Project 41

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DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON 25, D.C.

MEMORANDUM FOR THE SECRETARY OF DEFENSE

SUBJECT: Project No. 41 - SKYBOLT

Attached is the report on Project No. 41 - "Reassess the SKYBOLT project as presently oriented and for possible use in connection with weapons systems other than the B-52".

Harold Brown
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REPORT ON PROJECT #41

"Reassess the SKYBOLT project as presently oriented and for possible use in connection with weapons systems other than the B-52."

1. The response to Project #41 is in two parts. Part I is a reassessment of the SKYBOLT project as it is presently being re-oriented. Part II considers the possible application of SKYBOLT to carriers other than the B-52.

2. One of the results of the recent reconsiderations of the FY 62 budget was the addition of $50 million for the SKYBOLT program. This, added to the $150 million of FY 61 funds which were to have extended through FY 62, resulted in a reprogramming in February which provides $111 million for FY 61 and $89 million for FY 62. Final decisions resulting from this reprogramming are still being made and the Air Force has stated that a completed development plan cannot be available before June. In consequence the material contained in Part I is based on a two day review of the program carried out at the Weapons System Project Office on 27-28 April 61 during preparation by the Air Force of the final development plan.

3. In accordance with the earlier directives of OSD which approved a weapons systems research and development program for the SKYBOLT, it is being designed specifically for carriage on the B-52. Earlier Air Force directives had required that the weapon be capable of carriage by the B-52, B-58, B-70, KC-135 and the British "V" bombers. As a part of the reorientation of the program directed by OSD in 1959, this directive was changed and the SKYBOLT is being designed for carriage by the B-52 and the British Vulcan. In consequence, the SKYBOLT without modification is limited in its application to other aircraft. There is, however, little question but that with suitable modifications it could be adapted to the KC-135 or that the DROMEDARY could be designed to serve as a SKYBOLT carrier. The in-flight environment of the B-58 and the B-70 make the SKYBOLT application to these systems unattractive and would dictate a major re-design of the SKYBOLT as well as requiring extensive modifications of the carriers.

4. Our conclusions with respect to this project are as follows:

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

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a. The SKYBOLT will be delayed but should enter the inventory by the end of 1964.

b. There is no reason apparent which casts serious doubt on the technical feasibility of the SKYBOLT.

c. There is a serious question concerning the effectivity of management of the SKYBOLT program and the decision-making processes applicable to this program. This is brought into focus by the apparent difficulty in the Air Force generation of a new development plan.

d. Establishment of funding ceilings for FY 61/62 has resulted in a general tightening-up of the program which, in the large, is beneficial. There are, however, some areas where the element of increased risk appears undesirably large as, for example, the elimination of sled testing of the guidance system, the reduction in effort directed specifically toward the attainment of reliability and maintainability and a reduction of effort in qualification of hardware.

e. The SKYBOLT could be used with other carriers but in each case such use would require modification to a greater or lesser degree to both the missile and the carrier. A decision to so use the SKYBOLT other than on the B-52 and Vulcan if made at this time would seriously interfere with the orderly prosecution of the program.

f. The Air Force currently estimates the total cost of the R&D program, including both contractor and Air Force activities, at $415 million of which approximately 20 million will be U.K. reimbursable. The initial estimate in January of 1960 was $219 million, based on a very preliminary outline of the program, and was generally recognized as being too low. In the opinion of the Ad Hoc Group for Air-to-Surface Missiles, which was charged with the review of this program for DDR&E in 1959, a realistic estimate of the total development cost was thought to be in the neighborhood of $500 million. A thorough cost study directed by ARDC in May of 1960 resulted in an estimate in June of $372 million. Taking into account the current reorientation of the program and including those items which in our opinion should be reinstated (paragraph d. above), we have a reasonable degree of confidence that the estimate of the Ad Hoc Group will not be exceeded. Of this total, as shown in the following table, there will have been $238 million obligated by the end of FY 62 (This does not include MAP funds added to the program to cover specific expenditures for the U.K.).

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Fiscal Year	59	60	61	62
Actual or Planned Obligations ($M)	3	35	111	59
Cumulative Obligations		38	149	238

5. Justification for the SKYBOLT development solely as a weapon to be carried by the B-52 appears to be very marginal. There is, however, interest in exploring the future of this type of weapon delivery in applications such as DROMEDARY. The SKYBOLT does constitute a building block which could be used to enter into a DROMEDARY program recognizing even that ultimately a DROMEDARY would prefer a longer range missile. It is for the combination of the above two reasons that SKYBOLT should be carried at least through research, development, test and evaluation in order to gain the experience in air launching ballistic missiles. No production decision for use on the B-52 appears warranted at this time.

6. Pending any decision relative to a realignment of this program, especially with respect to other carrier systems, we will continue the development program as described in Part I, reviewing those decisions of the Air Force which cause concern because of the increased risk which they introduce to the program.

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PART I

1. In a memorandum to the Secretary of the Air Force, dated 1 February 1960, the Deputy Secretary of Defense approved a weapons system development program for the SKYBOLT (GAM-87A). This approval was based on a specific technical program presented by the Air Force to the Director of Defense Research and Engineering on 29 January 1960. Subsequent to this, certain revisions to the program were agreed upon jointly between the Air Force and the Director of Defense Research and Engineering and these were incorporated in a revision to the development plan, dated 1 October 1960. In general, these revisions have tended to simplify the program. Additionally, the Deputy Secretary of Defense commented on the need for a competent management structure requiring, among other things, that the management concept parallel that which had been proven in the Air Force ballistic missile program and that the nucleus of technically qualified management personnel be retained during the development period.

2. The objective set by ARDC for the new development plan is "to design a reasonable risk program which stays within the $200 million total fund limitations for FY 61 and FY 62". In the following paragraphs we have identified those areas of risk which, in our opinion, require further examination together with technical achievements and changes in the program of such a nature as to warrant identification.

a. Re-entry Vehicle

(1) The warhead was not defined until January 1961, approximately six months later than the required date. In consequence changes in the funding level have had little effect on this subsystem other than to limit the amount of qualification testing being planned.

(2) Shape of the re-entry vehicle was defined in March 1961 and, [redacted] Design criteria was established in April with a design freeze scheduled in July. The first flight of this design will occur as part of the fifth guided flight with earlier flight test vehicles carrying some sort of representative mock-up. In comparison with other ballistic missile re-entry programs, this program incorporates a greatly reduced amount of qualification testing of components. For simplicity and least cost the British intend to use the identical [redacted]

b. Guidance Subsystem

(1) Earlier difficulties in the development of manufacturing techniques to achieve required tolerances have been the principal contributors to a delay in this subsystem of several months. As a part of the current reorientation, an administrative decision has been made to eliminate in-flight demonstration of low altitude and off-course launches together with sled testing of the guidance equipment. The latter action, taken despite technical recommendations favoring such a test, are cause for concern especially when one notes that the guidance systems for all other ballistic systems have been subjected to sled testing with beneficial effects to the respective development programs.

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(2) Because of manufacturing problems the first astro-inertial unit scheduled for completion in February is expected to be completed in June. The pre-launch computer is only two to three weeks behind its earlier schedule. Weight of this unit has approximately doubled during development. Field tests of the astro-inertial tracker and its controlling unit will take place at Palmer in May. Air alignment tests using a C-131 to obtain pre-launch environment conditions will begin in December. As noted, the sled tests of the guidance equipment have been eliminated but the costs of accomplishing such tests are being re-examined in the hopes that this decision might be reversed. A complete radiating and conducting noise test has been made of an operational B-52 in an effort to prevent repetition of electrical interference troubles experienced by the HOUND DOG. Reliability testing of this subsystem has suffered less reduction than is the case in the other subsystems but much of the work has been deferred including long term stability testing of the Kearfott Gyro. This makes an exact estimate of CEP based on component performance somewhat funny but it is expected that initially the missile will have a CEP of 1 1/2 n.m. eventually reducing to 1 n.m. as operational difficulties are identified and corrected. The design of the SKYBOLT includes a capability for launch at high and low altitudes and for off-course launch up to 45°. While this design has been accomplished, a demonstration of this capability will not be performed, thus permitting an appreciable reduction in the flight test program.

c. Propulsion Subsystem

(1) The limitation of funds, while it has resulted in an early freeze of the design and a reduction in the number of units to be tested, has not affected the technical achievements in the propulsion area. Early measurements of ISP compared with a specification requirement of 245 seconds are running 248 seconds in the first stage and 243 seconds in the second stage. Graphite nozzle inserts have been successfully fired with both stages and, although the torque values are slightly high, the gimballing nozzle development appears to be in good shape.

(2) The only changes in the propulsion subsystem have been those earlier agreed to by DDRE, notably the substitution of a single gimballing nozzle for the four swiveling nozzles in the second stage. After some indecision a low operating temperature of minus 30° in combination with a heater blanket has been established. Problems which have appeared have been successfully resolved and the major problems anticipated are the final designation of a Class 2 explosive and the successful firing of a motor following vibration testing. This latter has been rescheduled as a result of earlier OSD holdbacks of funds for facility items. An additional problem is the need for radiographic inspection equipment at Eglin Field, this being considered a safety of flight item which because of tight fund control and allocation has not yet been ordered. A potentially serious change in the propulsion test program has been the large reduction in the

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number of units to be ground tested. On the other hand, in view of technical achievements to date, this may not be serious. The earlier program provided for a total of 305 tests prior to the end of 1963 while the present program is limited to 259 tests and extends into 1964.

d. Airframe Subsystem

Wind tunnel testing of the airframe is approximately 45% complete with the emphasis to date being on the stability and control problems rather than a drag investigation. The current range estimate is 950 miles as compared with a system requirement of 1,000 miles.

e. Flight Test Program

(1) There has been a significant reduction in the number of planned flight tests. Assuming a reasonable degree of success in combination with the elimination of the requirement for demonstration of low altitude and off-course launch capabilities, this would probably not be serious.

(2) For comparative purposes the numbers of missiles planned for the several types of flight tests is tabulated below for the original and current programs.

Type of Test	January 1960	April 1961
Dummy	12	11
Programmed	6	4
Captive Mechanical	3	1
Captive Electrical	3	2
Guided	38	31
Attrition	0	2

Dummy flight tests are used to check separation characteristics and to measure roll, pitch and yaw in unpowered flight. Programmed missiles do not contain the guidance system but fly a predetermined trajectory. Attrition tests refer to carry of complete missiles for a long period of time, these missiles to be X-rayed periodically to determine the life of the motors under flight environment. There has been no change in the Category 3 program but the 12 missiles will be procured as a part of the production program.

f. Aerospace Ground Equipment

(1) Because of early identification and design of the items making up the Figure 1 List, this area is not affected by the current fund limitations.

(2) Of 102 items identified for the Figure 1 List, 74 have received design approval, 49 of which are on procurement and 9 of which will be GFE. Design of the other items will be continued but

equipment fabrication has been deferred until FY 63 funds become available. Any risk in this area relates to the decision to defer environment testing rather than to the availability of equipment necessary to support the test program. The GTA-9 (Universal Ground Test Equipment) being procured separately is now available and the adaptors (now identified as Ground Test Sets) to be furnished by the SKYBOLT contractors will be available in time for use at Eglin.

g. Personnel Subsystem

(1) By administrative decision further work in preparation of training programs has been deferred. This is not serious because under the concept of concurrency much work was done early in preparation for the training program and because procurement of training equipment should await the decision to place SKYBOLT in production.

(2) Early work on this part of the program has included publication of maintenance flow charts, training concepts, individual training plans and the QPRI. Contractor manuals will be used in place of training manuals. Some of the initial training equipment has been deferred until FY 63 funds are available. This may not meet the currently defined SAC requirements for training in preparation of Category 3 testing but otherwise constitutes no immediate problem.

3. The total cost of the research and development program, including both contractor and Air Force activities, is currently estimated by the Air Force at $415 million including $20 million which will be reimbursed by the U.K. The initial cost estimate of $219 million in January of 1960 was prepared very hurriedly following a complete change in the program and was generally considered inadequate. Consequently, and in consonance with comments made by OSD at the time of program approval, ARDC directed a thorough review and re-estimate of program costs conducted by a team selected for that purpose in May and June. This resulted in an estimated cost for development of $372 million. This estimate and the current one are consistent with the estimate made by the Ad Hoc Group for Air-to-Surface Missiles of between $400 to $500 million. The tightening up of financial control of this program and the fact that much more is known of its actual content suggests that considerable confidence can be placed in a development cost estimate of between $400 to $500 million, even including those items which our assessment suggests should not be eliminated. While this tightening up process is beneficial, the present mechanism for making management decisions is not optimum and, in fact, may place serious limitations on the management flexibility required by the WSPO, especially if any further steps are taken in limiting contractor commitments vis-a-vis the placement of subcontractors.

4. As noted in paragraph 1, the original program approval document from OSD contained comments on program management. In particular, it pointed out that this was the first time an industrial contractor was being given prime contractor responsibility for a ballistic missile

program. The risks involved were such as to require the establishment of a very strong WSPO, stronger than this element of the Air Force has had in recent years. To date there has not been sufficient indication that the SKYBOLT program has been managed effectively.

There is clearly a need for selecting competent people and delegating to them the responsibility and authority for running the SKYBOLT program. In the recent programming reorientation and fund revision, the many levels of staffing have obscured the decision-making process. It is undoubtedly for this reason that a development and funding plan has not yet been submitted to OSD for approval. At the same time delays within OSD, as, for example, the delay in approving the Air Force request for a reprogramming action in September 1960, have resulted in the necessity for drastic program reductions in December, have further detracted from the ability of the WSPO to manage an orderly development program consistent with previously established schedules.

It is recommended that the Air Force specify the program manager and delegate to him the appropriate authority and responsibility for management of the development program. There should be specified one point of contact here at the Pentagon from which OSD can obtain information required in a timely fashion. Tight financial controls should be maintained at Headquarters, USAF, and at OSD; but although the DDRE should be responsible for advising the Secretary of Defense as to the program goals and whether they are being met, project engineering for the SKYBOLT program should be left in the hands of the WSPO together with its contractors.

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PART II

1. In the original systems requirement, the Air Force directed that the design of proposed air-launched ballistic missiles be suitable for employment with the B-52, B-58B, B-70, KC-135 and the British "V" bombers, Victor and Vulcan. During review of the program by DDRE's Ad Hoc Group on Advanced Air-to-surface Missiles, it became apparent that such a requirement greatly magnified the job and extended the time required to develop SKYBOLT. At about this time, the B-58B was cancelled and the B-70 program redirected to a prototype-only development. Accordingly, in the final presentation of the proposed SKYBOLT program the Air Force limited development to application to the B-52 and the Vulcan insofar as the latter did not result in serious compromise or unduly increase the complexity. It is now planned that the SKYBOLT will be fitted to the B-52 series F, G and H aircraft and the Vulcan Mark 2.

2. The following paragraphs discuss very briefly problems involved in any plan to adapt the SKYBOLT to other carriers.

a. KC-135.

(1) The SKYBOLT could be adapted to the KC-135 without modification. The in-flight environment of this aircraft is sufficiently similar to that of the B-52 that it would not require re-work of the missile.

(2) Some modification of the KC-135 would be required to make it a suitable carrier. The major requirement is for installation of that portion of the B-52 bomb-nav equipment required to provide the required inputs for the pre-launch computer. Internal power is probably adequate to meet the missile requirements. No study has been made of the wing structure but modification is believed necessary and the aircraft might be limited to not more than two missiles, having been designed for a smaller load factor than the B-52.

b. B-58.

(1) Modification of the missile is required for application to the B-58 if advantage is to be taken of the aircraft performance. Repackaging of the pre-launch computer and tracker control would also be required since the B-58 design does not include adequate space for the installation of this equipment.

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(2) Location of the missiles to insure satisfactory weight and balance for the aircraft results in a limitation of the field of view of the astro-tracker but is possible. The preferred installation for equipment to be carried in the aircraft results in deletion of the active defense system. Present electrical power is inadequate but can be supplied by the installation of another alternator. Installation of the SKYBOLT on the B-58 will undoubtedly decrease its performance but no data is available to indicate the magnitude of such effects.

c. B-70.

(1) In its present configuration the SKYBOLT is not suitable for carriage on the B-70 and because of the vastly different in-flight environment especially the effects of aerodynamic heating the missile would require complete redesign.

(2) At least in the earlier design studies consideration was given to carriage of an air-to-surface missile on the B-70. This requirement, however, was deleted and for at least the past two years has not received attention. If an ASM were employed with the B-70, its design would take account of the initial launch conditions of speed and altitude and would be vastly different than the current SKYBOLT. For example, it would probably be a single stage missile.

d. DROMEDARY.

(1) The SKYBOLT could be employed with an aircraft having the characteristics currently ascribed to the DROMEDARY. Such employment would not be optimum for the combined system and should be considered as a stop gap until such time as a better missile design becomes available. This subject was treated in Part II of our response to Project 40 which concluded that in the DROMEDARY concept missiles having ranges greater than that of the SKYBOLT would be necessary and suggested that minimum range be established at 2,000 n.m. Also, in our response to Project 40, we recommended that the DROMEDARY concept be the subject of a complete system study. As an interim the SKYBOLT consitutes a building block which might be used as a way to get into the DROMEDARY program recognizing that ultimately one requires a missile having an appreciably longer range.

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