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EVALUATION OF THE COMPATIBILITY
OF THE AQM-37A TARGET,
LAU-24/A LAUNCHER, AND
A-4B LAUNCH AIRCRAFT

By

W. M. HORTON
Flight Test Evaluation Division

12 March 1964

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This report describes work accomplished under WEPTASK RM-4501-001, Problem Assignment RM-45-1, AQM-37A (KD2B-1) Target System Support.

Mr. L. J. Szot, Deputy Head, Experimental Targets Branch; LCDR F. E. Masek, Head, Experimental Targets Branch; CDR D. D. Forsyth, Head, Flight Test Evaluation Division; Mr. W. L. MacDonald, Deputy Head, Aerospace Operations Department; Mr. V. J. Ketner, Deputy Head, Experimental Targets Office; and Mr. T. E. Hanes, Deputy Head, Missile Programs Department, have reviewed this report for publication.

THIS REPORT HAS BEEN PREPARED PRIMARILY FOR TIMELY PRESENTATION OF INFORMATION. ALTHOUGH CARE HAS BEEN TAKEN IN THE PREPARATION OF THE TECHNICAL MATERIAL PRESENTED, CONCLUSIONS DRAWN ARE NOT NECESSARILY FINAL AND MAY BE SUBJECT TO REVISION.

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SUMMARY

The AQM-37A target is a preprogrammed, high-performance, air-launched, liquid-fueled, rocket-propelled, expendable missile target designed for launch from many types of military aircraft. The compatibility of the AQM-37A target, the LAU-24/A launcher, and the A-4B aircraft was evaluated. Prior to this evaluation the target had been launched only from F-3B aircraft.

The evaluation, consisting of ground tests and flight tests, indicates that the centerline station of the A-4B aircraft is readily converted to a very satisfactory launch platform for the AQM-37A target, within the subsonic flight regime at altitudes between 30,000 and 40,000 feet, without producing any effect detectable by the pilots or through observation of films, upon the flight capabilities or characteristics of the aircraft.

INTRODUCTION

The AQM-37A (formerly KD2B-1) missile target is capable of simulating high-performance aircraft. This target has been developed for the U.S. Navy by the Beech Aircraft Corporation, Wichita, Kansas, as part of the AQM-37A expendable powered target system.

The compatibility of the AQM-37A target, the LAU-24/A launcher, and the A-4B aircraft has been evaluated to determine whether the centerline station of the A-4B could be used as a launch point without danger of jeopardizing the mission or the safety of flight of either the target or the launch aircraft.

Authorization was granted by a BUWEPS letter (RM-451:IFJ), dated 21 December 1960, for Beech Aircraft Corporation to proceed with powered free flights of the AQM-37A, as part of the flight-testing program. This letter also delegated to the Commander, U.S. Naval Missile Center (COMNMC) the responsibility for establishing operational standards and safety and range requirements, with particular attention to be given to details which might cause malfunction during a launch and flight.

This evaluation was performed under WEPTASK RM-4501-001/225-1/S417-B0-03 and Problem Assignment No. RM-45-1. ○

This report is limited to a description and evaluation of preliminary checks of mechanical fit, electrical continuity and adequacy of power supply; 4 straw-pit launches in April and June 1963; 5 captive-target flight tests in April of 1963; and 11 live-target launches during May through November 1963. It does not include any data obtained from strain-gauge tests or through telemetry or flight instrumentation.

Since the A-4B is not usually considered capable of supersonic flight with external stores, this flight regime was not investigated.

Following a description of the target, launcher, and aircraft under consideration and a listing of the test equipment used, the trial installation of the components of the AQM-37A target system on the aircraft is described, as well as the concurrent engineering studies of adequacy of clearances, strength, and electrical and aerodynamic suitability. The exploratory ground- and flight-test phases, as well as routine target-practice operations with missile-firing aircraft on the Pacific Missile Range are then described and evaluated.

DESCRIPTION OF COMPONENTS

AQM-37A Target

The AQM-37A target is an air-launched, liquid-fueled, rocket-propelled missile target designed to fly at a speed of Mach 2 at an altitude of 70,000 feet,

and capable of simulating high-performance aircraft. It is a center-delta-wing monoplane with fixed vertical stabilizers mounted on each wing tip. Pitch control is provided by forward canard surfaces, while guidance and control is achieved by a free gyro for roll and azimuth reference, and by an altitude sensor for altitude and rate-of-altitude-change data. Two electrical servos, mechanically linked to the canard and aileron surfaces, receive electrical impulses from the guidance system, which is preprogrammed for control of the target. The target, powered by booster- and sustainer-rocket chambers, is capable of supersonic cruise at altitudes from 1,000 to 70,000 feet. The flight-ready target weighs 560 pounds gross. The fuselage is 162.7 inches long and 13 inches in diameter. The delta-wing span is 39.5 inches; the vertical stabilizer is 20.0 inches in height.

LAU-24/A Target Launcher

The LAU-24/A target launcher weighs 181 pounds and is a cartridge-actuated, forced-ejection, scissors-linkage type. Its mounting bolts were designed to correspond, in location and size, with those of the Aero 7A ejector rack assembly so that it can replace this rack without the use of an adapter.

Figure 1 shows the shoe of the LAU-24/A launcher lowered on top of an

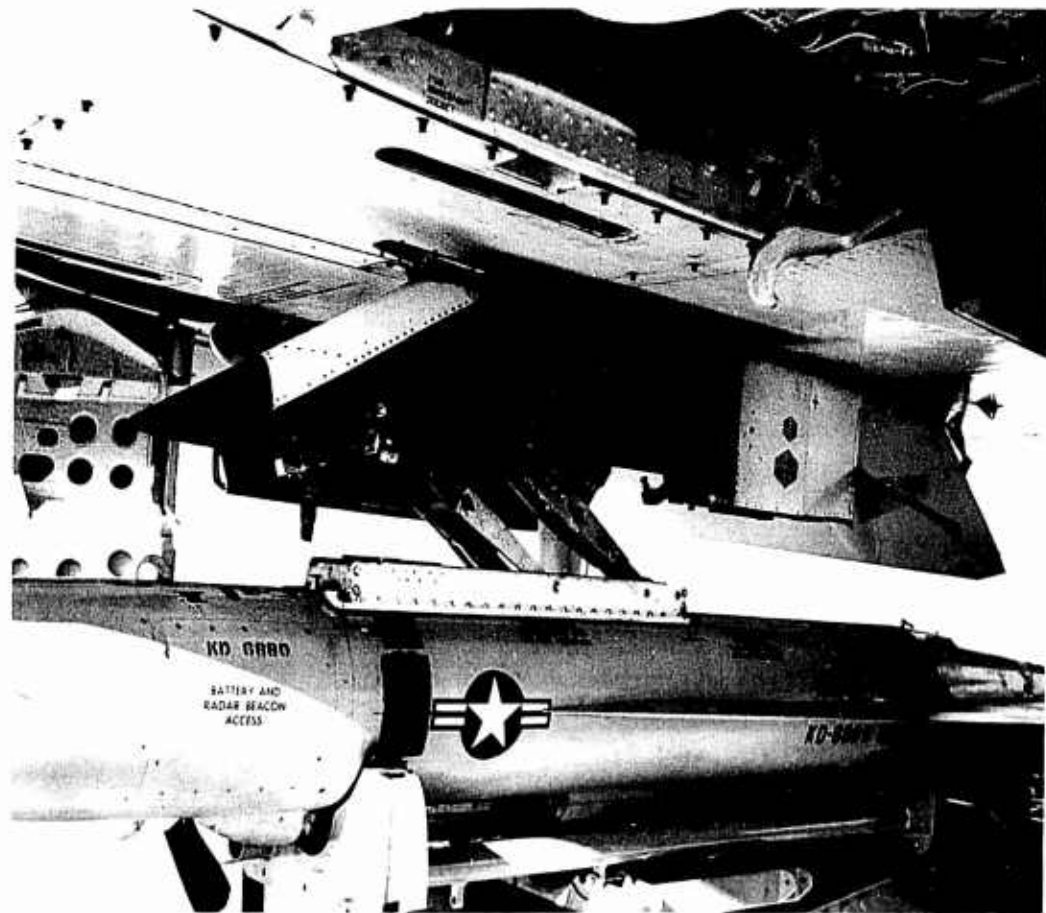


Figure 1. LAU-24 A Launcher With Side Door Open and Sway Brace Shoe Lowered.

AQM-37A target in a mock launch cycle position, illustrating the action of the linkage arms and actuating piston.

A-4B Aircraft

The A-4B aircraft is a low-wing, single-jet-engine attack aircraft which is in widespread use by the U.S. Navy and is capable of carrying a number of externally-stored bombs or other weapons.

TEST EQUIPMENT

The following listing indicates, by an X in the appropriate column, the equipment used for the different tests.

Test Equipment	Ground Tests		Flight Tests	
	Preliminary	Straw-Pit Launches	Captive-Target	Target-Launch
A-4B aircraft with T-system wiring and power supply	X	X	X	X
AQM-37A release console installed in A-4B cockpit	X	X	X	X
LAU-24/A launcher	X	X	X	X
Electrical adapter cable	X	X	X	X
Bomb trailer--Mark 7, Mod 1, or Aero 16B-48A combination -- with AQM-37A cradle assembly	X	X	X	X
Voltohmmer	X			
Dummy AQM-37A target		X		
Lifting device to suspend aircraft-target combination over straw pit		X		
Cameras, tripods		X		
Live AQM-37A targets			X	X
Airborne camera equipment			X	X
Yarn segments for airflow studies			X	
Chase aircraft			X	X

PROCEDURES

Ground Tests

Prior to modifying the A-4B aircraft by the addition of an external store which would place a drain on the aircraft's electrical system, preliminary studies were conducted to eliminate all the known possibilities of endangering the safety of flight of the aircraft.

Preliminary Steps and Initial Tests

Before the A-4B aircraft was available for the compatibility evaluation, a study was made of the A-4B wiring diagrams (shown in NAVWEPS 01-40AVA-2-10 and revised 1 October 1961).

The study disclosed that the A-4B aircraft contained a centerline-station, missile-release wiring circuit (known as the T system) similar to the one for which a preliminary, compatible, AQM-37A launch system had previously been developed for F-4B aircraft by Beech Aircraft Corporation, utilizing the LAU-24/A launcher of the AQM-37A/F-3B system. Beech proceeded to develop one relay box for the electrical function of the LAU-24/A launcher which could be used with F-3B, F-4B, and A-4B aircraft. After installation of the AQM-37A electrical adapter cable, checks of wiring continuity and DC power output were made to test the compatibility of the A-4B T-system wiring, the LAU-24/A launcher, the newly developed "universal" relay box, and the AQM-37A target.

Further investigation indicated that the AQM-37A release console developed by Beech for use in the F-4B aircraft for the centerline station should be satisfactory for application to the same function in the A-4B aircraft with the addition of one jumper wire. (The presence of this jumper does not in any way affect the use of the release console in the F-4B aircraft.) Figure 2 shows the AQM-37A release console installed in the pilot's left-hand cockpit console of the A-4B, where the T-249 control panel had originally been installed. Figure 3 shows the entire electrical wiring schematic from the AQM-37A target, through the LAU-24/A launcher, the A-4B T-system wiring, and the AQM-37A release console.

Beech attached the LAU-24/A launcher directly to the centerline fuselage station of the A-4B aircraft without an adapter, using the same attachment points from which the standard Aero 7A ejector rack assembly had just been removed. Figure 4 shows a live AQM-37A target on the LAU-24/A launcher beneath an A-4B aircraft.

The following steps must be performed to convert a Fleet-configured A-4B to an AQM-37A launch aircraft:

1. Remove the Aero 7A ejector rack assembly from the centerline station.



Figure 2. AQM-37A Release Console, Installed in Cockpit of A-4B Aircraft.

2. Install the AQM-37A electrical adapter cable between the centerline-station end of the T-system wiring and the electrical connector in the LAU-24/A launcher.
3. Install the LAU-24/A launcher on the centerline station.
4. Remove the T-249 control panel from the pilot's left-hand cockpit console.
5. Install the AQM-37A release console in the spot left vacant by the removal of the T-249 control panel.
6. Install an AQM-37A target on the LAU-24/A launcher.

Two A-4B aircraft (Bu.No. 142709 and Bu.No. 142141) were converted in this manner to launch AQM-37A targets; each aircraft was easily converted within 1 hour by three men.

Straw-Pit Launch Tests

A dummy AQM-37A target was launched four times into the PMR straw pit from an LAU-24/A launcher secured to the centerline station of an A-4B aircraft (Bu.No. 142709). The purposes of these launches were (1) to test the electrical circuitry of the aircraft compared to the wiring diagrams, (2) to study the angle of departure of the target from the aircraft, and (3) to note whether the 8g force imparted to the target upon separation would have any visually detectable reaction on the aircraft.

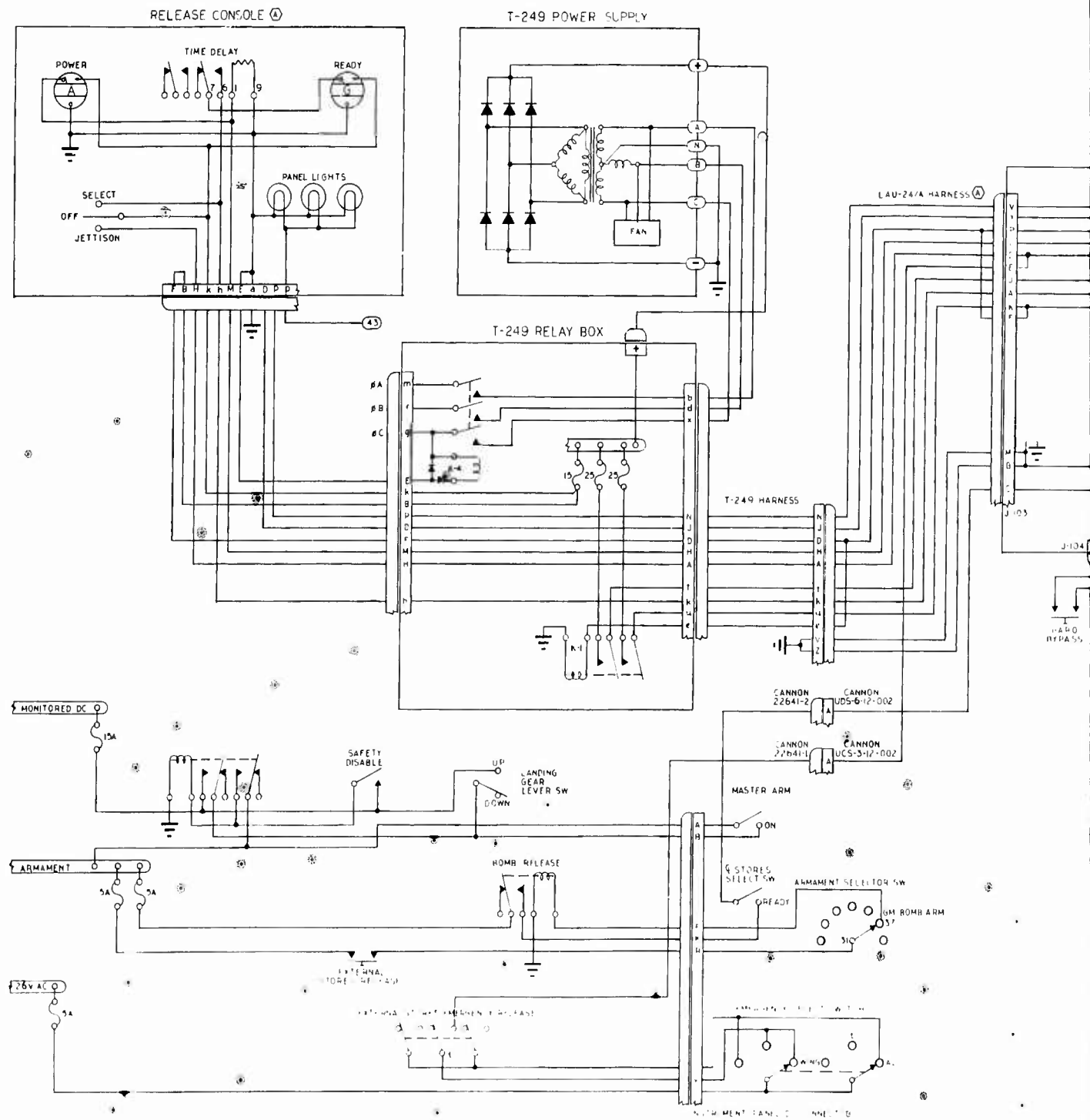


Figure 3. AQM-37A A-4B Launch System Electrical Wiring Schematic.

1



Figure 4. AQM-37A Target and LAU-24/A Launcher on A-4B Aircraft Centerline Station.

Figure 5 shows the dummy target, LAU-24/A launcher, and A-4B aircraft suspended over the PMR straw pit. This suspension was necessary, since the straw pit could not accommodate the A-4B tricycle landing gear. The dummy AQM-37A target had the same center-of-gravity location as a live target. The vertical fins had been removed from the horizontal stabilizer to prevent possible damage upon impact.

Two straw-pit launches were made to test the effectiveness of the regular launch circuit. These launches were photographed in color by a high-speed motion picture camera so that the target-launch angle, as seen in the film frames, could be checked by protractor against previous aerodynamic studies. On one occasion the jettison switch was actuated to test the electrical components of the emergency jettison system.

Flight Tests

After completion of all preliminary studies and ground tests, the target/launcher/aircraft combination was considered ready for the flight-test phase of the compatibility evaluation.

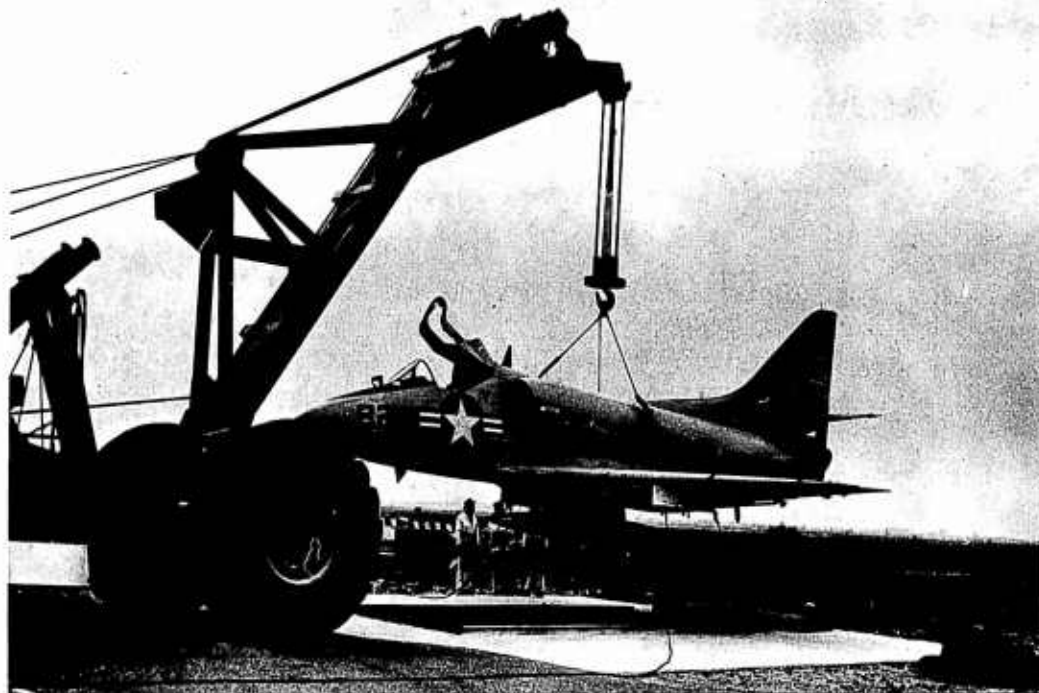


Figure 5. A-4B Aircraft and Dummy AQM-37A Target Suspended Over PMR Straw Pit.

Captive-Target Flight Tests

Two pilots made a total of five captive-target flights with an A-4B (Bu. No. 142709) carrying an AQM-37A target and an LAU-24/A launcher secured to the centerline station. The purposes of these captive-target flights were (1) to check the effect of the presence of the target on the taxi, take-off, climb, cruise, and landing characteristics of the aircraft, (2) to check, through a wide variety of maneuvers, whether the installation was free from objectionable vibration and had sufficient mechanical strength, and (3) to check for the presence of any upward airflow around the canard area of the target.

The airflow around the target nose was recorded by a wing pod camera photographing rows of yarn tufts which had been attached to the flank of the target confronting the camera, in various planes through the target axis, so that upward or downward flow of air in the area of the target canards would be indicated by the position taken by the free end of these tufts. Excessive fluttering of these yarn tufts would indicate air turbulence which would cause undesirable target vibration.

The judgment of the pilots was the only evidence deemed necessary to indicate any change in the flying and handling characteristics of the aircraft.

Extreme maneuvers were performed most frequently during descent and prior to high-Q runs. A -1g pushover, a +4g pullup, maximum sideslip, and rapid rates of roll were produced. Nearly-vertical banks were flown, as well as roll rates of up to 200 degrees per second, according to telemetered information.

In order to check the operation of position and acceleration sensors and related servo-mechanisms of the target, an antenna was installed at the lower surface of the target to transmit, on a monitored telemetry channel, the following information:

1. Responses from longitudinal and vertical accelerometers in the target.
2. Signals from gravity-directed gyro in the target.
3. Reactions of pitch and yaw axis gyros of the target.
4. Dynamic pressure at the tip of the target's nose-cone as sensed by an aero head pitot transducer.

Figure 6 is a close-up photograph of the target, launcher, and aircraft showing all the clearances of the target used for the captive-flight tests.

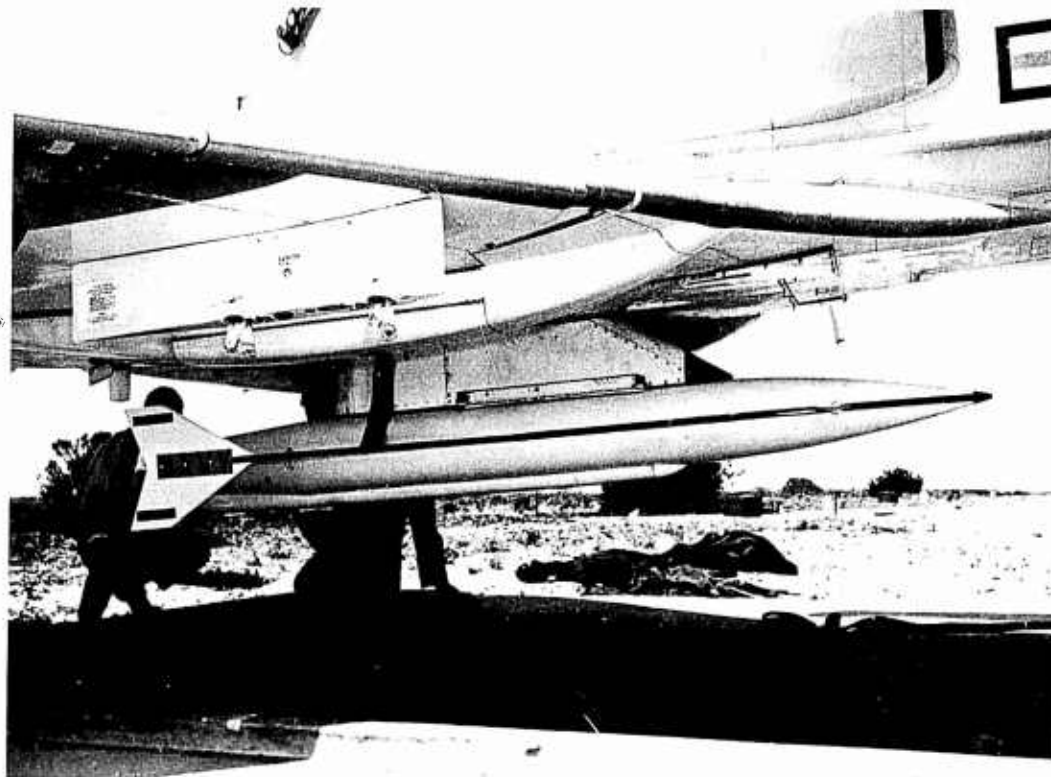


Figure 6. AQM-37A Target for Captive-Flight Tests Installed on A-4B Aircraft, Showing Clearances.

Target-Launch Flight Tests

Two different pilots successfully launched a total of three AQM-37A targets from A-4B aircraft (Bu.No. 142709 and Bu.No. 142141),* The maximum altitude of launch was 37,000 feet and the maximum speed was 0.90 IMN (indicated Mach number). The primary mission of these flights was the regularly scheduled launch of AQM-37A targets as part of the contractor's research and development program; however, a secondary mission was the testing of the compatibility of the A-4B aircraft, the LAU-24/A launcher, and the AQM-37A target.

These launches were photographed by motion picture cameras. All three launches were photographed from the chase aircraft. In addition, one launch was also photographed from an adjacent wing-pod camera.

RESULTS AND DISCUSSION

The following evaluation is based upon the previously described studies of wiring diagrams, photographs, and films, as well as upon verbal reports and conferences.

Ground Tests

Preliminary Steps and Initial Tests

The ground continuity checks indicated that the combination of the modified F-4B/AQM-37A release console, the A-4B T-system wiring and power supply, the LAU-24/A launcher with the newly developed "universal" relay box, and the Beech-designed A-4B electrical adapter cable were in every way electrically compatible and would furnish the AQM-37A target with all the power necessary for warm-up, prelaunch, and launch-command operations.

Straw-Pit Launch Tests

Visual observations and study of the films made of the four straw-pit launches (two on 12 April 1963 and two on 6 June 1963) confirmed the proper operation of that portion of the electrical system concerned with launching, and proved that the same setting of the scissors arms of the LAU-24/A launcher used for the F-3B aircraft resulted in the proper amount of target nose-down attitude for apparent satisfactory separation.

It was concluded from these tests that this aircraft/launcher/target combination was ready for captive-target flight tests.

*As of 6 January 1964, a total of 18 AQM-37A targets have been successfully launched from A-4B aircraft.

Flight Tests

Captive-Target Flight Tests

None of the testing pilots could detect any difference in the taxi, climb, cruise, maneuverability, or landing characteristics of the A-4B aircraft resulting from the presence of the attached launcher and target.

Study of the five films made during the captive-target flight tests showed that the airflow around the target ahead of its center of gravity always had a slightly downward or almost zero vertical component, and that the tufts did not flutter except directly after takeoff of the aircraft, before the airflow pattern had stabilized.

Accordingly, it was indicated that no aerodynamic net reaction existed which would tend to force the nose of the target upward at the moment of launch, and that the ambient air was free from turbulence which might cause launch irregularities.

The angles assumed by the tufts indicated that the nose cone of the target received a slight downward force and that, particularly at that portion of the target directly ahead of the launcher juncture, a pronounced downward component of flow existed, as might be expected due to splitting of the air at the leading edge of the launcher.

Successful completion of extreme aerial maneuvers demonstrated that the installation had adequate mechanical strength and was free from vibration. Study of the telemetry records of position and acceleration sensors and related servo-mechanisms of the target showed normal action of these components during captive-target flights, and thus indicated proper operating conditions for the target.

Since the results of all captive-target flight tests were satisfactory, it was decided that the aircraft/launcher/target combination could be cleared for target-launch flight tests.

Target-Launch Flight Tests

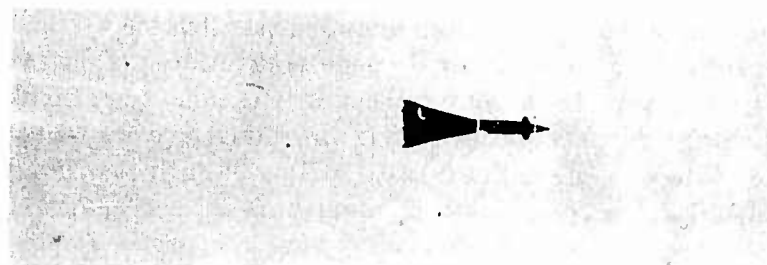
The film data of the target-launch tests indicate that the vertical separation of the target from the aircraft, under the accelerative force of the launcher is very rapid, even though the target commences to assume a horizontal attitude at about one-aircraft-length below the launch aircraft (figure 7). This correction in horizontal attitude is due to the relative airflow acting upon the target's horizontal stabilizer, which is a highly swept-back delta wing. Vertical momentum of the target drives it far below the launch aircraft. During the period when the aircraft can be used as a visual reference in the films, the target does not appear to have moved behind the launch aircraft; in fact the target initially



(a) A-4B Aircraft Carrying Target.



(b) AQM-37A Target Launched From A-4B Aircraft.



(c) AQM-37A Target in Free Flight.

Figure 7. Launching of AQM-37A Target From A-4B Aircraft.

tends to fly forward slightly faster than the launch vehicle as a result of the horizontal component of thrust imparted by the launcher.

The canard surfaces of the target are initially locked at an angle of -0.5 degree and are not released for gyro pitch control until about 2 seconds after launch, by which time the target is about 100 feet below the launch aircraft. Rocket ignition occurs 2.5 seconds following launch, and it requires at least 1 additional second to develop full thrust (3.5 seconds after launch). Before its rockets begin to accelerate the target rapidly away, the target is about 250 feet below the launch aircraft.

The speed of the vertical separation of the target from the aircraft is illustrated by the following measurements (within the limitations of metric-radar accuracy) made during a launch of an AQM-37A target from an A-4B aircraft (Bu.No. 142709) flying at an altitude of 35,000 feet and at a speed of 0.80 IMN.

<u>TIME AFTER LAUNCH, SECONDS</u>	<u>ALTITUDE OF TARGET, FEET BELOW LAUNCH AIRCRAFT*</u>
0	0
1	20
2	85
3	185
4	290
5	390
6	485
7	570
8	590
9	530
10	420

Films of the target launchings indicate that the nose-down attitude of the target was satisfactory for separation and that no difficulty was experienced by the gyro control in establishing the target in the desired attitude of flight.

The cartridge in the launcher breech serves the purpose of launching or jettisoning the target. The jettison differs from the launch only in that the target is not activated for propulsion and guidance.

All factors (weight, drag, aerodynamic effects) imposed by the target-and-launcher installation were less severe than those imposed by a 300-gallon fuel tank which is already qualified for the A-4B aircraft at the centerline station.

Six Navy pilots were involved in the test flights of the aircraft/launcher/target combination under consideration. Therefore considerable verbal evidence is at hand concerning the handling and performance characteristics of the aircraft carrying the launcher and target. When the target was launched, the pilot felt what he described as a slight "thump" in the aircraft. However, this effected no change whatsoever in the stability of the A-4B aircraft.

CONCLUSIONS

It is concluded that:

1. After the removal of the T-249 control panel and the Aero 7A ejector rack assembly, and the installation of the Beech-designed release console and the LAU-24/A launcher with the "universal" relay box and adapter harness, the Fleet-configured A-4B aircraft, with T-system wiring and power supply, is acceptable as a launch aircraft for the AQM-37A target within the sub-sonic flight regime at altitudes between 30,000 and 40,000 feet.
2. Based upon the evidence from the tests just discussed, no factor exists which could in any way result in a threat to the safety of flight of either the AQM-37A target or the A-4B launch aircraft.
3. An A-4B aircraft can be converted to launch AQM-37A targets in 1 hour and can be reconverted to its normal flight configuration in an equal amount of time.

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