~~TOP SECRET~~

NOV 29 1963
BYE 11451-63
COPY 2

SCG

Tagboard ~~(SECRET)~~

Honorable Brockway McMillan
Under Secretary of the Air Force
Washington, D.C. 20330

Dear Brock

1. Last summer, a brief study was made of the feasibility of using a modification of the Tagboard vehicle for weapon delivery purposes. These studies clearly indicated that this application had no merit. However, as an outgrowth of that study, a review was made of USAF reliability experience on aerodynamic missiles similar to the Tagboard vehicle. This experience indicates that an in-flight reliability of 80% was about the best we were able to achieve during development and test programs on the GAM-77, BOMARC B, and GAM-72 missiles. In view of the 5 years of effort involved in each of those programs and the $195-$322 million RDT&E costs of the GAM-77 and BOMARC B programs, it appears there may be great difficulty in achieving adequate reliability for Tagboard without a very long and expensive program. This may be a special problem for Tagboard because its mission appears to require a much higher in-flight reliability if the risks in its use are to be acceptable.

2. The rather alarming implications of the reliability problem have led to a review of other factors involved in Tagboard. The attachment to this letter includes a review of Tagboard technical problems, aerodynamic missile reliability experience, A-12 and D-21 survivability, sensor performance, and USAF capsule recovery experience.

3. It appears from our analyses that the overall probability of mission success for Tagboard may be considerably below that of the A-12. Considering the in-flight reliability problem, it is not clear that the risks in using Tagboard are lower than those involved with use of the A-12. Further, if the complete program costs for the Tagboard system (including recovery and operation and maintenance) were available, it is doubted if the system would be competitive on a cost/effectiveness basis with other existing approaches.

Copy 2 of 3

~~TOP SECRET~~ 20 FEB 1976 Handle via BYEMAN
Control System

4. It is recommended that a review of the Tagboard system including total program costs, schedules, operational effectiveness, operational plans, and risks involved in its use be made before further funds are expended on the program.

B. A. SCHRIEVER
General, USAF
Commander

5 Atch
Tabs A thru E

Copy 2 of 3

Handle via [illegible]
Control System

DESCRIPTION AND EVALUATION OF TAGBOARD (MD-21) DRONE RECONNAISSANCE SYSTEM

1. General Description

The system under consideration is a composite of a modified A-12 airframe for the carrier aircraft (M-21) plus a small ramjet powered reconnaissance drone (D-21). The airframes feature a high fineness ratio fuselage chine combination, thin, low aspect ratio wings and vertical tail surfaces, and high strength titanium and plastic structure. The drone (D-21) is powered by a modified RJ-43 ramjet engine. The length and span of the drone are 42 feet and 20 feet respectively and the loaded weight is approximately 11,000 pounds.

2. Technical Evaluation

a. General. Modifications of the A-12 to the M-21 carrier configuration are not trivial but require detail engineering rather than innovation. The drone airframe and the ramjet propulsion are straight-forward problems and should work out satisfactorily with normal development effort except for possible problems in achieving desired radar cross sections.

b. Navigation and Guidance. The mother aircraft uses a stellar-monitored inertial system with a specification bounded error of not greater than 2.8 nautical miles and the drone uses an unaided inertial system which will degrade with time but should be no worse than 2 to 3 nautical miles per hour for launch within 2 to 3 hours after take-off. A reasonable CEP for a 3,000 mile reconnaissance flight would be in the order of 5 nautical miles.

c. Camera. The drone payload is a single camera of 28 inch focal length. The film magazine capacity is 4,500 feet of 9 1/2 inch thin base film which will provide continuous coverage for 3,020 nautical miles. Lateral coverage is 14 nautical miles with five fixed depression angles are provided. Camera specification calls for weight of 385 pounds versus an allowance of 500 pounds, thereby adequate weight growth is available.

d. Launch and Recovery. The launch operation presents some severe analysis and design problems. Complexities arise from the following:

(1) The drone and carrier configurations provide only 14 inch clearance between the D-21 wing tips and the M-21 vertical stabilizers.

Copy 2 of 3

Yaw and roll control of the drone at launch must, therefore, be very precisely controlled.

(2) The flow field through which the drone must fly is very complex and includes a pattern of shock waves generated by the carrier nose, engines, and wings.

(3) Upon release of the drone, air loads, as well as weight loads on the carrier may change abruptly, posing control problems for the carrier vehicle.

(4) The inlet for the drone engine is a single point design which makes it possible to provide good performance at design point, but also causes very rapid degradation if conditions vary from the nominal. Effects of penetrating the nose and engine shock waves on engine performance are unknown at present.

Recovery of reconnaissance data will be accomplished by ejecting a package containing the camera, the navigation system, electronic components of the flight control system, beacon and command receiver. The total package weight is currently estimated at 880 pounds. Recovery operations will start with engine shut down at a programmed position. The drone will descend at constant ram pressure to approximately 40,000 feet, and will have a velocity of M 1.0 to M 1.4 at that altitude. The recovery package will be ejected at that point, and will be further slowed by deployment of a parachute. Primary recovery method will be the air pick up technique used for recovery of Discoverer payloads. In the event the pick up is not successful, surface recovery is possible, since the package is designed to float. Although some detail design has not been completed, e.g., ejection method, parachute size, the concept has been demonstrated, and payload recovery appears to be a completely feasible operation.

e. Performance

(1) Drone. The D-21 has been designed for a nominal range of 3,000 nautical miles. Variations from original design estimates to the present have been both favorable and unfavorable, so that the nominal 3,000 mile range remains a good estimate. Launch altitude is 75,000 feet, and since cruise operation is at constant Mach number, the drone will climb continuously, and will reach 95,000 feet at the end of a 3,000 mile leg.

Copy 2 of 3

(2) Camera. The camera specification calls out system resolution of 120 lines per millimeter or ground resolution of about 1.25 feet from nominal 85,000 foot operational altitude. The opinion of a consultant from the Reconnaissance Division, Air Force Avionics Laboratory, based on evaluation of the details of camera design, is that 70 lines per millimeter, or about 2 foot ground resolution against medium contrast targets is a very reasonable estimate of the camera potential.

f. Costs and Schedule. Both cost and schedule data are very inexact at present. Information presented below is best available at present, but may change radically.

(1) Schedule. The present program calls for fabrication and test of 19 drones, and modification of two A-12 airplanes to the M-21 configuration. The first drone is now scheduled for completion in April 1964, and the first carrier will be delivered in June 1964. The final drone will be delivered approximately one year after the initial delivery. Without the benefit of a detailed flight test plan, the project engineer estimated that 12 to 18 months of flight test would be required prior to any operational commitment. These estimates argue an operational capability early in 1966. This is an extremely optimistic estimate, and probably represents a possibility if no unanticipated development problems arise. For comparison, the original GAM-77 schedule allowed four years from initiation to operational capability, and was considered so optimistic as to approach the ridiculous. Direction was given to accelerate the program, but the development flight testing was nevertheless completed approximately a year later than planned on the original schedule. The parallel is not exact, but is an indication that the schedule is optimistic. An estimate of operational capability in mid-1966 is reasonable providing no major development problems arise.

(2) Cost. Original estimates for the present drone development program have grown to present estimate of $65 million. This estimate is believed to be so low as to be unrealistic. A planning estimate of $52 million for an additional 30 operational drones has been made. Given an operational program, additional mother airplanes will probably be required, at an acquisition cost of $20 million per aircraft.

Cost of acquisition or modification of recovery aircraft has not been estimated nor has maintenance and operations costs.

Copy 2 of 3

MISSILE RELIABILITY

1. The in-flight reliability achieved during the Category I, II, and III test programs for the GAM-72, BOMARC B, and GAM-77 has been examined to provide experience data on which to base aerodynamic missile reliability estimates. These missiles vary in mission and complexity with the GAM-77 being the only one which is air-launched and must then navigate with good accuracy to a ground target. The GAM-77 is most representative of the complexity required for the Tagboard vehicle.

2. The following tabulations list the in-flight reliability in terms of success, partial success, and failure. In applying these results to the Tagboard mission, it is probable that many of the partial successes should be charged as failures. The range of reliability shown varies with whether partial success is credited as failure.

a. GAM-72 (Quail, decoy missile)

	Success	Partial Success	Failure	Reliability
Category I	18	4	7	64 - 76%
Category II	12	2	4	67 - 78%
Category III	2	2	2	34 - 67%
Follow-On	7	0	1	- 86%
			Overall	64 - 78%

b. IM-99B BOMARC (Surface to air interceptor missile)

Out of 45 Category I, II, and III flights over a two year period, there were 19 failures of which 8 involved the target seeker, 3-electrical system, 5-flight control, and 3-miscellaneous. Overall, this indicates a 58% reliability. However, since target seeker failures were not determined unless the missile reached the target area, the probability of the missile reaching the target area was 78%.

Copy 2 of 3

c. GAM-77 HOUND DOG (Cruise missile launched from B-52)

	Success	Partial Success	Failure	Reliability
GAM-77 Cat I, II	15	11	6	47 - 81%
GAM-77 Cat III	4	7	5	25 - 69%
GAM-77A Cat I, II	8	2	1	73 - 91%
			Overall	46 - 80%

3. It is interesting to note that the demonstrated reliability did not necessarily improve steadily during the test programs. A separate review of the unsophisticated Q2C indicates that it did not exceed 80% in-flight reliability during its test program. In general, the experience indicates that aerodynamic missiles covering quite a range of complexity have exhibited in-flight reliability ranging from 56 to 80%.

4. All of the development and test programs described here were of at least 5 years duration and the RDT&E costs ranged from $116 million for the unsophisticated GAM-72 to $322 million for the BOMARC B. The GAM-77, which is most equivalent to Tagboard, required a 5 year development and test program and RDT&E expenditures of $194.4 million to achieve the reliability indicated.

5. It appears from this experience that expenditures of $150-$200 million, a flight test program encompassing 50-60 flights, and a development program of 4-5 years may be required to achieve in-flight reliability of 75-80% for a sophisticated unmanned system.

Copy 2 of 3

DETECTION AND SURVIVAL

1. Very little is known at this time about the radar cross section of the D-21. However, it is assumed that, based on size, we may expect the D-21 design to present from 1/4 to 1/2 the target presented by the A-12. A given radar will, therefore, achieve from 70-85 percent of its A-12 range against the D-21. It is believed that if the A-12 achieves its design goals of radar reflectivity, the Soviet early warning radars will have a 20% probability of detecting the A-12 when it rises above the radar horizon. Taking the most optimistic prediction of D-21 radar cross section, probability that Tall King early warning radar will detect the drone is 50% at approximately 200 nautical miles and 85% at approximately 85 miles.

2. Assuming that detection is not, in itself, a deterrent, we must consider Soviet capabilities for successfully attacking the reconnaissance vehicles. Against the Fruit Set "B" tracking radar with certain assumptions favorable to the defense regarding radar and missile performance, it is believed the A-12 can achieve immunity to intercept with track offsets of 20 to 30 miles. With the same assumptions, the D-21 would require track offset of 15 to 20 miles to avoid intercept.

3. In the A-12, the pilot will be able to monitor his actual position and correct errors developed by the automatic navigation system. For the D-21, the initial error boundary of the stellar monitored inertial system of the M-21 carrier aircraft plus the further error accumulation of the unaided inertial system of the D-21 leads to a D-21 navigational CEP of approximately 5 miles at the end of a 3,000 nautical mile flight. For reconnaissance track planning, it seems reasonable to offset by at least two times standard deviation in order to assure a high probability of survival. Using root sum square combination of errors, it would be necessary to offset the D-21 track by approximately 4 to 5 miles for probable guidance errors in addition to the offset required for theoretical immunity from SAM attack. With this consideration, there appears to be little to choose between the 20-30 miles standoff of the A-12 and the 20-25 miles standoff of the D-21.

Copy 2

SENSOR CAPABILITY

1. The A-12 and D-21 are designed as photo-reconnaissance vehicles. Both are expected to have a 1.3 - 2.0 foot ground resolution, linear coverage of over 3,000 nautical miles, and lateral coverages of 36 nautical miles for the D-21 and 41 miles for the A-12.

2. The R-12, a derivation of the A-12, has several photo sensors, one of which is expected to provide a ground resolution of 0.6 feet for covering up to 100 targets. Additionally, the R-12 will have other active and passive sensors. It is probable that some of the R-12 sensors could be adapted to the A-12 if future requirements make it desirable.

Copy 2 of 3

CAPSULE RECOVERY

1. It is intended that recovery of the D-21 reconnaissance data be accomplished by ejecting a package containing the camera, navigational system, electronic components of the flight control system, a beacon and command receiver. The total package weight is estimated at 880 pounds. Primary recovery will be by the air pick-up technique used for recovery of Discoverer payloads. In the event air pick-up is not successful, surface recovery is possible since the package is designed to float.

2. The following information defines the Discoverer capsule recovery program and experience as it may apply to the D-21 capsule recovery effort:

a. The capsule weighs approximately 180 pounds, the 30.7 foot main chute deploys at 50,000 feet, the time-to-water from main chute deployment is 26.5 minutes.

b. For detection, a radio beacon is actuated at capsule separation, the chute has alternate orange and white gores and at chute deployment, a flashing light is turned on.

c. Based on a three-sigma dispersion, the primary recovery area is 20 x 140 nautical miles.

d. Recovery forces consist of the following:

(1)

Aircraft	Required	Standby	Remarks
JC-130B	5	2	Capsule detection, air recovery and search
SC-54	1	1	Air rescue and surface retrieval by pararescue team

(2)

PMR Ships	Required	
Victory Ships	2	Detection, search, and surface recovery
Destroyers	1	Back-up surface recovery

Handle [illegible]
Control [illegible]

Copy 2 of 3

e. The JC-130B aircraft range for support of aerial recovery is 1,100 nautical miles with 3 hours on station. The aerial recovery range depends on the time from parachute deployment to pickup but is considered to be 70 nautical miles for planning purposes.

f. The following chart depicts Air Force experience with capsule recovery:

Calendar Year	Capsules Separated	Capsules Re-entering Recovery Area	Recovery		Lost
			Air	Sea	
1959	4	0	0	0	0
1960	6	5	3	1	1
1961	8	7	4	3	0
1962	20	20	16	0	4*
1963 (thru 15 Oct)	11	11	8	2	1**

*One Chute did not deploy, three attempts at air recovery damaged chute, capsules impacted in sea and sank.

**Power failure prevented chute deployment.

3. It is believed that the following conclusions can be based on applying the Discoverer experience to the D-21 recovery problem:

a. The larger weight of the D-21 recovery package (880 vs 180 pounds) may make aerial pickup more difficult.

b. A significantly large fleet (aircraft and ships) will be needed for recovery operations and the beacon on the D-21 must radiate for a relatively long period to permit re-deployment of the recovery aircraft to within sufficient range of the capsule separation point if air pickup is to be achieved.

c. Most Discoverer capsule losses in the last two years were of a type directly applicable to the D-21 problem. This implies no better than an 84% probability of data recovery unless improvements in recovery technique and design reliability are achieved.

Handle via BYEMAN
Control System

Copy 2 of 3