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HISTORY OF WRIGHT AIR DEVELOPMENT CENTER

1 JANUARY - 30 JUNE 1953

VOLUME II - TEXT

Classification canceled (changed to

by authority of

[redacted] 5 USC 552, (b)(6) date

[redacted]

53 WC-32806-B-4

[redacted] [redacted]

Classification changed to Conf.
by authority of

5 USC 552, (b)(6)
[redacted]

DOWNGRADED AT 3 YEAR INTERVALS;
DECLASSIFIED AFTER 12 YEARS.
DOD DIR 5200.10

03929 [redacted]

[redacted] C4-00612

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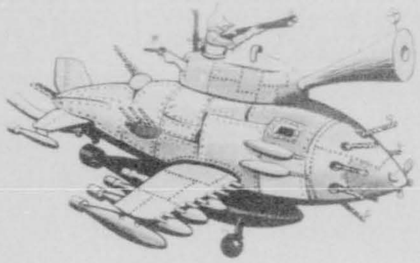

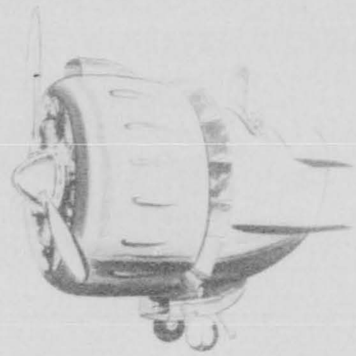

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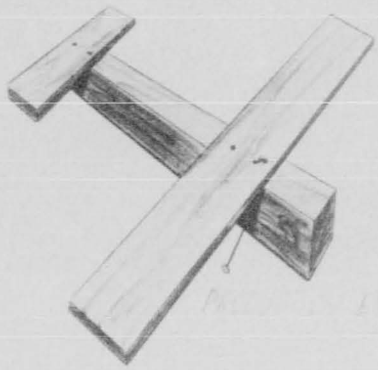

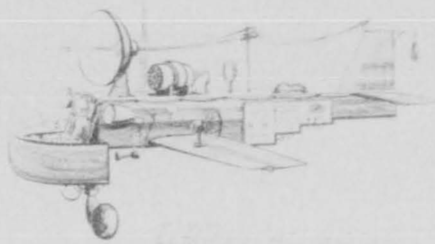

VI. DEVELOPMENT POLICIES AND PROCEDURES

Impetus for the establishment of a separate research and development command came principally from a small group of thinkers who recognized that the Air Force of tomorrow and the day after tomorrow was being endangered by disproportionate emphasis on the problems of today. Compartmentalization of research and development under a logistics command, where it received no more attention than maintenance, supply, and procurement, could not but have this effect. However, the formation of a separate Air Research and Development Command was only the first step toward a well balanced program; the whole of policy and method had to be revised if the infant organization was to be more than a new vehicle for the perpetuation of ancient evils.

Weapon System Policies

One of the first objectives of the new command was to emphasize the necessity for making each element of a combat instrument harmonious with all other elements. This idea had long been given lip service, but a formal statement of the objective and positive measures to promote it were important preliminaries to any real progress. Thus emerged the weapon system concept, not as a radically new theory or a strikingly original principle, but instead as official recognition of a long established fact of life which could no longer be ignored.

Experience with guided missiles had led the way to a weapon system concept. If it was impossible to fabricate a missile by the sausage process of stuffing assorted ingredients into a semi-elastic casing, it was obvious that the same limitation applied to aircraft. Every cubic inch of an airplane, no matter its size, was reserved for an important accessory. It was apparent to any competent observer that a "sausage process" was inappropriate once the total of ingredients exceeded the maximum capacity of the casing, as had become true.

The single prime contractor plan, first formally stated in December 1952, was but an offshoot of the weapon system concept. It was not grafted on the parent plant but grew there quite naturally, destined to be noticed sooner or later, whatever the trend of events elsewhere. The Air Research and Development Command, emphasizing the importance of planned, systematic, and reasonable development did not create the idea, it merely accelerated recognition.

On 8 December 1952, General Putt made the single prime contractor idea and the theory of unified development part and parcel of official Air Research and Development Command policy.[1] Thereafter the problem was to refine the policy and to plane off any rough spots in its application.

A question of legality raised by the Air Materiel Command was one of the first stumbling blocks. Specifically, the materiel command wondered whether or not the single prime contractor policy transgressed on Public Law 448 (82nd Congress)--the small business law. In April General Boyd called this to the attention of General Putt[2] who, in reply, emphasized that ". . . there is no question of legality of the single prime contractor concept. However, questions of legality can arise in the implementation of the concept."* He went on, "As in all questions of legality there is involved a strong element of intent. Certainly the intent of the concept as outlined by . . . my letter of 8 December raises no questions of basic legality." However, "Implementation by personnel not versed in the intent of the [policy] can obviously cause questions of legality."[3]

General Boyd also informed General Putt of Air Materiel Command fears that reposing such sweeping authority in individual contractors might prompt criticism of the Air Force on the score that the spirit of Congressional decrees on standardization was being violated.[4] General Putt answered on 10 July that the question was very largely one of semantics--the fact that the term "standard" was not uniformly interpreted by all those who used it. There appeared to be little actual danger that adoption of the single prime contractor method would violate the intent of Congress. The standardization process, he emphasized, was inherently limited by the requirement that components function with complete efficiency in each individual application.

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*Italics by this writer.

Standardization, as an abstract principle, could not be allowed to interfere with the objective of getting top performance from every piece of equipment. This meant the command would continue to give strong support to state-of-the-art work in the development of basic components, and that the single prime contractor plan actually would work against the existent "strong tendency on the part of prime contractors to use nonstandard components."[5]

General Putt also emphasized the importance of insuring "uniform, complete, and thorough understanding of the prime contractor concept throughout ARDC . . . particularly . . . at the operating levels." He asked General Boyd to aid "in spreading the 'gospel'" throughout Wright Air Development Center and in the adjacent Air Materiel Command.[6]

Later in July, General Boyd reported that the center staff had been thoroughly indoctrinated in the Putt philosophy through widespread distribution of both the 8 December and the 10 July letters.[7] A presentation on the single prime contractor idea, delivered by Colonel Boushey, Chief of the Weapons Systems Division, Mr. R. A. Schultz, the division's technical director for aircraft, and Mr. P. R. Murray, its technical director for guided missiles, subsequently served to aggregate current thinking on the topic.[8]

The foremost item discussed was the matter of contractor relations. By assigning full responsibility and full authority to the prime contractor, the Air Force seemed to have resigned its initiative in the selection of subcontractors. The equipment manufacturers, the subcontractors, associate contractors, and "small business" firms might be disturbed at the prospect.

Speaking from experience with the B-58 project, the first major aircraft system actually to fall under the single prime contractor mode of operation, Mr. Schultz pointed out that Convair was merely the weapon system manager, the team captain in industry. Moreover, Convair was responsible for development aspects only, and not production decisions assigning the fabrication and manufacture of components or subsystems. In any case, all decisions, whether production or development, were dependent on the contractor receiving approbation from an appropriate Air Force agency. Unilateral action that might exclude "small business" was virtually impossible.

Two other objections along the same line were that the prime contractor might expand his field of endeavor and activity without having adequate skills or facilities (simultaneously "freezing out" existent equipment manufacturers), and that he might select a subcontractor who did not meet with the approval of the Air Force. In practice, however, the contracts required Convair to take advantage of existing developments, projects, facilities, and programs, and practically precluded the firm's entrance into fields of development which would require building up an extensive new backlog of facilities or personnel. Moreover, the Air Force retained a veto power, and in this fashion could prevent the selection of unqualified subcontractors.

There appeared to be little chance that the contractor could discriminate against suitable government-furnished aeronautical equipment in favor of some component he developed or bought himself. Mutual agreement was required before any decision on government-furnished *versus* contractor-furnished equipment was made final. Common sense would keep the Air Force from agreeing to the installation of contractor-furnished equipment when the cost would be significantly greater, unless the contractor's proposal provided substantial advantages in another direction.

Mr. Murray took note of fears that the center might have little or no voice in the development of the overall system once the contract had been signed, that the laboratories might be excluded from participation in decisions on items being developed by subcontractors, and that these factors might permit the development and use of marginally satisfactory equipment developed by the contractor to replace standard government-furnished items.

Offsetting these possibilities were several circumstances. Foremost was the fact that Convair and every other single prime contractor had to secure approval of a detailed model specification. Furthermore, this had to be more than an airframe specification, as had been the case in the past; it had to be a weapon system specification. Then the laboratories had to approve contractor ideas before they could be incorporated in the aircraft. Since details of components would be covered in systems specifications, the chances of uncoordinated action on the contractor's part would be extremely slight. Performance specifications for major subsystems were similarly appraised; contractor-furnished equipment had to pass qualification tests as stringent as those required for government-sponsored development items, and the Air Force specifically reserved the right to maintain technical surveillance over the subcontractor's work. Thus, for practical purposes the laboratories would exercise almost the same type of technical control over the contractor's development effort as before.

These were the major areas of concern, although there were others. Their consideration impelled Messrs. Murray and Schultz and Colonel Boushey to several conclusions regarding the weapon system concept and the single prime contractor idea. The first was that people were reading too much into each; in no case was the Air Force aiming at anything other than the creation of better and more timely weapons. Secondly, the two ideas were not synonymous. The weapon system concept did not rely on operation by means of single prime contractor methods, although this appeared to be the wisest mode. The two logical alternatives, either of which might be applied, in case of need, to any specific development, were the associate contractor method and the older method of contracting for an airframe and specified government-furnished equipment--subsystems and components independently developed under government sponsorship.

VI

There was no reason to believe that any major questions would arise which had not been anticipated. Experience with the B-58 had borne out predictions, and there was no ground for fear that unique obstacles would suddenly appear.[9]

A viewer somewhat removed from the scene of action might have concluded that entirely too much attention was being paid the single prime contractor policy. Was it not detailed in the 8 December letter and had not all of its major implications been clarified early in 1953? General Putt supplied the answer. He wrote General Boyd on 1 August, "Ofttimes a reexamination of a policy or concept expressed in different words sometimes assists in better understanding. Also, as our experience increases we can sometimes explain our thoughts more concretely and specifically." It was with this thought in mind that elaboration on the original statement continued.[10]

There was one final point. It was clear that the single prime contractor policy involved no rigid, unyielding procedures. Like the basic weapon system concept, it had to remain flexible enough to accommodate new experiences and to adjust to new circumstances. Moreover, the period of field trials had only just begun. The B-58 and perhaps the F-102 were the first aircraft systems to conform even remotely to its requirements. Time alone would tell how it might have to be rearranged or altered.

Time was also an important factor in determining Air Materiel Command and industry reaction. It was too early to tell whether either would accept the principles of single prime contractor development without protest. By mid-1953 there were vague rumblings of discontent from several quarters, much of which might be the result of misinformation or insufficient information, but which nonetheless would have to be taken into account.

Acceptance and widespread application of the single prime contractor concept would do much to promote greater self-reliance on the part of the aircraft industry. If everything worked well, it would also provide better weapon systems at less cost in money and manpower. Nevertheless, the single prime contractor idea, as well as the whole weapons systems philosophy, was primarily intended to provide a means of doing a better job of system engineering than the capability of the Air Force permitted. It was an Air Force answer to the changed circumstances of aircraft development.

Industry had another approach to the basic problem. Late in January the commanding general of the Air Materiel Command received from the Aircraft Industries Association a brochure entitled "A.I.A. Report on the Influence of Military Specification and Administrative Procedures on the Cost of Aeronautical Equipment."[11] The association, citing 78 specific examples in support of its contentions, maintained that the military did not give sufficient free rein to an aircraft industry which ". . . has earned such a right after a quarter century of extraordinary progress which has established United States aviation as second to none."

Industry's principal contention was that the Air Force exercised entirely too much control by means of super-detailed specifications and administrative rules which hampered the average manufacturer in his work. From a broad viewpoint, the association advocated the establishment of performance specifications only and the assignment to individual contractors of the responsibility for satisfying them.[12]

The receipt of this lengthy dissertation stimulated the Air Materiel Command to invite research and development command participation in the preparation of a reply. By delegation, Wright Air Development Center received this assignment. The senior technical directors of the individual laboratories were responsible for the center's portion of the ultimate reply, which emerged as a precise and expert analysis of Air Force policy on the conduct of research and development by the Air Force-industry team.[13]

Ready in May, the rebuttal pointed out several major oversights in industry's presentation. Accountability--a vital adjunct to full responsibility--had not been given full weight. Secondly, industry had judged cost solely on the basis of manufacturing expense, while the Air Force had to consider a maintenance factor which in some cases amounted to twice the initial cost of production. In another instance, the inspections which industry viewed as excessive administrative control were considered by the Air Force to be a form of insurance; only regular product inspections could guarantee quality control. Finally, while procedural adjustments would always be in order, nothing in industry's presentation made a case for completely overhauling a way of doing business that had been proved workable over many years of evolution. The Air Force, like any other customer, had the right to specify its requirements, negotiate contract terms, and closely watch the product to insure that it received no less than it paid for.[14]

The aircraft association brochure was prepared before General Putt's single prime contractor plan received widespread distribution. Whether the Putt plan would in a sense satisfy industry's expressed desires was a question it was still too early to answer.

Complexity, Reliability, and Procurability

The problem of reaching a universally satisfactory compromise between the several requirements of weapon system development was one which probably never would be solved. The factors involved were too complicated and they varied too much from day to day. Nevertheless, it was necessary to work toward a middle point, or at least a central zone, from which only slight shifts in this or that direction would compensate for conditions of the moment. Essentially, the question was this: at what point should the increased complexity of equipment, necessitated by ever more stringent operational requirements, be halted because of the drain on supply and maintenance? Obviously there was no positive answer applicable to every specific example. However, it did seem possible to fix a sliding scale of diminishing returns if operating agencies would accept a limitation on possible performance to accommodate maintenance and supply requirements.

Every piece of equipment approved for production and subsequently sent to the field echelons had to satisfy minimum operational requirements. Otherwise the equipment was useless. Some complexity was inevitable if only because operational requirements demanded high performance, and high performance meant delicately adjusted, exquisitely precise, and extremely complicated mechanical and electronic devices. Mr. Murray once commented that there were three basic elements to the problem: reliability, supply, and maintenance. If reliability was good, maintenance and supply became relatively less important. If maintenance was simple, then reliability and supply were not troublesome. If reliability and maintenance were both poor, supply had by necessity to be bountiful.[15] Wright Air Development Center indirectly promoted progress in each of these by concentrating attention on reliability, maintainability, and producibility in design and development phases, but of course had no direct hand in solving supply problems or improving maintenance procedures.

One other consideration was important. The center was under pressure from as many as a dozen different directions to make each device conform to a variety of standards. Pilots wanted electronic gunsights that would insure kills and that would stay in operation all of the time. Maintenance people wanted equipment engineered so it would be easy to repair or replace although this conceivably could harm operating efficiency. Supply people wanted parts to be designed for easy production and ready interchangeability, even though this might mean more complicated maintenance and less reliability. Everybody wanted equipment immediately--regardless of its state of development. Manufacturers wanted more freedom of action, arguing that this would promote greater speed in production, although too much freedom to change specifications insured a void of interchangeability and vastly complicated both supply and maintenance. Staff planners wanted the latest equipment, engineers wanted to test and try their products before and after distribution, logistics people wanted to start production immediately. Tactical organizations demanded the abrupt elimination of deficiencies in existing equipment, while other echelons called for quick progress and early production of new equipment--which, if produced as demanded, would probably be marginally reliable and the subject of pained outcries for corrective engineering shortly after it reached the operating units! General Boyd twice used the simile of a family living in a glass house to describe the center.[16] Colonel White quipped on another occasion that the laboratories found directives coming in through chinks in the walls, ". . . the cracks under the doors and over the telephone. . . ."[17] And there was General Boyd's observation: "Everyone seems to want to operate the place!"[18]

One result was that the Air Force did not get all it deserved in the way of promptly delivered, adequately performing, and reasonably priced weapon systems. In April the chief of the Power Plant Laboratory, Colonel N. C. Appold, forwarded to the center commander an analysis of this condition in which he ascribed some portion of the overall failure to inadequacies in the performance of each major team member: the technical people, the logistics people, and the contractors.

Research and development, he felt, had been overcomplicated by the introduction of involved administrative procedures, the cross-coordination required at various echelons, and similar actions which prevented the engineer from incorporating "timely changes and improvements. . . ." He charged also that several echelons were meddling in project engineering and thus were stimulating duplication of effort, delay, conflicting decisions, and loss of morale on the part of the engineer ultimately held responsible for the project. Colonel Appold also decried the increasing number of working committees and boards "which tend to introduce indecision and delays in the implementation of specific engineering recommendations."

To correct this he suggested the "bold but time-tested procedure" of charging a single organization with the responsibility for development and holding that organization accountable for results. Coordination, he thought, should be limited to "those responsible for the mission and with authority to control the action proposed. . . ." He

[91]

doubted that many improvements resulted from "the administrative complexity or the numerous cross coordinations now required."

Colonel Appold said the leading error of the procurement command was putting excessive pressure on the technical command to approve the production of weapon systems, accessories, and components before they were adecuately develoned. He pointed out that a great deal of time could be saved and engineering manpower could be more appropriately applied to new equipment if the technical people were permitted a reasonable time to comnlete develonment before being pressured into approving production.

Industry, Colonel Anpold observed, "has an apparent attitude of indifference to a responsibility for satisfactory operation and performance of equipment after it has been accepted and paid for." He also deprecated industry's non-acceptance of responsibility for failure to meet technical objectives, development schedules, and cost estimates as prescribed in contracts. Insofar as this factor affected engines, the Power Plant Laboratory chief suggested a unique method of correction: requiring the contractor to sell operating hours rather than engines for the first prototype models. During the initial testing phase (prior to passing the 150-hour tests) the engines would remain the manufacturer's responsibility. He would be required to correct deficiencies which might develop and also to furnish those spare parts necessary to keep the engine in operation as specified in the original contract. Overhaul and maintenance of these early engines by the contractor would, he felt, "thereby emphasize deficiencies and give him a greater sense of urgency in improving the production version."[19]

Perhaps Colonel Appold's ideas were not immediately practicable, but at least his viewpoint was a refreshing outlook on the problem that affected all of Wright Field. However, there were two sides to the question. No doubt, as Colonel Haugen once pointed out, the Air Materiel Command was "continuously exerting pressure to go into production on equipment at the earliest possible date. . . ."[20] Yet at the same time there was considerable evidence that Wright Field engineers occasionally had a tendency to "over engineer" aircraft and equipment. General Putt expressed a measure of concern over this, conceding, however, that "it is difficult in many cases to determine just where the dividing line is between necessary engineering improvements and those that are desirable, but not required for the satisfactory and safe operation of the aircraft." It was his feeling that a great deal of thought should precede any decision to start a costly development program which would in the end provide only a slight improvement over available equipment.[21]

General Boyd replied in April that the center fully appreciated the concern General Putt expressed about "over engineering." He further assured the vice commander that Wright Air Development Center was "aggressively reviewing all refinements of design" to insure that the operational need for changes was weighty enough to compensate for the additional cost in money and time.[22]

Subsequently the technical directors discussed the topic but could reach no general conclusion. Colonel Haugen remarked that he had on occasion tried to find some good examples of "over engineering" and had actually located several that on the surface appeared to qualify. However, closer examination showed that there was a good or an extenuating reason for each action. The obvious difficulty was in defining the term.

Colonel H. B. Manson, flight test director, noted that his directorate had been basing its decisions on the amount of time required to obtain all the data an engineer requested. If the final five percent of the data accounted for 60 percent of the total test schedule, it was chopped. In this way the engineer got 95 percent of the desired data at an expenditure of 40 percent of the originally requested flight time. The shortcoming of this procedure, as one laboratory chief pointed out, was that the last five percent might be the critical data without which basic information derived earlier would be marginally reliable.[23]

"Over engineering" delayed the dispatch of equipment to operational units. But at the other extreme was "under engineering", resulting in the delivery of equipment which could not be used in combat operations because it was entirely too unreliable. Electronic devices provided a case in point.

In the past, tests of electronic equipment prototypes had largely utilized conventional reciprocating engine aircraft. Such test vehicles were slow moving, had a relatively low ceiling, and reached their maximum altitudes slowly in comparison with turbojet-powered aircraft. Equipment which might be perfectly satisfactory when tested in such an environment could easily prove to be unsuited to the rougher treatment it received when finally installed in a jet bomber or fighter. In that case, efforts to provide insurance against parts failures because of rapid temperature changes, or high frequency flight vibrations, would not be construed as "over engineering". Indeed, their absence would be good reason to charge "under engineering."[24]

The materiel command expressed some concern that specifications covering government-furnished aeronautical equipment frequently called for performance levels that lagged behind actual flight accomplishments, thus promoting equipment failures. Brigadier General W. G. Bain, that command's director of procurement and production, complained to General Boyd in April that current requirements specified the ability to withstand altitudes of 35,000 to 50,000 feet, while aircraft presently in the active inventory were capable of reaching 52,000 feet and plans for fighters able to reach 60,000 feet were well advanced. He suggested that all specifications be revised to reflect more accurately the current state of aeronautical art.[25]

Colonel Haugen pointed out in reply that the application of the weapon system concept to most development aircraft virtually obviated any danger from this source. If existent government-furnished equipment was not suitable for any specific system, new equipment was designed. Moreover, the prime contractor was principally responsible for the development of suitable new components when current equipment was unsatisfactory. But, since not all new production aircraft were under such controls, Wright Air Development Center had established a "configuration control" system to guard against incompatibility between the aircraft and their components. The center had also agreed to be responsible for conducting any reviews necessary to insure that government-furnished items satisfied environmental requirements. For these reasons, Colonel Haugen felt that the blanket change General Bain had suggested was inadvisable.[26]

With General Bain's expressed concern prompting him, Colonel Haugen reminded the chief of the Weapons Systems Division that a review of equipment performance requirements was appropriate and that the materiel command procurement and production directorate should be promptly notified of any changes found necessary.[27]

Procurability and producibility were other elements in the same stew, and could not be lightly dismissed. One of the first positive steps toward insuring procurability in new aircraft designs was taken early in 1953 when the Fighter Aircraft Branch of the Weapons Systems Division included as part of the contract for the Lockheed XF-104 a requirement that the contractor provide a study of all aspects of procurability.[28]

In conversation with Colonel Demler early in February General Putt expressed considerable interest in this aspect of the overall development picture. Subsequently, General Boyd provided Baltimore with pertinent current information on the status of the procurability program, still largely confined to that one aircraft. He mentioned that $400,000 of the total contract price for XF-104 development was reserved for procurability studies, and that Lockheed tentatively planned to study an entirely new design with the same performance potential but stressing procurability--"the ability to be turned out in large numbers in the shortest time after production is ordered." He also summarized the steps being taken within the center while an overall Air Research and Development Command policy on that point was being worked out.[29]

In March the command drafted a policy statement covering procurability. Its acceptance was a circumstance which could not be predicted in advance, but in its essentials it contained the germ of a firm policy of insuring producibility in new aircraft designs.

For working purposes, "producibility" was defined as ". . . the consideration during the design or development stage of Air Force equipment that facilities, production techniques, and/or materials are currently available or will be available to produce the equipment as designed or developed," while "procurability" was construed primarily as the ability to produce.[30]

The body of the policy statement merely enumerated means of insuring the existence of the procurability-producibility intangible. In the main, the command contemplated no radical changes in procedures, but merely an added emphasis on the factors that made timely and relatively uncomplicated production possible.[31]

The great difficulty encountered early in the procurability effort was Air Materiel Command inability to define clearly ". . . those technical features which make a weapon system 'procurable.'" Thus it was for the moment impossible to provide meaningful guidance to contractors. Moreover, the procurement and production directorate of the materiel command looked somewhat askance at the entire idea; though commending it in principle, the assistant director of procurement and production felt that "learning from experience and afterthought and disseminating the information thus gained" was the only practical approach.

The center did not agree with this concept. Said General Boyd, "'Learning from afterthought' during this period of semi-mobilization is an inefficient and invalid basis of engineering. During a period of actual war it would be disastrous." With this conviction in mind, the center attempted to bring materiel command thinking in line with that of the research and development command. At the same time, development planners started preliminary analyses of the individual problems in the concept of producibility and explored approaches to possible solutions. General Boyd told General Putt that Wright Field was preparing recommendations to cover policy and procedures for applying procurability principles to current and future development designs.

Wright Air Development Center also intended to "impress upon contractors the necessity for procurable designs, and . . . leave it up to them to find out what the technical problem areas are." Coordination with the materiel command was to be stressed. Further, the center wanted to enlist the assistance of several manufacturers to solve specific "typical and recurrent procurement bottlenecks by a coordinated development of design and production techniques."[32]

Another means of improving both maintenance and supply, and thus reducing the pressure for greater reliability, was standardization. Congress had virtually imposed on all the armed forces a program for standardizing commonly used parts, but as General Putt pointed out at mid-year, "We have always been vulnerable to criticism on this subject and are becoming more so every day." He continued, ". . . it [is] mandatory that the Air Force exert every effort to avoid criticism on this account."[33]

General Boyd replied that the center was exerting every effort to insure conformity to Congressional standardization directives. He mentioned in passing that he welcomed General Putt's letter because it eliminated some confusion that had arisen with the inception of the single prime contractor concept. Some supervisors, he reported, had expressed fear that maximum standardization might falter before this method of operation, although most project officers saw no reason for challenging the standardization program on the basis of the new contracting principle. With the Putt letter as support, the standardization effort could continue unaffected by the single prime contractor concept.[34]

In connection with the general standardization issue, General Putt mentioned several specific examples of non-standardization and deviation from set standards that he thought might give critics of the Air Force an opening.[35] The center replied that it had begun a study of the deviation procedures used by the various laboratories and systems offices with the objective of establishing center-wise uniformity. "Obviously," wrote General Boyd, "centralized technical control is no more feasible in the case of deviations than in any other part of the development effort. Centralized administrative control, similar to that we have established for Unsatisfactory Reports and Engineering Change Proposals, does not appear necessary in this case." As a concluding note, the center commander assured General Putt that his organization would establish adequate controls to insure full compliance with command policy on deviations.[36]

Unsatisfactory Reports

The problem of unsatisfactory reports, which had loomed so large in the earlier history of Wright Air Development Center, had virtually disappeared from the agenda of vital matters by mid-1953. Between July and December 1952 the number of unsolved unsatisfactory

[redacted]

NUMBER OF UR'S ON HAND

January - June 1953

	UR's on Hand
2 January 1953	368
30 January 1953	346
27 February 1953	286
27 March 1953	300
1 May 1953	257
29 May 1953	281
26 June 1953	388

Source: Monthly Statistical Summary

Chart prepared by: Historical Division

[redacted]

reports in the hands of Wright Field organizations diminished from more than 2,100 to about 350.[37] Revised handling procedures, heavy pressure on the laboratories, and full attention to the overall problem produced this result.

Finally, shortly before the start of 1953, the materiel command adopted a plan earlier proposed by Wright Air Development Center and instituted a mechanical accounting system for recording and deriving statistics from unsatisfactory reports. The use of automatic calculating machines was intended to provide a means of coding all categories of deficiencies, thus permitting an indication of dangerous trends as they developed. During early 1953, the system was tested at the Oklahoma City Air Materiel Area.[38]

Refusing to rest on its laurels, the center pressed continuously for further improvement. Indeed, there was in effect ". . . a major program to jar AMC loose on getting our engineering UR's to us so that WADC can start action."[39] In February the center participated in a team survey of procedures in force in two of the air materiel areas, uncovering several shortcomings. One of the major difficulties appeared to be the different emphasis accorded procedural directives by each of the materiel areas. There also existed some misunderstanding regarding the functions of the Wright Field laboratories. These points were clarified as conditions permitted, and improvement was anticipated immediately.[40]

One of the reasons for continued difficulty with unsatisfactory reports emanating in the air materiel areas was brought to light in April, when Colonel Demler wrote the director for materiel in the logistics command that the center's engineering representative stationed in the air materiel areas were being utilized for a variety of base duties not connected with their primary functions. In addition, the representatives were being flooded with requests for engineering support "on technical matters outside their jurisdiction".

Colonel Demler emphasized that the only authorized duty of the engineering representatives was "to provide the AMA with engineering support in connection with Unsatisfactory Reports, Technical Orders, and Engineering Change Proposals." That assignment was severe enough to require overtime work; accessory assignments and technical requests could only impede the performance of their basic duties.[41]

On the whole, the unsatisfactory reports situation seemed to be in good shape. Nevertheless, in some quarters the strenuous efforts Wright Air Development Center had exerted were not considered to be productive of particularly impressive results. Late in June at a meeting of high Air Materiel Command officials one of the participants mentioned receiving notice that the backlog of unsatisfactory reports at the center was again increasing rather rapidly.[42]

This charge brought a prompt and detailed refutation from General Boyd. He underlined the remarkable progress of the past year and cited statistics proving that since the start of 1953 the center's monthly backlog had grown only slightly. He further emphasized that there was great variance between the records of the center and those kept by the air materiel areas, and that in most cases the discrepancies reflected improper processing on the part of the areas. He informed the Air Materiel Command that the engineering representatives had been instructed to assist the materiel area control offices in correcting their records, and that other steps to improve statistical reporting were being instituted.[43] There appeared to be slight foundation for the report of a dangerously growing backlog.

In actual numbers, unsatisfactory reports on hand over the six months ranged from a low of 257 at the beginning of May to a high of 388 at the end of June.[44] There was a slight upward tendency in the number of unsatisfactory reports received and a leveling-off in the number of reports closed out, as the end of the fiscal year approached.[45] Nevertheless, on 26 June only about 30 percent of the unsatisfactory reports in center hands were more than 30 days old, and less than 12 percent were more than 60 days old.[46] When General Boyd had received the statistics on the backlog for April he had commented: "This is a very gratifying report."[47]

Static Testing and the Flight Loads Program

Over the years since the jet-powered aircraft had first approached and then surpassed the speed of sound, the Air Force had consistently had trouble with aircraft structures and air loads in the transonic speed region. To correct this persistent fault, a program of thorough flight testing from an air loads standpoint seemed essential. In

January 1953 Wright Air Development Center dispatched an announcement of the inauguration of such a program to the leading aircraft contractors.

The letter contained a formal announcement of the new Air Force policy ". . . of conducting an instrumented flight loads program on each new major aircraft design." Such tests were to be conducted early in the development stage of each new system and for nearly all existing aircraft and missiles. Plans called for the contractor to run the tests under the monitorship of Wright Field engineers.

The entire program was to be built around an extensive instrumented flight survey of each design. Sufficient test points were to be instrumented to assure complete coverage of "all possible critical flight conditions." Wrote General Boyd, "Air load shears, bending moments, and torsions shall be measured together with their spanwise and chordwise distributions." Data on aeroelastic problems and their effects on air loads were to be obtained concurrently. Finally, ground handling, taxiing, and landing characteristics were to be investigated. Tests formerly postponed until the structural integrity demonstration were to be performed in this early program.

To assure that static tests were made with loads representative of actual flight conditions, the flight loads program was to run concurrently with static tests. As a concession to development speed, however, the static tests would be allowed to begin on the basis of design loads. Later modifications, if needed, would allow for changing the static test schedule to compensate for information derived from flight loads tests.[48]

The first reaction to this letter was, surprisingly enough, from the Air Force Special Weapons Center. Major General J. S. Mills, its commander, wrote late in February to compliment General Boyd on the basic program as outlined ("I feel that this type of flight research has been definitely needed for many years, and your action certainly shows aggressiveness in the development of transonic Air Force aircraft with maximum combat effectiveness.") and to ask that consideration be given to utilizing the fully instrumented flight loads aircraft in subsequent studies of the blast effects of atomic and hydrogen bombs. He wrote, "The importance of this requirement cannot be over-emphasized since recent development in the thermonuclear field have out-distanced developments in structures and flight load data."[49]

While this proposal was being evaluated, General Boyd wrote Kirtland that "on the surface" it appeared feasible, and that Wright Field would support it if at all possible.[50] Further consideration reinforced this view. The chief of the special weapons center was informed in mid-March that not only did the idea appear feasible, but that it would be put into effect in the development of the B-52. This procedure would insure, for the first time, that "detailed weapons response data" would be available for an aircraft before it was produced in quantity. As a final note, General Boyd told General

Mills that all future planning of this nature would be coordinated with the people at Kirtland.[51]

Reaction from industry to the suggested flight loads program was equally favorable, though with some reservations. Convair endorsed the idea but called attention to several items which might retard the development progress of the B-58. Convair's assistant chief engineer remarked that early B-58's would probably differ from each other in structural configuration, thus restricting the application of data derived from any single aircraft. He also pointed out that early B-58's would be powered by the relatively less efficient J57 engine in lieu of the J79 intended for production versions. Air loads data might be misleading here also. Convair wanted assurance that the flight loads program would not be allowed to slow progress on static tests, because subsequent flight tests would be limited in their intensity by data derived from test stand operations.[52] But for the purposes of the basic program, none of these were tremendously significant objections.

One subsequent repercussion from the flight loads proposal was somewhat less enthusiastic. On 21 April the Air Materiel Command complained to General Boyd that Beech, Boeing, and Martin had asked for additional money to comply with the requirements of the flight loads program. Although prefacing its remarks with the statement that ". . . this command does not question the ultimate desirability of such flight test programs," the Procurement Division went on to list a number of major objections to the process tentatively prescribed in the January letter. First was the matter of conducting such tests using "current aircraft models." The materiel command protested that this would increase costs and disrupt production schedules and questioned the feasibility of this aspect of the proposal. Similar protests were directed at the effect this would have on the Phase I flight test program, the additional instrumentation that would be involved, and the cost of test equipment. Finally, the materiel command complained that the test requirements had been expressed "only as generalized objectives, rather than as a definite specification requirement" and that the center's simultaneous request for comments from the contractors ". . . is reflective of the prematurity of a concurrent direction to industry to perform such a program on current models."[53]

Late in May, General Boyd replied. He specified in clear terms that it was not the center's intention to interfere in any way with ". . . normal development or production schedules of present airplanes." No excessive costs would be involved because existent structural integrity test requirements would be satisfied by the flight loads program. Instrumentation would not be a problem since the equipment was in most cases available to the manufacturers for use in normal and customary development evaluation. Finally, specifications were in the process of preparation and in the interim the problem could be (and was being) handled on an individual basis as the various manufacturers became involved.[54]

Not mentioned, but implied, was the thought that any flight loads program which revealed defects in an advanced development airplane would save the government millions of dollars and years of time; the F-89 was an excellent case in point! Had flight loads tests been run on the Scorpion it probably would have been available when scheduled--and not two years later--and the multi-million dollar modification program currently under way would never have been required.

The Aircraft Industries Association had indicated a "keen interest" in the flight loads program and was prepared to submit suggestions for its active inception as soon as a study on the problem could be completed. The center expected to receive comments on the proposal shortly after mid-year and would then be prepared to consult with the materiel command.[58]

Static testing, although a well-established procedure, was also the topic of some discussion in the first months of 1953. In February General Boyd wrote General Putt to explain that the center was studying a new policy proposal--the conduct of static tests at the contractor's facility. Said the center's chief, "Many aircraft are becoming so large that it is very expensive to put them into flyable condition for transportation to WADC and then strip them for static tests on arrival." He mentioned also "the continual reduction of our available manpower" which made it more and more difficult to undertake all of the required tests.

The center proposed to make the determination of the test site a matter for individual decision in each specific instance. Facilities availability, cost of transportation, work schedules at the center, and the urgency of the evaluation were factors which would be considered before the location of the tests was determined.[56]

The first aircraft affected by this policy was the F-100. On 18 February the center formally gave permission to North American to run the static tests of this new air superiority fighter at the Inglewood, California, plant. In this instance the decision was based on the interrelationship of the airloads and the static tests, as well as on the importance of the time factor in the development of the F-100.[57]

Engineering Inspections

One of the more important policy changes of the first six months of 1953 was the inception of the development engineering inspection system. Such inspections were to be held frequently throughout the development phase of the evolution of each aircraft and missile. Thus it would be possible for the center to direct vital changes before advances in construction made them difficult and costly. Such inspections were to be held sufficiently far in advance of the mock-up inspections to permit changes to be incorporated in the mock-ups.[58] Colonel Demler characterized the new inspection plan as one way of solving some of the outstanding problems attendant to the center's participation in mock-up inspections. He credited the Weapons Systems Division with originating the procedure.[59]

Convair was the first contractor whose reaction was made known to the center. In its June report on F-102 progress, the contractor commented that such inspections were "invaluable" because "the conferees were able for the first time to readily see how their various requirements are integrated into the general designs."

General Boyd felt that such inspections would forestall a repetition of retrofit programs like those affecting the F-84F and B-47. Informal advice that the Office of the Secretary of Defense would in the future refuse to approve expensive retrofit programs of this nature underlined the need for improvement. Moreover, such inspections did much to guarantee "a well-engineered airplane."[60]

The development engineering inspection also provided Wright Air Development Center engineers with an opportunity to eliminate many minor design errors in advance of the mock-up board meeting, thus reserving for the mock-up board more time to consider matters of a more significant nature.

A new Air Force regulation empowering the Air Research and Development Command to conduct all mock-up boards also aided in the elimination of previous defects in the engineering inspection system. In January, Colonel Stewart outlined the requirements of a supplementary Wright Air Development Center regulation on the same topic,[61] and in February the center published its detailed rules for the conduct of mock-ups.[62] Later in the year a revised regulation, slightly modifying the original rules, was issued.[63]

In the main the changes gave greater responsibility to the project officer and provided further guarantees that the mock-up board would be spared the task of dealing with a mass of engineering details. Improvement in the overall system of configuration control was certain to result, although little that was radically new could be found in the new rules. However, there was apparent a general clarification of previous procedures and a tendency toward the elimination of conflicting directives.[64]

Notes, Chapter VI

1. Ltr., Maj. Gen. D. L. Putt, Vice Cmdr., ARDC, to CG, WADC, 8 Dec. 1952, subj.: General Policy Guidance on Use of a Single Prime Contractor for Development of a Complete Weapon System (see Appendix E-11 of "History of Wright Air Development Center, 1 July - 31 December 1952", Apr. 1953, prep. by Hist. Div., Hist. Div. files).

2. Ltr., Maj. Gen. A. Boyd, CG, WADC, to Lt. Gen. E. E. Partridge, CG, ARDC, 23 Apr. 1953, no subj., in CG files: Proc. (Note: WADC copy bears notation: "Letter was routed thru Gen. Putt.")

3. Ltr., Maj. Gen. D. L. Putt, Cmdr., ARDC, to Maj. Gen. A. Boyd, Cmdr., WADC, 10 July 1953, no subj., see App. E-32.

4. Ltr., Boyd to Partridge, 23 Apr. 1953.

5. Ltr., Putt to Boyd, 10 July 1953, see App. E-32.

6. Ibid.

7. Ltr., Maj. Gen. A. Boyd, Cmdr., WADC, to Lt. Gen. D. L. Putt, Cmdr., ARDC, 24 July 1953, no subj., see App. E-34.

8. Presn., "Weapon System Concept and Use of a Single Prime Contractor", 29 July 1953, by Col. H. A. Boushey, Chief, WSD, Mr. R. A. Schultz, Tech. Dir. for Piloted Airc., WSD, Mr. W. R. Murray, Tech. Dir. for Pilotless Airc., WSD, at WADC Tech. Dirs. Conf., see App. E-35.

9. Ibid.

10. Ltr., Lt. Gen. D. L. Putt, Cmdr., ARDC, to Maj. Gen. A. Boyd, Cmdr., WADC, 1 Aug. 1953, no subj., see App. E-36.

11. DF, Col. M. C. Demler, Vice Cmdr., to all WADC Dirs. & WSD, 4 May 1953, subj.: Policy Guide in the Area of Military Specifications and Associated Administrative Procedures; Suggested Reading for Technical Personnel in Supervisory Levels, in Hist. Div. files.

12. Brochure, "AIA Report on the Influence of Military Specifications and Administrative Procedures on the Cost of Aeronautical Equipment," 15 Dec. 1952, prep. by Airc. Industries Assn., Washington, in Vice Cmdr. files.

13. DF, Demler to all WADC Dirs. & WSD, 4 May 1953.

14. Tab B to DF, Demler to all WADC Dirs. & WSD, 4 May 1953.

15. Sum. of Tech. Dirs. Conf., 24 June 1953, Hist. Div. files.

16. Sum. of WADC Wk. Conf., 21 Jan. 1953, Hist. Div. files; Sum. of Tech. Dirs. Conf., 29 Apr. 1953.

17. Remarks by Col. D. B. White, Dir/Labs., in Sum. of WADC Wk. Conf., 28 Jan. 1953.

18. Remarks by Maj. Gen. A. Boyd, CG, in Sum. of WADC Wk. Conf., 21 Jan. 1953.

19. DF (incl. 1), Col. N. C. Appold, Chief, PPL, to R&D Office, Dir/Labs., 23 Apr. 1953, subj.: Proposed Item for Inclusion in May Letter from CG, WADC to CG, ARDC (incl.; titled: Air Force R&D and Procurement Procedures), in Exec. Secy. files: Mo. Ltr. to Gen. Partridge (Data).

20. Memo., Col. V. R. Haugen, D/Ops., to Exec. Secy., 23 Dec. 1952, subj.: Article for Monthly Ltr. to CG, ARDC, in Exec. Secy. files: Mo. Ltr. to Gen. Partridge (Data).

21. Ltr., Maj. Gen. D. L. Putt, Vice Cmdr., ARDC, to CG, WADC, 17 Mar. 1953, subj.: Engineering Change Proposals, see App. E-10.

22. Ltr., (1st ind.), Maj. Gen. A. Boyd, CG, WADC, to CG, ARDC, 14 Apr. 1953, subj.: Engineering Change Proposals, see App. E-10a.

23. Sum. of Tech. Dirs. Conf., 29 Apr. 1953.

24. Memo., Col. S. J. Gadler, IG, to Col. V. R. Haugen, D/Ops., 6 Mar. 1953, subj.: C-131's, C/S files: Airc., Misc.

25. DF, Brig. Gen. W. G. Bain, Dir/Proc. & Prod., AMC, to CG, WADC, 17 Apr. 1953, subj.: GFAE Limitations, in C/S files: Airc., Misc.

26. DF (cmt. 2), Col. V. R. Haugen, Actg. C/S, WADC, to Brig. Gen. W. G. Bain, Dir/Proc. & Prod., AMC, 5 May 1953, subj.: GFAE Limitations, in C/S files: Airc., Misc.

27. DF, Col. V. R. Haugen, Actg. C/S, to Col. H. A. Boushey, Chief, WSD, 5 May 1953, subj.: GFAE Limitations, in C/S files: Airc. Misc.

28. D/Ops. DAR, 4 Feb. 1953.

29. Ltr., Maj. Gen. A. Boyd, CG, WADC, to Maj. Gen. D. L. Putt, Vice Cmdr., ARDC, 17 Feb. 1953, no subj., see App. E-5.

30. Draft of Policy Statement, "Procurability Consideration in the Design and Development of Air Force Equipment", 26 Mar. 1953, prep. by Col. W. N. D'Ettore, Asst. for Dev. & Supporting Res., DCS/D, ARDC, see App. E-12.

31. Ibid.

32. Ltr., Maj. Gen. A. Boyd, CG, WADC, to Maj. Gen. D. L. Putt, Vice Cmdr., ARDC, 27 Apr. 1953, subj.: Design for Procurability, see App. E-20. Although there is no file notation or other positive evidence to that effect, it is quite possible that this 27 April letter never left the center. Another letter, addressed and signed identically but differing slightly in content and dated 12 May 1953, is also in the files (see App. E-22). There is, therefore, some ground for belief that the 27 April letter, redrafted, became the 12 May letter. The point is primarily academic, since in all but relatively minor details the two are nearly identical. For practical purposes, either could safely be adjudged an expression of the center's viewpoint.)

33. Ltr., Maj. Gen. D. L. Putt, Cmdr., ARDC, to Maj. Gen. A. Boyd, Cmdr., WADC, 2 July 1953, no subj., see App. E-31.

34. Ltr., Maj. Gen. A. Boyd, Cmdr., WADC, to Maj. Gen. D. L. Putt, Cmdr., ARDC, undated (about 15 July 1953), no subj., see App. E-33.

35. Ltr., Putt to Boyd, 2 July 1953, see App. E-31.

36. Ltr., Boyd to Putt, about 15 July 1953, see App. 33.

37. See "Hist. of WADC, 1 July - 31 Dec. 1952," pp. 220-231.

38. AMC WAR, 1 Dec. 1953, with note in handwriting of Col. M. C. Demler, C/S, "This is action we recommended to Gen. Brandt."

39. MRS, Col. B. E. Steadman, Chief, Op. Serv. Div., D/Ops., 12 Jan. 1953, to Col. S. R. Stewart, et al, in CG files: UR's.

40. Min. of AMC Dirs. Mtg., 3 Feb. 1953, in CG files.

41. Ltr., Col. M. C. Demler, Vice Cmdr., WADC, to CG, AMC, Attn.: Maj. Gen. C. A. Brandt, Dir/Maint. Engr., AMC, 14 Apr. 1953, subj.: Utilization of WADC UR Engineering Representatives for other than Assigned Responsibilities, see App. E-15.

42. Memo., Col. M. R. Williams, Asst. to C/S, to Maj. Gen. A. Boyd, CG, 25 June 1953, subj.: AMC Control Meeting, 23 June 1953, CG files: UR's.

43. Memo., Maj. Gen. A. Boyd, CG, WADC, to Lt. Gen. E. W. Rawlings, CG, AMC, 30 June 1953, subj.: UR Backlog at Headquarters, Wright Air Development Center, see App. E-23.

44. See chart facing page 161.

45. Monthly Statistical Summary, 1 July 1953, p. 50, prep. by Stat. Serv. Div., DCS/Compt., see App. E-24.

46. Ibid., 52, see App. E-26.

47. Remark by Gen. A. Boyd, CG, in Sum. of WADC Wk. Conf., 13 May 1953.

48. Ltr., Maj. Gen. A. Boyd, CG, WADC, to Boeing Airplane Co., et al, 20 Jan. 1953, subj.: Aircraft Flight Loads Program, see App. E-1.

49. Ltr., Maj. Gen. J. S. Mills, CG, AFSWC, to Maj. Gen. A. Boyd, CG, WADC, 25 Feb. 1953, no subj., see App. E-7.

50. Ltr., Maj. Gen. A. Boyd, CG, WADC, to Maj. Gen. J. S. Mills, CG, AFSWC, 4 Mar. 1953, no subj., see App. E-8.

51. Ltr., Maj. Gen. A. Boyd, CG, WADC, to Maj. Gen. J. S. Mills, CG, AFSWC, 13 Mar. 1953, no subj., see App. E-9.

52. Ltr., Mr. H. W. Hinckley, Asst. Chief Engr., CVAC (Ft. Worth Div.), to CG, WADC, 15 Apr. 1953, subj.: Contract AF 33(038)-21250 Aircraft Flight Loads Program, see App. E-16.

53. DF, Proc. Div., AMC (personal signature lacking on copy) to CG, WADC, 21 Apr. 1953, subj.: Aircraft Flight Loads Test Program, see App. E-19.

54. DF (cmt. 2), Maj. Gen. A. Boyd, CG, WADC, to Proc. Div., AMC, 27 May 1953, subj.: Aircraft Flight Loads Test Program, see App. E-19a.

55. *Ibid.*

56. Ltr., Maj. Gen. A. Boyd, CG, WADC, to Maj. Gen. D. L. Putt, Vice Cmdr., ARDC, 9 Feb. 1953, no subj., see App. E-3.

57. Ltr., Maj. Gen. A. Boyd, CG, WADC, to Mr. J. L. Atwood, Pres., NAA, 18 Feb. 1953, no subj., see App. E-6.

58. WADCR 80-18, 29 Dec. 1952; WADCR 80-18A, 27 Mar. 1953.

59. Sum. of WADC Wk. Conf., 7 Jan. 1953.

60. Sum. of WADC Wk. Conf., 15 July 1953.

61. DF, Col. S. R. Stewart, C/S, to Col. V. R. Haugen, D/Ops., 30 Jan. 1953, subj.: Conduct of Mock-Up, see App. E-2.

62. WADCR 80-20, 25 Feb. 1953.

63. WADCR 80-20, 17 Apr. 1953.

64. *Ibid.*

VII AIR DEFENSE SYSTEMS

Although the Korean episode undoubtedly provided the United States with a great deal of useful experience (though painfully, and at a rather high cost), it did little to alter existing concepts of air defense. The almost complete absence of any aerial offensive to exercise air defense weapon systems was the reason. The use of a few early model F-94 aircraft for night interception of enemy fighters or light bombers was almost the only action of any significance.

Korea, however, certainly could not be construed as a foretaste of World War III, if it ever came. In any future global conflict, air defense would undoubtedly be the dominant factor of operations, at least in the early stages of conflict. As far as the Air Force was concerned, it was the number one problem.[1] There was every chance that a prospective opponent would open an assault with a bomber-missile offensive against the continental United States. The form of such an assault might vary but its effect, if successful, held only one prospect for the United States: overnight reduction to the status of a third rate power.

Air defense was, therefore, a predominant consideration for survival through the initial stages of any conflict. Preserving the potential for a retaliatory strategic offensive and protecting the vital core of the nation from obliteration were matters of prudence that could not be set aside indefinitely.

VII

The destruction potential of the strategic offensive had increased so overwhelmingly since the end of World War II that an inefficient or relatively leaky air defense system promised to be as ineffective as none at all. No longer would great flights of bombers be needed to destroy large cities--one bomber or one large missile might do the job. It was apparent that the air defense system had to approach perfection.

Unless bombers or missiles could be destroyed before they left the ground, the only worth-while defensive action was to fend off or annihilate the attacking force while it was enroute to its target. The several elements that combined to make this possible were in a sense equally important, although one or the other might assume temporary predominance because of conditions of the moment. Detection and identification of hostiles were the first steps. In a situation involving high-speed, long-range bombers, early detection at a considerable distance from their target was essential to permit effective interception. Obviously, the longer the attacking force was under assault, the greater the attrition among the enemy, and the less damage to this country. Another factor inherent in the detection task was the direction of defending aircraft and missiles. Even a large and well-equipped defensive assembly would be relatively impotent if it never sighted the bombers.

Finally, interceptors not only had to be able to detect and locate the enemy, but also to destroy him. This potential was primarily a product of the aerodynamic efficiency and weapon effectiveness of the defending aircraft or missiles. In each instance, the interceptors had to possess a material performance advantage over their opponents and be able to score a high proportion of hits.

All of these circumstances received detailed and concentrated attention from the Air Research and Development Command in the first part of 1953. The development of an integrated detection and interception system was not primarily a task of Wright Air Development Center, although Wright Field participated in the creation or perfection of much of the equipment. But the development of the defensive vehicles themselves--both piloted and pilotless--was a very prominent facet of the center's mission.

In a field of such wide scope and complexity it was not surprising that the facts of life from an air defense standpoint were not universally appreciated. In an attempt to correct this situation, the center in mid-March 1953 held an air defense symposium for industry and the Air Force.[2]

The audience contained representatives from almost every organization concerned with air defense, ranging from initial research and development through procurement and production to tactical use. Although sponsored by headquarters of the research and development command, the program was presented at Wright-Patterson Air Force Base, with the center acting as host to the more than 400 participants.[3] The presentations, slides, motion pictures, and charts served not only as information adjuncts, but also as springboards for discussions that followed.[4] The final result was almost unanimous agreement that the symposium had clearly outlined the "magnitude of the problems involved in coordinating and making systems compatible and aided in reaching a decision on the ground environment to be adapted [adopted] for defense of the ZI [zone of the interior]."[5]

The matter of ground environment was of very considerable import to the workings of the whole defensive system. There was no disputing that a centrally controlled detection, identification, and interception mechanism of some sort was essential. The question for settlement was which of two major candidates should be chosen. A prompt decision was vital to the national security. Neither the Air Defense Integrated System nor the Lincoln system had been devised or developed at Wright Air Development Center; the former was a product of Rome Air Development Center, the latter of the Air Force Cambridge Research Center. Nevertheless, since the synchronization of the ground environment with the aircraft and missiles it would control was vital, Wright Field had an abiding interest in the eventual decision.

Late in May, the center received a letter from General Putt making official the choice of the Lincoln system. All work on the Air Defense Integrated System was cancelled. Cambridge became technically and administratively responsible for the ultimate perfection of the Lincoln system; General Putt recommended that Wright Field engineers immediately confer with Cambridge officials "to establish a sound plan to be followed by the Air Force to accomplish a timely and successful Bomarc weapon utilization."[6] However, the integration of manned interceptors into the Lincoln system was an important prerequisite to synchronization with the leading missile development. Otherwise there was no surety of compatibility between the weapon systems and the ground electronic environment that was designed to guide and coordinate their actions.[7]

Project Lincoln and the Lincoln Transition System had a relatively uncomplicated history.* They were the outgrowths of a Scientific Advisory Board recommendation that the air defense control system be built around high speed digital computers, the "one major advance in electronics since World War II."[8] Essentially, the Lincoln system consisted of detection stations (including picket ships, ground radar, airborne early warning radar, and ground observer posts) feeding information to a control center. In the control center the data was translated into suitable form for consumption by a digital computer, which previously had been supplied with information about flights within its surveillance area. The computer was prepared almost instantaneously to suggest the identity of an aircraft reported or picked up on the radar screens. In the event that defensive action seemed necessary, the computer was ready with information about the

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*No thoroughgoing discussion of either Lincoln or Rome Air Development Center's Air Defense Integrated System is attempted here since neither was, properly speaking, a Wright Field matter.

course, altitude, and speed of the aircraft under observation.

At this point the future course of action was dependent on the type of interceptor being used. If the primary interception device was a manned aircraft of the F-86D, F-89, F-94, or F-102A type, directions to the pilot would probably be verbal although an interim data link device might make visual presentation or semi-automatic control possible. If the F-102B or some similar airplane containing its own computing system was in use, a data link transmitter would automatically supply the interceptor with necessary information and the interceptor's own computer would calculate course, relative position, and the like.

Automatic interception, in which the interceptor pilot acted as little more than a monitor, was the ultimate objective of the Lincoln system, but until the day when that was entirely feasible, verbal radio command or an interim data link system would serve. They were perhaps not so efficient, but were sufficiently effective.[9]

The necessity for correlating the performance of each fighter and air defense missile with the Lincoln system was apparent--thus Wright Air Development Center's intimate concern with the development. It was further apparent that the rapid completion of work on the "manned missile" F-102B would be a major contribution in fulfilling the potential of the Lincoln system and would simultaneously serve the best interests of the air defense agency.

Development officials expected the initial Lincoln system to be in prototype form and "de-bugged" by mid-1955. Operational activation depended in large part on the speed of production after that time. The Air Materiel Command was in July 1953 working on a tentative procurement schedule envisaging a target date of 31 December 1956.[10]

The Interceptor Program

As of 30 June 1953, the Air Force had three interceptor aircraft in production. One of these, the F-94C, was but a limited performance aircraft scheduled to be manufactured for only about eight additional months. Another, the F-89, was still not completely clear of structural difficulties that had forced a major modification program and almost stopped the production line. The third, the F-86D, was a good airplane with a somewhat limited potential for further improvement. Two other interceptors had progressed to the initial development or advanced study phase: the F-102 and the F-103. The F-102 was, moreover, scheduled for production in an interim as well as an ultimate version. In its F-102A stage, the aircraft would utilize an existent engine and fire control system.[11] The eventual F-102B was to be a high performance interceptor incorporating the Hughes MX-1179 electronic system.[12] The F-103, relegated to a study project following the budget cuts of mid-1953, was designed as an exceptionally high performance fighter to be built around a radically new engine and the MX-1179 electronic system.[13]

Although this appeared to be an adequate development schedule, it contained one rather serious oversight. In the period between mid-1955 and early 1957, no well-proven interceptor was programmed for delivery in quantity. This circumstance presented a potentially dangerous situation and indicated that some "interim" interceptor might have to be scheduled for production in the period immediately before the F-102A entered the operational inventory in substantial numbers.[14]

The F-94 was all but entirely eliminated from any consideration. Its performance was definitely too limited. Both the F-89 and F-86D, however, were possibilities. With major modifications to the fire control system and rocket bays, either might be equipped to fire Falcon missiles, the probable standard armament of the "interim" interceptor. Northrop also proposed the development of an advanced F-89 with a more powerful engine as well as a delta-wing F-89 that bore little resemblance to its progenitor and a new interceptor designed to incorporate "packaged" parts from several existing aircraft and engines. In theory at least, any one of these would serve the purpose.[15] It was entirely possible, however, that none could be developed in time.

Two additional aircraft seemed reasonable candidates for conversion to the interceptor mission. The F-100, successor to the F-86, could probably accomplish the task, and the transition might not be extremely difficult. The success that had attended conversion of the basic F-86 to the F-86D interceptor configuration suggested that the same procedure might be profitably applied to the F-100. Advocates of this course found encouragement in the fact that the fire control system for an F-100 interceptor would be a proven device, a circumstance which had not been true in the case of the F-86D.[16]

The second aspirant for the "interim interceptor" role was the F-101. In that it was a twin-engine aircraft with a remarkably high performance potential, the McDonnell fighter seemed nearly ideal. Fire control system modification and possible conversion to a two-place vehicle were almost the only changes needed, and they did not appear to be especially formidable. But there was a drawback to any adaptation of the F-101; McDonnell's current assignments had the firm teetering on the edge of overwork. The F-101, RF-101, and a series of successful Navy fighters provided about all that McDonnell's ". . . rather limited engineering staff" could handle. Therefore center engineers concluded that it would be "extremely unwise" to add the responsibility for engineering and producing an interceptor model of the F-101. The assignment of production responsibility to another concern would not ease McDonnell's burden of engineering responsibility. The most logical solution was to give both engineering and production responsibility to another fighter contractor, thus reducing McDonnell's task to one of liaison engineering. Lockheed, Northrop, and North American were the leading prospects, in that order.[17]

There were additional factors that favored a decision to produce some sort of interim aircraft to fill the gap between the F-89 and the ultimate F-102. If the F-102 could be rescheduled so that no F-102A version was called for, an F-102 with the powerful J67 engine and the "human brain" MX-1179 electronic system would appear that much faster. Hughes, which was to develop and produce the MG-3 fire control system for the F-102A, as well as the MX-1179 integrated system, could not do both jobs on an equal basis. Expediency dictated a decision to delay MX-1179 work so the MG-3 would be ready for F-102A installation.* An interim F-100 or F-101 could accommodate another system, one which would not require interference with MX-1179 development.

Wright Air Development Center summarized all these arguments for the information of Air Force headquarters personnel in the course of a presentation on 1 June 1953. The only two "interim" aircraft suggested that were not already programmed as interceptors were the F-100 and the F-101. The former, according to Wright Field engineers, could be either a pilot-only or a two-place aircraft. Provision for 74 conventional aerial rockets, or 112 rockets of a new design, or four Falcons was possible. A modified E-7 fire control system could adequately handle rocketry, and by February 1957 it could be altered to provide Falcon direction. With a larger engine than its current

*Further details concerning these proposals will be found in the sections devoted to the respective aircraft.

J57, an F-100 interceptor could probably reach Mach 1.7. If necessary, the F-101 interceptor could also take larger engines, either J67's or J71's, in place of its J57's. With J67 engines the F-101 could probably reach Mach 1.5; in its standard (J57) configuration it was intended to be faster than the F-100. The E-7 fire control system with alternate provision for Falcon control could be used for this aircraft as well as the Super Sabre. In any case, the F-101 would have a substantially greater radius of action than the F-100 Sabre-45. In other respects the two were approximately equal. However, an interceptor prototype of the F-100 could be available for tests by October 1955, about six months before the interceptor F-101 could be ready.[18]

Whether the Air Force would decide on one of these to fill the deficit in the tactical inventory that seemed certain to occur between 1955 and 1957 remained to be seen. It appeared more probable, however, that production of a modified F-86D or F-89D would be the choice. The fact that several aircraft were available for adaptation in the event of an emergency, such as unanticipated engineering difficulty with an advanced F-89 or the F-102A, was a degree of insurance for the air defense program. The bad apple in the barrel was the fact that a hiatus would exist in the tactical inventory and that aircraft not originally designed for the interceptor mission might have to be pressed into service.

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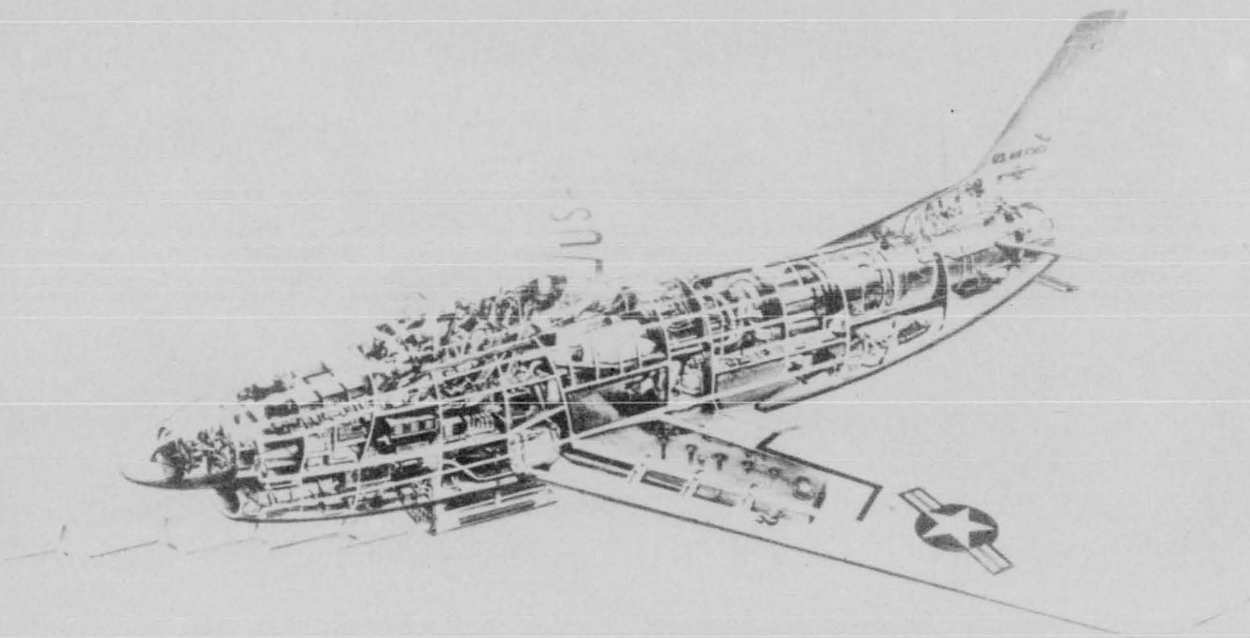
F-86D INBOARD PERSPECTIVE



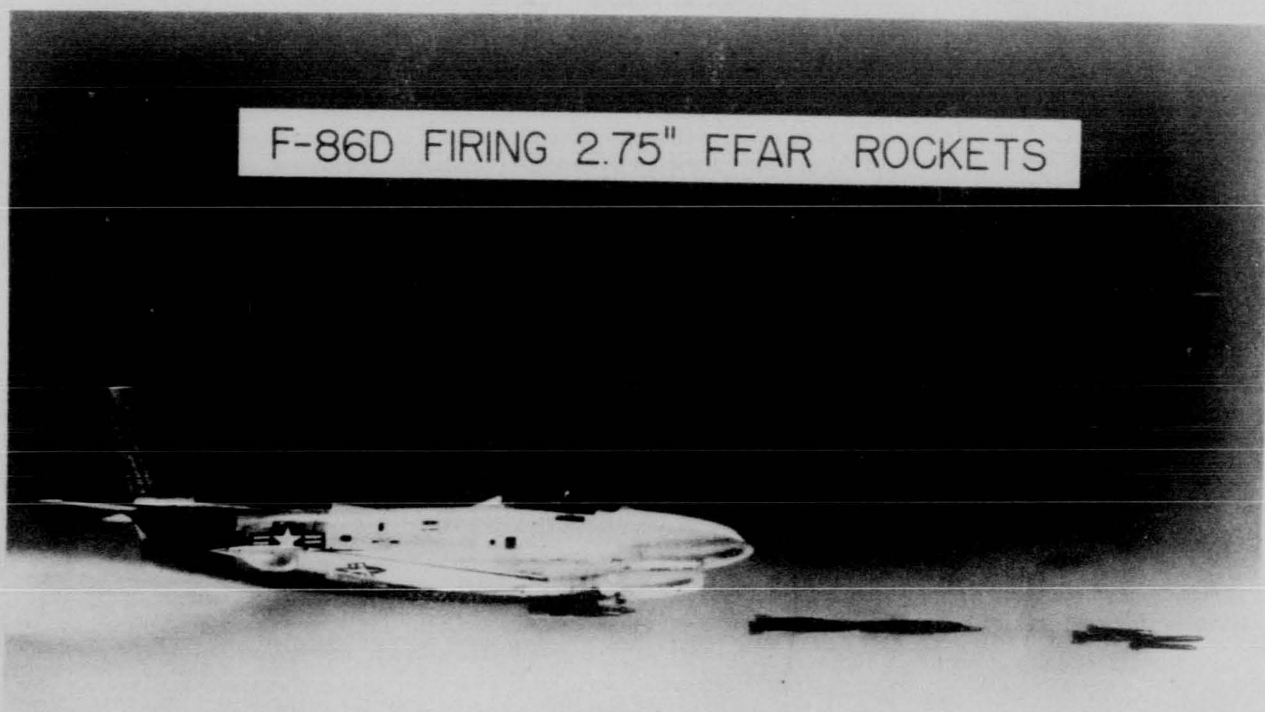
F-86D Aircraft--Inboard Perspective

The F-86D

North American Aviation described the F-86D as "a single-place, all weather interceptor derivation of the combat-proven, swept-wing, F-86 fighter."[19] And that, in essence, was the crux of the matter. In the first half of 1953 the F-86D provided no really outstanding development problems for Wright Field, although a number of improvements to components and subsystems were still necessary. In the main, however, the F-86D was a good, sound airplane.

Nevertheless, those F-86D defects which were objectionable to pilots received considerable attention. In February, General Boyd reported that he had discovered the major shortcomings to be concentrated in the F-5 autopilot, the hydraulic system, leaking external fuel tanks, the canopy latch, personal equipment, the control stick grip, and longitudinal sensitivity.[20] From the larger view these were minor items, but they were of considerable importance to those who flew the airplanes.

The longitudinal sensitivity problem was not constant in all flight conditions. Indeed, for some undetermined reason, it became extremely troublesome only at excessively low temperatures. Wright Air Development Center proved this by flight testing one of the aircraft at Ladd Air Force Base, Alaska, where outside temperatures ranged from -20 to -40 degrees Fahrenheit. Warming the entire aircraft prior to take-off eliminated the instability. North American was initially unable to locate the source of the difficulty, but kept


F-86D FIRING 2.75" FFAR ROCKETS

F-86D Aircraft Firing 2.75'' Aerial Rockets trying.[21] Under normal temperature conditions, no severe instability was noticeable.

The autopilot also presented some difficulty for engineers. The center's commander reported in March, after having flown an F-86D equipped with an F-5 autopilot, that proper altitude control was lacking. General Boyd complained that altitude variations were so marked as to be ". . . unsatisfactory to the point of being dangerous . . ." during instrument landings.[22] However, this appeared to be largely an operational defect, which would not require re-engineering the entire autopilot.

Much of the immediate difficulty with the F-86D flowed directly from the fire control system--the Hughes E-4. The peak of the trouble came in September 1952. After that time improvement was gradual but steady. The primary inadequacy was faulty operation of the E-4, which often required major readjustment or parts replacement before performing in accordance with Air Force specifications. Since the faults were largely undetectable before the actual acceptance flights and because they had to be corrected before the Air Force would take delivery of the aircraft, re-flights occurred with alarming frequency. Hughes, anxious to eliminate this trouble, incorporated a number of corrective design features in the production fire control systems and concurrently stationed as many as 30 maintenance people at the North American plant to make corrective changes to aircraft awaiting acceptance tests.[23]

Improvement in manufacturing processes also alleviated the earlier difficulty. Hughes began late in 1952 to deliver systems pre-aligned to the aircraft, thus eliminating the necessity for extensive installation adjustments and making it possible for North American to install the fire control system as almost the last item in the production line. This in itself was an advance, since late installation reduced the chance of improper handling during assembly of the aircraft. Beginning in December 1952, the number of test flights necessary to qualify an F-86D fell to 3.4 per aircraft from an average of 5.8.[24]

Integration of the K-4 vertical gyro indicator with the E-4 fire control system, an idea being investigated by the Armament and Equipment laboratories, also promised to reduce the complexity of the overall system, to save space, to eliminate some power requirements, and, incidentally, to cut the cost of each system by about $2,000. Completion of the modification was expected to take about six months.[25]

Despite these improvements, the E-4 system was held to be the primary factor delaying delivery of F-86D interceptors. Materiel command comments on this circumstance were frequent and pointed.[26]

Operational difficulty with the E-4, apart from that resulting from engineering shortcomings, concentrated mostly on the susceptibility of the E-4 to chaff. The E-4 showed indications of being entirely incapable of dealing with such countermeasures. Colonel Haugen told General Boyd in April that the pilot's alternative, when his radar failed because of chaff, was to switch to the alternate optical sight. "However," he noted, "the probability of being able to do so is very small." The only other possibility of a kill rested on a new pass from dead astern, and success was entirely dependent on visual conditions. The rocket armament of the F-86D could be salvoed at any time, but accuracy was extremely limited without the aid of the E-4 system.[27]

Trouble with its J47-GE-17 turbojet continued to beset the F-86D, but the power plant appeared to be basically sound. Early in the year the Air Materiel Command inquired about the engineering status of several parts which had failed in operation at the North American plant.[28] Colonel Demler, who replied, expressed the center's viewpoint that quality control, and not engineering, was at fault in most of the failures. He pointed out that over a period of time most of the engine components had "demonstrated basic reliability" which would improve still further with a continued betterment of production practices.[29] However, in at least one category additional engineering effort was required. General Electric continued to work, with little success, on the elimination of high altitude surging.[30] Electronic power plant controls were primarily to blame.[31]

Late in June, General Electric held an engine review conference at its Evendale, Ohio, plant. In the course of the event, the contractor's project engineer for the J47-GE-17 reported that an incorrect design philosophy was at fault in many of the power control system failures. He said, "Nearly every case of unexplained [power control system] instability has sooner or later boiled down to a case of bad cabling between components." The original design for the power control had provisions for 43 plug interconnectors and 359 individual pin connections between the various components. Elimination of such unnecessarily complicated circuitry was, therefore, a prime objective, both for the -17 engine and for any successors in the same family.[32]

In the field of product improvement, General Electric was also putting considerable emphasis on greater reliability, increased thrust, and decreased weight--in that order--while attempting to maintain complete parts interchangeability. Changes to the afterburner lining and new fuel control scheduling were at the moment the most promising means of improving the Sabre-D's rate of climb. These, and a variety of improvements somewhat akin in nature, were lumped together into a block change which would result in an engine series tentatively dubbed the -17A. General Electric engineers said, "This block change, along with a constantly improving reliability in the power control components, should make the -17 an interceptor power plant of which General Electric and the Air Force can be very proud."[33]

Improvements to the airframe of the F-86D fell into two categories, retrofit modifications which would increase the performance potential of the current version and model changes which would have a major effect on the configuration of the interceptor. The extended leading edge, proved by the media of combat tests with F-86's in Korea, fell into this first class. The flight test center, after testing the extended leading edge on a D-series F-86, reported that although performance gains were not as great as in the case of other F-86's, the modification should be incorporated.[34]

In addition to such modifications, North American proposed a series of major alterations to the basic airplane configuration. The incorporation of fuel cells in the extended leading edge would undoubtedly be profitable; however, it caused a center of gravity shift and induced an additional longitudinal instability. North American calculated that a fuselage elongation of 11 inches would correct this fault and improve maneuverability. At the same time, the contractor suggested, it would be appropriate to incorporate an improved engine, a relocated radar scope, a control surface tie-in with the armament equipment, improved maintainability, and other alterations.[35]

This proposal was so sweeping that its overall effect on performance and appearance might require redesignation of the F-86D. General Boyd's reaction to the idea was essentially negative. "Let's certainly drag our feet on coming out with a new aircraft until we have a few hundred 86D's in service," he commented. "We need them. They should be located on every base in this country. . . ."[36]


F-86D WITH FALCON MISSILES
USAF

F-86D Aircraft With Falcon
Missiles (Drawing)

As it turned out, the prospect was not that serious. Not until after 1,881 airplanes had rolled off the lines did North American propose to incorporate such radical changes.[37] Moreover, as far as the center was concerned for the moment, the whole idea was "purely a proposal."[38]

Shortly after the start of July, Lieutenant Colonel R. L. Johnson, one of the center's foremost test pilots, flew an F-86D modified by the contractor to simulate the flight characteristics of the improved version then being called the "Super D." His impression was that Wright Field might profitably reconsider its initial decision on the proposal.[39]

Another proposed modification of the basic F-86D stood a good chance of being adopted--but only if some untoward event forced the production of an interim aircraft to precede the F-102A in the active inventory. Although the F-89D with provision for carrying Falcons was supposed to be phased into service (as the F-89G or F-89H) prior to the F-102A, the Scorpion had a record of not meeting schedules. If history repeated itself, North American felt certain that the F-86D could be modified to accommodate an E-9 fire control system and four Falcon guided rockets. Rotating missile bay doors would solve the cartage problem. Those same doors could carry at least 40 standard aerial rockets identical to the 24 carried in current F-86D's. It appeared, however, that this program would have to be undertaken on a retrofit basis, and would affect only the "Super D" series, if that were ever produced. In that event, modification of the 624 eligible aircraft would cost in excess of $200,000,000. In mentioning this proposal to staff planners at Air Force headquarters, Wright Field recommended starting flight tests of a modified prototype by at least April 1955, if there was any real possibility that a Falcon-carrying "Super D" might be needed.[40]

One other suggested major modification of the F-86D was a good prospect. This was the version suggested for export to the countries participating in the European mutual defense program. In May, Wright Air Development Center recommended that a Sabre interceptor equipped with an MA-7 fire control system and 20-millimeter Hispano-Suiza guns in lieu of standard Air Force armament be selected for this purpose. This seemed to offer the best compromise of performance with maintenance ease, since the well-proven Hispano-Suiza gun was standard with most of our European allies. In forwarding the recommendation, however, General Boyd warned that training and ground support would be very important considerations in the use of the F-86D by other than United States personnel. He observed that maintenance and supply within the North Atlantic alliance had been marginal for aircraft much simpler than the F-86 interceptor. And he further pointed out that the F-86D would be virtually useless without a unified ground control system.[41] As the Air Force had discovered, although the F-86 was inherently a sound and reliable airplane, it was complicated.

The F-89

Over the years since 1946, when the basic design for the F-89 originated in the drawing rooms of Northrop, the Scorpion two-place all-weather interceptor had never fully satisfied the Air Force. Its development was a slow process, delays were frequent, and production seemed always to be behind schedule. Moreover, although the aircraft fulfilled, in general, the design requirements specified in 1946, "the actual aircraft as delivered lacks the performance and design criteria required of present day aircraft." Or so, at least, the project office reported.

One of the basic faults of the F-89 derived from the configuration and structure of the first two experimental prototypes. Many of the details of those aircraft were not adaptable to production, nor were they suited to a tactical configuration. The result was compromise, and the aircraft, in 1953, still showed the effects of such compromise. Although initially intended to attack ground targets in inclement weather, the ultimate F-89, redesigned to provide high altitude interception capability, did not have the necessary structural strength to withstand high speed maneuvers in low level flight. Essentially, said the project officer, "The lack of aircraft performance in speed, rate of climb, and altitude limit[s] its effectiveness to B-29 type targets."[42]

These were long-term shortcomings. More immediate deficiencies were the first order of business when 1953 opened. At that time the

F-89's outstanding difficulties evolved about the wing structure, the engine, and the afterburner. Each of these reduced the performance capability of the Scorpion to less than design estimates, seriously limiting its usefulness. Indeed, faulty wing design had been principally responsible for a series of mid-air disintegrations and had eventually prompted the Air Force to ground all F-89's. Also of importance was a controversy concerning the ability of the aircraft to carry the armament ultimately programmed for it--the Falcon guided rocket.[43]

The first six months of 1953 saw a substantial improvement in this unhappy situation. After what one observer characterized as ". . . its stormy and unfortunately spectacular early operational career," the F-89 seemed well on the way to recovery. Northrop maintained that the significant deficiencies had largely been eliminated.[44]

Modification and correction of the basic F-89 wing structure was the primary task involved in readying the airplane for full tactical use. This, however, was something of a monumental undertaking, since at the end of November 1952, when it was agreed that such a step was necessary, 115 F-89's were in the hands of tactical units; 120 of the latest series, the F-89D, were "either shop completed or in work to the extent that modifications would be required"; and other Scorpions were in various test programs. In November, Northrop stopped fabrication of those parts known to require modification,

VII

but in order to maintain a semblance of production continued building parts which presumably would not have to be altered at a later date. Production slowed to a rate of four aircraft each month (or "equivalent aircraft," as the phrase went), in contrast to the 17 aircraft per month originally programmed. Moreover, an additional 100 aircraft would be completed before the appropriate corrections could be phased into production. These, of course, would also require major modification.[45]

The total cost of this corrective engineering program threatened to exceed $24,000,000 and to involve the expenditure of at least 10,000 manhours for each aircraft. Vital alterations included reworking center sections on all F-89A, F-89B, and F-89C wings, as well as adding more rivets, beefing up bulkheads, replacing the lower wing attach angles, increasing the bolt size in lower attach angles, increasing the strength of stiffeners, rib webs, and spar caps, and installing fins on all tip tanks. The F-89D's were subject to all but the first of these modifications. In addition, at least nine major technical order kits had to be installed in all aircraft—and as many as 17 in some of them. They ranged from re-engineered fuel system components to new engine bay cowlings. In addition to the direct cost of the modifications, the time and labor involved in this work would add at least $5,000,000 to the total contract cost. An approximation of the work required could be gathered from the fact that about 60,000 manhours were consumed in the original construction of an F-89. The 10,000 additional manhours required for modification assumed greater significance in that light.[46]

Originally, the contractor had estimated that the entire modification program could be completed by May 1953. The Air Force was of a different opinion. In January 1953 Fighter Branch experts said that ". . . the schedule is . . . substantially beyond the capabilities of the company as it existed a few months ago." However, they continued, changes in management carried through late in 1952 "may enable the company to do a better job than they have done in the past."[47] Air Force estimates, taking this factor into consideration, showed a reasonable probability that the F-89's which had been in the tactical inventory would be back by the end of 1953, and that the total number of F-89D's on order could be delivered and accepted by August 1955.[48]

This program, which contemplated the delivery of the first five modified aircraft in March 1953, also proved slightly optimistic. Actually, the first four fully corrected F-89's did not leave the Northrop plant until 13 April.[49]

Whether or not the structural modifications to which existing F-89's were being subjected would be entirely effective was still unknown when the altered aircraft began to emerge from the factory. The Air Force admittedly took a calculated risk in committing the "fixes" to production before static, air loads, and structural integrity tests had been completed. But by the end of April, after the first few modified aircraft had been returned to service, aerodynamics experts were reasonably certain that the "corrected" F-89's would satisfy design load requirements at altitudes in excess of 12,000 feet.[50] However, uncertainty about the ultimate strength of the modified wings led to the issuance of a special interim technical order, on 4 March, imposing flight restrictions on the rebuilt aircraft. Wright Field recommended that such restrictions be observed until all flight and static tests had been completed, a process which would probably take six additional months.[51]

Initial static tests of F-89C wings at Wright Air Development Center were completed in April, when wing structures survived the imposition of maximum design loads. Additional experiments were scheduled for May and June, to determine whether low-level flight restrictions were still necessary.[52] On 11 June, after meeting some overstrength requirements, the right wing collapsed at 100 percent of design load while in a simulated low altitude pull-out. Flight restrictions remained in full force![53]

The F-89D, which in theory at least was a much sturdier airplane than its predecessors, also had stability faults which made flight speed restrictions necessary. Most of the difficulty stemmed from a hitherto unsuspected shift in the airplane's center of gravity when fuel alone was carried in wing tip pods. (The pods contained both rocket launchers and fuel cells.) Flutter trouble was also suspected but could not be identified or corrected until the stability problems were disposed of. Northrop's flight checks of this phenomenon had to await modification of the test airplane. In the meantime, with the concurrence of the Aircraft Laboratory, a variety of special circumstance flight restrictions were imposed on the F-89D. These were temporary, but eventual removal was largely dependent on the elimination of instability, and that might be a difficult task.[54] Project officers feared that the F-89D might prove as unsafe as others in the series, and recommended delaying delivery of the aircraft to tactical units until flight tests had been successfully completed.[55] Earlier in the year, September 1953 had been set as the probable date for completion of the air loads program on the F-89 aircraft;[56] there was little hope that the F-89D's would be released for unlimited operation before that time.

One additional structural deficiency turned up in March. The fittings which attached the horizontal stabilizer to the vertical fin developed cracks, compelling the Air Force to ground all of the early F-89's on 1 April.[57] In this instance, however, Northrop devised a quick repair method on the basis of static tests and hurriedly redesigned the attachment nuts which were causing the trouble.[58] On 24 June the Scorpions were again grounded when an inspection at the Northrop plant disclosed a missing bolt; on this occasion, however, no serious difficulty was anticipated.[59]

Such modifications and improvements notwithstanding, General Boyd was far from satisfied with the aircraft. He flew one of the altered

F-89D's at Edwards Air Force Base on 10 May and later reported to General Partridge that he was "somewhat disappointed" in its flight characteristics. He found, for example, that "rate of climb and level flight performance shows definite deterioration." The Wright Field commander also discovered that longitudinal control at speeds between Mach .7 and .8 was ". . . extremely delicate and could contribute to an unsafe flight condition in the hands of a careless or reckless pilot." Instability associated with the pods also disturbed him.[60]

Shortly after mid-year, the project office summarized the "known deficiencies" remaining in the F-89D even after the correction of those which had appeared in earlier versions. Twelve items were significant enough to receive mention. First, the anti-icing system still had not been flight evaluated in "wet air" tests. Then, the autopilot requirement had not been satisfied and a retrofit program would be necessary to provide this equipment in operational aircraft. Nose wheel steering was lacking. Engine problems remained unsolved. Pylons for external fuel tanks were still not available. The ejection seat contained highly objectionable features. Low altitude flight limitations seemed destined to endure forever, thereby affecting the practicality of automatic coupling of the fire control system to the autopilot. Since abrupt high-G maneuvers were dangerous, it might prove impossible to effectively tie-in the autopilot to a fire control system which might signal for a maneuver more strenuous than the aircraft could endure. Longitudinal stability was not entirely satisfactory and rate of roll was definitely marginal. Finally, heating problems resulting from the buried engine installation and the close proximity of the afterburner tailpipe to the aft fuselage promised difficulty. For the moment, prolonged ground operation of the afterburner was utterly impossible.[61]

Engine difficulties played a major part in future planning for the F-89 series. For a time prior to October 1952, an F-89F--a heavier, faster, more powerful version of the Scorpion--had been scheduled for production.[62] After its cancellation the engine test prototype, the YF-89E, was retained for use in proving the J71 engine originally scheduled to power the advanced F-89.[63] And as late as January 1953 the contractor still hoped to get Air Force approval of his proposal to install J71 engines in F-89's scheduled for 1954 and 1955 production. The Air Research and Development Command was not particularly enthusiastic about the proposal, as major modifications of the airframe components would have to accompany any changeover. About 40 percent of the airplane would have to be redesigned; yet there would be no appreciable improvement over the maximum speed or combat radius of the F-89D. The Northrop proposal would, however, result in a material improvement in rate of climb and combat ceiling.[64]

Although there was only a faint possibility that J71's would ever power the F-89, an engine change of lesser consequence was pending. The J35-A-33A engine produced by Allison and carried over from the

F-89C to the F-89D were definitely inadequate in altitude performance, primarily because of afterburner deficiencies.[65] On the other hand, Allison's J35-A-35 engines contained a specially designed flameholder which in theory permitted utilization of full afterburner thrust to an altitude of 50,000 feet.[66] These were scheduled to replace the -33A's once the combination had been perfected.[67] In the interim however, the -41 engine was being used; it was essentially a -33A equipped with retractable air inlet screens and rearranged compressor chamber bleed vents.[68]

Flight evaluation of the J35-A-35 was originally scheduled from 1 February through 15 March[69] but continued after that end date because the engine-afterburner combination did not operate as anticipated.[70] Earlier, engineers had believed that "in view of the F-89 schedule setback and reasonably satisfactory J35-A-35 engine development, it may be possible to install -35 engines instead of the comparatively inferior -41 engines in F-89C and D aircraft." Production of the -41 was therefore suspended after the completion of engine number 95.[71] The subsequent flight test delays made it necessary to authorize procurement of an additional 100 such engines, however.[72]

The flight tests disclosed several faults in the -35 engine, none of them serious. A special fuel control amplifier installed in the afterburner had been expected to materially improve performance;[73] evaluations showed this device to be entirely superfluous.[74] Early in April the test airplane reached an altitude of 48,000 feet only to experience engine failure because of a fuel control malfunction.[75] On 29 April, after the control fault had been corrected, the F-89 climbed to 50,000 feet, the test program goal, but the afterburners still did not perform as expected. Fuel control again was the limiting factor.[76] Two days later, however, the F-89 registered 50,100 feet, with the afterburner operating quite well.[77] The problem seemed to be substantially solved.

The introduction into service use of the J35-A-35 engine contained the seeds of another difficulty. Much earlier in the career of the F-89, engineers had found it advisable to add a jet wake fairing to the fuselage to reduce buffet and protect against heat damage. This immediately brought up new maintenance difficulties, principally because the "scabbed on" fairing burned and cracked after only about 12 hours of use. Northrop's answer was a new fairing, larger and heavier, to be retrofitted to the A, B, and C aircraft, and made a part of the integral structure of the D series. Approval of the change awaited completion of flight tests, but these were delayed by the grounding affair.[78]

An odd coincidence of events kept the new fairing from being made of titanium, which might have eliminated all subsequent difficulties. The decision to produce a steel fairing was predicated on the fact that it could be fabricated more rapidly; not long after manufacture began, the F-89's were grounded and the time element became unimportant. Moreover, the fairing for the F-89D, designed to be part of the basic structure, threatened to be less than satisfactory. Northrop had underestimated the magnitude and miscalculated the distribution of the temperatures on the aft fuselage of the aircraft. This problem was further compounded by the planned installation of J35-A-35 engines. Because the afterburner configuration of the -35 was not firm there was a good chance that the engine might produce a wake temperature distribution different from that of earlier engines.[79]

Two alternative means of eliminating the difficulty were available: the use of a fiber glass "blanket" to protect the fuselage structure or the substitution of a steel skin and former structure at the critical points. Because it involved less rework, the "blanket" solution was first tried. However, its effectiveness was largely dependent on the distribution of heat from the exhaust, and no data for the -35 engine was available. Thus, approval of the fairing modification for the F-89D was again held up pending tests with the new engine.[80]

Progress in tests of the fairing for the A, B, and C series F-89's was quite satisfactory. As early as 25 May it was apparent to engineers that the fairing would probably survive the 100-hour flight test,[81] and this proved to be the case. The Air Force quality control organization at the Northrop plant examined the fairing after 100 hours of flight and reported it ". . . far superior to any jet wake fairing that has been designed or tested by Northrop for the

F-89A, B and C model airplanes. After the minor design changes [we have recommended] have been incorporated, the fairing should be serviceable with a long service life expectancy."[82]

The armament of the F-89 was a question of major importance to the future effectiveness of the United States air defense system. Armament concepts for this aircraft as well as actual and proposed armament installations had varied considerably over the years since its inception. Indeed, some of the faults of the F-89 might well be laid at the feet of armament designers. As a Northrop spokesman pointed out in March, few remembered that one of the original design conditions imposed on the aircraft was that it should be capable of carrying the Martin ball turret. This requirement necessitated a 60-inch diameter nose bulkhead and dictated fuselage lines.[83] Although the turret had for practical purposes disappeared from F-89 plans early in its career, it was not until December 1952 that Washington decided to abandon the turreted fighter program. Contractor disinterest, ". . . the extreme difficulty in achieving success, and the small gains which would accrues to successful completion of the present type D-1 [turret] program" impelled the decision.[84]

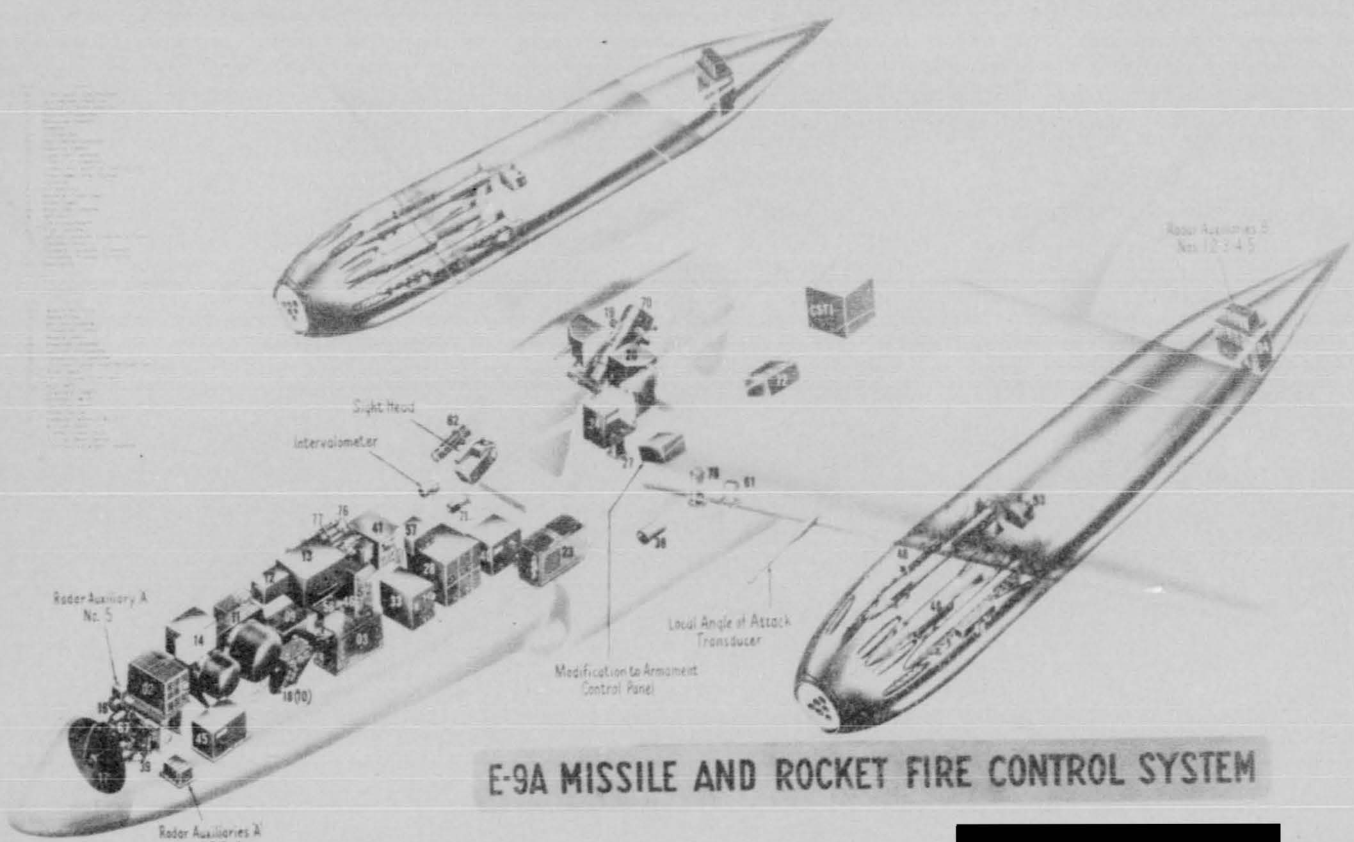
F-89A, B, and C series aircraft were armed with six 20-millimeter rapid firing aerial cannon, and had structural provisions for 16 wing-carried 5-inch high velocity aerial rockets.[85] The F-89D, which had the combination wing tip pods, possessed an immensely greater destructive capacity. It carried a total of 106 rockets of the

2.75-inch folding fin type, and could launch these either in salvo or in a series of two or three passes.[86] The proposed F-89G (or F-89H) would be essentially the same aircraft, but with the capability of firing six Falcon guided rockets and a reduced number of 2.75-inch unguided rockets.[87]

Although the Falcon-carrying F-89 was the Air Force's ultimate objective, the immediate problem was the F-89D with its cargo of 106 rockets. The E-6 fire control system was entirely unproved in the F-89D. Consequently, extensive flight tests would be required before the aircraft-fire control system combination was considered satisfactory. Northrop hoped that experience with the similar E-4 and E-5 systems might make perfection of the E-6 a relatively simple task, but only time would tell.[88]

Tests of the E-6 system were well under way before mid-year. In May, General Boyd informed General Partridge of reasonably good progress and called attention to one outstanding achievement. One salvo of 62 rockets produced three hits on a 6-by-30-foot banner target (with special radar reflectors on each corner). The run was made at an altitude of 30,000 feet and a speed of Mach .8 (about 542 miles per hour true air speed).[89] While not a superlative performance, this indicated that the combination of 2.75 rockets and the E-6 fire control system would apparently do the job it had been assigned.

Of greater concern for the future was the E-9 fire control system



E-9A MISSILE AND ROCKET FIRE CONTROL SYSTEM

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E-9A Missile and Rocket Fire Control System to be used in combination with Falcon guided rockets. The E-9 had twice as many "black boxes" as the E-6 and weighed almost twice as much. Moreover, the pod design, which had to provide for fuel, 2.75-inch rockets, and Falcon missiles, promised to be a real problem. A spokesman for the Fighter Branch characterized the installation as ". . . comparable to suspending an F-84 fuselage on each wing tip of the F-89." Furthermore, the only way of proving the design satisfactory was actually to fire Falcons from an F-89. The internal design of the pod, the tooling, and similar factors were all so ". . . complex, expensive, and difficult of solution that an extensive flight test program must be carried out before full production is released."

Some production was to be started on the basis of laboratory tests alone. This decision was made with full realization that "one or more significant modifications is almost a certainty before the systems can be delivered to a tactical unit." Providing E-9 systems for early installation in F-89C's and then testing of the production model involved a maximum risk that might add an additional 40 to 60 percent to the original cost of the equipment. Rework of such complex systems usually was at least that expensive. Since the cost of each basic E-9 system was estimated at about $200,000, this could be a major item.

The eight-month lead time necessary to produce complete systems in accordance with the schedule approved by the Air Force meant that only the contractor would know what the Air Force was getting when the first systems were delivered. This also might promote later difficulty.

Three F-89D's were allotted to the flight test program, but only to evaluate components. The first automatic firing of the missile was not scheduled before November 1953. Even that was an optimistic estimate, but as one observer remarked, that event ". . . will provide a major indication as to how close we are to solving the complete problem, and of course will indicate the magnitude of the changes required in the production system."[90]

Production of complete prototype systems was to begin in March 1954 and was to reach a maximum of 28 per month by the end of that year. This, of course, would be before flight tests of the system had been completed.[91] Falcon delivery schedules were revised early in 1953 to reflect the delay in F-89 production and the changed E-9 schedule. Unfortunately, the F-89 was the only fighter immediately suited to test the Falcon, so initial development of the production version of that guided rocket was largely dependent on the progress of F-89 and E-9 development.[92]

The missile-carrying features of the F-89 were not especially satisfactory, as air defense experts and the aircraft engineers pointed out to policy makers on the Air Council.[93] General Boyd told his staff members in February that top levels presumably did not realize the development time involved in perfecting the combination, or the complications the problem presented. It was more than possible, for example, that the F-89 would have to incorporate high thrust J71 engines to provide it with sufficient power to deliver Falcons in combat.[94] Despite this probability, planning for the retrofit of E-9 fire control systems and Falcon pods on F-89D's* continued, with July 1955 set as the effectivity date for production availability.[95] This, of course, meant making provision for the future installation of both the E-9 and the Falcon pod on production F-89D's, a process which was scheduled to begin about mid-1954. The pod and the fire control system were not due in production quantities before late 1955. It was apparent, therefore, that if current plans were carried through, a great number of the F-89D's would contain provisions for the Falcon and a very extensive retrofit program would be necessary to equip the aircraft with an operational Falcon capability once production equipment became available. In the meantime, 412 F-89D's would grow in weight because of the structural alterations necessary to accommodate such equipment.[96] Whether or not this was in the best interests of F-89 performance was a question that remained unsettled.

The F-89D was a candidate for another honor in the air defense armament field. Experts had long felt that the use of atomic explosives was a possible way of accomplishing large-scale destruction

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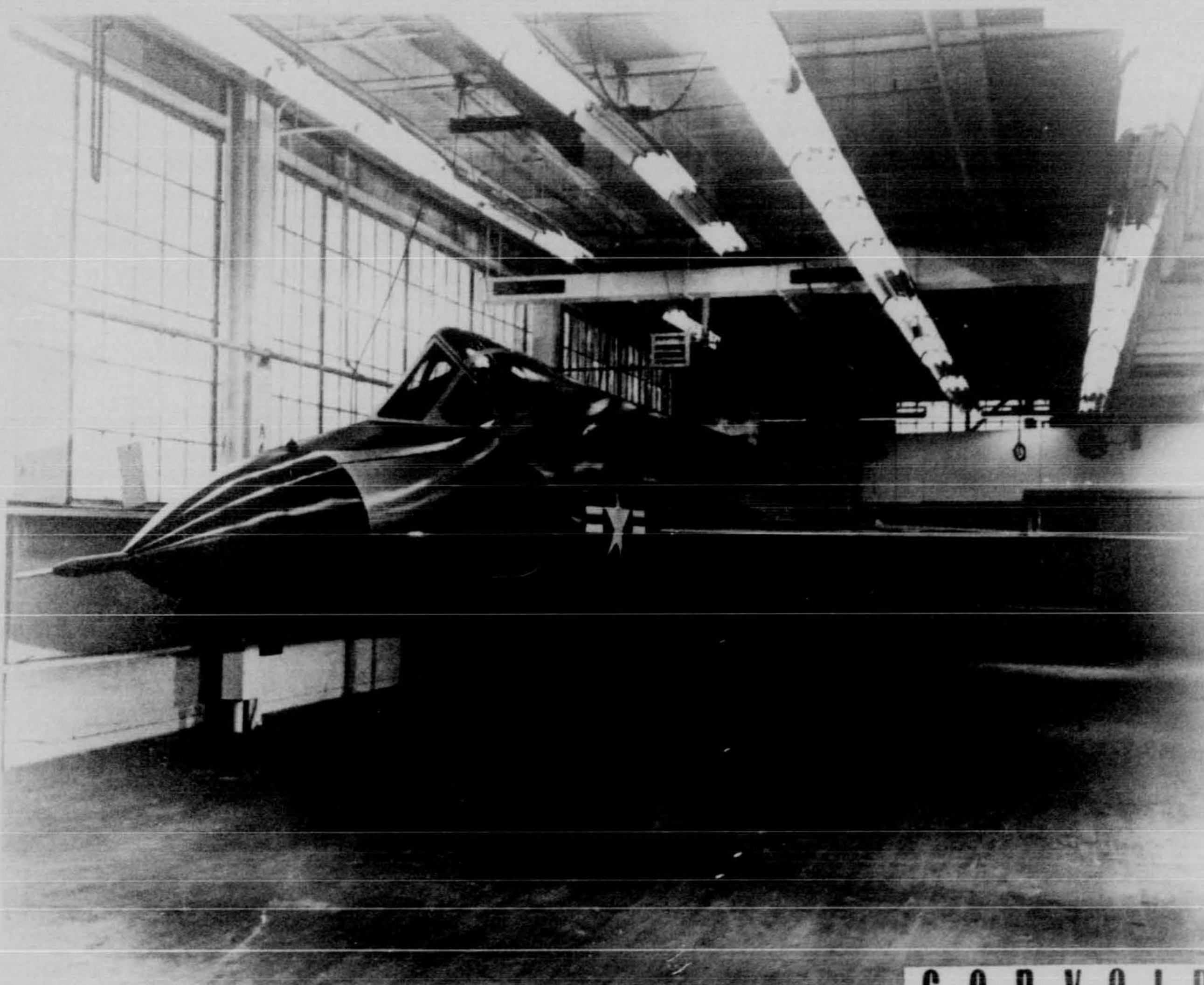
*The airplane so equipped would probably be designated either F-89G or F-89H when pods were actually installed.



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F-102 Aircraft (Mock-Up)

among attacking bombers with but a small expenditure of defensive aircraft. In March the center forwarded to the special weapons center a study of the possible use of the F-89D for this mission. Although only that aircraft was specified, the conclusion that ". . . air to air bombing with atomic weapons is not feasible with present fire control systems" applied equally well to interceptors like the F-86D and the F-94C.[97]

Presumably this summary was later incorporated into the full report compiled by the Air Force Special Weapons Center and forwarded to command headquarters shortly after mid-year. Baltimore remarked that the preliminary study had been "enthusiastically received," but commented that the section on delivery of the munition was inadequate. The special weapons center was therefore directed to investigate "all possible methods of delivery" and to list the advantages and disadvantages of each.[98] If such a defensive weapon were adopted, the F-89 was a prime candidate to carry it.

The F-102

Although the F-102 was scheduled to make its initial flight in October 1953,[99] the first months of that year were marked by an intense disagreement concerning the basic configuration of the aircraft, and later in the year the question of whether or not the airframe design was correct became a major issue. Both these questions were ultimately resolved, although perhaps not to the complete satisfaction of everyone involved.

Initially designed around the 21,000-pound thrust J67 engine and the MX-1179 "electronic brain," the F-102 interceptor had been intended to supersede the F-89F in the tactical inventory. During the competition that preceded the award of the F-102 contract, Convair had proposed building a few early F-102's with J57 engines, "purely as an expedient to provide test vehicles to de-bug the airframe and various major components." In the fall of 1951 the Air Force revised the interceptor program and decided to build a small number of the "interim engine" F-102's for tactical assignment. Among other things, this would give the operational squadrons a measure of experience with the basic aircraft before the J67-powered fighter became available. At the time all concerned agreed that it would not be necessary to procure an interim electronic system, since the MX-1179 was scheduled to be available in the same period as the initial airframe. Experts agreed "this configuration would provide an airplane with less performance, but it would meet the control requirements of the air defense system."

Subsequently, the MX-1179 schedule slipped and the question of a fire control system for the "interim" aircraft became pressing. Then in the fall of 1952 the Air Force washed out plans to produce the F-89F, creating a definite gap in the air defense inventory between the obsolescence of the F-86D and the planned phase-in of the "electronic brain" interceptor. After studying the situation, and considering a number of alternatives, the Air Research and

Development Command, with the concurrence of the Air Materiel Command, recommended the accelerated production of an interim F-102. This aircraft, to distinguish it from the ultimate "1955 interceptor," was dubbed the F-102A. The same airframe with J67 engine and MX-1179 electronic system was designated the F-102B.

The F-102A was to be the original airframe, unchanged in most essentials, with a J57 engine and afterburner in lieu of the J67 and a substitute set of electronic equipment in place of the MX-1179. The decision to rely on this interim aircraft was virtually unavoidable because of the unfortunate coincidence of MX-1179 slippage, F-89F cancellation, and the late programming date for the ultimate F-102.[100]

Whether the F-102A would satisfy requirements for the period in which its use was contemplated depended to some extent on the flight characteristics of the bombers it was designed to attack. Intelligence estimates of this factor concentrated, quite naturally, on Russian efforts in the bomber field. Indications were that in case of war in the 1955-1960 period, the F-102A would encounter medium and heavy bombers, both turboprop- and turbojet-powered, with speeds ranging between 350 and 550 knots, and maximum altitudes of 45,000 to 50,000 feet. Most of these aircraft would be able to carry a 10,000-pound bomb load as far as 10,000 miles, although the Russian medium bomber comparable to the American B-47 would probably not be capable of cruising more than 3,800 miles.[101]

Estimates conjecturing the effectiveness of the F-102A indicated a kill probability of about .85 against a heavy bomber comparable to the B-52--if Falcon missiles were used. Reliance on standard 2.75-inch aerial rockets would reduce this by 25 to 40 percent. The F-102A, by contractor estimates, would thus be able to handle any raid the Russians might mount, provided only that adequate numbers of interceptors were available, on the order of about 110 interceptors for each 100-plane attacking group.

The probability of success in actual combat attacks was little affected by the substitution of the MG-3 fire control system (a refinement of the E-4 and E-9 systems) for the integrated MX-1179. The essential difference between the two systems lay in the initial vectoring phase, from take-off to attack. In general, the MX-1179 would position the interceptor more accurately in preparation for the final attack phase. The MX-1179 would also lessen the burden on the pilot, allowing him to concentrate on detection of the target and the general tactical situation. Finally, it would shorten the time from scramble to attack through more efficient direction of the interceptor. It was safe to conclude that the MX-1179 would increase the number of bomber kills prior to bomb release time, although the MG-3 system appeared to satisfy immediate requirements.[102]

Nevertheless, there were well-founded arguments against reliance on the F-102A. The use of MG-3 would require separate autopilot, navigation, communication, and ground control equipment. While work on these devices would not greatly delay development of the complete aircraft, since most of the components were relatively well-proven, "it will not," said one Fighter Branch spokesman, "provide a system that will be compatible with the air defense environment in the time period that BOMARCK [sic] is to be available."[103]

There were also other important considerations. Because the F-102 and the MX-1179 had originally been designed for each other, there was no problem of accommodating one to the other. However, the substitution of the MG-3 would force Convair to repeat much of the integration work. Moreover, some of the most pleasing features of the MX-1179 would be lacking in the interim system, including the autonavigation capability described by one competent observer as ". . . extremely important in a saturated air defense system." The ability of the aircraft to automatically search out and track hostile bombers would be missing, and the pilot would have to operate under the voice control of a ground station until he contacted his target.[104]

The great advantage of the MG-3 was that it provided Falcon capability in a high performance airframe in advance of the F-102B. Some experts questioned whether these gains compensated for a probable two-year delay in developing the integrated system when there was a chance that the Air Force could have MX-1179 almost as soon as the MG-3--if Hughes were permitted to continue MX-1179 work at its current rate. There was also a possibility that the early availability date of the MG-3 might slip if it encountered any development difficulties.

The completely automatic MX-1179 was in its third or fourth redesign stage, and hence might be less susceptible to refinement trouble than a system more hastily thrown together.

Considering these factors, Wright Field recommended in January that the MG-3 not be developed or procured for the F-102, that the F-102B receive "greatest possible emphasis," and that other aircraft be used to fill the inventory gap created by cancellation of the F-89F. However, if higher authority decided that the safety of the nation required production of the F-102A for service inventory, the center conceded that the MG-3 would make it adequate.[105]

Arguments to the contrary notwithstanding, the Air Council decided early in 1953 to proceed with the development and production of the F-102A.[106] Air Force headquarters demanded no conformance to specific operational or component requirements. Some months later the project office reported, "The only parameter . . . was that the electronic control system, the armament, and the engine were to be the most advanced that would be available in sufficient time to meet the production schedule of the airframe." The F-102A was required only to incorporate the highest performing major components available and "be sufficiently advanced over the F-86D to warrant its procurement."[107]

Estimates of the advantages of the F-102A over the F-86D showed that this objective could easily be met. The Convair aircraft had a design maximum speed of Mach 1.5 as compared to .94 for the Sabre, and a combat radius more than twice that of the F-86D. Furthermore, the MG-3 was considerably better in performance, easier to maintain, and more versatile in armament control than the fire control system of the F-86D. Finally, the F-102's armament load would include Falcons in addition to the 24 aerial rockets which constituted the maximum load of the F-86D.[108] Such combat capability predictions were based on performance estimates advanced by Convair, but for a time early in 1953 it appeared that the contractor had sadly miscalculated the performance potential of the aircraft.

In February the Aircraft Laboratory reported that it was in basic disagreement with Convair on the amount of drag-due-to-lift that the F-102 would experience in the transonic zone. Aircraft Laboratory aerodynamics experts calculated a combat radius, speed, and ceiling considerably less than that forecast by Convair's engineers. Wright Field promptly asked the National Advisory Committee for Aeronautics to submit its estimates. When the advisory committee replied, on 13 February, it was to the effect that its engineering calculations, derived from experimental wind tunnel data, indicated that even the Aircraft Laboratory figures were optimistic. Immediately, it became apparent that a re-examination of the F-102 configuration and a re-evaluation of its ability to meet the specified performance requirements was essential.[109]

Convair insisted that the F-102, as designed, would reach an altitude of 57,600 feet and have a combat radius of more than 350 nautical miles; wind tunnel figures compiled at Langley Air Force

Base, Virginia, and Ames Aeronautical Laboratories in Cleveland indicated a probable ceiling of 52,400 feet and radius of 200 miles. A preliminary conference of Convair, Wright Field, and advisory committee engineers on 16 February was productive of no agreement.[110] On 16 March, after engineers had re-examined all the calculations, another meeting of the same groups produced unanimity on the location of the trouble spots. There were two: trim drag resulting from elevon defection needed to maintain the proper angle of attack, and zero-lift drag, the direct product of the aerodynamic configuration of the airframe. The aerodynamicists agreed that the data on which the disagreement was based were "somewhat theoretical" but felt there were sound reasons for further investigation. Moreover, three forthcoming events would provide experimental data to confirm or refute the conclusions drawn by engineers of the National Advisory Committee for Aeronautics. Engineers expected to obtain information derived from the launching of rocket-powered scale models at Wallops Island, transonic data from flights of the Convair-designed XF2-Y (a Navy delta-wing fighter), and drag data from flight of the prototype YF-102.[111]

Convair agreed that if drag figures so obtained bore out the reduced performance predictions, changes to the aircraft were needed. On 24 July the first rocket-powered scale model was launched, and, despite a poor flight, provided data that substantiated the predictions of the National Advisory Committee for Aeronautics.[112]

The aerodynamic theory borne out experimentally by this model flight was quite new; it actually postdated Convair's initial airframe design for the F-102. Known as the "Jones-Whitcomb theory of area progression," it said in effect that the aerodynamic drag of an airframe at transonic and supersonic speeds was largely dependent on the ratio of total airframe cross section area at any station to the total airframe length.* In part, this involved the "fineness ratio."[113] Therefore it appeared that the fuselage of the F-102 was too thick at the point where wing span was greatest and was not long enough overall. The effect of this fault was to induce high drag at low transonic speeds. An extended fuselage, narrowed somewhat at the trailing edge of the wing and expanded again near the tail, would (according to the Jones-Whitcomb theory) correct the defect and permit the aircraft to obtain a much higher speed before encountering the drag barrier.[114] This Jones-Whitcomb theory was also known as the "NACA ideal body theory,"[115] and, in a more graphic phrase derived from the appearance of the fuselage profile, the "Coke Bottle theories."[116]

The fuselage configuration change to a "coke bottle shape" compensated for drag produced at zero lift (aerodynamic drag), but did not correct for drag induced by trim. For a time designers feared this

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*This is not intended to be a definitive abbreviation of the Jones-Whitcomb theory, or anything approaching that. The theory is somewhat complicated (for the layman); one report describing it is 24 pages long.

might require adding a conventional tail to the F-102.[117] Fortunately, less drastic changes proved necessary. Ultimately the Convair, Wright Field, and national advisory committee engineers agreed that the addition of a cambered leading edge and a "warped" wing tip would substantially reduce trim-induced drag. The cambered leading edge increased lift and concurrently improved the ceiling of the aircraft as well. The "warped wing tip" induced additional trim moment without invoking the drag penalty involved in grafting on a conventional horizontal tail.[118]

Such changes stimulated other alterations to the airframe configuration. To correct for the center of gravity shift induced by extending the fuselage seven feet, engineers moved the leading edge of the wing rearward about three feet. At the same time, they took advantage of the longer fuselage and moved the vertical fin to the rear by about six feet, thus improving directional stability and reducing side travel.[119]

As a result of such changes, the "new configuration" F-102 would have a performance roughly equivalent to that originally predicted for the "old configuration" aircraft. Moreover, for the first time performance estimates compiled by the contractor, by Wright Field, and by the National Advisory Committee for Aeronautics were substantially in agreement. This alone was an accomplishment the project office characterized as "gratifying."[120]

The configuration change, naturally enough, had some effect on aircraft scheduling, although the contractor reported that it would not be necessary to change the design of any major parts previously subcontracted. Nonetheless, re-machining would in some instances be required.[121] The imminence of the first flight of the YF-102A, and the accessory fact that its fabrication had been virtually completed by June, meant also that the first flight tests would be run off with "old configuration" airplanes. Indeed, at least the first 10 of the more than 40 Convair deltas scheduled to enter the testing program would be of the "old configuration." Some of the redesigned substructures could be retrofitted to the old models after their first flights, and the actual results of such changes evaluated by test pilots. But experimental confirmation of the validity of major configuration changes would have to await the delivery of airplane number 11, the first scheduled to incorporate the "coke bottle" fuselage and the repositioned wing and rudder.[122]

Construction of the first prototype engines, the airframe, and the fire control system for the F-102A was progressing reasonably well. The engine, which threatened for a time to be something of a bother, seemed to be in fair shape by mid-year. Pratt and Whitney, producer of the J57-P-11 intended for use in F-102A's, indicated late in June that the 15 September 1953 delivery date for the engine would be met. However, first indications were that this would be a basic engine with a straight tail pipe, and not the afterburner-equipped

J57 intended for production aircraft. Colonel Haugen cautioned against disappointment on this score, since it was unlikely that the first F-102A would attain the level flight supersonic speeds anticipated until the afterburner was installed.[123] Two weeks after this warning was voiced, however, Pratt and Whitney shipped an afterburner-equipped engine to Convair for installation in the first YF-102A, scheduled to fly in October.[124]

The first production J57's were to have a thrust output of 14,800 pounds. Subsequent engines, programmed for early 1955 delivery, were to have a thrust output in the order of 16,000 pounds.[125] This last improvement might conceivably have important repercussions on the performance capability of the interceptor. Initial estimates of the speed to be anticipated from the "new configuration" F-102 were based on a J57-P-11 of 14,800 pounds thrust. In April 1955 the 16,000-pound engine was to be available. Remarked the project officer, "In this case the aircraft performance is substantially increased with a high speed peaking at Mach 1.67* /in contrast to the 1.32 possible with the -11 engine/."[126]

Of course a still more substantial performance increase would result from the incorporation of the J67-W-1 engine when the F-102A became the F-102B. With essentially the same airframe, weight, and external configuration, the advanced F-102 would contain an engine

*Mach 1.67 was about 960 knots at 35,000 feet, or approximately 1,110 miles per hour.

designed to produce a maximum of 21,500 pounds of thrust.[127] Some indication of the improved performance could be gained by a comparison of the original design speeds of the two similar aircraft. (In view of the fact that the "new configuration" F-102A had approximately the same performance as that originally predicted for the "old configuration," the ratio would probably hold true for the F-102B as well.) With the J57 of 14,800 pounds thrust, the F-102 had been scheduled to reach a maximum speed of 846 knots (about 978 miles per hour) at 35,000 feet altitude. The 21,500-pound thrust J67, designers thought, would push the aircraft to 1,177 knots (about 1,340 miles per hour) at the same altitude.[128] This was indeed, as the project office reported, ". . . a sizeable increase in performance."[129]

The J67 was based on a British design, the Olympus engine. Wright Aeronautical Division had the American license for the power plant and was charged with developing it to a configuration suitable for the ultimate F-102. Work on the engine in the first months of 1953 was largely confined to tinkering with four Olympus engines imported from England. By June the firm had completed nearly 500 hours of test stand operation of its borrowed engines and had derived a considerable bulk of useful data from the experience. But this constituted virtually the sum total of productive work on the J67. The Power Plant Laboratory felt, therefore, that Wright Aeronautical's October 1953 predicted completion date for the prototype J67 was optimistic by at least four months. Moreover, calculating a proportional delay all along the line, the laboratory conjectured that the delivery to the Air Force of the first test J67's could easily slip as much as nine months.[130]

General Bradley, materiel command production chief, was similarly worried about J67 progress. Early in March he wrote General Boyd that Wright Aeronautical appeared to be "overly optimistic" with respect to both the weight and the availability date of the engine. In order to meet weight requirements (and contractor weight estimates), the engine firm had designed the engine with one main bearing less than was customary for a turbojet of this type and had planned to use a very light weight exhaust nozzle. Both of these features were probable sources of trouble; in similar engines considerable bearing and exhaust nozzle trouble had been encountered in the past.[131]

The feeling that Wright Aeronautical was not realistic in estimating availability dates and that development difficulties might postpone availability even more than was presently feared led General Bradley to the conclusion that airframes for the advanced F-102B might be delivered in advance of the time when engines were available. Equally distressing was the prospect that other aircraft dependent on the J67 might be delayed by a retarded availability date for the engine. Therefore General Bradley recommended that the Pratt and Whitney J75 be considered as an alternate installation for aircraft then scheduled to carry J67's. The materiel command procurement chief observed that the thrust outputs of the two engines were reasonably close and that the 1,400-pound weight advantage of the J67 would probably disappear in the course of the development program. General Bradley pointed out again that Wright Aeronautical would "have a difficult time in meeting the weight limitations quoted in the specification for the J67" while Pratt and Whitney had a history of bettering thrust and simultaneously reducing the gross weight of its engines.[132]

The J75 of which General Bradley spoke was of the same general type as the J67; both were twin-spool, axial flow engines with afterburners and variable area exhaust nozzles. The 1,400-pound weight disadvantage of the Pratt and Whitney engine was to a degree offset by an anticipated thrust advantage of about 2,000 pounds.[133] Moreover, development progress was apparently better in the case of the J75. The contract had not been awarded to Pratt and Whitney until December 1952, yet by June the basic aerodynamic and mechanical design layout was complete, 95 percent of the detail parts drawings had been completed and released for manufacture, and the remaining 5 percent were drawings of internal parts which had a short manufacturing lead time. More than half of the parts for the first experimental engine were complete and the remainder were in the process of fabrication. An experimental J57 had been modified to incorporate some of the unusual design features of the J75 and instrumented to investigate some of the problems peculiar to that engine.[134] The Power Plant Laboratory expected the prototype engine to be ready for development testing by September or October 1953, and there was no threat of slippage dangling in the background.[135]

Wright Air Development Center reaction to General Bradley's suggestion took the form of reserved interest. Colonel Demler reported in April that center engineers were attempting to determine the impact of the engine changes on the performance and availability of the aircraft affected. He pointed out, however, that the final choice of an engine was dependent on a compromise between aircraft performance and production cost, and the center maintained that the relationship between the two should be very carefully weighed before any commitments were made. With this reservation, he promised that Wright Field would evaluate the factors involved and confer with the materiel command on the cost issue, leading ultimately to a resolution of the problem General Bradley had spotlighted.[136]

The mock-up inspection of the F-102A was held in November 1952, some months before a firm decision to produce an interim interceptor and prior to the discovery that the airframe design could be materially improved. Nevertheless, most of the comments applicable to the "old configuration" aircraft would probably be valid for the later F-102's. And there were a relatively large number of such comments--121 in all. Of this total, however, a portion related to the MX-1179, which was not Convair's responsibility. These were forwarded to the MX-1179 project officer for action. Many others were deemed momentarily less important and relegated to one of the lesser classifications. However, 53 items were approved by the mock-up board as relevant to the aircraft system and subjects for corrective action under the terms of the contract with Convair. They ranged in topic from windshield distortion and emergency brakes to landing gear jacks and recording cameras.[137]

An important minor item, cockpit lighting, was not included in the initial mock-up inspection. Instead, in April 1953 a separate inspection of this feature was scheduled. The result was somewhat startling. Although the overall mock-up had produced no dispute worth remarking, the lighting mock-up inspection fomented a furor. In the first place, the Air Materiel Command was very unhappy about the board's decision to use non-standard cockpit lighting in the aircraft. "Sandwich lighting" had been the board's recommendation.[138] The Air Materiel Command promptly asked General Boyd to support a return to conventional illumination in the aircraft.[139]

The Wright Field commander replied that the center had been testing sandwich lighting for some time and had not yet been able to determine what advantages or disadvantages over standard lighting its use might involve. He did express considerable concern, however, over what he characterized as the tendency "to dictate engineering changes to new aircraft in complete disregard of the advice of my engineers." This was, to say the least, not in the best interests of the Air Force.[140] General Boyd also expressed much the same opinion of the proceedings to the deputy director of the materiel command maintenance engineering directorate.[141]

Subsequently, the center scheduled special tests of the sandwich lighting system in an aircraft. There seemed no other way to determing its real effectivity.[142]

Some other airframe and equipment problems of a general nature were under study as well. Seven special scale models of the F-102 were being built in May to aid in a determination of the flutter characteristics of the interceptor. At the same time a contract for testing the separation characteristics of the Falcon and rocket armament was in the process of being drawn up. It was during the same period, of course, that the rocket model flights which finally led to a fuselage configuration change were being planned.[143]

Despite this activity, there was little chance that the fuselage design of the F-102A would differ in any important respects from the F-102B. Electronics, like engines, fell into an entirely different category. The principal concern of engineers was for the fire control system; although the MX-1179 combined a number of electronic functions, it still was primarily a device for producing lethal explosions inside enemy bombers. Thus the MG-3 fire control system was the leading concern of electronic engineers who were intent on equipping the F-102A with that same ability.

Item one in fire control system development was the predicted delay of 18 to 24 months in the completion of the first MX-1179, because of attention and emphasis redirected to the MG-3.[144] The inevitability of an interim fire control system having been recognized, there was no alternative to making the best of the situation. Therefore the first order of business was to accelerate work on the MG-3, while attempting to maintain some semblance of a reasonable development schedule for the MX-1179. In February Air Force headquarters directed that "every effort be made to expedite the tactical availability of F-102A aircraft . . ." and that the ultimate version with the J67 and MX-1179 "be phased in as soon as possible without affecting E-9 [MG-3] availability for the F-102A."[145]

The MG-3 fire control system was essentially a normal progression of earlier E-series systems, most of which were Hughes developments. In most respects, the MG-3 was virtually identical to the E-9 system planned for installation in Falcon-equipped F-89 aircraft. Since most major components were in an advanced stage of development, the details of the entire system installation were readily available. As early as August 1953, therefore, a development engineering inspection of the F-102A with the MG-3 installation was possible. The final configuration of the aircraft-fire control system was expected to be decided at that inspection.[146] Development engineering was scheduled to continue into 1955, although a prototype would be ready by August 1954. By July 1955 the Air Force expected to have the system prepared for operational use. The first availability of tactical equipments was programmed for that time.[147]

The MX-1179 electronic system quite naturally lagged behind this schedule. The first production system was not due to emerge from fabrication before the third quarter of 1957--now that the emphasis had shifted to MG-3 development.[148] By mid-June 1953, however, analytical studies of the system had "for the most part" been completed and development work on components started. Hughes had fabricated some prototype components, and could test these portions of the system. Designers felt it necessary, however, to continue some study work, especially in the areas of systems integration and component construction.

No provision for optical sighting had originally been required for MX-1179, but as the development program progressed it became apparent that the possibility of having to aim and fire rockets from low altitudes, or in the presence of either chaff or counter-radiations, could not be overlooked. Hughes accepted this premise, planned the addition of an optical sighthead, and prepared in June 1953 to subcontract for the element.[149]

Work on MX-1179 proceeded in five major phases, divided along the lines of the major subsystems. Radar development constituted one entity, identification facilities another, computing and control elements a third, communication, navigation, and blind landing equipment the fourth, and the power supply for the whole system the fifth.[150]

Although the almost automatic functioning of the MX-1179 was perhaps its most intriguing characteristic, project engineers felt that the integrated power system was the "dominant novel feature." . .

Elimination of the necessity for individual power supplies for various electronic components and subsystems made possible the promised "great reduction in size, weight, and heat generation in the MX-1179."[151]

No matter which electronic complex was in the aircraft, it would depend for much of its effectiveness on the satisfactory reception and interpretation of ground control data. In MX-1179, this feature was an integral part of the basic system. Any interim system, however, would have to rely on independently developed equipment of a like nature. During the early months of 1953 work on the airborne equipment which would permit a tie-in of the F-102A with the Lincoln system progressed reasonably well. Although the work was as yet in a preliminary stage, detailed plans not having been worked out, engineers from the center's laboratories were in close liaison with Project Lincoln personnel, to insure compatible developments. Tests of the existent data link equipment were scheduled for August, at which time the probable trend of future work would become apparent.[152]

Among the modifications and alterations planned for the F-102A were three which would probably have a considerable bearing on its ultimate usefulness. In February, Air Force headquarters directed the addition of range extension provisiens. While this might eventually take the form of some sort of in-flight refueling, initially the contractor concentrated on the addition of droppable fuel tanks.[153] The installation of a high pressure oxygen system, authorized in March, insured that sufficient oxygen would be available to permit utilization of the maximum range capabilities of the airplane.[154] Finally, the substitution of 2-inch T-214 rockets in lieu of 2.75-inch standard aerial rockets promised to better the destruction potential of the F-102. Whether or not this last change was feasible was not entirely certain, but Convair was studying the proposal at mid-year.[155] The change, if adopted, would provide 35 percent more rockets in the same space. Here again there was some uncertainty. Whether the space reduction should be utilized to save weight or to increase the firepower of the F-102 had not been decided as late as September 1953.[156]

The question of providing a special trainer for F-102 pilot orientation was tentatively decided in May by the issuance of a letter contract authorizing Convair to proceed with production engineering, tool design, fabrication of a mock-up, and the procurement of materials requiring a long lead time. Initially, only three YTF-102A aircraft were scheduled.[157]

The proposed TF-102 was to be a side-by-side, dual control, fully equipped version of the F-102A, identical with the interceptor except for some fuselage and canopy redesign to provide for dual seating, dual controls, and the reduction of armament to 3 Falcons (instead of 6) plus 24 rockets.[158] There was actually no reason why the TF-102 could not be operated as a combat interceptor, if that proved advisable.

Because first flight of the F-102A was rapidly approaching, the test program became increasingly important. A number of agencies were involved in the plans, including the National Advisory Committee for Aeronautics. General Boyd was especially insistent that the advisory committee be furnished one of the early test aircraft for supersonic tests.[159] A sequence of conferences among Air Materiel Command, Air Proving Ground Command, and Air Research and Development Command personnel marked the period from January to April, leading eventually to an agreement that 59 test aircraft were needed for the entire flight test program. There were strong indications that the requirement might be approved, since General Partridge was personally pushing it through channels.[160] The test schedule that existed shortly after mid-year, however, provided for only 43 aircraft.[161]

Lastly, there was the matter of a flight simulator for the F-102. Although in normal circumstances the design and procurement of a flight simulator was a routine affair, in this instance complications appeared. The deputy chief of staff for development in Air Force headquarters ruled that because of the developmental nature of the F-102 and the complexity of its electronic equipment the prime contractor should be given responsibility for developing a simulator. The decision was intended to insure that the simulator equipment would be developed in consonance with the aircraft and electronic system specifications, "neither of which are presently available, even to the prime contractor," as one center official quipped.[162] The question

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F-103 Airc aft (Mock-Up)

of simulator development promised to be somewhat thorny, since Convair would probably have to subcontract for the assembly because of its heavy workload in the primary area of aircraft development.

The F-103

Some degree of initial development effort was lavished on the XF-103 in the first six months of 1953, but by June the scheduled successor to the F-102B had become, for all practical purposes, a state-of-the-art development project.[163]

Several factors contributed to this result. Probably the foremost was design and development difficulty. Aerodynamic heating of the airplane skin limited maximum speed to Mach 3.0 and forced the use of an all-titanium skin structure.[164] Similar considerations derived from the extreme high speed of the aircraft motivated the selection of a periscope system for the pilot in lieu of the standard canopy.[165] Along the same line, the only suitable power plant that was at once practical and productive of the needed thrust was a combination turbojet-ramjet proposed by Republic Aviation Corporation engineers. The initial design of this double-cycle propulsion system was difficult enough; improving it to the point of operational suitability promised to be an even more formidable task.[166] Thus the decision that "the development of the critical components scheduled for the XF-103 is not yet to the state where prototype fabrication can realistically be initiated."[167]

Taking all of these factors into consideration, the Air Force decided early in 1953 that ". . . the XF-103 will be considered an experimental weapon system development, programmed to guide state-of-the-art developments in the various fields in the solution of problems inherent in the performance range contemplated for the F-103."[168]

Budget cuts which affected the financing of XF-103 development in fiscal year 1954 also had something to do with the decision to postpone any prototype work. The controversy about securing production funds to finance development of the Republic interceptor had, of course, been current for more than a year.* The highly experimental nature of the aircraft and its components gave support to those who maintained that it should be financed entirely from research and development funds. Yet because of the scope and complexity of the project, it was virtually impossible to allot from the relatively small research and development budget sufficient money to finance development.[169] Cost of the airframe, engine, and fire control system for the prototype alone was estimated at more than $41,000,000.[170] In comparison, the total budget (610 funds) for all aircraft development at Wright Field for fiscal year 1954 was about $35,000,000![171]

All in all, there was sufficient reason for postponing plans to advance the F-103 to the flying prototype stage, although Republic

*See "History of Wright Air Development Center, 1 January-30 June 1952," pp. 211-212.

felt strongly that any obstacles could be overcome in plenty of time to permit a routine production program.[172] However, progress in the development of specialized components of the F-103 did not bear out this prognosis. There was, for instance, substantial doubt in some quarters that the periscope configuration was entirely practical. General Boyd had earlier flown an F-84 with an experimental periscope installation and in October 1952 strongly recommended against the immediate commitment of such a device to the F-103.[173] Nevertheless, when the mock-up board met to evaluate the aircraft design during the week of 2 March 1953, it selected the periscope configuration for further development.[174] Although periscopes had a number of undesirable features, of which limited visibility was not the least, the fact that even an extremely small canopy, "just enough to get the pilot's eye into visibility position," would increase aerodynamic drag by at least five percent could not be disregarded.[175]

This circumstance notwithstanding, a periscope configuration would be fatal if it were not completely practical--and General Boyd pointed out that there was no experimental proof of worth in this case. He maintained that no periscope should be scheduled until a device identical to the one proposed had been built and successfully tested in a flight vehicle of some sort.[176] On 19 March he had occasion to confer with General Partridge and forcefully presented his viewpoint. The research and development command chief was in complete agreement, especially when it was pointed out that there would be no element of safety in the initial flight of the F-103 unless the periscope had first been thoroughly proven. General Partridge therefore authorized the modification of an F-84 or F-86 to the cockpit configuration of the F-103, and despite the initial decision of the mock-up board it appeared that the periscope decision would eventually depend on the results of this flight test.[177]

Progress toward a practical power plant for the F-103 was slow in the first months of 1953. This was due in part to financial troubles and in part to difficulty with the assignment of the contract for development of the power plant controls.[178] Because of the complexity of the installation, engineers did not believe it would be possible to have an entirely practical system ready in time for the scheduled delivery of the first test engines. Therefore Wright Aeronautical, which was to build the J67-W-3 engine, agreed to construct an interim power control system adequate to the needs of a flight test program. Development of the ultimate power controls, suitable for a production engine and airframe, was tentatively assigned to Bendix.[179] However, signature of a formal contract for this work was delayed more than nine months by funds controversies and the contractor's need for specialized test equipment not provided for in the original contract proposal.[180]

The Sperry Gyroscope Company, considered by project engineers to be the most suitable commercial firm to develop the transitional (initial) control system, was not much further along. Before Sperry could start design work, it needed information on engine requirements, and the study on which this information was to be based had not been completed by mid-year. Wright Aeronautical was at fault here.[181]

At mid-year the status of the F-103 was still somewhat in doubt. Although state-of-the-art work was the assignment of the moment, Air Force headquarters had allotted no fiscal year 1954 funds to carry out the extended Phase I development program. This meant that the engineering and component development that Republic was supposed to undertake was not adequately financed, since the initial apportionment of fiscal year 1953 funds was barely sufficient for the original Phase I program. And the airframe was not alone in being inadequately supported from a monetary standpoint. All of the components of the system were similarly affected by the funds lack.[182]

Two of the major components of the ultimate F-103 were having scheduling trouble or were, in the opinion of competent production experts, in danger of not meeting requirements. The MX-1179 system for the F-103 was subject to the 18- to 24-month delay occasioned by the shift of emphasis to the MG-3 for the F-102A.* Moreover, the J67 program as a whole seemed to be in imminent danger of falling out of phase with the rest of the project, not only time-wise, but in performance requirements as well. The materiel command, buttressed by the supporting opinion of the Power Plant Laboratory, had serious doubts

*See pages 229-232, above.

that the J67 would be satisfactory.* The possible shift to an alternate engine for all aircraft planned around the J67 would, if carried through, have a pronounced effect on the F-103 program.[183] And in the event of a switch from J67 to J75, all of the work devoted to making the J67 suitable for alternate ramjet operation might have to be done over.

Despite these shortcomings, the performance potential of the F-103, as supported by design estimates and wind tunnel tests, made it a worthwhile prospect for continued development. In March, Republic representatives told the air defense symposium of the advantages the aircraft offered over any other proposed interceptor and of some circumstances in which it would be more valuable than air defense guided missiles. The Mach 3.0 speed of the F-103, which in theory permitted three assault passes at a Mach 1.3 bomber, was a good talking point. Comparable but more conventional aircraft, as the contractor pointed out, would have difficulty in making more than one pass, and an effective interception might require a pair of conventional fighters for each enemy bomber. The brief time the F-103 needed to reach the scene of combat as well as its superior maneuverability were factors of considerable weight.

In comparison with defensive missiles, the F-103 offered similar advantages. One was the greater flexibility of the aircraft,

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*See pages 225-227, above.

permitting ground controllers more selectivity and a chance of compensating for feints. Another consideration was the "salvage value" of the fighter. With support from a Rand study, Republic maintained that defensive missiles would largely be shot away in the initial mission, while a piloted fighter could participate in a number of interceptions and also be utilized profitably in later tactical operations, either for defense of advanced areas or, with modification, as tactical aircraft in support of land operations. The importance of this circumstance in the total cost of a defense establishment was obvious.[184]

Guided Rockets

The existence of high performance interceptors equipped with exceptionally accurate fire control systems did not guarantee an effective air defense of the United States. The foremost requirement of an interceptor was destructive firepower delivered to a vital spot. Existent munitions devices--guns and unguided rockets--each possessed substantial disadvantages from this standpoint. Even relatively large-bore aerial cannons were deficient in two respects: precision and range. Unguided rockets were generally less accurate than machine gun or cannon projectiles, although they generally possessed greater explosive force. The air defense requirement for the United States posed the problem of overcoming these deficiencies, and for the moment the GAR-1 (guided aircraft rocket) Falcon was the only solution in sight.

The Falcon contained two essentials that promised relief from the shortcomings of unguided rockets or rapid-firing guns. It was designed to impact on the target, thus insuring a high ratio of kills to hits, and it was intended to be fired from positions well outside the effective cone of defense of any bomber. Implicit in these two conditions was a high degree of accuracy, assuring a respectable ratio of hits to missiles fired.

These were the principal reasons the Falcon was scheduled to become the main armament of forthcoming interceptor aircraft. Both the F-89 and the F-102 were definitely programmed for Falcon installations. The F-86D might well become a third in this group. Finally, the F-103 and any other advanced manned interceptors to be channeled into the Air Defense Command inventory would undoubtedly carry much the same armament. The vital nature of the Falcon in development plans was readily apparent.

In April, Wright Field formally learned that the official designation of the first model Falcon had been changed from F-98 to GAR-1. This was the missile intended to be launched from subsonic or low supersonic carriers at subsonic bombers. The F-98A, an advanced version for supersonic carriers and effective against supersonic targets, was retitled the GAR-1A. At the same time, Air Force headquarters announced the start of development work on an infrared-seeker version, dubbed the GAR-1B.[185]

Each of the more advanced versions of the basic Falcon lagged somewhat behind the original in development. However, schedules called for initial launching of the GAR-1B in March 1954, with the GAR-1A to follow early in 1955. The former was identical to the GAR-1 in all elements aft of the radar nose unit and electronic units, which were to be replaced by an infrared guidance seeker and a modified electronic package. The GAR-1A had an outward configuration different from that of its predecessor, was eight pounds heavier (132 pounds gross weight in launch configuration), and contained improved electronic and propulsive elements.[186]

The advantages of the infrared missile were obvious. It needed no complicated radar equipment, it had no minimum altitude limitation (ground echoes nullified the effectiveness of the GAR-1 at less than about 3,000 feet), it could, if it possessed sufficient detection range, be launched without recourse to any fire control system at all, it was virtually impervious to electronic countermeasures, and it promised to be of considerable value as a multiple weapon, intermixed with standard radar-guided Falcons in a salvo.[187]

Utilization of the Falcon in an operational interceptor was to a great extent dependent on the availability of a suitable aircraft to act as a carrier in the test program. The F-89 debacle had extremely serious repercussions for the Falcon program since flight tests with a fire control system specifically designed for the Falcon were vital. Shortly after the first of the year, the Air Force revised previous production schedules for the missiles, not postponing the first delivery date but reducing the first year's production rate. This move was frank recognition that satisfactory flight testing of the Falcon was not possible without F-89's.[188]

This meant, in effect, postponing the operational availability date for the first Falcons. Shortly after mid-year, Air Force headquarters recognized this misfortune by retarding, from July 1954 to January 1955, the target date for the start of operational suitability tests of Falcon. This move was based on the assumption that it would be early 1956 before F-89's equipped with Falcon pods and suitable fire control systems could be phased into operations.[189]

Originally, the F-102 aircraft had been programmed to receive GAR-1A missiles, since these were specifically suited to the MX-1179 and the airframe configuration.[190] The decision to produce an F-102 without MX-1179 and without the more powerful J67 engine meant a revision to those plans. Hughes, therefore, immediately began to examine the possibility of using the GAR-1 with the F-102A. The MG-3 was roughly equivalent to the E-9 fire control system planned for the F-89, and presented no problem. Nonetheless, it was undoubtedly a relief to the Air Force when Hughes reported in May that the GAR-1 was compatible with the F-102A, that no major modifications would be needed to permit satisfactory operation of the combination, and that work toward equipping F-102's with Falcons would not delay or compromise the F-89's Falcon program.[191] Somewhat later Hughes also determined that the E-9 (and by implication, the MG-3) was capable of launching the infrared-guided GAR-1B missiles. In this instance, however, there was a qualification. Only two such missiles could be launched in each salvo of six (the maximum load of both the F-89 and the F-102A) because additional infrared seekers might very possibly track missiles fired earlier.[192]

The GAR-1A and GAR-1B were still in the laboratory phases of development, but for nearly a year the GAR-1 had been definitely in the flight test stage. Early experimental models of the Falcon had been the sole subjects of actual flight experiments until shortly after 1953 opened,[193] but thereafter prototype tactical models occasionally intruded into the test program. Launching of the first hand-built tactical configuration Falcon took place at Holloman Air Force Base in March, but the flight was not successful.[194] A second attempt, on 5 June, was productive of more encouraging results; from a very respectable range the "bird" scored a direct hit on a foil-lined parachute, impacting less than five feet from dead center.[195]

Other launchings during the six months involved the earlier experimental version of the Falcon then coming off a "production line". A total of 15 guided flights were attempted, as well as a number of unguided flights designed to provide aerodynamic data.[196] Some of the former were worthy of note. For example, on three successive launchings prototype production models demonstrated satisfactory guidance and control.[197] Another in the same series scored a direct hit on a maneuvering drone B-17 from a range of 9,700 feet, destroying the bomber. While this was a pleasing performance, it had some unhappy consequences. The QB-17 which fell before that particular Falcon was the last drone allocated to the test program. Thus, shortly after mid-year the test organization reported, "unless additional drones are made available by Hq USAF, it is anticipated that [the] flight test program will be indefinitely delayed."[198]

Another interesting series of tests involved firing pilot-model Falcons at chaff-dispensing targets. The first attempt was a failure, as were three subsequent firings on 2 and 3 April. Miss distances in each instance varied from 300 to 1,000 feet.[199] However, further tests against chaff were planned, as well as additional tests to assist in improving the reliability of production-type missiles.[200] In addition to actual Falcon firings, countermeasures experiments involved the use of a B-25 harnessed to a captive GAR-1 missile. Simulated free-flight operation was to be attempted, with appropriate instrumentation in the B-25 recording the reaction of the seeker mechanism to various types of electronic and mechanical countermeasures.[201]

Another possible restriction on the use of Falcon was being investigated elsewhere. In July the center signed a contract calling for the development of an electronic system capable of controlling three QB-17 drones in a formation under the guidance of a single remote operator. The device was needed to check the reaction of Falcons (and Bomarcs) to multiple targets. In some quarters there was doubt that the seekers in those missiles could exercise selectivity. There was a chance that a guided rocket exposed to several radar echoes might develop a case of electronic schizophrenia, and the Air Force intended to find out.[202]

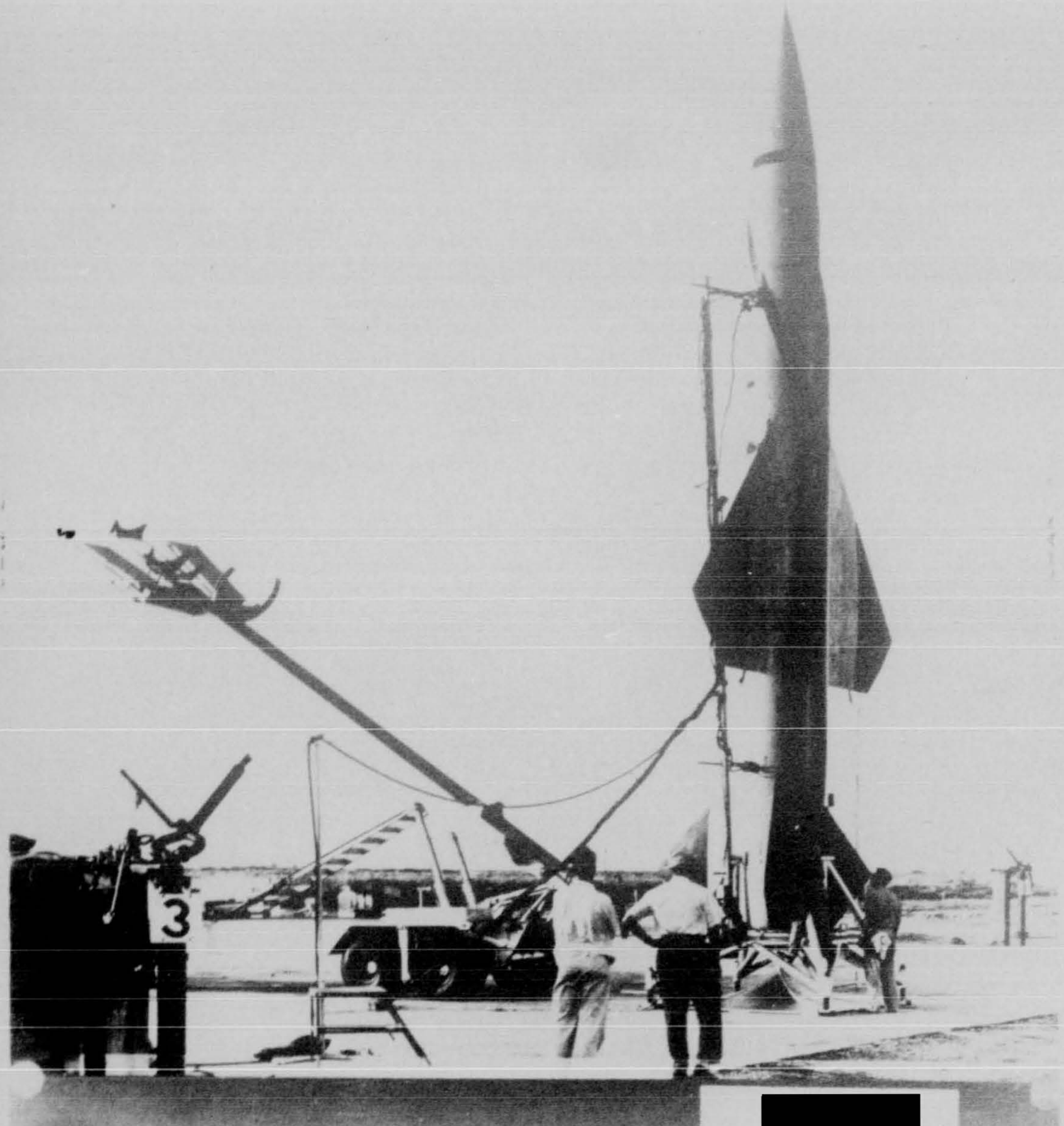
A small, infrared-guided aircraft rocket, similar in some respects to the GAR-1B Falcon, seemed for a time in early 1953 to be an excellent prospect for addition to the Air Force stable of aerial weapons. Shortly after the start of the year Wright Field learned that Air Defense Command planners had formally stated a requirement for an infrared air-to-air rocket suitable for use with aircraft which could not accommodate Falcons.[203] A design submitted by the Aerojet Engineering Corporation seemed to fill the bill. Designated the Aerowolf, it was intended to be simple in construction and operation and applicable to a large variety of aircraft.[204]

Project personnel described the Aerowolf as "of interdigitated cruciform canard configuration," powered by a solid propellant rocket, and possessing supersonic speed capabilities. Because it would have to be fired from within a 30-degree cone drawn from the tail of the target, it had some inherent limitations. Nevertheless, it had the advantages of being usable at ranges approximately equal to the limits of the human eye and of requiring no further attention from the interceptor aircraft after launch was complete. Infrared guidance would carry it to the target with no need for a boost from the mother aircraft.[205]

Although the proposal elicited "highly favorable comments" from the center's technical personnel[206] and from the Air Materiel Command,[207] the Aerowolf suffered the fate of several other proposed systems. In mid-June Wright Field learned that slashes in the fiscal year 1954 budget had forced cancellation of plans for the project. Prospects for later reinstatement did not appear bright.[208]

Pilotless Interceptors

In theory, at least, any danger of attack by means of subsonic or low supersonic bombers could be effectively countered by the use of high performance interceptors, especially by those equipped with Falcon guided rockets. However, several factors militated against indefinite reliance on manned interceptors. Extremely high bomber speeds, the introduction of long-range offensive missiles, the probability that ballistic missiles would ultimately be used, and the inherent limitations of the human pilot, all tended to offset the peculiar advantages of manned interceptors. Therefore the air defense of the United States for the period after 1956 would in large part be predicated on the use of several types of surface-to-air missiles. It was apparent that a simple anti-aircraft rocket for use against subsonic bombers would be useful; a special missile designed to counter low-level attacks would have to be developed; a standard missile capable of destroying semi-conventional bombers approaching at medium or high altitudes and speeds must necessarily be perfected; finally, SECRET



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Bomarc Missile on Launching Stand

some means of destroying a ballistic missile would have to be devised for the period when such devices became standard.

The Air Force had either in a study or development phase at least one missile project in each of these basic fields (and, of course, both the Navy and the Army had work under way which supplemented Air Force effort). However, probably the most important item of this nature for the relatively near future was the F-99 Bomarc, a comparatively large (about 40 feet long), supersonic, vertically launched missile being developed by Boeing.

Flight tests of the Bomarc ramjet engine and launch tests of the entire missile were the most prominent facets of development progress in the early months of 1953. Such experiments provided a quantity of useful information, but subpar engine performance dampened enthusiasm in almost every instance. Both the integral booster rocket and the cruise-phase ramjets were involved.

On 23 January the second prototype Bomarc missile left the launching stand at Patrick Air Force Base.[209] (The maiden flight had occurred in September 1952.)[210] Like the first, it crashed before reaching a condition of stable flight. The missile rose to a height of between five and ten feet, hesitated as boost propulsion failed, settled back to the ground, and exploded. Initially, there appeared to be little chance of determining the cause of the failure since the remains were not in any condition for detailed autopsy.[211] Subsequently, however, engineers deduced that a monitor plug had failed to eject on schedule and had introduced spurious signals into the circuits, actuating the rocket shutdown sequence.[212]

One additional source of difficulty disappeared with this second launching--the use of the original air-pressurized rocket booster. Future rockets were to incorporate a chemical pressurization system which was both safer and more efficient.[213] The first ground test of this remodeled rocket engine, on 26 February, resulted in a successful 27-second firing run, although a leaking valve limited the thrust output of the unit to 3,000 pounds less than its official rating.[214]

A new trial of the booster rocket at Edwards Air Force Base on 2 April was similarly unsuccessful. On the basis of these early results the scheduled flight test of a more advanced version of the missile (model 623-1) was postponed pending the elimination of rocket malfunctions.[215] Engineers finally decided that allowing pressure in the oxidizer (nitric acid) tank to build up before fuel tank pressure would provide an oxidizer-rich mixture during the ignition period and would correct the difficulty. Aerojet, builder of the XLR59-AJ-5 booster motors, proved the modification on a test stand and subsequently installed a modified rocket in the first model 623-1.[216]

Launching of this missile was temporarily delayed by a new fuel system failure, but investigation showed the trouble to be confined to the test equipment.[217] When the third Bomarc blasted off, on 10 June, it demonstrated reasonable reliability. Even though the completely fueled missile had been stored in the open for six days prior to launch, the operation was conducted without a major failure. The pilotless interceptor climbed to an altitude of about 18,000 feet on booster power. Thereafter the booster faltered as it neared complete burnout. Nevertheless, during this phase of the test, results approximated expectations.[218]

When the missile reached a speed sufficient to maintain operation of the two ramjet engines, they began functioning as scheduled. But a rocket malfunction, near the end of boost phase, was followed by a "low order explosion," after which the ramjets stopped operating, the missile coasted to the top of its trajectory (47,000 feet), and the whole episode ended with a large splash in the water two miles down range from launch point.[219]

Despite this highly humid climax, preliminary analysis of telemetered data convinced test personnel that no special modifications were required before the next Bomarc was flight tested. Therefore, while a more complete analysis of the radar and photographic records of the 10 June trial was being prepared, Boeing shipped the fourth F-99 to the missile test center, and it was prepared for firing in mid-July.[220]

Other notable dates for the Bomarc were 8 April and 10 June, when X-7 test vehicles powered by 28-inch Marquardt ramjets dropped from parent B-29's to begin flights productive of important data. The 8 April flight was probably more successful. On that occasion the

X-7 dropped free at 32,000 feet, the boosters cut in, the ramjet ignited properly, and the vehicle began a gradual climb, ultimately reaching a maximum altitude of 59,000 feet and a top speed of Mach 2.61. Stable flight with ramjet power lasted for about 20 seconds, after which leaks in fuel lines normally used only for ground tests curtailed thrust output. For a period of from 20 to 25 seconds thereafter, the engine burned intermittently and inefficiently. At the top of the glide, after power died, the parachute recovery system went into action, the missile descended, and ground parties subsequently recovered it virtually intact.[221]

Although the telemetering transmitter in the test vehicle went out of commission after two minutes of flight,[222] test engineers later agreed that "data covering all information of interest on engine operation were obtained."[223] And in view of the reasonably good operation of the ramjet engine, experts judged the flight to be ". . . particularly significant with respect to probability of future success of the F-99 weapon."[224]

The 10 June flight of the X-7 followed much the same pattern, although ramjet operation was of considerably briefer duration. After separation from the B-29, the test vehicle accelerated to Mach 2.2 on the strength of its booster rockets. At that point the ramjet took over and pushed the speed to Mach 2.45, but after only six seconds the engine developed extreme roughness and almost immediately burned out. Telemetering reception was excellent, and the

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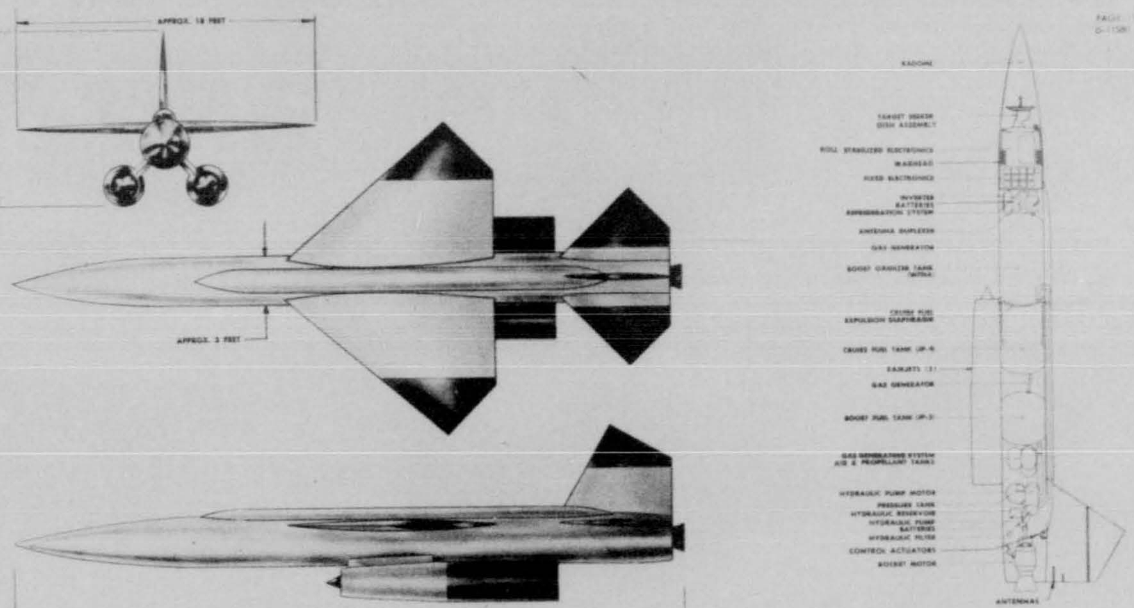

Figure 6
F-99 Configuration and Inboard Profile

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SECURITY INFORMATION

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Bomarc Missile-(3-View Drawing)

vehicle-engine combination sustained only minor damage in the parachute recovery maneuver. Consequently project officers felt certain that examination of the engine and analysis of the data would show the cause of the engine roughness.[225]

If there was one lesson to be gained from these flight tests, both of the complete missile and of the engine test vehicle, it was that additional ramjet flight evaluation was essential before any reliability could be assumed for the engines. On the premise that this would not be a short-term investigation, the project office asked for funds to buy more X-7 vehicles to support the required ramjet tests.[226]

The components development program for the Bomarc received one invigorating shot in the arm early in the year. The Components and Systems Laboratory learned that Boeing had devised a nose radome for the missile which not only provided the required streamlining but permitted radar beams to emerge undistorted.[227] Hitherto, the cone-shaped radomes needed to reduce aerodynamic drag at high speeds had warped the radar waves in their passage. Hemispherical radomes were suitable from an electronic standpoint, but they compromised the speed performance of the missile.[228] Unfortunately, solution of the Bomarc problem did not mean that the same fault in other missiles could be corrected by similar measures. The Bomarc radome difficulty, as the laboratory pointed out, was significantly less severe, principally because of the large size of the components involved.[229]

The experimental model of the Bomarc target seeker completed its fourth month of operation in February, with indications that satisfactory lock-on and tracking were perfectly possible. Westinghouse completed a more advanced model and delivered it to the missile contractor early in the year. A continuous wave seeker system, intended to either precede or supplant the eventual doppler radar seeker, was in the beginning stages of development.[230] The need for these last two seeker methods was based on the inability of the original system to resolve problems of ground clutter at low altitudes. There was some hope that a continuous wave seeker originally designed for use with manned interceptors might be adapted to the needs of the Bomarc program.[231]

The original schedule had called for missile-borne flight tests of the initial model seeker system designed by Westinghouse. Cancellation of these plans led to the idea of testing seeker assemblies in relatively high performance aircraft.[232] By 1 June an F-94B had been assigned to this task and preparations were under way to install a complete Bomarc nose assembly in the fighter.[233]

Shortly before 1953 began, Boeing had completed a series of free-flight drops of Bomarc scale models from F-86 aircraft. Preliminary indications were that the missile was less efficient from an aerodynamic standpoint than initial wind tunnel tests had hinted. On 23 January the center's 10-foot wind tunnel was used for a one-day check on the results of the free-fall experiments. The new wind

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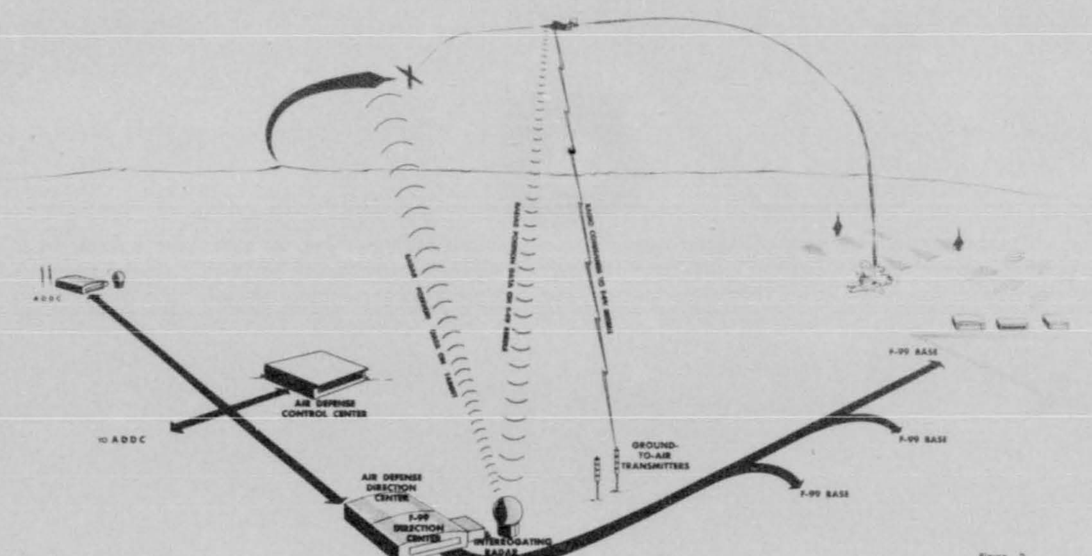

Figure 2

The F-99 Defense System

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Ground Control System for
Bomarc Missile (drawing)

tunnel data reinforced the pessimism prevalent after the completion of the scale model drops; transonic drag appeared to be quite high. Although the missile was in the transonic zone for only a few seconds during each flight, there were strong indications that overall performance was adversely affected. There was no way of further demonstrating the validity of this conclusion until instrumented flight tests of the full-size missile were possible.[234]

Early in January, command headquarters directed that the pending contract for the Bomarc ground-based control system be held in abeyance ". . . until assurance could be established on the compatibility of G-20 /the control system/ with the ADIS (ADEE)."* After "extensive review," command headquarters gave the center permission to proceed with the contract, with the proviso that the eventual system had to be compatible with both the Air Defense Integrated System or Cambridge laboratory's Lincoln system until one or the other was deleted from plans.[235] Development of an interim G-20 system was cancelled because the interim system would be available so shortly before the final G-20 that little advantage would accrue from the construction of the former.[236]

When information arrived that the Lincoln system had been selected as the "Air Defense Electronic Environment,"** project

*Air Defense Integrated System (Air Defense Electronic Environment).

** See pages 180-181, above.

personnel immediately began working to insure the compatibility of Bomarc with Lincoln.[237] The method of matching the missile's computer output to the Lincoln data link was settled in May, at a meeting of Boeing, General Electric (the data link contractor), Wright Field, and Rome personnel.[238] Henceforth attention could be concentrated on the perfection of the scheduled control system without worry that its ground electronic environment might be altered at some future date.

In March and April, programming planners undertook revision of the Bomarc flight test plan. Because of the time consumed in making changes and modifications resulting from each test, the program was getting out of phase. Tests were delayed while missiles were being altered. The schedule was therefore revised to permit firing in blocks of missiles, each block being made up of essentially similar "birds." The first block of missiles, consisting of two test articles, had been fired in September and January. Tests of the second block (four missiles) were to occupy the time between April and July 1953, and were to utilize the model-623 configuration. The same model was to be furnished for the 14 subsequent block III tests, to extend from October 1953 to May 1954; the final block was to be made up of model-623 missiles, with firing dates extending from November 1954 to August 1955.[239]

In a final programming change, shortly after mid-year, the projected completion dates for development, test, and operational evaluation of the initial (short range) missile were slipped back, respectively, to October 1953, August 1955, and July 1956. The advanced model Bomarc was scheduled to complete the same phases in October 1955, August 1957, and July 1958.[240]

One of the most pressing of Air Force problems was the provision of an air defense missile for the period before Bomarc became operational. Adoption of the ground-to-air missile engineered and produced by the Oerlikon Tool Machine Works of Switzerland seemed to be one solution. The Oerlikon missile had the advantage of being an off-the-shelf weapon requiring only adaptation to American needs; most domestic missiles of a similar nature were development items.

Despite the advantage this situation appeared to offer and in spite of the fact that a decision to test the Oerlikon missile had been made in 1951, fiscal year 1954 got under way before the first test missiles were fired under Air Force cognizance. In large part this was the consequence of two circumstances--the distaste of the Swiss company for the proposed test procedure and the lack of a test site at once suitable from a technical standpoint and yet remote from the installations being used for classified experiments with Air Force missiles.[241]

When 1953 opened, the first of these issues had been resolved to the marginal satisfaction of both parties and a test site near Holloman Air Force Base had been selected. However, before actual firing could start, test personnel needed a building to house equipment,

VII

missiles, and test items, and such construction in turn required the assent of the Secretary of Defense. At about the turn of the year the Office of the Secretary of the Air Force returned the original request for funds with the note that additional justification was required. Rejustification was expected to delay the actual start of tests still further, as well as to re-energize the unrest of Oerlikon people, who were none too happy with existing conditions.[242]

During the week of 2 February, Holloman Air Force Base received notice that the requisite funding had been approved; the following week, word arrived that all construction funds had been frozen. Project personnel predicted an additional three-month delay as a consequence of this action.[243]

In view of the difficulty involved in securing government construction funds for the erection of a suitable building, it seemed simpler to negotiate with the contractor for the provision of facilities.[244] With Air Force backing, Oerlikon rented a warehouse then under construction near Holloman, signed a three-year lease, and agreed to equip it for the assembly, check-out, and repair of missiles without additional cost to the government. This appeared to satisfy immediate needs.[245]

Twenty missiles previously stored in the east, awaiting the completion of a building at the test area, were scheduled to arrive at the New Mexico site during June, and initial training of the Air

Force personnel who were to participate in the test firing was to start on the 29th of that month. The first flight was tentatively set for 20 July.[246]

While all this was going on, five Oerlikon missiles were delivered to Wright Air Development Center for laboratory investigation.[247] Although five separate laboratories were to participate in the scheduled analyses, the Aircraft Radiation and Power Plant laboratories had a dominant concern. Electronic personnel were interested principally in those aspects of the Swiss-made missile involving ground radar, antennas, jamming and anti-jamming, remote control and telemetering, test equipment and procedures, design analysis, non-standard parts testing, specifications, and comparison with domestic missiles.[248]

The Power Plant Laboratory planned about 30 firings of the Oerlikon propulsion system, and in March it started the series of tests.[249] The early experiments were outstandingly successful. On one occasion the complete system was stored at outside air temperatures for several days before a routine firing--an important prerequisite to full utility. Indeed, the only notable malfunction resulted from the installation of an Air Force standard vent valve, part of the test equipment.[250] Spare parts shortages provided the only delay to the program.[251]

If no obstacles to their tactical use developed, the Oerlikon and Boeing surface-to-air missiles might provide answers to the immediate problems of air defense. But there were other areas where the future held no such bright promise. One of these was in the anti-ballistic missile field. Although the University of Michigan was devoting a great deal of effort to the attempt, there was absolutely no indication of success in the search for an effective counter weapon. The director of the Lincoln Laboratories frankly maintained that only a completely new invention would provide safety.[252]

Early in 1953 the project people surveyed Project Wizard (by which name the anti-ballistic missile work was known) and reached a series of disheartening conclusions. General Boyd agreed completely with the verdict of his engineers and missile planners and forwarded recommendations for a reappraisal of the entire situation, with considerably less effort on aspects currently being emphasized.[253]

The primary difficulty was time. Experts estimated that it would take from four to five years to develop a radar system efficient enough to detect and pinpoint the location of short-range ballistic missiles. Development of an aerial weapon that could utilize this data and destroy the ballistic missile would probably take another five years, and even then only a prototype would be available. But by 1960, General Boyd wrote, the long-range, high velocity ballistic missile or glide bomb would probably be the most dangerous threat to the continental United States, and the projected defending system (Shortstop) would be useless against such vehicles.

It appeared reasonable, therefore, to redirect attention to the most immediate problems of the moment. These largely involved the development of long-range search radar, improvement of radar illuminators and seeker combinations, improvement of the reflectivity characteristics of radar used against ballistic targets, perfection of fully automatic data-handling devices, radome work, development of propellants suitable for long-term storage in "ready to fire" defensive missiles, and related topics. General Boyd further recommended that systems and target studies be held in abeyance until component work showed more promise.[254]

Intelligence estimates of Soviet work in the ballistic field hinted at the gravity of the situation. The air technical intelligence people tentatively predicted that by 1956 the Soviets would be able to introduce into service a two-stage rocket with a maximum range of 1,280 nautical miles, a 3,000-pound warhead, and the probability of hitting within two nautical miles of its target. Within another two years the range of this missile could be extended to 2,700 nautical miles, although accuracy would decline. Of perhaps equivalent importance was the expectation that by 1955 the Russians would have a one-step rocket capable of carrying an 8,000-pound warhead 580 miles and impacting within one mile of the target.[255]

Perhaps the leading problem was radar. A ballistic vehicle of the Atlas type showed a nose-on radar reflectivity about 1/10,000 that of a B-29! This was a product of aerodynamic design, speed, physical cross section, and several other factors. Nevertheless, it meant that the detection of ballistics would in itself constitute a major problem. Fortunately, lowering the frequency of the search radar improved reflectivity immensely. Therefore the perfection of low-frequency detection major devices seemed a good place to start work. Other methods of increasing reflectivity also showed promise.

The speed of the missile and the range at which it could be initially detected were two leading variables which made it extremely difficult to counter. The very short-range missile and the Atlas type missile provided the defense with a period of only 60 seconds during which interception could be effective, and this was predicated on detection at a range of at least 250 miles. Intermediate-range missiles, with a flatter hyperbolic trajectory, would allow up to four and one-half minutes between detection and interception. It was obvious that the success of countermeasures would be dependent on a split second reaction from the defensive system.

The two types of counter weapons considered as candidates were homing missiles and barrage rockets, and the barrage idea seemed only marginally practical. The only positive conclusion that experts in England and the United States could agree on was that ". . . continued study and technical assessment of the situation is required until the defense can be visualized."[256]

Actual component development of Wizard was not notable. Radar reflectivity experiments continued, to the limit of available funds, throughout the six months. Similarly, experiments with a throttlable rocket engine, funds for which were also on the point of exhaustion, ended in May when the only available unit blew up during its final scheduled test. (The project engineer thereupon solemnly reported: "This portion of the project has now been completed.")[257]

Work on Lapis (Low Altitude Pilotless Interceptor System), under way at the University of Michigan and at Lockheed, continued on schedule.[258] The program began formally only on 1 January, with emphasis on study and research. Its objective was not to develop a specific missile, although a product of that nature might eventually result, but rather to recommend means of providing the air defense system of the next 10 to 12 years with a capability against low altitude attacks. For the moment, since the needs of the years immediately ahead came first, possible equipments considered for use in low altitude defense were being limited to those at least in an advanced prototype stage. Here again the primary problem was radar coverage, since radar was relatively ineffective except at line-of-sight ranges.[259] A preliminary report on the best appraoch to defense against attack by low-flying bombardment aircraft and missiles of the Loon (V-1) type was expected by October 1953, at which time future plans would be charted.[260]

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205. RDB Form 1A, R-448-111, 3 Mar. 1953 (Proposed Project).

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208. Sum. of WADC Wk. Conf., 17 June 1953.

209. Proj. Status Rpt., MX-1599, 2 Feb. 1953.

210. See "Hist. of WADC, 1 July-31 Dec. 1952," p. 886.

211. D/Ops. DAR, 30 Jan. 1953; Proj. Status Rpt., MX-1599, 2 Feb. 1953.

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213. PPL DAR, 4 Feb. 1953.

214. WADC WOR, 12 Mar. 1953.

215. Proj. Status Rpt., MX-1599, 1 May 1953.

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222. AMC WAR, 27 Apr. 1953.

223. Proj. Status Rpt., MX-883, 1 May 1953.

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228. D/Ops. DAR, 20 Oct. 1952; ARDC Form 82, R-112-12, 26 Nov. 1952.

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239. ARDC Form 82, R-448-83, 16 Apr. 1953; Proj. Status Rpt., MX-1599, 25 Mar. 1953.

240. Ltr., Keefer to Cmdr., WADC, 3 Sept. 1953.

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242. D/Ops. DAR, 6 Jan. 1953.

243. WSD DAR, 13 Feb. 1953.

244. Proj. Status Rpt., MX-1868, 1 Apr. 1953.

245. AMC WAR, 25 May 1953.

246. Ibid., 8 June 1953.

247. ARL DAR, 12 Feb. 1953; D/Ops. DAR, 12 Feb. 1953; WADC WOR, 12 Feb. 1953; AMC WAR, 26 Jan. 1953.

248. ARL DAR, 12 Feb. 1953 & 18 Feb. 1953.

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252. Notes on Air Def. Conf., 18 Mar. 1953.

253. Ltr., Maj. Gen. A. Boyd, CG, WADC, to CG, ARDC, 23 Jan. 1953, subj.: Recommendations For Future Program, Project Wizard, Contract W33-038-ac-142222, see App. F-1.

254. Ibid.

255. Study, "Estimated Characteristics of Soviet Air Weapons," 1 July 1953.

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257. Proj. Status Rpt., MX-779, 1 Mar. 1953, 1 Apr. 1953, 1 May 1953, & 1 June 1953.

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VIII TACTICAL FIGHTER SYSTEMS

If there was any discernible new tendency in the development of tactical fighters, it was toward greater specialization. The day of the universal fighter, which could act as a day fighter for one mission and then by linking on bomb shackles or rocket launcher rails become a fighter-bomber for the next, appeared to be rapidly waning. The F-86H and F-84F were both apparently destined to be used solely as fighter-bombers, and the proposed F-105 was designed specifically for that mission. The F-100 and the proposed F-104 were intended for use as day fighters, although there was a possibility that a series modification might change some of the former into interceptors.

Of all these aircraft, the F-84F gave the greatest difficulty in the first six months of 1953. Neither the F-86H nor the F-100 was a special problem, although both were in the pre-production flight test stage. The F-104 and F-105, of course, were still in the design phases of development.

Two additional tactical fighters had progressed as far as the tentative study phase when fiscal year 1953 ended. One was to be a lightweight with performance characteristics similar to those of the XF-104; a total of $6,000,000 from fiscal year 1954 funds was allotted for this purpose. The second was known as the "X-Fighter-Bomber Weapon," and for the moment consisted entirely of studies by North

American, Chance Vought, Martin, and Republic. Accelerated work on this project stopped in January when Washington decided to procure the F-105 to fulfill operational requirements for the immediate post-1957 period in which the use of the "X-Fighter-Bomber Weapon" had been contemplated. Initial design studies were expected from the four contractors by October 1953.[1]

The only other major developments of interest to the tactical fighter program concerned the performance improvement program, centered about the F-86 series aircraft, and the Gun-Val program. This last ultimately would benefit air defense interceptors and strategic fighters as well as tactical aircraft.

The F-84F

The advent and immediate success of swept-wing jet fighter aircraft had serious repercussions affecting a large portion of the Air Force development and production program. Shortly after the F-86 became operational, the Air Force realized that the straight-wing F-84 had become obsolete and, as the F-84F project officer said, "had lost the ability to live in the air, due largely to a limiting Mach of .82." Republic therefore proposed taking the last F-84E on contract, sweeping the wings, and flight testing the resultant aircraft. After approval by Air Force headquarters, the proposal was carried through--the swept-wing F-84 being initially designated the XF-96. Evaluation at the Air Force Flight Test Center showed this first prototype of the F-84F to be a marked improvement over the F-84E, needing only a higher thrust engine to completely surpass its progenitor. On the basis of these tests, Air Force headquarters directed the installation of a more potent engine and ordered the airplane into full-scale production with no further evaluation.

This procedure was directly responsible for most of the troubles that subsequently infected the F-84F. The Thunderstreak was not treated as a new aircraft, but merely as an extension of the previous F-84 series. Tooling and fabrication practices were carried over largely unaltered from the F-84E, an airplane which was inherently different in many respects. Project personnel later remarked that "this caused many production problems which need not have prevailed, such as main wing spars, fuselage frames, and the like, together with creating an aircraft which is now needlessly over weight."[2]

In the weeks immediately after the first production version of the F-84F made its maiden flights in November 1952, Republic test pilots reported good performance with no significant deficiencies.[3] That was probably the last time for some eight or ten months that a statement of that nature was heard. After the first weeks of the honeymoon, the Thunderstreak began to display an appalling variety of defects and shortcomings ranging over the airplane from air intake duct to tailpipe.

By February 1953, affairs had deteriorated so markedly that the F-84F became Wright Air Development Center's most urgent assignment, replacing the B-47 program as the most pressing development problem On the 17th of that month, General Boyd outlined the current situation to General Bradley. On the strength of that report and related events, the materiel command agreed that the circumstances required a slow-down in production until corrective engineering changes could be incorporated into final assembly procedures.[4]

More than a month before the first production F-84F flew, Wright Field had recommended an intentional production slippage, purely on the basis of persistent engine defects. At that time the Air Materiel Command had refused to consider the suggestion, citing a probable loss of 321 aircraft and a major deficit in the tactical inventory as inevitable consequences.[5] What made the affair even more distressing was that two years earlier Wright Field had directed Republic to correct specific defects in the prototype YF-84F; substantially these same defects were hobbling the production version.[6]

By April the center had concluded, as a result of continually more ominous test reports, ". . . that this aircraft in its present configuration is not acceptable as a weapons system for tactical use." Such a completely unfavorable judgment was announced only after engineers had thoroughly considered the status of the major and minor defects and proposed corrective actions.[7]

General Boyd recommended that the production schedule be rearranged to permit early incorporation of corrections to the major deficiencies. He said frankly that "while any single discrepancy could possibly be tolerated, the sum total of all does not permit an approval by this Center of the F-84F. . . ." Failure to insure the elimination of major defects from aircraft delivered to the using echelons would, he pointed out, result in the release of large numbers of unacceptable aircraft and engines and ". . . force the establishment of an expensive and lengthy modification program."[8]

The Department of Defense was intimately involved in the matter by this time. Air Force Assistant Secretary R. L. Lewis said in May that Washington was gravely concerned ". . . over the $1,000,000,000 invested in the F-84F program and the lack of air power to show for it. . . ." He personally directed an all-out effort to get the fighter "straightened out" in a hurry.[9] The combination of unsatisfactory flight characteristics and high production rate was by that time thought almost certain to produce ". . . a large inventory of aircraft unsuitable for operational use."[10] It was not a pleasant prospect.

A major portion of the dissatisfaction with F-84F performance centered about the YJ65-W-1 engine installed in early production aircraft. As early as June 1952 the Power Plant Laboratory had reported the engine's unhappy habit of shedding compressor rotor blades with little or no obvious provocation--a factor which would be unlikely to endear it to combat pilots. The fault, as initially diagnosed, lay in the fact that aluminum blades were used throughout the compressor assembly. Wright Field engineers felt that the use of steel blades in the first three stages would correct the difficulty. Failures of the aluminum blades were laid to "aerodynamically excited flutter coinciding with natural blade frequencies."

As a result of the deficiency, the Air Force decided to accept delivery of only 300 aluminum-bladed engines, although 2,000 had originally been scheduled. Nevertheless, the remnant constituted a substantial backlog of engines which would at least require substantial modification before they could be used in operational fighters. Perhaps the most unfortunate aspect of the entire situation was that no alternate engine was available. Shortly before the first production F-84F flew, Wright Field had recommended switching to another power plant, but the materiel command reported at that time that no suitable engine was either in production or in an advanced stage of development. Consequently, cancellation of the J65 program would have presented the Air Force with the perplexing problem of utilizing a rather substantial number of expensive and complicated single-place gliders![11]

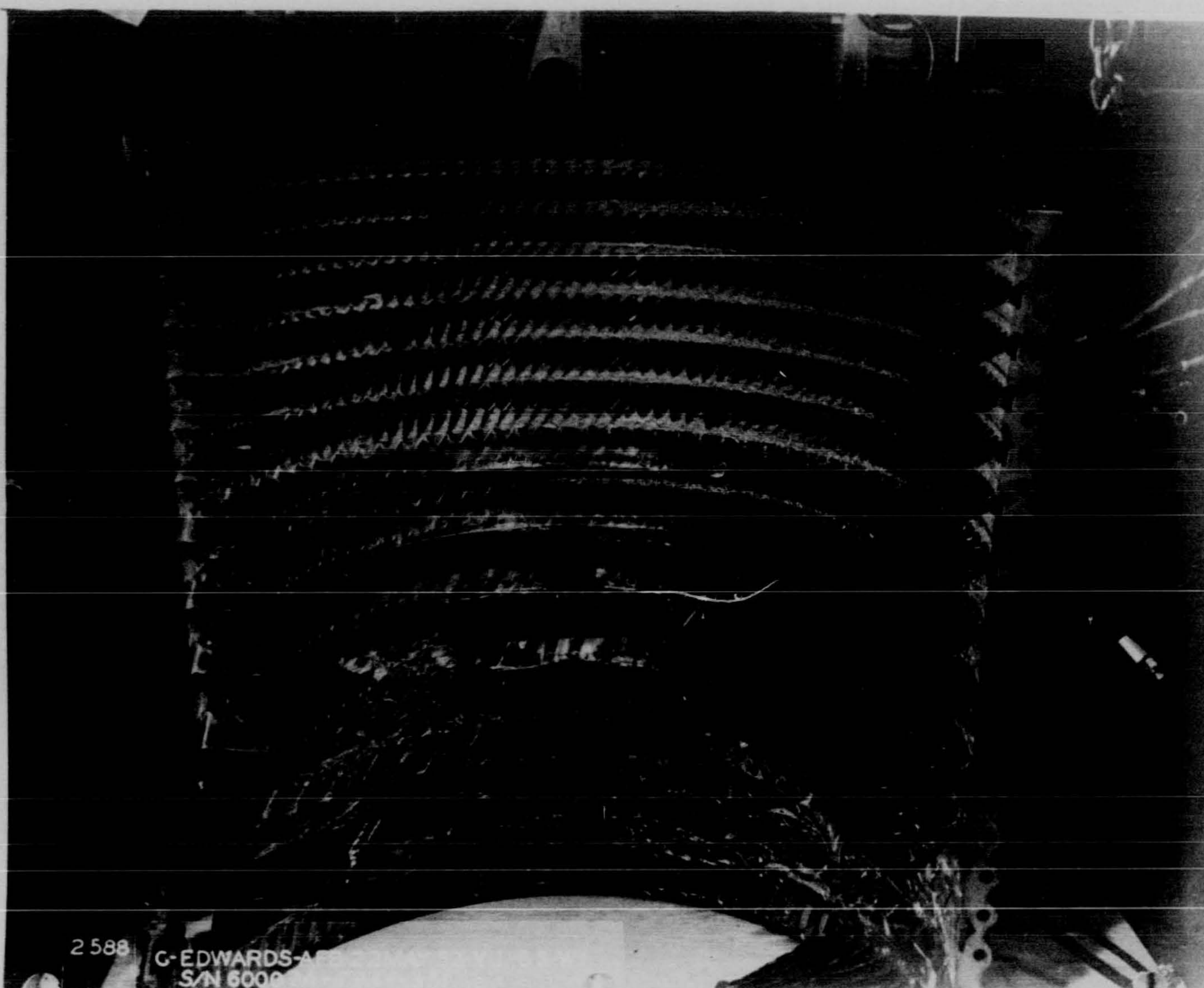
Wright Air Development Center pilots, including General Boyd, had a good foretaste of F-84F troubles still to come when on 18 February the first production airplane, on its way to Edwards Air Force Base, stopped off at Wright Field to refuel. A number of center pilots seized the opportunity to make familiarization flights. In the midst of the process, while one pilot was attempting a take-off, the compressor suddenly failed. Fortunately, no one was injured. Since almost identical failures had already appeared during Power Plant Laboratory tests of prototype engines, no new factor had been introduced.[12]

Partly as a result of this incident, the materiel command agreed on 25 February to ground all YJ65-W-1 engines, although production was to continue. No deliveries were to be made for the tactical inventory unless the engines were either equipped with steel blades or some other means of eliminating power control and compressor difficulties had been discovered. Wright Air Development Center maintained, in positive terms, that the YJ65 must have steel-bladed compressors and improved power controls before it could be released for routine flight.[13] In the interim, production engines were to be put in storage immediately after manufacture, except for a few which would be supplied to the experimental flight test program.[14]

Since such a decision in effect slowed down F-84F production, speeding up the flight test program immediately became a necessity. In mid-March, therefore, that program went into high gear. Fourteen aircraft were allocated to airframe and engine tests at Edwards in lieu of the four originally assigned, 500 flight hours were scheduled for the next six weeks, and each airplane was scheduled for 50 hours of flight by 1 June.[15] At about the same time the engine contractor (Wright Aeronautical) proposed a "fix" for the aluminum-bladed engines which involved cropping the blades in the first three stages by amounts varying from .12 inches to .25 inches. However, it appeared that even with cropped blades the YJ65 would not operate satisfactorily in a specific critical range of rotation speeds. Thus even after modification the engine would not be suitable for activities more extreme than test stand operation and flight tests at Edwards. Only the retrofit of steel-blade compressors or the engineering approval of J65-B-3 or J65-W-3 engines would unground the F-84F.[16]

The center decided to insist on the rejection of any cropped-blade engine which did not produce at least 7,100 pounds of thrust, while all those which produced between 7,100 and 7,220 pounds of thrust were to be stored. Only those with a thrust output of more than 7,220 pounds could be used in the test aircraft. In case of an emergency, the stored engines could be installed in F-84F's; otherwise, the plan was to hold them until parts were available to change them to a steel-blade configuration.[17]

Although the cropped-blade engines partially alleviated the critical engine situation, personnel at the flight test center continued to have trouble. In May the flight test director there complained, "A succession of engine difficulties combined with a shortage of replacement parts and serviceable spare engines limited the amount of flying during [this] . . . reporting period." He listed the major trouble factors as damage from foreign objects, turbine blade damage resulting from high temperature warping of the heat shield, faulty seals, and cracks occurring between the bases of the stator blades and the inner shroud of the compressor section.[18]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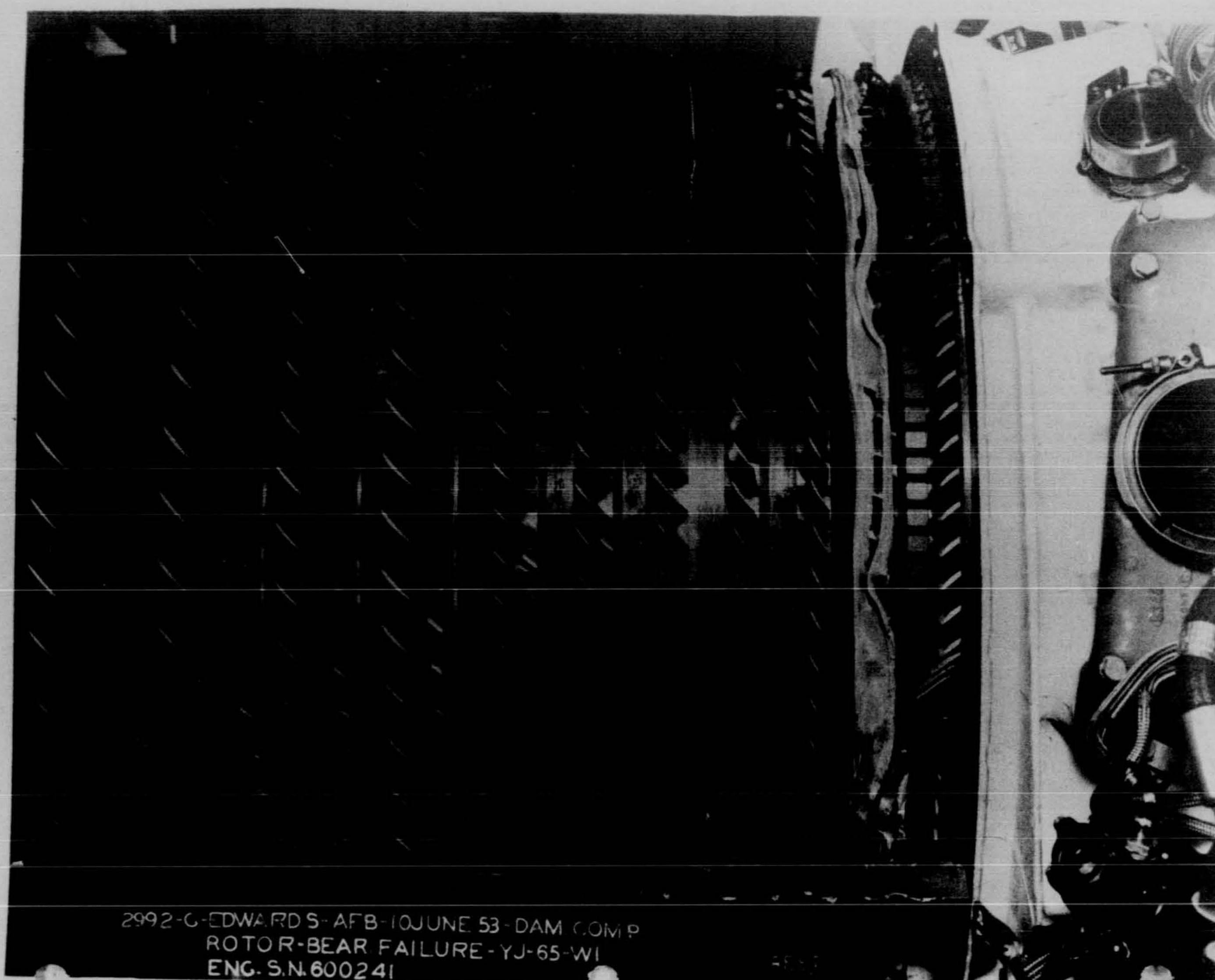
YJ65-W-1 Engine-Damaged Compressor Stator

Alarmed by the urgency of the situation, General Boyd in mid-May wrote Brigadier General J. S. Holtoner, commander at Edwards, to offer additional support for the F-84F test program as long as it was needed. He promised that the Power Plant Laboratory would make special technical assistance available where needed, that the center would insure adequate contractor representation, and the reporting system would be improved, field repair problems attacked, and engineering "fixes" pushed through.[19] General Holtoner promptly thanked him for the offer, and assured him that contacts between the centers had been entirely satisfactory. He noted in passing that less trouble was being encountered with the steel-blade engines (just entering the flight test phase) although tailpipe failures in engines so equipped had suddenly assumed ominous overtones. His personal conviction was that poor quality control at Wright Aeronautical had a great deal to do with the frequency of trouble.[20]

The explosion of one of the unmodified engines at Edwards immediately after take-off on 22 May was the last straw. The balance of the standard production engines were grounded.[21] However, even though only cropped-blade and steel-blade engines were in use, two additional engine failures occurred shortly thereafter. In each instance mechanics discovered that the turbine bearing retainer nut had unlocked, resulting in the eventual uncoupling of the turbine from the compressor. This problem was solved without great difficulty, but nevertheless it halted all test flying for several days.[22]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YJ65-W-1 Engine-Compressor Rotor Damage
Resulting from Failure of Main Bearing

A few days later two F-84F's were flying formation at 33,000 feet when the compressor exploded on one and the turbine broke loose on the other. Coming on top of everything else, this incident brought the dry comment from General Boyd, "Very reliable engine!"[23]

By mid-June most of the compressor troubles seemed to have succumbed to re-engineering and the use of cropped or steel blades.[24] But a new problem immediately intruded itself--bearing failures.[25] For a time this appeared to present even greater difficulties than had the compressor failures. Prompt and intensive attention to the matter brought about a relatively rapid correction, however, and shortly after mid-year the Power Plant Laboratory was able to proclaim the deficiency eliminated.[26]

By June the engine evaluation program was operating on a seven-day week, 24-hour day basis, with flyable aircraft in the air "during the hours from dawn to darkness."[27] And it was producing results. One cropped-blade engine and one steel-blade engine had completed 50 flight hours and been airlifted to Wright Air Development Center. On 29 June Wright Field, Air Materiel Command, and Wright Aeronautical representatives met to decide the future course of engine development. They decided to continue flight tests until the aluminum-and steel-blade engines had accumulated 100 hours, after which they would be inspected. The contractor agreed to start a 150-hour endurance test within a month, incorporating engineering corrections uncovered during the flight test program. Whichever version (steel-blade or cropped-blade) completed the 150-hour check in better shape would become the approved configuration, and the stored engines would thereafter be converted to that configuration.[28]

A number of other serious engine troubles appeared in the course of the first six months of 1953. Most were corrected, or were well along the road to correction, by mid-year. By 12 June, for example, there had been a total of 12 tailpipe failures involving both steel-blade and aluminum-blade engines.[29] Hoping to damp much of the vibration and eliminate the cracking, Republic designed an insulating blanket to replace the tailpipe shroud. New engine mounts were also intended to serve much the same purpose.[30] Guide vane failures meant another headache. Even after the ring of guide vanes had been re-engineered and the total number of blades reduced from 96 to 48, they still continued to break loose and plummet into the compressor on occasion.[31]

Although continual improvement of the YJ65-W-1 and J65-W-3 engines was apparent as a result of the accelerated effort, it was unfortunately true that even a perfected -1 or -3 would not produce all the thrust the F-84F needed. Pilots had reported that a higher thrust engine was definitely needed, if only to make take-offs practicable while carrying external stores.[32] After having flown the aircraft, General Boyd was in complete agreement with this idea. He put the Power Plant Laboratory and the F-84 project office to work on this specific problem early in March.[33] Initially, a 7,800-pound thrust J65 seemed to be required,[34] although ultimately it appeared that an 8,500-pound version might be needed.[35]

On 12 March the project office contacted the Power Plant Laboratory to pass along the information that General Boyd wanted flight tests of a 7,800-pound thrust J65 started as soon as possible. The project office noted at the same time that Republic considered this installation vital to the further development of the F-84F.

The Power Plant Laboratory decided that three possible courses of action were open. A J65-B-3 (Buick-built) engine could be modified, which would be neither exorbitantly expensive nor excessively time-consuming. The YJ65-W-1 (Wright Aeronautical) engine which had been giving so much trouble in flight tests could be altered, although this process would be higher-priced and definitely would require a longer time than -3 alteration. Finally, additional British-built Armstrong-Siddeley SA-6 Sapphire engines could be purchased. This last alternative promised to be both costly and prolonged. Moreover, the British progenitor of the J65 would fit only prototype F-84F's, and thus would yield data not directly applicable to the production airplane.[36]

On 13 March General Boyd wrote General Bradley suggesting that the materiel command put teeth into the procedure the Power Plant Laboratory favored by starting procurement action on the necessary J65-B-3 engines. There was some hope that if Buick were given an immediate "start work" order, the 7,800-pound thrust J65 might be available for tests by the end of April.[37]

The procurement division concurred in these recommendations, warning only that development of more advanced engines should not be allowed to interfere with service engineering devoted to current J65's. The Air Materiel Command was particularly concerned about reports that Wright Aeronautical planned to divert a large portion of its engineering effort to the 8,500-pound thrust J65, which was intended for the F-104 as well as the advanced F-84F.[38] Colonel Demler subsequently indicated the center's "complete accord" with the materiel command's position.[39]

Early in May the materiel command agreed to give Wright Aeronautical full authorization to proceed with the 7,800-pound thrust J65 engine. There were still fears that work on this high thrust power plant might divert effort from the correction of deficiencies in the 7,220-pound thrust J65, but when it was pointed out that the 7,800-pound engine would not be built and successfully operated until all existent deficiencies in the current engine had been eliminated, that objection was withdrawn.[40]

There were early indications of approaching difficulty with the 7,800-pound thrust J65. The first engine which attempted a 50-hour endurance run failed when the bolts holding the compressor to the turbine sheared. This was a deficiency which had existed in the basic engine and had been corrected much earlier; apparently Wright Aeronautical's oversight was solely responsible for this accident. Nevertheless, the engine was destroyed, and another test run had to be started.[41] This second power plant completed its endurance test shortly after mid-year,[42] but the Power Plant Laboratory was dissatisfied with results. Additional work and another test run were required before any serious plans for flight test could be made.[43]

One reason pilots demanded greater thrust from the F-84F was the failure of the YJ65 engine to produce its rated thrust when installed in an airframe. Work on improved sucker doors, a redesigned intake duct, and the new tailpipe configuration promised to eliminate much of this difficulty in both the basic engine and the improved version, but still there was some doubt that the 7,800-pound thrust power plant would provide all the benefits it promised. General Boyd directed that a thorough flight test program precede any operational installation.[44] With this precaution, the program promised some relief from earlier thrust troubles.

The matter of power controls also gave some initial difficulty, especially with the -1 engine. In June the control situation still rated as "the major problem" of the moment, in Colonel Arnold's opinion.[45] Nevertheless, a significant improvement had been achieved in the design of controls for the -3 engine, and since this latter control was destined for the 7,800-pound thrust J65, the defect might well disappear in the natural course of evolution.[46]

Apart from engine difficulties, the F-84F had consistently displayed a number of unsatisfactory flying characteristics. Control surface inadequacy was one of the outstanding shortcomings. Both the elevator and the ailerons were entirely too ineffective for safety, much less for combat operations. One pilot reported that "recovery from a normal dive bomb run would be impossible without the use of stabilizer trim." Aircraft maneuverability was severely hampered at all altitudes. This circumstance, said the test pilot, made it apparent that "the F-84F is not a good air-to-air fighter." Speed brake ineffectiveness, coupled with the other faults, led him to conclude that the airplane was ". . . of doubtful value as a fighter bomber." Yaw damping characteristics were rated "inferior" and rate of roll "insignificant." With the control boost turned off, handling ease vanished. Lateral control forces were extremely high, ". . . and cannot be trimmed out." Said the flier, "If the boost should fail during a high speed diving turn at low altitude, recovery would be difficult."[47] General Boyd remarked, apropos of the same item, that with the engine stopped and no power boost, an emergency landing was impossible ". . . unless you have Rogers Dry Lake!"[48]

Perhaps the most pressing of all these aerodynamic problems was aileron and elevator ineffectiveness. At any rate, it was the one most strongly attacked. Initial flight tests which indicated a poor rate of roll produced the suggestion that either spoilers or flaperons be added to the wing. Poor elevator characteristics were to be corrected through the medium of an integrated stabilizer-elevator similar to that installed on most F-86 aircraft and generally known as the "flying tail."[49]

Originally, the "flying tail" had been programmed for installation on the 276th aircraft. In January, however, Republic informally advised the project office that because of a subcontractor's production difficulties, the modification might not be incorporated until the 550th airplane, or even later.[50] Confirmation of this development arrived in mid-February, with the additional information that Republic engineers had devised an interim measure which would have the effect of the integrated stabilizer-elevator and which could be retrofitted to existent aircraft.[51] Nevertheless, the slippage in production effectivity involving the ultimate maneuvering stabilizer as well as the aileron changes and several other modifications alarmed Wright Air Development Center. In March General Boyd said, "The last report I saw on the F-84F would indicate that we're slipping backwards instead of making progress."[52]

On 16 March an engineering change proposal and detail drawing for the interim stabilizer-elevator hitch arrived at Wright Air Development Center. At that time it was not certain whether retrofit of the ultimate version would be necessary. If the interim "fix" worked out, retrofit would probably not be essential; if not, the choice was between retrofit and building entirely new tail sections.[53]

The Aircraft Laboratory approved the interim "fix" (dubbed the "poor man's flying tail" and popularly referred to as the PMFT), conceding that it was a definite improvement. However, as General Boyd emphasized, it "cannot be considered to be any more than marginally acceptable for tactical use."[54]

Initial flight tests indicated that the "poor man's flying tail" was a practical interim improvement, but the center had no surety of systems reliability or the worth of the modification under combat conditions. In May, therefore, the chief of the Fighter Branch requested the flight test center commander for detailed checks of flight characteristics. By that time Edwards had several aircraft equipped with the interim tail, and the center wanted detailed data on control response and performance in actual dive bombing, rocketry, and strafing attempts.[55]

Some of the doubt about effectivity of the "poor man's flying tail" might have been a consequence of the fact that the first flight test system "had been hurriedly fashioned from make-shift parts to prove the feasibility of the control system." As initially installed, this unit had a number of defects. By late May, however, kits containing more carefully prepared components were available, and changes to the system had corrected many of the faults.[56]

Earlier that month, General Boyd had finally been able to make a flight in an F-84F equipped with the "integrated stabilizer assist." He later reported to General Partridge, "While this device is not entirely satisfactory, as other pilots have reported, it is definitely an improvement over the conventional elevator type of control." Contingent on "certain improvements," the center commander tentatively approved the installation of the "poor man's flying tail" on a minimum number of aircraft. He much preferred, however, the idea of adding an all-maneuvering stabilizer to production aircraft.[57]

Still, these were preliminary conclusions, since it would be late in June before installation of the "PMFT" on flight test aircraft at Edwards could begin. Although early tests were neither conclusive nor complete, reports were very favorable. The center considered the installation to be "the most feasible, simplest, and most practical installation that can be bought."[58]

Ultimately, the all-movable stabilizer was to become standard. That much was certain. Republic continued work on this project as a major modification for production line installation as soon as possible. And although some engineering defects showed up, they generally proved susceptible to correction.[59] One of the major problems that fell into this category was the emergency actuating system--which proved ineffective in a power-off situation. By the end of June, Republic had developed a hydraulically actuated emergency system that seemed suitable for the tactical aircraft once the all-movable stabilizer became standard production equipment.[60]

The matter of whether flaperons or spoilers would best improve the aileron effectiveness of the F-84F could not be satisfactorily resolved until flight tests of the two devices had been completed. Initially, at least, flaperons appeared to have the edge, engineers concluding that they would be better than spoilers in improving roll control, especially at low altitudes where excessive wing twist caused deterioration of the rolling effectiveness of the normal outboard ailerons.[61] There was also some feeling, however, that the lack of confidence in spoilers might be in part the consequence of insufficient effort on Republic's part.[62] No test results were available for Wright Field evaluation by the end of the fiscal year;[63] although preliminary estimates showed the spoiler installation would add 117 pounds to the weight of each aircraft and about $20,000 to its cost. There was little doubt that spoilers would improve the rate of roll, but project officers had to balance this against the possibility that retrofit and maintenance would be considerably complicated.[64]

Several of the other major aerodynamic problems remained unsolved or only partially solved at the end of June. Yaw was still a problem; there was a chance that the yaw tendency might require a special National Advisory Committee for Aeronautics study, although Edwards did not believe matters were quite that serious.[65] Even light turbulence detracted from directional damping effectiveness. The resulting oscillations definitely made the airplane an unsatisfactory gun platform "unless," said General Boyd, "we want the bullets sprayed in shotgun fashion."[66] Trim tab actuator failures began to disturb flight tests late in June, adding to the difficulty previously experienced with elevator control.[67] One airplane showed such definite asymetrical wing heaviness at high speeds that at 630 miles per hour approximately 100 pounds of pressure was necessary to keep the stick full right and prevent an abrupt roll to the left.[68] Larger speed brakes were definitely required, since the air-deflection devices failed to slow the airplane in a dive.[69] Indeed, the list seemed unending.

In addition to these discrepancies, the autopilot situation was quite badly scrambled. As early as January it was apparent that provisions for fitting E-9 autopilots into production F-84F's would require major alterations.[70] Tests of the E-9 in an F-84F had long been delayed, and preliminary analyses of the worth of the system were based on an evaluation in an F-84E--an airplane with entirely different flight characteristics.[71]

On 20 April General Boyd wrote the presidents of Westinghouse Electric and Republic Aviation to express his concern over the slow rate of progress in the development and evaluation of the E-9. The result of events to date, he noted, had insured the delivery of several hundred F-84F's without autopilots. Since the effective performance of the fighter-bomber's mission was heavily dependent on the E-9, this represented a very serious compromise of the Air Force program. He forcibly voiced the necessity for greater effort toward completion of flight tests as one of the most profitable efforts Republic could make.[72]

Republic's president, Mr. M. I. Peale, replied with information indicating that work on the installation of an E-9 autopilot in an F-84F had been accelerated, and that as of 23 April only instrument calibration remained before one F-84F was completely equipped. The lack of an engine for the airplane promised to delay flight tests for a brief time, but this also was being overcome.[73]

Mr. G. A. Price, president of Westinghouse, on the contrary, seemed to have missed the point of General Boyd's letter. His reply mentioned the "very large investment" Westinghouse had in its new armament plant at Baltimore and said, in so many words, that Westinghouse was disturbed at the delay in starting full production of the E-9. He added the note, "It has been our experience that maximum development progress is made when we are permitted to go into production, even though the initial equipment falls somewhat short of the ultimate performance desired." Finally, he suggested a conference to discuss "a program to put the E-9 autopilot development on a sounder basis."[74] As General Boyd remarked, "It would appear that our letter to Mr. Price failed to serve the purpose intended."[75]

Letters to the contrary, in July the autopilot installation still was not satisfactory. By that time the center had begun seriously to consider the use of an alternate autopilot in the F-84F. Both Minneapolis-Honeywell's E-11 and Lear's F-5 were promising substitutes.[76]

Colonel D. C. Schilling, commander of the 31st Strategic Fighter Wing, summed up the situation in a 2 July letter to General Boyd. After advocating a trial of the F-5, he wrote, "I am afraid that too many people are of the opinion that an auto pilot is a little needed luxury and do not understand that it is a necessary item of equipment." Regarding the E-9 situation, he continued, "I, personally, don't care whether Tinkertoy makes the auto pilot, but I must have an auto pilot. If the E-9 is coming along and will make early production schedules, all well and good; if not, we must have a back-up."[77]

In reply, General Boyd noted that "considerable pressure" was being applied to both Westinghouse and Republic to get along with the E-9 program. At the moment there was no firm reason to believe that the autopilot would not be released for production at an early date. As for a backup program--funds cuts prohibited such an effort. He mentioned that the authorization for the Automatic Flight Control Branch of the Armament Laboratory had been reduced by 82 percent--evidence enough of a funds lack.[78]

By late July the E-9 autopilot was flying in F-84F's, but producing "very disappointing flights." And by that time, funds objections apparently having been overcome, the center had decided to install and test an F-5 autopilot in one of the F-84F's. It would be six to eight weeks before any determinative data would be available, however, so a decision on the further course of the E-9 program as well as the future of the F-5 would be delayed for that period.[79]

A number of relatively minor items also troubled the F-84F. The airplane was not equipped for probe and drogue refueling, even though Air Force headquarters had assigned three-point refueling tankers to support the Tactical Air Command. This contradiction would have to be resolved, probably by the installation of the necessary equipment on the F-84F.[80] The windshield in the airplane was unsatisfactory from an optical standpoint and the defroster system failed to function properly.[81] Finally, the continued submission of unsatisfactory reports on the F-84F had forced a delay in the development of the reconnaissance version--the RF-84F.[82]

The F-84F was in trouble. There was no doubt on that score. General Boyd mentioned late in June that the Air Materiel Command was sending Republic a letter labeling the contractor's quality of work as below the acceptable level "in engineering, production, and quality control."[83] Wright Air Development Center, hammering away at individual defects in engine, airframe, and equipment, felt the overall situation to be quite serious. The commander's view was that "this is our most critical airplane at this time, and it should be carried by all directorates and laboratories on a priority basis, just as the B-47 was carried some six months to a year ago."[84]

Nevertheless, the six months had seen considerable progress. There was full awareness of the work to be done. Many deficiencies had been eliminated in the course of the service test, and all other known corrigible defects were scheduled for correction either by phasing changes into the production line or by retrofit.

Moreover, in view of the procedure which had been followed in "developing" the F-84F, it was unrealistic to apply deficiency standards based on general operational requirements which had never been stated. More appropriate was the process of evaluating the aircraft in terms of the requirements of the two using commands--the Tactical Air Command and the Strategic Air Command.

The project office summed up in this fashion: "It is anticipated that with the incorporation of . . . [the scheduled alterations] the F-84F will provide TAC with a useful, serviceable fighter-bomber, able to deliver more weight of armament at a greater distance than any fighter bomber to date." And, "The F-84F will provide SAC with a long range escort fighter plus a strategic strike aircraft capable of delivering special weapons at short range on strategic targets. It is limited as an escort fighter in that it does not have the capability of combat above 40,000 feet against presently operational enemy fighters. However, it is anticipated that the F-84F will be a useful addition to the strategic striking arm."[85]

The F-105

One of the major factors fomenting delay and difficulty in the F-84F program had been the original idea of adhering as closely as possible to the F-84E configuration. The idea that swept wings could be grafted on an operational straight-wing fighter with little attention to consequences in other directions proved a misconception. Changing configuration in this fashion proved to be distinctly more difficult than had been anticipated. Further changes from the basic F-84E design were frequent and relatively radical--as well as virtually unavoidable.

Nevertheless, the Air Force had a number of definite ideas about fighter-bomber requirements which the F-84F only partially satisfied. Shortly after the production configuration of the Thunderstreak was approved, it became apparent that a number of additional changes could be embodied in the airplane to make it a more effective combat weapon. Such changes included altering the armament to provide more potent firepower, using larger wheels to improve flotation characteristics for take-off and landing, incorporating a still higher thrust engine (which meant enlarging the air ducts and otherwise rearranging the fuselage), attaching a straight wing spar to replace the "hockey stick" spar of the F-84F (this would simplify fabrication processes considerably), appending more radio, electronic and navigation equipment, and increasing special weapons capabilities.

It was obvious at once that the introduction of such a variety of changes would require a major redesign effort. The contractor (Republic) and the Air Force decided that it would be considerably more practical to design a new aircraft which, as the project office later said, "besides incorporating the desired changes, would give a far greater growth potential."

This new airplane was proposed in February 1952 and was initially designated by the manufacturer's model number--AP-63. It subsequently became the F-105. As a weapon system development, it was activated on 9 September 1952, when Air Force headquarters issued a procurement directive calling for pre-production engineering, tooling, tool design, and materiel procurement.[86]

One of the unique features of the F-105, setting it off from earlier fighter-bombers, was a special bomb bay which could contain either munitions or additional fuel. Although external stores could be carried--and provision for their cartage was made--use of the bomb bay would permit the F-105 to take off in a "clean configuration" even though carrying a full load of explosives. Maximum bomb load was 6,000 pounds.[87]

Work on the airframe of the F-105 had not progressed to the point of being significant to the non-engineer; the mock-up was not scheduled until September 1953. Nevertheless, Air Force headquarters had approved the recommendations of a configuration conference which met in the first months of 1953, and a tentative schedule calling for delivery of the first flight articles by late spring of 1955 was accepted.[88] A number of the components, including part of the electronic equipment, the guns, and the power plant, were in a somewhat more advanced state.

Ultimately, the F-105 was slated to incorporate a 21,500-pound thrust J67-W-1 turbojet, but because of other commitments for the power plant (to the F-102, for example) an Allison J71-A-7 with an afterburner-augmented thrust of 15,500 pounds was to be used as an interim installation. In the event of development difficulties with the J67, the J75 was a possible substitute.* Project engineers, well

*See pages 223-227.

aware of the importance of securing a satisfactory high-thrust turbojet to power the ultimate F-105, closely followed progress in this sphere.[89]

Guns and the fire control system as yet presented no significant problems, although important decisions affecting their installation still had not been made when fiscal year 1953 ended. In May, however, command headquarters advised Wright Field that the T-171D Gatling-type gun was programmed for eventual use in the F-105. Initially, while T-171D development was being completed, the .60 caliber T-130 revolver-type gun would be substituted. The mock-up was to include the T-130, with a special inspection of the T-171D installation to be held as soon thereafter as possible.[90]

At mid-year there was still no decision on the course that would be followed when (and if) the T-171D was qualified for operational use. There were two choices: the T-171D could be phased into the production line at a selected point (and previous aircraft allowed to retain their T-130's) or the changeover could involve an extensive retrofit program. Since the final results of flight tests of the T-171 model guns were not expected before December 1953, and a decision was dependent on those results, the contractor had to provide for accommodating either gun. No danger of airframe slippage was involved, but dual engineering was a costly process which tied up personnel who could more advantageously be used for other purposes.[91]

The benefits to be derived from substitution of the T-171D for the T-130 were considerable. In the first place, one gun would replace four, and the single weapon would have nearly the cyclic rate of fire of the four it supplanted (6,000 rounds per minute for the T-171D, 1,600 rounds each for four T-130's.) The weight of the T-171D would be 240 pounds less than the combined weights of the others. Finally, each barrel of the T-130's would be subjected to 60 percent more wear than each barrel of the T-171D for the total number of rounds fired. Maintenance advantages were obvious.[92]

The fire control system to direct these guns, as well as the bombs and special munitions, was to be the MA-8, a government-furnished item developed by General Electric. Two major elements of the General Electric system were not developed, however, and there was a possibility that M-1 and MA-1 computers might have to be used for long-range toss bomb work and time-of-flight calculations. The other elements of the system, the K-19 sight and the APG-31 radar, were both in prototype form when development of the airplane was started.[93]

Although no autopilot had yet been selected for the F-105, the Minneapolis-Honeywell E-10 was for a time a likely contender. Flight tests of the E-10, however, were delayed early in the year because of a fire which damaged the F-94A test vehicle. Because of the tight schedule involved in the development and production of an autopilot for the F-105 and the tentative estimate that the E-10 flight tests could not be resumed for a minimum of two months, the project office began casting about for other candidates, such as the B-9 and F-5.[94]

A reconnaissance version of the F-105 was scheduled to replace the RF-84F for the period from 1956 through 1959. Intended to have speeds initially bordering on and later extending into the supersonic range, it would be unarmed, relying on speed and maneuverability as a defensive weapon, and carry cameras instead of bombs.[95]

Several decisions pertinent to the RF-105 emerged in the first six months of 1953. Early in the year Air Force headquarters approved the camera installation proposals and the universal camera control system recommended by the center.[96] An electronic reconnaissance capability for the RF-105 was also under study, as it appeared to be the only aircraft fully suited to the tasks projected by tactical planners. A study of its potential in this field was due for completion shortly after mid-year.[97]

The F-86

Like the F-84, the F-86 had by mid-1953 progressed through a series of major modifications. Like the F-84 again, its basic design features had been perpetuated in a new model--the F-100. But--and here was the great difference--at no time was the F-86 so seriously deficient in performance that it required the sort of radical alteration productive of the F-84F. In the first six months of 1953 the standard F-86F and its day-fighter predecessors were still the object of a sweeping performance improvement program; the F-86H made its initial flight and became the first of the Sabres to be classified as primarily a fighter-bomber; and the prototype F-100, a very considerable improvement over earlier swept-wing fighters, flew for the first time.

Among the more encouraging developments of the period were the gradual tapering off of complaints of fire control system ineffectivity and the disappearance of the "excess gadgets" issue which many early Korean combat returnees had raised. By early 1953 discontent with the A-1CM and A-4 gunsights and the APG-30 ranging radar installed in most Far East F-86's had materially diminished in intensity. Greater experience with the system, improved supply and maintenance, and better training provided the answers. Moreover, improvements to the mechanics and electronics of the fire control system contributed mightily to the emergence of a more approbative attitude. The steadily increasing ratio of MIG-15 kills proved that this revised opinion was not ill-deserved.[98]

Of course there was one other major factor in the improved kill *versus* loss ratio recorded by F-86's in Korea. This was the extended leading edge.* Flight load recordings in the combat theater showed that the F-86F with the extended leading edge had a significant margin of advantage over the unmodified F-86E. Maximum operating

*See "History of Wright Air Development Center, July-December 1952," pages 423-426.

altitude went immediately to 52,000 feet, an increase of 4,000 feet over the ceiling of the earlier Sabre. Maximum Mach number went to 1.05, also an advance over the F-86E. At high altitudes the airplane with the extended leading edge was able to make tighter "high-G" turns, evidencing a superiority in maneuverability which meant much when thrown into the balance against the highly agile MIG-15. Both rate of climb and top speed in level flight improved, although the former still could not match that of the MIG-15. Drag decreased, permitting higher cruising speeds with no increase in power settings and thus, in effect, extending the range of the F-86.[99]

To balance against these advantages were some added handicaps at low altitudes and low speeds. Low speed stall became more severe, and stalling speed increased, necessitating a faster approach and a "hotter" landing. But as one combat pilot commented, "Since the air war is not won in the traffic pattern these characteristics should cause little concern."[100]

The combat trial of the extended leading edge having been adjudged successful, the Fifth Air Force asked for kits to modify all of its F-86 interceptors.[101] By the end of March, engineering and procurement action leading to the installation of the extended leading edge throughout the Far East Air Forces was well along. The cost of the equipment for the 450 aircraft initially affected amounted to slightly more than $1,500,000.[102] Delivery of the modification kits was scheduled to begin in June and to continue at a rate of 30 kits per month until all the aircraft involved had been altered.[103]

Plans to incorporate an extended leading edge with integral fuel cells in F-86F's coming off the production line hit a snag when North American and the joint project office decided that the process would delay production beyond permissible limits.[104] It therefore appeared that the fueled leading edge might have to be a retrofit proposition if it was to benefit the F-86F.[105]

The leading edge project had originally been part of the overall F-86 performance improvement program, which contained a number of other elements as well. One of these was water injection, a means of augmenting the thrust output of the J47 engine. Tests of this expedient ended in February with indications that thrust was effectively increased at altitudes up to 50,000 feet without appreciable damage to the engine. Thrust increases varied from about 15 percent at 24,000 feet to more than 20 percent at 45,000 feet.[106]

Pre-turbine injection of fuel, the alternative means of thrust augmentation, had not progressed as rapidly as water injection, principally because of the former's greater complexity. Nevertheless, by February General Electric had gathered sufficient data to indicate that thrust increases of about 25 percent were possible. The greatest difficulty till that time had been in fuel flow scheduling at high altitudes, although some trouble had been encountered in finding a tail cone configuration sufficiently sturdy to withstand the increased stresses and temperatures induced by the pre-turbine injection method.[107]

Flight tests of the pre-turbine injection system got under way late in March. At first, flameouts occurred immediately after fuel injection began, but changing the rate of fuel flow corrected this fault. A two-minute augmentation at 30,000 feet altitude gave the F-86F a 30 percent thrust increase, although heat damage affected the nozzle actuators adversely.[108] Subsequent attempts to correct excessively high temperatures in the tailpipe by means of a limited fuel flow were unsuccessful. If the temperature dropped too sharply, the flame went out.[109] In June, efforts switched to devising a shroud for the tailpipe.[110] A "truncated" tailpipe was tested at mid-year with some success, and additional flights with an elongated tail cone incorporating a corrugated liner and a tail shroud were scheduled to follow in July.[111] On the whole, results were both pleasing and promising. Indeed, because of the progress with pre-turbine injection and its inherent advantages over water injection (no need to carry a special fluid was one), the latter was virtually dropped from consideration.[112]

The addition of standard jet-assist-take-off bottles to the F-86 as a means of providing flash performance had been proved impractical in Korea, and that expedient was dropped. Notwithstanding the fact that solid-propellant rockets had not answered the need for emergency thrust, experience with the device promised to be of some aid in the development of a rocket engine specifically engineered to this purpose.[113] In January 1953, therefore, the center contracted with the Aerojet Engineering Corporation to develop a super-performance liquid-propellant rocket--the YLR-63-AJ-3. This engine was intended for ultimate installation in the F-86 and later fighters. With a predicted thrust output of 3,500 pounds and an endurance of 108 seconds, it might prove to be a valuable assist to fighters needing a sudden burst of power.[114]

Unfortunately for needs of the moment, Aerojet did not expect to have a flight test model ready for delivery before 1954. However, since the rocket engine would be built around components developed for a relatively well-proven liquid rocket--the LR-63-AJ-1--no significant difficulty was anticipated.[115]

Another long-term approach to the matter of improving the performance of the F-86 began to germinate shortly before fiscal year 1953 ended. A device designed by the Aircraft Laboratory, built by the Experimental Fabrication Branch, and tested at the Ames Aeronautical Laboratory, proved able to double the effectiveness of F-86 landing flaps. Porous wing leading edge tests sponsored by the Aircraft Laboratory had led to the discovery that similar suction applied to the leading edge of flaps considerably improved their performance. Practical application of the principle required a simple, low-weight instrument able to produce a substantial amount of suction. The Aircraft Laboratory objected to the weight and complexity of the mechanical blower initially proposed, and subsequently it agreed to furnish the necessary equipment--an air ejector which operated partly on engine compressor bleed air and partly on secondary airflow. No moving parts were involved. As the device worked in wind tunnel tests, the National Advisory Committee for Aeronautics planned to verify early results by means of actual flight tests and in June was modifying an F-86A to this end. Such tests were considered significant in that they could point the way to simple means of considerably reducing take-off and landing distance requirements for fighter aircraft.[116]

Somewhat akin to the performance improvement program was that portion of the Gun-Val program immediately applicable to F-86F's in Korea.* On 31 December 1952 the eight F-86F's, equipped with T-160 revolver-type guns and intended for combat tests in "MIG Alley," arrived in the Far East. Personnel assigned from the several agencies supporting the combat tests were either on hand or on their way to Korea at the same time.[117]

By mid-January the Gun-Val F-86's were in combat; by February they had been withdrawn again. The first indication of trouble was the loss of an airplane because of engine flameout.[118] Other flame-outs during combat firing passes forced the conclusion that there was some relationship between the discharge of exhaust gases from the gun muzzles and the failure of engine ignition. Investigators at Wright Field determined that about four times as much gas was emitted from the muzzles of the four T-160's as from the six

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*See "History of Wright Air Development Center, July-December 1952," pages 434-435, 529-530.

.50-caliber machine guns in standard aircraft. Power Plant Laboratory technicians conceded that a sizeable puff of burning gas entering the air intake could snuff out the engine--and the Far East Air Forces reported observance of "unusual yellow flashes forward of the nose" in three instances of engine failure.[119]

The Fifth Air Force had experienced 3 compressor stalls in 23 combat missions, had withdrawn the aircraft from combat for checks, and had subsequently induced similar stalls on 4 out of 45 test flights. Attempts to duplicate the stalls at Eglin Air Force Base and at North American's plants were unsuccessful, but there was strong evidence to support the "puff of gas" theory. Since the phenomenon seemed to be confined to high altitudes, the Korean aircraft returned to combat but were limited to using only two guns simultaneously at altitudes above 35,000 feet. The entire battery could be fired together at lower altitudes.[120]

A variety of test agencies within the United States failed in early attempts to reproduce the burning gas effect. Experimenters did determine, however, that pre-ignition of incendiary rounds could not be the source of the difficulty. The remaining alternatives were: inert gases entering the air intake, waste from the gun gas purge doors (located in the air duct) which reduced the normal flow of free air to the compressor at high altitudes, and possible interference with free air flow due to the momentary "bucking" of the aircraft during firing.[121]

The two measures initially adopted to avoid recurrence of compressor stalls were mounting flash suppressors on the gun muzzles and coupling the gun trigger to the fuel sensing unit to reduce fuel intake during firing.[122] Almost immediately, the latter measure proved unavailing.[123]

Before March ended, North American succeeded in reproducing the compressor stalls at will, using a special lot of ammunition. Although this neither explained nor overcame the defect, it at least permitted positive tests of the abilities of several suggested corrections.[124]

Initial tests with flash suppressors and the "fixed" ammunition failed to solve the trouble; compressor stalls still occurred in the test flights. The Armament Laboratory thereupon ordered North American to drop this approach and try blast deflectors--devices welded to normal blast channels slightly forward of the muzzle and in line with the bore. Their purpose was to deflect the blast away from the nose duct. On 9 April, North American reported that in a series of five flights with the deflectors no stalls had been encountered. The path of the flash (which still was being purposely induced so the course of the gun gas dispersion could be observed) was away from the nose and well to the side of the F-86. On the basis of these tests, North American was instructed to fabricate deflector kits and ship them to the Far East as quickly as possible.[125]

By early May the results of this latest "solution" were available for analysis. Although the deflector had worked in trials in the

United States, they failed in Korea, apparently for some climatic reason. In mid-May, with these facts before him, General Boyd wrote General Partridge, "This stubborn problem will remain as one of particular concern until a more complete understanding of the phenomena is acquired."[126]

There was little doubt by this time that an explosion of unburned gun gas was the principal, if not the only, cause of the compressor stalls. Colonel White, with the preface, "It's certainly a very curious phenomenon," explained that the explosion under the nose of the airplane took place in less than one-fiftieth of a second. The bullets came out so fast that they pushed out unburned gas, which accumulated, to be ignited by some random flame from the muzzle. If the "puff" went down the engine intake, which was not always the case by any means, it cut off the oxygen supply to the engine, and flameout followed.[127]

Although this disheartening problem still existed when the Korean phase of Gun-Val ended on 1 May, overall results were on the encouraging side. The T-160-equipped F-86F's had flown 284 combat sorties, sighted a total of 139 MIG's, and fired on 41 of these. Extreme ranges or angles of deflection prevented any observation of hits on 19 of the 41 occasions when shots were fired; of the 22 MIG's seen to have been hit, 6 were destroyed, 3 probably destroyed, 10 damaged, and 3 probably damaged. No Gun-Val F-86's had been lost as a result of enemy action, although two were damaged. One aircraft had gone down because of gun gas-induced compressor stall, and one because of engine failure unrelated to gun gas explosions. The remaining aircraft were returned to the United States to continue the flight test program,[128] and intensive (though still unavailing) efforts to find a practical solution continued through the end of the fiscal year.[129]

For the future, the F-86H was probably the most important (and undoubtedly the last) modification of the basic Sabre. Unlike others in the F-86 series, the F-86H utilized a J73-GE-3 turbojet in lieu of a J47. The more advanced engine produced a maximum of 8,920 pounds of thrust as compared to the 5,910-pound thrust output of the older turbojet. The improvement thus stimulated in the performance of the aircraft was in part offset by an increase of 4,000 pounds in the combat weight of the F-86H over that of the F-86F. Moreover, although it still retained the capability of flying day fighter missions, the F-86H was intended to be primarily a fighter-bomber aircraft.[130]

Between 19 and 22 January the F-86H had the formal aircraft engineering inspection required for all aircraft prior to first flight. A total of 99 comments and recommendations for contractor action resulted, and 66 were adjudged immediately important to the perfection or safety of the aircraft in flight. These were submitted to the contractor with instructions to make suitable changes prior to the airplane's first flight.[131] Despite this relatively large volume of remarks on the F-86H, none of the directed changes was of major significance.[132]

The YJ73-GE-3 engine, which was to be used in the first few F-86H fighters, lagged somewhat behind the airframe in development progress. Its 50-hour preliminary flight rating test did not begin until late in February 1953, and the first attempt to qualify the power plant for flight ended in failure when a rotor blade in the fifth stage of the compressor broke loose. Previously, inlet screen trouble had been encountered, but this fault had been passed over as not relevant to the design of the production engine.[133] General Electric decided the compressor failure was the consequence of overly close tolerances in the fit of blades to the rotor. Having corrected the fault, the company attempted once again to qualify the engine.[134] Early in April the second YJ73 successfully completed a total of more than 62 hours of running time with only minor difficulty.[135] However, a routine test of a third engine ended with the failure of a turbine wheel, and the flight of the first F-86H was delayed pending replacement of an identical part in the flight test engine. In this instance, improper heat treatment was at fault; correction was a simple matter.[136]

Finally, on 9 May, the F-86H flew for the first time. True to the family tradition, the youngest of the Sabres operated with complete propriety, evidencing no malfunctions in more than an hour of air time. The pilot easily took the airplane to an altitude of 40,000 feet and a maximum speed of Mach .93.[137]

For the balance of May and throughout June, contractor pilots continued to report favorably on the flight reactions of the F-86H. It was not until early July that Air Force fliers had the opportunity of trying the aircraft in flight, and in most respects their initial reports reflected the contractor's estimates. Low altitude operation was reasonably good, although rudder flutter appeared at high speeds and yaw occurred immediately prior to stall. Engineers felt that the extended leading edge was responsible for the yaw and thought a stall fence would eliminate this defect.[138] High altitude performance was not impressive, and although it was too early to say with any certainty that this factor would detract materially from the generally favorable impression of the airplane, it certainly was not at all impossible.[139]

Although essentially satisfactory, the engine still had not completed the required 150-hour qualification test at mid-year, still did not have an acceptable control system, and was in the process of being changed somewhat in turbine wheel design.[140] On the whole, there was nothing in early test results to prove that trouble was ahead, but hints of that nature were too strong to be ignored.

The F-100

North American presented the preliminary proposal for the F-100 to the Air Council in January 1951 in the form of a brochure and a brief design specification. Essentially, the company proposed an extension of the F-86 series with substantial modifications including a change from a 30-degree wing sweep to a 45-degree sweep. With the informal approval of the Air Council, North American shortly thereafter began preliminary development work on the airplane, which became colloquially known as the "Sabre-45." A formal contract, effective as of 17 November 1951, was the signal for the start of intensive development of the fighter, subsequently assigned the designation of F-100.[141]

When 1953 opened, the first prototype YF-100A's were well along the road to completion, and Pratt and Whitney's XJ57-P-7 turbojet, power plant for the prototypes, successfully completed its 50-hour flight rating test in December.[142] (Production versions of the F-100A were to utilize the J57-P-7, which produced a maximum afterburner-augmented thrust of 14,800 pounds as compared to the 13,200 of the XJ57.)[143] By the end of March the engine had been installed and the wings, fuselage, aft fuselage, and empennage mated, so the major item remaining before first flight was the installation of equipment and special test instrumentation.[144]

In radical contrast to the delays and postponements that all too often affected prototype aircraft, the flight schedule for the YF-100A twice jumped ahead. Early in May the first-flight date was advanced from the end of June to the 8th of that month. The safety of flight inspection, one of the final preparatory actions prior to actual flight, was held the week of 11 May--another advance over the original schedule.[145]

The YF-100A actually made its inaugural flight on 25 May, two weeks in advance of the most optimistic estimates. Moreover, the first 53-minute flight revealed no defects in the limited number of items checked and the contractor reported no major flight problems. In a second flight, which lasted 30 minutes, the pilot pushed the aircraft past the speed of sound in level flight, a performance which Colonel Boushey subsequently characterized as excellent, especially "in view of the relatively lower thrust of the prototype J57 engines. . . ."[146]

By mid-June the contractor had conducted more than 30 flights of the YF-100A. Afterburner inadequacy was the only major defect reported in that period, and since the existent afterburner would be replaced in later aircraft, this appeared to be insignificant.[147] Nevertheless, there were indications that as more flight experience was gained other deficiencies would prove troublesome. General Boyd urged immediate and forceful attention to any defects, attempting to insure that corrective engineering would not be so long delayed that large numbers of the fighters would enter the Air Force inventory before engineering changes could be phased into production.[148]

Preliminary reports of Air Force test pilots, who first tried the airplane in late June, supported the contractor's estimates of worth in most essentials.[149] However, by mid-year it was clearly apparent that three major deficiency areas would require concentrated attention. Low speed handling characteristics, poor visibility over the nose during take-off and landing, and inappropriate static and dynamic stability all had prompted unfavorable comment.[150]

Several unusual design features insured a high degree of maneuverability, even in the supersonic range. Rate of climb was quite good, especially at high altitudes. Top speed was limited only by structural design.[151] However, all this resulted in a much higher performance than was characteristic of contemporary fighters, and there were indications that the Air Force pilot of average talents might have some difficulty in coping with the F-100, at least in its existent state. Project personnel frankly anticipated that a great deal of deficiency engineering and much flight testing would be necessary before the F-100 would be suitable for release to the tactical inventory.[152]

Completion of the second prototype aircraft was scheduled for July and the first of the early production versions was to be ready for tests by October.[153] The presence of these and subsequent aircraft would ease the problem of determining precisely what were the major deficiencies of the F-100.

The XF-104*

On 8 January 1953 Colonel W. D. Gilchrist, chief of the Fighter Branch, Weapons Systems Division, presented to the Air Force director of research and development, General D. N. Yates, the Wright Air Development Center evaluation of Lockheed's proposed lightweight day fighter.

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*The XF-104 designation had initially been assigned Lockheed design 227, a relatively heavy, delta-wing day fighter. This development was abandoned and subsequently Lockheed design L-246, the lightweight fighter herein discussed, was assigned the XF-104 symbol. See "History of Wright Air Development Center, July-December 1952," pages 421-422 and 446-448 for additional details.

The discussion that followed, with a number of officers from other Air Force headquarters' agencies participating, resulted in a tentative decision to give the airframe manufacturer a contract for two prototype aircraft based on the design proposal. By late January this decision had been formally enunciated in a directive from Baltimore, the requisite purchase order had been processed, and a project office was in business preparing development plans and general design specifications.[154]

General operational requirements specifying the details of the program arrived at Wright Field while this activity was in process, together with a letter from command headquarters authorizing the negotiation of a sole-source contract with Lockheed.[155] In February Lockheed representatives arrived to discuss details of the model specification,[156] and on 14 March the definitive contract was signed.[157] The mock-up inspection was held on 30 April and 1 May, and necessary action was started to incorporate changes required by the 108 comments then submitted.[158] The speed with which matters had gone to this point prompted optimism that a first flight, with an interim engine, could be carried out by March 1954.[159]

The XF-104, unlike every other fighter in the advanced development program, was to be neither a swept-wing nor a delta-wing airplane. Instead, it was to incorporate an extremely thin, straight, low aspect ratio wing attached to an unusually long, slender fuselage. The horizontal tail surfaces perched atop the rudder. The XF-104 would look very much like the Douglas X-3 from above, and had more than a passing resemblance to the profile of the experimental Lockheed XF-90 of several years earlier.[160]

The ultimate F-104A, when and if produced, was intended to be a "minimum concept weapon" with the ability to perform the day fighter task at relatively slight expense. Thus it had to be of moderate size and weight. Said the project officer, "To continue the normal trend in fighter aircraft of increasing cost and complexity would place an excessive demand on our natural resources in event of an all out war." The XF-104 was the product of an effort to build an airplane which departed from the general trend. It was not small, light, or inexpensive when compared to the production fighters of 1953, but when rated against aircraft in the category of the F-100 and others like it, it became a lightweight vehicle.[161] (The rated combat weight of the F-104A was within 100 pounds of that for the F-86E!)[162] However, in most respects it conformed to the description of "stripped-down fighter" conferred on it by the aviation industry press, which had long been clamoring for the development of such an airplane.[163]

The F-104 was to use a J65 engine, of a series not yet developed. With this power plant, producing a maximum of 12,000 pounds of thrust, the fighter was expected to have a top speed in the neighborhood of Mach 1.83--which was a very fast neighborhood indeed. At 35,000 feet it was designed to fly at 1,048 knots--about 1,215 miles per hour. With a prospective combat ceiling of nearly 53,000 feet and a sea level rate of climb of 49,200 feet per minute, the F-104 would be a dangerous opponent for any enemy fighter.[164]

In large part the F-104A was to be of conventional construction, although several unique design features contributed to its outstanding performance potential. The high tail would be of the all-maneuvering type, and both leading and trailing edge flaps were to be employed. Much of the fuselage load was to be borne by a structure which project engineers described as a keel, and the wing was to be composed of five spars covered top and bottom by milled aluminum skin. Both wing and tail were very thin, and would tend to be quite flexible in flight. Pilot escape was by means of a downward-ejecting seat. Landing gear extension was accomplished largely by gravity, and a great many auxiliary or emergency devices considered standard in fighters such as the F-100 would not be provided in the F-104A. Armament was to consist of a T-171 Gatling-type gun of 20 millimeters, with provision for a K-19 sight aided by APG-34 ranging radar. No autopilot, navigation devices, or similar accessory systems were contemplated.[165]

It was far too early to tell what problems might be encountered in the development of the XF-104, but even before fabrication had gotten well under way one obstacle appeared. Funding plans had envisioned financial support from the Air Materiel Command for the construction of the two prototypes, and the Air Materiel Command had accepted this concept. However, the Procurement Directorate ruled that "since the XF-104 aircraft is a WADC project," funds for the development and procurement of the engines would have to be provided from the research and development appropriation. Inasmuch as the engine was to have the 8,500-pound thrust J65 (the afterburner would send thrust to 12,000 pounds) planned for the F-84F,* this stand was a little hard to understand. Colonel Demler summed up these circumstances for the information of the materiel command director of procurement and production, and in June he forwarded a request for the funds required to finance the model improvement of the J65 then in production. In view of previous decisions from Air Force headquarters on this sort of thing, there appeared to be little doubt that ultimately the requisite financing would be made available. In the interim, however, the XF-104 was on a tight schedule, and delay might endanger the planned flight test program.[166]

Thus at the close of the 1953 fiscal year, the engine situation was somewhat complicated by funds problems, the design was reasonably stable, and fabrication of the first two prototypes had begun. In view of the brief time that had elapsed since the decision to proceed with a lightweight fighter, this sort of progress was not at all bad. Funding, especially for the engine, might provide a stumbling block, but there was no reason to believe that the first flight of the XF-104 would be unduly delayed.[167]

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*See page 289-291.

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IX TACTICAL BOMBER SYSTEMS

Only three weapon systems in development fell into the category of tactical bombers as distinct from tactical fighters. Two of these--the B-57 and the B-66--were reasonable approximations of conventional light bombers. The third--the B-61 Matador--was a pilotless bomber, a guided missile. Each had as part of its tactical assignment tasks that fighter-bombers could perform, but each had also some attributes that, by reason of range or equipment limitations, the fighter-bomber could not match. Essentially, the primary mission of the tactical bomber systems was interdiction, with close support operations that characterized fighter-bomber activities a secondary field.

For planning purposes, the B-57, B-66, and B-61 were adjudged able to satisfy operational requirements for the period extending at least through 1957. After that time, however, some superior performance systems would be needed to maintain tactical supremacy. Specifically, a bomber known as the BX(TB) and a night intruder aircraft identified as the BX(N/I) were contemplated for use starting somewhere in the 1958-1960 period. Both were to be manned aircraft, but there was little doubt that a new air-to-surface missile would be a major element in the offensive armament of each. The principal features setting off the proposed new developments from the B-57 and the B-66 were considerably higher speed requirements (maximums ranging from Mach 0.9 at sea level to Mach 2.0 at altitude), better altitude

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performance (a 60,000-foot ceiling was apparently indispensable), and a considerably more extensive and versatile array of electronic equipment. Preliminary work with these objectives in mind got under way in 1952, and by early 1953 had progressed to the stage of design studies.[1] Plans to continue and accelerate work on these proposed systems were, however, radically altered as a consequence of the budget cuts affecting fiscal year 1954 appropriations. In June the center learned that development of the night intruder had been deferred until after fiscal 1954 and work on the tactical bomber reduced to the status of a study only.[2] This meant, in effect, that the originally planned operational dates for the two aircraft would have to be pushed further into the future or, if development began without schedule slippage, that design, development, and testing would have to be considerably compressed. Neither was a particularly attractive prospect.

Secondary missions of all the basic tactical bomber systems included reconnaissance. But as this generally required only a modification of the basic airframe-equipment combination and not a distinct and separate development program, the RB-57, RB-66, and reconnaissance versions of any future tactical bombers could be considered almost identical to their munitions-carrying sisters.

The B-57

Work on the B-57 continued through the first six months of 1953 in a routine and unspectacular fashion. Fabrication and assembly of the first B-57A were virtually complete by the end of June, and shortly after mid-year the first production article was flown. In this stage of development it was too late to do much about changing design or configuration, and too early to begin making corrections for defects uncovered in flight tests.

Nevertheless, project personnel were still far from pleased with the basic B-57 configuration. This situation was primarily the product of the early "development" history of the airplane. When it had been decided to build the B-57 as a night intruder and tactical bomber, engineers had not been permitted to change the aircraft materially from the design originated by the British. And although some improvements had subsequently been incorporated in the B-57B (as contrasted to the RB-57A version), a number of serious defects persisted. Several of these grew from the fact that the original Canberra had been designed as a high altitude bomber and was not ideally suited to low level missions of the type contemplated. Another detraction from the probability of mission success was the low wing loading--a British design characteristic--which virtually insured that the airplane would provide an unsubstantial gunnery and bombing platform for high speed, low level operations. Empennage location and design restricted the airframe to a speed of Mach 0.8; wing root, tip tank, and canopy design also induced severe buffeting at speeds above that limit. Rate of roll was unsatisfactory above 300 knots because high control forces limited aileron deflection and at speeds near stall because of aileron ineffectiveness. Finally, the project office pointed out, the area and aspect ratio of the fin and rudder were insufficient to permit satisfactory directional control during single engine operation.

The B-57 also failed to satisfy the only applicable general operational requirements for the time period in which its use was planned. It was deficient in operational range, navigation and bombing capability, communications equipment, countermeasures potential, and sensing elements. These shortcomings would definitely limit the use of the B-57B to night operations, and even in that situation performance and stability characteristics would detract from operational effectiveness. In summary, the project officer was able to say only that the B-57B would provide "a limited Military Capability for denying enemy forces freedom of action during the hours of darkness."[2]

Such limitations applied to the B-57B, which incorporated a number of relatively major changes to distinguish it from the B-57A. Only a few of these early aircraft, conforming in almost all essentials to the original British design for the Canberra, were to be built, as a sort of preliminary to RB-57A production, and they would not be assigned to operational units at all.[3]

In view of all these circumstances, it became apparent shortly after data on the B-57 configuration became available that a number of changes to the basic design would be necessary before even a limited night intruder capability could be provided. The 8th to the 75th aircraft were therefore programmed as RB-57A's, which would have a limited utility for night photographic reconnaissance and daylight mapping. The 76th airplane would be the first into which the changes necessary to insure some night intruder ability could be incorporated.[4] The best that could be said for any of the presently programmed Canberra-type aircraft was that they would probably serve adequately in the tasks to which they were assigned, provided only that those tasks were not too exacting.

One improvement which would not be available in time to meet the B-57B production schedule was a shift from eight standard .50 caliber machine guns to four .60 caliber T-130 (M-38) revolver-type guns. Although the 91st Canberra was scheduled to receive the heavier armament, Air Materiel Command officials feared a slippage might delay this effectivity point to the 101st aircraft. If the schedule was maintained as Air Force headquarters ultimately directed (official effectivity point at airplane number 91 and a concession that the 101st airplane might well be the change-over pivot), the last 203 B-57's would carry the T-130 guns.[5] In the event that any time could be gained along the way, the joint project office was directed to "make every effort" to accelerate the change-over and install the heavier weapons "in as many B-57B aircraft as possible without delaying production schedules."[6]

The engine for the B-57B was the J65-W-5, in most respects identical to the J65 installed in the F-84F. Because of the intensive effort being directed at correcting deficiencies in the power plant for the fighter installation, there was little worry on that score for the B-57.* Electronic equipment and defensive installations were other matters, however. No defensive guns were provided. The crew was, however, provided with devices which indicated when the aircraft was under surveillance from enemy gunlaying radar. Survival thereafter depended entirely on effective countermeasures and evasive action. Countermeasures were limited to an externally mounted chaff dispenser, and in March when a passive warning device (AN/APS-54) was substituted for the originally programmed active radar tail warning equipment (AN/APS-55) successful evasive action became less certain. The Aircraft Radiation Laboratory cautioned immediately that although the APS-54 was smaller and lighter than the APS-55, and would probably be available sooner, it merely indicated that the aircraft was being illuminated by enemy radar and failed to give even rough range and direction information. Both of these later features were on the Tactical Air Command's list of requirements.[7] Whether this might later be corrected remained to be seen.

Shortly before the first flight of the B-57A was scheduled to take place, Martin completed fatigue tests of the lower wing attachment fitting for the aircraft. Data derived from these tests when

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*See pages 283-292.

correlated with existent Air Force information indicated that the safe life of the fittings was 1,800 flying hours. Inasmuch as this was the sole wing support member, structural adequacy was definitely affected. Action had to be quick and sure, because the wing attachment fitting was an integral part of the fuselage center section and the local fuselage structure. Thus, retrofit action was not feasible. The center therefore immediately requested three steps be taken: the increase in the bulk of the existent fittings, the evaluation of modified standard fittings, and the complete redesign of the fittings. Tests of the modified fittings indicated a 100 to 150 percent longer life; increasing the bulk of the fittings was expected to raise the fatigue life beyond the 5,000-hour acceptable minimum. Since the fault had been discovered before any great quantity of B-57's had been manufactured, there was little doubt that it would be corrected. Nevertheless, it was not a particularly encouraging development.[8]

Such mishaps notwithstanding, on 20 July the first B-57A to come off the Martin production line recorded a 46-minute flight without untoward incident.[9] The test pilot later reported that the airplane was "in all respects superior to the British Canberra." He took it to an altitude of 27,000 feet and a maximum speed of Mach .79. Control appeared to him to be more effective than in the Canberra, and the engine operated quite satisfactorily. The airplane used only 2,500 feet of runway in its take-off (although the significance of this figure was tempered by a take-off weight of only 36,000 pounds) and touched down at 86 knots. Both of these performances were important adjuncts to any night intruder mission.[10]

Some preliminary flight test results on which engineers could base their future work would be available in the latter part of 1953. Until that time little could be done with respect to the flight characteristics of the aircraft. But in the interval, work continued on the perfection of vital components. The Sartack navigation system being developed with the B-57 in mind was progressing reasonably well; delivery of production systems was thought possible by 1956, at which time a retrofit program would probably have to be undertaken.[11] (The last of the B-57's was scheduled to be produced in July of 1955.)[12] Other articles to which particular attention was being devoted included the chaff dispensers, an infrared bombing system, new tip tanks, a new fuel control system, and the Model II Shoran navigation and bombing system.[13]

The B-66

Like the B-57, in early 1953 the B-66 was in an intermediate stage of development which to a degree limited observable progress. Although the Navy prototype of the B-66--the XA3D--had flown for the first time on 28 October 1952, no Air Force version would reach the flight stage for another two years.[14] Work in the interim would consist largely of preliminary engineering and related work based to a degree on the Navy's XA3D flight test program.

In the light of these circumstances, information concerning the XA3D test program was of peculiar significance to the Air Force. For practical purposes, the aerodynamic configurations of the Navy prototype and the ultimate Air Force reconnaissance and bomber versions were identical. Five basic changes distinguished the land-based version: the deletion of special provisions for carrier landing, an increase in the load factor at take-off, the addition of an all-weather capability, the incorporation of a crew ejection system, and the installation of a 45-inch antenna for the search radar. These alterations brought the basic airplane into conformance with Air Force plans for a light reconnaissance aircraft.[15] Aerodynamically, the B-66B was to be identical to the RB-66 version except for its specially designed bomb bay.[16]

In April the center learned the results of the first 21 flights of the XA3D. To that time, maximum Mach had been 0.9 in a shallow dive at an altitude of 37,500 feet, and maximum level flight Mach, .815 at 40,500 feet. Moreover, these speeds had been achieved with power derived from J40-WE-8 engines with 7,500 pounds of static thrust.[17] The B-66B and its companions would incorporate J71-A-9 engines with a thrust rating of 9,750 pounds.[18] This would promote an even better performance.

The primary aerodynamic difficulty uncovered in the flight evaluations had been tail buffeting of undetermined origin.[19] However, from their design analyses, engineers had been led to expect some other aerodynamic troubles. Wind tunnel tests had indicated that interference between the wing, fuselage, pylons, and nacelles would limit the top speed of the B-66 and that this limitation could be overcome by moving the nacelles forward from their current positions relative to the wings. But any such relocation of the engines also required that the fuselage be extended somewhat to provide balance readjustment. Flutter might also be encountered at speeds below the dive speed limit of the airplane. Fortunately, the studies which disclosed this prospective fault also indicated that a flutter limitation on maximum speed might be avoided by careful selection of nacelle pylon rigidities, suitable fuel usage sequences, and proper location of external stores.

Having the results of numerous wind tunnel tests at their command, project engineers were able to forecast other faults of the airplane--and to provide corrections in advance. Oscillation damping, for instance, was only marginally effective with landing gear and flaps retracted, which took in virtually all flight conditions. However, a yaw damper, coupled to the autopilot, was expected to correct this prospective defect. The yaw damper would also supply rudder coordination in turns when the pilot was unable to exert sufficient physical force to the rudder pedals or when engine thrust was asymetrically applied. Similarly, swept-wing aircraft characteristically experienced a loss in longitudinal stability because of wing flexibility under varying loads. On the B-66, engineers had compensated for this undesirable condition by locating the aileron push rods so that upward wing deflection tended to induce a downward deflection of the control surfaces.[20]

Equipment and accessory difficulties which showed up in the initial tests of the XA3D were confined almost entirely to Navy items deleted from or radically changed in the B-66.[21] It was entirely possible, of course, that other difficulties might show up, but the method by which B-66 development was being undertaken virtually assured that they would not be crippling. The first 25 production aircraft--B-66B's, RB-66A's, and RB-66B's--were to be channeled directly into the test program, there to be allocated to various agencies in accordance with a schedule jointly agreed upon.[22]

In February, the use of the K-5 bombing system in the B-66 series aircraft again became a topic of concern. There was no thought of reopening the question of which bombing system should go into the airplane--a matter which had been exhaustively investigated some months earlier*--but merely of examining again the operating characteristics of the chosen system.[23] From all indications, the K-5 was the only system being considered. Indeed, in July the separate K-5 development project was cancelled and the work assigned as an element of overall B-66 development. And by that time tests of the prototype

*For information regarding the rather involved controversy concerning the bombing system for the B-66, see "History of Wright Air Development Center, 1 July-31 December 1952," pages 363-366.

systems in B-50 and B-47 aircraft were under way. Completion was anticipated by the spring of 1954.[24]

Shortly after mid-year, a suggestion that the crew of the B-66 be reduced from three to two came up for a decision. The position occupied by the crew member who was at once co-pilot and gunner had been listed as possibly surplus. The Aero Medical Laboratory, assigned the task of evaluating the human factor elements of the suggestion, decided that neither the pilot nor the bombardier-navigator could efficiently assume the job of watching the tail-radar scope presentation and directing defensive action. Existing duties of both men were too complex to permit the addition of any others. At the same time the laboratory recommended, apropos of this and similar suggestions, that the assignment of crew duties be an integral part of the Phase I study for a weapon system. If crew reduction was to be attempted in any instance, all the equipment involved in each crew member's position would have to be redesigned with his complete assignment in mind. As another recommendation, Aero Medical Laboratory specialists flatly stated that "old fashioned equipment packaging techniques" should be abandoned by all laboratories and a new and more flexible technique adopted for full efficiency. Finally, there was agreement that any reduction of the basic crew for such aircraft as the B-66 would have to await the evolution of new combination presentation systems, permitting the allocation of more basic tasks to one individual.[25]

As a sort of postscript to the B-66 development plan, in April Air Force headquarters decided on the procurement of 65 electronic reconnaissance RB-66's as part of the order for 216 photographic reconnaissance aircraft from fiscal year 1954 funds.[26] These specialist vehicles in most respects resembled the basic RB-66B in external configuration, but they incorporated a special bomb bay pod with provisions for four operators and their equipment. The general configuration for this version received high level approval in April, but no formal procurement directive had been issued by the close of the fiscal year.[27]

Thus in the latter part of 1953 there were four versions of the B-66 under development: the RB-66A and RB-66B photographic aircraft, the B-66B light bomber, and the RB-66C electronic reconnaissance airplane. Each would require special attention, since each was a highly complicated combat vehicle in its own right, but for practical purposes only one aerodynamic configuration had to be considered. The task of supplying the Tactical Air Command with a weapon system able to function in a variety of assignments appeared to be well in hand.

The B-61

Ever since the Battle of the Bulge in the closing phases of World War II, the danger of losing control of a battlefront situation because of bad weather and the consequent ineffectiveness of tactical support aviation had been of pressing concern to United States ground forces. The absolute inability of the unaided human mechanism to cope with fog, snow, misty rain, or similar climatic conditions made close support operations extremely hazardous. Nevertheless, close support and interdiction could not be allowed to lapse because of unseasonable weather. The obvious solution was to develop a pilotless aircraft capable of supporting tactical operations. The B-61 Matador was the weapon.

Of course the Matador had other uses. It would not under any circumstances be confined to bad weather operations. The first operational Matadors were to have assignments consistent with their range limitations (175 to 500 nautical miles) and warhead capacities (3,000 pounds). Range was substantially limited by guidance system characteristics and fuel capacity. The terminal guidance system was expected to impact the missile within 500 feet of the target after a maximum range flight.[28]

These were expectations. Unfortunately, experience had not yet borne them out. The first flight of an experimental Matador had occurred in January 1949, the first flight of the production prototype YB-61 on 22 December 1950, and the first flight of the production version B-61A on 17 November 1952.[29] By 3 June 1953, a total of 61 Matadors of all types had been fired,[30] yet the missile was still relatively far from being truly operational.

In large part the activities of Wright Field with respect to Matador development in the first six months of 1953 centered about the correction of defects and shortcomings. All of the major components of the B-61A, including two different guidance systems, were available for testing, so the principal tasks were corrective engineering and redesign of critical components. And while the engineers were confronted with this work, the center began an accelerated effort to perfect the B-61B, an improved missile which incorporated the Atran guidance system and largely overcame the basic operational shortcomings of the B-61A.

Work of importance to the B-61A fell into several distinct categories. Probably of paramount importance were discovering the reasons for persistent terminal dive breakup, correcting, compensating for, or overcoming this defect, and finding a way of insuring that the missile would at least remain intact until impact on the target. Whatever its other limitations or advantages, any missile which consistently fell apart in the course of its final dive toward the target was of no great use to the operational forces.

Almost equally vital was perfection of a guidance system which would operate effectively in the missile, and not merely in the cloistered environment of a test vehicle where it was surrounded by solicitous technicians prepared immediately to correct the slightest irregularity. Work on the booster rockets, the warhead, a recoverable drone missile, and several other subtasks also continued at full pace.

By January 1953 it was apparent to project people that terminal dive breakup was an extremely serious factor in the Matador program. A large proportion of the missiles which got as far as terminal dive fell apart before reaching the ground. Most of the failures seemed to occur at a Mach number near 1.0, after the missiles passed the 20,000-foot level on their way down. This suggested to engineers that the failures were caused by some dynamic instability--flutter or severe vibration--triggered off when the missile reached a specific flight condition. No information was yet available to indicate definitely either the nature or the cause of the instability.

One of the most detailed analyses of the failure sequence started with the assumption that antisymmetrical wing bending was one of the initial effects of terminal dive velocities. If this were so, such bending induced a fuselage roll, which the gyros automatically attempted to correct by changing the deflection of the spoilers. Spoiler deflection caused reactive wing bending, inducing additional roll, though probably in reverse rotation, and this started the sequence once again. The consequence was a rapid oscillation and the probability of exceeding the structural limits of some portion of the missile.[31]

Incomplete verification for these conclusions was obtained from telemetered records of the third B61-A flight. The missile, launched from Patrick Air Force Base on 14 January, flew a normal course over most of its flight path and then broke up about 5,000 feet from impact point, while in the terminal dive phase.[32] Telemetered data showed that the wing tips and the spoiler actuator were oscillating at a frequency of 11.5 cycles per second, but that the amplitude of oscillation was relatively stable (and presumably reasonably slight).

This alone apparently was not sufficient to cause breakup. However, the recorders detected a 1.33 cycles per second oscillation of the spoiler actuator superimposed on the 11.5 cycle. This first appeared shortly before data transmission ceased, rapidly increased in amplitude throughout its recorded life, and appeared to be a completely unstable motion. At the apparent point of breakup, when the telemeter transmitter ceased sending, the amplitude was sufficient to have caused a deflection of at least six inches in the spoiler. At the same instant, wing tip acceleration (induced by the gyros and spoilers in an attempt to eliminate the roll) was well over 50 G's. This set of conditions seemed to have been sufficient to cause breakup of the missile, although the Aircraft Laboratory concluded cautiously, "no information was obtained from the records which would indicate what part of the bird broke up first, and the data are still insufficient to disclose the precise cause of the failure."[33]

Aircraft Laboratory representatives who visited the Martin company early in January recommended a special ground vibration test of the B-61A wing in order to find out whether antisymmetrical wing bending could actually cause spoiler actuation. Martin agreed to this and also agreed to incorporate additional instrumentation in the next few YB-61 and B-61A flights in order to obtain more information on the behavior of the missiles during terminal dive.[34]

During the first week of February the contractor ran a series of ground tests of vibration which showed positively that antisymmetric wing bending could set off high amplitude vibrations. But there was still no absolute proof that such a sequence was the cause of missile breakup.[35] On 18 March, however, photographic coverage of the flight of a modified B-61A provided a clue to the breakup sequence. There was definite evidence that the tail and the wings came off in terminal dive; in this instance at least, the fuselage remained intact until it hit the ground.[36]

Although Matadors continued to break up during their terminal dives, thus constantly providing new data, the exact cause of the phenomenon remained uncertain. Project personnel interpreted available engineering data to the effect that structural failure of the tail during the violent oscillations was probably the main difficulty. And despite the continuing uncertainty about precise cause and effect, a three-pronged attack on terminal dive failures started late in May. The project officer estimated that by the end of July it would be possible to flight test a Matador with important structural changes, largely affecting the torsional stiffness of the fin and wing. Some additional electronic safeguards to stable flight were also to be incorporated in this modified missile, but in the main this aspect of the program revolved about the substantial reinforcement of the Matador's structure.[37]

Earlier, Wright Field and Martin people had come up with the idea of releasing a drag parachute during the terminal dive phase. The idea, of course, was to keep the Matador at a subsonic cruise speed throughout the descent. Under existing flight conditions, the missile had to pass through the troublesome transonic range twice during each dive--once at about 20,000 feet altitude when accelerating to Mach 1.25, and at about 5,000 to 7,000 feet when air resistance slowed it to subsonic speed once again.[38] Martin calculated that a four-foot drag parachute would reduce the Mach number to .75 at the critical altitudes. This experiment also would require several weeks to complete.[39]

The third proposed correction was to keep the missile in the transonic zone over the entire terminal dive course. This would probably require modifying the servo controls as well as changing the dive plan to maintain a negative G trajectory. Again, it would be at least July before any results became available for analysis. Each of the three primary "fixes" was to be tried on at least two missiles. Moreover, this correction program constituted the whole of Matador flight tests for the time being.[40]

The parachute solution received its baptism on 12 June, after a series of preliminary ground tests on the rocket sled at Edwards had revealed several minor defects, which were corrected on the spot.[41] The 12 June flight test at Patrick was only partially successful, since the missile failed to start its terminal dive on schedule. Regardless of this fact, the dive brake parachute deployed according to plan, noticeably slowing the speed of the missile. When further efforts to induce a dive were unavailing, chase pilots destroyed the "bird." They later reported that the parachute remained firmly attached and fully deployed until the missile disintegrated.[42]

A second trial of the parachute system was attempted on 2 July, with slightly better success. Pilots observing the dive sequence reported the parachute functioned properly, but that the missile entered violent roll oscillations between 10,000 and 15,000 feet, finally breaking up at about 2,000 feet above the earth. Unfortunately, telemetering failed at the start of the terminal dive.[43]

Although the drag chute seemed not to be the solution to the plague of terminal dive breakups, tests of the strengthened missile and the supersonic dive program still remained. So it was still too early to say with certainty that no answer was in sight.

The B-61A, which differed from the YB-61 principally in the matter of wing attachment and tail configuration,[44] appeared to be less susceptible to breakup while passing through the first transonic zone than its predecessor. At least one B-61A had hit the ground intact, and there was some conjecture about others on which telemetered information was missing.[45] This circumstance indicated that the B-61A configuration was in some fashion better than its YB-61 predecessor, but here again there was an area of uncertainty.

Early in 1953 there was a suspicion that the unique structure of the wing--metal honeycomb and structural adhesive in lieu of the conventional rib-stringer-skin construction--might be contributing to the failures. In January a representative of the Materials Laboratory

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spent two days at the Martin plant in Baltimore reviewing the structural design, materials, and processes. This examination indicated that both materials and processes were satisfactory and had not caused the flight failures.[46] Thus disappeared another suspect.

Guidance for the B-61A remained an outstanding problem throughout the six months. Actually, two guidance systems had been tried out--the MARC system consisting of a ground control radar (AN/MSQ-1) used in conjunction with a beacon (AN/APW-11) carried in the pilotless aircraft and the Shanicle system which used four base stations and was capable of controlling several missiles at one time.[47] The comparative quality and worth of these two systems were summarized for the commanding general of the Air Research and Development Command in February.

Essentially, neither the MARC nor the Shanicle system satisfied the accuracy requirements specified by Air Force headquarters. Of the two, the MARC system appeared to be considerably more reliable and accurate, although it had the handicap of being able to manage only one missile at a time. The project people felt that by mid-1953 "we will have a fairly reliable and capable MARC guidance system." But they then added a toe-stubber, "However, insufficient data is available to determine a firm reliability figure and the accuracy will not be that stated in the specifications (1000' CEP /Circular Error Probability/)."[48]

Nevertheless, results at the missile test range were quite promising. The B-61A launched on 14 January was controlled by MARC throughout its flight and hit within one-quarter mile of the target.[49] A 1 April flight of the same combination resulted in a zero range error and a one-quarter mile azimuth error,[50] a performance which was characteristic of five successive flights in the period just before mid-May. In each instance, range error was absent, and azimuth error never exceeded 1,800 feet.[51]

The situation with respect to the Shanicle development program was quite different. As a starting point, accuracy estimates compiled by contractor and Wright Field engineers differed considerably. The aircraft firm conjectured that by January 1954 the Shanicle system would be capable of consistently guiding missiles to within 1,000 feet of target center; Wright Air Development Center felt that a 2,000-foot error was the best that could be expected of the system by that time. The July 1953 figures were similarly in disagreement--1,250 feet and 2,500 feet for Martin and Wright Field, respectively.

Project personnel explained the variance in estimates as arising from a combination of several factors. Said the project officer, "The WADC figures are based on knowledge of the status of the Shanicle development program combined with past experience with the contractor's estimates. The contractor has based his figures on the fact that he has designed for a 1000' CEP and on the result of simulated missile flight tests with B-29's in Florida." On the surface, these appeared to be reasonable assumptions. But, continued the project engineer, "these simulated missile flights are conducted in a pressurized cabin under ideal conditions with a constant monitoring and adjustment of the equipment by technicians. Terminal dive errors are neglected. These tests form a poor basis for estimates of accuracy when the equipment is installed in a missile."[52]

Personnel in the project office at Wright Field also felt that because "the job of developing and producing the Shanicle system for the desired accuracy and reliability would have been a real challenge to a first-class electronic contractor," Martin should have sub-contracted for the system. Frankly stated, the problem came down to the fact that Martin had been unable to attract "enough high calibre electronics personnel" to do the job properly and on schedule. Realizing this, Martin had begun to subcontract for the solution of specific guidance problems and to ask assistance from the laboratories at Wright Air Development Center. However, the center experienced extreme difficulty in obtaining records of Shanicle testing. The inference was either that only scanty testing had been performed or that few records were kept. As the project officer remarked, "Neither conclusion inspires confidence in the reliability and capability of the equipment."[53]

Three attempts had been made to use Shanicle guidance in pilotless aircraft flights prior to the end of March. None was successful.[54] Usually, the missile failed to respond to Shanicle signals, although on one occasion an apparently successful contact was followed by a false dive signal from the control mechanism.[55]

On 17 June a technical assistance team from the Aircraft Radiation Laboratory completed a detailed evaluation of the Shanicle components in production at the Martin facility. More than six months and 6,000 manhours had gone into the attempt to obtain a basic improvement in the equipment. Data on which to base an evaluation was not available when the laboratory entered the program on an active basis, but as additional information became available the laboratory's original opinion that airborne Shanicle components did not meet Air Force requirements for missile electronic equipment was confirmed. Engineers decided that the required improvement was impossible in view of the urgency of the production situation. Contractor component lists indicated that 37 percent of the components were non-standard or of a totally unknown quality. Said a laboratory representative, "All units subjected to Enviromental [sic] Tests failed to the extent that acceptable 'quick fixes' were not possible. The same is true for vibration and shock tests."* Radio noise tests and susceptibility-to-interference tests gave equivalent results. Engineers finally concluded that, "in fact the airborne Shanicle equipment jammed itself."[56]

Following its evaluation, the Aircraft Radiation Laboratory called a conference of interested elements at Wright Field and submitted

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*Italics inserted by this writer.

a series of recommendations regarding Shanicle. The first was to stop production immediately, the second to discontinue the missile flight tests of the Shanicle system, and the third to cancel the test program in B-29's. In lieu of this, the laboratory recommended "a properly planned and directed" flight test program utilizing C-47 aircraft, further production engineering leading to the submission of a "first article" that met Air Force requirements, and preparation of a new production specification after production engineering had been completed. The project office, laboratory directorate, and operations people accepted these recommendations immediately. On 30 June, Martin received an outline of the plan and began construction of a detailed program to conform to it.[57]

Revision of the B-61A requirements to reflect this development was equally prompt. Before mid-July, Air Force headquarters had verbally approved deletion of the Shanicle system from the B-61A and restriction of that operational missile to the MARC system. Simultaneously it was agreed that a YB-61C program be established for the further development of Shanicle. After Shanicle had entered the stage of practicality, the production line would be converted to turning out B-61C's. Space, power, and weight provisions were to be retained in the B-61A, thus permitting a later conversion of stockpiled Matadors to the B-61C configuration.

By means of this development schedule, engineers hoped to have a reliable, usable Shanicle system available by July 1954 and the first production articles ready for operational use late in 1954.[58]

These decisions left the MARC system alone in the field of B-61A guidance. In view of the performance of the system in flight tests, this was not a serious compromise of the Matador's performance potential. Some difficulty was anticipated in the delivery of the airborne beacon set (AN/APW-11A) because development was not yet complete. Nevertheless, in March the center took action to permit early acceptance of a limited quantity of beacons. The first pilot run equipments were not expected to meet all performance requirements, but there was slight doubt that they would satisfy immediate B-61 needs.[59] The contractor received enough early production models of the beacon late in March to permit continuation of the development and flight test program.[60]

Although this portion of the program provided support for early operational assignment of a Matador missile, it had definite limitations. As early as October 1952, the Air Research and Development Command had concluded that the B-61A Matador would be only marginally useful after 1956. In view of the need for a replacement and the uncertainty of providing a new tactical weapon by that time, a very low altitude missile was selected as the most satisfactory interim solution. Command headquarters therefore directed that a model improvement program be started, using the basic B-61A, with the objective of providing a suitable missile having the ability to penetrate 1,000 nautical miles into enemy territory and utilizing an improved guidance system. The tentative nomenclature of B-61B was assigned to such a weapon.

The decision to mate Atran guidance with the improved missile airframe was quite natural. In 1946 the two developments had begun on parallel levels. In 1949, when the need for flight testing the guidance system in an unmanned vehicle became apparent, the B-61 was selected. Although there was at that time no stated requirement for Atran use in a missile, further work on the guidance system proceeded with emphasis on adapting Atran to Matador operation. This proved to be a fortunate decision, since the October 1952 requirement for an improved Matador with a better guidance system was practically tailored to the Atran performance capability. The decision to adopt this procedure shortened the B-61B development program by 12 to 18 months.

Studies made by a variety of agencies had produced evidence that it would require equipment, manpower, and funds of almost astronomical proportions to defend a target from a weapon flying in at a very low altitude. This problem would be compounded if concerted low level, high speed attacks could be mounted. The B-61B seemed to supply this potential, and the Air Force would have such a weapon by 1956 unless serious and unexpected difficulties intruded. Moreover, such a weapon would maintain its advantage for a number of years.[61]

Use of the Goodyear Aircraft Corporation as the contractor for the B-61B was determined largely by the fact that in 1950 the firm had first submitted a proposal for an Atran-guided low altitude pilotless aircraft with characteristics remarkably similar to those defined in the October 1952 directive.[62]

By 22 January the B-61B contract with Goodyear had been negotiated,[63] and shortly thereafter intensive preliminary work got under way. In February a number of the contractor's key personnel visited the center to meet their Wright Field counterparts and to insure that understanding of the center's B-61B requirements was mutual. Arrangements were also made at this time for Goodyear personnel to participate in a Matador training program at the Air Force Missile Test Center, starting on 1 March and lasting for about six weeks. The project office also organized "B-61B teams" within several laboratories, charging each with task responsibilities.[65]

In March, the contractor began reorganizing his personnel and facilities, separating the B-61B work from the Atran research and development job in order to permit more intensive effort on the former. Negotiations with prospective subcontractors for part of the development task began at the same time.[66] By May, layouts and dimensional data were in the process of preparation for the wing-fuselage attachment fittings, so that initial design work could get under way. The idea of a folding wing to facilitate handling began to receive serious consideration. Work on the boosters, the propulsion system, the guidance subunits, instrumentation, and recovery procedures applicable to the test missiles was in a preliminary stage.[67]

One of the most encouraging developments of the period was the first successful flight of the model "M" Atran. Installed in the nose of a T-33 aircraft in a configuration simulating a Matador missile, the unit on 6 April guided a completely automatic flight over a 47-mile course. Aircraft control was stable and all equipments functioned properly. Although no accuracy measurement was recorded, the pilot reported his inability to distinguish any error in passing over the calibrated range.[68] Later the same month modification of an experimental model "M" system began, with the intent of creating a system comparable to that proposed for the low altitude missile.[69]

Atran (the title was derived from Automatic Terrain Recognition and Navigation Guidance System) worked by comparison of radar data obtained from its own scanner with pulses abstracted from a radar reconnaissance map of its intended course. Differences between these beams were resolved into signals that corrected the flight path so that at all times it corresponded with the course recorded on the reconnaissance map. Thus, the system was capable of providing continual position information under all weather conditions. Furthermore, although Atran was dependent on radar impulses and was in theory extremely susceptible to jamming, enemy interference actually had little effect on the accuracy of the system. This peculiar circumstance was the consequence of a difference between the frequencies of jamming waves and those emitted by the missile. Moreover, the process of map matching required a type of cross-correlation which reduced the effect of jamming.[70]

There were a number of other features to Atran which made it peculiarly attractive for its assigned mission. But it was still far too early to foretell the success, or the freedom from trouble, of the B-61B development program. At any rate, the B-61A remained the paramount problem of the moment.

Notes, Chapter IX

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15. Dev. Plan, The RB-66 Weapon System . . . , 26 Sept. 1953, p. 9.

16. Ibid., Suppl. I, p. 71

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18. Standard Aircraft Characteristics (Green Book), B-66B, 5 Mar. 1953, prep. by Flt. Data Br., DCS/O, in Hist. Div. files.

19. WSD DAR, 7 Apr. 1953.

20. Dev. Plan, The RB-66 Weapon System . . . , 26 Sept. 1953, pp. 12-13.

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22. AMC WAR, 23 Mar. 1953.

23. WSD DAR, 18 Feb. 1953, see App. H-1.

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66. Ibid., 28 Apr. 1953.

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X STRATEGIC FIGHTER SYSTEMS

In the strictest sense, the F-101 was the only strategic fighter in development when fiscal year 1953 ended. However, several other aircraft by virtue of mission assignments or special range extension devices fitted loosely into this category. The Ficon (Fighter Conveyer) project was one, but wing tip coupling, the fuel wing, towing, fighter inflight refueling, and a number of other minor projects also qualified standard tactical fighters for long range strategic operations, if only marginally. The main task of a strategic fighter was either to escort strategic bombers or to bomb targets distinct from those generally conceded to be tactical in nature. Long range reconnaissance missions might also be performed by fighter-type aircraft, but in a majority of cases reconnaissance versions of fighters, unless provided with some very unusual range extension feature, were still primarily tactical fighter systems.*

In addition to the F-101, another long range fighter was being considered for support of strategic operations, although not in the immediate future. Such a strategic fighter system was to be capable of speeds from Mach 1.0 to 1.3 at 55,000 feet with a potential for five minutes "flash performance" at Mach 1.75. The true top speed of

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*All of the fighter aircraft which also bore RF- designations were to a degree "strategic fighter systems," but as most have been treated separately, in their F- configurations, they will not be considered within this chapter.

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the aircraft, which would probably be at least Mach 2.0, would be virtually useless because of the length of time needed to accelerate. The balance of the design requirements--apart from a 60,000-foot ceiling and a 1,500-nautical mile radius without refueling--were to be considered when the preliminary design estimates arrived.

The results of these preliminary studies, being conducted by five major contractors in an attempt to establish physical characteristics for the proposed aircraft, were scheduled to arrive at Wright Field by the end of November 1953. Air Force headquarters wanted an aircraft capable of delivering special weapon packages at low altitudes yet still competent for high altitude air-to-air combat. The airplane would in all probability be designed to satisfy high altitude requirements in the expectation that it would thereby automatically possess the performance required for low altitude. Prospective size, weight, and complexity were all increased by the need for this high altitude capability.[1]

The Phase I detailed study was not due for evaluation before August 1954. The first flight of a prototype probably would not occur until the second quarter of 1957, and the first production aircraft, in the event production was scheduled, would not be ready until 1958.[2]

<u>The F-101</u>

Although the F-101A could not perform in the fashion of the proposed long-range strategic fighter, it had some rather startling characteristics all its own. Engineers calculated its basic speed at 35,000 feet to be 919 knots, nearly Mach 1.6. Mission outlines projected a 1,000-nautical mile radius of action for the fighter--fully loaded. The airplane itself was more than 65 feet long (nearly twice the length of the F-80) and would carry an internal fuel load heavier than the total design weight of the F-84D.[3]

This McDonnell-designed fighter was to support Strategic Air Command bombers by attacking the enemy's air defenses with atomic weapons. It would also be used to carry the same munitions against heavily defended strategic targets in instances when the use of slower, heavier, more expensive and less expendable carriers would result in prohibitive losses. Secondarily, the F-101 was to be used in an air-to-air combat role, as conditions dictated.[4]

The original F-101 had been conceived as an escort fighter with long range intruder missions included only as a secondary feature. Late in 1952, however, the Air Council redefined this concept of operations to put more emphasis on penetration and attack. Subsequently, on 23 January 1953, Air Force headquarters indicated that the F-101 was henceforth to be considered "a strategic escort fighter with a primary capacity for performing strategic strikes and a secondary capability for engaging in air-to-air combat."[5]

One of the unique advantages of the F-101 was its superlative thrust output. With special short afterburners (originally designed by McDonnell for the F-88), each engine would have a rated maximum

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thrust of 15,000 pounds.[6] Without afterburners, the weight-thrust ratio would be 1.6. This feature permitted take-off without the aid of afterburners and also meant that the fighter would have exceptional acceleration characteristics.[7]

Development of a special short afterburner presented one of the few relatively major obstacles in the F-101 program. In December 1952 General Bradley advised General Boyd that Pratt and Whitney, contractor for the F-101A's J57-P-13 engine, was "reluctant to assume responsibility for . . . development of the short type afterburner." Company engineers were frankly skeptical of the afterburner's practicality, or at least doubted that it could be perfected in time to meet the engine schedule. The firm therefore made engine deliveries contingent on afterburner progress. And although Pratt and Whitney lacked experience in such work, the company did not want to contract directly with Marquardt, which then had in its employ the men who had designed the original short afterburner for McDonnell's XF-88. Pratt and Whitney wanted to develop the engine alone and suggested that McDonnell be permitted to contract for the afterburner separately. The Air Force objected on the grounds of divided responsibility for engine development (since the afterburner was an organic part of the complete power plant) and the possibility of an additional middleman's profit.[8]

General Bradley's suggestion was that Wright Air Development Center investigate the possibility of substituting the engine-afterburner combination from the F-100 or the F-102. This possibility, he said, "should be fully explored by your command and adopted if practical."[9] (The F-100 and the F-102 used J57 engines, though both were in different configurations from that proposed for the F-101.) Colonel Demler, in replying for the center, stated unequivocally that the short afterburner had been proven feasible, but he conceded that initially it would probably give a reduced thrust (costing perhaps Mach 0.1 in top speed). However, he noted that 18 months after the first aircraft was produced an improved engine would be available to more than overcome this loss.[10]

The center felt that engine-afterburner combination developed for either the F-100 or the F-102 would increase the take-off and landing distances for the F-101 by at least 10 percent. Substitution of the J57-P-7 for the -13 would also require modification of the rear fuselage of the McDonnell fighter and would probably involve a basic structural rearrangement affecting wing position and intake duct design. The basic difference, of course, was the use of a standard "long afterburner" in each of the other aircraft. The center's position remained unchanged; every conceivable action should be taken to insure that a short afterburner would be available for the F-101.[11]

Apparently Colonel Demler's persuasion was effective, for on 12 January the Air Materiel Command issued a letter contract to Pratt and Whitney calling for the development of the special afterburner.[12]

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However, a critical delay of nine months existed between the time engine work was requested and the time a contract was actually issued. On that basis the project office foresaw a definite possibility that several of the early test aircraft might fly without afterburners, thereby limiting their performance.[13] But as General Boyd pointed out on another occasion, afterburner operation was not required for take-off, even at maximum gross weight, and the airplane could be operated in the supersonic speed range, although marginally, without afterburners.[14]

This delay in engine development would force the use of "50-hour engines" in the early production program, a process much like that adopted for the F-100 and the B-52. To some extent this alarmed the Air Materiel Command, but the center's commander explained that "50-hour engines" were fully satisfactory for flight installations--that the 50-hour endurance test had been designed specifically to insure that circumstance. Therefore the use of "50-hour engines" in F-101 aircraft until such time as the power plant passed the 150-hour qualification test would benefit both the airplane and engine development schedules. Much important information was usually derived from flight tests of early engines.[15]

Agreement having been reached on these matters, there still remained the question of a schedule for the short afterburner engine. A letter contract was rather too fragile an instrument for continued use in so important a project. On 4 February, therefore, Pratt and

Whitney accepted a definitive contract incorporating a "best efforts clause." Although not absolutely promising a completed engine within a specified period, the contractor indicated that a production version qualified for 50 hours would be available by December 1954, with the "150-hour engine" following in July 1955. Inasmuch as both these dates fell after the first flight of the airplane was scheduled, it was necessary to provide non-afterburning engines. The materiel command therefore planned to procure 40 suitable engines for the early phases of the test program. In all probability, these would be J57-P-13's without afterburners. A straight tailpipe tailored to the F-101 or a prototype (but inoperative) afterburner would satisfy immediate requirements.[16]

These matters out of the way, engine-afterburner development started. By May, Pratt and Whitney had reported favorable results from initial tests of the short afterburner used in conjunction with the basic J57.[17] A mock-up of the proposed ultimate configuration, complete with short afterburner, reached the McDonnell plant in St. Louis on 20 May. It was installed in a mock-up of the F-101 and, on 14 July, was formally inspected by Air Force personnel. In the main the installation was satisfactory. One especially promising feature was that a complete engine change could be made in less than 20 minutes.[18]

Extensive wind tunnel tests of the F-101 design occupied the attention of the Aircraft Laboratory in the early months of 1953 since

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data on drag, stability and control, and duct efficiency were needed. Special attention was being paid to the speed range above Mach .95, although the tests included speeds between Mach 0.6 and 1.2. The tests indicated that some modification of the tail surfaces and the inlet duct might be necessary.[19]

One outstanding feature of the F-101 would be a combination of a 1,200-gallon externally carried fuel cell with an integral inflight refueling drogue. Since the F-101 would have a retractable refueling probe, this would make "every fighter a tanker and every tanker a fighter." In effect, it permitted F-101 squadrons to be self-sufficient rather than dependent on support from tanker squadrons for extremely long range missions.[20]

Development of the RF-101 followed much the same pattern, since the two aircraft would have essentially identical flight characteristics. The point of departure would be the equipment installed forward of a line drawn across the mouths of the engine inlet ducts.[21]

Preliminary planning for the configuration of the RF-101 began in December 1952. The major issue in doubt at that time was camera equipment and the camera control system. Photographic Reconnaissance Laboratory personnel favored the installation of the existent universal camera control system or some commercially developed equipment similar in weight, size, and cost.[22] The Air Materiel Command, however, held out for "on the shelf" equipment previously service tested, a status still not attained by the "UCCS." Photographic engineers countered

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that a special installation based on the universal camera control system was the only one which could be available in the required time period and could function efficiently at the speeds proposed.[23]

Ultimately, arguments for K-series cameras and a simplified version of the universal camera control system won out, and Air Force headquarters approved this configuration--although for mock-up purposes only. However, the materiel command had already received instructions directing procurement of the RF-101, so any major change in the basic arrangement of either the reconnaissance equipment or the engine-airframe combination was certain to delay production. On that basis, the RF-101 configuration was as "firm" as that of its fighter companion.[24]

It was barely possible that a second production source for the F-101 might be required, especially if plans for the use of the fighter were significantly expanded. Persistent suggestions that the McDonnell aircraft be used as an air defense interceptor,* coupled with high expectations for the basic fighter version, gave weight to hints that production might be enlarged. However, instructions from Air Force headquarters delayed any decision on that point past the end of June.[25]

Project Ficon

The idea of combining the abilities of a high speed but short

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*See pages 184-187.

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range fighter with those of a long range but relatively slow carrier aircraft was not new. In the 1930's the Navy had successfully launched and retrieved a small fighter using Zeppelin-type airships. The British had tested a "mother-daughter" transport aircraft arrangement in 1938 and 1939. Shortly after the close of World War II, the specially designed XF-85 had been carried in, launched from, and retrieved by a B-36 mother ship.[26] But limitations of one sort or another had always restricted the use of such special purpose airplanes. These limitations appeared to have been overcome in the case of the Ficon project.

Project Ficon involved the use of a parasite RF-84F in combination with an RB-36D mother ship. The purpose of the junction was to provide the Strategic Air Command with a high performance fighter aircraft usable on a global range scale, thus permitting a more fluid pattern of long range strategic bombing and photographic reconnaissance.[27]

The feasibility of the basic idea had been proven in wind tunnel tests, ground experiments, and flight evaluations extending from February 1951 through April 1952. Further refinement by means of flight tests continued after that time, but by then the overall scheme of operations had been proven practical. Early tests were run with an F-84E, a straight-wing model which had flight characteristics different from those of the RF-84F intended for eventual tactical utilization. The problem of the moment, when 1953 began, was to correlate the results of earlier tests with actual performance data drawn from experience with a swept-wing F-84.[28]

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One of the major difficulties in this undertaking had resulted from Republic's extremely slow progress in modifying a prototype YF-84F aircraft to the parasite configuration. A contract change notice authorizing such work had gone to the contractor on 14 January 1952. Later that month the firm had estimated that it would take only about 90 days to complete the task. By March that time had grown to eight months, and by May the contractor had decided that the airplane could not be ready before December 1952. From June through December the project office did its best to accelerate the modification, but by the end of the year Republic still had not completed the work, and indicated, moreover, that late January would be the earliest possible completion date. Subsequently, even this slipped, and late February became the projected deadline.[29]

In the meantime, the original 35-hour flight test program involving a modified F-84E had been completed on schedule (in April 1952, when the YF-84F had originally been due) and a secondary flight test program had begun. While awaiting delivery of the swept-wing parasite aircraft, the flight test agency had tried a better version of the contact and retraction mechanism and indoctrinated a number of flight crews in the operation of the system.[30]

Despite this progress, Wright Field project personnel were deeply concerned by Republic's failure to supply the YF-84F needed in further tests. Colonel Boushey, chief of the Weapons Systems Division, frankly admitted that efforts to impress Republic with the vital nature of the

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undertaking had not been successful. He therefore asked General Boyd to take the matter up personally.[31] The commander's reaction was prompt and to the point. In a letter to the company president he mentioned that a decision regarding future production plans was held up pending availability of an evaluation of the YF-84F's suitability, that the RB-36 had long been prepared for the experiments, and that "any assistance which you can furnish in accelerating completion and delivery of the parasite YF-84F will be deeply appreciated."[32]

Whether or not this letter had the desired salutary effect, it would be difficult to determine. At any rate, Republic announced a new scheduled completion date and stuck to it.[33] Modifications were completed, and on 10 March the airplane was airlifted to Edwards Air Force Base for a 10-hour flight stability program.[34]

Apart from the installation of the necessary hook-up gear, the modified YF-84F differed from its fellows only in having a slight negative dihedral (droop) in the swept tail. This was needed to clear the structure of the RB-36D while in a stowed position.[35] And this was the primary reason for a flight test program. Engineers realized in advance that the changed tail structure would alter the low speed flight characteristics of the airplane, giving less elevator effectiveness. The program at Edwards bore out this prediction but also showed that in other respects the airplane conformed to the behavior of its unmodified predecessors. The fixed nose probe (which was to be made retractable on production models) induced a mild buffet

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around the canopy at speeds in excess of 400 knots, but again this was not a serious defect. Flight stability tests were completed in less than a week.[36]

Flights of the complete Ficon system, scheduled to start on 28 April, were delayed by the death of the Wright Field pilot, Major J. M. Davis. However, on 16 May the first attempts to fly the YF-84F into a hitch with the RB-36 were successful.[37] Initial tests demonstrated that the stability of the swept-wing airplane was satisfactory throughout the retrieving process and actually better than that of the straight-wing F-84E in some portions of the operation. Minor latch malfunctions, quickly eliminated, provided the only trouble for the first portion of the program.[38]

One of the minor headaches encountered in the flight test program, affecting both the F-84E and the YF-84F, had been a persistent tail buffet. This condition was eventually eliminated by the installation of faired bomb bay doors on the B-36 which cut off turbulent air flow. The fairings initially tested (on 2 July) were temporary structures of wood, but there was no reason to believe that more permanent fittings could not be constructed.[39]

The first 25-hour phase of tests with the swept-wing YF-84F and the RB-36D ended on 23 July. By that time three Wright Field pilots had checked out in the fighter with no particular difficulty. In view of this success, Wright Field scheduled an expanded test series to permit early evaluation of devices intended for production and to conduct related tests in direct support of the Ficon production program.[40]

After the original series of tests had demonstrated the feasibility of the Ficon technique, Convair began an investigation of the factors involved in operational use of the parasite combination for both reconnaissance and bombing missions. Inasmuch as the F-84F would be utilized in any such operational plan, calculations encompassed the capabilities of that aircraft.[41] Receipt of information that Ficon was quite practical prompted Air Force headquarters to inquire into the production problems involved in adopting the system for operational use. Tentatively, a figure of 150 F-84F's for low level bombing and 50 RF-84F's for reconnaissance was set as the production goal. No mention was made of the carrier portion of the enterprise.[42] Subsequently, however, information arrived that a total force of 60 RB-36's would be involved if the large-scale Ficon program was finally accepted.[43]

Despite the considerable progress in flight tests of the prototype system, project personnel felt that it would take 16 months of additional work to get Ficon to the stage of operational suitability tests. This, of course, envisioned the use of production aircraft instead of the hand-tailored early models. To forestall the possibility of retarding operational availability until 1956 or 1957, the center recommended that production be started immediately and that further tests, including those of operational suitability, be undertaken with

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an early production prototype.[44] This was the most reasonable solution to the problem, so in June the materiel command's Maintenance Division asked that a program of that nature be started, using maintenance funds. The only qualification was that the test articles be built to production standards with production engineering and tooling. Wright Air Development Center thereupon asked Convair and Republic to provide estimates for the manufacture of one airplane and the production engineering for the quantities tentatively established (60 RB-36D's and 200 F-84F's and RF-84F's).[45]

This ambitious program was somewhat reduced at mid-year, when Air Force headquarters authorized the modification of only 10 RB-36 carriers. Convair was to undertake this work in connection with a B-36 modernization program then under way at Fort Worth. Simultaneously, while awaiting approval from Washington, the center began planning ahead for work on 25 RF-84F's, the number which appeared to be currently favored.[46]

Adaptation of a limited number of carriers and parasites to the Ficon configuration did not mean that the affected aircraft would be unable to perform their basic assigned missions when separated. The RB-36D's were so designed that ready conversion to a normal reconnaissance configuration was possible and the RF-84F's were to be capable of normal reconnaissance missions at all times. Individual fighters could also be quickly converted to a fighter-bomber configuration in the field. This fighter-bomber ability could be utilized either conventionally or in conjunction with the Ficon cartage provision.

The only handicaps were increased take-off and landing speeds for the fighter and a slightly reduced range for the loaded carrier. In general, the range of the Ficon system was comparable to the range of the standard RB-36D.[47]

The cost of the entire program was not exorbitant, considering the advantages to be gained. Convair would probably receive about $6,400,000 for modifying 10 RB-36D's, and Republic, about [illegible] for work on 26 RF-84F's.[48]

The Range Extension Program

In view of the fact that cartage in a B-36 converted the short range F-84F into a potentially valuable strategic fighter, there appeared to be considerable profit in seeking other means of achieving the same end. Several methods of substantially extending the basic range of fighter aircraft had been devised in the past, and a number of projects aimed at that target were still more or less current. Coupling fighters to the wing tips of bombers was one means, a supplementary "fuel wing" was another, "floating wing tips" filled with fuel still another. And there were others. Simple inflight refueling was probably the simplest and best proven means of giving standard fighters longer legs, but towing, hitching fighters together, and a number of unique ideas along the same line received consideration from time to time.

The wing tip coupling project, which utilized a B-29 and several F-84's for initial flight tests, abruptly halted on 24 April when one of the fighters stalled out while hitched to the B-29, rotated into

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the bomber's wing, and subsequently crashed, killing the pilot. The B-29 being used in the flight tests lost a wing in the initial impact, and all crew members died in the resulting crash. The accident occurred over Long Island Sound, near the Farmingdale, Long Island, plant of the contractor, Republic Aviation.

There was little doubt that the accident resulted from a coincidence of several unfortunate circumstances. The autopilot equipment which was intended to synchronize the maneuvers of the linked aircraft was highly experimental and unproven in routine flight. There seemed also to have been some laxity on the part of contractors involved in not completely checking out the equipment before trying it in flight.[49]

Since the experimental equipment used in the wing tip coupling project had for the most part been installed in the fighter and bomber that crashed in April, there was a strong possibility that further work would start anew with swept-wing aircraft. Experience with the B-29 and the F-84 had demonstrated the feasibility of the concept, as had earlier tests utilizing a C-47 and a Q-14. Wing tunnel tests of stability and performance aspects had also indicated that the idea was essentially practical. The most critical items, identified both by the crash and by earlier test results, were the coupling device and the automatic flight control system which governed the actions of the three aircraft in linked flight.[50]

Two other experimental developments, which held promise of providing substantially increased fuel capacity for fighters at no increase in aircraft gross weight and no material penalty in drag, were the floating wing tip (floating panel) and the fuel wing proposals. Each overcame the disadvantages of standard external tanks in that aerodynamic support for the added fuel weight was provided in the design of the device.

The floating panel idea involved attaching controllable tanks outboard of the wing tips of a fighter. These tanks were shaped to conform to the wing plan and designed to provide aerodynamic lift. Wind tunnel tests, studies, and experience with small aircraft coupled to larger aircraft had demonstrated the feasibility of the basic design. The most persistent difficulty was the apparent impossibility of designing the floating panels so that the maneuverability of the carrier aircraft would not be detrimentally affected. Studies which Republic had conducted showed that the panels would tend to lag behind the airplane at its maximum rate of roll. However, such studies also showed that the floating panel combination was relatively stable and thoroughly controllable under all level flight conditions. Thus, as in the wing tip coupling project, the most serious difficulty which appeared involved automatic flight control of the mechanisms attached to the wing tips.

Work contemplated for the near future included model test involving an OQ-3 and a C-45G. But because Republic had not performed assigned work in accordance with the terms of the contract, the project people at Wright Field were in mid-1953 seeking a new prime contractor. This meant a further delay in progress.[51]

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Work on the fuel wing, designed especially for F-86 aircraft, was terminated in May. After the project had been originally approved in November 1952, the center attempted to negotiate a contract using fiscal year 1952 funds. Unfortunately the Air Materiel Command failed to complete negotiations in sufficient time, and the purchase request was returned without action. Since authority to obligate the authorized funds had lapsed, the project office recommended suspension of programmed work until wind tunnel tests had further proven the feasibility of the basic idea. Headquarters of the Air Research and Development Command accepted this suggestion and approved the termination action. Fabrication of full-scale flight test articles had never begun, so nothing was actually lost except time. If wind tunnel tests demonstrated that the fuel wing concept satisfied requirements, it was probable that another attempt would be made to flight test a full-size model.[52]

The assembly for which wind tunnel tests were scheduled consisted of an airfoil mounting two tip tanks and supported by two struts. As a unit, it had the appearance of a second or upper wing attached to the basic airplane. Engineers insisted that to be practical it would have to demonstrate satisfactory stability and control, permit jettisoning under normal flight conditions, provide for crew escape with the wing in place, allow normal and unrestricted take-off of the fully loaded airplane, and have no limitations which would preclude all-weather operations.[53]

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Neither of the remaining undertakings in the field of range extension for fighters was an entirely active project in the first months of 1953. Devices to permit wing tip towing, a process involving two fighters, had previously been tested at Wright Air Development Center. At mid-year no contractor had yet been chosen to perfect the design on the basis of experience gained in the preliminary tests. Two somewhat similar designs were scheduled for further study.[54] The pickup and rigid tow process, primarily intended for bombers, was also being held in abeyance. Most of the necessary flight test equipment was on hand, but delay in the assignment of suitable aircraft to the project had forced postponement. Before June 1953 the original electrically powered reels had been replaced by hydraulic power devices, and the latch for the tow bar had been redesigned. Some aerodynamic problems remained for solution, however.[55]

On the whole, apart from in-flight refueling, Ficon remained the only process for substantially enlarging fighter range which had been proven. Most of the other projects were possessed of severe faults that as yet limited their utility or were in such an early stage of development that evaluation of their prospective usefulness was impossible.

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II. [illegible]

The whole of the strategic bomber development program--[illegible] aircraft excepted--was wrapped up in four basic aircraft. One of these, the Convair B-36, was described as "the newest obsolete aircraft,"[1] and although still in production was for practical purposes well past the development stage. The other Convair bomber, the B-58, was at the opposite end of the scale. It had not proceeded much beyond initial design, and many of its features might well be changed long before it ever flew. Boeing, which had the balance of the strategic bomber contracts, was developing the B-47 and B-52. The first of these, although in production, still was the subject of considerable development effort in the first six months of 1953. The B-52 was in the pre-production era of its life, in the midst of an intensive development program.

Another strategic bomber development had been in the overall program when 1953 began, but merely in the form of preliminary design studies. Two contractors, Martin and Douglas, had since May 1952 been working on the design of a low altitude strategic bomber. (The Douglas proposal was assigned the identification code MX-2091; the Martin proposal, MX-2092.) Rapid progress was impeded by the unfulfilled need for electronic devices to make extremely long distance, low level flights practical. Another deterrent was inadequate state-of-the-art work in the low altitude field, particularly in obstacle avoidance.[2] It appeared, however, that intensive effort applied to several phases of the low altitude problem might eliminate these roadblocks in time to permit a normal development schedule.[3] Several advances encouraged this feeling--the delivery of the "Tactual Thumb Guidance System," for example. This device, turned over to the Aero Medical Laboratory for study shortly before mid-year, substituted tactual signals for the visual and aural directions on which pilots usually relied. In theory it would permit the pilot to devote his attention to the immediate problems of terrain clearance without having constantly to refer to instruments.[4] Similar developments in several areas gave promise of eventually alleviating the major problems of low altitude flying.

General Phase I work was completed in May 1953, at which time Wright Air Development Center began its evaluation. Early in June, however, the center received strong hints that all was not well with plans to continue the MX-2091 and MX-2092 development program as scheduled. On 8 June command headquarters asked for a new estimate of the program's funds requirements for fiscal year 1954. Moreover, Baltimore asked that the estimate be based on the assumption that one contractor would be eliminated as soon as possible and a complete detailed Phase I contract issued to the survivor. The Bombardment Aircraft Branch arrived at a figure of $9,000,000 for such a program and immediately transmitted it to Baltimore.[5]

There was but one inference to be drawn from this event. The reduced Air Force budget for the next fiscal year was about to have an effect on development plans for the low altitude strategic bomber. At the weekly staff conference of 17 June this conclusion was verified by the flat announcement that budget cuts had forced the deletion of the entire program.[6] On 1 July, Douglas and Martin received notice that no fiscal year 1954 funds would be available for continuance of their work and that immediate contract termination was necessary. Until 23 July, however, when command headquarters issued a formal directive discontinuing all work on the system, there had appeared to be a slight chance that a minimum program could be carried on with funding support from a "kitty" maintained by the Department of Defense. Conversations with Baltimore on the first of July poured cold water on any remaining hope; the 23 July directive extinguished the last spark.[7]

Although the elimination of the low altitude strategic bomber from immediate plans reduced the size of the total development program, it did not eliminate the need for additional weapon systems in the strategic inventory. A number of seemingly unrelated circumstances practically insured that the strategic bomber program could not long remain static. There was, for example, the matter of thermonuclear weapons and the effect of their adoption on the configurations of existent aircraft. A conference at the Air Force Special Weapons Center, on 8 January, took up the question of possible changes to the B-36, B-47, and B-52 as a result of this development.[8] Somewhat later Baltimore approved a Wright Field plan to begin studies of a system designed specifically for the cartage of the new high yield weapons.[9]

By June Boeing had contracted for a study of a suitable carrier for operation in the period from 1960 to 1965. Rand agreed to aid in the study.[10]

This Boeing project was concerned with discovering the requirements and characteristics ". . . of the optimum means of delivery of, primarily, high yield special weapons on intercontinental strategic targets." The whole effort was predicated on the incontrovertible fact that "these new, heavy weight, special weapons" drastically penalized both currently operational and proposed carrier systems.[11]

Reconnaissance, a vital adjunct to successful strategic bombing, was largely dependent on slightly modified bomber and fighter aircraft which retained most of the characteristics of their munitions-carrying relatives. Although this arrangement appeared to satisfy most requirements, there were some indications that extant and projected reconnaissance vehicles were not all that could be desired. Concern for this matter mounted so much that late in 1952 command headquarters began to organize special guidance teams to aid in the improvement of Air Force reconnaissance methods.[12] In May 1953, at the request of Baltimore officials, Wright Air Development Center started a survey of current and future production aircraft in an attempt to discover which was best suited for the strategic reconnaissance mission. By this time the situation was admittedly critical; one complete wing (45 aircraft) was needed by early 1955.[13]

A slightly modified requirement finally resulted in the issuance of three contracts for studies of a special photographic reconnaissance airplane to be operational by 1956. The final weapon system was to operate subsonically at altitudes above 65,000 feet and have a combat radius of 1,500 nautical miles. On 1 July, Bell and Fairchild began five-month studies of new weapon systems to satisfy these requirements, while Martin devoted attention to the possible modification of the RB-57A for the special high altitude mission.[14]

Another interesting but apparently abortive development in the reconnaissance aircraft field involved the proposed use of a small radioactivity-powered vehicle. Wright Field laboratories, on instructions from command headquarters, began considering such a craft in September 1952.[15] By November these preliminary analyses were virtually complete.[16] The ultimate recommendations, made shortly before the end of the year, contained both favorable and unfavorable elements. One outstanding shortcoming of the proposal was readily apparent in an Atomic Energy Commission estimate that five years and one-half billion dollars would be needed to provide a ten-year fuel supply for the aircraft. This at once brought up the question of whether the project was even remotely practical. The very nature of radiation prompted another question: because of the extreme ranges at which detection by early warning radar would be possible, would not the effectiveness of the overall system be debatable? On the other hand, there appeared to be no insurmountable technical obstacles to the construction of such an aircraft. Nevertheless, when the final report went forward in December it must have been convincing on those two unfavorable aspects, for nothing of moment was thereafter heard about the original proposal.[17]

Project Gopher, the development of a free balloon vehicle for very high altitude reconnaissance, was, after June 1953, no longer a matter of concern to Wright Air Development Center. By that time the entire undertaking--all files, preliminary results, and initial reports--had been transferred to the Air Force Cambridge Research Center. However, because of the chance that further assistance might be required from the Wright Field laboratories before the project ended, Wright Air Development Center was instructed to continue in the role of a "supporting Center."[18]

These were all endeavors involving the development of vehicles accessory to the primary strategic bombing mission. There were also in progress a number of state-of-the-art developments in the area of components not assigned to a specific weapon system. Several of the most important such developments concerned navigation systems, either alone or in conjunction with bombing systems. This was understandable, since accurate guidance was one of the primary essentials of successful strategic bombing.

One of the landmarks of fiscal year 1953, insofar as state-of-the-art work was concerned, involved the successful demonstration of the Spire (Space Inertial Reference Earth) navigation system. Spire, developed by Massachusetts Institute of Technology under contract to Wright Air Development Center, was the first completely inertial system, requiring no radar input for operation, to reach the flight test stage. On 8 February the device was tested in a B-29 aircraft on a flight from Bedford, Massachusetts, to Los Angeles, California. Bad weather at the outset led to the introduction of inadequate data into the system (placing the bomber about 20 miles off its charted great circle course when Spire assumed control), and the flight was troubled by severe turbulence, as well as a 130-knot wind reversal. When the flight ended, however, the B-29 was but nine miles from its objective. Considering the fact that the journey covered 2,800 nautical miles, this was a remarkable accomplishment. Moreover, engineers estimated that, had the flight been extended, much of this error would have disappeared. Although Spire was not currently scheduled for installation in a specific weapon system, the Armament Laboratory subsequently characterized this first flight using purely inertial techniques as "the beginning of a new era in the field of bombing-navigation guidance for future weapons systems."[19]

Along similar lines, North American Aviation was working on a "star supervised" inertial navigation system. The North American device was based on essentially the same principles as Spire (stabilized gyros), but course errors were to be corrected by a stellar navigation device intended ultimately to be capable of tracking stars in full daylight. The development effort had begun early in 1950, and since

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that time had progressed through four experimental models, each more elaborate and precise than its predecessor. Flight tests of the model X-2 autonavigator had produced errors as slight as 6,000 to 9,000 feet after three hours of cruising. The model X-4 system, still being ground tested in the early months of 1953, showed promise of being even less prone to error in its position determination. Perfection of the autonavigator would not only aid in conventional bombing-navigation flights but would probably result in a considerable increase in the accuracy of missiles.[20] Principal difficulties encountered in the early months of 1953 involved the gyro-stabilized "intertial portion" of the autonavigator. By April, however, North American's engineers had concluded that the inertial system, in its existent form, was sufficiently accurate to permit operation in conjunction with stellar reference devices.[21]

The almost unbelievable complexity of such navigation systems was in stark contrast to one other development of early 1953. Bomber defense against night fighters over Korea had proved particularly troublesome. Heavy bombing was more or less confined to such semi-obsolete aircraft as B-29's because of the danger in using more modern bombers containing advanced equipment. Security was thus maintained, and for a time the B-29's proved quite adequate. The introduction of MIG-15 jet fighters made the daylight use of B-29's virtually impossible; therefore, night bombing became the accepted mode of operations. Eventually even this method became uncertain because of increasingly active enemy night fighters. But a device dubbed Glow Worm promised to ease the primary task of bomber defense.

Glow Worm consisted of an experimental 500,000,000-candlepower light complete with reflector which was coupled to tail turret fire controls and flashed at enemy fighters with the objective of temporarily blinding their pilots. Experiments conducted by the Strategic Air Command showed that exposure to the intense light for only a minute fraction of a second could destroy a fighter pilot's night vision ability at ranges up to 2,000 yards, thus aborting any attempted visual pass at a bomber after nightfall.[22]

Existing Air Force equipment, including ranging and tracking radar (AN/APG-30), was to be linked to the Glow Worm light and installed in a B-29 for tests in Korea. The radar would track an enemy fighter until it was within critical range, then cause the light to be flashed in the pilot's eyes. There was a good chance that he might crash before he could reorient himself, since the temporary blindness lasted from five to six seconds. At any rate he would be unable to complete his pass.[23] Operational tests of the device, to precede the Korean trials, were not scheduled to start until late July.[24] Plans to test the device in combat necessarily were shelved after the cease-fire agreement of 27 July.

These were but a very few of the literally dozens of important component developments, generally unrelated to specific weapon systems, which were being carried on constantly. Radar warning devices, television reconnaissance systems, new cameras, oxygen system components, canopies, and a vast array of other equipments were under study, in development, or being tested.[25] Many would later make unheralded appearances as proven elements of very advanced bombers, bearing no signs of the huge bulk of early work that had gone into their fabrication. The immense complexity of the average strategic bomber was in itself a hindrance to anything resembling complete coverage of the story of the development of its components.*

The B-47

With careful attention to the facts of the case, it could truthfully be said that by mid-1953 the B-47 had passed from the twilight of an engineer's limbo toward the full light of day. All was not right with the airplane, serious defects and deficiencies still remained, but the B-47 could be used in combat operations if the need arose. That alone was an accomplishment worth emblazoning over the gateway to Wright Air Development Center.

Such progress very largely resulted from the intensive efforts of Wright Field engineers working in conjunction with their Boeing-employed opposites and in cooperation with fliers, maintenance experts,

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*Space and time limitations, as well as the inherent impracticality of attempting to record advances in such a multitude of development areas, prevent the inclusion in this volume of more than the bare essentials of some of the most striking evidences of progress. Nevertheless, the fact that a very large portion of the center's work was concentrated about such component development, unremarked and overlooked as it often was, must not be forgotten.

and executives of the Strategic Air Command. But, at the same time, the contributions of the Air Materiel Command, the Air Training Command, a large number of Boeing subcontractors, and a variety of other sources could not be overlooked. Indeed, it was wholly true that the progress of the B-47 toward true operational readiness was the product of the whole working strength of the Air Force.

The first production B-47 to meet the Strategic Air Command's so-called "target combat configuration" would probably be the 731st article. However, great numbers of earlier airplanes would incorporate post-production modifications making them in all major respects identical to the 731st and later aircraft.[26] This "recycling program" which gulped down each production airplane shortly after it rolled off the line was for practical purposes in effect by early 1953. At the end of June, Boeing had produced a total of 521 Stratojets, was turning out another 25 each month, and was climbing toward an end-of-the-year rate of more than an airplane a day.[27] The "recycling program," involving retrofit action to change early B-47's to the "target combat configuration," was scheduled to reach back to the 235th airplane. Shunting these early production aircraft through modification centers would produce combat ready vehicles containing ejection seats, the A-5 fire control system, the 33-bottle rocket assist take-off accessory, a modified K-4A bombing and navigation system, and structural provisions for maximum internal and external fuel stowage. Aircraft which conformed to this pattern were to be designated B-47E. Others of the early production lots were TB-47B's (the first 87 B-47B aircraft, definitely not combat qualified), YRB-47B's (standard aircraft equipped with photographic pods), and B-47B's, which were combat disqualified because of equipment shortcomings.[28]

In the early months of 1953 the Strategic Air Command took an increasingly aggressive interest in the nature and number of the engineering changes scheduled for the B-47.[29] Colonel C. F. Walter, chief of the B-47 Branch, reported that strategic command representatives often "took a strong stand against any engineering changes being made to the B-47 without SAC examination and approval." The Strategic Air Command also established an internal board to review proposed changes to the bomber and wanted authority to make the "final binding decision" in each case. Colonel Walter noted that the bomber command, which had no authority for such action, had asked Air Force headquarters for the necessary power. The B-47 project officer commented that no thought had apparently been given to unsatisfactory reports handling, contract problems, and similar factors.[30]

Another demonstration of this dissent from previous practices appeared in April, when Boeing informed Wright Field that the Strategic Air Command had obtained detailed cost and engineering information on the installation of fire extinguishers on B-47's. No one at Wright Air Development Center or the Air Materiel Command had ever heard of such a project. General Boyd called the affair to General Partridge's attention; after that it was a matter for higher authority to handle.[31]

The major duty of the B-47 was to deliver a bomb load to a particular location somewhere on the earth's surface. While from an abstract viewpoint almost every essential of the airplane's performance entered into this function, the bombing system itself was the major element involved. The K-4A bombing and navigation equipment had for some time been of major interest to development agencies. One new complication to this effort arose on 21 April. In the course of a conversation with General Boyd, General Putt inquired whether or not it was true that the Armament Laboratory was dealing with the K-4A system on a components basis "and refused to vest systems responsibility in a suitable contractor."[32]

General Boyd, after investigating, passed along to the research command vice chief more detailed and precise information. Actually, when development of the original K-system had begun in 1944, there was no systems engineering concept. Therefore responsibility was divided among various laboratories at Wright Field. The result was development of the K-systems in three separate packages controlled by three different contractors, with overall responsibility assigned to none. By the time the fallacy of this situation had become apparent, Sperry, the logical systems contractor, was unwilling to accept total responsibility. In the meantime, for production reasons, the Air Force had brought other manufacturers into the picture. By 1953 seven firms were engaged in K-series work. Although the Armament Laboratory had advocated the assignment of systems responsibility for a number of years, it was not until April 1953 that an agreement of sorts was possible. At that time Sperry indicated willingness to extend its current responsibility for all computer units to include overall systems monitoring. The other contractors agreed to work with the firm on that basis.[33]

But even at this late date there was no complacency with respect to the K-series bombing and navigation system. Although it was in large part satisfactory, that circumstance did not preclude consideration of discarding it in favor of another method. The Atran system, scheduled for Matador usage, was a promising candidate. The idea of using Atran originated in a discussion between the B-47 office and the Atran project officer, Mr. Dewey Bassett, on 12 January. Subsequently Strategic Air Command and Air Force headquarters became interested, and Goodyear started construction of a prototype bomb-aiming attachment for use in tests with the basic Atran device. If the equipment worked as satisfactorily as prevailing theory and experience indicated, automatic bomb releases would produce considerably better accuracy than would "a good radar observer and the best radar set." Radar-directed bomb scoring runs using Atran equipment assembled from existent parts were scheduled to be followed by live bomb drops. The Strategic Air Command indicated that if the demonstrations produced satisfactory results it would probably file a formal requirement for automatic bomb aiming from the B-47 aircraft.[34]

In view of the marginal reliability of the K-4A system, as demonstrated in repeated tests, this Atran introduction promised to become one of the most important single developments of the six months. Completion of Project Skytry, the Strategic Air Command attempt to operate a B-47 squadron under pseudo-combat conditions over a 30-day period, produced evidence that the bombing system was the primary obstacle to complete operational suitability. A total of 150 sorties were run; all aircraft reached the target area but only 87 percent were effective as bombers at that point.[35] Almost every abortive mission could be traced to bombing system malfunctions. The bulk of the difficulty appeared to be centered about the K-4A's electrical system, with the inverters the major offenders.[36] Ground maintenance errors and component failures were secondary contributors. Finally, the near impossibility of performing in-flight maintenance on the K-4A was the subject of several unflattering comments.[37]

On the whole, of course, the Skytry record was rather impressive. But there were several factors that weighed against any uniformly favorable conclusions. In the first place, even though the K-4A systems did not perform with anything approaching complete accuracy, they had been modified in advance to improve their operating characteristics. This alteration produced so substantial an improvement that the Strategic Air Command asked for modification of an entire wing of aircraft to permit further evaluation.[38] Secondly, from a purely objective viewpoint it was obvious that the Skytry results could not be described as typical of what might be anticipated in actual combat operations. The tests were run with "rather experienced crews," as Colonel Haugen mildly described the situation. Such crews would certainly not be characteristic of wartime bomber outfits.[39] Finally, a special set of conditions, unlikely to be duplicated even in the most leisurely combat operation, surrounded Skytry. A special airlift plus an exceptional Air Force priority insured superlative logistic support. The tests were supported by the maintenance facilities of the entire base "plus maintenance crews heavily larded with Boeing, G. E., Sperry, Western Electric, and other technical representatives." Moreover, Wright Field had a full-time project officer and a K-system specialist at MacDill Field throughout the experiments, as well as "a constant stream of laboratory specialists who go down on call as specific troubles arise."[40] Apart from the rigorous flight schedule, therefore, Skytry bore little actual resemblance to any foreseeable combat operation.

However, Skytry definitely pointed up the remaining shortcomings of the B-47. Any component or subsystem which malfunctioned in spite of the devotion accorded it by the vast array of specialists at MacDill was certain to give trouble when there was no _cordon sanitaire_. Thus it was with the fire control system. Those B-47's which participated in Skytry were outfitted with the admittedly inadequate B-4 equipment, an interim optical-sighting system adopted when the more advanced A-2 failed to materialize on schedule.* Skytry proved the B-4 to be mechanically defective in a great many respects--all of these in addition to its inherent ineffectiveness as a defensive device.[41] Moreover, in February, Wright Air Development Center was forced to the extremity of requesting that an "immediate attention" technical order be issued restricting the airspeed of B-47's incorporating the B-4 fire control system. Boeing Airplane Company and the Aircraft Laboratory found evidence that operating the turret--turning it into the air stream--produced yaw angles sufficiently great to endanger the vertical fin. At indicated air speeds above 310 knots the turret alone was capable of producing a yaw angle greater than the fin had been designed to withstand. Below 310 knots, a combination of turret rotation and rudder action intended to correct yaw could induce excessive stresses on the fin. Engineers therefore recommended the prohibition of corrective rudder movement while the turret was in motion. The center was likewise firm in its opposition to operation of the turret whenever the aircraft was cruising at more than 310 knots unless the autopilot was engaged and functioning properly. Even with that safeguard, pilots were advised to pay strict attention to flight reactions during turret operations, regardless of the airspeed.[42]

When the technical order finally saw the light of day in March,

*See "History of Wright Air Development Center, July-December 1952," pp. 319-320.

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it contained limitations still more rigorous than those initially proposed. The pilot was directed to maintain directional control by use of the ailerons alone when the B-4 tail turret was operating. Rudder movement was forbidden in those circumstances. Further, the autopilot was not to be used in conjunction with the tail turret at indicated speeds in excess of 330 knots.[43] Thus engineers hoped to keep the B-47's defensive armament from parting company with the body of the airplane in mid-flight. This particular fault would disappear when the A-5 fire control system became standard on all operational B-47's, as was planned for the future. Moreover, the bomber would be considerably better qualified to give a good account of itself defensively when so equipped.

The A-5 system contained 20-millimeter guns, in themselves significant improvements over the .50-caliber weapons coupled to the B-4 sighting system. But probably of greater importance was the modification of the A-5 system to accommodate 30-millimeter guns (a T-168 or T-182 gun was to be the ultimate installation). In March, Air Force headquarters established a firm requirement for retrofit of B-47's with the 30-millimeter A-5's.[44] At about the same time the first prototype installation was completed by General Electric. The Aircraft Laboratory, Armament Laboratory, and flight test directorate subsequently approved the equipment for flight test.[45] Operational suitability tests at Eglin Air Force Base were scheduled to precede any full-scale adoption of the device.[46] Deliveries of the basic A-5 fire control system were well ahead of schedule by February, so little delay was anticipated in the programmed utilization of the equipment in B-47E aircraft.[47]

Buffeting, which limited the speed and altitude of the aircraft much as did the B-4 turret, was present when bomb bay doors were open. It continued to be troublesome even after the installation of bomb bay deflector-diffusers provided by Boeing. In a separate attack on this problem, the Aircraft Laboratory designed a new air shield which promised to eliminate most turbulence.[48] On 9 January two special stores were dropped without incident from a B-47 operating out of the Air Force Special Weapons Center. At the time of drop the bomber was flying at maximum allowable air speed for its altitude, a condition which had previously fomented extreme bomb pitching and a significant degree of bomb bay buffeting. The Aircraft Laboratory-designed deflector for practical purpose eliminated these faults.[49] Receipt of the news at the center led General Boyd to recommend official commendation for the originators of the device.[50]

Nevertheless, there still remained a major problem. While installation of the deflector would permit full exploitation of the B-47's bomb delivery potential, particularly with respect to special weapons, it would not be available in quantity until approximately 1,000 B-47's were off the production line. Retrofit would be an extremely expensive and time consuming process. Therefore the center foresaw two alternative courses. Either the Aircraft Laboratory design and the accompanying retrofit program could be accepted or the Boeing design could be continued with the understanding that in the case of at least one important special weapon the B-47 would have to operate under a minimum altitude limitation.[51] The whole matter of high speed bomb release was still being investigated when mid-year arrived.[52]

Another matter which received detailed attention throughout the first six months of 1953 was countermeasures. Actually, two basic and readily distinguishable methods were involved: electronic countermeasures and chaff. In both, a great deal of progress was recorded; in both, much remained to be done.

The background history of electronic countermeasures for the B-47 was characterized by a remarkable degree of confusion, contradiction, and disagreement among the several commands concerned, between the field commands and Air Force headquarters, and between the several commands and the contractor. The whole affair evolved from the initial decision to accept **preset** jamming equipment for the B-47 because of space considerations. The **preset** jammers were admittedly inadequate, so in February 1951 Boeing proposed the construction of an inhabited bomb bay pod containing all the necessary electronic countermeasures devices. The Strategic Air Command, attracted by what appeared to be a quick and easy solution to the space problem, immediately contacted Air Force headquarters with the information. It was June, however, before any positive action resulted, and even then moves toward the design and fabrication of the pod were largely preliminary in nature.[53]

Between June 1951 and April 1952 a great deal of effort was expended in an attempt to get a firm proposal from Boeing. Late in April the contractor presented a development proposal for a four-man inhabited pod, which a conference of personnel from interested commands immediately rejected. Boeing was asked to start again, using a two-man pod as a design objective.[54]

By June 1952 the original Boeing proposal had been modified to conform to Air Force desires (as stated in April) but was again rejected because it did not satisfy the formal requirements of the using command. The design features discussed in that June meeting proved to be generally satisfactory, however, and were the basis of further discussions involving Boeing, the Strategic Air Command, the Air Research and Development Command, the Air Materiel Command, and Air Force headquarters. There was some confusion in the issuance of authorization orders, but by December 1952 the B-47 contractor was ready with a "very preliminary cost proposal which indicated that two (2) years would be required for the first prototype of the B-47 with improved ECM capabilities and two (2) years to 30 months . . . [for] a prototype of the inhabited bomb bay pod." Furthermore, Boeing estimated that it would take at least an additional year to phase such equipment into the B-47 production line.[55]

The fact that nearly two years had elapsed from the time of the Strategic Air Command's original proposal for an inhabited bomb bay pod to the moment when Boeing filed a "very preliminary cost proposal" was indication enough that the B-47 countermeasures program was in trouble. At the start of 1953 there appeared to be but one possible course for events to follow. Existent installations would continue to bear the main weight of countermeasures responsibility for at least a year. New tail warning radar and a chaff distributing unit then undergoing development would thereafter provide some additional protection, though limited in coverage. Replacement with more modern devices would ultimately be possible, although not until 12 months after the Air Force had approved prototype equipment that was not scheduled to be available for evaluation before June 1953. Further improvements and the basic necessities for hooking an inhabited pod to the standard B-47 could not possibly reach a prototype stage before July 1954, while the first experimental pod would in all probability not be ready for tests before December 1954. Moreover, Boeing estimated that it would require 12 to 18 months to get the pod into production once the prototype was approved. These long development periods were necessitated by two major factors: the extremely complex nature of the required equipment and the need for redesigning virtually the entire B-47 electrical system. Airframe changes would be tedious and unwelcome, a product of "the natural reluctance of AMC and the contractor to push ECM incorporation in [the] face ~~of~~ the overburdening responsibility of getting large quantities of the B-47B operational."[56]

Such considerations notwithstanding, the overwhelming importance of electronic countermeasures to the combat success of the B-47 could not be overlooked. Nor were they. A conference with Boeing on 12 January solidified the issues and gave coherence to future plans. General Boyd subsequently directed an "all-out effort" on the electronic development aspects.[57] On 15 January the center received from Boeing concrete proposals for the basic bomber installations and the inhabited bomb bay pod. Negotiations for the development of jammers and an improved tail warning radar device began. The first model of an interim tail warning device arrived at Wright Field, via special messenger, on 14 January. Tests begun the day of its arrival indicated that it would be quite satisfactory. Earlier delays were written off the books. General Boyd wrote General Partridge, "I intend to personally follow this program in order to insure adequate complete action."[58]

In some quarters the slow progress in electronic countermeasures was laid to a failure at Wright Field. In February General Boyd pointed out to command headquarters that such criticism was not fully justified. He wrote General Partridge that ". . . the Center operated without a firm requirement or directive over a period of time and further, that ECM was not supported financially during the period of 1945-1950." Sudden awakening to the tremendous importance of this means of defense resulted in "pressure beyond reason" directed at Wright Air Development Center. In the main there was nothing improper about this. But, the center commander emphasized, "Time must be allowed for the orderly development of this type of equipment."[59]

General Partridge conceded the worth of this viewpoint. "Just because we have finally recognized the importance of this field of endeavor," he wrote, "and have increased the money and personnel emphasis many fold, is no assurance that all the accumulated deficiencies will be solved immediately." At the same time, he continued, it was vital that every possible effort be made to insure progress toward effective electronic countermeasures at the earliest possible moment.[60]

Early in February the Boeing proposals covering development of an advanced electronic B-47 and an inhabited pod were approved and the necessary contractual coverage extended. At the same time the physical task of modifying a B-47 to the prototype "interim preset" electronic countermeasures configuration was assigned to the Mobile Air Materiel Area.[61] Colonel Demler aptly deecribed the situation of the moment: ". . . the current four-alarm fire on B-47 electronic countermeasures."[62] General Boyd personally directed that every organization in the center give the program its concentrated attention. "You each have a responsibility," he pointed out, "and that responsibility must be expeditiously and completely fulfilled in order to get on with this program."[63]

The fact that almost every laboratory had a part in the countermeasures program was vividly illustrated almost immediately. From a technical standpoint the problem of containing two operators and a mass of equipment in a special bomb bay pod presented no insurmountable obstacles. But there was also the human element to consider. How would individual men react to being confined in a sealed and isolated compartment for the entire course of a combat mission? In the midst of enemy action they would be harnessed to their equipment, denied even that glimpse of events available to the rest of the crew. The Aero Medical Laboratory, at the request of the B-47 project office, undertook a study of this factor. Early in March the laboratory reported that the pod concept was feasible but at the same time indicated that prospective operators had evidenced a thoroughly mixed opinion on the proposition. Equipment operators who were also pilots would be more susceptible to the pressure of the pod environment than would other flying personnel; however, windows would significantly alleviate the claustrophobia. Laboratory personnel planned to continue the investigation, eventually extending it to include interviews with Navy submariners.[64]

Work on the "interim preset" configuration B-47 was slow in getting under way. Delay in the assignment of a suitable airplane was the principal reason.[65] However the mock-up installation of improved countermeasures equipment was ready for inspection at mid-year, receiving the approbation of the Aircraft Radiation Laboratory at that time. The Hayes Aircraft Corporation, contractor for the installation, estimated that a prototype would be ready some time in August.[66]

Additional delay and confusion was introduced into the "ultimate preset" program by a requirements change first revealed to Wright Field in May. By intensifying pressure on Boeing, the center had succeeded in having the date for the development engineering inspection moved forward from 1 June to 5 May. All this was done on the assumption that the configuration had been agreed upon by all concerned. But notification of the inspection brought from Air Force headquarters the information that "the B-47 ECM configuration is neither approved nor firm" and that there were tentative plans for establishing a new configuration in the course of the development engineering inspection. General Boyd immediately protested to command headquarters that ". . . a development engineering inspection is neither the time nor place for a review of requirements. Knowledge by Boeing of such Air Force indecision cannot but undermine the pressure we have built on them regarding ECM."[67]

These drawbacks notwithstanding, progress in the countermeasures program was apparent. The chaff portion was especially promising. Installation of a chaff dispenser (AN/APS-54) in place of the assist take-off rockets amidships was completed early in the year, and by February the equipment had been operated satisfactorily at speeds up to 420 knots and altitudes below 20,000 feet.[68] Further tests were scheduled for March, in Texas. The delay was unwelcome, but as the center's commander said philosophically, "We're in trouble, so we might as well take time to get out of trouble intelligently."[69]

Wright Air Development Center had previously run functional flight tests of the "ATO compartment" chaff installation as well as flight tests of similar dispensers mounted in wing pods. The chief of the

Aircraft Radiation Laboratory, Colonel Lewis, reported early in March that mechanical dispersion from these devices ". . . is superior to dispersion from any of the standard systems now used in other types of aircraft."[70]

The dispenser-equipped B-47 used in these tests left Wright Field for Austin, Texas, on 27 February. Engineers planned to use facilities of the Air Proving Ground Command for further experiments. Some indication of the urgency of the program could be gained from the fact that by 3 March two familiarization flights had been made to indoctrinate air and ground radar crews.[71] One month later the tests had convinced project personnel that "the chaff installation in the ATO compartment of B-47 No. 2300 is considered highly satisfactory."[72]

The development of a successful chaff installation for the B-47 did not mean, however, that the countermeasures problem was near solution. In June the Aircraft Radiation Laboratory completed experiments using a moving target indicator type radar (airborne) against chaff dispersing bombers. Laboratory personnel discovered that the moving target indicator gave considerably better results than conventional equipment. Additional tests were scheduled to permit observation of ground-based equipment operating under the same circumstances.[73] If nothing else resulted from such tests, there were already strong indications of the fallability of chaff in the presence of refined radar equipment.

In connection with the defensive equipment development program, B-47 project engineers were anxious to discover the vulnerability of the aircraft when exposed to enemy fire. A number of agencies were engaged in a variety of tests intended to determine vulnerability. The Ballistics Research Laboratory at Aberdeen, Maryland, the Air Force Armament Center, and the Power Plant Laboratory were especially concerned with discovering fuel tank and engine susceptibility to enemy fire. No final results would be available for some months, but in June it appeared that self-sealing tanks were not sufficiently effective. On the other hand there were indications that disabling one engine in the two-engine pod of a B-47 would not force a shut-down of the other engine. It was still too early to reach any conclusion regarding the overall vulnerability of the Boeing bomber, however.[74]

A means of escape with some degree of safety was essential to B-47 operations; yet only the 400th and subsequent aircraft had provisions for crew ejection. A retrofit program applicable to earlier aircraft was probable, but it would be both expensive and time consuming.[75] In the meantime, 400 B-47's (mostly B-47B's) were being flown about the country without ejection seats. And past experience with the aircraft had shown that in every case in which canopies, hatches, wheel well doors, or similar parts had been torn from the aircraft in flight, they had struck some portion of the aircraft. From this, the center concluded, quite logically, that a crew member making a non-assisted bailout would have no better chance. Survival probability was virtually nonexistent.[76]

In September 1952 command headquarters forwarded to Wright Air Development Center a directive for tests of crew escape from B-47B aircraft.[77] The center reacted by asking cancellation of the directive, taking the stand that wind tunnel tests were quite impractical and full scale tests with live subjects highly dangerous. With respect to the overall escape problem, General Blake had this to say:[78]

> Tests conducted to date indicate that crew escape would, in all probability, be successful if the ventral hatch were used under 300 knots and bailout procedures followed as outlined in the T.O. This avenue to escape is certainly not the best available for all conditions; it only covers the egress where the aircraft is under control. The best and only known way at present for crew escape from high speed or uncontrolled aircraft is the use of ejection seats. This has been proven both in this country and in England many times in the past. It is recommended by this Center that immediate retrofit of jettisonable canopy and ejection seats be incorporated into the B-47 program. The conduct of the tests required by the Test Directive involves considerable risk to the crew and the aircraft for dubious reasons.

General Putt, who answered General Blake, did not fully accept this viewpoint. He was in accord with the general view that ". . . the likelihood of successful escape from the B-47 may not be increased by employment of other possible exits." His next statement, however, made a point of difference: "This . . . represents conjecture rather than established fact." The Air Research and Development Command felt the need for some firm exploratory data "in view of the seriousness of such a decision to the operational readiness of the Strategic Air Command, and the financial penalties involved in taking such a position. . . ." The directive was not rescinded. Instead, Wright Air

Development Center was relieved of responsibility for its performance and the test assignment given to the Air Force Flight Test Center.[79]

As it later developed, the center's position had been misinterpreted in Baltimore. There had been no intention of questioning the wisdom of the directive. Rather, the center had intended merely to point out the probable outcome of the tests as indicated by past experience. In effect the whole matter became academic in February when the center was directed to support the test program at Edwards. General Boyd assured headquarters at that time that his organization would give all possible assistance and immediately ordered contact with the Edwards liaison officer to see in what respects Wright Field could aid in the program.[80]

By July the tests had proceeded to the point at which some interim conclusions were possible. Escape from the various exit hatches of a B-47 had been investigated in ground tests, the ventral hatch receiving the most attention. Time studies indicated that crew evacuation required from 25 to 45 seconds, depending on the bulk and type of equipment worn. The survival kit, which limited body positions for bailout, proved to be the single most restrictive item. To date, however, the tests had failed to answer the question of whether a B-47 in trouble could remain in the air as long as the 25-second minimum required, nor had there been any answer to the vital question of whether a crewman could survive entry into the slipstream after he managed to squeeze through the hatch. Tests on this aspect of the problem were planned for the first months of fiscal year 1954--with dummies![81]

A variety of other circumstances related to human factors in the use of the B-47 were under study at the center in the first six months of 1953. Ejection seat improvement was a major objective. (The center also participated, as a consultant, in the ejection seat retrofit program under way at the Douglas plant in Tulsa, Oklahoma.) Workspace, illumination, feeding, pressurization, air conditioning, humidity control, crew composition, workload distribution, and crew arrangement were among the many items receiving concentrated attention. The objective of all this work was to improve the flight conditions in the aircraft, thus promoting more efficient utilization of its potential.[82]

Apart from its bombing mission, the B-47 would serve the Air Force in a reconnaissance version, the RB-47. Successful development of a fully operational reconnaissance aircraft with all essential photographic equipment was in one sense equally as important as work on the munitions carrying type. Yet early in 1953 it became apparent that, unless some drastic measures were enforced, the RB-47 would become available stripped of minimum necessities in the way of cameras and accessories. Actually this proved to be more a procurement oversight than a development deficiency, since the basic cameras were available in approved and tested form for other reconnaissance aircraft. Nevertheless, an undeniable camera shortage gave pertinence to the question of whether the RB-47 could be suitably equipped. General Boyd stated flatly that the camera installation problem was potentially as serious as the electronic countermeasures program. In this instance it might be "years" before the early RB-47's could be outfitted with the proper equipment.[83]

The overwhelming danger that the B-47 might be completely incapable of performing its photographic mission disappeared in the early months of 1953 as a result of intensive effort on the part of the Photographic Reconnaissance Laboratory and Air Materiel Command procurement expediters. Initial attention was devoted to the "pod airplane," intended to provide an interim capability for high altitude day photography before the RB-47E production program got under way. Although equipment initially programmed for the pod installation was not available in sufficient quantity to satisfy requirements, substitute items were selected from service stocks. Photographic laboratory engineers devised acceptable alternate installations in instances where shortages were particularly acute.

The RB-47E, intended to provide a much wider scope of operations, was in considerably more difficulty. Laboratory experts estimated that it would emerge with a good capability in high altitude day photography, a poor high altitude night photographic ability, and absolutely no capability for low altitude photography, either by day or night. This condition was certain to persist for at least one year after initial production began. Here again equipment shortages provided the major obstacle, and in this instance to make substitutions was in large part either extremely difficult or entirely impossible. Provision of a limited high altitude capability was the best that could be anticipated. As Colonel D. B. Avery, Photographic laboratory chief, and Colonel White, director of laboratories, were quick to point out, although substitute equipment filled the most gaping holes, it fell far short of satisfying minimum mission requirements. The forecast that by June 1954 there would exist a satisfactory RB-47E equipped with the universal camera control system was the most optimistic prediction heard anywhere.[84]

The universal camera control system was an electronic control device built from specifications originated by Wright Air Development Center. While providing for simultaneous automatic operation of as many as 12 aerial cameras, the system controlled shutter speeds, aperture setting, and image motion compensation on the basis of manually preset data on ground speed, light conditions, and altitude. Earlier aerial photographic procedures required individual manual control of each camera. Laboratory acceptance tests of the first production model began in February 1953.[85]

Flight tests proved that the early production system was, on the whole, quite satisfactory. Late in February, in demonstration flights at altitudes between 20,000 and 40,000 feet and airspeeds below 615 knots, the universal camera control system adequately governed the simultaneous operations of six aerial cameras. A night mission, utilizing only one camera, indicated that the system would be satisfactory in this assignment as well.[86] Subsequent high altitude tests at Edwards Air Force Base further proved the system fully capable of night photography and also helped to eliminate a power supply failure which had troubled earlier ground experiments. Finally, on the B-47's return flight from Edwards to Wright Field, the system automatically and successfully operated three cameras through varying light conditions and over constantly changing terrain. Nearly 500 satisfactory exposures were obtained at altitudes above 35,000 feet.[87]

Additional flight tests carried out near Wright Field and at Eglin Air Force Base in the succeeding months proved that the universal camera control system would satisfactorily operate six cameras (the K-17, K-22, K-38 and T-11 standard cameras and the S-8 and S-12 strip cameras). Additional tests using K-36, K-43, and K-46 cameras were expected to produce similar results. Final proof of the system's efficiency would probably be available shortly after September 1953, when it was to be installed in an early production version of the RB-47E.[88]

Improvements to the system and a substantial reduction in its overall cost were also realized in the early months of 1953. By April the center, acting in coordination with the Air Materiel Command, had succeeded in eliminating 190 of the equipment's original 566 pounds and in chopping its cost from $209,000 to $75,000. The center hoped that the materiel command might be able to negotiate an even lower price for large scale production items, but no further reduction of weight or complexity could be anticipated until the basic system was completely re-engineered.[89]

Such a move was not so far-fetched as it sounded. Although the original camera control system would not be installed in operational aircraft for some time to come, a miniaturization program was well under way by January 1953. The system contractor and the photographic laboratory were conducting investigations along similar lines. There were indications that elimination of components required only for special missions and the restriction of the equipment's operating ranges permitted considerable reduction in size, weight, power requirements, complexity, and cost. Less demanding performance requirements would allow the use of small, inexpensive power supplies in lieu of larger and unnecessarily precise components. Technical compromises of this nature would not detract from the overall accuracy of the device, but simplify if considerably. Minor changes would reduce the number of electronic tubes by 80 percent, eliminate about 50 percent of the weight, and result in a far less complex system. Not only would the modifications benefit the B-47 and other reconnaissance aircraft in the bomber class, but they would allow installation of the universal camera control system in such fighter-type aircraft as the RF-101 and the RF-105.[90]

In addition to the countermeasures pod and the photographic pod, one other "quick-change" modification was scheduled for B-47 aircraft.

This was the bomber tanker conversion. Although Air Force headquarters was still "studying possibilities of using B-47's in a dual interchangeable bomber-tanker capacity" when July began, [91] the idea had reached the flight test stage several months earlier. In March, after a prototype B-47 had been modified by the installation of equipment to allow quick conversion to tanker configuration, ground tests utilizing a pair of the strategic bombers were begun at the Boeing plant in Seattle. Flight tests started in April and, after two consecutive mechanical failures, culminated in triumph. Probe and drogue contacts at altitudes between 10,000 and 35,000 feet were repeatedly satisfactory. Similar success marked the first attempt to make a fuel transfer at night. In this instance two pilots from the Strategic Air Command participated in the exercise, the last of a factory-conducted series. After personally making a total of 28 contacts, their comments were "highly favorable." [92]

Although a great many minor deficiencies of one sort or another undoubtedly troubled the B-47, only a few outstanding issues disturbed the basic development program. However, a number of items, such as assignment of engine test aircraft, revision of the rocket assist take-off program, and radio noise suppression, provided bumps along the road of smooth progress.

In late 1952 the General Electric Company, whether by design or by chance, succeeded in giving further impetus to the already rapid-paced engine development program. The acceleration had its origin in a request from the contractor for the assignment of an additional B-47 for engine tests. General Electric contended that the bomber was needed to prove out continuing improvements in the engine and engine control system.[93] The Power Plant Laboratory opposed such an arrangement as unnecessary on the grounds that suitable aircraft were available at Wright Field.[94]

In commending this stand to General Irvine, Colonel Demler added the further note that the idea of assigning another test B-47 to General Electric, "presumably at their base in Schenectady with its short runways and bum winter weather," was not sound because better facilities and trained personnel were available within an hour's drive from the engine manufacturing center at Lockland, Ohio. Close coordination with General Electric's engineers was, therefore, a relatively simple process. He commented, however, "If General Electric's purpose in the letter was to 'expedite' our joint power plant test program, they have been successful." He promised that the Power Plant Laboratory would ". . . go all out to provide General Electric the best flight test service they ever had on engine development testing and at the same time we will evaluate their 'fixes' for production release by the Air Force."[95]

By mid-1953 most development work involving the J47-GE-25 engine installed in B-47B and B-47E aircraft was complete. Test and engineering efforts were concentrated primarily on product improvement and increased life. (The same situation existed with respect to the -27 engine, proposed for B-47 installation at a later date.) Major changes in the first six months of the year were few. Cambered compressor rotor blades were discarded as a "fix" for compressor stalls when their use provided but a small improvement. Water injection rates for service use were increased by slightly more than 40 percent in an effort to improve the thrust output, while additional effort was directed at improving the entire water injection system. Undesirable engine pulsation was largely eliminated by the incorporation of a new accumulator in the fuel control system. A persistent droop in revolutions-per-minute at high altitudes was being thoroughly investigated, though results still were not fruitful. On the whole engine development appeared to be progressing quite well.[96]

The success of the external 33-bottle jet-assist-take-off installation in the B-47 led indirectly to cancellation of the requirement for a liquid rocket assist device. Although some tests of liquid rockets in the B-47 were still planned, the Air Force cancelled parallel developments, placing the bulk of reliance on the Aerojet YLR45-A-1. Kellogg's YLR47-K-1 and XLR75-K-1 were eliminated.[97]

Another of the relatively minor issues which troubled the B-47 program involved radio noise, a product of the decision to use ultra-high-frequency communication equipment (AN/ARC-27) which had not been modified to conform to specifications of the Components and Systems Laboratory. Upon learning of such a decision the laboratory immediately protested, warning that reliance on stock equipment might severely detract from communications capabilities.[98] Subsequently the several agencies concerned agreed to the incorporation of a modification kit which had the effect of filtering out much of the interference to which the laboratory objected.[99]

Malfunction of the B-47's brake parachute became a pressing issue in the middle months of 1953, but again prompt action on the part of Wright Air Development Center prevented any significant impairment of operations. The Equipment Laboratory quickly devised a new riser which made it possible to deploy the chute at speeds up to 160 knots. Previously the limit of operation had been 115 knots. The whole process, from the completion of engineering drawings to the first successful flight test, took less than a month--an excellent testimonial to the promptitude and accuracy of center action in B-47 development.[100]

Apart from deficiency engineering and product improvement, Wright Air Development Center devoted considerable attention in the first six months of 1953 to B-47 basic design proposals. Cancellation of the J57-powered YB-47C in December 1952 denuded that program of the one advanced turbojet bomber on the schedule, but two possibilities remained for additional study. The XB-47D, powered by two turbo-prop and two turbojet engines, still was programmed for delivery, though only in test quantities; the so-called Model II B-47, a substantially altered version of the basic airframe-engine combination, was being recommended as the logical successor to the B-47E for the period following production completion on that series. Although neither of these developments was yet scheduled for large scale production, there were indications that in some respects each would materially benefit the strategic command.

It became more and more certain as the months passed that the XB-47D would not fly on schedule. Principal impediment to meeting the "early 1953" flight date originally programmed proved to be engine and propeller development difficulty. Delivery schedules for both slipped often through the early part of the year, each slippage further retarding the overall program. By mid-1953 the target date for first flight had become March 1954; that was nearly a year later than the time for which the maiden flight had earlier been planned.[101]

The situation in March, when it became apparent that a 1953 flight date was highly improbable, was this: Wright Aeronautical had not yet accepted the Air Force proposal for a flight qualification test program; the YT49-W-1 engine had not yet been operated on synthetic oils, as required by the engine specification; the contractor had been unable to operate prototype engines at more than 75 percent of rated power; turbine compressor failure had occurred after 45 hours of test run; the delivery schedule was then so tight that it did not allow for the occurrence and solution of any major design deficiency in the period preceding the delivery of a flight engine. Taking these factors into consideration, the project officer was rather pessimistic about the probability of an early flight of the aircraft, although there was unanimous agreement that "the value of the turbo-prop development of the B-47 hinges upon how soon it can be proven."[102]

A shortage of parts at the contractor's facility caused a further slippage of delivery dates in March, leading the Power Plant Laboratory to assign an engineer to the plant "to better determine the status of experimental production on this and other Wright-Aeronautical projects."[103] The following month the contractor revised his delivery schedules and promised to ship three engines to Boeing by November. This would permit flight tests in the first quarter of 1954. But at the same time the contractor notified Wright Field that currently obligated funds expired in June and that additional funding would be required if the T49 program was to continue.[104]

Financial problems disturbed airframe development as well. In December 1952 the Air Force had authorized the modification of a B-47E into a second XB-47D (the first airplane had originally been a B-47B). In support of this program, the Air Materiel Command supplied $2,500,000 from maintenance funds. The additional engines were to be financed by diversion of funds from the cancelled YB-60 contract. Since there was no provision for propellers in this arrangement, the materiel command subsequently asked Air Force headquarters for an additional $900,000. On 13 March the project office received a call from Washington and learned that the initial $2,500,000 had been intended to cover propeller expenses as well as airframe modification. The Air Materiel Command request for additional funds was therefore returned for further justification, a procedure the project office was certain would ". . . delay and possibly jeopardize the second XB-47D airplane."[105]

A final note on funding came from Boeing when that contractor learned that deliveries of the first YT49-W-1 engines would not start until July 1953. This additional delay of six to eight months before delivery could begin naturally affected budgeting provisions. Therefore, Boeing withdrew all its cost commitments for the project, making it virtually certain that the XB-47D could not remain within budgeted funds.[106]

The entire situation looked little brighter at mid-year. In June the first YT49 engine (prototype for the eventual YT47) had run a total of 33 hours but had never produced the power output required by specifications. A maximum shaft horsepower of 8,800 could be maintained for only short periods because of overtemperature conditions.[107] The first propellers (also behind schedule) were due to arrive at Wright Field in June for instrumentation and test on the Propeller Laboratory's electric motor whirl rigs.[108] None of this offered any great degree of encouragement to project engineers. The whole effort seemed to be badly mired.

For all practical purposes the XB-47D was a test bed for turboprop engines--an attempt to determine what effect the substitution of two turboprops for four J47 turbojets would have on the performance of the basic airframe. Hypothetically at least, the XB-47D would have better take-off and range characteristics than the B-47E. Top speed would be little affected. Providing a B-47 with a combat radius of 2,735 nautical miles would more than satisfy immediate requirements, since the current B-47E had but a 1,617 nautical mile radius of action.[109]

The project office also had plans for a vastly improved turbojet-powered model of the B-47. Actually, of course, plans had existed, in one form or another, since the first Stratojet took to the air. The YB-47C with four J57 engines in place of the six J47's of the B-47E was an example of one idea that actually reached the fabrication stage. But Air Force headquarters had ordered the cancellation of this particular airplane, at the behest of the Air Council, at a time when only 40 percent of the modification work remained to be done.[110]

Deletion of the YB-47C project brought two separate problems into focus--one considerably more important than the other. The lesser concerned disposal of the partially completed YB-47C. The center recognized that completion of this aircraft for the sole purpose of evaluating its performance could not be justified in view of the Air Council verdict. "However," wrote General Boyd in March, "if additional productive uses can be found for this aircraft, the Air Force can realize a worthwhile return on the sizeable investment already made in this project." The use he had in mind was as a test bed for the J57 engine. He explained: "Current difficulties with the J-57 engine in the B-52 airplane emphasize the need for more high speed, high altitude power plant testing prior to installation in production airplanes. On preliminary analysis it appears that the B-47C airframe may be the most economical vehicle which we can adopt as a flight test developmental tool for the J-57 engine program." Pending an expression of approval or disapproval from command headquarters, the center contacted Boeing to see what would be required in the way of funds and time to complete this proposed undertaking.[111] No decision had been made by mid-year.

But the YB-47C was a relatively minor matter as compared to the overall problem of getting the most from the basic B-47 airplane. In January Colonel Haugen reported that the B-47 model improvement program, of which the YB-47C was one part, had been cancelled and that all work on this endeavor was to cease immediately.[112] (This did not affect the XB-47D.) In spite of the fact that the center had carefully concentrated on changes needed for improved survival capability and had, as the center's commander phrased it, excluded all "'knob polishing' or 'lily gilding' improvements' from consideration, past recommendations for major changes had run into heavy resistance. There appeared to be a widespread belief in operational quarters that additional effort devoted to improving the B-47 would detract from the B-52 program. Such a viewpoint was substantially at variance with Air Research and Development Command philosophies on the continued technological development of basic aircraft. In the case of the B-47, the advantages to be gained through a model improvement program appeared to be so enormous that General Boyd felt it his duty to call them to the personal attention of General Partridge. Economic considerations and other factors notwithstanding, there was little doubt that the improvement program warranted attention. Proceeding on this premise, the center had over a period of 18 months worked out a plan for materially improving the Stratojet. In the second week of May, General Boyd formally asked General Partridge to hear the center's ideas.[113] Acceptance was prompt. On 26 May General Partridge and members of his staff assembled at Wright Field to hear project officers outline their ideas for the "optimum configuration for the B-47. . . ."[114]

Lieutenant Colonel R. B. Kuhn of the B-47 office, who made the presentation, in explaining the center's persistence on the issue pointed out that the B-47 was supposed to phase out of production in 1956 and that the B-52 would not reach a high production rate until at least one year, and perhaps three years, later. The B-58, successor to the B-52, would be even further behind. Available evidence pointed to a production gap in 1957 and 1958, and very possibly in 1959. Wright Air Development Center had concluded, with logic, that the B-47E was the only aircraft available for large scale production in that period. But after 1956 it would be quite illogical to continue in production the same B-47E that scarcely satisfied 1953 requirements. The center's stand was that an improved airplane, designated the Model II B-47, or the B-47-II, would provide the answer. (The proposed B-47C had been known as the Model I or B-47-I.)

The general idea of increasing the performance of the B-47 had been discussed frequently, but for practical purposes this was the first concrete proposal, with details, for such a materially changed airplane. Previous efforts had largely centered about the B-47C idea, which was by this time a completely dead issue.

The B-47-II differed from the E series in several respects. It was to have J57 engines, a 33.5 percent greater wing chord, and a taxi weight of 224,000 pounds. Wing spars were identical on the two aircraft, but the II would have new leading and trailing edges. This change produced a better thickness ratio and gave the airplane a better high speed and high altitude ability. Combined with proposed split ailerons and new high-drag flaps, the wing would permit better landing approaches and considerably improved handling characteristics. Wind tunnel tests indicated that the high speed pitch present in the B-47E would be absent from the II. Enlarged tail area was suggested as a means of improving control and stability in conjunction with the new wing, but with a reduced fuel load the redesigned tail might not be needed. Other changes affected the control system and fuel system, as well as some relatively minor components.

Engineers forecast excellent performance for the II. It was expected to climb about 8,000 feet higher than the E and to cruise at Mach .79, instead of the Mach .75 of the B-47E. Combat performance would be similarly advanced. The B-47E was designed to bomb from 38,400 feet at a maximum range of 2,100 miles, while the Model II would be able to drop bombs from 43,400 feet at a maximum range of 2,900 miles, or (alternately) to bomb from 45,600 feet at 2,100 miles.

Either was "quite an improvement from a tactical point of view," the center spokesman pointed out. There was also the prospect that as the specific fuel consumption of the J57 improved--and this was certain--the airplane would have still better range and altitude.[115]

Overall, the B-47 II offered a number of advantages. From a performance standpoint the most important were improvements in take-off run, maximum cruise speed, bombing speed, bombing altitude, and an 800-nautical mile growth in the non-refueled range of the II over the maximum obtainable from the B-47E.[118]

The Model II could be made available either through modification of the B-47E or by production of an entirely new airplane. In either instance the availability date would be about the same--16 months after the start of work. The project office indicated that the best time to phase the Model II into the production (or modification) lines would be November 1954. This would put the first aircraft on the flight line in February 1956--the most appropriate date in view of B-52 production plans.

On the basis of plans for 500 aircraft a modification program would cost $133,400,000 while the production of an equivalent number of new B-47-II's would cost approximately $1,226,500,000. Production would utilize perhaps 80 to 90 percent of existent tooling, depending on what was done with the tail.

The center argued that on a cost basis alone the proposal was worthy. More than $8,500,000,000 had been invested in the B-47 program to date, exclusive of the costs of bases, crews, and similar items. Recycling 500 B-47E's would cost relatively little but would produce a large increase in technical capability. Other circumstances favored the proposal as well. The B-47 was the only bomber completely tooled for large scale production between 1953 and 1956. Obviously the tooling would be useful after that terminal date with no additional expenditure of funds. The Stratojet constituted most of the Air Force bombing capability and would be in inventory beyond 1960. As a mere matter of insurance the B-47 would have to be improved, otherwise both quality and mobilization potential would be questionable in the event of war. Engine availability, like airplane availability, was not a problem. Finally, of course, a very marked increase in combat competence could be obtained at what was, from an overall standpoint, a reasonable cost.

On the basis of these facts, therefore, Wright Air Development Center recommended that Air Force headquarters immediately issue a procurement directive for two prototypes, 16 engines, and recycle tool designs. This would cost about $10,260,000. Project officers felt that this should be done in any case, purely as insurance, even if nothing else was scheduled.

Further steps in support of the Model II proposal followed a logical sequence. As a second step the center recommended that the Air Force establish a recycle program for at least 50 Strategic Air Command B-47E's. This would give the bomber command "a feeling for the aircraft" and give development people "a chance to really know what we've got."

The remaining recommendations were equally brief: that J57 production be expanded to support the B-47 effort, and that action on the prototypes begin immediately, notwithstanding decisions on recycling or production.[117]

Although General Partridge felt that the current economy policy would weight the scales against the Model II proposal, he urged that Wright Field push it through channels and promised his support in getting a fair hearing for the whole idea.[118] Subsequently the proposal was forwarded to command headquarters for evaluation. No decision had been reached by the close of the fiscal year.[119]

On the whole, the B-47 was definitely on the way to becoming a good workday bomber. The extremely intensive effort applied to the eradication of its outstanding shortcomings over a period of more than a year had paid off. A number of deficiencies and defects remained--range still was less than the Strategic Air Command desired, flutter and vibration persisted at speeds in excess of 425 knots, bombing-navigation system reliability was marginal, the defensive fire control system required minor improvements, offensive potential was not all that could be desired, and bombing capability was still unproven--but[120] on the whole the B-47 was ever nearing the position of being a worthy successor to the B-17 and B-29. As General Boyd said in August, "The B-47 is pretty well out of trouble now. It is doing a good job and the combat people are quite happy with it."[121]

The B-52

By January 1953 the more spectacular phases of early B-52 development had given way to the routine of an entirely normal test program.[122] Major difficulty had been absent in the initial phases of flight test, and this condition persisted throughout the first six months of 1953.

If there was a central theme to the B-52 work, it was that no single defect or deficiency had appeared which was incorrigible or even extremely disconcerting. A number of minor shortcomings troubled engineers, it was true, but none held precedence over the others. Moreover, none seemed to be of the type that would seriously detract from the combat potential of the aircraft.

Apart from production snarls, of which there were several, the only pressing problems involved persistent oil fumes which penetrated the cabin through the air conditioning system, fuel cell vent and hanger defects, and somewhat faulty engine operation. The fire control system, the ejection seat impellers, the main bulkhead, and a number of structural components were behind schedule in either development or production but did not constitute major problems in themselves--as yet. A small number of other comparatively insignificant defects, some corrected or eliminated in the course of the six months, intruded in the smooth course of the test program, but again none threatened to impede overall progress.[123]

XI

The Phase I tests (structural integrity flight demonstrations) of the YB-52 ended in November 1952. Evaluation of the results took some time, but by early January (while the XB-52 was undergoing Phase II) the Aircraft Laboratory had prepared a list of recommended limitations for observance during the balance of the flight test program.

Laboratory recommendations were consistent with the requirement that the aircraft not be permitted to exceed 80 percent of design load limits prior to structural static tests. But at the same time the airplane had to be qualified for operation at a minimum of two G's to satisfy Air Force flight test needs. In view of these requirements, and with the previously demonstrated flight characteristics of the B-52 in mind, the Aircraft Laboratory suggested that the existent limiting airspeed of 350 knots (indicated) in calm air be continued and that the aircraft be held to a maximum gross weight of 268,000 pounds to assure that the two-G maneuver limit would not be exceeded. With the same weight limit, an indicated air speed of 250 knots was suggested for gusty air. In order to avoid excessive rates of roll and consequent strain on wing and engine pylons, the laboratory submitted that only the three inboard spoilers and the ailerons be activated during rolls and turns at altitudes above 30,000 feet. As a final caution, the laboratory urged that pilots keep in mind the probability of "tuck under" at speeds greater than Mach .87.[124]

The Air Materiel Command communicated these findings to Boeing with no significant additions or deletions.[125] Boeing reacted by citing a total of 18 postponements "or severe limitations of most of the presently scheduled flight tests" which would result from wholesale adoption of the recommendations. In the main, it appeared that, except for low speed stability and control experiments, most scheduled activities would have to be curtailed until both static and flight tests had proved that the recommended limits could safely be exceeded. The contractor argued that Aircraft Laboratory estimates were based on minimum design conditions which did not necessarily indicate the actual strength of the airframe. For instance, Boeing called attention to the fact that wing flexibility was sufficiently great to make unnecessary any concern for a critical gust point. This circumstance and a number of other factors prompted the contractor to the conclusion that stringent limitations were not necessary, that operation within the boundaries observed during the preliminary structural demonstration was quite safe, and that demands of the developmental flight program prohibited the imposition of the severe flight restrictions listed. However, the firm did not oppose the idea of applying such restrictions to production aircraft in the interests of complete safety.[126]

With considerable logic, in view of the need for high performance flight evaluation, the oppressive limitations initially proposed were not accepted in their entirety. While restraining maneuvers, speeds, and gross weights to the minimum safe zone, the Air Force and Boeing decided to fly the airplane in a manner that would indicate its performance ability. Obviously this would have been impossible if the proposed restrictions had been entirely adopted.[127]

B-52 production aircraft were changed in several respects as a consequence of Phase I flights and early results in the Phase II program. Flaperons, modulated spoilers, and cross-wing landing gear had been programmed even before the YB-52 took to the air, and early flight tests confirmed the need for their installation. In the early months of 1953, prototype models of these devices were fitted to either the XB-52 or the YB-52 as insurance that the modifications would be entirely practical when applied to production aircraft. The flight test program also uncovered a number of hitherto unsuspected defects, the correction of which generally resulted in changes applicable to the production aircraft. Wheel well baffles were constructed to eliminate buffet when the landing gear was extended. Flap drive links were redesigned subsequent to an in-flight failure. A new anti-skid brake system was found necessary when the original installation proved unable to handle asymmetrical weight distributions. Revisions to the drag chute and its release mechanism resulted from experience with the original. The cabin pressurization control was reworked to eliminate "hunting" in temperature and cabin altitude. Finally, two major defects were the subjects of continuing intensive investigation: engine surging at high altitude (to be corrected, it was hoped, when J57-P-1 engines replaced the -3 engines of the prototype aircraft) and the introduction of smoke and fumes through the cabin pressurization system.[128]

These last two items were probably the most important of the persistent deficiencies. As early as October 1952 the presence of smoke and fumes which seeped in through the cabin pressurization system had resulted in a requirement for the introduction of air filters. At the time the fault was considered an annoying but not a dangerous condition.[129] Subsequently, however, researchers at the University of Cincinnati discovered that chemical breakdown of the synthetic oil used to lubricate the engines produced fumes that killed rats in two to 24 hours. B-52 flight crews were promptly instructed to wear masks and breathe 100 percent oxygen until further notice.[130] Concurrently the Aero Medical Laboratory authorized a university expedition to Seattle, where animals could be directly exposed to the concentrations of fumes prevalent in the cabin of the B-52. As an added precaution, the Power Plant Laboratory and Weapons Systems Division warned all other project officers to guard against the possible exposure of aircraft crews to atmospheres contaminated by fumes from synthetic lubricating oils.[131] Boeing undertook a separate and parallel research program using test J57's and installed air samplers in the cabins of the B-52's to obtain some indication of the toxic nature of the atmosphere there.[132] Eventually, project officers expected the solution to be found in sealing off the oil leaks in the J57, although the design and development of a supercharger that utilized outside air (not bled from the engines) for cabin pressurization was equally probable. For the moment, since these developments were not expected to be available for use in the early production B-52's, the perfection of suitable air filters was the pressing issue.[133]

The Equipment Laboratory had previously indicated that filters would be acceptable only as an interim answer to the contamination problem. Even Boeing admitted the inadequacy of filtration. There was more than a slight suspicion that available filters would be too short-lived to operate throughout a complete mission. The logistics implications were plain.[134] Nevertheless, Boeing was instructed to install filters in the air conditioning system and promptly incorporated such a change in the design of the production aircraft.[135]

Engine problems initially encountered on the YB-52 (the first of the prototypes to fly) included medium altitude high speed surging followed somewhat later by a tendency toward high altitude low speed surging. Modification of the surge valves and compressor and turbine stages of the test engines (YJ57-P-3's) alleviated but did not completely eliminate this condition.[136] However, the J57-P-1 engine intended for production B-52's had been designed specifically to operate without such surging, so there was no expectation of difficulty on that score. Unfortunately, this proved to be somewhat optimistic. As a quick check on the validity of test stand results, an experimentally built -1 engine was installed in number 6 position of the XB-52 in March and flown to altitude early the following month. Surging was present in all acceleration attempts between 9,000 and 25,000 feet. Similar results followed flights with a -1 engine in a B-50 flying test bed. Indeed, the -3 engine was adjudged somewhat superior in this respect.[137]

Project engineers and power plant experts ascribed the difficulty to improper design of the airbleed passages and improper setting of the stall suppressor circuit in the electronic engine control, causing faulty fuel scheduling. An orifice, which restricted bleed flow from the valves, and a revised stall suppressor circuit did much to reduce surging in the -1, leading engineers to believe that the remaining problem was one of tailoring the acceleration circuit in the engine control to give optimum acceleration rates at all altitudes with a stall margin adequate to prevent surging of the engine.[138]

Another interruption in the advance toward a fully qualified J57-P-1 engine was the failure of the number 4 bearing in the compressor assembly in the course of an official 150-hour endurance test run. Again during a 91-hour penalty run, the same bearing failed.[139] Pratt and Whitney immediately started an intensive search aimed at finding and eliminating the source of the difficulty. Five engines with various bearing configurations were prepared for endurance tests.[140] Subsequent modification, permitting a reduced load on the critical bearing, proved sufficient to satisfy the Air Force. At the same time the contractor redesigned the compressor stator vanes, which had demonstrated a tendency to crack, and made other minor changes. As a result the engines qualified easily. Four of the 150-hour tests were actually run at a maximum of 10,000 pounds thrust, leading Pratt and Whitney to propose increasing the engine rating to that figure from its previous 9,500 pounds. Basic engines with water injection provisions (J57-P-1W and -9W) were simultaneously to be rated at 11,100 to 11,400 pounds of thrust, although this power was intended to be used only for take off and low altitude flight.[141]

Satisfactory operation of the -1 and -9 convinced the Air Force that Pratt and Whitney was justified in moving to increase thrust ratings. Teardown of the test engines revealed no significant parts failures. The center therefore ruled that the 150-hour requirements had been satisfied and agreed to revise the engine ratings to correspond to actual performance output.[142]

On 15 June the XB-52 entered the Boeing shops for installation of a complete set (eight) of the improved J57-P-1 engines. To provide smoother engine operation and better acceleration characteristics at high altitudes, six of the eight incorporated improved electronic fuel controls. The other two utilized a hydro-mechanical system which through a different method was designed to achieve the same ends. Flight tests would undoubtedly indicate which was the more effective.[143] One would eventually be fitted to production aircraft.

Further improvements to the basic J57 engine were scheduled in the course of normal development, as was usual with any engine. One important factor received special attention in June, however, and promised to be of some concern for a continued period. The Air Force chief of staff directed the establishment of an aggressive program aimed at keeping aircraft weight to a minimum. Immediately designers proposed the use of titanium in the J57 as one profitable expedient. There were indications that the substitution of titanium for other materials in the low pressure compressor section alone would reduce weight by 2,000 pounds per aircraft. More widespread use of titanium bore promise of eventually providing a 5,600-pound weight reduction. To promote this objective, the Air Research and Development Command and the Air Materiel Command scheduled joint studies on a priority basis, planning to apply the results of their work to production engines.[144] (The J57-P-9 engine was the production version of the titanium-modified -1.)[145]

Several logistical difficulties promised to have an ultimate effect on the titanium program. Materiel command personnel in the project office estimated in advance that each -9 engine would cost $25,000 more than a comparable -1 engine. This would add $200,000 to the flyaway price of each B-52 or $400,000 to the cost of each airplane delivered with its required number of spares. At the same time the project officers cautioned that these were preliminary estimates and might be inaccurate since the availability and allocation of titanium alloys for B-52 production were unpredictable factors.[146]

Uncertainty about the ultimate configuration of the B-52, hinted in the engine development program, was reflected in other aircraft components as well. This was largely a factor of the designers' natural desire to incorporate new equipment just becoming available, although the weight reduction program was also a contributory element. There were four major essentials to such uncertainty. The defensive fire control system, the bombing system, in-flight refueling, and fuel cell design were not firmly established in production plans as late as the end of May. Programming offices favored postponing final decisions on these items as long as possible, hoping in this way to eliminate the possibility of extensive retrofit programs which would be required if interim or only marginally satisfactory equipment was installed and more adequate equipment became available shortly thereafter.[147]

A judgment on the fire control system could perhaps have been made on the basis of engineering expectations and preliminary test results, but as experience with the B-47 had indicated, this was not the wisest course. The programmed system was the A-3A, which utilized four .50-caliber machine guns. A prototype system, the A-3, was equipped with two guns, while the Air Force hoped to convert the basic A-3A to 30-millimeter guns and to install the combination in production aircraft at some future date. Should neither the A-3 or the A-3A system prove acceptable, engineers were prepared to use a modified A-5 system in the tail turret of the B-52.[148]

The A-3A was on an extremely close schedule when the year began, principally because of a sequence of incunabular slippages. Then on

19 January, engineering personnel at the Arma Corporation (which had development responsibility) called a strike. Fortunately the crisis was not so serious as it had first appeared, and little delay in A-3A work resulted.[149] Subsequently, however, another strike disrupted the program. The new work interruption came not at the Arma plant, but at the General Electric facility in Syracuse. Since General Electric had concentrated work on the radar elements of the A-3A in that location, the resultant three-month work stoppage threw the entire program out of phase. Late in June, Arma notified the Air Force that its predicted delivery date for a flight test system would have to be retarded by at least 90 days.[150]

This situation and a number of related factors nurtured doubt that the A-3A would be entirely ready for installation in early production articles, although programming officials still believed the final deadline could be met. However, as a damper on the effects of further slippage and because of the possibility that A-3 systems might have to go into the giant bomber, it was decided to install a two-gun turret in at least one test B-52 aircraft so that the requisite engineering data would be available.[151] In preparation for this move an experimental A-3 system was fitted to a B-29 and, on 17 March, was for the first time flight tested. Quite satisfactory operation resulted. Turret motion had no deleterious effects on the flight characteristics of the B-29 at indicated speeds up to 200 knots. Operational stability was good, both in normal flight and while the guns were firing.[152]

These initial flights were purely mechanical in nature, intended to prove out the physical adequacy of the installation. On 29 May the first active radar airborne tracking test was carried out against an F-86 mock attacker. The three-hour flight produced absolutely no equipment malfunctions. Lock-on attempts met with immediate success on every try. Moreover, radar operation proved more than adequate from a range standpoint; the F-86 was satisfactorily tracked at ranges of more than three miles.[153] Colonel J. M. Silk, B-52 project officer, commented in July that continued flights of the A-3 on the B-29 had been equally successful. "To date," he remarked, "the system looks good."[154]

The decision to adapt 30-millimeter guns to the A-3A system was definite.[155] On the other hand, there was no certainty about the effectivity point of such a modification. The start of a formal development program was being delayed at mid-year because the leading contender for the contract was in financial straits. But since the Air Staff considered the modification particularly urgent, there would probably be little delay once contractual aspects were settled.[156]

Like the fire control system, the bombing-navigation system was in the process of transition. A modified K-3A system would initially be installed in B-52 aircraft,[157] but by early 1953 there was strong evidence that an MA-2 (Bomb Director for High Speed Aircraft, frequently referred to as the BDHSA or HSBD system) would be better suited to the ultimate production aircraft.[158]

The major factor in the proposal to shift emphasis from the K-system to the more modern (though still unproven) MA-2 was the unsuitability of the K-3A for extreme high speed or high altitude work. In December 1952 General Irvine asked General Boyd what progress was being made in modifying the K-3A to provide more flexible operation. The current model, General Irvine pointed out, was limited to about 25 miles and to altitudes below 50,000 feet. It appeared that the B-52, to fully utilize its performance ability, would have to be fitted with a system capable of operating at ranges in excess of 50 miles from the target and at altitudes up to 70,000 feet.[159] General Boyd, in reply, emphasized that the results of experience with the B-47's K-system were being applied to the K-3A and mentioned that the Armament Laboratory was presently attempting to change the computer elements to provide for operation at 50-mile ranges and 60,000-foot altitudes. He cautioned, however, that providing a 70,000-foot operating capacity "would require a major redesign of the K-3A system."[160]

Those who knew the capabilities of the K-3A system best were quick to admit that its engineering design contained inherent defects making it inferior to the MA-2 in almost every respect. All K-systems were extremely complicated, and modifications to provide greater range and altitude ability could only further complicate them. The MA-2 had the advantage of being specifically engineered for high speeds and high altitudes. Moreover, wrote one official in Baltimore, the MA-2 "has been engineered with reliability as a primary consideration."[161] As past experience proved, that certainly was not true in the case of K-systems in general.*

The great drawback to early installation of the MA-2 in production B-52 aircraft was that it had not yet been sufficiently tested. Considerably more flight evaluations were essential if it was to meet the B-52 production schedules, even on a retrofit basis.[162]

It was obvious that two distinct courses of action were necessary if the B-52 was to be suitably equipped for bombing and navigation operations when it reached the combat squadrons. First, the K-3A had to be modified to provide a current capability; second, the MA-2 or some equally adequate system had to be perfected in time to meet the production schedule. Air Force headquarters approved both these actions in a letter to headquarters of the Air Research and Development Command on 18 May. That command was directed to oversee modification of the K-3A to provide a tracking range of 50 miles and an operating altitude of 60,000 feet. Other changes to the radar system, computer element, and power source were scheduled at the same time. Fittings suitable for doppler radar were also to be provided, with the equipment to be installed when available--and after having demonstrated reasonable realiability.[163]

Simultaneously, Washington approved the proposal to install the MA-2 in later B-52's and authorized the assignment of a B-52 to the MA-2

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*See pages 408-411.

development program.[164] Tentative plans were laid for incorporating the MA-2 in the 84th and subsequent aircraft. No positive decision was possible, however, until more evidence of MA-2 suitability was available. The research and development command was therefore directed to schedule MA-2 tests that would provide Air Force headquarters with the information it needed to reach a final decision. If all went well, complete information, with particular emphasis on reliability and suitability, was to be ready by April 1954.[165]

The bombing-navigation system did not by any means constitute the whole of the bombing problem. Two shortcomings, each of some considerable significance, popped into being in the early months of 1953. One of these contained some very interesting background.

Originally the design of bomb racks for biological and chemical bomb clusters had been tailored to a 16-inch diameter bomb weighing no more than 750 pounds. In January 1951, however, the Air Force and Army Chemical Corps agreed on a 16½-inch diameter cluster as more suitable. At about the same time, the weight also went up. While coordination within government agencies was thorough, by some oversight the Armament Laboratory failed to notify Boeing of the change until late in 1952, at which time it was found that the racks in the B-52 would take only 16-inch diameter bombs weighing less than 750 pounds. In addition to being too large to fit, some of the new series bombs weighed more than 800 pounds. No corrective action was started until several more months had passed, with the consequence that the first 20 sets of racks would not provide the B-52 with the required chemical-biological bombing capability. Of course the situation was being corrected as quickly as possible, but this did not ease the pinch of the moment.[166]

Similar difficulty, though from a different cause, impeded delivery of the combination bomb-rack and bomb-hoist designed specifically for the giant bomber. In this instance the rack-hoists failed to operate under icing conditions, delaying their delivery and forcing postponement of the first scheduled release of bombs from the B-52 in flight.[167] Until such tests had been run, there could be no certainty that the bomber would escape the bomb bay buffeting troubles that had so handicapped the B-47.

These problems were ultimately resolved, and on 2 June the XB-52 was loaded with bombs for a practice run. At the midpoint of a six and one-half hour flight the bomber arrived over the Salton Sea bombing range at an altitude of 47,200 feet. This figure, and the gross weight of 261,000 pounds, corresponded to design target conditions for the B-52. Unfortunately, the two dummy bombs could not be dropped at this altitude or at the design bombing speed because the F-86E photographic chase plane could not maintain contact under such conditions. Nevertheless, a dry run was made at a true airspeed of 461 knots and the specified bombing altitude. Two actual drops at lower altitudes and speeds followed. Little bomb pitching was observable--none in one instance--and buffet with the bomb bay doors open was negligible. An accuracy determination was impossible since the experimental aircraft contained no bombing equipment.[168] (The first bombing system checks were scheduled to begin in October 1953 using a K-3A installed in the YB-52.)[169]

Provisions for inflight refueling the B-52 was an afterthought, since the airplane had initially been designed to operate independently of such support. However, this matter became of concern early in 1953, when a consideration of the possibilities was undertaken. At that time the KC-97 was the only tanker scheduled to be operational in the period of B-52 usefulness. Although there was no serious doubt that the two aircraft were compatible for refueling operations, in April Air Force headquarters asked for experimental validation of this conclusion.[170] Command headquarters forwarded this request to Wright Field.[171]

The center initially planned a preliminary flight test of the KC-97 and B-52--without equipment for actual fuel transfer--in early May. By January 1954, a boom receptacle was to be added to the B-52. Flight tests, consisting of dry contacts, would then begin the following month; actual fuel transfer tests would not be possible until September 1954.[172]

In addition to the flying boom process, for which the KC-97 was equipped, there was a possibility that probe and drogue refueling methods might be adapted to the needs of the B-52. The B-36, the B-47, and the B-52 itself were either proven drogue tankers or good prospects.

Baltimore called this matter to the attention of planners in Air Force headquarters, suggesting that if the use of probe and drogue in the 1955-1960 period was even vaguely possible, production line changes to the B-52's should be scheduled without allowing too much time to elapse. At the moment the B-52 was scheduled for flying boom refueling only.[173]

Preliminary flight tests of both the flying boom and the probe and the drogue contact systems were conducted on 1 and 4 May near the Boeing plant in Seattle. Pilot comments were quite revealing. Although compatibility of the B-52 with the KC-97 was definitely established, pilots registered slight discontent with the flying boom system in comparison to the probe and drogue technique. Control of the B-52 during simulated contacts with the KC-97 proved somewhat more difficult than similar maneuvers in conjunction with a B-47 probe and drogue tanker. Power response and stabilization of the B-52 in the boom contact position were marginal, as was lateral control. The first of these shortcomings was less noticeable when probe and drogue contact was simulated; the latter would not exist in production aircraft. On the whole, the probe and drogue process appeared to be more promising, if only from the standpoint that vision was better during drogue contacts.[174]

If B-52's were to be adapted to probe and drogue refueling techniques, a shift on the production line would have to be approved in short order. The research and development command felt that the probe and drogue system unquestionably had a greater potential and a better current performance, all factors considered. The Strategic Air Command, however, continued to insist on flying boom refueling because there was no logistics tanker in the development program to replace the KC-97. The earliest possible date one could be made available was 1958.[175]

Other proposed changes to the basic B-52 were suggested from time to time. Some survived detailed analysis and were programmed for incorporation in the production bomber. Others bobbed up once and then disappeared without a ripple. In the former category appeared to be the suggestion that the reconnaissance capability be deleted from all B-52's after the 64th article. Late in July the project office asked Boeing to forward revised specifications reflecting this change in plans.[176] In February a decision that would have boosted B-52 production to a peak of 7 airplanes a month was rescinded,[177] an event which fell into the latter category in that it permitted continued modification of small numbers of aircraft in the early months of production.

In July, Colonel Silk listed a number of items still in the undecided category. There was the Air Force headquarters' decision to delete all requirements for conventional weapons in the superbomber. At the same time there appeared to be a continuing chance that the Rascal missile might ultimately be carried and launched. Questions about the still not entirely satisfactory fuel tank design and such passive defense measures as fuel tank sealing and purging also existed. The multipurpose pod intended for countermeasures, reconnaissance, weather reconnaissance, and photographic work was on procurement schedules but its configuration still remained uncertain. Although an evaluation panel had recommended the purchase of a special ferret pod, the Strategic Air Command had disagreed and cancelled its requirement.[178] Physiological factors were in the process of being studied at the close of the fiscal year. The Aero Medical Laboratory planned to send a team to Seattle in August to study human factors in B-52 crew station design so results would be available for use in the production program.[179]

As far as general flight test progress was involved, the Phase II program (which concerned the XB-52 only) ended in March 1953 and both prototype aircraft began Phase III evaluation shortly thereafter. That aspect of the program would continue into 1954. There was little chance that test agencies would have additional B-52's to work with before July 1954, although the official delivery date for the first production article remained set at January of that year.

To mid-1953 the B-52 program had cost in excess of $60,000,000--for the XB and YB aircraft alone. Estimates for the balance of the production and test schedule indicated that the cost of individual aircraft would gradually diminish--from $24,301,710 each for three B-52A's to $7,854,000 each for the 48 B-52's programmed in fiscal year 1955.[180] On the whole, however, the entire B-52 program seemed to be progressing well. Outstanding difficulties were in every instance receiving full attention, and the deficiencies uncovered in early flight tests were steadily being corrected. Most encouraging was the fact that the B-52 had as yet displayed no tendency to repeat the unfortunate early history of the B-47.

The B-36

As the project officer for the B-36 was always careful to point out, not one but four different bombers fell into the general model classification. The B-36D, F, H, and J were either in service, in production, or ready to enter production. All earlier B-36's had, by early 1953, been modified to conform to the D series configuration--four J47 engines in two pods in addition to the six reciprocating engines. The F series differed from its predecessors in utilizing R-4360-53 engines in lieu of -41's. An additional flight engineer was provided in the B-36H, since experience with the D had proved the job to be too much for one man to handle. The B-36J, with a gross weight of 410,000 pounds, was due to reach the flight stage late in 1953. It would be the last of the production series.[181]

Apart from its bomber assignment, the B-36 was also programmed for a rather large variety of accessory missions. A DB-36 to be used in conjunction with the B-63 Rascal missile, a pure reconnaissance version, a convertible bomber-tanker, and a special Ficon version were all in progress. The Rascal and Ficon projects were for practical purposes virtually independent of the basic program, while the tanker and the reconnaissance aircraft were either in service or reasonably far along the development road. Since production was due to end in August 1954, Wright Field's attention was focused on a sequence of modifications intended either to improve the combat ability of the B-36 from a defensive standpoint or to qualify it for one or more of the special assignments not originally contemplated.[182]

The B-36 was, for the moment at least, the only operational

5 USC 552, (b)(3), 10 USC 128

[redacted]

the aircraft through the resultant blast were matters about which there was considerably less certainty. In December 1952 the center had become preoccupied with "certain apprehensions as to the B-36 capabilities as a carrier for certain special weapons." Since Convair had previously been instructed to modify a limited number of the giant bombers to a "special package" configuration, the resolution of this issue was of paramount importance.[183]

The whole affair apparently resulted from the fact that B-36's

5 USC 552, (b)(3), 10 USC 128

[redacted]

would withstand the same stress in an upward direction. However, Wright Air Development Center was unwilling to accept Convair's calculations without conducting static tests.[184]

Since a prompt answer was extremely important, a further static test was scheduled. Convair completed the physical aspects of the experiment on 22 May, establishing that its original premise regarding

5 USC 552, (b)(3), 10 USC 128

[redacted]

The absence of data on upward stress limits was understandable in view of the late emergence of requirements. But more difficult to understand was the fact that stability and control data had never been obtained. For four years the Aircraft Laboratory had tried to secure a suitable airplane and approval of such tests. Success had been notably absent. Although scheduled on several occasions, the evaluations had always been postponed because of "higher priority" work. No B-36 had ever been tested for quantitative stability and control, though the information would be needed as support data in the event of an accident involving flight characteristics. Nevertheless, the center had failed twice more during 1952 in attempts to obtain approval. Finally, on 17 February 1953, representatives from the center's laboratory directorate and operations organization met with delegates from command headquarters, the Strategic Air Command, and the flight test center. Command representatives eventually acceded to scheduling the tests, but only on condition that they be run on a B-36J. This would impose another delay of six months, but since there seemed to be no reasonable alternative, all agreed to that plan. In extenuation of its continued absorption with this matter, the Aircraft Laboratory pointed out that some future accident could well be prevented by the early discovery of any unfavorable flight characteristics. Moreover, the lack of such data had interfered with autopilot and bombing equipment design. All in all, it had signs of being a profitable course of action.[186]

At mid-year the center was engrossed with eight major problem areas involving the B-36. Three landing gear failures had prompted action to "beef-up" the undercarriage structure to withstand gross weights in excess of 370,000 pounds, while additional work was being devoted to the 410,000-pound configuration. Project Tie-Down--a means of preventing wind damage to B-36's which, because of their size, could not be hangared--was virtually over, the center having approved a better method of securing the massive aircraft in parking areas. The electronic countermeasures program was in its final stages, with an approved configuration on the verge of acceptance. Modification of the K-series bombsights continued to give trouble, but in the main the issue was one of coordination between the materiel command's Maintenance Division--which was making independent recommendations--and the center. No major revision of the installed bombing-navigation system was contemplated. Fire detection, explosive decompression of the pressurized cabin, and improvement of the fuel consumption characteristics of the six reciprocating engines still received attention from engineers, but in each instance the remaining difficulties appeared to be relatively simple of solution. The final, and still critical, issue was defensive armament.[187]

The B-36, unlike more modern bombers in the B-47 and B-52 category, could not rely on superior speed when attacked by enemy interceptors. (The maximum speed of the fastest in the B-36 series was only 385 knots at combat altitude.)[188] Therefore, the effectiveness of the fire control system was of very considerable importance to the success of any combat mission--not to mention the well-being of the crew. In 1948, fire-out percentages (the ratio of ammunition actually fired to the total carried) averaged about ten. By 1950, fire-out had climbed to about 30 percent. The further increase to between 60 and 65 percent, recorded in the first half of 1953, was evidence that additional advances were possible. However the declining rate of improvement indicated that future progress would be slow.[189]

This program, conducted largely by Strategic Air Command gunnery experts, was to a great degree monitored and directed from Wright Air

Development Center. In particular the center's Armament Laboratory worked with such critical items as the feeder mechanism and electrical system malfunctions. Considerable success was recorded in both these categories, contributing substantially to the betterment in Strategic Air Command performance.[190]

The results of other B-36 projects--such as Featherweight, the attempt to improve altitude characteristics by stripping the B-36 of marginally essential equipment, and Tanbo, conversion to a probe and drogue tanker--were not available in mid-1953. Although Featherweight flight tests had been run by both the strategic command and Convair, operational elements had apparently not yet decided whether the modification was worthwhile. Tanbo modifications had resulted in the conversion of one prototype aircraft, but engineers still had not solved several hose reel difficulties.[191]

Work on the B-36 was in the transition stage between production engineering and wholly service-connected problems. The diminution in production engineering effort had serious implications for the project office, since Air Materiel Command engineers who had borne much of the earlier workload were steadily being withdrawn for other assignments. Wright Air Development Center assignees to the project office would, of course, continue to be concerned with the B-36 as long as it was in service. Moreover, work on such projects as Ficon and the DB-36 promised to be of major importance for some time to come. For that reason, and despite the fact that the B-36 could no longer be categorized, even loosely, as a development airplane, Wright Field work on the gigantic bomber would probably continue at a high peak. There was little likelihood, however, that the B-36 would ever again be one of the center's major projects.[192]

The B-58

The B-58 might well be the last of the manned bombers in the tradition of the B-17 and the B-24. In its own fashion the B-58 would be as far advanced from those World War II aircraft as the B-47 was from the Martin Bomber of 1920. In planning to produce the B-58, the Air Force in one gigantic stride passed over the sonic barrier, over the transonic and low supersonic speed areas for which advanced fighters were still being prepared, and kicked out a toehold in the still unexplored realm that existed at nearly twice the speed of sound.

Still there was nothing fantastic or unattainable in the design of the B-58. Admittedly, the appearance of the aircraft, the performance of its engines, the characteristics of its bombing, navigation, communication, and armament systems, and the idea of an integral "pod" missile were all based more on designs, drawings, and theories than on well-tested experimental data. But essentially each of these had a progenitor somewhere in the recent background of research and development. The distinguishing characteristic in each instance was that the B-58 would not be made up of equipments that derived directly and immediately from existing experimental models. Instead, the B-58 would start three steps in advance of this stage. In a sense it was almost as though Boeing's designers had looked at the B-9 in 1932 and gone directly to the B-47, without stopping for the B-15, the B-17, the B-29, and the B-50.

The B-58 was unique in other ways. Barring misadventure like that which had stolen the honor from the F-102, the B-58 would probably be the first aircraft designed and carried through development in strict compliance with the weapon system idea. There was no doubt that it was the first to be planned along the lines of General Putt's single prime contractor concept. It would be the first American delta-wing bomber, the first bomber to incorporate a guided missile as part of its basic structure, the first supersonic bomber; the list seemed interminable.

Before actual work could begin on the Convair proposal, a number of pressing issues had to be decided. Foremost was the contract. This was a matter considerably more complicated than was the case with the usual development-production contract, since the agreement with Convair had to contain clauses firmly establishing the principles of the single prime contractor concept. In January a number of conferences between project office personnel and Convair produced agreement on basic contractual clauses as well as on a series of policy statements which assigned wide responsibility to Convair while allowing the Air

Force to retain ultimate control of the project.* As the negotiators had no previous experience with this sort of settlement to draw upon, contract agreements were of necessity quite different from anything that had gone before.[193]

Preliminary arrangements between the center and the contractor had to be tentative in most instances, since the legal aspects were as uncertain as most other factors.[194] Nevertheless, by 12 February these matters had been disposed of, and on that date the contract received essential signatures which had the effect of formally launching the B-58. This in itself was sufficient to bring a hearty sigh of relief from those most concerned. General Boyd's reaction was probably typical; "Good," he wrote crisply across the brief note that told him detailed work could now get under way.[195]

Of course this action did not automatically rid the center of all concern for contract problems. There still remained, for example, the matter of deciding how Convair should be paid for the additional management work involved in administering the development of a complete weapon system. Since the Air Force had exercised most of this responsibility in the past, the issue had never before arisen.[196]

In the main this was all to the good. It relieved the Air Force, and particularly Wright Field, of a burdensome task. But as General Boyd continually emphasized, the center would have to follow every

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*See pages 138-148.

thread of the program with alert attention. "We can't afford to have another B-47--550 aircraft on the line before we have one suitable for combat," he declared.[197]

From the moment the B-58 became an active development, project personnel closely adhered to this policy. The process followed in selecting a basic design for the aircraft was example enough. When the MX-1964 proposal had received approval from Air Force headquarters in November 1952, it had been on the basis of Convair's design approach. No approval of a specific design was implied or intended, although in general the plan form, outline, engine provisions, and similar features were considered as part of the "approach." Between November 1952 and 24 March 1953, Convair had proceeded with preliminary work on the MX-1964, utilizing data submitted to the Air Force the preceding August. However, everyone concerned was awake to the probability that a number of changes would be required to insure satisfaction of specific military requirements.[198]

At the turn of the year Convair had been at odds with Wright Field and engineers of the National Advisory Committee for Aeronautics over the matter of the supersonic drag developed by the contractor's proposed aircraft. Rocket model and wind tunnel tests had indicated a considerable degree of unwarranted optimism on the contractor's part.[199] Between January and March the disagreement resolved itself into a matter of the application of the Jones-Whitcomb theory;* the original

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*See pages 218-220.

B-58 proposal, like Convair's initial F-102 design, was essentially inconsistent with the requirements of "the NACA Area Progression Rule." A series of conferences to discuss the application of this theory to the B-58 ended on 24 March, at which time Wright Field, Convair, and advisory committee representatives agreed on a configuration. Convair received authorization to proceed, on the basis of the agreement, toward the construction of a full scale mock-up.[200]

The chosen configuration differed in several essentials from that proposed by Convair in August 1952. Most changes were made to bring the final design into conformance with the area progression theory. This was the reason behind the adoption of a "coke bottle" fuselage shape, perfectly apparent to the observer from a glance at three-view drawings.[201] Wind tunnel and rocket model drag data were also responsible for the decision to use "split" nacelles in lieu of the "siamese" nacelles (like those inboard on the B-47) first proposed. However, Convair was instructed to continue with studies of the "siamese" nacelle design; it provided a weight saving of nearly 1,000 pounds and better maintenance characteristics, while at the same time "there were some indications during the wind tunnel tests that the penalties in supersonic drag to be incurred by the use of the siamese [nacelles] could be tolerated on the B-58."[202]

The fact that an overall design configuration had been approved and detailed work begun on it did not by any means preclude further changes. In June the Aircraft Laboratory obtained a model of the

B-58 for use in Wright Field wind tunnel work. Tests aimed at determining a correct airplane configuration were scheduled to continue into July, after which the laboratory would concentrate on obtaining basic aerodynamic data, including information on probable stability characteristics. September 1953 was the anticipated terminal date for this series of experiments.[203]

In the course of these model tests the Aircraft Laboratory expressed "particular concern" about the flutter characteristics of the B-58. The elevons and rudder (there was no horizontal stabilizer or conventional elevator) were not inherently balanced and would depend on the rigidity of their actuating systems to prevent flutter. Other factors in this situation were the position of the engines with respect to the delta wing and the fact that the expected maximum Mach number (2.1) was more than twice that of any other existent or planned bomber.

Although engineers had devised theoretical methods of predicting delta wing flutter, these were both time-consuming and unproven. Moreover, experimental delta wing flutter experience was quite meager, even for wings without externally mounted engines. Thus it was apparent to aerodynamicists that the safety of the B-58 from this particular standpoint could not be determined without recourse to a special flutter model program. The Aircraft Laboratory therefore recommended in July that a subsonic flutter model be evaluated in wind tunnels and supersonic flutter studied by means of rocket-powered models. In view of the expensive nature of the latter, rocket model tests would probably be limited in number. Work toward design and construction of the necessary models was under way at mid-July.[204]

The initial phases of wind tunnel tests at Wright Field proceeded on a priority basis through June and early July. During this operation project engineers and wind tunnel personnel set new records for obtaining and processing data. As many as 350 different test points were calibrated in a single night's activity and the data reduced to aerodynamic coefficients by the end of the next day. Over a period of several weeks this process paid dividends that would ultimately result in material acceleration of the overall program.[205]

One of the disturbing elements of the early B-58 program was the absence of a firm statement of desired military characteristics. The original set of proposed military characteristics had been drawn up by Wright Air Development Center in October 1952, but these were, in effect, supplanted by tentative characteristics forwarded from Washington to Convair late in March.[206] Project officers found strong indications that the criteria tentatively specified by Air Force headquarters were considerably in advance of the best that could be anticipated for the B-58. The whole affair was of major concern to Wright Field administraters. Convair was immediately asked to conduct a study to determine precisely which of the tentative standards were possible of attainment and what effect their adoption would have on the B-58 program. There was considerable difference between the military characteristics on which work had thus far been based and those newly proposed by Air Force headquarters.[207]

Convair's comments arrived at the center the second week of May. The center's analysis confirmed Convair's conclusion that the original appraisal prepared in October 1952 was still realistic "and that it will be impossible to meet the majority of the requirements proposed by Headquarters USAF." The major stumbling block was a contemplated change for the free-fall and missile pods; if satisfied, this would make fulfillment of range specifications quite impractical.[208]

Wright Air Development Center's comments on the proposed military characteristics were forwarded to command headquarters shortly before mid-year. In general, officials in Baltimore appeared to agree with the center's viewpoint. As well as could be determined at that time, the Air Research and Development Command would reflect the center's judgment on any recommendation sent to Washington. However, the matter was still uncertain at the end of June.[209]

There would be no XB-58 or YB-58, in the manner of the B-47 or the B-52. Instead, the first 30 aircraft in a slowly expanding production program were to be assigned to the development and test program. For planning purposes, the first airplane was scheduled for completion in January 1956--a very optimistic estimate, to say the least.[210] Production was to be maintained at a slow rate until the complete weapon system had been proved suitable for delivery to the Strategic Air Command. As a means of insuring an early first-flight

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date, the initial batch of 18 aircraft would be equipped with J57-P-15 engines. The remainder of the 30 aircraft were to incorporate prototype production versions of the General Electric J79 engine which would power the ultimate operational bomber. This process would serve two ends. It would permit flight evaluation of the airframe and major subsystems at an early date and would eliminate the maintenance problems usually associated with new engines.[211]

The XJ79-GE-1 turbojet was a single rotor, afterburner-equipped engine with variable compressor stator blades and a variable exhaust nozzle. It was designed to deliver a static thrust of 14,350 pounds with afterburner operating.[212] By the late summer of 1953 the important preliminary design details of the engine had been settled and installation drawings completed. However, still awaiting resolution were a number of questions which had arisen from conflicting design requirements stated by the engine contractor, the system contractor, and the Air Force. The design portion of the project was to be completed by the end of calendar year 1953.[213]

Although the J79 was apparently firmly scheduled for the B-58, alternate engines were probable contenders for the job in the event that unexpected delay disturbed its progress. General Electric was working on the XJ77, an engine which General Boyd described as "larger than the J79" and "intended for use in fighter and bomber aircraft in a period beyond 1957."[214] Actually, insofar as design objectives were significant, the XJ77 would be considerably more powerful than the J79. A maximum thrust output of 30,800 pounds (with afterburner) was anticipated from the engine, permitting low altitude flight to Mach 1.0 and a limit of 2.0 above 35,000 feet. However, at mid-year the funding aspects of the XJ77 were complicated when, as a result of reprogramming, the $4,000,000 allocation originally scheduled for the engine was eliminated, leaving only $440,000 which had been salvaged from the cancelled XJ53 program. This was enough to cover only the initial design work. However, changes to the schedule, and probably to funding, were expected to follow a September 1953 conference with industry to consider what type of engine would be most needed in 1958.[215]

A second engine which bore the notation "for possible installation in the B-58" was the XJ75-P-1--an advancement and substantial improvement over Pratt and Whitney's J57.[216] Contract negotiations were successfully concluded in December 1952, when the company accepted an assignment covering the first phase of XJ75 development.[217] The essential mechanical and aerodynamic design was completed shortly thereafter,[218] and by June about 95 percent of the detail parts drawings had been released for manufacture. The remainder consisted of drawings of internal parts, such as pipes and cables, which had a short manufacturing lead time.[219] The Power Plant Laboratory expected the first experimental engine to be available for evaluation in September or October 1953.[220]

Utilization of the single prime contractor concept, as had been anticipated, somewhat handicapped the Air Force when the time arrived to select firms to develop the major subsystems of the B-58. The bombing-navigation-missile-control assignment was an excellent example. Convair wanted Sperry to have the job, partly because other major electronic concerns were so completely deluged by government work that they were unable to attempt the task.[221] Project officers and personnel of the Armament Laboratory were convinced that the MA-2 ("HSBD") bombing-navigation system could be modified successfully to control missiles and would be best for the B-58. General Boyd mentioned on one occasion that the start of a new and independent effort in this field bordered on unnecessary duplication, and this too was of vital import to Wright Air Development Center.[222] However, meetings at Wright Air Development Center during February and March resulted in agreement, Convair's recommendation was accepted,[223] and on 26 March the Sperry Gyroscope Company was approved as the major subcontractor for the B-58's bombing-navigation system.[224]

The subcontract for a defensive system for the supersonic bomber was also delayed by differences of opinion over application of the single prime contractor idea. Both a tail turret and electronic countermeasures were part of the planned installation; therefore, it was important to select a firm which had experience in both types of work. Convair and Wright Field agreed that General Electric was the proper choice, and in early June the center gave formal approval to that decision. However, this approval was contingent on General Electric's acceptance of a cost-plus-fixed-fee contract, and when Convair and General Electric met on 10 July to discuss the matter, the latter "firmly declined. . . ." Convair thereupon informed the center of plans to break the system into two phases, active and passive, and to ask other prospective subcontractors to consider undertaking the overall system on this basis. The whole affair was still very much undecided in July.[225]

Performance specifications for the autopilot and flight controls, photographic reconnaissance equipment, ferret reconnaissance pod, and the missile propulsion system had been approved by the end of May. Subcontractors were selected for all but the ferret pod by 30 June.[226]

Work on the missile pod was necessarily limited by its dependence on the final configuration of the aircraft. Another complication arose in March when the "new" tentative military characteristics forwarded from Washington specified a missile with a range of 100 nautical miles and a maximum target error of 2,500 feet. The original requirement had been 50 nautical miles and 2,500 feet. Convair felt that while range extension was itself relatively simple, involving only expansion of fuel storage provisions, accuracy was another question. The missile pod would be inertially guided, and the contractor maintained that gyro drift for 100 nautical miles would probably result in an accuracy error averaging 4,500 feet rather than 2,500.[227]

In resolution of this issue, the center recommended that initially the 50 nautical mile missile be accepted, with a view toward ultimately increasing range to 100 nautical miles when weapon yields increased and inertial guidance systems improved.[228]

In other respects, little could be done to establish more detailed specifications for the missile pod. Nevertheless, keeping in mind the inherent complexities and uncertainties that would accompany any program intended to provide a weapon system as radically advanced as the B-58, overall progress was more than satisfactory. Accessory problems involving the application of the weapon system concept and the single prime contractor idea made initial settlements more difficult than usual. This also contributed to a slow start. But in the final analysis full utilization of the weapon system and unified development theories could not but have a beneficial effect on the ultimate rate of progress. Unless some unexpected and exceptional mishap disturbed the schedule, the B-58 would reach operational units well within the period when it could be most profitably used.

Notes, Chapter XI

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56. WADC Staff Analysis, B-47 ECM Program, 17 Dec. 1952, prep. by Lt. Col. R. B. Kuhn, B-47 Br., WSD, see App. K-7.

57. Sum. of WADC Wk. Conf., 14 Jan. 1953.

58. Ltr., Maj. Gen. A. Boyd, CG, WADC, to Lt. Gen. E. E. Partridge, CG, ARDC, 16 Jan. 1953, no subj., in CG files: Mo. Ltr.

59. Ltr., Maj. Gen. A. Boyd, CG, WADC, to Lt. Gen. E. E. Partridge, CG, ARDC, 10 Feb. 1953, no subj., in CG files: Mo. Ltr.

60. Ltr., Lt. Gen. E. E. Partridge, CG, ARDC, to Maj. Gen. A. Boyd, CG, WADC, 6 Mar. 1953, no subj., in CG files: Mo. Ltr.

61. Ltr., Boyd to Partridge, 10 Feb. 1953.

62. Remark by Col. M. C. Demler, Vice Cmdr., in Sum. of WADC Wk. Conf., 11 Feb. 1953.

63. Remark by Maj. Gen. A. Boyd, CG, in Sum. of WADC Wk. Conf., 11 Feb. 1953.

64. Aero Med. Lab. DAR, 11 Mar. 1953; WADC WOR, 12 Mar. 1953.

65. Memo., Lt. Col. M. P. Hays, B-47 Br., WSD, to Col. V. R. Haugen, D/Ops., 1 Apr. 1953, subj.: Action on ECM for B-47, in C/S files: Electronics.

66. WADC WIR, 10 July 1953.

67. Memo., Maj. Gen. A. Boyd, CG, WADC, to Lt. Gen. E. E. Partridge, 4 May 1953, subj.: B-47 ECM, see App. K-18.

68. Ltr., Boyd to Partridge, 10 Feb. 1953.

69. Remark by Maj. Gen. A. Boyd, CG, in Sum. of WADC Wk. Conf., 11 Feb. 1953; Sum. of WADC Wk. Conf., 18 Feb. 1953.

70. DF, Col. C. H. Lewis, Chief, ARL, to Ops. Office, Dir/Labs., 4 Mar. 1953, subj.: Items for Monthly Letter from Gen. Boyd to Gen. Partridge, in Exec. Secy. files: Mo. Ltr. to Gen. Partridge (Data).

71. Memo., Col. H. Y. Sewart, Asst. C/S, to Maj. Gen. A. Boyd, CG, 11 Mar. 1953, subj.: Monthly Letter to ARDC, in Exec. Secy. files: Mo. Ltr. to Gen. Partridge (Data).

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73. WADC WOR, 18 June 1953.

74. WADC WIR, 19 June 1953.

75. AMC WAR, 9 Mar. 1953.

76. Ltr., Brig. Gen. G. A. Blake, Vice Cmdr., WADC, to CG, ARDC, 28 Nov. 1952, subj.: Test Directive No. 5093-F-1, see App. K-2.

77. ARDC Test Directive 5093-F-1, 26 Sept. 1952, in Dev. Ops. Div., DCS/O, files: Tech. Directives.

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79. Ltr. (1st Ind.), Maj. Gen. D. L. Putt, Vice Cmdr., ARDC, to CG, WADC, 5 Jan. 1953, subj.: Test Directive No. 5093-F-1, see App. K-2a.

80. Sum. of WADC Wk. Conf., 11 Feb. 1953.

81. WADC WIR, 17 July 1953.

82. DF, Mr. R. F. Cunningham, Actg. Asst. Chief, Dev. Ops. Div., D/Ops., to Col. S. R. Stewart, C/S, 1 Apr. 1953, subj.: Progress Report on Human Factors in B-47 Operation, see App. K-13.

83. Sum. of WADC Wk. Conf., 11 Feb. 1953.

84. WSD DAR, 4 Apr. 1953, see App. K-14.

85. WADC WOR, 15 Jan. 1953 & 5 Mar. 1953.

86. Ibid., 5 Mar. 1953.

87. Ibid., 26 Mar. 1953.

88. WADC WIR, 17 June 1953.

89. WSD DAR, 1 Apr. 1953.

90. Photo. Recon. Lab. DAR, 20 Feb. 1953.

91. AMC WAR, 6 July 1953.

92. ARDC Form 82, R-426-266, 27 Aug. 1953.

93. Ltr., Mr. E. S. Thompson, Mgr., Contr. Ops., Airc. Gas Turbine Div., General Electric Co., to CG, AMC, attn.: Maj. Fred Sporer, 24 Nov. 1952, no subj., see App. K-1.

94. DF, Col. N. C. Appold, Chief, PPL, to Col. M. C. Demler, C/S, 3 Dec. 1952, subj.: Bailment of B-47B Aircraft at General Electric Company for Improvement of J47 Engines, see App. K-3.

95. Memo., Col. M. C. Demler, C/S, WADC, to Maj. Gen. C. S. Irvine, Dep. Cmdr. for Prod., AMC, 4 Dec. 1952, subj.: Bailment of B-47B Aircraft to General Electric Company for Flight Testing, see App. K-5.

96. ARDC Form 82, S-506-224, 1 Aug. 1953.

97. WADC WOR, 22 Jan. 1953 & 12 Feb. 1953; Sum. of WADC Wk. Conf., 21 Jan. 1953.

98. C&S Lab. DAR, 15 Jan. 1953.

99. AMC WAR, 25 May 1953.

100. WADC WIR, 10 July 1953.

101. Memo., Col. C. P. Walter, B-47 Project Office, WSD, to Maj. Gen. A. Boyd, CG, 6 Mar. 1953, subj.: Delay in the XB-47D Program, see App. K-11; Dev. Plan, The B-47 (RB-47) (DB-47/B-63) Weapon System, 25 Sept. 1953, p. 9.

102. Memo., Walter to Boyd, 6 Mar. 1953, see App. K-11.

103. Proj. Status Rpt., MX-1637, 15 Mar. 1953, in Hist. Div. files.

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105. WSO DAR, 17 Mar. 1953.

106. Ibid., 20 Apr. 1953.

107. ARDC Form 82, S-506-234, 15 June 1953.

108. WADC WIR, 19 June 1953.

109. Dev. Plan, The B-47 (RB-47) (DB-47/B-63) Weapon System, 25 Sept. 1953, p. 9; Standard Aircraft Characteristics (Green Book), prep. by Flight Data Br., DCS/O, XB-47D, 13 July 1953 & B-47B, 16 May 1953.

110. Ltr., Maj. Gen. A. Boyd, CG, WADC, to CG, ARDC, 26 Mar. 1953, subj.: Utilization of Test Airplane No. 50-082 (ex-YB-47C), see App. K-12; Dev. Plan, The B-47 (RB-47) (DB-47/B-63) Weapon System, 25 Sept. 1953, p. 9.

111. Ltr., Boyd to CG, ARDC, 26 Mar. 1953, see App. K-12.

112. Sum. of WADC Wk. Conf., 7 Jan. 1953.

113. Ltr., Maj. Gen. A. Boyd, CG, WADC, to Lt. Gen. E. E. Partridge, CG, ARDC, 14 May 1953, no subj., see App. K-19.

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117. Presn., The B-47 Potential, 26 May 1953.

118. Remarks by Lt. Gen. E. E. Partridge, appended to presn., The B-47 Potential, 26 May 1953.

119. Dev. Plan, The B-47 (RB-47) (DB-47/B-63) Weapon System, 25 Sept. 1953, p. 9.

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132. WADC WOR, 30 Apr. 1953.

133. Memo., Bradley to Rawlings, 30 Mar. 1953.

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137. Proj. Status Rpt., MX-839, 16 Apr. 1953; ARDC Form 82, R-506-169, 30 Apr. 1953; memo., Bradley to Rawlings, 30 Mar. 1953; WSD DAR, 13 Apr. 1953.

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149. Arm. Lab. DAR, 21 Jan. 1953.

150. WADC WOR, 7 May 1953; WADC WAR, 26 June 1953.

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152. Proj. Status Rpt., MX-833, 16 Apr. 1953; WADC WAR, 26 Mar. 1953.

153. WADC WIR, 5 June 1953.

154. Presn., The B-52 Aircraft, 15 July 1953.

155. AMC WAR, 18 May 1953.

156. DF, Rowe to Plans and Programs Office, Dir/Proc. and Prod., AMC, 24 June 1952; presn., The B-52 Aircraft, 15 July 1952; AMC WAR, 18 May 1953; memo., Jeffrey to Partridge, 20 May 1953.

157. Dev. Plan, The B/RB-52 Weapons System, 25 Sept. 1953, p. 23, prep. by B-52 Proj. Office, Dir/Air Weap. Sys., in Proj. Control Br., DCS/O, files: Dev. Plans.

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172. Ltr., (Ist ind.), Col. J. C. Maxwell, Chief, Bomb. Airc. Br., WSD, WADC, to CG, ARDC, 4 May 1953, subj.: Refueling Compatibility KC-97/B-52, in Dir/Strat. Combat Sys., D/Dev., ARDC, files: B-52, Study, Design, Mock-Up; ltr., Col. T. S. Jeffrey, Dir/Strat. Combat Sys., D/Dev., ARDC, to Dir/R&D, DCS/D, USAF, 21 May 1953, subj.: Refueling Compatibility KC-97/B-52 Aircraft, in Dir/Strat. Combat Sys., D/Dev., ARDC, files: B-52, Study Design, Mock-Up.

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179. WADC WIR, 24 July 1953.

180. Presn., The B-52 Aircraft, 15 July 1953.

181. Presn., The B-36 Status, by Lt. Col. D. E. Good, B-36 Proj. Officer, in Sum. of WADC Wk. Conf., 13 May 1953.

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183. D/Ops. DAR, 29 Dec. 1952.

184. AMC WAR, 16 Feb. 1953.

185. WADC WOR, 4 June 1953; WADC WIR, 5 June 1953.

186. Airc. Lab. DAR, 18 Mar. 1953.

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188. USAF Aircraft Characteristics Summary (Black Book), B-36H, 11 July 1953, prep. by Flt. Data Br., D/Ops., in Hist. Div. files.

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190. Air Weapons Review, I, No. 1, Mar. 1953, pp. 30-31.

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193. Hist. Rpt., WSD (MX-1964 Proj. Office), 1 Jan.-30 June 1953.

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196. Memo., [Lt. Col. J. W. Howell, B-58 Proj. Office] to Maj. Gen. A. Boyd, CG, late Feb. 1953, subj.: Informal Memo to General Boyd - General Status of MX-1964 (B-58), see App. K-10.

197. Remark by Maj. Gen. A. Boyd, CG, in Sum. of WADC Wk. Conf., 18 Feb. 1953.

198. Hist. Rpt., WSD (MX-1964 Proj. Office), 1 Jan.-30 June 1953.

199. "Hist. of WADC, July-Dec. 1952," pp. 353-355.

200. Hist. Rpt., WSD (MX-1964 Proj. Office), 1 Jan.-30 June 1953.

201. Black Book, XB-58 (Version I), 12 Aug. 1953; Proj. Status Rpt., MX-1964, 14 May 1953.

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204. WADC WIR, 10 July 1953.

205. Ibid., 17 July 1953.

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209. TT, NR 11063 (Hq. ARDC to CG, WADC, attn. Bomb. Br., WSD), 6 June 1953, in MX-1964 JPO files; WADC WIR, 19 June 1953.

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215. ARDC Form 82, R-506-258, 29 June 1953.

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217. ARDC Form 82, R-506-259, 12 June 1953.

218. DF, Mr. E. C. Phillips, Chief, Ops. Office, PPL, to P&O Office, Dir/Labs., 30 Mar. 1953, subj.: Monthly Letter from General Boyd to General Partridge, in Exec. Secy. files: Mo. Ltr. to Gen. Partridge (Data).

219. ARDC Form 82, R-506-259, 12 June 1953.

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222. Ltr., Maj. Gen. A. Boyd, CG, WADC, to Lt. Gen. E. E. Partridge, CG, ARDC, 13 Mar. 1953, no subj., in CG files: Mo. Ltr.

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XII STRATEGIC BOMBER SYSTEMS - UNMANNED

To a nation which still treasured human life above materiel, the guided missile was an obvious boon. A properly designed and operationally suitable missile could achieve all the aims of a strategic bombing offensive without requiring the sacrifice of a single flier, and no matter how effective manned bombers became, they could never guarantee this. The pilotless strategic bomber had other advantages as well. It could deliver lethal warheads to targets hitherto unattainable by conventional means. Strong enemy defenses, unfavorable weather, and extreme distances meant little. Only in their presumed ability to survive more than one assignment did manned bombers promise any significant advantage over the unmanned variety. However unfavorable the circumstances, it was unthinkable that all of the conventional aircraft dispatched on a bombing mission would become casualties; in the case of the guided missile the entire cost of production, fabrication, and preparation was consumed in the dust and smoke that signaled "mission accomplished."

If a logical development pattern which appeared to provide for every possible demand over a long period of years could be taken as an indication of probable success, the Air Force was well prepared for the transition between manned and unmanned bombers. Ever greater dependence on missiles for the strategic bombing assignment was indicated by the development schedule. The supersonic but short range B-63

Rascal, an air-launched vehicle, would be available in roughly the same time period as the long range but subsonic B-62 Snark. Many of the inherent disadvantages of each would disappear with the introduction of the B-64 Navaho, which had both long range and supersonic flight ability. The final step--at least for the time being--was the Atlas ballistic spacecraft, designed to hit almost any spot on the earth from launch stations within the boundaries of the United States.

In these four was bound up the major guided missile effort in support of strategic bombardment requirements. But particularly in the period after mid-1952, other and unique assignments were suggested. Missiles equipped with photographic, radar, or television reconnaissance devices appeared to be a profitable field for investigation. The idea of a radar-seeker missile to destroy enemy ground electronic installations rapidly gained favor. Decoys, intended to confuse enemy defenses both by their mere presence and by active interference with defensive radar, also provided the Strategic Air Command with an attractive means of increasing the overall potential of the Air Force offensive.

Work on the radar-seeker got under way in August 1952 with the receipt of an interim directive from headquarters of the Air Research and Development Command. The objective of the preliminary investigation was to select from available missiles or drones one that could detect and destroy enemy radar antennas of several types. It would be launched from carrier aircraft cruising just outside the enemy radar curtain immediately prior to a strike by Air Force strategic bombers. Preset to the frequency of the station it was to destroy, the missile would follow the radar signal to within a specified range of the antenna and then dive into the target.[1]

In the words of the project officer, "Sensing the urgency of the situation, and the short time available for study, the WADC contacted directly the manufacturers of various missiles and drones, soliciting their recommendations for adaption of their missiles to the problem."[2] The most encouraging reactions came from Radioplane, Ryan, and Bell, contractors respectively for the Q-1 and Q-2 drones and the (Navy) Meteor missile. Evaluation of these three proposals was complete in January; the Q-1 was chosen as the best available for the anti-radiation mission. The identification code MX-2013 was assigned to the proposed modification. Massachusetts Institute of Technology agreed to undertake the alteration of a Navy-developed seeker, and several agencies were called in to assist in the design of a special warhead.[3]

Since the Q-1 was well along in development, the remaining problems centered about adapting the vehicle, acquiring a suitable seeker and warhead, and flight testing the complete system. Securing test facilities at Holloman posed a momentary difficulty but by May reasonable satisfactory arrangements had been made.[4] Funding difficulties also intruded, and in this instance no solution appeared before mid-year.[5]

Other facets of the work proceeded rather well. Fuze, warhead, and vehicle tests were set for the later portion of 1953.[6] The first working model of a seeker was shipped to Radioplane on 17 June, two weeks ahead of schedule.[7] However, captive flight tests, originally programmed for July, were delayed when the B-26 assigned to the program was recalled for overhaul. They were subsequently rescheduled for September. The first free flight tests of the system would probably not be attempted before December.[8]

Although some obstacles existed in almost every area of the complete system, none seemed to be of such nature as to precipitate a major slippage. The outstanding production problem was centered about the Americanization of the French-designed Marbore V engine (YJ69-T-7) utilized in the Q-1.[9]

Development of a decoy missile to confuse and dilute the enemy's air defense system with realistic but false target signals was undertaken in a tentative fashion shortly before the end of the fiscal year. The project stemmed from a Strategic Air Command request, early in March, that the research and development command assemble and evaluate available missiles and components to determine the feasibility of a decoy technique. The initial decoy was to be carried by bombers and to have a range of 200 nautical miles.[10]

About six weeks later, the center learned informally that a set of general operational requirements for two decoys--one to be long range and surface-launched, the other short range and air-launched--was in existence. But a call to Baltimore uncovered the fact that neither command headquarters nor Air Force headquarters was entirely satisfied with its contents.[11] Nevertheless, on 11 May, the former forwarded the operating requirements to Wright Field with the request that a development plan be evolved. Since the projected operational date was 1 July 1955, Baltimore conceded that it ". . . automatically dictates the use of on the shelf components in lieu of any long term development projects."[12]

By mid-June, Wright Field had completed the preliminary development plan.[13] At first glance, the Q-1 and Q-2 drones appeared to be the most likely candidates; therefore, the center immediately began negotiating with Radioplane and Ryan for feasibility studies.[14] In the interim, pending receipt of a development directive and more definite information from higher headquarters, Wright Field marked time.[15]

Several reconnaissance systems based on missile cartage were at the stage of being seriously considered,* and here again, as in the case of the proposed decoy and radar-seeker missiles, careful thought was given to the possibility of adapting available pilotless aircraft to the job. In some instances, as with the TV-CQ-19, the vehicle was better suited to tactical operations, in direct support of battlefield action, than reconnaissance of targets destined for strategic bombardment.

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*The RB-62, reconnaissance version of the Snark, is discussed separately. See pages 523-525.

But the majority of the proposals dealt more or less directly with the idea of devising an inexpensive method of accomplishing strategic reconnaissance--and drone missiles seemed to be the most promising unexplored area.

Rand Corporation was devoting attention to a reconnaissance system which would rely on radio transmission of radar or photographic intelligence from a missile cruising 60,000 feet over enemy territory to a relay aircraft 500 miles distant, and thence to friendly territory. Basing his conclusions largely on information supplied to him by Wright Field laboratories, Dr. Lewis Larimore of Rand suggested in July that missiles, transmitters, receivers and accessory equipment currently in existence were suitable for adaptation to the mission. However, there was at the time no indication that this proposal had received the high level approval necessary to convert it into something concrete.[16]

January flight tests of the TV-OQ-19--a television-equipped drone--produced evidence that available television equipment installed in a target drone would supply some portion of the intelligence required for tactical reconnaissance in a battlefield area, but again no immediate application of the information appeared to be planned.[17]

It was evident in 1953 that both the Q-1 and Q-2 were potential "triple-threat" missiles. Not only were they candidates for roles as anti-radiation and decoy vehicles, but they seemed to qualify as strategic reconnaissance agents as well. In July the Q-2 displayed that it had at least one of the major qualifications for this task; during an experimental flight at Holloman Air Development Center an XQ-2 attained a true air speed of 656 miles per hour at 22,500 feet—leaving an F-86 chase airplane far behind.[18]

On 1 April headquarters of the Air Research and Development Command asked for a Wright Field evaluation of the potential of a television-equipped Q-2 Firebee drone. The center's reply reflected the basic feasibility of such an expedient.[19] This particular proposal was aimed at satisfying the need for battlefield surveillance, and the preliminary reply from Wright Air Development Center was so favorable that it elicited a request for a detailed test proposal.[20] However, on the face of it, there was no reason why the air-launched Firebee could not be as readily adapted to the needs of strategic reconnaissance. Therefore, the issuance of a contract for a feasibility study of that idea was logical. On 1 July Ryan received the necessary contractual authority and began work on such a study.[21]

Wright Field also examined the possibility of employing the Q-1 in the strategic intelligence mission. By 25 May, Radioplane had submitted a proposal of this nature.[22] Center engineers found that it contained several appealing features and began negotiating a formal contract for a complete feasibility study. At mid-year only legal technicalities held up signature.[23]

Apart from the missiles and drones which were being considered for accessory missions, and distinct from the development missiles of comparatively long standing, were two preliminary proposals which might well become research and development projects in the near future. The need for an air-to-surface missile specifically tailored to the B-47 and the B-52 had been long apparent, although the B-63 Rascal was generally conceded to be reasonably well suited for use by these aircraft. In April, Bell and Boeing undertook design studies of "an optimized" air-launched missile "that would increase the weapon system range of the B-47 and B-52."[24]

Somewhat later in the year, Wright Field missile experts received and analyzed proposals from Boeing, Northrop, and North American "for a long range, turbojet powered, strategic pilotless bomber having a supersonic dash capability of approximately 1000 n. miles at speeds in excess of Mach No. 2.0." Contracts for appropriate studies were delivered to Northrop and North American on 24 June and the center hoped that final results would be available for analysis within four months. Each firm was also directed to consider the possibility of adapting the Snark and Navaho missiles to the assignment.[25]

Further indications of constant progress in the development of entirely satisfactory long range pilotless aircraft were not lacking. At the end of April, for instance, Rand concluded an analysis of the status of stellar inertial navigation systems with the hopeful statement that such devices "will soon be satisfactory." Although operational availability dates were still in the uncertain future, this was principally because of the advanced state of the art required. Rand recommendations for a future course of action mentioned the virtual necessity of starting the production of components considerably in advance of system production, the advantages of separating component manufacturing from system manufacturing and assembly, and the probability that a "catalog-selection" process might benefit system manufacturers concerned by the need for securing the best available components.[26]

From another standpoint the general topic of missile development was coming to have a new meaning for Wright Air Development Center. Several of the leading missiles were in a transition stage between research and development and the early aspects of production engineering. This was a new situation, and one for which the Air Force was probably not fully prepared. The differences between the research and development processes suitable for missiles and those best fitted to aircraft had only become apparent at a time when the gap between them was narrowing. There was some controversy within the Air Force and between the Air Force and its contractors concerning the matter of "over-engineering vs. under-engineering" as it applied to pilotless aircraft. By mid-1953 it was clear that issues resulting from missile development were gradually approaching the status of contemporary aircraft problems. There was little doubt that the courses followed in each were slowly converging.[27]

The B-63 Rascal

As the Rascal missile came within sight of its goal--operational readiness--its development program tended more and more to diverge into two distinct but parallel efforts. For the moment the completion of work on the basic missile remained of paramount importance, yet adaptation of prospective carrier aircraft to the task of transporting the pilotless parasite bomber became ever more urgent.

In January 1953 the transition from work with the test vehicle for Rascal--the X-9 Shrike--to flight analysis of the basic XB-63 was completed. The first "hot" Shrike had been launched in June 1950.[28] The last intact X-9 was expended on 23 January 1953 in tests of a chemical warhead.[29] In that period the Air Force obtained a great deal of information which was directly applicable to the ultimate Rascal. The Shrike had been an extremely useful test vehicle.[30] But its passing brought no great sorrow, since the first full scale, rocket-powered XB-63 had made its initial flight on 30 September 1952 and further work would be with this prototype.[31]

Two additional XB-63's were flown at Holloman in the course of the six months. The fourth, scheduled to be the first Rascal to fly under the control of its own guidance system, was delayed past mid-year by difficulties with the guidance equipment.[32]

Malfunctions of the remote control system disturbed the tests of the last two Shrikes, but representatives from the Army Chemical Center who observed the flights reported that the data obtained had been adequate nonetheless.[33] Fortunately, the second and third XB-63 flights were satisfactory in almost all respects, regaining some prestige for the program. Flight number two, on 15 January, successfully demonstrated servo stabilization, power plant performance, and flight ability, as well as supplying information on vibration and pitch characteristics. The flight proceeded almost precisely according to plan, the Rascal reaching a maximum velocity of Mach 1.39 and covering slightly more than 30 nautical miles.[34] The third test, on 13 March, virtually duplicated the performance of the second. In this instance the missile specialists gathered additional data on servo system operation, aerodynamic characteristics, the efficiency of the propulsion system, and the recovery parachute.[35]

Handicaps to the steady improvement of the missile itself were mostly confined to a few components or caused by funding. In January the project officer reported that a $4,000,000 deficiency existed in fiscal year 1953 funds. Unless additional money became available before the end of the month, effort at the contractor's main plant would have to be reduced by at least 15 percent.[36] The required supplement was not forthcoming, so, on 13 February, Bell cut back the rate of work. Fortunately, some increased funds were allotted to the Rascal project in March and the work reduction did not prove so severe as first anticipated. Nevertheless, so tight was the budget that the work schedule for the balance of the fiscal year had to be predicated on the assumption that fiscal year 1954 funds would be made available to the contractor on the first day of the new accounting period.[37]

Major component difficulties centered about the guidance system and the propellant pump for the rocket engine. In January the effects of past difficulties with the fuel pump forced another slippage in the scheduled flight test program. Project officers believed that a concurrent lag in preparations for the delivery of director aircraft more than overlapped this, indicating that the delay in operational availability would be more dependent on the status of carriers than on the B-63 itself.[38] At any rate, adoption of a turbine pump fuel system, scheduled for all except five of the programmed XB-63's, appeared to offer a feasible solution to the fuel system problem.[39]

Neither single-operator terminal guidance nor the inertial mid-course guidance system would be ready in time for use in the first guided XB-63, to be launched in July. Instead, an interim arrangement containing a radiating mid-course control and a two-station terminal guidance director would be utilized.[40] A complete prototype of the eventual guidance system was not scheduled for delivery until the middle months of 1955.[41]

Both B-47 and B-36 aircraft were slated for modification to carry Rascal missiles. The B-52, for which plans were somewhat more uncertain, had space provisions for the B-63, but for the moment it was not definitely listed among the prospective launch aircraft.[42] A total of 12 B-36's and 19 B-47's were initially scheduled for conversion; total cost would approach $43,000,000.[43]

Early in 1953 the Air Materiel Command received instructions from Washington to provide three DB-47's and three DB-36's by July 1954 for operational suitability tests in conjunction with the Rascal system.

Wright Air Development Center promptly registered an exception to this procedure, citing the fact that basic research and development would not be complete before December 1954 and that any system subjected to such tests would still be experimental in nature. There was little doubt that a major retrofit program would subsequently be required if the suitability tests were based on experimental equipment.[44] The plan to start such tests at a time when basic development still had not been completed was part of an attempt to make the parasite bomber systems operationally available at an early date, but apart from the underlying contradiction involved in such a procedure, there were several factors which made its success somewhat doubtful. The major deterrent was that "Y-models" of the director aircraft and of the missile check-out equipment could not possibly be ready in time.[45]

Representatives from Air Force headquarters, the Air Materiel Command, the Strategic Air Command, and Wright Air Development Center met on 26 May to review this aspect of B-63 plans. The persistence of engineering difficulties in both the Rascal and the prospective carriers virtually insured that the operational suitability tests could not be conducted on schedule, in addition to which there was substantial objection to the procedure of simultaneously carrying on research and development and operational tests. Free discussion of these circumstances spotlighted the handicaps. Therefore at the end of June there appeared to be a good chance that both the suitability tests and the operational availability dates would be retarded to correspond to the realities of the situation.[46]

The apparently widespread expectation that Rascal would be operationally ready at an early date troubled project officers--who were considerably less optimistic about the whole affair. In April, for example, the project office warned that the term "prototype" was being improperly applied to the first DB-36's and DB-47's to be procured. They were to be designated YDB aircraft, and the office felt that this nomenclature had encouraged a misunderstanding of their intended use. In actuality, they would not be prototypes in the commonly accepted sense of the word but would be used principally for development flight testing of the B-63 system and, therefore, should properly be considered flying test beds.[47]

Progress toward a fully modified DB-36 was appreciably faster than the corresponding DB-47 work. In November and December 1952 the first mock-ups of the two aircraft had been examined, and while the DB-36 design was approved, that of the DB-47 had been found wanting in several respects.[48] On 25 January 1953 a second mock-up board decided that a revised DB-47 configuration was essentially acceptable, although submitting several recommendations for changes. Work on the flight test version began almost immediately.[49]

Structural modification of the YDB-36 was completed and a development engineering inspection held by 26 June; the first flight occurred on 3 July.[50] Two weeks later Convair flew the YDB-36 with a dummy missile stowed in the bomb bay. Reported the project office: "No noticeable differences in flight characteristics of the composite YDB-36 were observed."[51] After conducting further flight tests with the stowed mock-missile to prove out flight characteristics in a wide range of conditions, the contractor planned to drop the dummy in flight as a test of the launch mechanism.[52]

This then was the situation at the start of fiscal year 1954: the XB-63 was flying, and would shortly be tested in guided as well as powered flight; although engineering problems of some considerable weight remained unsolved, difficulties in component work did not threaten the overall schedule; the YDB-36 was in flight test and the YDB-47 fast approaching that stage. For the moment the only impediment to rapid qualification of the B-63 system for operational use appeared to be the time required to perform necessary engineering and test work. This was a process that could not be greatly compressed, so much did eventual success depend on the prosaic matter of applying the results of one test to the conduct of the next.

The B-62 Snark

Just as the Rascal was admittedly an interim device for adding supersonic capability to the striking potential of existent bombers, so, in a sense, was the B-62 Snark a provisional means of extending the striking power of the Strategic Air Command past the range of these bombers. Ultimately each of these missiles would give way to one which combined the speed of the first with the range and all-weather ability of the other. But in view of the fact that wars were rarely timed to coincide with the completion of a research and development program, a long range pilotless weapon system capable of operating in the relatively near future was a necessary article for the Air Force arsenal.

Unfortunately for the complete success of this estimable plan, affairs did not run entirely smoothly for the B-62 Snark in the first half of 1953. Three major difficulties made a clear definition of the future course of Snark development temporarily impossible. One of these was technical in nature--delay in the perfection of a satisfactory guidance system. The others were administrative in that they involved, first, a major reorganization of the contractor's engineering department and, secondly, an appreciable departure from the funds schedule.[53]

Evidence of Air Force uneasiness over the status of the Northrop organization reached Wright Air Development Center in mid-January. Brigadier General F. B. Wood, deputy for development at command headquarters, wrote General Boyd that his office was not concerned by the reorganization itself, but by the chance that "the recently established development schedule for the B-62 . . ." would no longer be valid. He mentioned the undesirable frequency of program slippages over the past years and added, "This weapon is of great importance to the future Air Force inventory and every effort should be employed to insure that additional slippages are not incurred."

The present danger, advised General Wood, was that some of the key personnel employed in the Snark program would either resign or be released as a consequence of the reorganization. There was also a chance that flight test activity at Patrick might be adversely affected by the job uncertainty among Northrop employees. "Either of the above eventualities would be serious to the SNARK program," the general concluded.[54]

A few days later, General Boyd advised command headquarters of his feeling that "while there might be some immediate loss in efficiency within the Company as a result of the organization action [recently] taken , . . . I believe that in a reasonable period of time we can expect greater efficiency with a higher quality of engineering." He further cautioned against precipitate action with the counsel, ". . . patience within reason may be our best approach to the Northrop problem at present."[55]

After more information became available, General Boyd informed General Wood that from all appearances the reorganization would improve Northrop's effectiveness. "Moreover," he continued, "there appears to be ample realization within the company of the importance of the B-62 to the Air Force and to the company." Finally, although the firm had reassigned certain personnel, there had been no large scale resignations and the apprehensions entertained by company engineers seemed to have been dissipated without major incident.[56]

Despite the favorable implications of the reorganization, the Air Force was cautious about relying too heavily on the good intentions of the new management. At about the same time that General Wood inquired of General Boyd about the stability of Northrop's program, General Bradley was writing directly to the new president of the company, retired General O. P. Echols. He called attention to two areas where the firm had fallen down in recent months. Foremost was the program schedule. A "firm" program had been drawn up and accepted by all concerned in March 1952, after earlier setbacks had delayed the development of the B-62. Re-examination of this schedule in December 1952 had uncovered evidence of new slippages, and a revision was arranged. But only one month later Northrop had advised the Air Force that the December schedule was unrealistic, and that it would have to be revised again to reflect a new four-month slippage.

Second in listing, but perhaps of equal importance, was funds. In November 1952 the aircraft contractor had signed a definitive contract covering the period through 30 April 1953. Subsequently, program revisions and lessened funds availability had necessitated a reduction of work. This information had been communicated to Northrop but apparently had made no impression. At any rate, on 12 January a Northrop representative informed the Air Materiel Command that "a substantial increase in funds" would be required to carry the assigned program through the balance of the fiscal year.

General Bradley assured General Echols that the Air Force appreciated "the magnitude and the multitude of problems associated with the development of the B-62" and also recognized that on occasion conditions arose about which the company could do nothing. "On the other hand," he added, "wild fluctuations in schedules and budget requirements as indicated by the above examples places the Air Force in an almost untenable position."[57]

Positive information on the extent of the funds lack and the total of over-expenditure incurred by the contractor was not immediately available. But by March it was apparent that the completion of work programmed for the rest of the fiscal year would require a further authorization totaling $2,600,000. The contractor in exceeding the directed rate of expenditure had incurred an additional funds deficiency of $3,800,000.[58]

Money for the remainder of fiscal year 1953 could probably be secured without too much difficulty since that deficit had been anticipated, but the $3,800,000 overrun was another matter entirely. Project personnel filed the conventional request for essential fund increments, (production and research and development monies both had to be tapped), but simultaneously estimated that this reprogramming would create a deficiency in excess of $10,200,000 in the center's fiscal year 1954 budget for Snark. The only way of recovering this difference was to eliminate effort on second priority warheads and forego modification of the B-62 to supersonic configuration. Another immediate consequence of reprogramming would be a slowing of the rate of work to correspond to funds availability in the next fiscal year. This action would have the effect of causing another five-month slippage in the development schedule.[59] An alternative solution, but one which would only partially alleviate the crisis, was to shift a greater proportion of the financial load to the Air Materiel Command. The project office proposed this action in May, suggesting that the materiel command assume funding responsibility for a variety of items including engineering changes, production and design drawings, design tests, prototype equipment, and flight test equipment.[60]

These were, in the main, problems for fiscal year 1954 funding. The most critical issue was obtaining enough funds to keep development moving until the end of fiscal year 1953. Considerable reprogramming was required, but eventually the money was secured and the Snark program took another lease on life.[61]

At one time, early in its life, Snark had been scheduled to start service tests in January 1952 and to be available to operational squadrons by January 1953.[62] Continual difficulties with airframe, propulsion, guidance, and a multitude of other components had caused a gradual but steady slippage over a period of years. At the beginning of 1953, no reliable estimates were available of how long it would take to complete research and development and qualify the missile for operational use. This condition persisted in May and June, principally because the new management of the Northrop firm was trying to establish realistic dates but also because engineering and flight test difficulties introduced new uncertainties.[63] At the end of June 1953, planners placed the operational availability date for the B-62 at about December 1957--one and one-half years later than the most pessimistic of previous estimates. Basic research and development was scheduled to end in June 1956.[64]

Flight experience had thus far been limited to dynamic models and experiments with the N-25 version of the eventual missile. The N-25 was actually a small scale semi-prototype, and as such did not completely reproduce the performance expected of the XB-62. Flights of the XB-62 itself, for a time scheduled to start in December 1952, were gradually set back until the first-flight date had slipped into fiscal year 1954.[65] Nevertheless, a considerable amount of useful data was acquired from experience with several flights of the N-25 version in the first six months of 1953.

The third of these "live bird" flights took place at Patrick Air Force Base on 6 February.[66] (Flights number one and two had been completed late in 1952.)[67] Terminal dive evaluation was the major objective, although engineers were also interested in obtaining additional data on operation in the launch and mid-course phases. Previous experience had indicated the unsuitability of the braking mechanism--a drag parachute--for insuring stability throughout the dive into the target, so the 6 February flight incorporated a modified parachute with increased porosity. Nevertheless, it ended in much the same fashion as earlier flights; the missile disintegrated in the final phase of its dive.[68]

The basic difficulty appeared to be very much like that which affected Matador missiles.* Aeronautical engineers felt that the missile's survival through the terminal phase depended on maintaining a speed of less than Mach 1.0 throughout the dive, as well as a flight pattern which permitted a "zero lift" trajectory. A drag parachute had earlier been added to guard against excessive dive speeds and severe oscillation. On the first test flight the parachute had failed to deploy, and structural failure had followed. The second flight was entirely successful, but any encouragement it offered disappeared when results of the third (6 February) flight were made available for detailed analysis. Telemetered data revealed that the parachute had actually induced oscillations which contributed to missile breakup. On the basis of this evidence, designers abandoned the drag chute expedient and planned to try once again the idea of maintaining "zero lift" by means of trim tab settings.[69]

A fourth and last in this series of tests was postponed to await completion of Northrop's studies of flight control during terminal dive. The contractor finally decided against any attempt to keep the missile in the subsonic speed zone throughout terminal dive. Engineers hoped that close tolerances in control settings would maintain stability and prevent breakup.[70]

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*See pages 352-358.

The fourth launching finally took place on 10 March. Take-off and climb to altitude went according to plans; however, after 18 minutes of flight the test vehicle began behaving erratically and all attempts at control failed. After oscillating wildly in pitch and roll, it finally entered an uncontrolled dive from an altitude of 27,000 feet. At 17,000 feet the missile broke apart. Later analysis indicated that power failure induced by inverter malfunction had been the cause of the mishap.[71]

Despite this dismal ending, the N-25 program was later described as having "accomplished the development of pilotless aircraft launching, flying, controlling and recovery techniques . . ." and as having "proved the basic missile design and furnished extensive aerodynamic and control data useful in the design of the tactical missile."[72].

This concluded the schedule of N-25 tests. Further flight experience would utilize the N-69A version of the XB-62--a radio controlled full scale test missile.[73] However, as has been noted, difficulty in both missile and guidance development postponed the start of such experiments past the first of the 1954 fiscal year. At the end of June the eventual flight schedule was quite uncertain. At that moment Allison engineers were attempting to solve engine control problems affecting the J71-A-3 turbojet which powered the XB-62. It appeared that August would be the earliest possible flight date.[74]

The J71-A-7 engine had originally been programmed to power the B-62, but in the early months of 1953 a number of circumstances combined to promote the substitution of the J57. The two engines were roughly comparable in performance, size, and weight, but, in addition to being ahead in several technical respects, the J57 had the major advantage of being substantially further along in development and test.[75] As a more thoroughly proven engine with demonstrated reliability, the J57 promised to be more suitable. Such a substitution had been proposed some time ago but had been denied because J57's were in demand for a host of other piloted and pilotless aircraft planned by the Air Force. Moreover, there was not enough time between the date at which sufficient J57's would be available and the projected operational date of the B-62 to permit the substitution. By March 1953, however, it was apparent that the slippage of the Snark development program plus a setback in the B-52 production schedule would make J57's readily available. On this basis, Wright Air Development Center and the Air Materiel Command Procurement Division resubmitted their request for the assignment of J57's to the B-62.[76]

It would be impossible, of course, to introduce the J57 immediately, but initially the project office suggested testing the combination in the last 20 of the 65 programmed XB-62's.[77] The J57-P-3 engine, a number of which were in the inventory as surplus to the B-52 program, was ultimately slated for the late portions of the XB-62 flight test program, while the -1 engine was definitely earmarked for the production prototype YB-62 missiles. These propulsion changes received the approval of Air Force headquarters in June.[78]

As with the power plant, the constant schedule slippages finally necessitated a change in the original arrangements for a guidance system. Initially Northrop had agreed to develop an automatic celestial navigation system which would control mid-course flight in daylight and in darkness. However, status reviews had clearly shown that this guidance project was more than a year behind schedule. Since it would be ridiculous to continue work which might culminate with a missile but no practical means of governing its flight, project personnel suggested dividing the guidance task into two phases and concentrating on a weapon system with nighttime-only guidance potential for the initial production versions.[79] This expedient was subsequently adopted, and Northrop redirected effort toward the perfection of such a system (the Mark 0) while continuing the development of the ultimate automatic celestial navigation system (Mark I) which was capable of operating in daylight.[80]

Aircraft equipped with the Mark 0 system began flight tests in April. The first two flights demonstrated the feasibility of the design, but at the same time indicated that component development was far from complete. Both flights ended prematurely due to equipment failures. A similar mishap halted the third test, on 21 May.[81] A fourth flight ended after the navigation system had been in operation almost two hours. This trial, on 27 May, was terminated by a combination of equipment malfunctions and unfavorable weather.[82]

The Mark I system lagged slightly behind its less adaptable brother, taking full advantage of experience with the more rudimentary system. One major innovation scheduled for the Mark I as a result of experience with the Mark O was the use of a punched steel tape in place of the magnetic tape used to record the missile flight path. Greatly improved accuracy and reliability were anticipated as a result of the change.[83]

Information from the contractor shortly before mid-year indicated that the first Mark O system for missile installation might be on hand by December 1953, with the prototype experimental Mark I system following in March 1954.[84] This, however, was very much a tentative schedule.

A third guidance system for the Snark was also in development, as insurance against the complete failure of the entire project, should the Northrop systems fail to meet requirements. In 1950 North American Aviation had agreed to construct a stellar-supervised inertial system for the B-62. Designated the Mark N-2C, this system was an offshoot of the Navaho (B-64) program. Bench and flight tests of components had begun in 1950 and continued through late 1952. The first complete experimental system was to be fabricated and ready for evaluation by December 1953.[85]

In addition to the basic Snark intended for the long range strategic bombardment mission, two other versions were in development. One, the RB-62, was in many respects a separate task, although it would utilize the basic airframe-power plant combination of the standard B-62 to perform reconnaissance. The other, the QB-62, was to be a drone aircraft identical to the operational B-62 in virtually every respect except guidance. The drone would be entirely radio controlled. Its procurement was dependent on rate of progress with the basic missile.[86]

Early in 1953 engineers decided that the external configuration of the RB-62 would differ from that of its bombardment counterpart only in the nose section. Recovery of the missile was to be accomplished by means of landing skids and a brake parachute. Modifications of the guidance system would be necessary to permit a return journey and the transfer of position information to the recorder.[87]

Based on the results of configuration conferences and estimates of the time needed to properly develop the required equipment, project engineers worked out a flight evaluation schedule which called for an initial test of the first XRB-62 late in 1954 and tests of the complete system in the last half of 1955.[88]

One of the major problems which immediately presented itself was that of range. Air Force headquarters in its statement of desired military characteristics had specified that the reconnaissance missile have a total range of 8,000 nautical miles. Both contractor and Air Force project engineers stated flatly that such a range was not attainable without a major redesign of the airframe and propulsion system. Therefore, initial work was directed at a range potential of 5,500 nautical miles.[89] Even this range was possible only through the use of the J57 engine in place of the J71 and the addition of two 350-gallon external fuel tanks.[90]

An accessory to the original plans for a reconnaissance version of the Snark was the requirement that an electronic (or ferret) capability be provided. The project office decided in April that a limited ferret capacity could be incorporated without sacrificing photographic, radar, and weather reconnaissance ability.[91] However, it appeared that it would be impossible to develop equipment for the entire frequency spectrum in time to meet the December 1955 target date. Therefore, the work on ferret equipment was divided into two phases, with the immediate objective being adequate coverage of the 1,000 to 11,000 megacycle area.[92]

At mid-year the preliminary design of the reconnaissance system for the XRB-62 had been completed and the model specification was in the process of being revised to include the ferret equipment. The project office conceded that meeting the June 1954 date for the start of a flight test program would be entirely dependent on the progress of the basic B-64 program.[93] Indeed, the eventual success of Snark appeared to depend on the contractor's facility in eliminating the defects of airframe and guidance components. The Northrop reorganization made any estimate of success or failure in this respect most uncertain. In the past, schedules had been fantastically optimistic. Although progress was encouraging in the first six months of 1953, there was no certainty that the remaining issues would be resolved in time to meet the current schedule. For the moment, the program appeared to be realistic. Nothing more could be said.

The B-64 Navaho

The Air Force was interested in three parallel aspects of Navaho development. Actually these were divisions for the sake of convenience in handling and were not supposed to reflect any intention to develop three distinct missiles. The relationship between the X-10, the XB-64, and the XB-64A was close, but still they remained readily distinguishable. The X-10 was a turbojet-powered test vehicle. The XB-64, destined to be the first operational version, was a long range ramjet missile, also known as the G-26 and the Navaho II. The XB-64A, which carried additional designations of G-38 and Navaho III, was intended to be a considerable improvement over the XB-64, especially in range.[94]

For the moment the major concern was initial flight tests of the X-10 and component development and program scheduling for the XB-64. A great deal depended on the degree of success obtained in evaluating the X-10; unfortunately, obstacles cropped up continuously throughout the first six months of 1953. The first test vehicle had been ready in almost all essentials since early December 1952; the major item still lacking at that time was the XJ40-WE-1 turbojet power plant.[95] The first of these engines was actually delivered to North American, the missile contractor, on 12 February, with the second due eleven days later. On the assumption that no further difficulty would be encountered in this respect, the first flight of the X-10 was projected for mid-June 1953.[96] Teardown and inspection of the first engine, following the "green run" which preceded the final inspection, had revealed only a slight crack in the afterburner fairing.[97] The engineering inspection of the X-10, complete with both its engines, was tentatively set for 23 March, early enough to make corrections before the first flight.[98]

Several incidents led to the almost immediate jettisoning of this timetable. Difficulties in gearbox and electrical control operation delayed shipment of the second engine for three weeks, then a strike at Westinghouse forced another postponement. Delivery dates shifted to early April.[99]

Although the second engine was finally sent in April,[100] the flight test program received another setback shortly thereafter. In May, Westinghouse recommended grounding all engines in the J40 series and discontinuing ground operations because of "recent compressor failures and the discovery that aluminum compressor discs are operating at temperatures considerably in excess of design limits." Symptomatic of the malfunction was a chronic leakage of high temperature air into the rear of the compressor rotor and thence forward through the rotor to the first stage rotor discs.

The Navy was the largest user of J40 engines. In fact, the X-10 was the only Air Force aircraft affected. Therefore, it appeared practical to continue tests on a limited scale, restricting engine revolutions to 60 percent of maximum.[101] North American accepted these limitations pending elimination of the difficulty, and it appeared feasible to fix the engines temporarily to allow their operation in flight tests of the X-10. Ceramic paint was suggested as a sealer to prevent air leakage. As a permanent correction, Westinghouse considered the substitution of steel for aluminum in the rotor discs or the addition of a thin aluminum gasket insert to seal off the gases.[102]

The first-flight date had by this time slipped to August, and project personnel could only pray that engine difficulties would not further obstruct progress--a prayer that must have gone astray. New delays involved the inability of additional engines to pass the final run of the acceptance test. Exhaust nozzle actuators required replacement, and in one instance a bolt or nut, presumably left loose in the engine after the "green run" reassembly, passed through the first stages of the turbine, with unhappy consequences. This accident caused further postponement, forcing the contractor to concede that the X-10 would not fly before 15 September.[103]

Work on the booster rockets for the XB-64 advanced considerably in the early months of 1953. In January the first complete system evaluation of the XLR43-NA-3 produced a 35-second firing at an effective thrust level of about 115,000 pounds.[104] On 9 March the -1 engine, which generated less thrust but permitted a longer firing period, reached and maintained rated full thrust of 75,000 pounds for 20 seconds.[105] On 7 April the first of the prototype flight boosters, an XLR71-NA-1 (composed of two XLR43-NA-3's with a common gas generator)[106] was delivered to Edwards Air Force Base for test stand installation.[107] Hooking up vital accessory equipment was expected to take some time, therefore no firing tests were anticipated until later in the year. In the meantime, test stand operation of the experimental -1 and -3 versions of the XLR43 continued on schedule, no severe difficulties appearing.[108]

Another factor held out additional promise for the future of the rocket engine program. Early in 1953 a series of tests proved that rockets could safely be operated on white fuming nitric acid and JP-4 fuel. Investigations in this field had been going on since 1948, when the combination was selected for study because of logistical and operational reasons. The major problem was devising a means of insuring safety during starting and stopping. The final solution was to design the control system to sense impairment of combustion and shut the engine down before a dangerous quantity of propellant could accumulate in the thrust chamber. Such control systems were more complex and required more durable components than existent devices, but the Air Force had obtained an immediate answer to the problem of safety in the operation of liquid propellant rockets. Application to a variety of rocket engines awaited further work, but the basic tasks seemed to have been completed.[109]

The third of the engines which ultimately would be required in the XB-64 program--the XRJ47-W-5 ramjet--was the object of extensive test stand experiments in the early months of 1953. Free jet testing, scheduled to take place in the Cleveland facilities of the National Advisory Committee for Aeronautics, was retarded by necessary modifications to the test equipment and stands. However, the original schedule, which called for the start of free jet testing of the first heavy duty flight engine in May, was maintained.[110] Unfortunately the initial tests were of short duration, and subsequent equipment failures (unrelated to the engine itself) forced a shutdown which extended into the second half of the year.[111]

Several additional tests of the ramjet engine were either under way or were in preparation at mid-year. Wright Aeronautical was making good progress on the design of acceptance test stands at its plant and planned to have the facility in operation by the fall of 1954. The Ordnance Aerophysics Laboratory, at Dangerfield, Texas, expected to receive a flight engine for high pressure tests some time in July. Setting up equipment for the actual tests would consume some additional time, but there was no present fear of schedule slippage.[112]

Guidance systems for the Navaho were bound up in two major developments, one a stellar-monitored inertial autonavigator and the other a completely inertial system. Further, the stellar inertial system was handled in two stages: an experimental version, the XN-2 (formerly designated X-2), and the proposed production version, N-2B (earlier known as the Mark 2B). The purely inertial system, the XN-6 (once called the Mark X-6), was vaguely related to the stellar systems but incorporated no provisions for correcting course errors by reference to the stars.[113]

Flight tests of the XN-2 continued from January through May with a great deal of emphasis being accorded the inertial components. Results from flights conducted in the last two months of testing were considerably less pleasing than previously, a circumstance later ascribed to deterioration of the gyroscopes because of their excessive use. Errors of 10 to 30 miles for a flight of no more than five hours were not uncommon.[114] This contrasted sharply with the results obtained with equipment at peak condition, when an error of slightly more than a mile was the usual maximum.[115] Since the substitution of new components would apparently restore the system to its former accuracy, there seemed to be nothing in these results to worry guidance experts. Moreover, with the stellar monitor in operation, earlier tests had consistently produced maximum errors somewhat less than 5,000 feet.[116]

For the most part, activity involving the N-2B system was confined to the test stand and the drawing table. The first model of the autonavigator operated satisfactorily in May, producing an indicated error of only 1,650 feet over a theoretical course equivalent to that projected for the operational missile. This, however, was under laboratory conditions and could not be accepted as indicative of the accuracy to be expected in actual flight.[117]

The completely inertial XN-6 system, using many components evaluated in the stellar-monitored systems, still was in a pre-prototype stage. Engineers concentrated on improving economy, reliability, and simplicity aspects and on weight reduction. The advantages of such a system, in being entirely self reliant, more than overcame the handicap of lessened accuracy. Furthermore, there was little doubt that the autonavigator could be fully developed in time to meet the B-64 schedule, a certainty which did not extend to the stellar systems.[118]

The major problems facing the Navaho were largely of the sort that required flight testing for solution. Such was the matter of vertical launching, since nothing of this nature had ever been attempted using a missile as large and heavy as the B-64. Wind tunnel tests indicated that strong aerodynamic forces would affect separation of the booster and the missile, and the autopilot would have to be designed to compensate for them.

The construction of flight test facilities at Patrick was lagging and bade fair to impede the start of flight tests by six months unless immediate corrective action was taken. Similarly, there remained the matter of providing facilities for the production of the Navaho. This affair still was in the hands of higher headquarters.

The guidance situation was not especially serious, but it could become so with little urging. Most of the components of the stellar inertial and pure inertial systems required additional work to make them reasonably reliable. Some transparent substance usable as a window for star observations was needed but high temperatures precluded the use of available materials. Although this particular shortcoming would not affect the XN-6 inertial system, in that case there remained the matter of compensating for errors induced by launching accelerations.

Finally, the hydraulic system was an issue of importance. Fluids, seals, pumps, and the like would have to operate in extremely high flight temperatures, yet would be required to perform satisfactorily in the low temperatures that might exist at the launch site.[119]

The project of improving the Navaho design to provide for a maximum operating speed of Mach 3.25 in lieu of the Mach 2.75 for which the XB-64 was designed dropped from development plans concurrently with budget cuts in mid-1953. This version of the Navaho, known as the XB-64A or, alternately, as the G-38, was relegated to a study status. Attention thereafter was restricted almost entirely to the X-10 and the XB-64.[120]

In June the future schedule for the Navaho was this: research and development were to be complete by July 1958, enabling the Air Force to make the operational pilotless bombers available in squadron strength by 1960. Initial tests of the X-10's were to start in the latter half of 1953. Thereafter, progress with the XB-64 would depend to a great extent on the results of X-10 flight tests.[121] At the moment, however, the major problems were still insignificant in comparison with those which affected other missile programs. Of course all this might change overnight.

The Atlas Spacecraft

An uninformed passerby presented with a picture of the Atlas missile would probably be little impressed. The spectacular flaming take-off of Matador, the swept-wing aerodynamic beauty of Snark, the complex launching process for Rascal, or the space ship appearance of Navaho would undoubtedly attract his interest much more readily. To the passerby the Atlas would probably look vaguely like an overstuffed .30 caliber bullet--no fins, no wings, no complicated superstructure. Even internally, apart from the huge volume of its fuel tanks, Atlas presented nothing startling. The guidance system would appear--rightly enough--to be nothing more than an ordinary radar set. No stellar viewers, no radar scanners, no infrared or doppler equipment were observable, simply because there were none. Yet the Atlas project office was probably quite correct in its blunt statement that the spacecraft was ". . . what today appears to be the ultimate strategic warfare weapon system."[122]

Atlas would be the first of the purely "push button warfare" weapons. Guidance was a matter which was determined forever within three minutes of launch. Once it was aloft, nothing presently conceivable by man could interrupt its course or prevent it from impacting less than 30 minutes later on a target half a world away. Equipped with the atomic warhead for which it was designed, Atlas would indeed be the latest, if not last, step in the long road that had its beginning in a jagged piece of flint hurled by a Neanderthal man at a club-swinging enemy.

Nor was Atlas expected to be a particularly difficult system to bring into being. In January General Boyd received from a member of the Atlas team an informal proposal called "Atlas, Regardless of Cost," which set forth in readily understandable terms the difficulties that the center and contractor faced, the advantages of accelerating work to the utmost, and the inherent simplicity of the Atlas scheme.

Lieutenant J. S. Yasechko, who prepared the study, stated that the ballistic missile could be available by 1956 if the project was put on a no-cost-limit basis. Moreover, he thought that a short range version could be ready by 1955. Other versions, varying in range capability and size of warhead, could also be constructed within the general time period. In support of his thesis, the lieutenant pointed out that rocket motors used for Navaho would be available by April 1954. Most of the other components, except perhaps the nose cone which had to withstand extreme temperatures on its re-entry into the earth's atmosphere, were either in development or readily convertible from standard Air Force items.

The Atlas, the officer explained, was in reality considerably simpler in most respects than such "conventional" atmospheric missiles as Navaho or Snark. Cost of accelerated development and production was the only major obstacle. It would take $500,000,000 to construqt the Atlas system and $4,000,000,000 to provide weapons in sufficient quantity to equip the strategic forces. The expenditure of such monies would result in a missile having a 7,000-pound warhead and a 5,500 nautical mile range. Another version of Atlas, with the same range but only a 3,000-pound warhead, would cost $2,600,000,000. A still smaller Atlas, with a reduced range and warhead, could be perfected and produced for less than $2,000,000,000.

In view of the simplicity of the Atlas system and the ready availability of most of its essential components, the lieutenant thought it foolhardy to pursue a conventional "evolutionary" test program. He felt strongly that Atlas was attainable at less cost by more direct methods. Instead of the usual test vehicles, he favored putting into service as quickly as possible a limited capacity weapon system capable of ready improvement yet sufficiently advanced to maintain an advantage over Russia. As it was, intelligence estimates had Russia entering into production of a 600-mile ballistic missile with an 8,000-pound warhead sometime in 1953.[123]

This was only one of several ideas on the issue of how Atlas should be developed. A committee of the Scientific Advisory Board visited the Convair plant in December 1952 to examine the Atlas program and prepare recommendations for its future course. The committee strongly recommended that the Air Force continue its efforts in the ballistic missile field, but also suggested reorienting the Atlas plan to provide a step-by-step program using V-2 type missiles, Navaho boosters, and other existing or experimental missiles.

Subsequent analysis of these proposals by another committee of the advisory board produced a divergent opinion. The second group felt that the course originally recommended would contribute comparatively little to the final objective and would constitute an unnecessarily intricate program. In its stead, the second group proposed a program involving missiles of three different configurations built around the same prototype fuel tanks.

The first version would be a single-motor missile consisting essentially of the second stage propulsion system planned for the ultimate missile. A detachable nose cone would provide data on phenomena relating to re-entry into the atmosphere. The second version would in most respects be identical to the configuration of the ultimate (complete prototype) missile except for having three instead of five rocket motors. This change would simplify flight experiments and would permit guidance tests as well as the dispatch of an instrumented nose cone. The third version would be the five-motored prototype with a full size warhead-type nose cone.

The balance of the recommendations of the second committee related to tests of the Azusa tracking system, which, although designed for another purpose, seemed admirably suited to perform the initial guidance function for a ballistic rocket.[124]

Whatever their differences, the findings of the two committees had this in common: a belief in the practicality of the Atlas proposal and substantial faith in the ability of the Air Force to develop it quickly.

Late in April there arrived at Wright Field an advance copy of a letter from the director of strategic combat systems at command headquarters. It opened with the statement, "The SNARK, NAVAHO, and ATLAS programs were originally progressed in a logical manner, considering the estimated availability and capabilities." However, the situation had changed, particularly in the last year. Continued the letter: "The slippages in the SNARK and NAVAHO programs and the now apparent optimism in the ATLAS project have resulted in a situation which requires that our entire strategic program be thoroughly scrutinized to be certain that it is logical, necessary, and realistic." The particular point at issue was that the Atlas and Navaho were scheduled to be complete within little more than a few months of one another. Therefore, "the problem of supporting the programs which are becoming increasingly expensive throughout the years must be solved."[125]

The implications were clear. If the predictions of experts were to be taken at their face value, Atlas could be perfected shortly after its long range "conventional" companions. The directive which formally launched the Atlas project was not specific with respect to a time schedule other than requiring the system to be operational "sometime after 1964."[126] Project officers, when preparing the system's development plan, said frankly that "with adequate support" they could better that date by two or three years.[127] In view of the continuing difficulties which plagued the work on Navaho and Snark, particularly their guidance systems, it would be inappropriate to promise that any single system would be ready by 1961; at least it appeared that none with an efficiency that even remotely approached that of Atlas could be operational. From an objective standpoint, therefore, there appeared to be considerable logic in Lieutenant Yasechko's basic idea and a great deal of merit to the suggestion that Snark and Navaho programs be reviewed again with the potentialities of Atlas in mind.[128] The Air Force could conceivably save a great deal of money and an even more valuable amount of time by concentrating on the ballistic missile.

A discussion of Atlas occupied the attention of the Scientific Advisory Board when it met at the end of March. By this time more evidence was available that no insurmountable obstacles intervened between the start of hardware and test vehicle work and the completion of an operationally satisfactory Atlas. The center's representative, Mr. Keto, learned informally that Dr. C. S. Draper of Massachusetts Institute of Technology felt certain that he could build a prototype guidance system within the two-year period that it would take to complete a flight test missile.[129]

Further encouragement stemmed from General Electric's success in operating rocket motors on a combination of gasoline and liquid oxygen. Since this had been one of the uncertainties of the Atlas program, proof that the project was practical gave a new boost to those who felt that development of the ballistic rocket would not be extremely difficult. In essence, one of the major obstacles had been eliminated even before Atlas people came to grips with it.[130] Subsequent experiments, equally successful, caused the project office to report, "This is another indication that developing gasoline-lox rocket motors may not be as difficult as some experts have estimated or as lengthy a process as had been allowed for in the Atlas program." On this basis alone, it seemed reasonable to schedule the Atlas for earlier delivery. Only the absence of adequate test stands made this action inadvisable, and there was some hope that this hindrance would be overcome if more wholehearted financial support was forthcoming.[131]

On 6 February the Azusa tracking system was successfully demonstrated at Convair's San Diego plant. Later that month an experimental working model of the nose cone stabilization platform was completed and operated, with complete satisfaction to engineers.[132] In March experimenters learned that the idea of using transpiration to cool the nose cone during re-entry into the atmosphere was not so practical as had previously been believed, but at the same time the use of ceramic insulation for the nose cone awaited tests which were expected to produce favorable results. Almost simultaneously Convair revealed the success of experiments with a newly devised electronic filter which eliminated another of the major drawbacks to accurate guidance of Atlas.[133] At the beginning of June, engineers were hard at work on the problems of aerodynamic effects on the nose cone during re-entry. Wind tunnel tests had been run at maximum speeds up to Mach 9.1, and results were reasonably pleasing to that point.[134]

All this was to the good. Nevertheless, as the first half of

1953 drew to a close, Air Force headquarters still favored a cautious approach to the ballistic missile. Consequently budgetary support for the Atlas program was somewhat deficient. Exhaustive laboratory tests were scheduled to be undertaken before the rocket progressed to the stage of flight tests.[135] The outstanding obstacles to more rapid progress were largely administrative, although a lack of knowledge in the field of hypersonics remained a leading technical problem.[136]

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XIII NONCOMBAT AIRCRAFT SYSTEMS

Readily distinguishable from the weapon systems intended to participate in the "give and take" of combat operations were a relatively large number of aircraft generally characterized as "noncombat or supporting systems." The term was somewhat misleading, since helicopters, liaison airplanes, cargo carriers and tankers were noncombatant only in the sense that they were usually not equipped to fire back at an attacker. The enemy had no serious compunctions about shooting up and then shooting down any American airplane within range of their guns. And most such aircraft were by the very nature of their assignments likely to be habitual occupants of air space adjacent to and over enemy lines.

Also included among the noncombatant aircraft were several that never by the widest stretch of the imagination could come within range of enemy fire. Experimental test vehicles, both those specifically designed for that task and those utilized for aeronautical research after a start as proposed fighters or bombers, were very important to the research and development program. Trainers had an equally prominent role to play in preparing aircrew members, and their development was in a sense as important as similar work applied to combat craft.

The Air Force had a great variety of such models and types in design or construction. They ranged all the way from test stands which suddenly became aircraft, as did the XH-17, to tactical airplanes converted into flying test stands, which described the XF-84H. They included both the world's fastest and the world's slowest aircraft. Power plants ranged from reciprocating engines through turboprop and turbojet to ramjet and rocket. Some aircraft were so small two men could carry them, others so large they could contain hundreds of fully equipped troops. In one instance the Air Force was trying to create an airplane that would move forward not one inch on take-off and which would operate conventionally thereafter. Other airplanes were completely incapable of independent take-off and had to be dropped from mother aircraft at high altitudes. Some could land and balance on a chimney top, others required most of the level area of the world's greatest natural flying field for their landing runs. They had one characteristic in common however. Each one could do something that no other airplane in the world could do as well.

Two of the most interesting aircraft in this category were used for propeller research, a field which immediately after the second World War had become a sort of poor cousin, likely at any moment to wither and blow away in the hot blast of the ever more numerous jets. The emergence of helicopters almost simultaneously with jets presented researchers with new problems equally as perplexing as those solved in the evolution from Wright Flier to B-29, but still helicopters were not fighters and bombers. The continuance of propeller-driven aircraft in battlefield assignments depended largely on the success of the

Propeller Laboratory and the Power Plant Laboratory in perfecting supersonic propellers and turboprop engines to power them.

The satisfactory testing of propellers for turboprop aircraft required suitable test vehicles, and in the first months of 1953 the two major efforts in this direction bore considerable fruit. On 14 April the XF-88B, a prototype McDonnell fighter converted to incorporate an XT38 engine in its nose in addition to its usual turbojet power plants in the aft fuselage, made its first flight.[1] Subsequently both contractor and Air Force pilots took the aircraft aloft, and on 27 June the XF-88B was flown past the speed of sound. This was the first time in history that a propeller-equipped aircraft had managed such a performance.[2] A high-speed level-flight Mach number of .91 was attained on the same occasion. Both these flights were made with the XT38 operating at full power.[3]

After this flight demonstration, action began to transfer the aircraft to the keeping of the National Advisory Committee for Aeronautics, which had a full range of propeller research experiments awaiting its arrival.[4] On 13 July, after a normal cross-country flight from St. Louis, Missouri, to Wright Field and thence to Langley Air Force Base, the XF-88B was formally turned over to the advisory committee. The Air Force and the Navy would be full participants in all subsequent work carried out under committee jurisdiction.[5]

At the end of June, work on the XF-84H, the other aircraft programmed for use in supersonic propeller tests, was progressing satisfactorily. The Allison 500-B5 engine was then undergoing acceptance tests preceding its delivery to Republic for afterburner experiments, the airframe fabrication process was on schedule, and the supersonic flight propeller was about a month away from the start of Propeller Laboratory evaluation. The engineering inspection of the entire aircraft was scheduled for late September or early October.[6]

One fly in the ointment was the receipt of news, early in July, that because of budget limitations the Navy had been forced to cancel plans to finance the third of the XF-84H's. This particular aircraft had been intended for tests of a new Navy supersonic propeller, but its installation would have necessitated a fuselage contour forward of the cockpit different from that of the two Air Force airplanes. Fortunately a compromise which satisfied some of the Navy requirements was possible. The funds previously obligated to Republic by the Navy were sufficient to permit fabrication and installation of a new forward fuselage on one of the Air Force test vehicles. Therefore, the Propeller Laboratory agreed to cooperate in such a modification program with the understanding that no commitment would be made regarding the date of installation of the Navy nose.[7]

Of the other test vehicles in the research and development program (apart from those directly associated with a specific weapon system), only the XF-91 was particularly active in the early months of 1953. By March the Republic aircraft had made a total of ten flights with its accessory four-chamber rocket motor operating. In its current configuration it was believed capable of reaching Mach 1.2, but had not done so because of high frequency vibrations at about Mach 1.18. The installation of a new aft fuselage with a "V" tail, in place of the conventional superstructure, was then undertaken. This change could conceivably overcome the vibration handicap, and with a higher output engine than the J47-GE-13, engineers thought it might be feasible to push the XF-91 to a top speed of Mach 1.4. The replacement of the existent rocket engines by more efficient models was also expected to help in this program.[8]

The X-2

The two Bell X-2 aircraft could be considered the logical extension of the X-1 series. While the intended employment of the X-2 was much the same as that of the X-1--for flight research in aerodynamic heating, stability and control, and air loads--the speed potential was well beyond that of the X-1, being in the vicinity of Mach 3.0 or better, and the altitude limit at least 140,000 feet. Special features of the X-2 included stainless steel construction, a jettisonable nose capsule for emergency escape, a skid type landing gear, circular-arc airfoil wings, and an XLR25-CW-1 throttlable rocket engine (the thrust of which could be adjusted from 2,500 to 15,000 pounds).[9]

At the beginning of the year, the center expected first powered flights of the X-2 to take place during the last month of 1953.

Curtiss-Wright, after encountering considerable engineering difficulty in building the rocket engines, had delivered the first one in June 1952--almost four years after the originally scheduled date of August 1948. Despite this long delay, test stand checkouts disclosed deficiencies, primarily with the liquid oxygen turbine pump. In December 1952, Curtiss-Wright experienced three pump explosions but held that minor modifications would forestall any future recurrence.[10]

By mid-January, Bell had completed the installation of an engine in the first X-2[11] and within a month had finished initial flow tests and engine control evaluations.[12] The next step was to be an evaluation with the questionable pump in operation. However, another pump explosion on the Curtiss-Wright test stand forced a cessation of Bell's engine tests. Finally, after another failure on 3 April, Curtiss-Wright and center engineers decided that the aluminum alloy impeller was structurally deficient and would have to be replaced with another, probably of stainless steel. The engineers also agreed to strengthen the diffuser vanes and change the location of the screens in the liquid oxygen line. These measures, they felt, would eradicate the difficulty. However, the alterations delayed the program from four to six weeks and pushed back the flight date to sometime in January or February of 1954.[13]

In the meanwhile, the first captive flights of the number one X-2 had begun with the objective of operationally checking the transfer of liquid oxygen from the B-50 carrier to the X-2. During the second such flight, on 12 May, an explosion occurred in the vicinity of the fuel tanks, the X-2 disintegrated, the B-50 received extensive damage, [redacted] the B-50 and disappeared into Lake Ontario.[14]

The accident set off an extensive investigation. Ultimately the investigating board recommended that no flights of the remaining X-2 be permitted until every system had been thoroughly examined by center engineers, (and General Boyd immediately transformed this into a directive). Further, the board felt that the in-flight transfer of liquid oxygen from the B-50 to the X-2 should be eliminated, that a means of keeping moisture out of the system should be devised, and that a method of dissipating all combustible vapors was essential. Finally, the board suggested that Bell crews receive extensive instruction in certain servicing and flying practices.[15] In addition, General Boyd directed the Power Plant Laboratory and the Weapons Systems Division to formulate a standard Air Force operating procedure for the operation of rocket engines and rocket-powered aircraft.[16]

The center called a conference for 9 June to decide how best to carry out the board's recommendations. In attendance were representatives from Bell, the flight test center, the National Advisory Committee for Aeronautics, and Wright Field. It was apparent that those present believed that the remaining X-2 required extensive and drastic modification. Bell agreed to conduct studies with the following objectives in mind: to "clean-up" the airplane by rearranging the plumbing, electrical systems, and other such equipment; to provide leak-proof fuel tanks in a readily accessible location; and to examine tank design criteria. The results, corrective proposals, and cost and time estimates were due at Wright Field by 1 September.

The conferees, especially those from the national advisory committee, stressed the point that modifications should not be allowed to lower existing anticipated performance. As it was, the originally expected performance of the X-2 had deteriorated over the passing years because of increased weight, a reduction in engine thrust below that initially planned, and revised aerodynamic calculations. The advisory committee members also declared that "the X-2 aircraft is considered to be more important than ever to the research program and that, in fact, new requirements are being established for very high altitude research which can be accomplished by the X-2." Even though the delay was undesirable, it did not in any way reduce the importance of the airplane.[17]

The X-1A and X-1B

The X-1A and X-1B research aircraft were the last of six roughly similar test articles that at one time had been scheduled or actually built. The two survivors were offspring of the original X-1's--the major changes being integral fuel tanks of considerably greater capacity, a turbine pump drive, an improved canopy, and a lengthened fuselage. These gave the X-1A and X-1B better altitude, speed, and endurance characteristics than their predecessors. Such aircraft were designed to obtain data on heating, heat transfer, stability and control, and air loads at speeds of Mach 2.0 or better and at altitudes up to 100,000 feet.[18]

Although the first powered flight of the X-1A had been slated for sometime in December 1952 (with the X-1B flight to follow in June 1953), explosions in the X-1D and the third X-1 had forced major modifications in the low pressure system and retardation of the flight dates.[19]

Early in January, Bell moved the X-1A from its plant at Niagara Falls, New York, to Edwards Air Force Base. At this time the lake bed was flooded, and it was feared that flights could not be started until as late as June.[20] However, the situation quickly improved and the flight test center was able to send the X-1A aloft, on a captive flight, late in January.[21] Several weeks later, on 14 February, the aircraft made its first glide flight. It successfully jettisoned a full load of "lox" and alcohol, and it encountered no difficulty in a skid landing.[22]

The Phase I evaluation program officially got under way on 21 February with the first powered flight. After being dropped from the B-29 carrier at 29,000 feet, [redacted] rocket chambers numbers 1, 2, and 3, in order, but a fire warning signal (subsequently proved to be false) led him to cut the power before firing the fourth chamber. During the flight, the aircraft attained a speed of Mach .80.[23]

Subsequent flights occurred on 26 March, 10 April, and 25 April. Throughout, the rocket engine generally operated satisfactorily, with only minor malfunctions and some erratic performance. A speed of Mach .88 was obtained, but so were elevator flutter and fuel pump turbine overspeeding. Believing that minor structural differences in the elevator might have induced the flutter, engineers decided to install a set of elevators identical to those of the original X-1. The center felt that low altitude operation (below 30,000 feet) was the major factor in liquid oxygen overheating and subsequent pump overspeeding. Thus, the next flight was set to evaluate the new elevator configuration and to determine the limit of flight duration under "lox" overheating conditions.[24] Before this flight could be made, the X-2 exploded (on 12 May) and the grounding of the X-1A immediately followed.

After being briefed on the X-2 accident investigation, on 29 May, General Boyd directed center engineers to check each and every system of rocket-powered aircraft to insure that no inherent hazards existed. He also ordered that the X-1A not be flown until he personally had released it.[25]

On 9 June, representatives from Edwards, the National Advisory Committee for Aeronautics, Bell, the Power Plant Laboratory, and the project office met at Wright Field to chart the future of both the X-1 and the X-2. After hearing a report on the X-2 accident, the conferees agreed that the findings were not directly relevant to the X-1A.

Although this may have been the case, Mr. John B. Trenholm, the project officer, noted, "Evidently the X-2 accident has convinced the [AF]FTC that any suspected item must be replaced." At any rate, Lieutenant Colonel J. L. Ridley of that center informed Wright Field that his organization considered the nitrogen storage system unsafe and that his pilots would not fly the X-1A until the system had been changed. (Edwards received the job of completing the Phase I evaluation [redacted] left Bell without an experienced pilot.) Unfortunately, recent national advisory committee tests tended to substantiate the flight center's view. The center therefore directed Bell to seek alternate materials or different methods of nitrogen storage, even though this work would probably take many months and cost a great deal. It was also agreed at the meeting that the safety inspection would start on 15 June 1953.[26] Thus, at the close of June, further flights with the X-1A awaited a new nitrogen system.

While the discussions were being held and the decisions made, the center withdrew authorization to begin the ground power plant testing of the X-1B. Work would probably remain at a standstill until Bell had finished its nitrogen system study and recommended some alternate storage method.[27]

On 27 April the Weapons Systems Division recommended that an assault on existent speed and altitude records be made once the Phase I evaluation was complete. At the time (27 April), completion was less than a month away. The division thought both records could be easily broken since the X-1A was capable of reaching speeds in excess of Mach 2.0 and altitudes above 90,000 feet. The division further suggested that Colonel Ridley of the flight test center be honored as the pilot.[28] Of course the X-2 accident and the grounding of the X-1A dispelled any hope for a favorable reply, at least for the time being.

The X-3

In June 1949, when the Air Force authorized the construction of two Douglas X-3 aircraft (after an extensive study and mock-up program), it fully expected that these aircraft would be invaluable in obtaining data on thermodynamic, aerodynamic, and structural problems associated with flight in the speed range of Mach 2.0 and at altitudes between 35,000 and 50,000 feet.[29] Unfortunately, numerous engineering difficulties beset the propulsion portion of the development, leading ultimately to termination of the X-3 project.

The engine first designated to propel the X-3 was the Westinghouse XJ46-WE-1, a variation of the Navy's -2.[30] It was to have 6,100 pounds of thrust at sea level and the capability of generating an additional 500 pounds at 35,000 feet.[31] Since the airframes would be available before the engines, the Air Force selected the XJ34-WE-17 as interim power plants to permit early flight tests of the aircraft.[32]

In February 1951, Westinghouse informed Wright Field of an anticipated delay of 14 months beyond the August 1951 delivery date for the XJ46. Attempting to alleviate the effects of the delay, the Air Force approved the use of a de-rated XJ46 with only 5,720 pounds of thrust. This was designated the -3. Thereafter, the contractor reported several additional postponements on both the -1 and -3 versions of the basic XJ46 engine.[33]

Because the -1 showed no signs of attaining the desired power output, the National Advisory Committee for Aeronautics laboratory in Cleveland, Ohio, began working on a water-alcohol or ammonia injection system for it. Tentatively labeled the -5, the engine so modified was expected to be the "optimum" power plant. Availability was estimated at March 1955.[34] Meanwhile, center and Douglas engineers cast about for other possible propulsion systems which would not force extensive modification to the airframe. A possibility considered for a time was a standard -2 engine changed only to allow installation within the X-3. However, this expedient was discarded when it became known that the basic standard version was incapable of generating the necessary 6,100 pounds of thrust.[35]

On 15 January 1953, in a general overall review of the X-3 project, the center reached two conclusions. Growth in weight of the airplane necessitated a more powerful engine than even the -5 engine with its injection system. Secondly, for lack of suitable engines, it was apparent ". . . that the airplane cannot be made available in a time period which would permit it to fulfill its flight research mission."[36] On this basis, the Air Force abandoned further work on the aircraft.

Twelve days later, Wright Field instructed Westinghouse, through the Bureau of Aeronautics, to stop all work on the -1, -3, and -5 power plants.[37] General Boyd followed up on this order with a personal letter wherein he recounted the detailed history of the engines, citing specifically ". . . the lack of suitable progress in the engine development program . . ." as the basic cause for terminating the X-3 project.[38]

In the meantime, the first X-3 continued its Phase I flight evaluation. As General Boyd told General Partridge, "There appears to be no alternative but fly the first airplane 'as is' for whatever data we can get. . . ."[39] Of course this pessimistic view stemmed directly from the fact that the airplane was equipped with XJ34 "interim" engines, which undoubtedly would become a permanent installation.

By the end of June, six flights of the X-3 had taken place. The Douglas test pilot took it into the air for the first time on 20 October 1952. Another flight followed on 31 October. Thereafter flight activity was held in abeyance until 30 April because of the flooded condition of the Edwards lake bed.[40]

Since the flights were Phase I tests, no research data were obtained. Rather, such items as the fuel, control, power, and emergency landing gear systems, the speed brakes, and cockpit pressurization received check-outs for proper operation. The X-3 attained speeds of Mach .88 and altitudes around 16,000 feet in most of the flights; however, during the sixth, it climbed to 25,000 feet and achieved a speed of Mach .93.[41]

The flights in the main were uneventful. On 11 June, the left-hand engine encountered a compressor stall at 16,500 feet,[42] and two weeks later, during the landing roll, the left wheel brake locked, causing the tire to blow. The airplane made a 180-degree turn, but it sustained no damage other than to the tire and wheel.[43]

The YC-130

The first turboprop-powered aircraft scheduled to enter the Air Force operational inventory was the C-130, an all-metal high-wing model incorporating four Allison T56-A-1 engines (formerly designated T38-A-7).[44] Intended to replace the C-119, the C-130 would be used for such tasks as personnel and cargo drops, personnel transport, and air evacuation of the wounded. On contract were two YC-130's and seven C-130A's--all of which were slated for test purposes. Operational aircraft for Tactical Air Command use would probably not be available until January 1956.[45]

In January, command headquarters asked Washington to authorize the procurement of four additional YC-130's to precede the C-130A's. The idea, said the project officer, was ". . . to preserve the continuity of manufacture of components, such as engines, propellers, etc.; to advance the flight test program; and, to advance the delivery of tested C-130's to the using agency."[46] However, Air Force headquarters refused the request, directed the materiel command to reserve the second C-130A for static tests, and thus forced the center to request one or more additional C-130A's from any subsequent production to make up the loss in the projected flight test inventory.[47]

Fabrication of the airframes remained on schedule throughout the first half of 1953. Early in February, Lockheed received approval of its model specification for both the YC-130 and the C-130A.[48] In that same month, the Air Force began negotiations, later successful, for the development of an aerial delivery system.[49] The system was expected to be ready at the time of the YC-130 contract technical compliance inspection, slated for July 1954.[50]

At the beginning of the year, Lockheed and the center expected the first flight of the YC-130 to take place sometime during the last week of 1953.[51] Initial test runs on the YT56-A-1 engine, started on 27 October 1952, were extremely encouraging and bolstered the impression that a flight would occur before the beginning of 1954.[52] However, in mid-February Allison reported that delivery of qualified engines could not be made until several months after the original May 1953 deadline.[53]

The power plant in question was the YT56-A-1--rated at 3,750 equivalent shaft horsepower. So that the engine development program would not impair early delivery and the start of a flight test program, the center had agreed that the first 28 engines could be de-rated to 3,000 horsepower; however, the production version for the C-130A's was to be fully rated.[54] As late as 23 January 1953, the Air Force thought that the 50-hour preliminary flight rating test could be successfully concluded and deliveries made by May.[55] Allison's announcement killed such hopes.[56]

There were several reasons for the delay. From the first, the Power Plant Laboratory had warned that the schedule was optimistic. Moreover, Allison was developing the engine almost as a by-product of a Navy contract for a different power plant. The priority of the T56 was therefore low. Eventually, the Navy decided against production of its version and withdrew all support.[57] Finally, Allison's use of its two test stands for T56 work brought the program into conflict with evaluations of a higher priority Navy development.[58]

Inasmuch as the airframe was still on schedule, the announcement of the engine delay set off a rash of proposals--all aimed at making it possible to meet the first-flight schedule. Allison stated that delivery of a combination of the YT38-A-3 power section and the YT56-A-1 gear box could be made by May or June. The Power Plant Laboratory recommended this to the project office, which then discussed with Allison the possibility of dropping the YT56 program entirely by going directly from the "composite" engines to production T56's.[59]

Other suggestions called for the use of T38's, T34's, and even R3350's.[60] By late April, the Air Force had decided to stay with the original power package, push back the marriage of the engine and airframe, and delay the first flight until February or March 1954.[61]

This decision notwithstanding, much yet remained to be proven on the propulsion system. To insure the efficacy of the new Curtiss-Wright propellers, the Propeller Laboratory planned to begin qualification tests in July, utilizing T38 engines. The project office proposed starting wind tunnel tests in October, either at Wright Field or at the Ames Laboratories, to obtain evidence that the propeller and the decoupler mechanism would operate satisfactorily in conjunction with the YT56. Finally, the center hoped to install a YC-130 power package in a Lockheed Constellation to secure actual flight test time on the engines prior to YC-130 flights.[62]

In spite of engine difficulties, most people at the center felt that the airplane could do its job satisfactorily; General Boyd remarked, ". . . it looks pretty good."[63] Nevertheless, several problems still lacked solution. In summing up the situation, the project officer said, "The development of the T-56 engines in general and the negative torque indicator in particular are the controlling element in meeting the overall system schedule. . . ."[64]

The XC-132

The XC-132 aircraft was intended to satisfy two Air Force requirements by acting both as a long range heavy transport and as a tanker (primarily for the B-58). Tentatively, the system was programmed to meet a 1959 operational date. However, by the end of the fiscal year, Air Force headquarters still had not decided whether Phase II development would be carried out. On the other hand, the Phase I detailed study and mock-up program was not due to be completed until March 1954, so several months remained before the deadline for charting the future course of the XC-132.[65]

Phase I engineering and mock-up fabrication began in December 1952, but no letter contract was signed until early 1953.[66] And although the evaluation board had selected the Douglas proposal in August, it had not chosen between the two designs submitted--one a straight wing, the other a swept wing airplane. Therefore, early in February, representatives from the C-132, the B-58, and the low altitude strategic bomber project offices considered the speed and fuel transfer requirements and on that basis selected the 25-degree swept wing version as that most compatible with the bombers. Fuel exchange would probably take place at about Mach .75. They expected a KC-132 with a 110,000-pound fuel cargo to be able to refuel two bombers, permitting each to cruise as far as 4,000 miles from its home base. This satisfied formal operating requirements for strategic aircraft in the time period during which the KC-132 and the B-58 would be in use.[67]

By 30 June Douglas had completed approximately 15 percent of the mock-up. Inspection of that full-scale model was tentatively set for February 1954.[68] In the meantime, considerable work remained to be done on the engines, the propellers, and the aerial refueling equipment, each of which was in need of further attention from a state-of-the-art standpoint. In fact, any hope of bettering the planned completion date required, as the project officer emphasized, devoting more intense effort to the power plant, since the rate of completion of the whole aircraft largely depended on the rate of progress with the engine.[69]

The power plant was the Pratt and Whitney T57-P-1 turboprop, an adaptation of the J57 turbojet. Although the T57 incorporated some of the basic parts of the J57, such as the compressor section and burners, nevertheless, Lieutenant Colonel F. E. O'Brien, the C-132 project officer, warned, "A period of debugging can be expected even though certain features will have already been proven in the J-57 predecessor."[70]

For a time early in the year, work on the engine was delayed because of the Air Materiel Command's reluctance to commit funds without a specific directive from Air Force headquarters.[71] The latter, however, eventually granted its approval, and on 19 March the contract was ready.[72] Pratt and Whitney signed 11 days later.[73] Under the terms of the document, the contractor was to furnish two XT57's for development evaluation in November 1954.[74] Shortly after the close of the fiscal year, Pratt and Whitney was able to report completion of about 30 percent of the design work.[75]

Several general propeller studies had been in progress for sometime--all oriented toward employment in an aircraft similar to the C-132. In January, center and industry personnel discussed such details as gear ratio, diameter, and speed of rotation.[76] Subsequently, Wright Field selected Hamilton-Standard to design, develop, and build a 20-foot diameter, four-bladed propeller with full feathering, reversible pitch, and de-icing features,[77] and Curtiss-Wright was assigned the job of constructing a second propeller which would serve as a back-up while also advancing the state of the art.[78]

The planned rate of fuel transfer and the speeds at which such transfers were to occur imposed performance requirements far beyond those obtainable with existing probe and drogue equipment. Simultaneously refueling two receivers at a flow rate of about 1,200 gallons per minute and speeds approximating Mach .75 would be difficult. A large scale work program to attain this performance from the pumps, reels, and hoses was anticipated.[79]

An important facet to inflight refueling was successful rendezvous of the receiver with the tanker. B-58 and other bomber aircraft were to focus on an AN/APN-69 radar beacon installed in the tanker. Fighters would chart their course to a meeting with the C-132 by means of signals emitted from the AN/APA-87 rendezvous radar.[80]

A host of other components were still under study by 30 June and it would be some time before the center and Douglas would make their selections. These included the starter, alternators, generators, inverters, the autopilot, de-icing and anti-icing equipment, and fuel system components.[81]

The YC-133

The YC-133 aircraft began originally as a model improvement of the C-124, the major change contemplated being a conversion from reciprocating to turboprop engines.* "However," as the system officer noted, "it soon became evident that this [the use of the basic C-124] would not provide a suitable vehicle for employment of turbo-prop engines." This dictated design changes which resulted in the development of an entirely new system, designated the C-133.[82]

The new aircraft featured a low level cargo floor, tail-gate loading (instead of nose loading), complete pressurization, and four Pratt and Whitney T34-P-3 engines (rated at 5,700 equivalent shaft horsepower). It was expected to have a cruising radius 148 percent greater than that of the C-124C, a payload for short missions exceeding that of the C-124C by 81 percent, a 46 percent increase in cruising speed, and a 45 percent greater initial rate of climb. Its main tasks would be the deployment and resupply of Strategic Air Command units.[83]

After encountering some initial difficulty in arriving at a satisfactory configuration, Air Force headquarters on 29 February directed that work on the originally-contemplated low wing version be halted and that the effort be shifted to a high wing model which Douglas had submitted late in December 1952. By March, the contractor had formulated the specification, weight and balance data, and performance figures. These were reviewed by the interested laboratories in the following weeks.[84] Shortly thereafter, on 7 and 8 April, the center and materiel command conducted an inspection of the flight compartment mock-up. If progress continued at this rate, the first flight of the YC-133 could be expected in October 1955, approximately seven months behind the original schedule which had been delayed by differences of opinion involving the first--or low wing--proposed configuration.[85] Although no operational date had yet been established for the C-133, project personnel felt that the airplane could meet a 1957 deadline.[86]

Development and evaluation of the propulsion system was being accomplished by means of a prototype YT34-P-1 power plant and a YC-124B flying test bed. Douglas completed a ground test of the installation in January and, after subsequent propeller evaluations in May, the Power Plant and Propeller laboratories deemed engine control and propeller operation generally satisfactory. Several operating procedure problems yet remained, but the center expected that the YC-124B and YT34-P-1 combination would make its first flight in October 1953. Also, after an engine specification coordination conference on 8 July 1953, the Power Plant Laboratory expressed the belief that an approved specification for the -3 would be available shortly. This would permit the 150-hour test needed to qualify the engine for production to start in October.[87] The first production -3 engine was to be available in May 1954 if no large-scale deficiencies were found in the 150-hour evaluation.[88]

The XT-37

The center made considerable progress during the six months in its effort to develop the first originally-designed Air Force jet trainer. On the last day of 1952, Air Force headquarters notified the center and the Cessna Aircraft Company that the latter's design proposals had been adjudged the winner in the competition which had seen 15 proposals submitted by eight prospective contractors. Two weeks later, the center forwarded a letter of intent to Cessna and followed up on 16 April 1953 with a letter contract for Phase I development.[89] Two months later, the contract was further amended, calling for the construction of three XT-37's.[90]

The XT-37 was a low to mid-wing twin-jet light-weight aircraft with side-by-side seating. The first prototype was expected in August 1954, with the other two experimental articles to follow in September and October of that year. Initially, the XT-37 was to be powered with French-built Marbore II engines, (designated J69-T-15), each with 920 pounds of thrust. These engines would be slightly modified by the Continental Aviation and Engine Company to make them compatible with the aircraft's fuel system.[91] On 22 May, Washington directed the materiel command to purchase nine of these engines at a cost of $225,000.[92]

In the midst of detailed design planning, Cessna suggested the use of magnesium in place of aluminum. However, materiel command and center representatives concluded in mid-February that the weight reduction and increased performance obtained from such a change did not warrant the additional cost. Actually, the trainer was well under weight limitations, and it met all performance requirements with only minor exceptions.[93]

By the end of the fiscal year, there were still no signs that a production order would be forthcoming. As a matter of fact, on

17 June, Colonel Haugen reported that the XT-37 had been dropped from the fiscal year 1954 program, at least temporarily.[94] If the Air Force finally decided to complete development and go into production, the joint project office expected YT-37's to be available in November 1956 for service test by the Air Training Command, with T-37A's to be operational in August 1957. These projected dates were dependent in large part on the availability of J69-T-9 American-built power plants. But, in turn, authority to proceed on the production engineering, tool design, and tooling for the -9 awaited a production decision on the trainer.[95]

One unpleasant consequence of the trainer competition was a written protest by Ryan, a participant. In mid-February, the company claimed that the full results of the competition had been suppressed. Ryan added that it was difficult to understand "this new Air Force policy of encouraging contractors to prepare and submit over-elaborate and costly design proposals only to subsequently refuse to point out the shortcomings of such designs so that the contractor can improve his position in future competition."[96]

The center was caught in the middle of this situation. Although its engineers and materiel command production and maintenance representatives had made evaluations of the individual proposals, the elimination process and ultimate selection of a trainer had been the task of an Air Force evaluation board.[97] Even so, as Colonel Stewart pointed out in a memorandum to Colonel Demler, it had always been a policy ". . . to release to the losers the information as to their standings in the competition but not to go into detail as to why they stood where they did because it was felt that it this were opened up it would be an endless wrangle over the merits of their relative designs." In this particular competition, the chief of staff commented, the board had not followed the numerical rating system. Therefore, relative standings were not at hand and ". . . they [the losers] are very unhappy about it."[98]

The evaluation board had established the elimination criteria. For excessive weight factors, three designs were eliminated. Another three dropped from consideration because they were not jet-powered. Another received no further attention since it incorporated an unproven primary structure. Facilities cost factors caused the deletion of two proposals. Only the Cessna and Ryan designs remained, and the board felt the former had a better cockpit arrangement for use with ejection seats. Almost all other factors were even.[99]

Although General Putt had earlier requested that the center give Ryan some "constructive criticism" of its design,[100] upon learning the details of the evaluation he agreed that such criticism was not in order. Accordingly, on 17 April, the center replied to Ryan, stressing that it had been an Air Force policy, even before World War II, not to release a report of actions leading to the results of any competition--only the results themselves. The reply also noted that the original request to bid had stated: ". . . and invites your company to submit one or more designs. . . ." No other "encouragement" had been given the prospective contractors.[101]

Convertiplanes

Convertiplanes, air vehicles having take-off and landing attributes of the helicopter and cruising characteristics of fixed wing aircraft, were in the process of being designed and fabricated by three different contractors--McDonnell, Bell, and Sikorsky. Although each of the designs was intended to have as an end product an airplane capable of undertaking tactical reconnaissance, liaison, and observation missions (primarily for the Army), they differed radically in their contemplated mode of propulsion. McDonnell planned to use the "unloaded rotor" type wherein both the wing tip rotors and the propeller (in a normal position) drived their power from an R-975 reciprocating engine. The rotors received the output in take-off and landing, the propeller while the aircraft was in horizontal flight. Lift was supplied by the rotors or the wings, depending on the type of flight. Bell designs called for a "tilting rotor" which served in a dual capacity--for horizontal and vertical flight. Sikorsky intended to employ a rotor for take-off and landing; in cruise, however, this rotor would be stopped and faired along the top of the fuselage.[102]

By the end of June, two of the three designs had received designations--McDonnell's being the XL-25 and Bell's, the XH-33. The latter was approved only on 20 March, but since it seemingly contradicted the "type" designation accorded McDonnell's and since the center had not been satisfied with "XL-25", the Weapons Systems Division requested a change to the "H" category for the XL-25.[103] Air Force headquarters had authorized no alteration by the close of the fiscal year. Nor had the Sikorsky design received an Air Force designation by that time.

At the start of 1953, both McDonnell and Bell were in the midst of Phase II design and development work. Although the two contractors had begun this phase in the first half of 1952, a dispute over patent rights delayed agreement on the definitive contracts. The materiel command was under instructions from Washington to include clauses which gave the government the right to produce the end item, including all components patented by the contractor. Bell and McDonnell would not agree, inasmuch as most development contracts allowed the government to reproduce only those items developed under the contract itself. No immediate agreement was in sight.[104]

By 30 June, McDonnell could report considerable progress. All Phase II engineering drawings had been completed and fabrication of two "stripped" aircraft begun. The rotor system, after falling behind schedule for about three months, started its whirl tests late in May. Whirling tests of the propeller were also under way. In this instance, a case of flutter developed; a decrease in pitch at the blade tip corrected the difficulty and produced satisfactory results. Continental encountered a delay in changing the R-975 from a tractor to a pusher type engine; however, the company promised delivery within the first two weeks of July.[105] Tests of the full scale model in the Ames wind tunnel, originally set for April, continued to slip and probably would not begin until March 1954.[106]

Preliminary wind tunnel tests completed at the center in May indicated several undesirable flight features of the McDonnell model. There was definite rotor instability which limited the high speed capability, and the model exhibited such poor longitudinal stability and control characteristics that the tail would have to be redesigned.[107] The model also induced a drag greater than that originally calculated, and the engine continued to generate insufficient power to meet specifications.[108]

Estimates at the beinning of the year had placed the maiden flight sometime in November 1953.[109] By mid-year, the need to correct apparent deficiencies had caused a postponement to April 1954.[110]

Bell's work on the XH-33 had thus far consisted mainly of compiling the design drawings of the rotor, transmission, and rotor conversion actuating system.[111] By 15 June, center engineers had reviewed and approved the drawings and layouts for the rotor and transmission. In the meanwhile, Bell began preliminary engineering work on the detailed structure, the redesign of the cockpit and canopies, and the study of an alternate landing gear.[112] Additionally, in separate tests from January through March, the Transcendental Aircraft Corporation (which had an aircraft similar in design to Bell's proposal) gathered data on rotor stresses and motions. It seemed extremely likely that such information would prove valuable in the Bell designs.[113]

Wind tunnel tests of a model at Wright Field disclosed that power-off conversion from horizontal to vertical flight was not satisfactory. Redesign of the collective pitch device would probably correct the condition.[114] The center foresaw no other particular difficulties at the moment.[115]

Although the schedule called for a flight in December 1954,[116] project personnel conceded that an April 1955 first-flight date was more likely and more realistic.[117] This was about a year after the expected initial flight of the XL-25. Nonetheless, no decision for production of one or the other would be made until the two had been thoroughly evaluated. It was certain that only one would survive, however.

The Sikorsky proposal lagged behind the other two, still being in Phase I. In the spring of 1952, based upon wind tunnel tests of a one-twentieth scale model, the center proposed a redesign of the aircraft and propulsion system. The changes were to be incorporated in a one-fifth scale model, and tested at Wright Field in August 1952. Subsequently, because of unresolved design questions and many changes in the instrumentation and calibration of the model, the starting date for the test began to slip--from August 1952, to November 1952, to February 1953, to March 1953, and finally to July 1953.[118] Moreover, on 20 May, center inspectors determined that the instrumentation and calibration were still unsatisfactory.[119] So there was a distinct possibility that the tests would again be postponed. At mid-year, the chances of the Sikorsky convertiplane's ever getting beyond Phase I were very slim.[120]

Helicopters

The major trend evident in Wright Air Development Center's helicopter program through the first six months of 1953 was a gradual shift of workload and emphasis from Air Force rotary wing vehicles to those intended for use by the Army. The Air Force did not alter its basic mode of operation, but in the main the systems under development were Army aircraft. In furtherance of the effort to create a closer working relationship between the two agencies, assistant project officers from the Army were assigned to several of the center's helicopter offices. The agreement which made this action possible was worked out early in the year and by the end of June the first two assignees had reported. Additional support through the media of clerical spaces allotted to the project offices by the Army was anticipated later in 1953. The net result would be to eliminate misunderstandings between the developing and the using agencies.[121]

Most technical advances made during the period were in the development of components. No remarkable first flights were recorded and no strikingly original designs progressed to the stage of initial fabrication. However, there was continued interest in the unique design of the rotor assembly for the YH-16, and a considerable amount of attention was devoted to the heavy-lift helicopter program--the XH-17 and the proposed H-28. Completion of qualification tests of new tip-mounted pulse jet engines for the XH-26 was another step forward, although the improvement in XH-26 performance was not expected to become demonstrable until the latter half of the year, when the new pulse jets were actually installed and operated on the one-man helicopter.[122]

Evaluation of the unique structural properties of the rotor blades developed by Piasecki for its big cargo helicopter, the YH-16, was completed early in the year. Each blade consisted of two aluminum plates milled to form airfoil-shape skins which were contoured over honeycomb filler blocks, joined at leading and trailing edges, and attached to the hub by thickened skin at the blade roots. Piasecki believed this construction would provide an excellent aerodynamic surface and contour, a skin free of stress concentrations, means of attaching blade to hub without excessive strain on the connection, and easy producibility features.

Propeller Laboratory and project engineers felt that this method had several major drawbacks. A great amount of material was wasted in the milling process (a 3,000-pound billet was shaved down to 180 pounds of skin), but more serious from a performance standpoint was the method of bonding together the skin sections. The bonds were extremely difficult to make consistently strong, and the high stresses on the leading edges of the blades thus presented the possibility of a sudden and disastrous delamination of the honeycomb and the blade surfaces. This appeared to be the major fault. Its seriousness was emphasized by engineers who also noted that the bonding adhesive lacked certain desirable qualities and that Piasecki's method of applying the adhesive was inherently inappropriate.

The success of the YH-16, a very important development, was dependent as much on blade adequacy as any other single factor. For that reason there was some unfavorable reaction within the center to the idea of using such a radically new blade design in an experimental helicopter. Propeller experts decided the design would have to be thoroughly tested in a whirl rig before it could be installed on a flight test aircraft. Since this might be a lengthy process, a Prewett all-metal blade was being held in reserve as an "adequate alternate." The use of combination steel-wood blades was not recommended for the YH-16, and size alone virtually precluded the use of all-wood blades.[123]

On 8 May, after a long delay in the fabrication process had disarranged previous schedules, the first of the Piasecki honeycomb center blades was delivered to the Propeller Laboratory for evaluation.[124] The tests lasted until early July, at which time reduction of the obtained data began. No final evaluation of the worth of the blade would be possible until all results had been calibrated and analyzed, a process which would probably take some weeks.[125]

The first of the Prewett laminated stainless steel rotor blades for the YH-16 was airlifted to the Propeller Laboratory on 4 July. Installation on the whirl rig occupied the next two weeks, after which actual tests began. Here again results and an evaluation of worth would be delayed until the late months of 1953. However, preliminary results indicated that the Prewett blade would at least withstand the maximum stress imposed by helicopter maneuvers.[126]

Funding problems intruded into the YH-16 development program late in fiscal year 1953. Development had proved to be more expensive than had initially been anticipated; an overrun of $3,410,562 was processed in June and additional financing in the amount of $4,112,750 provided shortly thereafter. This money came from the Air Materiel Command, which had been authorized to expend production funds to continue the program. However, at about the same time, the materiel command received instructions from Washington to stop work on the production implementation contract for the H-16 series. The decision was based largely on the fact that the helicopter would be used only by the Army. Thus any production beyond that authorized initially would require financial support from the Army. This funds situation had no effect on development, but unless additional money arrived early in fiscal year 1954 the production program would have to be delayed.[127]

Funding was also the major issue in the heavy-lift cargo helicopter project. The XH-17, which had begun life as a ground test rig for a huge tip-mounted, jet propulsion rotor system, later had been modified to permit flight. Operation of the experimental rig had revealed the existence of excessive vibratory stresses in the main rotor blades during forward flight. This condition was not present during hovering maneuvers, but evidenced itself whenever the "flying crane" proceeded at a rate greater than 10 knots. Tentative corrections to blade balance had failed to eliminate the vibration. Engineers estimated that redesigning the blades and changing their structural qualities would take one to two years and cost more than $1,000,000--an expenditure which did not seem justified in terms of the data that could be derived from a perfected rotor system.

The information gained from experience with the XH-17 demonstrated the practicality of the total system and made it apparent that the construction of a practical vehicle for battlefield transport of heavy equipment would not be either impossible or impractical. In the main the details of the XH-17 design were quite sound, and their application to a tactical carrier did not appear to be a difficult process. Little was to be gained by additional effort devoted to the experimental version, therefore the project office recommended closing out work.[128]

Tentatively, this course was adopted.[129] However, there were subsequent indications that the Army would not be able to finance the logical successor to the XH-17, the proposed H-28. Therefore the Army proposed extending the process of obtaining experimental data from the original test vehicle,[130] and for fiscal year 1954 provided a total of slightly more than $125,000 to continue work on the heavy-lift helicopter program.[131]

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GLOSSARY OF ABBREVIATIONS

Acctg.	Accounting
Actg.	Acting
Admin.	Administration, Administrative
Aero.	Aeronautical
AF	Air Force
AFB	Air Force Base
AFCRC	Air Force Cambridge Research Center
AFD	Air Force Depot
AFFTC	Air Force Flight Test Center
AFR	Air Force Regulation
AFSWC	Air Force Special Weapons Center
AIA	Aircraft Industries Association
Airc.	Aircraft
AMA	Air Materiel Area
AMC	Air Materiel Command
Anal.	Analysis
App.	Appendix
Approx.	Approximately
ARDC	Air Research and Development Command
ARL	Aircraft Radiation Laboratory
Arm.	Armament
Asgd.	Assigned
Assn.	Association
Asst.	Assistant
ATIC	Air Technical Intelligence Center
ATO	assisted take-off
attn.	attention
Auth.	Authorized, Authorization
Avn.	Aviation
Bd.	Board
bet.	between
Bomb.	Bombardment
Br.	Branch
Brig.	Brigadier
Bud.	Budget
Bul.	Bulletin
C	Confidential
Capt.	Captain
CEO	Capital Expenditure Order
CG	Commanding General

Chm.	Chairman
Civ.	Civilian
Cmdr.	Commander
Cmt(s).	Comment(s)
C&N	Communication and Navigation
Co.	Company
Col.	Colonel
Com.	Committee
Compt.	Comptroller
Conf.	Conference
Contr.	Contractor
Corp.	Corporation
Corresp.	Correspondence
C/S	Chief of Staff
C&S	Components and Systems
CVAC	Consolidated Vultee Aircraft Corporation
D/	Deputy
DAR	Daily Activity Report
DCG	Deputy Commanding General
D/Compt.	Deputy for Comptroller
DCS/D	Deputy Chief of Staff, Development
DCS/M	Deputy Chief of Staff, Materiel
DCS/O	Deputy Chief of Staff, Operations
DCS/P	Deputy Chief of Staff, Personnel
DD	Department of Defense
D/Dev.	Deputy for Development
Def.	Defense
Dep.	Deputy
Dept.	Department
Dev.	Development
DF	Disposition Form
DIR	Daily Information Report
Dir.	Director(ate)
Dir/Air Weap. Sys.	Director(ate) of Air Weapon Systems
Dir/Eng.	Director(ate) of Engineering
Dir/Eng. Stds.	Director(ate) of Engineering Standards
Dir/Flt. & All-Wx Testing	Director(ate) of Flight and All-Weather Testing
Dir/Labs.	Director(ate) of Laboratories
Dir/Maint. Eng.	Director(ate) of Maintenance Engineering
Dir/Mgmt. Anal.	Director(ate) of Management Analysis
Dir/Proc.	Director(ate) of Procurement
Dir/Proc. & Prod.	Director(ate) of Procurement and Production
Dir/Program Admin.	Director(ate) of Program Administration

Dir/R&D	Director(ate) of Research and Development
Dir/Res.	Director(ate) of Research
Dir/Spt.	Director(ate) of Support
Dir/Stat. Servs.	Director(ate) of Statistical Services
Dir/Strat. Combat Sys.	Director(ate) of Strategic Combat Systems
Dir/Sup. & Servs.	Director(ate) of Supply and Services
Div.	Division
Dly.	Daily
D/Mat.	Deputy for Materiel
D/Ops.	Deputy for Operations
D/Pers.	Deputy for Personnel
Dtd.	Dated
ECM	Electronic Countermeasures
Ed.	Editor
Eng.	Engineering
Engr.	Engineer
Eqpt.	Equipment
Eval.	Evaluation
Exec.	Executive
Exp.	Experimental
Fisc.	Fiscal
Flt.	Flight
FRL	Flight Research Laboratory
FY	Fiscal Year
G, g	Gravity
GE Co.	General Electric Company
Gen.	General
GFAE	Government Furnished Aeronautical Equipment
GO	General Order
Gp.	Group
Hist.	History, Historical
Hq.	Headquarters
IG	Inspector General
Impr.	Improvement
Inc.	Incorporated

Incl.	Inclosure
Ind.	Indorsement
Info.	Information
Insp.	Inspection
Intell.	Intelligence
JPO	Joint Project Office
Jr.	Junior
Jt.	Joint
Lab(s).	Laboratory, Laboratories
Lt.	Lieutenant
Ltr.	Letter
Maint.	Maintenance
Maj.	Major
Manp.	Manpower
Mat.	Materials, Materiel
MDAP	Mutual Defense Assistance Program
Med.	Medical
Memo.	Memorandum
Mfr.	Manufacturer
Mgmt.	Management
Mil.	Military
Min.	Minutes
Misc.	Miscellaneous
Mo.	Monthly
MRS	Memo Routing Slip
Mtg.	Meeting
n.	nautical
NAA	North American Aviation, Incorporated
NACA	National Advisory Committee for Aeronautics
No.	Number
Op(s).	Operational, Operations
Org.	Organization(al)
p. (pp.)	page(s)
Para.	Paragraph
Perf.	Performance

Pers.	Personnel
Photo.	Photographic
P&O	Plans and Operations
PPL	Power Plant Laboratory
Prep.	Prepared
Pres.	President
Presn.	Presentation
Proc.	Procurement
Prod.	Production
Prog.	Program
Proj.	Project
Prop.	Propeller
Publ.	Published
Qtr.	Quarter(ly)
R	Restricted
RADC	Rome Air Development Center
R&D	Research and Development
RDB	Research and Development Board
RDO	Research and Development Order
Recon.	Reconnaissance
Reg.	Regulation
Rep.	Representatives
Req.	Requirement
Res.	Research
Restr.	Restricted
Ret.	Retired
RIF	Reduction-in-force
ROTC	Reserve Officer Training Corps
Rpt.	Report
S	Secret
SAB	Scientific Advisory Board
SAC	Strategic Air Command
SAE	Society of Automotive Engineers
Sect.	Section
Secy.	Secretary
SEO	Service Engineering Order
Serv(s).	Service(s)
Spt.	Support
Stat.	Statistical
Std(s).	Standard(s)
Strat.	Strategic

Sum.	Summary
Sup.	Supply
Suppl.	Supplement
Sys.	System(s)
TD	Technical Directive
Tech.	Technical
Telecon	Telephone Conversation
Tfr.	Transfer
T.O.	Technical Order
TT	Teletype
U.	University
UR	Unsatisfactory Report
U.S.	United States
USAF	United States Air Force
Vol.	Volume
vs.	versus
WADC	Wright Air Development Center
WADCN	Wright Air Development Center Notice
WADCR	Wright Air Development Center Regulation
WAR	Weekly Activity Report
Weap.	Weapon(s)
WIR	Weekly Information Report
Wk.	Weekly
WOR	Weekly Operations Report
WSD	Weapons Systems Division
Wx	Weather
XSO	Cross Servicing Order

GLOSSARY OF TERMS

Accessory - a supplementary device which, when used in conjunction with an end item, contributes to its effectiveness without extending or varying its basic function (AFR 80-13)

Alloy - a substance that has metallic properties and is composed of two or more chemical elements of which at least one is a metal

Applied research - application of the results of basic research to the design of specific devices; it may also include the initial steps in realizing a technique or device which makes practical use of a research idea or discovery (AFR 80-13)

Armament - guns, ammunition, and explosive materials including bombs, propellants, rockets, pyrotechnics, and incendiary compounds, protective armor, equipment for dispensing toxic and biological warfare materials, sights, computers, launchers, and control systems, together with components, accessories, supplies, fixtures, handling, training, analyzing, maintenance, and test equipment (AFR 80-13)

Assembly - a combination of parts or sub-assemblies which may be taken apart without destruction and which does not have any application or use of its own, but is essential for the completeness of a more complex item with which it is combined (AFR 80-13)

Attachment - a supplementary device composed of parts or assemblies which, when fastened to or mounted on an end item, varies or extends the basic function (AFR 80-13)

Automatic tracking - the process of using data computed from electronic observation of an air vehicle to drive devices that keep a tracking system locked on the target

Azimuth - an arc of the horizon

Basic research	- fundamental, theoretical, or experimental investigation to increase man's knowledge and understanding of the natural world; immediate practical application is not a direct objective of the investigation but usually such application will emerge from discoveries in new fields of interest (AFR 80-13)
Budget series	- classification of obligations and expenditures by related projects within a major development program; broken down into: 610-aircraft 620-guided missiles 630-propulsion 640-electronics 650-armament 660-equipment 670-sciences 680-special projects 690-laboratory operations
Celestial navigation	- navigation by means of fixed celestial points
Chaff	- strips of material, dropped from aircraft in flight, which reflect and confuse transmitted radar beams
Combat ceiling	- that altitude at which rate-of-climb is 500 feet per minute at stated weight and engine power
Combat radius	- practical round trip mission without refueling
Combat range	- a practical one-way cargo flight without refueling
Commitment	- an administrative "earmarking" of funds for future obligations based on requisitions, purchase requests, or other written evidence of intent to expend
Crazing	- making small cracks on the surface

Creep - the flow or plastic deformation of metals held for long periods of time at stresses lower than the normal yield strength; the effect is particularly important if the temperature of stressing is in the vicinity of the recrystallization temperature of the metal

Cross servicing order - a document used by the center in planning and administering projects accomplished for non-Air Force agencies

Deficiency - in present center usage, any defect of an aircraft which had not been foreseen by the designing and developing engineers; often confused with genuine development problems

Development - extension of the investigative findings and theories of a scientific or technical nature into practical application, including the construction and testing of prototype models or devices, and such design changes affecting qualitative performance as may be required during the service life of any item (AFR 80-13)

Development project - an undertaking to develop an assembly, accessory, attachment, end item (or principal component thereof), or materiel; to develop a related family of components; to explore a field of knowledge in search of scientific information; a distinct unit of development effort which is of sufficient importance to warrant appropriate review at all Department of Defense levels (AFR 80-13)

Doppler effect (radar) - for aeronautical purposes, the apparent change in the frequency of radiations beamed from a moving air vehicle and reflected back from the earth

Drag - aeronautical term for air resistance

Drogue chute - a parachute deployed by an aircraft to increase drag upon landing, thereby decreasing the distance of the landing roll

Electronic countermeasures - the use of electronics to negate or reduce the effectiveness of enemy electronic devices

Emergency funds - monies from the special emergency fund reserve maintained by the Secretary of Defense, or by the Research and Development Board

Fatigue - the tendency for a metal to break under conditions of repeated cyclic stressing considerably below the ultimate tensile strength

Fix - an action or measure which may be either a permanent or an interim correction for a deficiency that impedes the proper operation of a piece of equipment

Flying boom - a rigid, telescopic fuel transfer tube to which are affixed aerodynamic control devices (elevators) operated by a crew member; the device is attached to a tanker aircraft, is first extended below the tanker aircraft, and then engaged by a probe extending from a receiver aircraft; the technique was primarily a Boeing development

G, g - a symbol used to denote gravity; a term used to express the unnatural weight of an object relative to its normal weight, when it is subjected to inertial force; a force of four g would be the same as increasing the weight of the object four times

Heat treatment - a combination of heating and cooling operations, timed and applied to a metal or alloy in the solid state in a way that will produce desired properties

Human engineering - the application of scientific knowledge concerning human limitations and performance capabilities to the establishment of requirements for, and to the design, development, evaluation, and utilization of all types of airborne and ground equipments and systems required by the Air Force for the accomplishment of its mission (AFR 80-18)

Hypersonic - speeds in excess of Mach 5

Jet wake fairings - devices, a part of the tailpipe of a turbojet powered aircraft, which direct or channel the jet exhaust (wake) so as to exert the greatest amount of thrust and the least possible angled stress on the airframe

Laminated - composed of layers or coatings

Landing roll - the distance which an aircraft takes to come to a complete stop after touching the runway

Leading edge - the edge of an airfoil or propeller blade facing the direction of motion

Loran - long range navigation

Low frequency - a frequency of 30 to 300 kilocycles

Mach number - the ratio of the speed of the flow of air to the speed of sound at a specific temperature; used to designate the flight speed of aircraft

Mid-course guidance - the means by which an uninhabited missile is directed in the cruise portion of its flight between the launching area and the immediate target area

Military Characteristics - required qualities of equipment to fulfill a specific military purpose

Modification - any change in functional components and accessories of the equipment as initially procured, which will alter military characteristics and tactical utility (WADCR 65-1)

MOS classification - an Army system of classifying personnel according to talent and training

Non-radiating system - an electronics system which contains a detection device but no transmitting element

Obligation - the amount of an order placed, a contract awarded, or any other similar transaction which legally reserves an appropriation or fund for expenditure

Precedence rating - a rating assigned to a project to insure that services or items needed in support of that project receive proper priority in relation to other projects

Pre-turbine injection - a means of thrust augmentation which consists of injecting a special additive into the combustion chamber of a gas turbine engine, thereby accelerating the expansion rate of the ignited fuel; pre-turbine injection creates an afterburner effect in the combustion chamber

Probe and drogue - a flight refueling technique developed by the British, in which the tanker aircraft reels out a flexible hose tipped with a cone-shaped "drogue" to the "probe" or receiver of the aircraft needing fuel

Production engineering - adaptation of design to economical quantity manufacture, and the choice and improvement of the manufacturing processes incident thereto, as long as the qualitative military capabilities of the materiel are not changed; interchangeability of parts and modification of fabrication processes are in this category (AFR 80-13)

Pulsejet - a jet engine which delivers power in periodic bursts, rather than continuously

Purchase request - the document used to request procurement of items or services

Ramjet - an engine, with no moving parts except the fuel pumping system, which scoops in air through a nose inlet and gains thrust from the expansion and rearward expulsion of the ignited fuel-air mixture

Research - fundamental investigation of all activities wherein the discovery of applications of interest to the Air Force may be expected; it includes theoretical analysis, exploration, and experimentation directed to the increase of knowledge, and with it the power to control phenomena, but without completely defined goals (AFR 80-13)

Research and development order - the basic document used by Wright Air Development Center in planning and administering its research and development work

Service ceiling - that altitude at which rate-of-climb is 100 feet per minute at stated weight and engine power

Service engineering order - the basic document used by Wright Air Development Center in planning and administering its service engineering work

Service testing - a general term used to describe the entire testing program; it includes all proving or testing required to insure that materiel delivered to using activities is reliable and safe for service use, can be maintained by average Air Force personnel and skills, is logistically supportable, and is operationally effective (AFR 80-13)

Shoran - short range navigation

Specific fuel consumption - the quantity of fuel in pounds per hour required per brake horsepower or per pound of thrust; the lower the specific fuel consumption, the more efficient the power plant

Stall - when the wing assumes an angle of attack greater than the angle of maximum lift; the condition in which the lift forces are less than the weight of the airplane

Standard equipment - a classification assigned to a piece of equipment when it is placed in a Table of Organization and Equipment; this status designates the equipment which can be procured for field use for the Air Force; sub-standard equipment is that used as a substitute for standard when no comparable equipment classified as standard exists, or no specification covers it

Stellar inertial guidance - the electronic guidance of an aircraft or missile to its destination by means of automatic reference to celestial points

Telemeter - to electrically transmit information to a distant station, where it is recorded

Terminal guidance - the means by which a non-inhabited missile is directed to the small area of its specific target after having traveled from its launching site to the locale of the target

Torque - that which produces or tends to produce rotation or torsion; the turning force exerted on a shaft

Transistor - a semi-conductor amplifier which can be used for many functions performed by a vacuum tube; is more rugged, smaller, lighter, and lasts longer than a vacuum tube

Turbojet	- an aircraft engine propelled by the expansion and subsequent expulsion of compressed air and burned fuel
Turboprop	- a conventional turbine engine which propels the aircraft by means of power transmitted to a propeller as well as turbojet thrust
Ultra-high-frequency	- a frequency between 300 to 3,000 megacycles
Unsatisfactory report	- the formal report which describes defects or unsatisfactory conditions encountered by using Air Force agencies; consists of Department of Defense Form 535 and Air Materiel Command Form 50E (WADCR 80-11)
Very-high-frequency	- a frequency between 30 and 300 megacycles
Weapon system	- an assemblage of components, the arrangement of which is capable of sustaining a military airborne objective; a group of interdependent elements united by a common objective
Wing chord	- a straight line joining the trailing and leading edges of an airfoil section
X-band	- a frequency of 5,200 to 11,000 megacycles

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OFFICE FILES

Office of the Commanding General

Correspondence file of monthly letters between the commanding generals of Air Research and Development Command and Wright Air Development Center

Correspondence files on numerous and varied administrative and operational matters

Office of the Vice Commander

Correspondence files on numerous and varied administrative and operational matters

Office of the Chief of Staff

Correspondence files on numerous and varied administrative and operational matters

Office of the Assistant Chief of Staff (Executive Secretary)

Master file of the daily activity reports submitted by the deputies, directorates, and laboratories to the commanding general

Deputy for Comptroller
(Deputy Chief of Staff, Comptroller)

Manpower and Organization Division

Files on manpower allocations and ceilings and organizational structure

Deputy for Operations
(Deputy Chief of Staff, Operations)

Programming Office

Files on programming, technical directives, and development plans

Development Operations Division

Files on functional transfers

Operational Services Division

Service Engineering Branch

Files on unsatisfactory reports

Technical Information and Intelligence Branch

Files and worksheets for daily activity reports and weekly operations and information reports

Weapons Systems Division
(Directorate of Air Weapon Systems)

Files from numerous systems offices on specific aircraft

Files from Systems Planning Office on future weapon system plans

Deputy for Personnel

Civilian Personnel Division

Files on strength, reduction-in-force, turnover, and training

Headquarters, Air Research and Development Command

Deputy for Development

Directorate of Strategic Combat Systems

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The reports, one for each missile, contain a concise summary of background data plus progress during the month. Publication ceased in June.

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