALS FOR SELECTED AIRCRAFT SYSTEMS

Model		Devel- opment Start Date (1)	First Flight Date (2)	Months to First Flight (3)	First Opera- tional Delivery (4)	Months to First Delivery (5)	200th Opera- tional Delivery (6)	Months to 200th Delivery (7)	Time to Produce 200 a/c (8)
F-84	P	11/44	2/46	15	6/47	31	4/48	41	10
F-84		1/45	1/47	24	6/47	29	4/48	39	10
F-86	P	5/45	10/47	29	5/48	36	10/49	53	17
F-86		12/46	5/48	17	5/48	17	10/49	34	17
F3D	P	4/46	3/48	23	8/50	52	4/53	84	32
F3D		6/48	2/50	20	8/50	26	4/53	58	32
F-89	P	6/46	8/48	26	9/50	51	1/54	91	40
F-89		10/48	6/50	20	9/50	23	1/54	63	40
F-94		10/48	7/49	9	12/49	14	4/51	30	16
F4D	P	12/48	1/51	25	5/55	77	8/57	104	27
F4D			6/54		5/55		8/57		27
F-100	P	10/51	5/53	19	10/53	24	7/55	45	21
F-100		2/52	10/53	20	10/53	20	7/55	41	21
F-101		10/51	9/54	35	5/57	67	5/58	79	12
F-102		9/51	10/53	25	6/55	45	1/57	64	19
F-104	P	3/53	2/54	11	1/57	46	12/58	69	23
F-104		7/54	2/56	19	1/57	30	12/58	53	23
F-105		9/52	10/55	37	5/58	68	4/61	103	35
F-106		11/55	12/56	13	6/58	31	4/60	53	22
F-4		5/55	5/58	36	12/60	67	10/62	89	22
F-111		12/62	12/64	24	4/67	52	12/69	84	32
F-14		2/69	12/70	22	5/72	39	7/76	89	50
F-15		12/69	7/72	31	11/74	59	7/77	91	32
F-16	P	4/72	2/74	22	8/78	76	1/81	105	29
F-16		1/75	12/76	23	8/78	43	1/81	72	29
F-18	P	4/72	6/74	26	5/80	97			
F-18		1/76	11/78	34	5/80	52			

Table 5—continued

Model		Development Start Date (1)	First Flight Date (2)	Months to First Flight (3)	First Operational Delivery (4)	Months to First Delivery (5)	200th Operational Delivery (6)	Months to 200th Delivery (7)	Time to Produce 200 a/c (8)
A3D	P	3/49	10/52	43	1/55	70	6/60	135	65
A3D			9/53		1/55		6/60		65
A-4		6/52	6/54	24	8/55	38	12/57	66	28
A-5		6/56	8/58	26	2/60	44			
A-6		1/58	4/60	27	4/62	51	2/67	109	58
A-7		3/64	9/65	18	3/66	24	1/68	46	22
A-10	P	12/70	5/72	17	11/75	59	5/79	101	42
A-10		1/73	2/75	25	11/75	34	5/79	76	42
B-47	P	10/45	12/47	26	12/50	62	6/52	80	18
B-47		9/48	6/50	21	12/50	27	6/52	45	18
B-52	P	7/48	4/52	45	1/55	78	8/57	109	31
B-52		2/51	8/54	42	1/55	47	8/57	78	31
B-58		2/53	11/56	45	11/59	81			
B-70		12/57	9/64	81	Project canceled during development				
B-1		6/70	12/74	54	Project canceled during development				
C-130	P	7/51	8/54	37	12/55	53	2/59	91	38
C-130		9/52	4/55	31	12/55	39	2/59	77	38
KC-135P		5/52	7/54	26	1/57	56	1/59	80	24
KC-135		8/54	8/56	24	1/57	29	1/59	53	24
C-133		2/53	4/56	38	8/57	54			
P-3		4/58	11/59	19	3/62	47	12/66	104	57
C-141		4/61	12/63	32	10/64	42	4/67	72	30
C-5		10/65	6/68	32	10/69	48			
S-3A		8/69	1/72	29	10/73	50			

(1) Formal start of aircraft development. Usually denoted by issuance of a contract, but sometimes by source selection when formal contract ratification was delayed but design work continued. The date shown applies to start of actual hardware design and development, not to the usual design studies that precede actual development. Occasionally (B-58, for example) a development program was started, then canceled, redirected, and restarted. The last such start is noted in the table.

Table 5—continued

(2) Date of first flight of the very first flight article to emerge from the specified development project.

(3) (2) - (1), in months.

(4) Date at which the first fully operational configuration was accepted by the using service for operational inventory (as opposed to development testing). Note that this does not coincide with IOC, which usually implies delivery of several aircraft to the using command, while the first operational aircraft may well go to a training unit. The intent here was to mark a milestone in the system development program, not to measure establishment of a true operational capability.

(5) (4) - (1), in months.

(6) Date of delivery of the 200th operational item (again excluding the units produced for development testing).

(7) (6) - (4), in months.

(8) (6) - (1), in months.

Table 6

ACQUISITION INTERVALS FOR SELECTED MISSILE SYSTEMS^a

Model	Devel- opment Start Date (1)	First Flight Date (2)	Months to First Flight (3)	First Opera- tional Delivery (4)	Months to First Delivery (5)
Matador	6/47	1/49	19	6/52	60
Falcon	3/48	5/51	38	11/54	80
Bomarc	1/51	9/52	20	4/59	99
Navaho	3/52	11/56	56	Canceled during development	
Quail	4/55	8/58	40		
Mace	1/56	2/58	25	11/60	58
Hound Dog	8/57	4/59	20	12/59	28
Skybolt	2/60	4/62	26	Canceled during development	
SRAM	10/66	7/69	33		
Maverick	7/68	8/69	13	12/72	53
Harpoon	5/73				
ALCM/SLCM	1/77				
Pershing II	12/78				

^aSee notes to Table 5 for explanation of column headings.

Table 7

ACQUISITION INTERVALS FOR SELECTED HELICOPTER SYSTEMS^a

Model		Devel- opment Start Date (1)	First Flight Date (2)	Months to First Flight (3)	First Opera- tional Delivery (4)	Months to First Delivery (5)
UH-43		6/50	9/56	75	4/58	94
HH-52	P		5/58			
HH-52		2/62			1/63	11
SH-34	P	6/52	3/54	21	9/54	27
UH-1	P	6/55	10/56	16		
UH-1		2/57	2/58		6/59	
SH-3		9/57	3/59	18	9/61	48
UH-2		11/57	7/59	20	12/62	61
CH-46	P		4/58			
CH-46		7/58	10/60	27	5/61	34
CH-47	P	6/59	9/61	27		
CH-47					8/62	
OH-6	P	5/61	12/62	19		
OH-6		5/65			9/66	16
CH-53	P	8/62	10/64	26		
CH-53		8/63			6/66	34
CH-54	P		5/62			
CH-54		6/63				
AH-1	P	3/65	9/65	6		
AH-1		4/66			6/67	14
OH-58	P		1/66			
OH-58		3/68			5/69	14
UH-60		8/72	10/74	26	10/78	74
AH-64	P	6/73	9/75	27		
AH-64		12/76				

^aIn many cases the development of commercial and military versions of a particular helicopter model was intermingled, complicating interpretation of the data in this table. Additional information is contained in Appendix B.

See notes to Table 5 for explanation of column headings.

order as other prototype-to-operational configurations in the sample.¹⁸ To aid in the identification of time trends, the four intervals noted above were plotted against calendar time. Figure 4 shows time to first flight for the entire sample. Prototypes are shown as open circles, and the FSD phase of programs without prototypes are shown as solid circles. The FSD phase of a system that had been previously prototyped is not shown, so that each system is represented only once on the figure.

The data in this figure contains considerable scatter, and any least squares regression analysis must be treated with some reservations, but the result is a line of essentially zero slope. Because of the wide variety of aircraft contained in the sample, one immediately suspects that some of the scatter may be due to mixing of bomber, cargo, attack, and fighter aircraft together. In Fig. 5 only fighter and attack aircraft are shown, and this does reduce the scatter somewhat. The regression analysis again yields a line of nearly zero slope, and the statistics offer no basis for any other interpretation. A visual inspection shows little change in average time to first flight over the span of three decades.

Figures 6 and 7 show time to delivery of the first operational item. As in Figs. 4 and 5 a distinction is made between systems that started with a prototype phase and all others. In Fig. 6 all intervals were calculated from the earliest start date—from the start of the prototype phase if there was one, otherwise from the start of FSD. This interpretation essentially treats the prototype phase as part of the development phase. In Fig. 7 the intervals were calculated from the beginning of FSD (the prototype phase was excluded).¹⁹ A regression analysis of the full sample shown in Fig. 6 yielded a slope of four months per decade, but the corresponding significance probability of 34 percent indicates there is no confident evidence for the assumption of a change in interval over time. Furthermore, if the somewhat anomalous F-18 is deleted,²⁰ the slope goes to zero. The data in Fig. 7 yielded a slope of five months per decade, but with a significance probability of 15 percent. When the sample was restricted to only fighter and attack types the analysis yielded a slope of seven months per decade (Fig. 6) and five months per decade (Fig. 7). Again the significance probability was fairly large (10 to 15 percent) and a visual inspection shows little evidence of strong trends.

We conclude from this analysis that although the regression tests suggest a change in interval duration of several months per decade, the large significance probability associated with all of the tests suggests some caution in asserting that any real change has occurred. Because the difference between this interval and the time to first flight discussed above is largely devoted to production and testing of an initial set of units (in preparation for start of production for operational use), there is little basis for claiming that recently increased emphasis on testing prior to production go-ahead (Milestone III) has significantly lengthened the time required to deliver the first operational unit.

¹⁸The change in designation, from F-17 to F-18, was an OSD initiative.

¹⁹Another interesting result suggested by Fig. 7 is that systems preceded by a prototype phase tended to move through subsequent FSD rather more quickly than all others.

²⁰Although the F-18 has technical roots in the YF-17 Lightweight Fighter Program, it was really not started as an independent weapon system development program until some time after the prototype program was completed. Therefore, when measured against the beginning of the prototype phase the F-18 shows an artificially long development program.

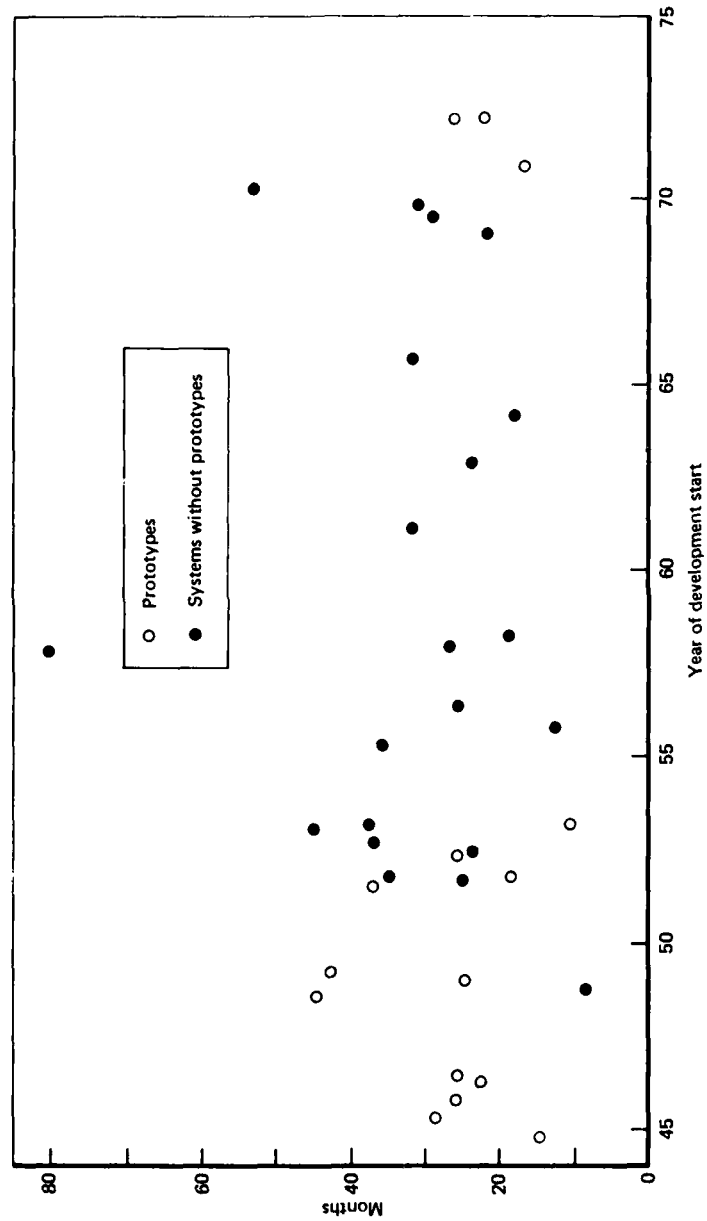


Fig. 4—Time to first flight

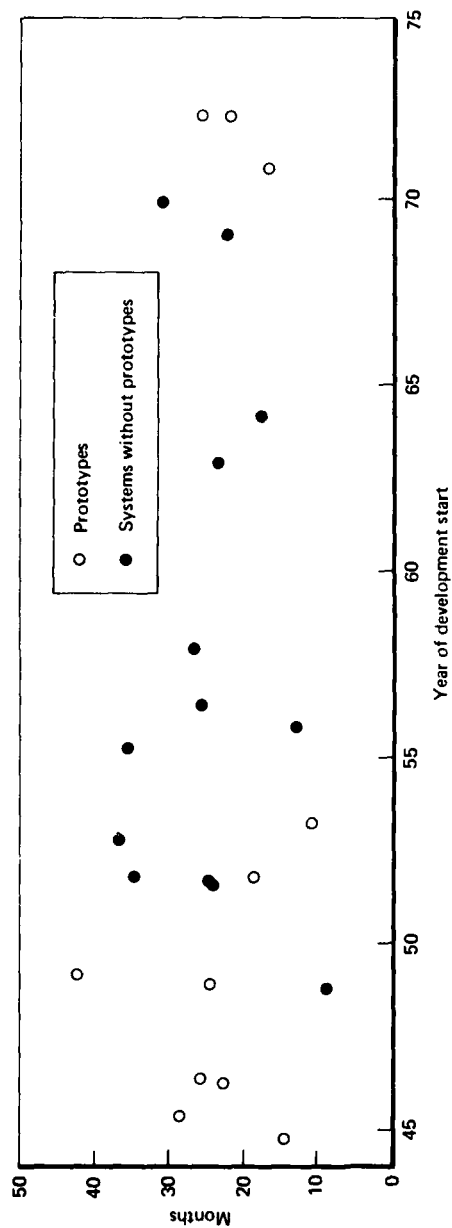


Fig. 5—Time to first flight, fighter and attack types only

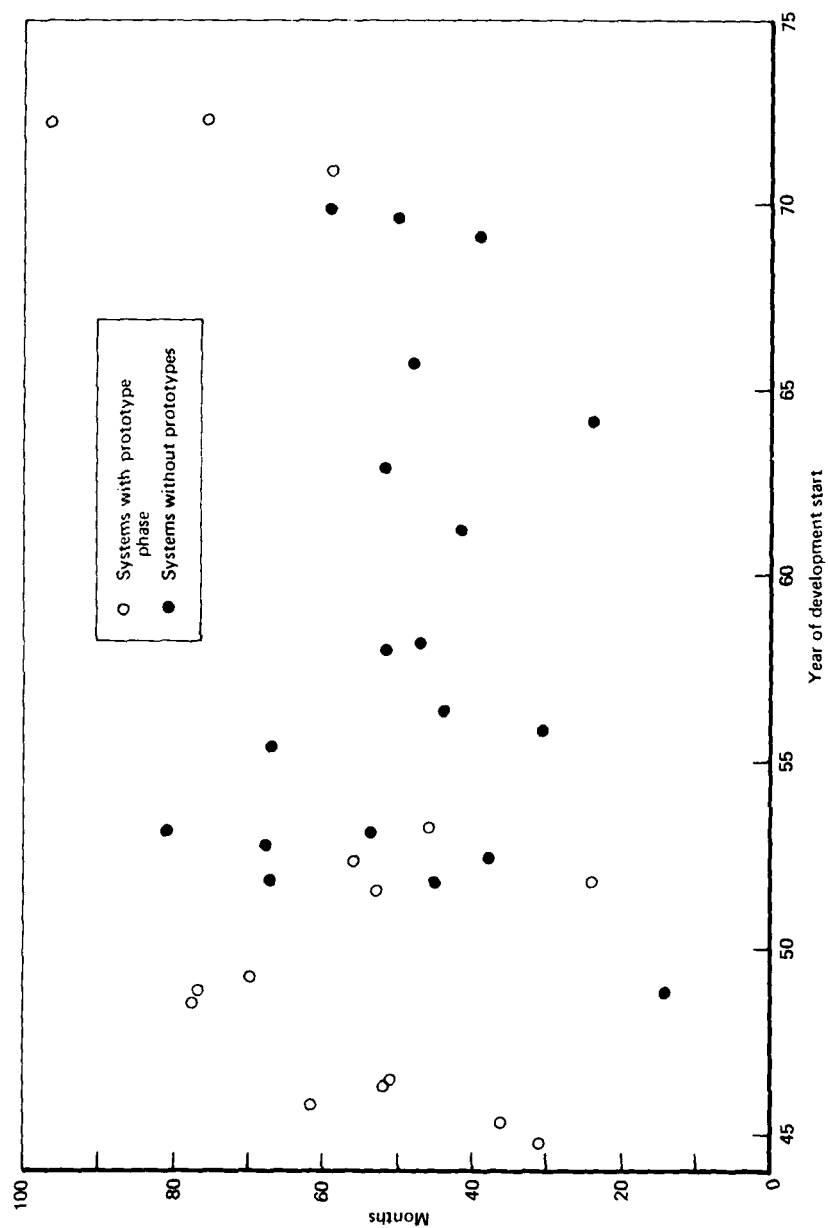


Fig. 6—Time to first operational delivery measured from earliest development start

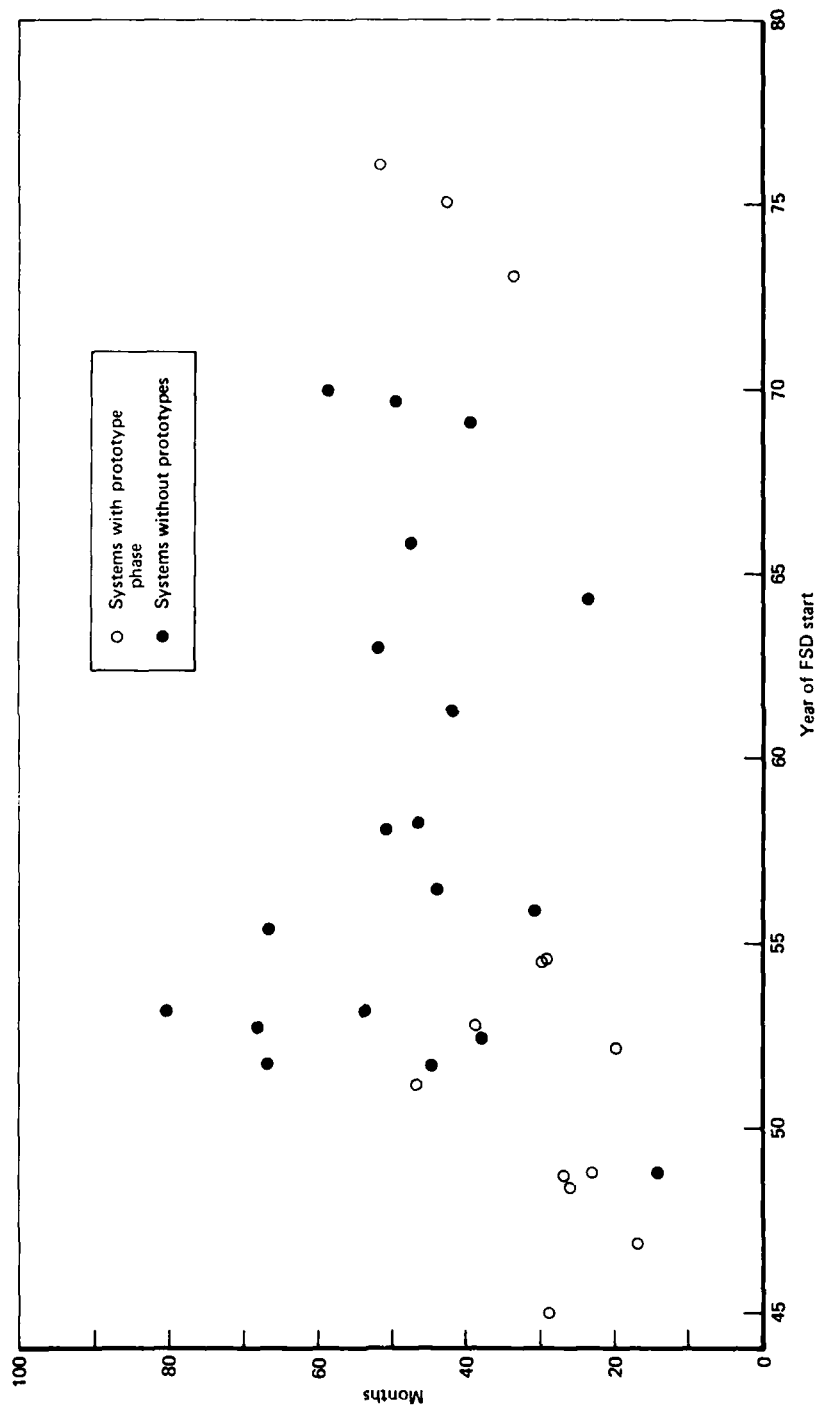


Fig. 7—Time to first operational delivery measured from start of FSD

Figures 8 and 9 show time to delivery of the 200th operational item. As in the previous case, Fig. 8 shows all intervals measured from the earliest development start date, and Fig. 9 shows intervals measured from the beginning of FSD. Although analysis of the data in Fig. 8 yielded results of low statistical significance, a linear regression of the data in Fig. 9 produced a line with a slope of 12 months per decade and a significance probability of 2 percent. When the sample was limited to fighter and attack types only, the result showed the same slope but with slightly poorer statistical confidence (4 percent rather than the earlier 2 percent). Thus there is a suggestion that this phase has been growing at a rate of one half to one year per decade, but that conclusion is weakened by the poor statistical confidence of the data measured from the earliest start date.

Finally, Fig. 10 shows the time interval between delivery of the first and 200th operational aircraft. Here the data show a pronounced trend toward lower production rates as time progresses. A regression analysis yields a slope of six months per decade, with an 8 percent significance probability. This is not unexpected, because the recent aircraft are up to ten times as expensive (in terms of percent of total available acquisition budget) as those produced in the late 1940s.

To explore the relationship between unit cost and production rate, the unit costs of several aircraft were estimated on a constant-dollar basis (see Appendix D). Results show that for the aircraft in our sample the average investment rate (\$/month) per system has actually been increasing over the past three decades. This supports the intuitive notion that production rate is strongly limited by financial resources, and that the lower production rates of recent years can be traced in large part to the increase in average cost of production and operations.

Because of the large scatter in all forms of the interval data, several models were suggested that might yield a better fit. One idea was that aircraft size (weight) or cost might systematically affect the interval, with large, expensive aircraft taking longer to plan and to develop than smaller, cheaper ones. Another hypothesis is that some systems are more technically difficult, and that those take more time to develop than the simpler types. To test these possibilities a multiple regression was performed with aircraft empty weight, unit production cost, a difficulty rating,²¹ and the date for FSD start as the independent variables. When analyzed against the time required to move from FSD start to delivery of the first operational unit, and time to delivery of the 200th unit, neither aircraft weight, cost, nor the technical difficulty rating were found to be statistically significant.

Finally, another approach to explanation of the data scatter was based on the suggestion that a complex project would tend to take longer in both the planning and the hardware phases. To normalize for this expected effect, the Phase I duration (from the Milestone I equivalent to beginning of full-scale development) was

²¹Unfortunately, no really satisfactory method has been devised for measuring the technical difficulty of a sample as heterogeneous as that used in the present study. However, two approaches were tried in an attempt to make a first-order test of the hypothesis. First, we conducted a subjective assessment of relative technical difficulty, using the method outlined in Perry, et al., *System Acquisition Strategies*. The Rand Corporation, R-733-PR/ARPA, June 1971. This method calls for assigning to each design a difficulty rating of one to 20, with the higher ratings denoting greater technical difficulty. A second estimate of the technical difficulty of each model was obtained using the method described in W. L. Stanley and M. D. Miller, *Measuring Technological Change in Jet Fighter Aircraft*, The Rand Corporation, R-2249-AF, September 1979.

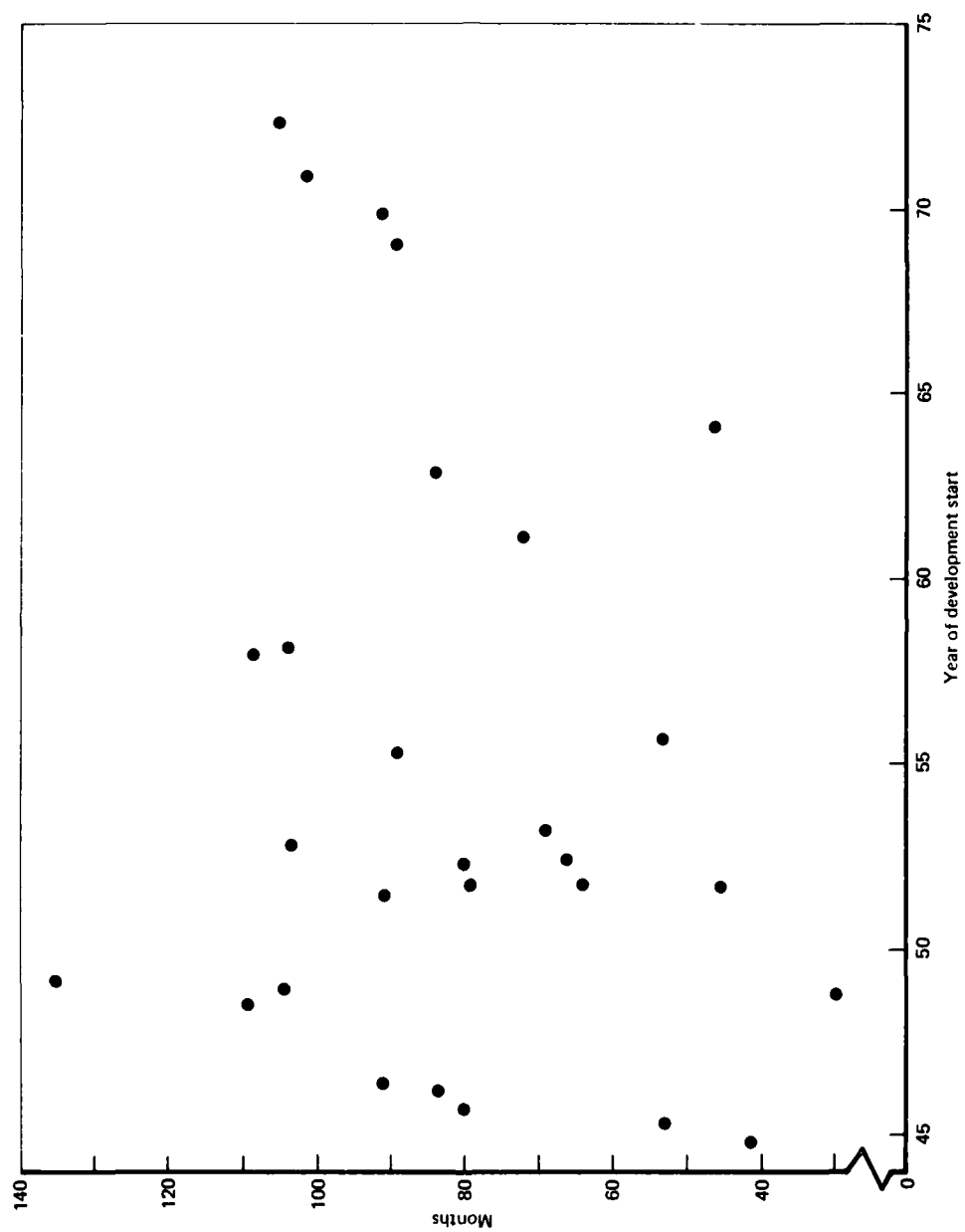


Fig. 8—Time to 200th operational delivery measured from earliest development start

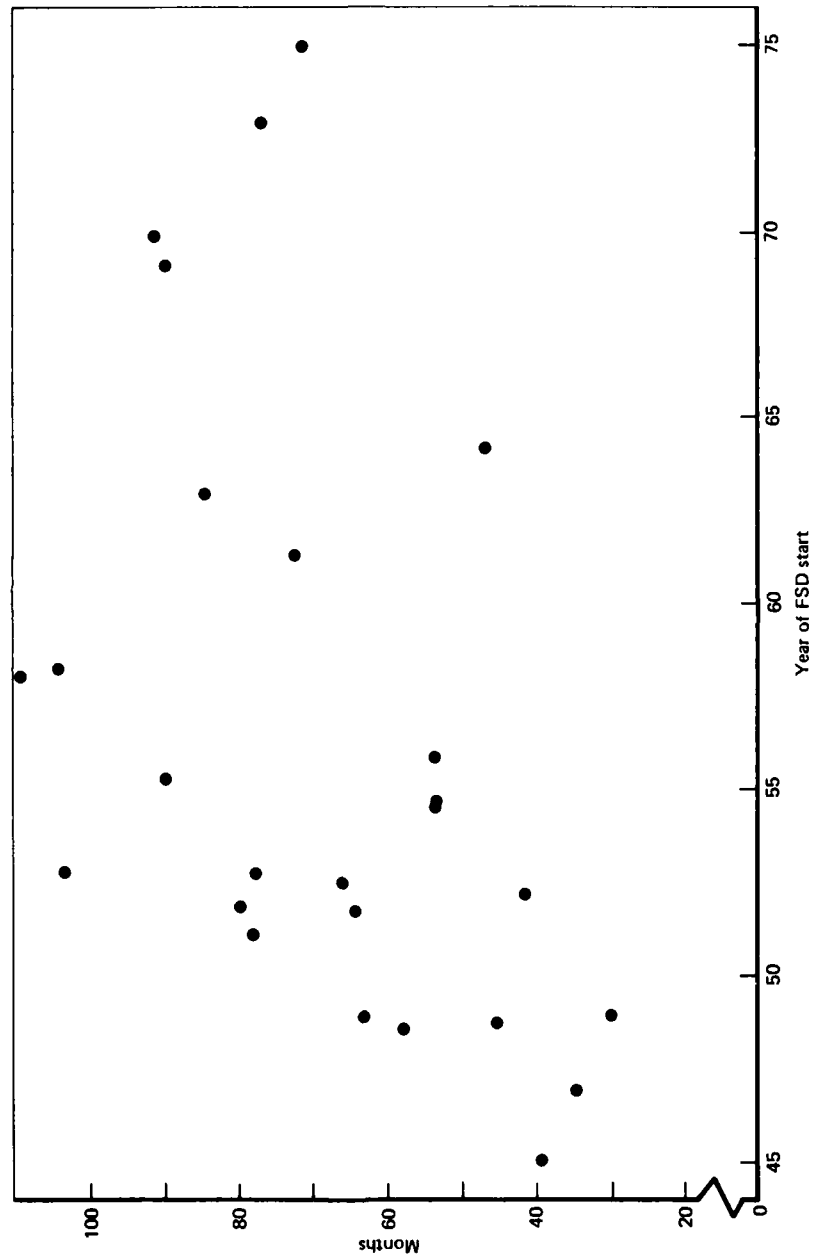


Fig. 9—Time to 200th operational delivery measured from start of FSD

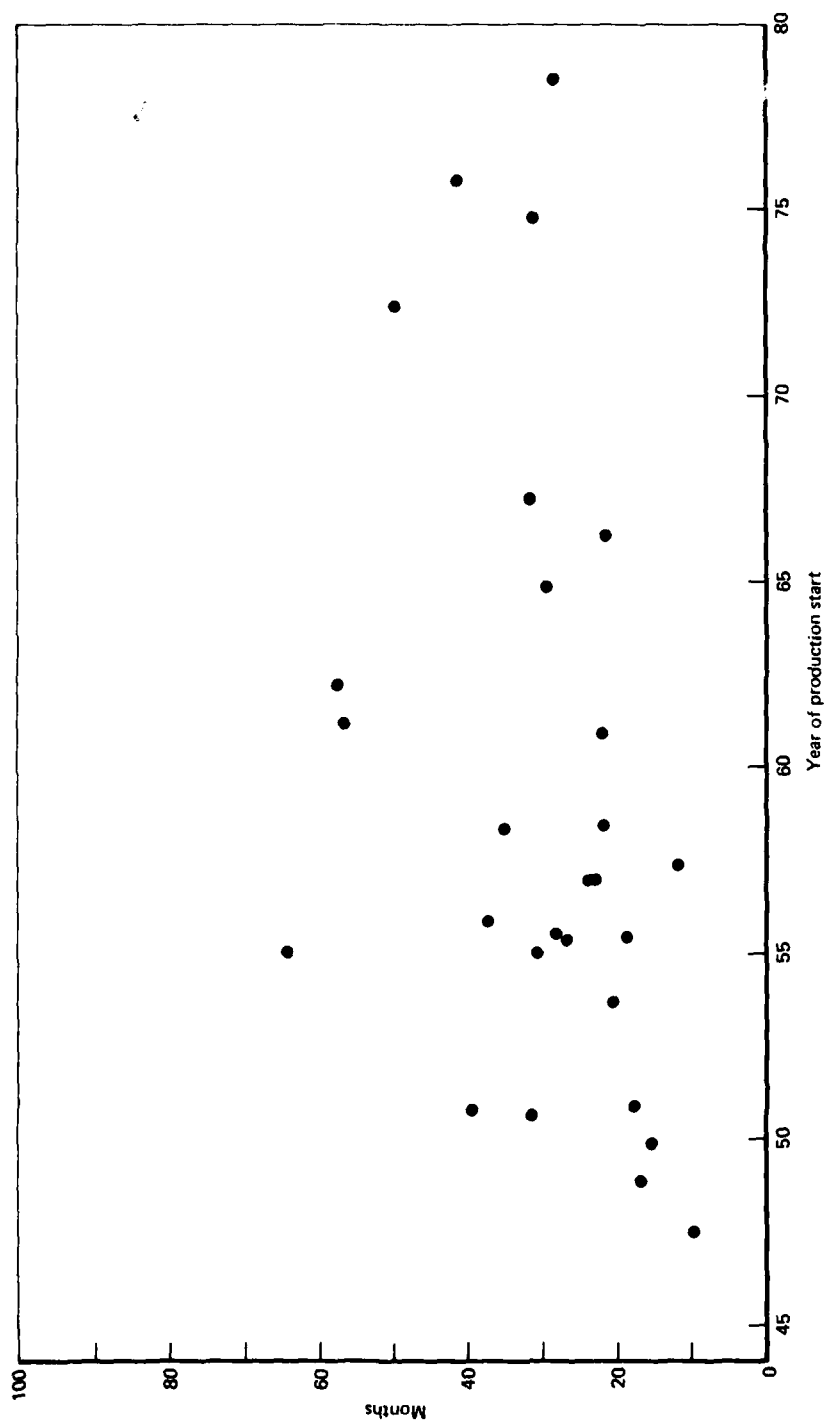


Fig. 10—Time to produce first 200 units

measured as a fraction of total acquisition time (from Milestone I equivalent to delivery of the 200th item). Results are listed in Table 8 and displayed in Fig. 11. As in earlier displays, the data are badly scattered, with a regression yielding insignificant results (i.e., there is no basis for rejecting the null hypothesis of no change over time). Moreover, a visual inspection of Fig. 11 suggests that modern projects are not much different from earlier ones, except in the absence of projects that spent a very small fraction of time in the planning phase. Most projects spend 1/4 to 1/3 of their total acquisition time in the planning phase, a result that intuitively seems reasonable.

Table 8

PHASE I DURATION AS PERCENT OF TOTAL ACQUISITION TIME

System	FSD Start Date	DSARC I to FSD (months)	FSD to 200th Delivery	Total Time (months)	Percent of Total Time
F-84	1/45	3	39	42	7
F-86	12/46	19	34	53	36
B-47	9/48	59	45	104	57
F-89	10/48	38	63	101	38
B-52	2/51	70	78	148	47
F-102	9/51	32	64	96	33
F-101	10/51	9	79	88	10
F-100	2/52	17	41	58	29
F-105	9/52	4	103	107	4
C-130	9/52	20	77	97	21
F-104	7/54	18	53	71	25
F-4	5/55	7	89	96	7
A-6	12/57	7	109	116	6
F-111	12/62	34	84	118	29
F-14	2/69	15	89	104	14
F-15	12/69	56	91	147	38
A-10	1/73	37	76	113	32
F-16	1/75	40	72	112	36

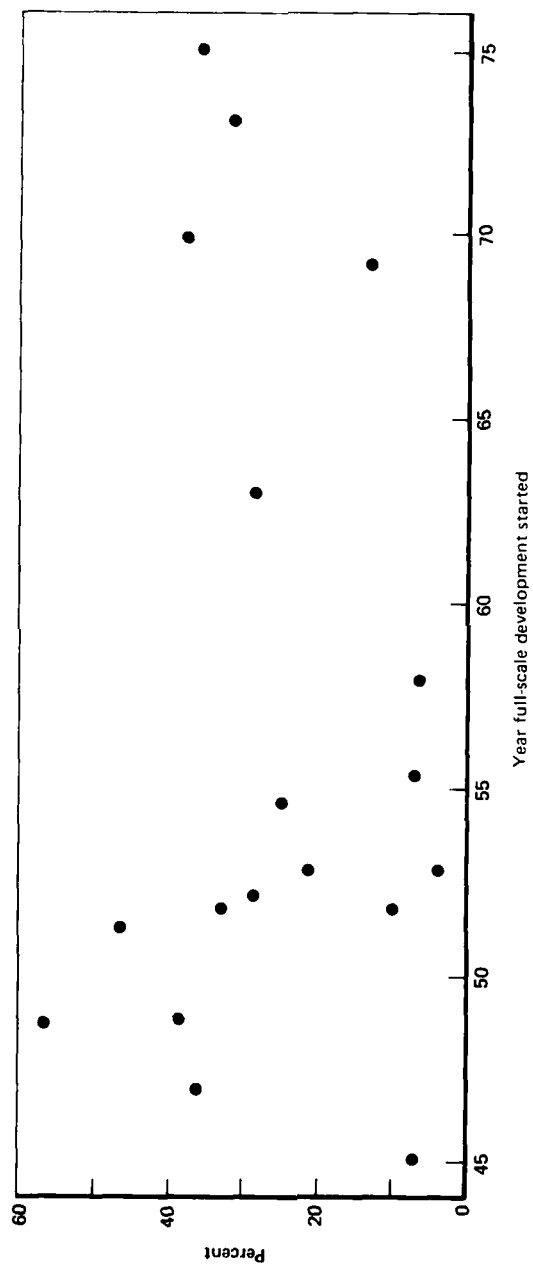


Fig. 11—Phase I duration, percent of total acquisition time

IV. SUMMARY OBSERVATIONS

A major objective of this analysis was to determine if there were any patterns or trends in acquisition intervals over the past few decades. An examination of the data presented in the previous two sections reveals one strong and consistent pattern: a wide variability from system to system within any one time period. Despite that variability, some conclusions regarding long-term trends in interval duration can be drawn from the data.

INTERVAL TRENDS

A summary of statistical results is shown in Table 9. It can be seen that with the exception of time to first flight, all entries show a positive slope (interval increasing over time) of several months per decade. A few of the data samples yielded results of apparently strong statistical significance, while others were less robust.²² Cumulatively, these data suggest that the time required to develop an aircraft has been increasing over the past three decades. The growth has been most pronounced in the typical duration of Phase I (from Milestone I to Milestone II). Starting from an average of just over two years during the late 1940s and the 1950s, that interval has increased to an average of between three and four years today. Preliminary experience suggests that a Phase Zero duration of one to two years might be added before Phase I, thus causing the total decision time (leading up to Milestone II) to have at least doubled during the past three decades. However, effects of Phase Zero must be considered as highly speculative because of inadequate experience as yet.

Changes in typical interval duration have been less pronounced in the phases immediately after the start of full-scale development. In fact, there is no evidence that the time required for the initial engineering development of the system has changed significantly during the past three decades. This is rather impressive, considering that aircraft of recent vintage tend to be much more complex than those of earlier times.

Although there is some slight evidence that the test phase (between first flight and first operational delivery) has been lengthening somewhat, the statistical support for such a trend is very weak and is certainly inadequate by itself to justify any change in policy. This finding is particularly significant because of recent complaints that "excessive" testing has unduly delayed the operational availability of systems.

Finally, a clear change has occurred in the production phase of aircraft systems, where average production rate has been steadily decreasing over time. The central

²²Changing one or two data points can make large differences in the statistical results, both in the slope of the trend and in the level of statistical confidence indicated. Thus even the trends that appear to have strong statistical support must still be treated with some skepticism.

Table 9

INTERVAL CHANGE TRENDS OVER THREE DECADES

Interval	Sample	Change Rate (months/decade)		Significance Probability (percent)	
DSARC I to II	Fighter/Attack Aircraft	10		1	
	All Aircraft in Sample	7		9	
	Aircraft + Missiles	6		3	
	Complete Sample	4		16	
Development start to first flight	Fighter/Attack Aircraft	-0.6		77	
	All Aircraft in Sample	0.6		83	
Development start to first operational delivery	Fighter/Attack Aircraft	(a)	(b)	(a)	(b)
		7	5	10	15
	All Aircraft in Sample	4	5	34	15
Development start to 200th delivery	Fighter/Attack Aircraft	9	12	20	4
	All Aircraft in Sample	7	12	27	2
Time to produce 200 units	Fighter/Attack Aircraft	5		13	
	All Aircraft in Sample	6		8	

^aBased on interval measured from earliest development start (Figs. 6 and 8).

^bBased on interval measured from beginning of full-scale development (Figs. 7 and 9).

phase of the aircraft acquisition cycle has apparently not changed and the early and late phases have been lengthening.

APPROACHES TO SHORTER ACQUISITION INTERVALS

A second objective of the study was to understand why any changes in acquisition intervals have occurred and (if possible) to suggest ways of reducing the typical interval duration. The variability within any one time period is large compared with any changes between time periods, suggesting that many factors other than administrative procedures are responsible for interval duration. However, it is possible to identify a few specific causes of the observed lengthening of average acquisition intervals. For this discussion it seems useful to first examine the later phases of acquisition, where the causes are obvious, and then to examine the more difficult aspects of the pre-DSARC II intervals.

Production Phase

There is little question that the steady trend toward lower production rates for aircraft systems has been strongly influenced by the corresponding and well-known trend toward ever-increasing costs of production and operations. Higher production rates could easily be achieved if additional resources could be made available.

Development Phase

The transition from development to production has been the subject of considerable discussion and analysis for some time, and the current impression of DoD and industry officials seems to be that the idea of "fly before you buy" had been overemphasized. However, our analysis provides scant support for the notion that testing time has been increasing to any significant extent. Furthermore, recent experience with the early service years of new weapon systems provides little evidence that the systems have been excessively refined before being put into production. In fact, assuming that some modest increase has occurred recently in the amount of time spent testing before high rate production, probably (although proof is lacking) at least some of the extra time is recaptured later through the more rapid maturation of recent systems. For example, the Hound Dog missile moved very rapidly through full-scale development and into production, but that fact alone tells a misleading story. The early missiles delivered to the using command were largely unworkable and would probably have been worthless in combat. The first fully successful flight test occurred *after* delivery of the last item (#161) in the first production lot. Such performance would be unlikely under the present management and review system, and not many would argue that the Hound Dog missile development was a model to be emulated. Whether too much pre-production testing is now being required is a question this study cannot address in detail, but the evidence collected here is certainly not sufficient to support any suggestions for change in the present policy.

Requirement Formulation and Concept Validation Phase

Because little or no change has occurred in the engineering development time, we can turn our attention to the phase where an increase has apparently occurred—the requirements formulation and concept validation phase leading up to the beginning of full-scale engineering development. Here several different forces appear to be at work. For example, the urgency associated with a system development varies widely from one system to another and it is not inconceivable that long-term changes in national attitudes toward military expenditures could cause some of the observed variations in acquisition intervals. Furthermore, the decisions being made today during Phases Zero and I are of a somewhat different nature than was the case 20 years ago, in part because fewer new systems are being started every year. Figure 12 illustrates this trend as applied to fighter aircraft for the USAF. Other contributing factors may be the increasing difficulty of canceling programs

once they are underway, and the trend that makes each system cost more than its predecessor. Those factors are well known and must surely increase the time spent (before FSD begins) on debating the need and deciding on a development approach to a new program.

Increases in the duration of concept formulation and validation phases (at least of the size noted here) should not automatically be viewed as undesirable. For example, projects undertaken in the 1950s and 1960s exhibited fairly large cost growth, schedule slip, and performance shortfalls. It seems reasonable to expect that some of the increased acquisition time suggested by this analysis has contributed to the observed improvements in our ability to produce systems that come closer to predicted cost, schedule, and performance.²³ Furthermore, delays in the decision phase may have little effect on how "modern" a system is when delivered to the troops. Technology is continually changing, and designs are updated and refined throughout that phase, so that the quality of the product should be improving as time goes by. It is incontrovertible that decision delays will cause a slip in IOC, but if a delay occurs the system may be able to take advantage of new knowledge and be a more effective weapon when it is fielded.

There are several possible approaches to shortening the pre-Milestone II decision time. If the current directives are to be strictly observed, with MENS approval required before Phase Zero, then opportunities lie mainly in the area of streamlining budget procedures. Gaps of a year or more could occur because the necessary study funds were not budgeted before MENS approval, thus requiring another budget cycle before funds can be made available. To cope with this problem it may be appropriate to establish a "revolving fund." Once a MENS is approved, work could promptly start on the ensuing studies using money from the fund, and then later when the regular project appropriations have been provided by Congress, the "advanced" money could be repaid to the fund. Such a procedure would probably require the establishment of a specific budget line item for the revolving fund. Otherwise, the process would require no change in policy or procedure and could save over a year in some cases.

A more functional approach to reducing front-end decision time would be to administer the process with more flexibility than is suggested by the regulations and directives. As noted earlier, there is a wide variation among projects in terms of perceived urgency of operational need and in the degree of consensus that exists regarding the major issues surrounding the project. Under some conditions it would seem appropriate to permit the Services to proceed with Phase Zero studies on the basis of a draft MENS, and require final MENS approval only as a necessary condition for a DSARC I (or in some cases even DSARC II) review.

This suggestion does not imply a reversion to the days when programs were started with inadequate attention to long range consequences and were difficult to cancel after they accumulated momentum and broad political support. Although a small step back from the present formal policy, such a measure seems necessary if decision times are to be significantly reduced. Furthermore, the approach suggested here leaves intact many opportunities for control that did not exist during the 1950s and 1960s, and it in no way contravenes the letter or the spirit of OMB

²³See E. Dews et al., *Acquisition Policy Effectiveness: Department of Defense Experience in the 1970s*. The Rand Corporation, R-2516-DR&E, October 1979.

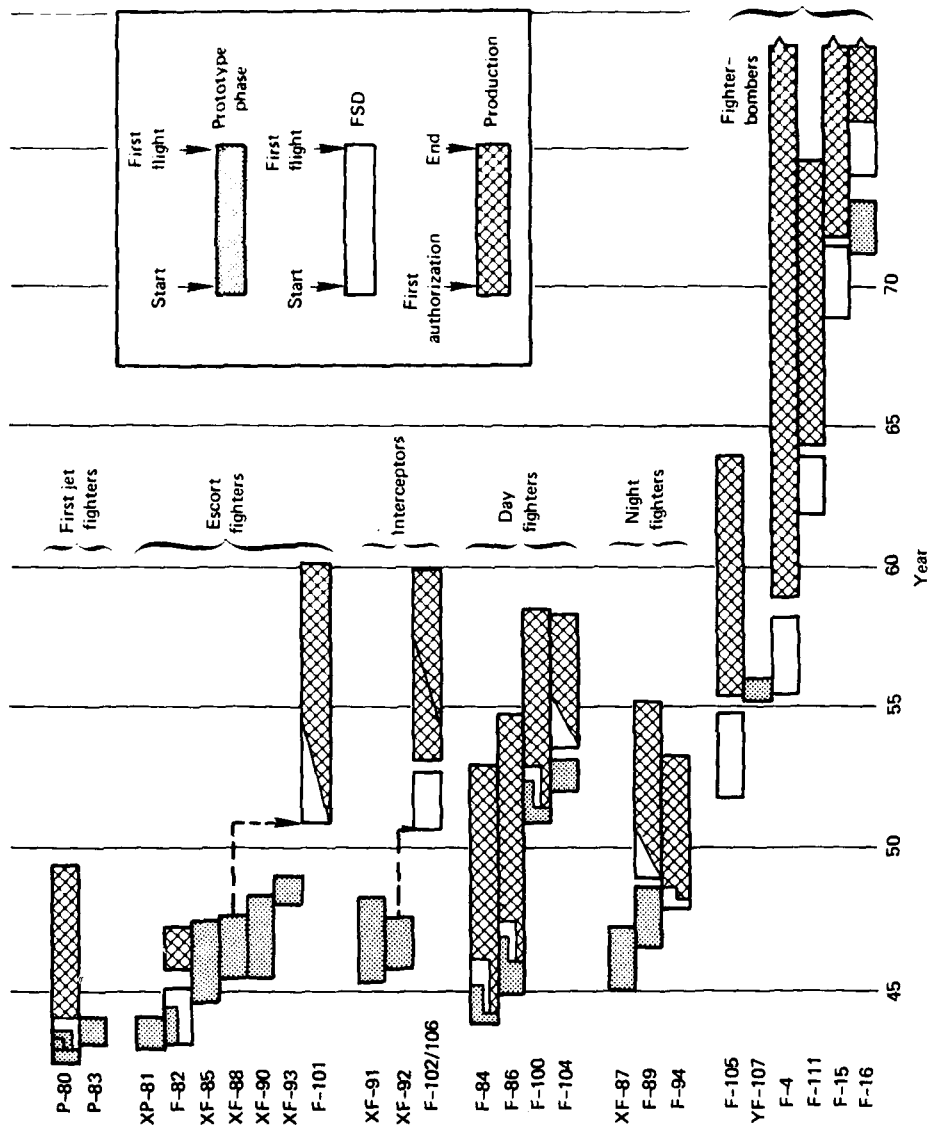


Fig. 12—Fighter aircraft development history

circular A-109. By having the Service submit a draft MENS before starting Phase Zero studies, the OSD would insure itself of being fully informed and would still have an early opportunity to review both the need for the system and the recommended approach to satisfying that need. Surely it should not be too difficult to cancel, or significantly redirect, a program at that stage.

Such a procedure would almost certainly reduce the front-end decision time (compared with the time required under strict observance of the directives), but it would also have three other consequences worth noting:

1. The "critical decision point," where the intention to complete the full acquisition program is affirmed, would be pushed downstream to at least Milestone I, and possibly into Phase I, but in no case later than Milestone II. Such a change should be advantageous because more information (Phase Zero study results) would be available to those responsible for approving the MENS. The approval of a mission need in the absence of some assurance that the desired capability can actually be achieved is a meaningless exercise. Therefore, results of Phase Zero studies cannot but help in MENS review.
2. It would sometimes be necessary to cancel a project after Phase Zero studies had started, but before Milestone II. This would have only a small fiscal consequence because in the vast majority of cases Phase Zero and Phase I expenditures are a very modest fraction of total acquisition cost. However, some institutional stress is obviously introduced by any such cancellation.
3. A somewhat larger menu of mission elements would be addressed early in the planning phase, and additional options would be presented to the decisionmakers at a point later in the acquisition cycle. Considering the rate at which perceptions of military needs and priorities change, such added flexibility is well worth the possible cost of having to cancel an occasional program during its study phase.

The approaches outlined above certainly would entail some costs of one kind or another, and some may prove to be impractical. However, if no action is taken along the general lines suggested here, there seems to be no feasible way of reducing the duration of Phase Zero or Phase I and still providing for a thorough and responsible review of the proposed weapon systems.

Appendix A

A COMPENDIUM OF AIRCRAFT PROGRAM MILESTONES

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Aircraft Number	Manufacturer	Name	Page
F3D	Douglas	Skynight	43
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F-89	Northrop	Scorpion	46
F-94	Lockheed	Starfire	47
F4D	Douglas	Skyray	48
F-100	North American	Super Sabre	49
F-101	McDonnell	Voodoo	50
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F-104	Lockheed	Starfighter	54
F-105	Republic	Thunderchief	55
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F3D DOUGLAS SKYKNIGHT

- o First jet-propelled night fighter(a)
- o Deployed to Korea soon after the war there began, Skynights were responsible for the destruction of more enemy aircraft than any other type of aircraft flown by the Navy or Marines
- o Two-seat, jet-propelled, carrier-based, all-weather fighter

Date	Event	Source
3 April 1946	Contract issued to Douglas for design and construction of three prototypes	18; 29
23 March 1948	First F3D prototype flight	18; 29
June 1948 (Full-scale development (FSD) start)	28 F3D-1s purchased	29, p. 415; 18
13 February 1950	First production F3D-1 flown	18, p. 182
May 1950	First of 28 F3Ds completed	29
August 1950	First F3D-1 accepted	
December 1950(b)	First F3Ds delivered to Night Composite Squadron VC-3 at Moffett Field	43
April 1953	200th delivery	

(a) The designation for fighter aircraft was changed from "P" to "F" on 11 June 1948 by the newly created USAF. For consistency throughout this listing, the "F" designation will be used.

(b) 18 gives approximate delivery date as February 1951.

F-84 REPUBLIC THUNDERJET

- o last of the subsonic fighter-bombers to see operational service with USAF
- o Flight-refuelling techniques for fighters were developed for this aircraft
- o First single-seat fighter bomber capable of carrying a tactical nuclear weapon
- o Developed to test the GE-TG 180 jet engine

Date	Event	Source
11 September 1944	GOR issued	10, p. 23
October 1944	First design initiated	
11 November 1944(a) (Prototype start)	First development contract for 3 fighter airplanes for static test, flight article mock-up	10, p. 23
4 January 1945(b) (FSD start)	AAF ordered 100 service test and production F-84s	10, p. 24
November 1945(c)	First prototype completed	47
28 February 1946(d)	First flight XF-84 at Muroc AFB, California	10, p. 25; 9
August 1946	Second XF-84 prototype completed	9, p. 214
6 September 1946(e)	Second XF-84 sets speed record	9, p. 214; 20
January 1947	First flight of YF-84	
February 1947(f)	AF takes delivery of 15 YF-84As	10, p. 26
June 1947	First production deliveries of F-84B	17, p. 463
December 1947	Enters operational service	10, p. 26
April 1948	200th delivery	10, p. 27
November 1950	TAC begins development of the F-84 to carry nuclear bombs for tactical warfare	17, p. 464
Spring 1952	F-84G--first single-seat fighter bomber with atomic capability	17, p. 464
June 1953	Last delivery	137, p. 36

- (a) 9, p. 214 confirms the order for three but dates it as early 1945.
 (b) 47 gives December 1944 as date of quantity order.
 (c) 9, p. 214 gives completion date as December 1945.
 (d) 47 dates first flight one day earlier--26 February.
 (e) 10, p. 25 claims second prototype flew in August and established speed record in September.
 (f) 29, p. 257 gives April 1947 as first acceptance.

F-86 NORTH AMERICAN SABRE

- o USAF's first swept-wing fighter
- o First American fighter to pass Mach 1
- o Significantly increased our air power in Korean War
- o Design influenced by German scientific data on swept-wing

Date	Event	Source
1944	North American submits several straight-wing fighter configurations to the AF	114, p. 4
11 April 1945(a)	GOR issued	
18 May 1945(b) (Prototype start)	Contract for 3 XF-86 prototypes (straight-wing design)	114; 19
June 1945	USAF approves first version mock-up	114
1 November 1945	AF endorses North American's proposal to scrap the straight-wing design in favor swept-wing	10; 114; 9, p. 225
28 February 1946	AF approves swept-wing mock-up	114
August 1946	North American releases their XF-86 engineering drawings to the manufacturing division	114
20 December 1946 (FSD start)	Production go-ahead for 33 F-86s	10, p. 53; 114
8 August 1947	First of 3 XF-86s completed and turned over for flight tests	114
1 October 1947	First prototype flight, XF-86	9, p. 225; 10; 114; 20
25 April 1948(c)	F-86, equipped with Allison TG-180 (J-35) engine, becomes first American fighter to exceed Mach 1	22, p 258; 46; 114
20 May 1948(d)	First flight production aircraft	10, p. 54; 20, p. 258
28 May 1948(e)	First production acceptance	137, p. 38;
February 1949	Enters operational service	10, p. 54
October 1949	200th delivery	
8 November 1950	Sabres ordered into combat in Korea	9, p. 225
17 December 1950	F-86 flew first mission in Korea	10, p. 54
October 1955	Last delivery	137, p. 38

(a) 10, p. 53 gives GOR date as May.

(b) 10, p. 53 claims only 2 prototypes were ordered. 8 notes that 3 Navy prototypes, ordered 1 January 1945, were built and flown as conventional straight wing aircraft.

(c) 9, p. 225 gives April 26.

(d) 17 states May 18 as first production flight.

(e) 8, p. 42 gives December 1948 as the date of F-86A service delivery.

F-89 NORTHROP SCORPION

- o All-weather ground attack fighter
- o Designed to succeed P-61 Black Widow

Date	Event	Source
August 1945(a)	Advanced Development Objective (ADO)	
28 August 1945	AF asks for design proposals	10
23 November 1945	GOR/SOR issued	
December 1945	Northrop submits their proposal to AF for all-weather ground attack fighter	9, p. 238; 29, p. 264; 17, p. 441
March 1946	Six aircraft manufacturers enter competition	10, p. 83
13 June 1946(b) (Prototype start)	Initial procurement--Northrop receives \$4 million letter contract for two experimental F-89s	10, p. 84
September 1946	Mock-up inspection	29, p. 264
18 December 1946(c)	Contract for two experimental planes finalized	29, p. 264; 17, p. 441; 19
16 August 1948	First flight of prototypes with J-35-A-9s	20; 10, p. 84; 5, p. 207; 29, p. 264
14 October 1948 (fSD start)	Go-ahead decision	10, p. 84
14 July 1949	Approval of F-89A contract; production orders placed	17, p. 442
27 June 1950	YF-89A (second prototype modified with new engines, J-35-A-21s with after-burners) makes first flight	10, p. 86
28 September 1950(d)	First acceptance of production aircraft	10
Mid-1951	F-89A and B began to reach ADC squadrons	17, p. 443
January 1954	200th delivery	
September 1956	Last delivery	137, p. 40

(a) 10 gives "Spring" as ADO date. 137, p. 40 gives August 1945 as requirement date.

(b) 17, p. 441 claims that Northrop's design was accepted and a development contract was issued on 3 May 1946; 29, p. 264 confirms May.

(c) 10 disagrees; claims December marks second mock-up and Northrop is authorized to proceed with construction of first airplane.

(d) 17, p. 442 and 29, p. 265 give July 1950 as the date for first F-89A delivery.

F-94 LOCKHEED STARFIRE

- o First jet-powered, all-weather fighter to enter USAF service
- o Two-place interceptor version of the F-80 "Shooting Star"
- o Designed for high-altitude, radar-controlled interception of enemy aircraft

Date	Event	Source
8 October 1948	GOR issued	10, p. 101
14 October 1948 (FSD start)	Go-ahead decision on F-80 two-place modification; becomes F-94 in 1959	10, p. 101
January 1949(a)	Letter contract with Lockheed Initial procurement	10, p. 101
16 April 1949(b)	First flight of XTF-80C (radar equipped TF-80C)	10, p. 101
1 July 1949(c)	First flight of YF-94	10, p. 101; 17, p. 340
December 1949(d)	AF accepts first F-94A	10, p. 103 29, p. 265
August 1950	IOC	10, p. 102
April 1951	Enters operational service with ADC's 61st Fighter Interceptor Squadron at Selfridge AFB 200th delivery	10, p. 104

(a) This L/C was replaced a few months later by a definitive contract (AF-1849) covering 150 F-94s (later reduced to 109)--10, p. 101.

(b) 29 says this was the first flight of YF-94.

(c) Two T-33A trainers, improved and redesignated TF-80Cs, were modified for the interceptor role by adding radar noses and rear-fuselage afterburners. These aircraft were used by Lockheed as F-94 prototypes to speed development--10, p. 101.

(d) There is little agreement on "delivery" and "enters operational service" dates. 10, p. 102 says that the F-94A enters operational service and begins to reach air defense units in May 1950. 9, p. 253, and 17 claim that deliveries begin to the 319th All Weather Fighter Squadron in June 1950. 66, p. 1152 gives 16 June 1950, as the date when the Air Force accepts delivery of the first two F-94s.

F4D DOUGLAS SKYRAY

- o Bat-winged interceptor designed for catapult operation from carriers
- o Designed for rapid rate of climb and high speeds

Date	Event	Source
1947	U.S. Navy proposal for a short-range, carrier-based interceptor fighter	18, p. 184
1948	Basic design work begins	119, p. 492; 126, p. 251
16 December 1948 (Prototype start)	Two prototypes ordered	18; 29
23 January 1951 (Prototype start)	First XF4D-1 prototype flown with XJ40-WE-6 and XJ40-WE-8	5, p. 167 29; 18; 119; 23, p. 237
March 1953	Switch in engine--production F4D-1s to have J57-P-2	18
5 June 1954	First production flight of F4D-1	18; 29; 5, p. 167
May 1955(a)	First delivery	
August 1957	200th delivery	
1958	Production stopped--420 F4D-1s had been built	34, p. 166
September 1962	Redesignated F-6A	18

(a) 34, p. 166 claims that deliveries began in 1954 but that the first operational squadron was not formed until 1956. 18 gives 16 April 1956 as the date for first delivery to a Navy unit and 29 confirms April as the correct month.

F-100 NORTH AMERICAN SUPER SABRE

- o Evolved from the F-86 Sabre
- o Originally designated by North American as "Sabre 45" because of the aircraft's 45 degrees of wing sweepback
- o North American spent one year on its own on development before working with the Air force

Date	Event	Source
February 1949	F-100 begins to take shape as F-86 goes into production	130
September 1950	ADO issued	10, p. 113
January 1951(a)	GOR/SOR issued	
15 January 1951	Unsolicited proposal--North American submits Sabre 45 design for consideration as supersonic day fighter	10, p. 113; 171
October 1951 (Prototype start)	AF gives go ahead on Sabre 45	10, p. 113
30 November 1951	Sabre 45 renamed F-100	10, p. 113
3 January 1952(b)	Development contract--two prototypes ordered	10, p. 113
11 February 1952 (FSD start)	First contract for production 23 F-100As	10, p. 113
24 April 1953	First prototype completed	171; 96
25 May 1953	First flight of prototype (YF-100A)	10; 23; 80; 83, p. 41
28 September 1953	First production F-100A completed	171; 96
October 1953	First production acceptance	
14 October 1953	First flight, second prototype	10
20 October 1953	First production F-100 rolls out	35, p. 15; 83
25 October 1953(c)	F-100A sets an official world speed record of 755.149 mph	45
29 October 1953	First flight of production F-100A	10, p. 114; 171
29 September 1954(d)	F-100A becomes operational with Tactical Air Force's 479th Wing	109; 62
12 October 1954	F-100A accident--kills pilot George Welch	126, p. 251
11 November 1954	F-100s grounded	
February 1955	AF lifts grounding	35, p. 15
July 1955	200th delivery	
September 1955	IOC	10, p. 115
October 1959	Final delivery	8, p. 90

(a) 10 dates GOR as 27 August 1951.

(b) 9 and 29 claim that on 1 November 1951, the AF authorized two YF-100s and 100 F-100As. No mention of this date or purchase of 100 aircraft is found elsewhere.

(c) 23 and 96 note that speed record was on 29 October.

(d) 10, p. 115 dates this as 27 September.

F-101 MCDONNELL VOODOO

- o Derivative of McDonnell F-88
- o Designed to escort very high-flying, long-range bombers
- o Twin-jet supersonic fighter

Date	Event	Source
August 1945	Engineering Division at Wright Field issues industry-wide, preliminary design competition characteristics; thirteen companies respond with 20 design proposals	
May 1946	McDonnell receives a Phase I development contract covering work through mock-up of the XF-88	
June 1946	Detail design work begins	17, p. 363
August 1946	Mock-up inspection	
June 1948	Plane completed and ready for engineering inspection	
September 1948(a)	First flight of XF-88A	
March 1949	Plane ready for shipment to Edwards; Phase I flight testing completed	
April 1949	Phase II test program completed	
August 1950	Experimental contract terminated because of cutback in funds	25, p. 347
January 1951	AF decision to seek new escort fighter design	10, p. 135
6 February 1951	GOR issued	10, p. 136
May 1951	McDonnell F-88 chosen in AF competition	10, p. 136
October 1951 (FSD start)	Production go-ahead; FY52 funds released to get F-88 into production; speed-up because of Korean War	10, p. 136
30 November 1951	F-88 renamed F-101 Voodoo	10
15 January 1952(b)	Development contract--77 planes (no prototypes) ordered	
	McDonnell accepts initial L/C offered by AF	10, p. 137
May 1953	Construction of the first F-101 begun	9, p. 269
29 September 1954(c)	First flight F-101A	17, p. 363; 25, p. 347; 5, p. 193;
10 May 1956	First flight YRF-101A	17, p. 363
27 March 1957	First F-101B flown	10, p. 151
2 May 1957	First delivery of F-101A; enters operational service with TAC	17, p. 363; 5, p. 193; 10, p. 140; 25, p. 347

F-101 MCDONNELL VOODOO--continued

Date	Event	Source
May 1958	200th delivery	
March 1961	Final delivery	8, p. 25

(a) 10 disagrees; dates first flight 20 October 1948, as does 8.

(b) 96 says McDonnell received a sizable production contract in January 1952 with appropriations totaling \$20 million. Source 29 confirms that the January L/C was for 29 F-101As, for design and development through mock-up. 10 states that the contract was not finalized and signed by the AF until 11 June. 29 reports that an order was placed for the 77 aircraft after the 29 September 1954 flight.

(c) 105 dates first prototype flight as October; 17, p. 363 gives more specifically 20 October 1948.

F-102 CONVAIR DELTA DAGGER

- o First delta-wing design accepted for operational use by the Air Force
- o First use of the Weapon System Concept
- o Grew out of Convair's experimental XF-92A, first true delta-wing powered aircraft to fly in the U.S.
- o First fighter to dispense with gun armament completely in favor of guided missiles and unguided rockets

Date	Event	Source
August 1945	Tentative interceptor requirements	
September 1948	XF-92 first flight	
13 January 1949	ADO issued	10, p. 259
18 June 1950	Request for proposals for Project MX-1554 (operational date of 1954)	10, p. 159
18 August 1950	GOR issued	
31 August 1950	First development contract	
January 1951	Bidding closed--six contractors had submitted nine proposals	10, p. 160
2 July 1951(a)	AF names three winners for Phase I development: Convair, Republic, Lockheed	10, p. 160
11 September 1951 (FSD start)	Convair awarded L/C	10, p. 160
24 November 1951	AF decides to expedite the 1954 Interceptor program--will follow Cook Craigie plan for early tooling, limited production at first, elimination of faults by test flights, and accelerated production thereafter	10, p. 161
October 1952(b)	Production order to Convair	127
18 November 1952	F-102A mock-up inspection	10, p. 162
12 June 1953	Definitive contract for production; supersedes previous L/Cs	10, p. 163
24 October 1953	YF-102 makes first flight	5, p. 154; 17, p. 169; 10, p. 163; 25, p. 287
2 November 1953	The first YF-102 is wrecked in emergency landing	10, p. 164
11 January 1954	First flight of second YF-102	17, p. 169; 25, p. 287
March 1954	AF gives Convair second production contract	10, p. 164
4 November 1954	New GOR--Convair forced to meet new altitude and combat radius requirements	10, p. 164
19 December 1954(c)	First flight of production configuration, YF-102A	10, p. 165
June 1955	F-102A production models begin delivery	5, p. 154;
24 June 1955	First flight production F-102A	10, p. 165; 17, p. 169

F-102 CONVAIR DELTA DAGGER--continued

Date	Event	Source
June 1956(d)	First squadron becomes operational	29; 5, p. 154
January 1957	200th delivery	

(a) 10 states that soon after the three winners were announced, the AF decided against letting three manufacturers work through Phase I. Lockheed was canceled entirely and the letter contract of September declared Convair the winner--although the Republic XF-103 development was still authorized.

(b) 10 states that a definitive contract for production was not awarded until 12 June 1953.

(c) 24 dates YF-102A flight at 20 December as does 17, p. 169; 5, p. 154; and 8, p. 117.

(d) 10 says the F-102A enters service with the Air Defense Command's 327th FIS at George AFB in April 1956.

F-104 LOCKHEED STARFIGHTER

- o First operational interceptor capable of sustained speeds above Mach 2
- o Developed from Lockheed F-90
- o First aircraft in history to hold world records for both absolute speed and altitude (1,404.19 mph and 91,249 ft) simultaneously

Date	Event	Source
November 1952	Lockheeds submits unsolicited proposal for new air superiority fighter	9, p. 278; 10, p. 175; 17, p. 343
12 December 1952	GOR for lightweight air superiority day fighter to replace TAC's F-100s in 1956	10, p. 175
January 1953	Competitive bidding by Republic, North American, and Lockheed	10, p. 175
11 March 1953 (Prototype start)	Letter contract given to Lockheed for two XF-104s and one year of flight testing	9, p. 278; 10, p. 176; 17, p. 343
30 April 1953	Mock-up inspection	10, p. 176
November 1953(a)	Definitive contract	
7 February 1954(b)	First flight XF-104	17; 19; 5; 27; 29; 8
July 1954 (FSD start)	AF decides to purchase 17 aircraft for development tests	10, p. 176
October 1954	First production contract for 17 F-104s--initial procurement	10, p. 176
October 1955	New letter contract to Lockheed exceeds \$100,000,000	38, p. 12
17 February 1956	First flight production aircraft F-104A	10, p. 177; 5, p. 187; 26, p. 372
January 1957	First production acceptance	
26 January 1958	Becomes operational with the Air Defense Command	10, p. 178; 9, p. 278; 29; 5, p. 187; 17, p. 343; 26, p. 372
December 1958	200th delivery	
1964	Final delivery	8

(a) This date was not confirmed by any other source.

(b) 10, p. 176 gives 28 February 1954.

F-105 REPUBLIC THUNDERCHIEF

- o Single-seat, single-engine aircraft, meant for a nuclear role but also having an air-to-air capability
- o Designed from the start as a Tactical Air Force fighter-bomber to succeed the F-84F

Date	Event	Source
1951	Design work begins	26, p. 339
March 1952	Requirement issued	137, p. 46
April 1952	Republic submits a proposal for their model AP-63	10, p. 191
May 1952	Air Staff, upon recommendation of the Aircraft & Weapon Board, endorses F-105 development	10, p. 191
September 1952(a) (FSD start)	Letter contract for 199 aircraft--first to be operationally ready by 1955	10, p. 191
10 September 1952	GOR issued	
March 1953	Letter contract reduced to 37 F-105s and nine RF-105s	10, p. 191
October 1953	Mock-up inspection	10, p. 191
December 1953	AF suspends procurement because of Republic's excessive delays	10, p. 191
February 1954	Procurement reinstated but order reduced to 15	10, p. 191
September 1954	AF reduces order to three because of further delays	10, p. 191
October 1954	AF restores order to six	10, p. 191
1 December 1954	Amended GOR 49 called for inflight refueling capability, a more complex fire control system, improved performance, installation of J-75 engine	10, p. 192
22 October 1955	First flight of YF-105A (with interim J-57 engine)	26; 5, p. 213; 17, p. 469; 10, p. 192; 72, p. 7
28 January 1956	Second YF-105A makes first flight	10, p. 192
March 1956	AF releases \$10 million of FY57 funds for the acquisition of 65 F-105Bs and 17 RF-105s	10, p. 192
26 May 1956(b)	First YF-105B makes first flight (first model with J-75 engine); damaged on landing--flight test program delayed	10, p. 192
24 May 1957	First F-105B flown	17, p. 470
22 November 1957	Further revision to GOR 49	10, p. 193
27 May 1958	First acceptance of production aircraft, F-105B	5, p. 213; 17, p. 470; 10, p. 193; 113, p. 8; 76, p. 31
August 1958	Enters operational service	10, p. 193

F-105 REPUBLIC THUNDERCHIEF--continued

Date	Event	Source
January 1959(c)	F-105 declared operational	17, p. 469
April 1961	200th delivery	
1965	Final delivery	8, p. 94

(a) Letter contract covers preproduced engineering, tooling design, fabrication, and material procurement.

(b) 26 gives 22 May 1956 as first F-105B flight.

(c) 10 disagrees; as late as March 1960, none of TAC's F-105s were operationally ready.

F-106 CONVAIR DELTA DART

- o Grew out of Convair's delta wing XF-92
- o Developed during 1955 under the designation of F-102B
- o Originated as part of 1954 Ultimate Interceptor Program
- o All-weather jet interceptor

Date	Event	Source
13 January 1949	ADO--1954 Ultimate Interceptor	10, p. 207
September 1951	Convair's entry selected, design work started on F-102	10, p. 207
24 November 1951	AF production decision, F-102A	10, p. 207
December 1951	AF authorizes two step production F-102A and B with same airframe	10, p. 207
November 1955(a) (FSD start)	Convair awarded new production contracts: 562 F-102As and 17 F-102Bs (brings A total up to 749)	10, p. 208
18 April 1956	F-102B production contract finalized-- 17 F-102Bs earmarked for testing	10, p. 208
17 June 1956	F-102B re-designated F-106	10, p. 209
28 September 1956	AF issues System Development Directive outlining requirements	10, p. 209
26 December 1956	First F-106A flight	10, p. 209; 5, p. 155; 95, p. 6
April 1957	AF conditionally accepts several F-106s	10, p. 210
	F-106B ordered into parallel production with F-106A	25, p. 286
June 1957(b)	Quantity production begins	9, p. 287
19 June 1957	GOR--28 September 1956 requirements finalized	10, p. 210
9 April 1958(c)	F-106B makes first flight	17, p. 172; 10, p. 219; 25
June 1958(d)	Initial delivery of production aircraft	
October 1959	IOC	10, p. 212
April 1960	200th delivery	

(a) First distinguishable event identified with the F-102B/F-106, although actual development work can be traced to early phases of F-102A program.

(b) 5 gives August.

(c) 5 gives April 19.

(d) First acceptance after initial development lot of 17 airplanes. Actual operational service was delayed until 1959. (10 says May; 8, 17, 29 and 25 say July.)

F4H MCDONNELL PHANTOM II

- o Designed as a twin-engined replacement for the Navy's F3H all-weather fighter
- o Originally designated AH-1

Date	Event	Source
Mid-1953	Specification for a new carrier-based aircraft is drawn up	84, p. 213
September 1953	McDonnell presents Navy with unsolicited proposal	29, p. 424
1954	Construction of a full-scale mock-up of F3H-G with J65 engines	84; 6, p.11
18 October 1954(a)	Letter of intent for design work only (no firm requirement) on AH-1 ground attack types with J-79 engines	29; 27, p.341
April 1955	Six months work scrapped--new specification details necessitate a major re-design	84; 6
26 May 1955(b) (FSD start)	Development authorized; redesignated as XF4H-1 missile fighter	29; 27; 6
July 1955	Agreement reached on detail specification for F4H-1	6
27 May 1958	First flight of XF4H-1	29; 27; 84
December 1958(c)	McDonnell receives order for 375 F-4s from the U.S. Navy	84
December 1960(d)	First operational delivery	
1962	F4H-1 redesignated F-4A	29
March 1962	First F-4 accepted by USAF	34, p. 166
October 1962(e)	200th delivery	
1978	5,000th Phantom rolled off assembly line--operated by 11 countries--served in Vietnam War with USAF, Navy, and Marine Corps	84
	Still in production in 1979	34

(a) 84 gives November 1954 as the date of the letter of intent.

(b) The complete system with avionics and missiles was included in prototypes.

(c) 8 claims that in December 1958 BuAer awarded a limited contract for 23 development Phantom IIs plus 24 production aircraft.

(d) Considerable confusion exists in the records on early deliveries. The initial production run of 23 aircraft (in lots of 7, 11, and 5) were clearly F-4A, with the last five incorporating the larger radar dish diameter. Some sources show the second batch of 24 to be F-4A, while other sources call those airplanes F-4B. Regardless of designation, all sources except 84 (including personal recollections of the McDonnell program manager) indicate that the lot starting with unit #24 were the first airplanes delivered to the Navy for operational use. Initial acceptance date of that 24th airplane is also a matter of some uncertainty. Factory records show the first item of that lot to be delivered in December 1960. 27 also gives December 1960 as the date that the first production Phantom II was delivered to a U.S. Navy Squadron, VF-101. However, 6, p. 26, gives February 1961 as date of delivery for inventory.

(e) This assumes that all F-4As were development items.

F-111 GENERAL DYNAMICS

- o World's first variable-geometry aircraft designed as an operational plane
- o First tactical fighter designed from the start to meet the requirements of two major fighting services

Date	Event	Source
27 March 1958	GOR issued	10, p. 223
29 March 1959	GOR canceled--AF feels vertical takeoff not yet possible	10, p. 223
5 February 1960	System Development Requirement 17 incorporated most of the original requirements except vertical take-off	10, p. 223
March 1960	NASA reports feasibility of variable wing sweep	1, p. 179
April 1960	ARDC/IAC joint agreement on development program	1
14 July 1960	SOR 183 issued	161
October 1960	AF request for proposals prepared but deferred by Eisenhower	10, p. 224; 3, p. 451
February 1961	McNamara says TFX should be developed to meet needs of AF and Navy	1, p. 179
7 June 1961	McNamara concludes TFX should fulfill Navy and AF requirements; directs AF to begin development	1, p. 179; 155
September 1961	Official program go-ahead for joint Navy-AF program	
29 September 1961(a)	New request for proposals	10, p. 225
December 1961	TFX designated F-111A	10, p. 225
19 January 1962(b)	Source Selection Board votes unanimously to recommend Boeing as winner of TFX contract	1, p. 180
1 February 1962(c)	\$1 million L/C to Boeing and General Dynamics for more design data	155; 151
11 September 1962	Boeing and General Dynamics submit their fourth and final proposals to the Source Selection Board	1, p. 180
2 and 8 November 1962	Source Selection Board and AF Council recommend Boeing	1, p. 181
24 November 1962	General Dynamics design selected	29, p. 280; 9, p. 297; 1, p. 181; 17; 151
21 December 1962 (FSD start)	R&D letter contract issued to General Dynamics for 18 F-111As and five F-111Bs	155; 161; 151
1 May 1964(d)	Definitized contract for 23 development aircraft	10, p. 226
15 October 1964	Roll-out of the first F-111A	17
21 December 1964	First prototype flight	9, p. 297; 10, p. 226; 161; 26, p. 346

F-111 GENERAL DYNAMICS--continued

Date	Event	Source
6 January 1965	Second prototype flight	17
12 April 1965	Production L/C to General Dynamics	29, p. 281; 10, p. 227; 19; 161; 17
18 May 1965	First F-111B flies	19
July 1966	An F-111 reached maximum design speed of Mach 2.5 for the first time	
12 February 1967	First flight F-111A production aircraft	10, p. 278; 153, p. xvi
April 1967(e)	First production acceptance	
16 October 1967	First delivery of F-111A production aircraft to operational wing	37, p. 119; 17, p. 296; 10, p. 229; 9, p. 300; 29, p. 281
25 March 1968	F-111As enter combat over Vietnam	29, p. 281
28 April 1968	IOC	10, p. 229; 161
April 1968(f)	Cancellation of F-111B	18, p. 252
December 1969	200th delivery	

(a) 1, p. 180, dates RFP as 1 October.

(b) The Source Selection Board and AF Council recommend Boeing three more times in 1962: 14 and 24 May, 20 and 21 June, and 2 and 8 November, respectively--1, pp. 180-181.

(c) 17, p. 295, report that General Dynamics and Boeing are selected as finalists in January 1962.

(d) 155 says that the contract is approved May 22 and distributed on May 27.

(e) 7 claims first service delivery occurs in June 1967. 37, p. 119, gives July 1967 as the initial delivery date of an F-111A to a training unit.

(f) Secretary of the AF Harold Brown stopped work on the F-111B after the House Armed Services Committee disapproved an appropriation for further development and procurement of the Navy model.

F-14 GRUMMAN TOMCAT

- o All-weather, carrier-based, weapon system capable of performing air-to-air combat and air-to-surface attack missions
- o Twin-engine, two-place variable sweep wing, supersonic fighter

Date	Event	Source
September 1966	Preliminary studies	170
October 1967	Grumman submits unsolicited proposal to Navy	135
30 November 1967	Navy Fighter Study initiated to determine Navy tactical fighter requirements and the feasibility of the Grumman design	139, p. 10
March 1968	Navy Fighter Study results published recommending Navy proceed with contract definition	
April 1968	F-111B cancelled; however, use of avionics and engines that had been developed under the F-111B program enabled development and production to proceed rapidly	18, p. 252; 145, pp. 6-7
21 June 1968(a)	Requests for proposals to five manufacturers	159; 26, p. 355
17 July 1968(b)	USN awards contracts to five manufacturers to initiate contract definition phase of VFX program--\$3 million each to five contractors	159; 26, p.355
1 October 1968	Due date for proposals	26
17 December 1968	Source Selection authority announces Grumman and McDonnell Douglas as finalists--proposals to be modified and re-submitted in January 1969	26
15 January 1969	Grumman Model 303 announced winner	18, p. 252 9, p. 341
3 February 1969(c) (FSD start)	Grumman awarded engineering development contract for six F-14As--contract signed	159
May 1969	Airframe mock-up	159
21 December 1970(d)	First flight of development aircraft	9, p. 341; 18, p. 252; 159
30 December 1970	Second flight--hydraulic system fails and plane is lost, causing testing delays	159; 18, p. 252
24 May 1971	Flight testing resumes with second plane	9, p. 341 18, p. 252
May 1972(e)	Production deliveries begin	135; 16
12 October 1972(f)	F-14A delivered to Fleet	9, p. 341; 27, p. 308; 8
July 1976	200th delivery	

- (a) 135 dates RFP release as December 1967.
 (b) 170 gives June as CDP contract award date.
 (c) 9, p. 341 says that six planes were ordered for the development program and six more as preproduction F-14As.
 (d) 159 notes flight occurred one month ahead of schedule.
 (e) 144 dates first delivery of F-14A one month later, in June. 18 gives "late 1972."
 (f) Squadron delivery occurs in early 1973--14, p. 171. 135 gives July 1974 as F-14A fleet deployment date.

F-15 MCDONNELL DOUGLAS EAGLE

- o Originally named F-X
- o Tactical fighter aircraft designed to maintain air superiority through air-to-air combat with nonnuclear weapons

Date	Event	Source
April 1965	Department of the AF directed AFSC to initiate actions to develop and acquire a new tactical support aircraft weapon system	151, p. 3
April 1966	F-X study awarded to three firms	170
12 August 1966	F-X System Program Office established	
September 1966	A Preliminary F-X Concept Formulation Package presented to the ASD Council	
June 1967	Concept Formulation Package (CFP)	151, p. 3
June 1968	Requirement issued	137, p. 52
8 August 1968	RFP released for F-15 attack radar	
9 August 1968	Revised CFP and a Technical Development Plan (TDP)	151, p. 3
27 August 1968	AF awards initial development contracts for the F-15 engine to Pratt and Whitney and GE	
16 September 1968	DoD Development Concept Paper outlines guidelines for F-15 program	151, p. 3
28 September 1968	DCP approved--AF authorized to proceed with contract definition	151, p. 3
30 September 1968	RFP released to eight manufacturers, four respond	151, p. 3
24 October 1968	F-X redesignated F-15A	
19 November 1968	F-15 contract proposal evaluation begins	
31 December 1968	AF announces award of definition contracts to North American, McDonnell Douglas and Fairchild	151, p. 4
13 February 1969	Pratt and Whitney and GE receive competitive contracts to furnish data on engine-airframe compatibility for the F-15 designs	
June 1969	System contract definition reports and proposals for development received from three manufacturers	151
23 December 1969 (FSD start)	McDonnell Douglas named winner	17, p. 370
1 January 1970	F-15 program enters full scale development	151
April 1971	Critical design review	
27 July 1972	First F-15A flight	9, p. 344; 27, p. 343; 135
1 March 1973(a)	Production go-ahead for 30 operational aircraft	27, p. 343

F-15 MCDONNELL DOUGLAS EAGLE--continued

Date	Event	Source
14 November 1974	Squadron delivery (inventory)	27; 13; 8, p. 30
September 1975	IOC	
July 1977	200th delivery	

(a) 135 dates "production decision" as February 1973. 39, p. 19, confirms the number 30 as the initial order. 9, p. 344, claims an order for 20 planes was approved in the spring of 1973.

F-16 GENERAL DYNAMICS

Date	Event	Source
1965-1970	Industry supported design studies	
June 1970	President's Blue Ribbon Panel Report issued; recommended abandoning Total Package Procurement and more use of competitive prototyping	136
September 1971	Lightweight Fighter Program announced	170
6 January 1972(a)	RFP issued for Lightweight Fighter (LWF)	
18 February 1972(b)	Five aircraft manufacturers enter design competition: General Dynamics, Northrop, Boeing, LTV Aerospace and Lockheed	9, p. 347
1 April 1972(c) (Prototype start)	AF awards LWF prototype contracts to General Dynamics and Northrop	136
13 December 1973	First YF-16 prototype rolled out	27
8 January 1974	YF-16 arrives at Edwards AFB	27
20 January 1974	Unscheduled first flight--pilot takes off during taxi tests	27; 9, p.347
2 February 1974	Official first flight of General Dynamics YF-16	27
Spring 1974	Iran, Belgium, Netherlands, Denmark, Norway interested in lightweight fighter; in June, a consortium (without Iran) is formed to find a replacement for the F-104	
9 May 1974	Second YF-16 prototype's first flight	9
9 June 1974	Northrop's YF-17 makes first flight	136
11 July 1974	Written U.S. commitment setting source selection by 1 January	165
7 August 1974	General Dynamics and Northrop awarded "transition" contracts of \$4 million to help them prepare full-scale development proposals	
7 September 1974	USAF issues formal proposal instructions for full scale development of ACF	
November/December 1974	Proposals received and evaluated	
13 January 1975 (FSD start) DSARC II	General Dynamics YF-16 wins; full-scale development contracts awarded	74, p. 75; 27; 9; 97; 37, p.118; 86
7 June 1975	European Consortium chooses F-16	27; 165
27 February 1976	Required operational capability (ROC) TAF 303-76 published	
20 October 1976	First of eight full-scale development F-16s rolled out	136; 77, p.19
8 December 1976	First flight full-scale development F-16A	136
13 October 1977	DepSecDef authorizes full production	166, p. i
7 August 1978	First flight production aircraft	111, p. 159

F-16 GENERAL DYNAMICS--continued

Date	Event	Source
17 August 1978	First production F-16 accepted by AF	111
6 January 1979	First operational F-16 delivered to TAC	37, p. 118
January 1981 (estimated)	200th delivery	

(a) RfQ, January 1972; RfP submitted to USAF in February 1972--170.

(b) 27, p. 299, gives 28 February.

(c) 27 gives April 13 as contract award date. 132, p. 71 does not give an exact date but rather says, "Early in 1972, General Dynamics was awarded a \$38 million contract to develop and produce two YF-16s and Northrop \$39 million for two YF-17s."

F-18 MCDONNELL DOUGLAS HORNET

- o Single-seat, carrier-based naval strike fighter
- o Designed to replace F-4 fighter and A-7 attack aircraft and to complement the F-14

Date	Event	Source
1971	U.S. Navy becomes concerned at cost of F-14	8, p. 32
April 1972	Lightweight fighter prototype program (YF-16, YF-17) started	See F-16
1973	U.S. Navy studies low-cost versions and compares them with navalized F-15 versions and improved F-4s	8, p. 32
April 1974	DoD accepts proposal from the U.S. Navy to study a low-cost lightweight multi-mission fighter, VFAX	27, p. 346
June 1974	USN approaches manufacturers to submit critiques and concepts; USN has responses from six manufacturers	27; 86
9 June 1974	First flight of YF-17	9, p. 350
28 August 1974	Congress terminates VFAX concept; changed to NACF program--Navy issues operational requirement for a new multi-mission aircraft	27; 70, p.25
Fall 1974	Navy is directed to limit its competition to YF-16 (General Dynamics) and YF-17 (Northrop) derivatives	70
12 October 1974	Requests for quotation sent out to industry	149, p. 6
October 1974	Northrop teamed with McDonnell	170
December 1974	McDonnell and LTV respond with preliminary technical proposals	149, p. 6
December-January 1975	McDonnell and LTV furnish additional data	149, p. 6
15-16 January 1975	Navy Source Selection officials meet and advise LTV and McDonnell on the shortcomings of their proposals	149, p. 6
January-February-March 1975	Contractors submit revised proposals	149, p. 6
28 April 1975	Source Selection Authority selects McDonnell Model 267	149, p. 6
2 May 1975	Public announcement of selection; initial short-term contract of \$4.4 million to McDonnell Douglas/Northrop and \$2.2 to GE	27, p. 346 86; 70
9 May 1975	LTV files formal bid of protest with GAO	149, p. 2
1 October 1974	GAO and House of Representatives uphold procurement decision; reject LTV's protest	94; 149, p. 3
21 November 1975	Full-scale development contract to General Electric for F404-GE-400 engine	70
December 1975	DSARC II	
22 January 1976(a) (FSD start)	full-scale development contract with McDonnell Douglas for 11 R&D aircraft	70, p. 25

F-18 MCDONNELL DOUGLAS HORNET--continued

Date	Event	Source
September 1978	F-18 rolled out	70
18 November 1978	First flight	71, p. 19; 93
July 1979	Five aircraft have been delivered to Patuxent Naval Air Test Center	87, p. 45
May 1980 (estimated)	First production delivery	71, p. 19

(a) 27 gives 28 January as contract date. 149, p. 2 gives 26 January.

A-3D DOUGLAS SKYWARRIOR

- o First swept-wing jet attack bomber produced for the Navy
- o Capable of carrying heavy loads of all types of weapons

Date	Event	Source
1947	Discussions between Navy and Douglas; Bureau of Aeronautics outlines requirements for a bomber to operate from a large carrier	18, p. 186; 120
1949	Douglas completes design	19; 18
31 March 1949(a) (Prototype start)	Two prototypes (XA3D-1) ordered	18, p. 186; 19
28 October 1952	First prototype flight (J40 engine)	79; 18; 23, p. 239; 120 5, p. 168
?	Production orders placed	5, p. 168
16 September 1953	Airplane re-equipped with Pratt and Whitney J57-P-6 engine--first flight of this production version	23; 5; 18; 120
January 1955	First acceptance from production batch	
31 March 1956(b)	Enters operational service	18, p. 187; 148
June 1960	200th delivery	

(a) There is no record of a subsequent, separate decision to initiate full-scale development.

(b) April 1956 is given as the date the A3D-1 "begins to reach the Fleet" in 32, p. 18.

A-4 MCDONNELL SKYHAWK

- o Simple, lightweight design
- o Named "Heinemann's Hotrod"
- o Originally designated A4D-1

Date	Event	Source
1951	U.S. Navy requirement for a low-cost attack aircraft	118
21 June 1952 (FSD start)	Initial development contract given Douglas for prototypes and preproduction aircraft	18, p. 305
	Navy inspects mock-up and places orders	19
September 1952	Prototype construction begins	27, p. 352
22 June 1954	First prototype flight, XA4D-1	19; 118; 27
14 August 1954	First flight, A-4A preproduction aircraft with J65-W-2 engine	18, p. 306; 19
August 1955	First delivery--production batch	
26 March 1956	First flight A4D-2 (A-4B)	26, p. 402
26 October 1956(a)	Deliveries begin to Navy Attack Squadron VA-72--enters operational service	18, p. 306; 118; 19; 135
December 1957	200th delivery	
1977	Deliveries neared 3,000	8, p. 84

(a) 148 lists 27 September 1956 as "squadron delivery" date.

A-5 NORTH AMERICAN VIGILANTE

- o Attack bomber designed to carry nuclear or conventional weapons over a range of several hundred miles at high altitudes, with an over-target speed of Mach 2
- o A3J designation changed to A-5 in 1962

Date	Event	Source
1955	Navy requirement for a high-performance attack aircraft with all-weather capability	19; 18, p.352
29 June 1956(a) (FSD start)	Letter contract to North American	19; 18
29 August 1956(b)	First development order	29, p. 361
	Two prototypes ordered	18; 19
31 August 1958(c)	First prototype flight	
January 1959	Large follow-on production contract awarded North American	26; 29, P. 361
February 1960	First production acceptance	18, p. 353; 19
June 1961	Enters squadron service; VAH-7 is first operational unit to receive A-5 (did not reach 200th delivery)	29, p. 361; 18; 11

(a) 29, p. 361, says a "letter of intent" was issued in June 1956. Actual contract followed on 29 August.

(b) 26, p. 412, dates prototype contract as September 1956. This contract apparently included provision for full-scale engineering and an initial production commitment because production deliveries began 18 months after first "prototype" flight.

(c) Three sources agree on the date but differ on designation: 26--YA-5A; 19--YA3J-1; and 11--XA3J-1.

A-6 GRUMMAN INTRUDER

- o World's first fully all-weather/night attack aircraft capable of detecting and identifying tactical or strategic targets and delivering conventional or nuclear weapons on them under zero-visibility conditions

Date	Event	Source
1956	Requirement for a low-level, long-range strike aircraft for U.S. Navy service	18
May 1957	Competition announced; eight manufacturers begin study	27, p. 305; 29, p. 361
31 December 1957(a) (FSD start)	Source selection--Grumman G-128 proposal chosen out of 11 submitted	18; 27; 11
26 March 1959(b)	First contract: initial order for eight development aircraft	148; 18; 26, p. 353; 29
19 April 1960	First flight, development aircraft	29, p. 361; 148; 26, p. 353 11; 135
April 1962	First acceptance from production batch	
Late 1962	First 10 production aircraft are flying	18
1 February 1963(c)	First squadron delivery	18; 26; 11; 148
February 1967	200th delivery	
1975	Final delivery	8, p. 71

(a) This assumes that FSD started immediately after source selection although contract was not signed until 15 months later. This assumption allows 27 months to first flight.

(b) 26, p. 354, notes that the A-6A was developed under the first cost-plus incentive contract placed by the U.S. Navy. Further, 26 states that an additional contract followed in March 1960 and the two contracts together covered the development of eight aircraft. 29 confirms that first contract was for only four aircraft.

(c) 29, p. 361 says A-6 did not reach operational service until 1964.

A-7 VOUGHT CORSAIR II

- o Attack aircraft developed by the U.S. Navy for carrier operation and subsequently flown by both the U.S. Navy and Air Force
- o Adopted by the AF virtually off the shelf, a precedent set by the McDonnell F-4

Date	Event	Source
1960	Bureau of Naval Weapons (BUWEPS) study group recommends development of a new Navy attack a/c to take advantage of new turbofan jet engine, TF-30	138, p. 7
1960-1962	Discussions on visual attack light (VAL) a/c continue	138, p. 7
November 1962	Chief of Naval Operations asks BUWEPS for its VAL recommendations	138, p. 7
December 1962	Sea Based Air Strike Study Group formed	138, p. 8
Early 1963	Group briefs a meeting of eight aircraft contractors on purpose of study--solicit help of entire industry	138, p. 8
April 1963	Group continues to meet with contractors to study plan	138, p. 9
May 1963	Navy Sea Based Strike Study recommends a follow-on visual attack carrier aircraft to replace the A-4	140
17 May 1963(a)	USN initiates design competition for a light attack aircraft to replace the Douglas A-4 Skyhawk, SOR W11-26 drafted by Navy	18; 151
24 May 1963	Synopsis of A-7 requirements transmitted to industry	140
29 June 1963	Formal Request for Quotation distributed to industry	140
12 August 1963	North American, Douglas, LTV submit proposals	138
4 November 1963	Navy evaluates proposals	140
13 November 1963	Secretary of the Navy approves LTV selection as prime contractor	140
11 February 1964	Ling-Temco-Vought named winner	27; 18; 29, p. 362
19 March 1964 (FSD start)	Contract awarded LTV--seven A-7As for flight testing and first 35 production aircraft	27; 18; 151; 138
September 1965	Second production contract for 140 additional F-7As	18
27 September 1965(b)	First A-7A flies	27; 18; 65
March 1966	First delivery from production batch	
13-15 September 1966(c)	U.S. Naval Air Test Center receives first four aircraft	27
14 October 1966	Delivery to user squadrons begins	27
1 February 1967	VA-147 commissioned as the first A-7A tactical squadron	18

A-7 Vought Corsair II--continued

Date	Event	Source
January 1968	200th delivery	
26 September 1968	First A-7D flies with Allison's TF 41-A-1 engine	
11 December 1968	First A-7D aircraft (#5) accepted by the AF at LTV facilities in Dallas	

- (a) 138 dates the Specific Operational Requirement W11-26 as 17 May and says the RFP was not distributed until the following month.
(b) 29, p. 362 dates first flight as 25 September 1965.
(c) 18, p. 293 states that September and October mark delivery dates to first two "training units."

A-10 FAIRCHILD

Date	Event	Source
8 September 1966	Gen. John J. McConnell, USAF Chief of Staff, initiates design of a specialized close-air-support aircraft; issues Chief of Staff Decision Letter	
December 1966	SOR/RAD (AX Design for Advanced Attack Aircraft)	170
6 March 1967	RFPs issued to 21 companies for design studies of a new, low-cost attack aircraft, the A-X	
2 May 1967	Close Air Support (CAS) study contracts to General Dynamics/Convair, Grumman, McDonnell Douglas, and Northrop	
June 1968	AF develops initial concept formulation package for the A-X	
December 1968	Initial decision coordinating paper (DCP) is approved	
September 1969	Supplemental CFP studies completed	
December 1969	Milestone I DSARC Review	
April 1970	DepSecDef approves the A-X for competitive prototype development	
7 May 1970	RFP issued to 12 airframe manufacturers	
10 August 1970	Six aircraft companies submit proposals	
18 December 1970 (Prototype start)	Development contracts awarded to Northrop and Fairchild (competitive prototype development phase)--DSARC I	157
1 March 1971	AF designates A-X prototypes: Northrop, A-9; Fairchild, A-10	
October 1971	Engineering prototype designs complete	157
May 1972	First prototype flights: A-9, May 30; A-10, May 10	
18 January 1973 (FSD start/DSARC II)	AF announces Fairchild's A-10 winner	27, p. 293
28 February 1973	AF awards contracts to Fairchild and General Electric	157
31 July 1974	DoD releases \$39 million to proceed with initial production of 52 A-10s	
December 1974	First flight DT&E	
February 1975	First DT&E aircraft delivered; IOT&E using preproduction aircraft begins	
15 February 1975	First preproduction flight, DT&E at Edwards AFB	
October 1975	First A-10 operational	170
21 October 1975(a)	First production A-10 completes first flight	

A-10 FAIRCHILD--continued

Date	Event	Source
November 1975	First production aircraft delivered	135; 157
5 March 1976	LOT&E testing ends	
20 March 1976	Turnover of the A-10 from the developing command, AFSC, to the using command, TAC--ceremony	
March 1977	First combat-ready A-10 wing	
1 July 1977(b)	First operational squadron of A-10s activated	157
October 1977	First squadron achieves IOC	37
May 1979	200th delivery (estimated)	

(a) 135 reports first production flight as April 1976.
 (b) 37, p. 119, says June.

B-47 BOEING STRATOJET

o First jet bomber to serve in quantity with Strategic Air Command

Date	Event	Source
Autumn 1943	AF invites Boeing and several other manufacturers to study jet bomber designs; AF outlines its tentative requirements	17, p. 114; 67
March 1944	Boeing submits design for Model 424: straight-wing fuselage and tail unit like B-29	17, p. 114; 67
April 1944	AF preliminary characteristics for medium bomber	67
August 1944	ADO issued	
November 1944	GOR/SOR issued	
December 1944	Boeing Model 432 Phase I contract awarded	29, p. 147; 17, p. 114
June 1945	Construction of mock-up authorized	17
September 1945	Model 448 with swept-back wing proposed	29, p. 147; 17, p. 114
October 1945 (Prototype start)	Model 450 with external jet nacelles at various locations proposed--go-ahead from AF	17, p. 114; 29, p. 147; 67
April 1946	Mock-up approved; Boeing receives L/C for Model 450; construction of two airplanes, spare parts, and tools authorized for Phase II	29, p. 147; 17, p. 115
June 1946	Prototype construction begins	17, p. 115; 29, p. 147
12 September 1947	First XB-47 rolls out 17 months after AF approval	67; 2
17 December 1947	First flight of XB-47 prototype	21, p. 204; 17, p. 147; 19; 67; 5, p. 148
21 July 1948	Second prototype flies with more powerful J47	21; 17, p. 115
3 September 1948 (FSD start)	Letter of intent to Boeing for \$30 million to build the A model	67
November 1948(a)	L/C awarded for 10 planes	67
November 1948	First prototype accepted by AF	17, p. 115; 67
December 1948	Second prototype accepted; flight testing begins	17; 67
7 October 1949	First XB-47, re-equipped with J47 engine, makes first flight	17
1 March 1950(b)	First B-47A completed	67
25 June 1950	First production B-47A flies	19; 17, p. 116
December 1950	Delivery of A models begins	17; 67
March 1951	First B-47B completed	67

B-47 BOEING STRATOJET--continued

Date	Event	Source
26 April 1951	First B-47B flies	17, p. 116
Mid-1951	Deliveries of the B-47B begin	17, p. 116
August 1951	First B-47 assigned to SAC	75, p. 25
June 1952	200th delivery	

(a) 17 states that September is the contract date. 29, p. 148 gives October 28 as the date on which 10 B-47As were ordered at a cost of \$37 million. 5, p. 148 confirms the number 10.

(b) 29, p. 148, gives 1 March as the date of first flight of the B-47A with the J47-GE-11 engine.

B-52 BOEING STRATOFORTRESS

- o Still constitutes the major piloted element of SAC
- o Capable of delivering a wide range of weapons, including conventional and nuclear bombs
- o In third decade of service with USAF

Date	Event	Source
April 1945	Design study begins; AF indicates interest to Boeing for turbine-powered long-range bomber	17, p. 120
November 1945	GOR/SOR issued	
January 1946	AF releases a new set of requirements for a heavy bomber; invites industry to submit	29, p. 152; 99; 91
June 1946	Source Selection; Boeing wins contract for further development	17, p. 120; 91
Late 1947	Contract for new full-scale mock-up	91
July 1948 (Prototype start)	Boeing receives contract for two prototypes	17, p. 120; 29, p. 152
27 October 1948	Design accepted	29, p. 152
April 1949	Mock-up approved	29, p. 152
February 1951 (FSD start)	Production order for 13 B-52s	17, p. 121
29 November 1951	XB-52 moved out of factory for ground test	17, p. 120; 91
15 March 1952	YB-52 rolled out	17, p. 121; 91
15 April 1952	First flight YB-52	22, p. 205; 29, p. 152; 91; 135; 17, p. 121
2 October 1952	XB-52 makes first flight	29, p. 152; 23, p. 215; 17, p. 120
18 March 1954	First production B-52 rolled out	53, p. 278
5 August 1954	First production B-52A flight	29, p. 152; 23, p. 215; 17, p. 121
1955	B-52 enters service	17, p. 120; 37, p. 116
29 June 1955	First deliveries of RB-52B to SAC	17
January 1956	\$248 million contract to Boeing	125
August 1957	200th delivery	

B-58 CONVAIR HUSTLER

- o first supersonic strategic bomber put into production for the USAF
- o Three seater, no internal weapons bay
- o Ordered as one of the first systems under the "weapon system concept"

Date	Event	Source
October 1946	ADO issued	
March 1949	GEBO II generalized bomber studies indicate B-58 feasible	92, p. 52
1949-1950	Convair conducted an exhaustive study for USAF to determine technical feasibility and general configuration of a supersonic bomber	69, p. 112
1949	Convair designs win AF competition	17, p. 174; 25, p. 288
17 February 1951	Letter contract for partial Phase I development awarded to Convair	156
26 February 1951	Letter contract for partial Phase I development awarded to Boeing	156
October 1951	Definitive contract negotiated with Convair for Phase I: wind tunnel tests and design studies, prior to construction of a mock-up	156
8 December 1951	GOR published	92; 156
28 February 1952	Plans made to terminate Project MX-1626 (Convair) because of lack of funds, but \$100,000 increment granted to extend program through March 1952	156
10 March 1952	Major realignment of MX-1626	156
12 March 1952	General Phase I program initiated with Boeing and Convair: work limited to generalized design studies to narrow the range of alternatives	156
15 May 1952	Definitive contract supersedes letter contract to cover general Phase I development	156
9 October 1952	WADC recommends to HQ ARDC that MX-1964 be selected	156
18 November 1952(a)	Convair MX-1964 selected over Boeing	156
12 February 1953 (FSD start)	Convair given complete go-ahead for detailed Phase I development program	156
17 February 1953	Letter contract authorizing preproduction planning to permit procurement of 18 weapon systems; detailed engineering; manufacturing of tools and fabrication of parts	
August 1953	Mock-up inspected	29, p. 154
13 October 1954(b)	Contract for 13 aircraft	19; 29, p. 154
11 November 1956	First flight of experimental airplane (J79-GE-1 turbojet engine)	17, p. 174; 19; 29, p. 154; 5, p. 156; 25, p. 288

B-58 CONVAIR HUSTLER--continued

Date	Event	Source
4 December 1956	First supersonic flight of B-58	156
February 1957	Second prototype's first flight	25; 17, p. 14
Spring 1957(c)	Additional order of 17 aircraft added to original 13	25
September 1959(d)	First production B-58A flies	17, p. 174; 15, p. 42
November 1959(e)	First production acceptance (aircraft #31)	
15 March 1960(f)	SAC receives first B-58A with J79-GE-5A engine	17, p. 175; 29
	Did not reach 200th delivery	

(a) 17 and 12 give August 1952 as Convair MX-1964 selection and contract date. 25 agrees on August.

(b) 29, p. 154, gives this date as the ordering of first 13 aircraft. 19 and 25 agree first order is for 13 but do not give date.

(c) In 19 and 40, October is noted for the ordering of 17 planes.

(d) This was the 31st airplane produced.

(e) 29, p. 155 gives September 1959 as date of delivery. Two other sources (25 and 54) give December 1959 as first production delivery, and 15 specifically gives 1 December 1959.

(f) 25 states that in 1960 the B-58 reached operational status. 69 agrees.

B-70 NORTH AMERICAN VALKYRIE

Date	Event	Source
14 October 1954	Original USAF requirement issued, GOR 38, for an Intercontinental Bombardment	25
1955	Designated Weapon System 110A	25
18 February 1955	System Requirement 22 issued	147
22 March 1955	GOR 38 superseded by GOR 82	
13 July 1955	Joint ARDC-AMC Source Selection Board proposed a list of six contractors	
8 November 1955	Boeing and North American (the only contractors to submit proposals) were given Phase I development contracts	
23 December 1957	North American was selected as prime contractor for Phase I	25
24 January 1958	Letter contracts signed with North American and GE	147
7 March 1958	Revised GOR 82 published; greater emphasis placed on speed	147
19 March 1958	Acceleration of program announced	147
7 October 1958	B-70 program set back to slower pace	147
11 August 1959	Decision to use high energy fuel abandoned; J-93-GE-5 engine canceled and J-93-GE-3 turbojets substituted	147
December 1959	Program cut back to one prototype	25; 147
Mid-1960	Partial restoration of budget cut	25
31 October 1960	Announcement that \$265 million would be available for the B-70 program	25
March 1961	President Kennedy stated that B-70 development as a full weapon system is unnecessary; suggests program be continued to explore flying at Mach 3; wanted only a few experimental prototypes	25a
March 1963	Decision to build only two XB-70A for aerodynamic research	25a
11 May 1964	First public showing	25a
21 September 1964	First flight, first prototype	25a
12 October 1964	Mach 1 exceeded (3rd flight)	25a
17 July 1965	First flight, second XB-70A	25a
14 October 1965	Mach 3 first attained (17th flight)	25a
8 June 1966	Second XB-70A lost when it collided with F-104	25a
25 March 1967	NASA takes over program management	25a

B-1 NORTH AMERICAN ROCKWELL

Date	Event	Source
1962	Informal design studies began	27, p. 388
September 1963	DepSecDef approved \$15 million in FY 1965 funds to initiate development of a penetrating strategic aircraft	151
October 1963	Approval changes; funds reduced to \$5 million to provide for aircraft studies only	151
April 1964	Advanced Manned Strategic Aircraft SPO established	
July 1964	Funded studies started	
April 1965	Requirement issued for an Advanced Manned Strategic system	27
20 November 1968	B-1 Development Concept Paper approved by the DepSecDef. This DCP approved a competitive design approach aimed at reducing the lead time from development to operational use without a commitment to FSD	151
Early 1969	The SecDef changed the procurement plan from a competitive design approach to a full-scale engineering development program to be initiated in FY 1970	151
3 November 1969	DoD issued RFP to industry (three airframe and two engine finalists)	27
14 January 1970	Airframe proposal due-date	47a
10 February 1970	Economic proposals due	47a
4 June 1970	DSARC authorization to proceed into full-scale development	
5 June 1970 (FSD start)	Research, development, test, and evaluation contracts awarded to Rockwell and GE (original cost-plus-incentive contract for five flying prototypes, two structural test airframes and 40 engines)	27
January 1971	Design of the B-1 frozen. Contract quantities reduced to three flight test aircraft, one ground test aircraft, and 27 engines	27
26 October 1974	First B-1 bomber prototype	49
23 December 1974	First flight successfully completed	50, p. 12
10 April 1975	First supersonic flight	51, p. 17
FY1976 Budget	Procurement of a fourth test aircraft as a preproduction prototype approved	27
1 April 1976	No. 2 prototype flies	52
14 June 1976	Third prototype flies	52, p. 32
October 1976	Production decision scheduled	50, p. 12
December 1976	DSARC III (production go-ahead)	
30 June 1977	President Carter announced that production of the B-1 would be canceled	27a

C-5A LOCKHEED GALAXY

- o large, long-range, heavy logistic aircraft
- o Developed under Total Package Procurement Concept (TPPC)
- o Able to operate from short landing fields and unpaved runways
- o Cargo volume is four times greater than C-141

Date	Event	Source
1963	CX-4 requirement issued by the USAF's Military Air Transport Service for a large logistics transport aircraft	17, p. 356
1964	C-5A studies confirmed that concept of heavy logistics transport is feasible	141
25 March 1964	AF released SOR 214 for a heavy logistics aircraft system	
May 1964	Initial design competition. Boeing, Douglas, and Lockheed invited to develop their initial designs further. Pratt and Whitney and General Electric invited to develop accompanying powerplant	27, p. 338
11 December 1964	RFP released to contractors	151
31 December 1964	AF awarded program definition contracts	
April 1965	Proposals received--AF Source Selection Board begins evaluation	151
August 1965	Source Selection Board recommends Boeing	151
1 October 1965(a) (FSD start)	General Electric and Lockheed proposals selected. Contract for five RDT&E aircraft plus an initial run of 53 aircraft	141; 27, p. 338; 158; 151
December 1965	\$1,400 million to cover development and production of first 58 C-5As	100
August 1966	Initial construction begins	27
2 November 1967	GAO begins investigation of C-5A program	153
February 1968	Roll-out of first aircraft	158
30 June 1968	First of five development aircraft flies	27; 158; 17; 98
30 June 1969	C-5A Category II testing began	
October 1969	Delivery of first operational aircraft	158
17 December 1969	First delivery to MAC	17, p. 356; 37, p. 122; 8, p. 173
June 1970	Enters operational service	48, p. 40
September 1970	IOC	158
May 1973	Final delivery. Deliveries do not reach 200	8, p. 173

(a) Source selection date: 30 September 1965--167.

C-130 LOCKHEED HERCULES

- o First transport produced under weapon system concept
- o Has been in service 25 years

Date	Event	Source
1951	Development starts after USAF decision to equip with turboprop transports	17, p. 350
18 January 1951	ADO issued	
January 1951	USAF issues requirement for medium transport and work begins	24, p. 316; 89, p. 93
12 March 1951	GOR/SOR issued	
2 July 1951 (Prototype start)	Source Selection: Lockheed	89
11 July 1951	Contract for two prototype YC-130s	17, p. 350
August 1951	Work begins at Lockheed-Burbank on two prototypes	89, p. 93
September 1952(a) (FSD start)	Production contract	17, p. 350; 146
23 August 1954	First prototype YC-130 flight	89; 5, p. 181; 17, p. 350; 135; 81, p. 15
March 1955	First production model rolled out	81
7 April 1955	First production C-130A flies	5, p. 181; 89
December 1955(b)	First acceptance from production lot	
9 December 1956	Deliveries begin to Troop	17, p. 350; 24 89; 146; 37, p. 122
1 June 1957	First wing combat ready	90, p. 32
February 1959	200th delivery	

- (a) 24 gives 19 September 1952 as date of "prototype contract."
- (b) 146 gives September 1955 as date of a conditional acceptance.

C-133 DOUGLAS CARGOMASTER

Date	Event	Source
1952	Operational requirement for a heavy strategic freighter	17, p. 272
February 1953 (FSD start)	Douglas design accepted. Detail design work begins	17, p. 272; 24, p. 282
1954	Production contract for 35 aircraft. No prototypes built (six preproduction aircraft, however)	11; 17, p. 272; 5, p. 161; 8
31 January 1956	C-133 rolled out from Douglas, Long Beach	68, p. 186
February 1956	First C-133A completed	24, p. 161
23 April 1956	First flight C-133A	5, p. 161; 24; 17, p. 272; 8, p. 177
End of January 1957	Four planes had been delivered to AF for testing	24
29 August 1957(a)	First operational C-133 delivered	24; 17, p. 272; 5, p. 161
31 October 1959	First flight C-133B	8, p. 177
1961	Delivery completed (did not reach 200th delivery)	8, p. 177

(a) Fuselage shape changed after first seven aircraft.

C-141 LOCKHEED STARLIFTER

- o First jet aircraft designed from the outset as a military cargo airplane
- o Its purpose was to provide fast transportation over global ranges for the USAF Military Airlift Command and on strategic routes for Strike Command
- o Equipped with all-weather landing system

Date	Event	Source
4 May 1960	SOR 182 issued for a large capacity intercontinental cargo jet	17
13 March 1961	Design competition. Lockheed named winner over Boeing	17; 59, p. 762
April 1961	Letter contract	146, p. 3-1
May 1962(a)	Definitive contract for five aircraft	146, p. 3-2
August 1963	Roll-out, Lockheed-Marietta	41
August 1963	First AF acceptance	146, p. 3-2
17 December 1963	First development C-141A flies from Dobbins AFB, GA	17, p. 354; 103, p. 8
May 1964	Definitive contract for 127 aircraft	146, p. 3-2
19 October 1964(b)	First production delivery	17, p. 354; 135; 146, p. 3-1
23 April 1965	Begins squadron operations with MAC	17, p. 354; 37, p. 124
April 1967	200th delivery	
July 1968	Final delivery	8, p. 174

(a) 17 gives 16 August 1961, as the date of the contract for five development C-141As.

(b) This assumes that the first three aircraft of the production lot were used for development testing.

KC-135 BOEING STRATOTANKER

- o High speed, high altitude capability
- o Standard USAF tanker in the 1960s
- o Used as a tanker, cargo or personnel transport

Date	Event	Source
20 May 1952 (Prototype start)	Development of a Boeing jet transport prototype begins--"DASH 80"	17, p. 126; 85; 142
August 1952	Boeing announces it is developing prototype (investing \$15 million of its own funds)	142
May 1953	Prototype mock-up	
November 1953	Gen. Curtis LeMay issues a requirement for 200 jet tankers to support future B-52 and B-58 fleet	142
March 1954	Design initiated	
May 1954	DASH 80 rolled out	142
	Hq ARDC invites Lockheed, Convair, Douglas, Boeing, Fairchild, and Martin to submit proposals for an advanced jet tanker	142
15 July 1954	First DASH 80 prototype flight	17, p. 126
5 August 1954(a) (FSD start)	AF announces purchase of a limited number of the Model 707 jet transports--cost: \$240 million	25, p. 270; 128
2 March 1955	AF decides to order substantially more aircraft--brings total order to \$700 million	128
18 July 1956	KC-135A rolls out	25; 82, p. 11
31 August 1956	First flight KC-135A	25; 17, p. 126 37, p. 123
31 January 1957	First KC-135A accepted by AF	17, p. 126;
18 June 1957	Becomes operational. Initial delivery to Castle AFB	25; 17
January 1959	200th delivery	
Mid-1966	Final delivery	8, p. 156

(a) 17 gives 5 October as the Air Force announcement date of the initial purchase of 29 KC-135s. 8 also chooses October as the order date for 29 aircraft. 142 adds, "Because of SAC's urgent tanker requirements and logistics constraints, the competition idea was dropped and Boeing was chosen sole source contractor."

P-3 LOCKHEED ORION

- o Four-engine, turboprop, land-based ASW patrol plane
- o Based on the commercial turboprop, Electra
- o Replaced the P2V/P-2 Neptune and P5M/P-5 Marlin as the U.S. Navy's standard patrol aircraft

Date	Event	Source
1954	Design of the Electra began to meet requirements set by American Airlines for a short-medium range transport	4
June 1955	American and Eastern Airlines buy Lockheed's model L-188. Combined order: 75 a/c	4
Mid-1956	Navy considers alternative to P-2. Works with Lockheed on Model CL-353. Electra goes into serial production about this time	
August 1957	USN calls for design proposals to provide a replacement for the P-2 Neptune. Manufacturers to modify aircraft already in production	18, p. 278
December 1957	Lockheed submits Electra proposal to Navy	
6 December 1957	First commercial Electra flies	4
24 April 1958 (FSD start)	Lockheed wins Navy competition with adaptation of commercial Electra turboprop. R&D contract issued for P-3 system	18; 29, p. 318; 26
19 May 1958	Fifth Electra flies (this is first aircraft delivered to the airlines)	4
19 August 1958	First P-3 prototype flight (modified Electra)	26; 18; 14
September 1958	Mock-up review	
12 January 1959	Electra enters commercial service with Eastern	4
25 November 1959	First flight of second prototype, YP3V-1, with full electronics	29, p. 318; 26; 11; 18
October 1960	Seven production planes ordered	29, p. 318
Late 1960	Name "Orion" adopted	18
15 April 1961(a)	First flight production P-3A	11; 26
March 1962(b)	First acceptance of operational configuration	
December 1966	200th delivery	

(a) There is much confusion on the flight date of the first production P-3A. 150 claims March is the correct date. 18 and 29 confirm 15 April but call it first flight of the preproduction P-3A.

(b) Assumes first lot of seven aircraft were for test (supported by 18, who say six aircraft were used for flight test and evaluation). Actual squadron delivery was not until mid-1962. Delay of squadron service was presumably due to avionics system. (18 and 26 give 13 August 1962 as squadron delivery date; 11 confirms August while 29 and 14 agree on July.)

S-3 LOCKHEED VIKING

- o Carrier-based anti-submarine search and strike aircraft (VSX)
- o Compact, high-wing monoplane powered by two GE TF34 turbofan engines in underwing pods

Date	Event	Source
February 1965	Tentative requirement by Chief of Naval Operations as follow-on to Grumman S-2E	
November 1965	Navy requested an expression of interest by aircraft manufacturers to perform concept formulation studies	
December 1965	SOR issued. Ten companies respond	163
	Study contracts awarded to Lockheed-California and McDonnell Douglas	
December 1967	Release of RFP to five manufacturers: General Dynamics/Convair, Grumman, McDonnell Douglas, North American Rockwell, and Lockheed-California	163; 17
April 1968	Five manufacturers submit proposals	11
August 1968	Award of contract definition contracts	163
	Lockheed and General Dynamics asked to refine their proposals	11
23 December 1968	Lockheed and General Dynamics submit new proposals	
1 August 1969 (FSD start)	USN issues Engineering Development contract to Lockheed for six prototypes	163
4 August 1969	Lockheed announces receipt of \$461 million contract	27, p. 328
March 1970	Full-size mock-up completed	163; 11
8 November 1971(a)	First development aircraft rolls out	11; 27; 115, p. 38; 101, p. 18
21 January 1972(b)	First flight development aircraft	11; 27; 8, p. 146
4 May 1972	USN announces order for 13 S-3As, first production lot	27, p. 329
November 1973	First S-3A carrier landing (USS Forrestal)	17, p. 282
Late 1973(c)	Deliveries begin to U.S. Navy	11
20 February 1974(d)	Officially introduced to fleet	27, p. 329; 8
July 1975	First operational deployment	27

(a) 27 claims 8 November is the date of the first R&D flight.

(b) 48a states first flight is scheduled for early January (1972).

(c) 17, p. 282 says that "deliveries to the Air Anti-Submarine (Training) Squadron 41 (VS-41) begin in February 1974 for crew training."

(d) Service delivery occurs October 1973--8, p. 146. This assumes that the first four development aircraft were used for testing.

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Appendix B

A COMPENDIUM OF HELICOPTER PROGRAM MILESTONES

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Helicopter Number	Name	Manufacturer and Model No.	Page
AH-1	HueyCobra	Bell Model 209	103
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OH-23	Raven	Hiller UH-12	115
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UH-1	Iroquois	Bell Models 204/205/212	120
UH-2	Seasprite		122
UH-60 (UTTAS)	Blackhawk	Sikorsky S-70	124
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AH-1 HUEYCOBRA (Bell Model 209)

Date	Event	Source
March 1965	Design work begins	6, p. 269
	The original prototype was developed solely on the initiative of the Bell Helicopter Company through its Independent Research and Development Program	36, p. 21
7 September 1965	First prototype flight	6, p. 269; 11, p. 210; 35, p. 188
October 1965	Department of the Army authorizes the Army Materiel Command to conduct "comparative" test of the Piasecki 16H, the Boeing-Vertol CH-47A (modified) and the Bell Model 209 at Edwards AFB	37, p. 35
December 1965	Prototype delivered to U.S. Army for testing and evaluation	6, p. 269; 11, p. 210
11 March 1966	U.S. Army announces HueyCobra will be produced	6, p. 269; 11, p. 210; 35, p. 188
4 April 1966	Bell announces receipt of development contract for two "preproduction" helicopters, designated AH-1G	6, p. 269; 11, p. 210; 37, p. 35
13 April 1966	U.S. Army issues initial production contract for about 100 AH-1G helicopters	6, p. 269; 11, p. 210; 37, p. 35
June 1967	First delivery of AH-1G	6, p. 269; 12; 36, p. 21
8 October 1967	Initial deployment of AH-1G in Vietnam	6, p. 269; 12; 13, p. 30
March 1968	USMC requests funds for AH-1J (twin-turbine version, designated "SeaCobra")	14, p. 18
May 1968	Initial production order for 49 AH-1J SeaCobras	6, p. 270; 12
1969	USMC acquires 38 AH-1G's for training and transitional deployment pending delivery of the AH-1J	6, p. 269
14 October 1969	Preproduction AH-1J displayed	7, p. 240
Mid-1970	First production AH-1J delivered	6, p. 270
March 1973	First delivery of preproduction AH-1Q to U.S. Army for firing tests. (The AH-1Q is an anti-armor version of the AH-1G that fires TOW missiles and has helmet site subsystem)	15, p. 9
January 1974	U.S. Army awards contract to Bell to convert 101 AH-1Gs to the AH-1Q configuration	6, p. 270
	A total of 290 AH-1Q conversions was ordered, but after 92 had been completed, the AH-1Q program was terminated in favor of two improved models, the AH-1R (without TOW) and the AH-1S (with TOW)	36, p. 21

AH-1 HUEYCOBRA (Bell Model 209)--continued

Date	Event	Source
10 June 1975	First delivery of production AH-1Q to U.S. Army	6, p. 270
1975-1976	U.S. Army awards contract for new production of advanced version of AH-1Q, designated AH-1S	7, p. 240
16 March 1977	First delivery of new production AH-1S	7, p. 240

AH-64 (AAH) BLACK HAWK (Hughes Model 77)

Date	Event	Source
7 August 1972	U.S. Army Systems Acquisition Review Council recommends ending Boeing-Vertol Cheyenne program	4, p. 7
10 November 1972	RFP for advanced attack helicopter released	4, p. 8; 12
22 June 1973	U.S. Army awards Phase I development contracts to Bell and Hughes for airframe and full system	16, p. 11; 4, p. 12; 7, p. 320
19 April 1975	Bell begins airframe ground tests	17, p. 35; 4, p. 21
June 1975	Hughes begins airframe ground tests	4, p. 21; 7, p. 320
30 September 1975	First prototype flight of Hughes YAH-64	18, p. 23; 4, p. 21; 36, p. 44
1 October 1975	First prototype flight of Bell YAH-63	18, p. 23; 4, p. 21
February 1976	U.S. Army changes armament and targeting requirements	4, p. 30
May 1976	Hughes delivers first prototype to U.S. Army for flight tests	36, p. 44; 7, p. 32
June 1976	Bell delivers first prototype to U.S. Army for flight tests	4, p. 23
September 1976	U.S. Army changes machine gun ammunition requirements	4, p. 30
30 September 1976	Government Competitive Testing ends	4, p. 23
27 November 1976	TADS/PNVS proposals submitted	12
10 December 1976	U.S. Army awards Phase II development contract to Hughes	4, p. 24; 42, p. 728
10 March 1977	TADS/PNVS development contracts awarded	12
June 1979	First prototype flights with TADS/PNVS systems	41, p. 43
January 1980	Competitive flyoff between Northrop and Martin Marietta TADS/PNVS systems begin	41, p. 43

CH-3, HH-3 JOLLY GREEN GIANT (Sikorsky S-61R)

Date	Event	Source
November 1962	USAF selects S-61R for transporting troops, cargo, personnel, or casualties	2, p. 93
8 February 1963	USAF orders 22 CH-3Cs	10, p. 295; 36, p. 68
17 June 1963	First prototype flight of CH-3C	10, p. 295
July 1963	USAF announces CH-3C selected for long-range support system	2, p. 93; 10, p. 295
July 1963	First flight of production CH-3C	10, p. 295; 34, p. 258; 36, p. 68
30 December 1963	First operational delivery of CH-3C for drone recovery duties at Tyndall AFB, Florida	6, p. 454; 10, p. 295; 36, p. 68
30 December 1963	S-61R receives FAA Type Approval	10, p. 295
February 1966	USAF orders all CH-3Cs converted to uprated configuration, designated CH-3E	6, p. 454; 11, p. 348; 24, p. 122
	(Forty-two new CH-3Es were built in addition to the CH-3C conversions)	36, p. 38
	USAF Aerospace Rescue and Recovery Service used a version of the CH-3E designated HH-3E. It differed from the CH-3E in having armor, self-sealing fuel tanks, retractable flight refueling probe, defensive armament, and a rescue hoist	11, p. 348
	(Fifty CH-3Es were converted to the HH-3E standard)	36, p. 68
1968	First delivery of the HH-3F Pelican. The USCG used the HH-3F for extended search and rescue missions. While similar to the HH-3E, it is unarmed and has no armament but is fitted with advanced electronic search equipment	36, p. 68

CH-46, UH-46 SEA KNIGHT (Boeing-Vertol Model 107)

In 1956, Vertol began preliminary design and engineering of a twin-turbine transport for commercial and military markets. Vertol wanted to take advantage of the high power, small size and light weight of the shaft turbine engines that were then becoming available. The prototype work was performed entirely under company funding.

Date	Event	Source
May 1957	Construction of prototype begins	8, p. 294; 10, p. 193
22 April 1958	First prototype flight	8, p. 294; 12; 11, p. 222
July 1958	U.S. Army orders ten Model 107s for evaluation	3, p. 174
27 August 1959	First flight of U.S. Army evaluation aircraft	3, p. 174; 34, p. 246; 36, p. 32
25 October 1960	U.S. Army tests begin	8, p. 294; 10, p. 193
February 1961	USMC announces Model 107 as the winner of a design competition for a medium assault helicopter, designated CH-46A. Boeing-Vertol receives initial order for 14 aircraft	3, p. 175; 12; 11, p. 223; 36, p. 32
19 May 1961	First flight of production CH-46	10, p. 193
26 January 1962	Model 107 receives FAA Type Approval	10, p. 193
16 October 1962	First flight of production CH-46A	8, p. 295; 11, p. 223; 34, p. 246; 12
July 1964	First operational delivery of the UH-46A to Utility Helicopter Squadron One, Ream Field, California. (The UH-46A is the USN version of the CH-46A)	8, p. 294; 12
1 November 1964	CH-46A officially accepted by USMC	19
November 1964	USN Board of Inspection and Survey test completed (required for fleet release)	8, p. 295; 11, p. 223
December 1964	First operational deployment	12
March 1966	First deployment in Vietnam	12; 11, p. 223
September 1966	First production CH-46D delivered from converted CH-46A production line. (The CH-46D is an updated version of the CH-46A and all aircraft produced after September 1966 were of the 46D configuration)	12
September 1966	First UH-46D delivered from converted 46A production line	12

CH-47 CHINOOK (Boeing-Vertol Models 114/234)

Date	Event	Source
1956	U.S. Army announces intention of replacing piston-engined transport helicopters with turbine-powered versions	6, p. 290
March 1959	Boeing-Vertol Model 114 wins design competition	6, p. 290; 3, p. 173
June 1959	U.S. Army/USAF Selection Board awards initial contract for five prototypes	6, p. 290; 11, p. 224; 36, p. 34
1960	First production contract for CH-47A	11, p. 224
28 April 1961	First prototype delivered for ground tests	2, p. 23; 10, p. 195; 11, p. 224
21 September 1961	First prototype flight	2, p. 23; 10, p. 195; 11, p. 224; 34, p. 245
16 August 1962	First production delivery of CH-47A	2, p. 23
December 1962	First operational delivery of CH-47A to U.S. Army	36, p. 34
October 1966	First flight of CH-47B. The CH-47B was developed from the CH-47A with larger engines, redesigned rotor blades, and other minor changes.	3, p. 174; 11, p. 224; 34, p. 245; 36, p. 34
10 May 1967	First delivery of CH-47B	3, p. 174; 11, p. 224; 36, p. 34
14 October 1967	First preproduction delivery of the CH-47C for testing. The CH-47C was a further development in the Chinook series with larger engines, strengthened transmission, and increased fuel capacity	3, p. 174
14 October 1967	First flight of CH-47C	36, p. 34
Spring 1968	First delivery of production CH-47C	3, p. 174
September 1968	First deployment of CH-47C in Vietnam	36, p. 34

CH-53 SEA STALLION (Sikorsky S-65A)

Antecedents to the S-65A: The S-56 was a new design (Sikorsky's first twin-engine helicopter) built to meet USMC requirements for an assault transport capable of carrying about 26 troops. It retained the classic Sikorsky layout of a single main rotor and anti-torque tail rotor. The new features included placing the two engines in pods on each side of the fuselage (leaving the cabin area for load carrying). The main legs of the under-carriage were retractable into the engine pods and clam-shell doors below the flight deck provided direct access to the cabin. Empty weight was about 20,800 lb and gross weight was about 31,000 lb. It used two Pratt and Whitney R-2800 engines and could carry 20 troops or 1900 cu ft of cargo.

Date	Event	Source
9 May 1951	USN issues prototype contract	2, p. 87; 3, p. 135
18 December 1953	First prototype flight	2, p. 87; 3, p. 135
25 October 1955	First production model flight	2, p. 87
26 July 1956	First operational delivery to USN	2, p. 87; 3, p. 136

The U.S. Army also bought some S-56s

The S-60 was Sikorsky's first attempt at building a flying crane helicopter. The design work was jointly funded by the company and the USN. To speed development and minimize flight testing, the S-60 used the power plant, rotor, and transmission systems from the S-56. As with the S-56, the Pratt and Whitney R-2800 engines were mounted in outriggered pods into which the wheels could be partially retracted. The fuselage was a boom with a cockpit at the front end, the main rotor mounting in the middle and the tail rotor at the back end. The payload of up to six tons could be attached under the boom between the wheels like a module or could be slung from a hoist.

Date	Event	Source
May 1958	Design work begins	2, p. 97
25 March 1959	First prototype flight	2, p. 97
3 April 1961	S-60 prototype destroyed in crash	2, p. 97

Work on the S-64 had begun before the S-60 crash and was a company-funded development of a turbine-powered variant to the S-60. It had a similar fuselage and rotor system but used a six-bladed rather than a four-bladed main rotor. It also differed in that its two 4050 shp JFTD-12A shaft turbines were mounted side by side on top of the fuselage boom immediately below the rotor. It also had a new under-carriage design with "kneeling" capability. Its personnel and cargo pod could carry 68 troops or 48 stretchers or 55 airline passengers. Its empty weight was about 17,200 lb and its gross weight was about 38,000 lb. For related dates, see CH-54A.

The S-65 incorporated parts from the S-64, but its fuselage resembled a scaled-up version of the S-61R although it was flat-bottomed, which differed from the S-61R's boat hull. The watertight hull had sponsons amidships that housed the fuel tanks and main undercarriage. The rotors, transmission, and other dynamic components were taken from the S-64. However, the S-65 had a rear-loading ramp and could carry about 8,000 lb internally or 13,000 lb externally. Standard power plant was the T64-GE-6 shaft turbine.

CH-53 SEA STALLION (Sikorsky S-65A)--continued

Date	Event	Source
27 August 1962	USN announces that Sikorsky has been selected as the USMC heavy assault helicopter	6, p. 456; 10, p. 297; 11, p. 250
August 1962	Initial production contract awarded for the CH-53A	1/Part 1
14 October 1964	First prototype flight	6, p. 456; 10, p. 297; 20, p. 37;
June 1966	First delivery of CH-53A	12
September 1966	USAF orders eight HH-53Bs. The HH-53B was similar to the CH-53A. It was used by the USAF Aerospace Rescue and Recovery Service. It was armed and had jettisonable fuel tanks, retractable refuelling probe, and a rescue hoist.	6, p. 457; 11, p. 350
January 1967	First deployment of CH-53A in Vietnam	11, p. 350
15 March 1967	First flight of production HH-53B	6, p. 457; 11, p. 350; 21, p. 67; 24, p. 122
June 1967	First delivery of HH-53B	6, p. 457; 11, p. 250; 24, p. 122; 36, p. 71
30 August 1968	First delivery to USAF of HH-53C, an improved version of the HH-53B	6, p. 457; 24, p. 122; 36, p. 71
3 March 1969	First delivery to USMC of CH-53D, an improved version of the CH-53A	6, p. 457; 36, p. 71
27 October 1970	USN announces plans to form mine countermeasures squadrons; the unit was formed using 15 CH-53As borrowed from the USMC and redesignated RH-53A	6, p. 458
31 January 1972	Last delivery of CH-53D. (A total of 265 were delivered to the USMC.)	6, p. 457; 36, p. 71
February 1972	Sikorsky announces receipt of USN award of an advanced procurement authorization for 30 RH-53Ds, an improved version of the RH-53A	6, p. 458
27 October 1972	First prototype flight of the RH-53D	6, p. 458
September 1973	First delivery of the RH-53D	6, p. 458; 36, p. 71
1 March 1974	First YCH-53E prototype flight. The CH-53E was developed for the USMC and USN as a utility and tactical support helicopter. It is a three-engine development of the S-65A and has a seven-bladed main rotor with titanium blades, an uprated transmission, modified tail surfaces, and other airframe and equipment improvements	36, p. 72
Early 1976	Flight testing of preproduction models begin	36, p. 72
May 1976	Structural demonstration tests begin	36, p. 72
28 February 1978	First production order for six CH-53Es received from USMC	36, p. 72

CH-54 TARHE (Sikorsky S-64A)

Background: See CH-53.

Date	Event	Source
9 May 1962	First S-64A prototype flight	2, p. 97; 10, p. 296; 8, p. 451; 36, p. 70
June 1963	U.S. Army orders six S-64As to test the heavy lift concept for increasing mobility under battlefield conditions (designated YCH-54A)	8, p. 451; 10, p. 296; 25, p. 324; 36, p. 70
30 June 1964	U.S. Army accepts first YCH-54A	10, p. 296; 22, p. 57; 36, p. 70
October 1964	First delivery of test vehicle	10, p. 296
Late 1964	First operational delivery to U.S. Army	7, p. 403
3 July 1965	S-64A receives FAA Type Approval	6, p. 455
January 1968	First delivery of skycrane modular van accepted by government	23, p. 23
4 July 1968	Sikorsky announces receipt of U.S. Army contract to increase payload capacity of the CH-54A. Required design improvements to the engine, gearbox, rotor head and structure. The Army also wanted improved altitude and hot weather operating capabilities (designated CH-54B)	6, p. 455
1969	First operational delivery of CH-54B	6, p. 455

HH-43, UH-43, OH-43 HUSKIE (Kaman K-600/600-3)

Kaman had developed several predecessors to the K-600 during the late 1940s and early 1950s. The USN bought one K-225 for evaluation in March 1950 (the K-225 had received FAA Type Approval September 16, 1949). In June 1950, the USN purchased another K-225. These tests led to a USN contract to develop the K-240 and on 5 September 1950, the USN ordered 29 K-240 helicopters (first delivery was November 1951). The K-240 was the immediate predecessor to the K-600.

Date	Event	Source
June 26, 1950	USN announces K-600 winner of a design competition for a USMC liaison and general utility helicopter. The contract was for "off the drawing board" development, designated OH-43D	2, p. 53; 3, p. 162
27 September 1956	First prototype flight using an XT53 engine in a modified OH-43D airframe (predecessor to the K-600-3)	2, p. 51; 3, p. 162; 9, p. 249; 34, p. 249
27 December 1956	USN orders 24 UH-43C (the K-600) for general utility duties	2, p. 53; 3, p. 162
1957	USAF conducts evaluation for local crash rescue. It found no acceptable design, but ordered the K-600 as an interim measure until the K-600-3 was ready	2, p. 51
April 1958	First delivery of OH-43D to USMC	3, p. 162
May 1958	First delivery of production UH-43C to USN	2, p. 53
1 August 1958	First operational delivery of UH-43C	2, p. 53
19 September 1958	First flight of production USAF HH-43A (differed from USMC and USN K-600s only in its rescue equipment)	3, p. 162; 2, p. 51
November 1958	First delivery of HH-43A to USAF.	2, p. 51
13 December 1958	First flight of K-600-3 prototype (which became the HH-43B)	3, p. 162; 2, p. 51; 34, p. 249
August 1964	First flight of the production HH-43F. (This was an improved version of the HH-43B, with greater power, increased fuel capacity, and other minor changes. It was designed for operations where optimum altitude performance under hot-weather conditions was required.)	24, p. 122; 34, p. 249

HH-52A (Sikorsky S-62A)

Based on the S-55, the S-62A had identical main and tail rotors, transmission systems and other dynamic components to this predecessor. The main difference was that it used turbine rather than piston engines. It had a different fuselage design for fully amphibious operations (flying boat hull and undercarriage wheels that were semiretractable within two outriggered stabilizing floats. The single GE shaft turbine engine was mounted above the main cabin, which could accommodate a two-person crew and 10-12 passengers.

Date	Event	Source
Late 1957	Sikorsky begins design work on S-62	3, p. 150
14 May 1958	First prototype flight	10, p. 296; 36, p. 69
30 June 1960	S-62A receives FAA Type Approval	3, p. 150; 10, p. 296
6 February 1962	After service testing the S-62A, the USN orders four production models for the USCG	3, p. 150; 2, p. 95
January 1963	First production delivery of HH-52A	10, p. 296

OH-6 CAYUSE (Hughes Model 369)

Date	Event	Source
1960	DoD issues Technical Specification No. 153 to initiate design competition for a light observation helicopter (light-weight, four-place helicopter with Allison T63 gas turbine engine capable of carrying a 400 lb payload plus pilot and full fuel load. Minimum speed was to be 110 kt)	3, p. 156; 2, p. 46
October 1960	RFP issued	12
19 May 1961	U.S. Army announces Bell and Hiller selected to build prototypes (Twelve companies had submitted 22 designs in the LOH competition)	6, p. 359
June 1961	Hughes is added to the list of winners; all three companies to build five prototypes each	6, p. 359
8 December 1962	First prototype flight, Bell Model 206	2, p. 14; 12
26 January 1963	First prototype flight, Hiller Model 1100	2, p. 46; 11, p. 254
27 February 1963	First prototype flight, Hughes Model 369	3, p. 156; 9, p. 245; 11, p. 275; 36, p. 42
November 1963	U.S. Army selection trials begin	3, p. 157
26 May 1965	U.S. Army selects Hughes 369 as LOH. Initial order for 714 helicopters issued, designated OH-6 Cayuse.	9, p. 245; 11, p. 275; 26, p. 20
September 1966	First delivery of production OH-6	3, p. 157

OH-23 RAVEN (Hiller UH-12)

During the late 1940s, Hiller designed a light single-engine helicopter that subsequently evolved into the UH-12 prototype.

Date	Event	Source
14 October 1948	UH-12 receives FAA Type Approval	3, p. 121
1950	Modifications to the rotor blades and use of a larger engine became the UH-12A model	3, p. 121
May 1950	USN and the U.S. Army each procure one UH-12A for evaluation	2, p. 41
8 May 1950	UH-12A receives FAA Type Approval	2, p. 41
August 1950	Service evaluations completed	2, p. 41
1950	USN orders small number of UH-12As as trainers, designated HTE-1	2, p. 41
1950	U.S. Army orders about 100 UH-12As as the OH-23 Raven	2, p. 41
1951	Deliveries to USN and U.S. Army begin	2, p. 41
1951	After operational experience in Korea, the U.S. Army requested certain modifications to improve performance under wartime conditions. This led to the development of the UH-12B	2, p. 41
2 November 1951	UH-12B receives FAA Type Approval	2, p. 41
Date NA	U.S. Army orders UH-12B as OH-23B; Eventually bought about 273 OH-23Bs most of which were assigned to the Primary Helicopter School	2, p. 41
1955	Major design changes lead to the UH-12C	3, p. 122
12 December 1955	UH-12C receives FAA Type Approval	3, p. 122
1956	U.S. Army begins receiving UH-12C designated OH-23C	3, p. 122
3 April 1956	First prototype flight of UH-12D which was an improved version of the UH-12C	3, p. 122; 2, p. 42
December 1957	First delivery of UH-12D to U.S. Army, designated OH-23D	2, p. 42
23 December 1957	UH-12D receives FAA Type Approval.	2, p. 42
6 January 1959	UH-12E receives FAA Type Approval (it was an improved version of the UH-12D)	2, p. 42
1963	U.S. Army orders UH-12E as the OH-23G with the last order for OH-23Ds specifying that they be upgraded to the 23G configuration	10, p. 232

OH-58 KIOWA (Bell Model 206A)

Bell developed the Model 206A JetRanger as a commercial venture after losing the original LOH competition to Hughes (see OH-6). The Model 206A was based heavily on Bell's LOH entry.

Date	Event	Source
July 1965	Company-funded construction of the Model 206A prototype begins (two months after Hughes won the LOH competition)	11, p. 207
10 January 1966	Bell Model 206A first prototype flight	3, p. 158; 11, p. 207
20 October 1966	Model 206A receives FAA Type Approval	3, p. 158; 11, p. 207
August 1967	U S Army reopens LOH competition	12; 27, p 15
February 1968	USN selects Bell 206A JetRanger for trainer, designated TH-57A SeaRanger	29, p. 17
8 March 1968	U.S. Army names Bell winner of reopened LOH competition and orders first increment of planned 2,200 helicopter buy, designated OH-58A	6, p. 268; 28, p. 326
October 1968	First delivery of TH-57A to USN	12
23 May 1969	First delivery of OH-58A Kiowa	12; 6, p. 268; 36, p. 24
August 1969	First deployment of OH-58A in Vietnam	6, p. 268; 36, p. 24
30 June 1976	U.S. Army grants "development qualification contract" to Bell to convert OH-58As to an improved standard, designated OH-58C	7, p. 239

SH-3 SEA KING (Sikorsky S-61A/B/F)

Date	Event	Source
23 September 1957	USN awards contract for development of an amphibious anti-submarine helicopter	6, p. 452; 10, p. 294; 36, p. 65
11 March 1959	First prototype flight of the SH-3A (first known as the HSS-2)	2, p. 91; 6, p. 452; 10, p. 294
1960	First delivery of prototype for service testing (seven had been ordered)	3, p. 148
8 February 1961	Navy Board of Inspection and Survey trials begin	10, p. 294
September 1961	First fleet delivery	6, p. 452; 36, p. 65
April 1964	USN contract announced for conversion of SH-3As for mine countermeasures duty (carry, stream, tow, and retrieve a variety of mine countermeasures gear), designated RH-3A	6, p. 453; 10, p. 293
1965	Deliveries begin of RH-3A conversions	6, p. 453
June 1966	Deliveries begin of uprated SH-3As, designated SH-3D	6, p. 453; 11, p. 346
10 June 1971	USN announces contract to convert all SH-3A, SH-3D, and SH-3G helicopters to an improved configuration, designated SH-3H (had new sonar equipment for anti-submarine warfare duties and new radar for anti-missile defense)	6, p. 453

SH-34 SEABAT, CH-34 CHOCTAW, UH-34 SEAHORSE (Sikorsky S-58)

The S-55 was the forerunner of the S-58 and the S-62. Before this model, Sikorsky had built primarily small single-seat or two-seater helicopters, mainly for the USAAF and USN during World War II. The layout of the S-55 was similar to earlier Sikorsky efforts with the single main rotor and a tail boom carrying the tail rotor. The S-55 differed in its larger size and in the location of the engine in the nose of the vehicle with the transmission shaft running up through the center of the cockpit to the rotor head, leaving the main cabin area free for cargo.

Date	Event	Source
1948	Five S-55 prototypes ordered	2, p. 89
10 November 1949	First S-55 prototype flight	2, p. 89; 34, p. 254
1951	USAF issues first contract for production S-55s	2, p. 89
	USAF eventually bought over 450 S-55s	
28 April 1950	USN places first production order for S-55	2, p. 89
27 December 1950	First operational delivery to Utility Squadron HU-2	2, p. 89
	USN eventually bought almost 200 S-55s	
August 1950	USMC adopts S-55 as assault transport with self-sealing fuel tanks	2, p. 89
2 April 1951	First delivery of S-55 to USMC	2, p. 89

The S-58 was designed specifically for anti-submarine warfare duties with the USN. The S-55 had been used but lacked sufficient load-carrying ability and range. The S-58 is larger but retained the S-55's general layout. It has a larger engine and a four-bladed rather than a three-bladed main rotor that can be folded for ship-board storage. It could accommodate twice as many passengers as the S-55.

Date	Event	Source
30 June 1952	USN contracts for S-58 prototype	2, p. 89; 36, p. 64
8 March 1954	First S-58 prototype flight	10, p. 292; 2, p. 89; 35, p. 173; 34, p. 255
	Preliminary production contracts had already been issued for the SH-34G Seabat by the time the first S-58 prototype had flown	2, p. 89
20 September 1954	First production SH-34G flight	2, p. 89
August 1955	First operational delivery to HS-3 Squadron	2, p. 89; 3, p. 138

The USMC bought S-58s as utility transports (UH-34D Seahorse). The first USMC production order was 15 October 1954 with the first operational delivery occurring on 5 February 1957. The U.S. Army also purchased S-58s (CH-34A Choctaw). The first Army production order was placed in 1953 and the first delivery was in April 1955.

TH-55A OSAGE (Hughes Model 269A-1)

Date	Event	Source
1954-1960	Hughes commissioned an extensive market research program that persuaded management of a substantial market potential for light helicopters	2, p. 49
September 1955	Hughes begins development of a light-weight helicopter on its own for the commercial market	2, p. 49; 10, p. 236
October 1956	First prototype flight of Model 269	2, p. 49; 10, p. 236; 36, p. 41
1958	U.S. Army orders five Model 269As for tests as a light helicopter trainer	2, p. 49
July 1960	Hughes decides on commercial production of the Model 269A (an improved version of the Model 269)	2, p. 49
25 October 1961	First commercial delivery of production Model 269A	2, p. 49; 36, p. 41
Mid-1964	U.S. Army selects Model 269A-1 as a light helicopter trainer	8, p. 362

UH-1 IROQUOIS (Bell Models 204/205/212)

Date	Event	Source
1954	U.S. Army initiates design competition for a helicopter to perform general utility duties, front-line casualty evacuation, and instrument flight training	12
June 1955	Bell wins design competition. U.S. Army orders three prototypes	2, p. 11; 12; 34, p. 244
22 October 1956	First prototype flight of the UH-1 (Model 204)	2, p. 11
1957	U.S. Army orders six UH-1s for service testing	2, p. 11
February 1958	First service test flight of UH-1	2, p. 11
Early 1958	U.S. Army places first production order for the UH-1A. (The UH-1A was the first large-scale production version of the Iroquois series. It was generally similar to the UH-1 prototypes with only minor changes.)	2, p. 11
September 1958	First flight of production UH-1A	1/Part 2
1959	U.S. Army requests development of improved version of the UH-1A	2, p. 12
June 1959	Development of improved version begins	2, p. 12
30 June 1959	First delivery of production UH-1A	2, p. 11; 12; 36, p. 29
1960	First deployment of the UH-1A	2, p. 11
1960	First prototype flight of UH-1B	2, p. 12
July 1960	U.S. Army announces contract for seven test models of an improved Iroquois with larger carrying capacity and longer range at faster speeds, designated the UH-1D (Bell Model 205)	2, p. 12; 6, p. 266; 11, p. 208
December 1960	U.S. Army issues first production order for the UH-1B	2, p. 12
March 1961	First production delivery of UH-1B	2, p. 12; 10, p. 182
16 August 1961	First prototype flight of UH-1D	2, p. 12; 6, p. 266; 11, p. 208
1961	U.S. Army orders production of UH-1D	2, p. 12
March 1962	Bell wins USMC design competition for an assault support helicopter with a variant of the UH-1B (differing mainly in equipment), designated UH-1E	2, p. 13; 6, p. 266
March 1962	U.S. Army flight testing of UH-1D begins at Edwards AFB	11, p. 209
February 1963	First flight of production UH-1E	10, p. 182; 11, p. 209
May 1963	First delivery of production UH-1D	2, p. 12
June 1963	Bell wins USAF design competition for missile site support helicopter with a variant to the UH-1B, designated UH-1F	30, p. 55; 10, p. 182

UH-1 IROQUOIS (Bell Models 204/205/212)--continued

Date	Event	Source
June 1963	USAF first production order for 25 UH-1Fs	6, p. 266; 11, p. 209
9 August 1963	First deployment of UH-1D (11th Air Assault Division, Ft. Benning)	6, p. 266; 36, p. 30; 10, p. 182; 11, p. 209
20 February 1964	First test flight of UH-1F	31, p. 21; 24, p. 121; 6, p. 266; 10, p. 182
21 February 1964	First operational delivery of UH-1E (Marine Air Group 26, New River, NC)	6, p. 266; 10, p. 182; 11, p. 209
September 1964	First production delivery of UH-1F (4486th Test Squadron, Eglin AFB)	6, p. 266; 10, p. 182; 24, p. 121; 11, p. 209
September 1967	First production delivery of the UH-1H (Bell Model 205A-1, which was similar to the UH-1D with a larger engine and was ordered as replacement to the UH-1D)	7, p. 237; 36, p. 30
1 May 1968	Bell announces receipt of a development of a contract from the Canadian government for a twin-engine version of the UH-1H (uses the UH-1H airframe but has twin turbines and advanced avionics), designated UH-1N (Bell Model 212)	6, p. 271; 24, p. 121
19 September 1969	Bell announces production order from Canadian government for the UH-1N	6, p. 271; 24, p. 121
September 1969	USAF orders 79 UH-1Ns, USN orders 40 UH-1Ns, and USMC orders 22 UH-1Ns	6, p. 271; 24, p. 121
September 1970	First delivery of UH-1N to USAF	6, p. 271
4 November 1970	USAF issues fixed-price contract for 30 local base rescue helicopters, designated HH-1H (the same as the UH-1H Bell Model 205, but with different equipment)	6, p. 266; 24, p. 121
April 1971	First delivery of UH-1N to USMC	6, p. 271
Late 1971	First delivery of UH-1N to USN	6, p. 271
1972	First delivery of HH-1H to USAF	24, p. 121

UH-2 SEASPRITE

Date	Event	Source
1956	Kaman wins USN design competition for a fast long-range utility helicopter. Its primary role was search and rescue. Other duties included all-weather carrier guard duty, gunfire observation, courier duty, personnel transfer, reconnaissance, tactical air controller, and medical evacuation. It was to have emergency flotation capability.	2, p. 55
29 November 1957	USN order four test models and 12 production models, designated UH-2	2, p. 55
2 July 1959	First test flight	2, p. 55; 10, p. 241; 34, p. 250; 36, p. 45
18 December 1962	First delivery of production version, designated UH-2A	2, p. 55; 9, p. 250; 10, p. 241; 11, p. 278; 36, p. 45
4 June 1963	First shipboard service (aboard the USS Independence)	3, p. 142; 10, p. 241; 11, p. 278
8 August 1963	First shipboard delivery of the UH-2B (aboard the USS Albany). It had been developed from the UH-2A for VFR conditions and differed only in its electronic navigational equipment	6, p. 364; 3, p. 142; 10, p. 241; 11, p. 278; 36, p. 45
2 January 1964	Kaman announces receipt of USN contract to add special rescue equipment to the UH-2A and UH-2B. The converted model was designated UH-2C	10, p. 241; 11, p. 278
March 1965	First conversion to the UH-2C configuration completed	3, p. 142
August 1967	Deliveries of converted UH-2C models begin	6, p. 364; 8, p. 366
February 1970	First operational delivery of the HH-2D, an armed and armored twin-engine development of the UH-2C. Its primary mission was the search and rescue of downed pilots	6, p. 364
October 1970	USN awards Kaman a contract for modifying 10 HH-2Ds to the interim LAMPS (Light Airborne Multi-Purpose System) configuration for anti-submarine warfare and anti-ship missile defense duties, designated the SH-2D	6, p. 364
	LAMPS modifications involved (1) installation of Canadian Marconi LN 66 high-power surface radar in a glassfibre honeycomb dome under the chin; (2) ASQ-81 MAD deployed by winch from a pylon on the starboard side of the fuselage; (3) 15 AN, p. SSQ-47 active or AN, p. SSQ-41 passive sonobuoys launched by a small explosive charge from a removable rack on the port side; (4) ALR-54 electronic support measure; (5) 8 Mk 25 marine	

UH-2 SEASPRITE--continued

Date	Event	Source
	flares, p. smoke markers; (6) data link; (7) tactical navigational system and associated communications and control units, recorders, displays and antennae; (8) auxiliary fuel tanks hardened for launching Mk 44 and Mk 46 ASW homing torpedoes.	
16 March 1971	First flight of the SH-2D	6, p. 364; 36, p. 45
July 1971	Additional 10 conversions ordered	6, p. 364
7 December 1971	First operational deployment	6, p. 364; 36, p. 45
March 1972	All 20 conversions completed	6, p. 364
February 1973	First USN contract for SH-2F LAMPS. This was an improved version of the SH-2D. It had a new rotor developed under joint USN-Kaman funding that increased performance in terms of reliability and maintenance through elimination of most of the vibration. It also had a shorter wheelbase, stronger landing gear, improved navigational and communications equipment and new engines. The USN planned to convert all HH-2s and SH-2Ds to the SH-2F configuration.	6, p. 364
May 1973	First delivery of converted SH-2F	6, p. 364; 7, p. 322
11 September 1973	First operational deployment of the SH-2F	6, p. 364; 7, p. 322

UH-60 (UTTAS) BLACKHAWK (Sikorsky S-70)

Although improved performance (over that of the UH-1 series) was one goal of the U.S. Army's Utility Tactical Transport Aircraft System (UTTAS), more important was minimizing lifetime cost by enhancing reliability, availability, and maintainability (RAM). Believing that reliable RAM statistics could be generated only by using full-scale production prototypes, and believing that performance requirements could be met with available low-risk technology, the service initiated the program as a full-scale development; the UTTAS program began with DSARC II and ended with a production decision. To generate statistically significant RAM figures before making a production commitment, the Army hoped to take six full-scale prototypes from each of two competing contractors through a total of 11,360 flight test hours. Although subsequently abbreviated by the Congress, the approved program still involved several thousand hours of aircraft and engine testing over two years.

Date	Event	Source
July 1968	Concept formulation	12
August 1968	First study contracts awarded	12
22 June 1971	Blackhawk approved for full-scale development. (DEPSECDEF, on the DSARC recommendation, signs Decision Coordinating Paper No. 13.)	40, p. 3
July 1971	Engine RFP issued	5, p. 32
5 January 1972	Airframe RFP issued	5, p. 32
6 March 1972	Engine development contract awarded to General Electric Company	40, p. 3
31 March 1972	Airframe proposals received	40, p. 3
30 August 1972	Airframe prototype development contracts awarded to Sikorsky and Boeing-Vertol	5, p. 32; 36, p. 74; 40, p. 3
17 October 1974	Sikorsky first prototype flight	5, p. 21; 32, p. 22; 36, p. 74
29 November 1974	Boeing-Vertol first prototype flight	5, p. 21; 33, p. 21
20 March 1976	Three prototypes from each contractor accepted by the U.S. Army	40, p. 6
March 1976	Government fly-off begins	40, p. 6; 36, p. 74
31 August 1976	Sikorsky ground test vehicle delivered	40, p. 6
1 September 1976	Boeing-Vertol ground test vehicle delivered	40, p. 6
23 December 1976	Sikorsky wins production contract with 12 helicopters ordered. Also received option to produce up to 330 more UH-60s over three years	5, p. 41; 43, p. 4; 36, p. 74
23 December 1976	GE awarded engine production contract for 53 T-700 engines	36, p. 74; 40, p. 6
1 September 1977	S-70 elected by USN as the SH-60B LAMPS III helicopter to replace the SH-2F Seasprite. It differs from the UTTAS in having automatic rotor blade and tail	36, p. 74

UH-60 (UTTAS) BLACKHAWK (Sikorsky S-70)--continued

Date	Event	Source
	rotor pylon folding, movement of the tail wheel further forward, MAD, and surface search radar. It can carry two Mk 46 torpedoes	
28 February 1978	Development contract for five prototype SH-60B's received	36, p. 74
October 1978	First flight of production UH-60A	39, p. 22
31 October 1978	First production delivery of UH-60A UTTAS to U.S. Army	40, p. 6
11 June 1979	Flight Development Test and Evaluation of UH-60A begins	40, p. 6
12 December 1979	First prototype flight of SH-60B Seahawk	38, p. 19

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Appendix C
A COMPENDIUM OF MISSILE
PROGRAM MILESTONES

CONTENTS

Missile Number	Name	Page
GAR-1	Falcon	130
IM-99A	Bomarc	131
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Unless other sources are specifically cited, all data in this appendix were derived from the files of the Historical Office, Aeronautical Systems Division of AFSC, Wright-Patterson Air Force Base, Ohio.

GAR-1 FALCON

Date	Event
<u>YGAR-1</u>	
7 November 1947	Requirement established
March 1947	Project initiated--study and development program for a small supersonic air-to-air guided rocket
June 1947	Project reduced to the development of the semi-active radar seeker because of budget limitations
March 1948 (FSD start)	Project reinstated as a complete missile development
February 1949	Hq USAF directed that development of the fighter-launched guided aircraft rocket for offensive use have priority over the bomber launched missile development
May 1951	First YGAR-1 air launch
January 1954	Service procurement of YGAR
November 1954	First production GAR-1s delivered
<u>XGAR-1A</u>	
30 March 1955	GOR 84 issued
12 May 1955	First XGAR-1A missile was air-launched
November 1956	Production of GAR-1 missiles terminated

IM-99A BOMARC

Date	Event
24 November 1949	Study begins under Hq USAF authority
January 1950(a)	Boeing Airplane Company and the Aeronautical Research Center of the University of Michigan requested by Air Materiel Command to make a cooperative study
May 1950	Study completed; Boeing authorized to begin preliminary design
22 September 1950	Military characteristics for missile are published
31 December 1950(a)	Boeing's preliminary design work completed
12 January 1951(a) (FSD start)	AF contract authorizing development
10 September 1952(a)	First flight test
August 1954(a)	First successful flight (6th missile)
30 April 1959	Initial delivery date
1 September 1959(b)	Operational date
September 1959	Category II test program held in abeyance because of inadequate test results
February 1960	Testing resumed
September 1960	Category II tests successfully completed

(a) Development of USAF XIM-99A Weapon System, Jan. 1951-Mar. 1959, Boeing Aircraft Co.

(b) Charles E. Minihan, "The BOMARC Weapon System," Air University Review, Vol. 13, No. 4, Summer 1962.

TM-76B MACE

Date	Event
12 October 1954	GOR 37 issued
19 January 1955	System requirement No. 15
Late 1955	Funds allocated and contract let to Martin
27 January 1956 (FSD start)	Development contract
1956	Active R&D
1957	Funds severely cut
7 August 1959	Production contract
6 February 1958	First inertial guidance flight
November 1960	First production delivery

AGM-69A SRAM

Date	Event
24 April 1963	Hq USAF issued ADO 51 for all-weather, tactical air-to-surface missile
1 August 1963(a)	USAF published a draft SOR on SRAM
18 March 1964	SOR 12 issued
23 March 1965(b)	Secretary McNamara approved the initial development of SRAM
29 April 1965	Hq USAF issued System Definition Directive ZAGM-69A, which formally authorized initiation of project definition
28 July 1965	Hq USAF approved release of RFP to industry for Phase I
30 July 1965	RFP released
30 August 1965	AF received SRAM definition proposals from five contractors
2 November 1965	AF announced that Martin-Marietta Corp. and Boeing had won Phase I competition
2 September 1966	Contractor completed Phase I tasks
31 October 1966 (FSD start)	Secretary of the AF announced Boeing as Phase II contractor
7 November 1966	Boeing awarded propulsion contract to Lockheed Propulsion Co.
21 November 1966	Acquisition contract awarded to Boeing
6 December 1967	First dummy missile dropped
1 April 1968	SecDef approved Development Concept Paper 51 for the AGM-69A program
1 August 1968	AF begins FB-111 SRAM Category I flight testing
July 1969	First powered launch
9 July 1969	Contractor launched first SRAM from a B-52 carrier
26 January 1970	DoD approved 1,900 missile procurement program on an incremental basis
June 1970	Long lead production authorized
5 December 1970	DoD approved SRAM production
12 January 1971(b)	Hq USAF awarded a contract to Boeing for SRAM production
1 March 1972(b)	First production SRAM delivered to SAC
August 1972	AF activated first B-52 SRAM squadron
12 January 1973	Procurement reduced from 1,900 to 1,500

(a) "Chronology of Events Related to the Advanced Manned Strategic Aircraft Program, 1954-1964" (unpublished USAF working paper).

(b) Strategic Air Command Chronology, 1939-1973, Office of the Historian, Hq Strategic Air Command, 2 September 1975.

AGM-65A/B MAVERICK

Date	Event
15 July 1964	SOR 215 issued
7 June 1966	Concept formulation started
10 July 1968 (FSD start)	Contract definition completed contract awarded
3 September 1968	DCP approved
3 March 1969	Preliminary design review
1 August 1969	Category I flight test begins
15 May 1970	Critical design review
22 December 1970	Preliminary configuration inspection
16 January 1971	Category II flight test begins
June 1971	DSARC III
26 November 1971	Category II flight test ends
1 September 1972	Engineering development ends
December 1972	Delivery date of first production missile
15 February 1973	IOC
24 July 1973	FACI

GAM-87 SKYBOLT

Date	Event
July 1957	RFP for missile to be launched from B-52; ballistic mode considered, but rejected because of long development time
October 1957	System requirement #187, calling for an advanced air-to-air missile
January 1958	One-year demonstration program started
March 1958	Contract to Martin for 4-missile flight test.
July 1958	Range goal of test vehicles extended, more test items added to Martin contract
December 1958	Demonstration program completed; possibility of air-launching a ballistic missile proven
January 1959	GOR #177 issued, development program for operational system authorized, RFP issued
May 1959	Source Selection announced; DDR&E directed that initial work be limited to design studies
July-October 1959	Major subcontractors selected
February 1960 (FSD start)	OSD authorizes full scale development
December 1960	Development funds reduced, program stretched
April 1962	First powered flight
December 1962	Program canceled

GAM-72 QUAIL

Date	Event
13 October 1952(a)	SAC requirement forwarded to Hq USAF
March 1953	GOR issued
October 1953	Development Directive authorized ARDC to start full development program
November 1954	Source selection forwarded to Hq USAF
April 1955 (FSD start)	Development contracts awarded for Phase I (to mockup)
September 1955	Funding cut
18 January 1956(b)	Hq USAF issued GOR #139 for a short-range, air-launched missile, later designated Quail
1 February 1956(b)	McDonnell selected for Phase II development
November 1957	First glide launch
August 1958	First powered flight
31 December 1958(b)	Letter contract for initial production lot awarded McDonnell
1 March 1960(b)	First successful powered flight of a prototype Quail missile
13 September 1960(b)	First production Quail missiles delivered
1 February 1961(b)	First squadron operational

(a) From Snark to SRAM: A Pictorial History of Strategic Air Command Missiles, Office of the Historian, Hq Strategic Air Command, 21 March 1976.
 (b) Strategic Air Command Chronology, 1939-1973, Office of the Historian, Hq Strategic Air Command, 2 September 1975.

GAM-77 HOUND DOG

Date	Event
15 March 1956(a)	GOR 148 issued, calling for B-52 ASM; major contenders were Rascal and Regulus II
June 1956	Proposals submitted by Bell and Vought for System 131A
September 1956	System 131A canceled
March 1957	North American submits initial proposal for a lightweight ASM
April 1957	Draft revision of GOR #148 issued, emphasizing lightweight missile
June 1957	New system specs issued, system designated 131B
July 1957	Proposals submitted by firms
July 1957	Navaho program canceled
August 1957	Revised GOR formally issued
23 August 1957(a) (FSD start)	NAA selected; design start authorized
October 1957	P&W J52 engine selected
16 October 1958(b)	Letter contract for first year's production
December 1958	Rascal program canceled
23 April 1959(a)	First powered flight of a prototype Hound Dog
August 1959	First guidance flight
August 1959	150 hour test on engine completed
Late 1959	First production autopilot used in flight test
21 December 1959(a)	AF accepted first production missile, and delivered it to SAC that same month
September 1960	Negotiations on production start
October 1960	Nuclear Weapons System Safety Board judged system safe for alert status and peacetime flying
November 1960	Production rate ordered reduced to 17/month because of continuing reliability and performance problems
January 1961	Announcement that B-52s at W-P AFB would be equipped with missiles in mid-1961
June 1961	215 missiles delivered by end of June, at rate of 18/month
June 1961	First missile delivered to Air Training Command
September 1961	Last of 247 GAM-77 missiles delivered
Late 1961	Fully satisfactory flight tests obtained
28 March 1963(a)	Production of the Hound Dog missile completed

(a) Strategic Air Command Chronology, 1939-1973, Office of the Historian, Hq Strategic Air Command, 2 September 1975.

SM-64 NAVAHO

Date	Event
April 1946	Navaho research and development program began as a one year study and research effort by North American Aviation
1947	Original program expanded to develop three missile designs with gradually increasing ranges
26 May 1948(a)	First Navaho research test vehicle (NATIV) successfully launched at White Sands Proving Ground, New Mexico
Late 1949	AF decided to develop the intermediate range vehicle with 1,000 nautical mile range into an air-launched weapon
February 1950	Three phases outlined
July 1950	AF had dropped plans for the air-launched missile in favor of supersonic, intercontinental guided missile
September 1950	New program aimed at a surface-launched 5,500 mile missile by 1958 was proposed by North American and accepted by the AF
March 1952	AF contracted for two XB-64 vehicles to be delivered in January and May 1954
May 1952	\$4 million budget cut in FY1953 budget; schedule slippage pushes acceptance date to May 1954 XB-64A program delay also. Delivery of first missile rescheduled for June 1957 with first flight for December 1957
October 1953	AF decides to increase the size of the XB-64A rather than depend on super fuels to increase the range
Early 1955	B symbol eliminated, replaced by SM
June 1955	Formal mock-up inspection
23 February 1956(a)	AF Secretary Donald A. Quarles directed the acceleration of the Navaho missile program
August 1956	Three attempts made at static firing of the rocket booster for XSM-64, all unsuccessful
6 November 1956	First XSM-64 firing and flight was unseccessful; flight lasted only 26 seconds.
22 March 1957	Second launch of XSM-64 missile; considered a partial success
25 April 1957	Third attempt to launch XSM-64 failed
12 July 1957(a)	Navaho program canceled

(a) Strategic Air Command Chronology, 1939-1973, Office of the Historian, Hq Strategic Air Command, 2 September 1975.

TM-61A MATADOR

Date	Event
24 August 1945	AAF military characteristics published for development of a ground-launched pilotless bomber with a 175-500 mile range and a 600 mph speed
Mid-December 1945	Glenn L. Martin Co. submitted a development proposal
March 1946	letter contract for \$864,000 for a one year research agenda awarded to Martin for a subsonic and supersonic 175-500 mile range guided missile
October 1946	Further contract awarded Martin to continue research
December 1946	Because of a reduction in AAF R&D funds, Martin was requested to continue research on subsonic missile only
30 June 1947	Materiel Command contracted for production of one missile
10 December 1947	First dummy missile launched
May 1948	AF contracted for 14 experimental (XSSM-A-1) missiles
June 1948	Contract signed
19 January 1949	First experimental missile launched
January 1949- December 1950	15 experimental missiles launched
September 1950	AF gave Matador 1-A priority
September 1950	First experimental missile delivered
21 December 1950	Letter contract calling for production line to be set up
22 December 1950	Second letter contract provided for 70 missiles
7 December 1951	First experimental Matador launched by military personnel
24 March 1952	New contract raised number of TM-61A missiles to 255
June 1952	First production Matador delivered
December 1952	First successful flight of a TM-61A
November 1954	Martin authorized to procure materials and begin necessary engineering work for the TM-61C production program

Appendix D

TRENDS IN AIRCRAFT PRODUCTION UNIT COST

One possible explanation for the apparent decrease in typical production rates is that investment rates have not kept pace with the increase in unit cost of modern aircraft. To explore the relationship between unit cost and production rate, the unit cost of several aircraft was estimated on a constant-dollar basis.

Table D.1 documents the flyaway cost estimates for most aircraft models in the sample. Although the sample contains 36 types, the reasons reported in the note on the table caused ten deletions. In some cases data were not available for the exact aircraft model in the sample, so a similar aircraft (listed in column (2)) was used as a basis for the estimate.

Column (3) shows the flyaway cost estimates. Flyaway cost includes the following airborne and installed equipment: airframe, propulsion, electronics, armament, and other government furnished equipment. The estimates ignore RDT&E, operations, investment in peculiar support (i.e., peculiar aerospace ground equipment, training equipment, and technical data) and initial spares. Costs are shown as averages for the first 200 units in millions of fiscal year 1975 dollars.

The analysis adjusted costs for actual quantities to the first 200 units by means of assumed log-linear cumulative average learning curves. Manufacturing experience of the aerospace industry suggests an 80 percent slope for attack, fighter, and bomber aircraft and a 75 percent slope for patrol, cargo, and tanker aircraft. A Department of Defense procurement price index standardized costs to fiscal year 1975 dollars.²⁴ The date at which production for operational inventory began is shown in Col. (4), and the length of time required to produce the first two hundred items is in Col. (5). The average monthly production rate is shown in Col. (6). The last column (7) shows the average investment rate (in millions of FY 1975 dollars) implied by the production rate and the unit cost. That investment rate is then plotted for each aircraft in Fig. D.1 as a function of the date at which production began.

The data show considerable scatter and thus are subject to some different interpretations. The entire sample has so much scatter that a linear regression yields statistically insignificant results (i.e., no trend can be confidently identified). However, the two large strategic aircraft in the sample (B-47 and B-52) had exceptionally large investment rates, and if those are eliminated from the sample the average investment rate actually appears to be rising somewhat over the time period in question. This simply strengthens the argument that production rate is largely a resource-limited parameter and that the reduced production rates during recent years can be traced mainly to the increase in average unit cost.

²⁴Department of the Air Force, *Department of Defense Deflators, USAF Cost and Planning Factors*, AFR 173-10, Vol. I (C6), Attachment 49, May 2, 1977.

Table D.1

FLYAWAY COST ESTIMATES FOR SELECTED AIRCRAFT^a

Model (1)	Proxy Aircraft (2)	Cumulative Average Flyaway Cost (\$M FY 75) (3)	First Produc- tion Accep- tance (4)	Time to Produce 200 a/c (5)	Units per Month (6)	Invest- ment Rate (\$M/mo.) (7)
Attack						
A-3D-2	A-3A/B (A-3D-1/2)	5.8	1/55	65	3.1	18
A-4D-1	A-4A/B (A-4D-1/2)	1.8	8/55	28	7.1	13
A-6A	same	10.5	4/62	58	3.5	37
A-7A	A-7A/B/E	5.0	3/66	22	9.1	45
A-10A	same	4.8	11/75	42	4.8	23
Fighter						
F-84B	same	0.5	6/47	10	20.0	10
F-86B	same	1.6	5/48	17	11.8	19
F-89C	same	1.5	9/50	40	5.0	8
F-4D	same	5.2	5/55	27	7.4	38
F-100A	same	2.0	10/53	21	9.5	19
F-101A	same	3.8	5/57	12	16.7	63
F-102A	same	3.3	6/55	19	10.5	34
F-104A	same	2.7	1/57	23	8.7	23
F-105D	same	5.2	5/58	35	5.7	30
F-106A	same	8.7	6/58	22	9.1	79
F-4H	F-4A/B	7.7	12/60	22	9.1	70
F-111A	same	10.5	4/67	32	6.2	65
F-14A	same	20.5	5/72	50	4.0	82
F-15A	same	13.0	11/74	32	6.3	82
F-16A	same	8.5	8/78	29	6.9	59
Bomber						
B-47B	B-47E	11.3	12/50	18	11.1	125
B-52D	B-52 all models	25.0	1/55	31	6.5	162
Patrol						
P-3A	P-3A/B/C	12.0	3/62	57	3.5	42
Cargo						
C-130A	C-130A/B/D	8.0	12/55	38	5.3	42
C-141A	same	11.5	10/64	30	6.7	77
Tanker						
KC-135A	same	10.7	1/57	24	8.3	89

^aData unavailability, presence of preproduction estimates only, or manufacturing runs less than 200 units prevented calculations for the following aircraft: A-5A, F-3D-3, F-18A, F-94, B-58A, S-3A, C-5A, C-133A, B-70, and B-1.

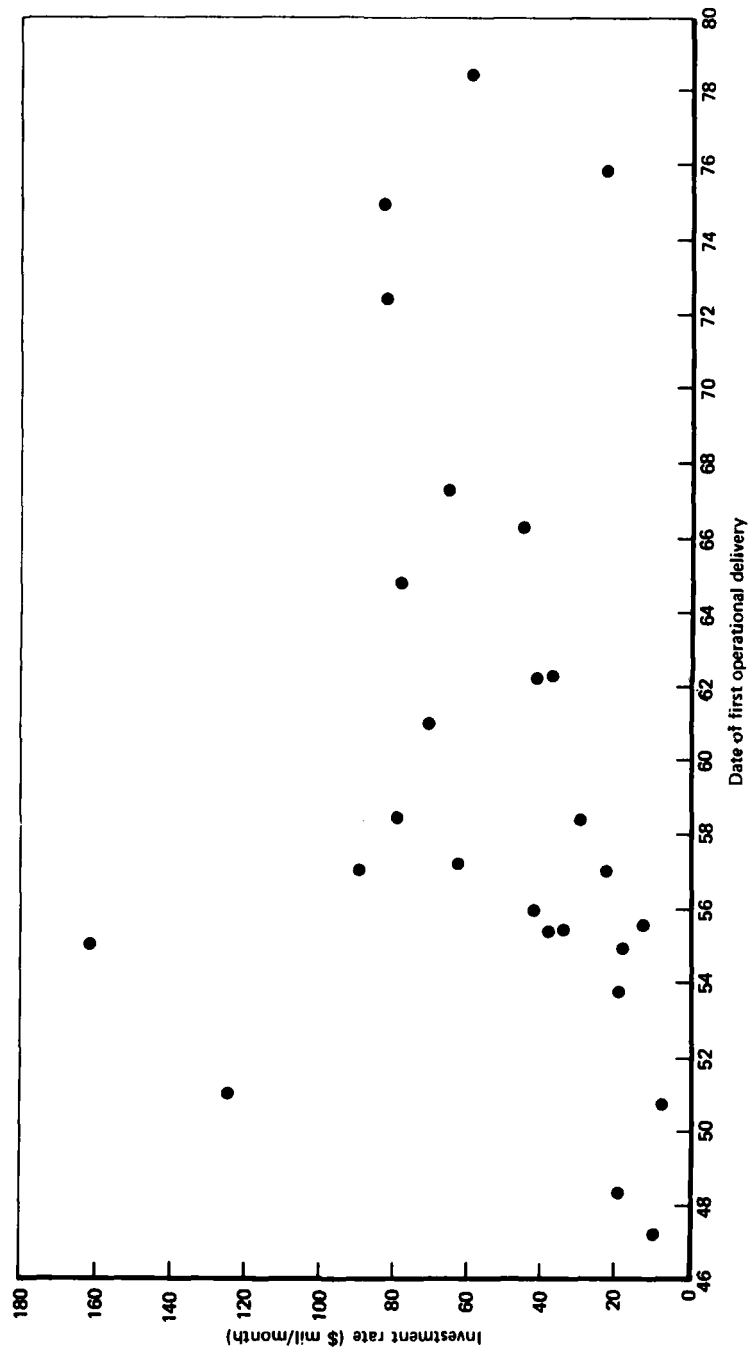


Fig. D.1—Aircraft production investment rate, average over first 200 units (constant-year dollars)