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This report summarizes the PENNY Drone Program sponsored by the Bendix Aviation Corporation and the Bell Aircraft Corporation, and hence contains information proprietary to these organizations.

For additional copies or information, please contact the Long-Range Planning Office, Bendix Systems Division, Ann Arbor, Michigan, NOrmandy 5-6111

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ORIGINATOR, LETTER

R. GLASSON & E. C. LOUG

DTIC 1598.59

MODEL 1C *is a*
Low-Cost, Expendable,
Powered Target Drone

designed to meet the joint requirements of the United States Navy and Air Force. It is the result of more than two years of development sponsored by the Bendix Aviation Corporation and the Bell Aircraft Corporation. This program has been based on a careful analysis of service requirements and has, from the start, recognized that a low-cost expendable target system is most desirable. As the result of extensive system design, subsystem development, and test, a prototype has been constructed, including actual materials and components.

PENNY 1C features a fixed-surface airframe. Control is achieved through a swivelled rocket engine and reaction jets mounted on the wings. Subsystems include guidance and control, radar and infrared augmentation, scoring, and electrical.

The Bendix-Bell PENNY 1C Team is already in being, and has adequate existing facilities for both development and production.

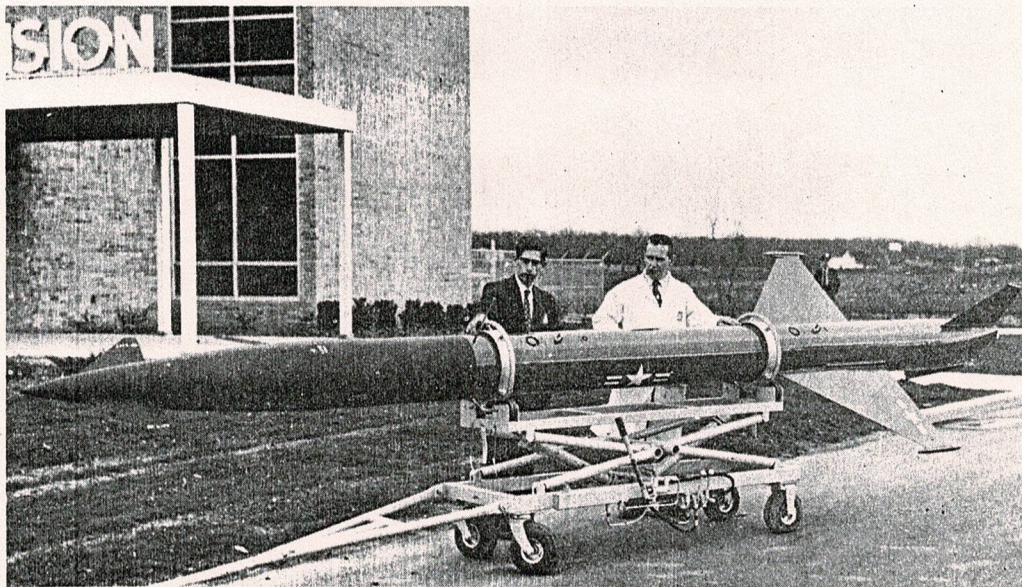
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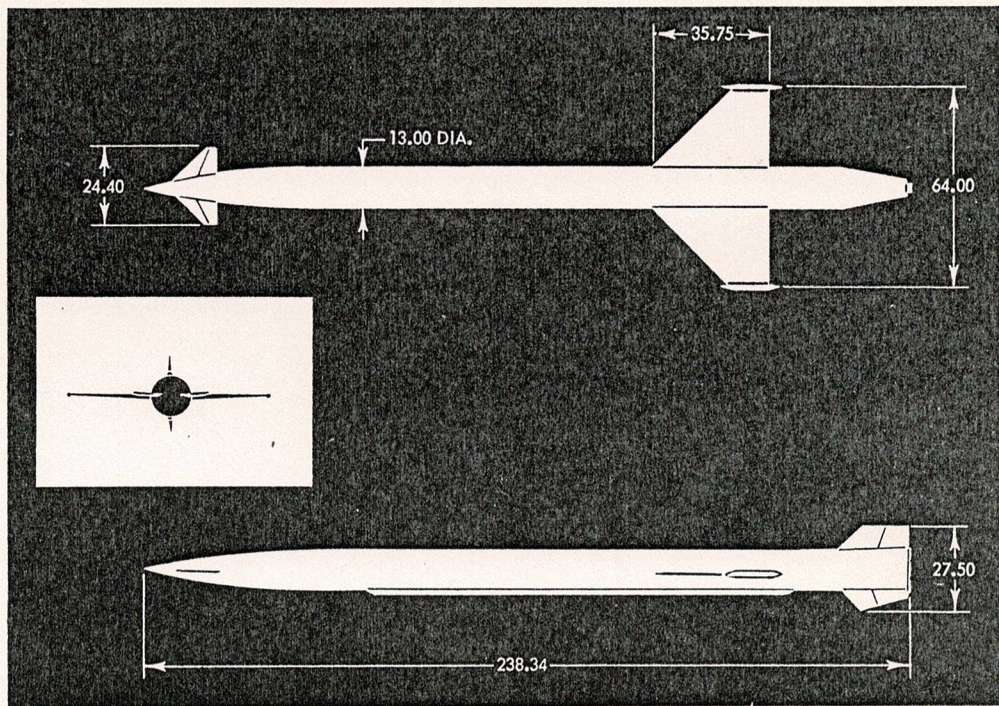
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PENNY 1C *configuration*

PENNY 1C is a supersonic air-launched target. It is a canard configuration employing a slender cylindrical body, a small forward horizontal surface, an aft horizontal mid-wing, and ventral and dorsal fins. All surfaces are fixed. Control is achieved by means of swivelling the sustainer rocket motor in the pitch plane and by means of reaction jets mounted in the wings. Yaw is accomplished by combining pitch and roll.

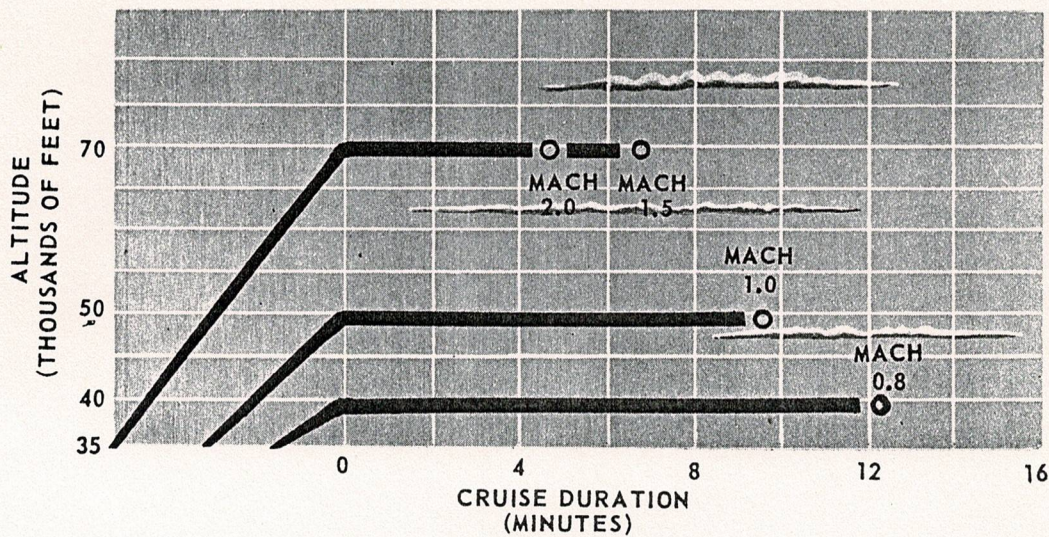
The PENNY 1C target is 13 inches in diameter and 238 inches long. The nose is a 3.8-to-1 ratio Von Karman type. All surfaces are clipped-tip delta shaped. Wing area is minimized by using a mid-wing position. The use of fixed surfaces minimizes both weight and cost. Performance is predicated on wind-tunnel test data and extensive analysis and simulation.





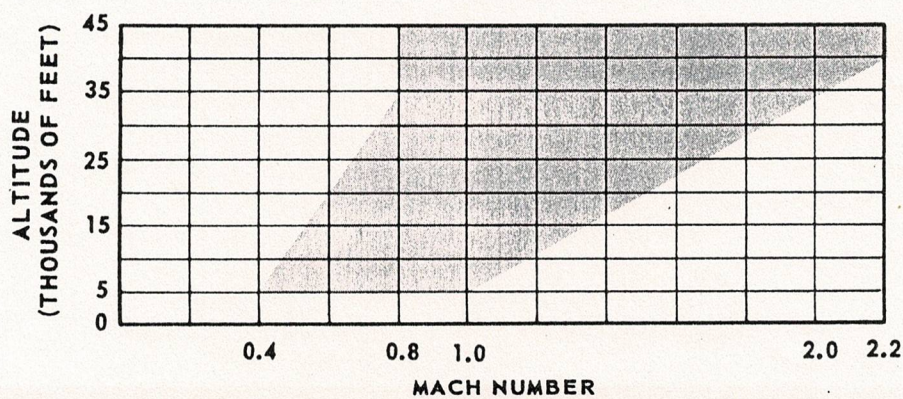
The propulsion system consists of a dual-chamber liquid rocket engine and roll control jets. All propulsion units use a hypergolic combination of inhibited red-fuming nitric acid and unsymmetrical dimethylhydrazine propellant. The fixed boost chamber of the main engine provides 950 pounds of thrust at 50,000 foot altitude. The movable cruise chamber can be throttled from 110 pounds to 330 pounds of thrust at 70,000 foot altitude. The cruise motor is positioned in the pitch plane by an electrical actuator.

performance



The prime mission for the PENNY IC Target consists of launch at Mach 0.8 at 35,000 feet with cruise at Mach 2.0 at 70,000 feet. The second priority mission utilizes the same launch conditions with cruise at Mach 1.5 at 70,000 feet. The duration for the prime mission will increase to 5.7 minutes if the launch altitude is increased to 45,000 feet.

The PENNY IC Target can be launched from aircraft operating within an envelope with bounds of Mach 0.4 to 1.0 at 5000 feet to Mach 0.8 to 2.0 at 35,000 feet. The target is capable of flights at all altitudes ranging from 5000 to 70,000 feet. Maximum deviation from a preset course will not exceed plus or minus eight miles per 100 miles of range.



Aerodynamic Surfaces

	Wing	Forward Horizontal Surface	Upper Vertical Tail	Lower Vertical Tail
Root Chord (Inches)	35.75	11.44	21.00	20.00
Rip Chord (Inches)	9.90	2.29	12.00	14.39
Taper Ratio	.277	.20	.57	.72
Exposed Span (Inches)	48.50	14.10	9.00	5.52
Leading Edge Sweep (Degrees)	46.8	46.8	45.0	45.5
Exposed Aspect Ratio	2.12	1.68	1.09	.81
Exposed Area (Square Feet)	7.70	.82	1.03	.52
Airfoil Section	Modified Double Wedge	Modified Double Wedge	Modified Double Wedge	Modified Double Wedge
Thickness Ratio - Root	.035	.040	.010	.010
Thickness Ratio - Tip	.049	.016	.007	.010

Body

Length	236.34 inches
Fineness Ratio	18.22
Nose Length	49.34
Diameter	13 inches
Boattail Length	20 inches

weights

Wing	40.0 lb
Forward Horizontal Surfaces	3.2
Vertical Fins	3.7
Body	249.6
Autopilot	31.4
Beacons	17.0
Roll Control Jets	5.0
Supports and Brackets	6.4
Electrical System	26.0
Engine Installation and Lines	24.8
Scorer and Mount	5.0
Lens and Reflectors	9.0
Destructor	1.0
Fuel	157.0
Oxidizer	338.0
Nitrogen	30.0

Gross Weight 947.2 lb

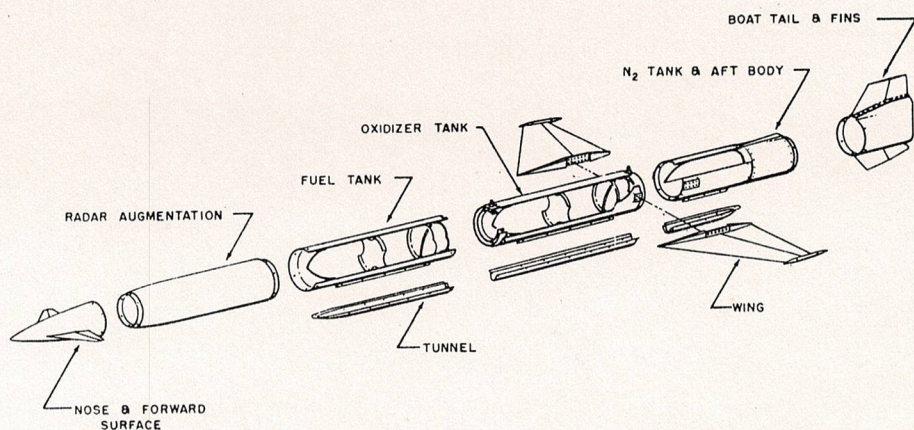
construction

The PENNY 1C Target is designed specifically for low-cost production and ease of assembly and handling. Emphasis has been placed on low structural weight and minimum drag. The target is designed with interchangeable body splices to permit separate shipment and storage of the pre-packaged propellant tanks. The interchangeable body splices permit replacement of any section.

In the aft end of the target body the boattail section can be detached by loosening four screws. The power plant and its mount can then be rotated to one side without disconnecting the fuel lines. The electronic equipment in the aft section can be withdrawn on a sliding tray.

A significant reduction in overall target drag is achieved by use of jettisonable launch fittings.

The nose section, including the canard surfaces and the radome section, are of radar transparent material. The radome section contains the Bendix passive radar augmentation lens. This section attaches to the forward splice ring of the fuel tank.



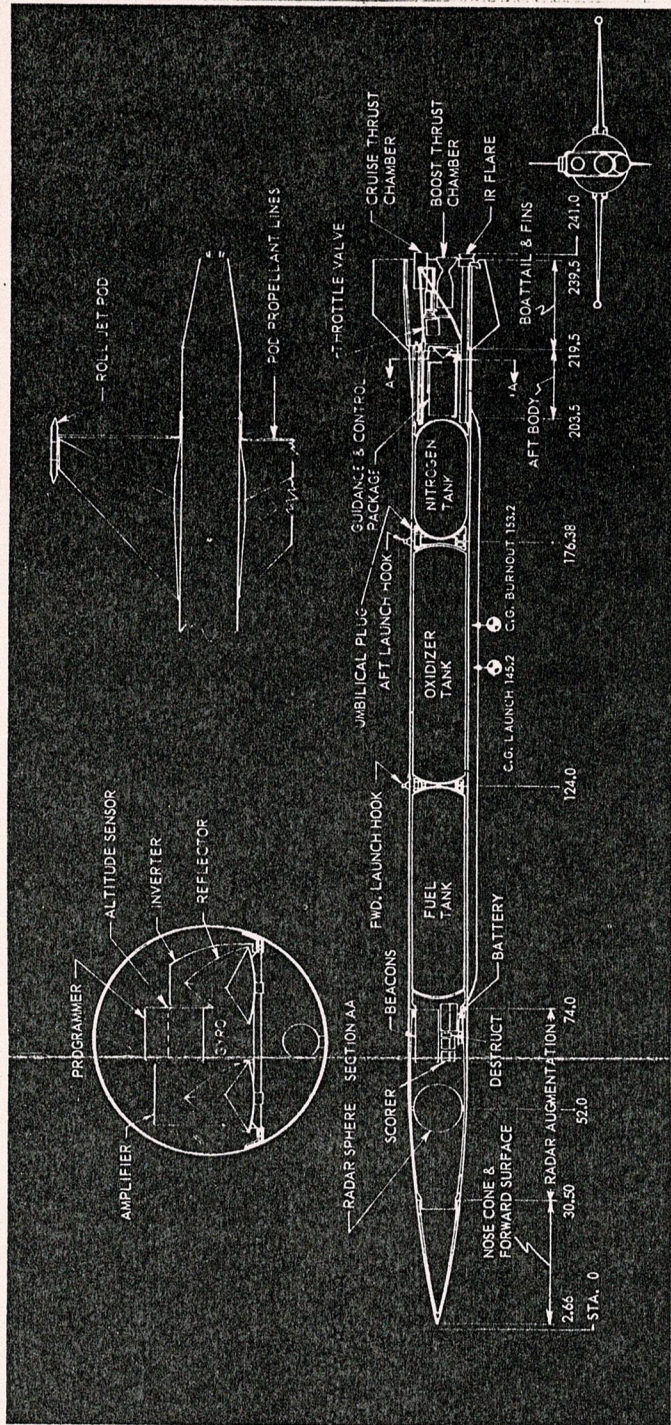
The fuel and oxidizer tanks are fabricated of 6061 aluminum alloy. They are cylindrical pressure vessels designed as an integral part of the airframe. The nitrogen bottle is fabricated from 6A4V titanium alloy. This section provides for wing attachment. The wings and fins are diecast magnesium sections. The roll jet pods are mounted on the wing-tips.

The aft section is an aluminum alloy extrusion, containing the guidance and control equipment and the propellant system plumbing. The boattail assembly is fabricated from radar transparent material, to which are attached the ventral and dorsal fins. It also contains the infrared flare assembly and the rocket engine.



internal arrangement

The main cylindrical body of the target is made up of the integral tanks for fuel, oxidizer, and nitrogen.



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The Bendix lens for passive radar augmentation and the radar beacons are located in the radar dome section of the target. This section also includes the Bendix FM/CW scorer, the destruct charge, and the battery.

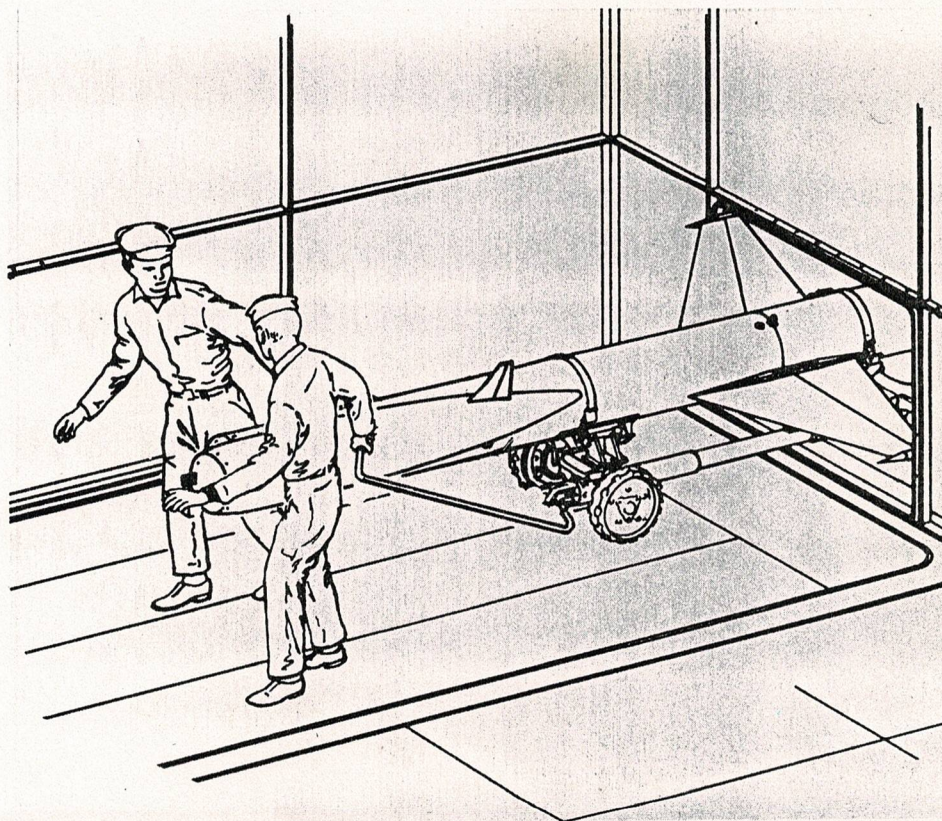
The aft sections of the target contain the guidance and control package, small radar corner reflectors, the infrared augmentation flare, and the dual chamber rocket engine.

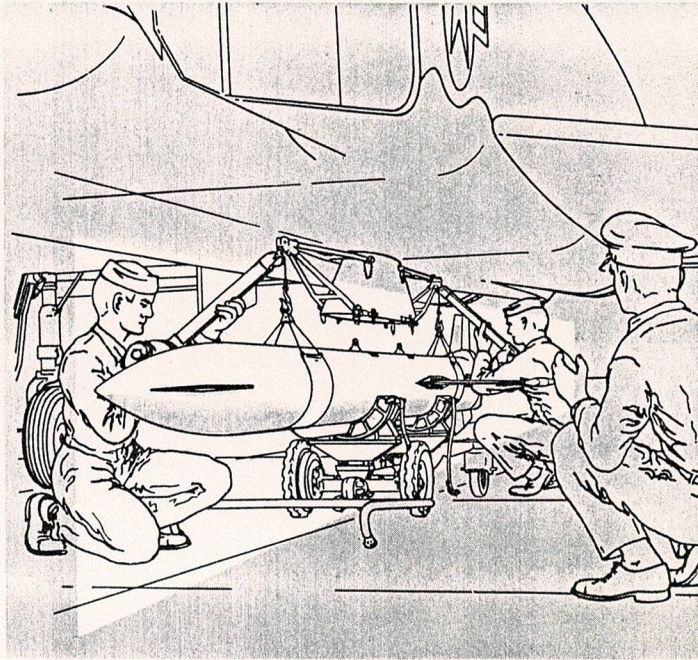
All subsystems are packaged and mounted for accessibility and easy adjustment or replacement. To meet specific mission requirements, augmentation or beacon subsystems may be omitted or replaced by different models.

handling and launching

The PENNY 1C handling equipment provides smooth transition between storage, assembly, and operation areas. This equipment is compatible with other weapon systems and utilizes government furnished equipment wherever possible. The target containers consist of metal reusable containers for the two major sections of the target, and plastic boxes for the remaining small sections. The design of these containers provides ease of handling and storage.

The handling equipment includes a modified Aero 16-B bomb skid, a pallet, and a sling set. The skid is modified with an adapter ring to accept the PENNY 1C target. The pallet will support the target sections. The sling set will be used for removing target sections from their containers and for assembly. Mark 8 Mod. 0 hoists may be used to place the target on an aircraft from the Aero 16-B skid.



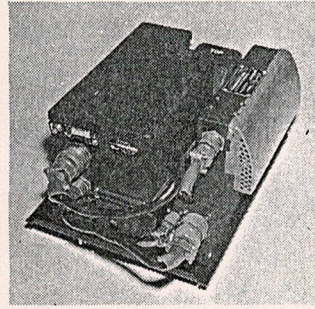


Targets are attached to the launching aircraft pylons by means of jettisonable launch fittings in order to minimize over-all target drag. Free-fall launch is recommended with propulsion initiation after safe separation. The launch sequence, using a simple control panel, includes warm-up, internal power check, ready indication, select, and launch.

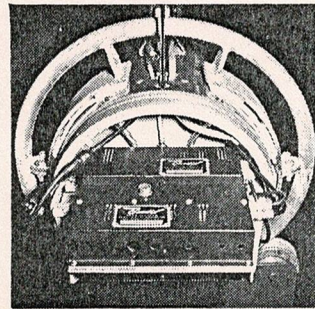
PENNY 1C check-out will be made with semi-automatic go/no-go test equipment. This equipment will detect and isolate faults down to major subsystems which are quickly replaceable. Check-out equipment will be housed in standard 19-inch panel assemblies adapted to a field skid for maximum mobility.

*subsystems**guidance and control*

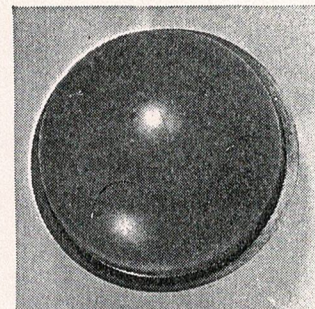
Target guidance, control, and destruct are pre-programmed and self-contained. A two-axis system measures pitch and roll displacements. References include a vertical gyro, a pitch program, and a barometric sensor. Speed is controlled to ± 0.1 Mach; altitude to ± 200 feet for any 20-second period; cruise altitude to $\pm 10\%$; lateral deviation to ± 8 miles per 100 miles of flight.

*scorer*

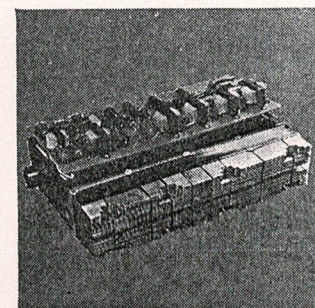
The Bendix self-contained scorer includes a FM transmitter and receiver operating in the VHF region. Scoring ranging is 30 feet with 10 percent accuracy. An alternate IF amplifier will provide a scoring range of 15 feet. A transmitted modulation signal can be recorded or used as a hit indication to the interceptor pilot.

*target area augmentation*

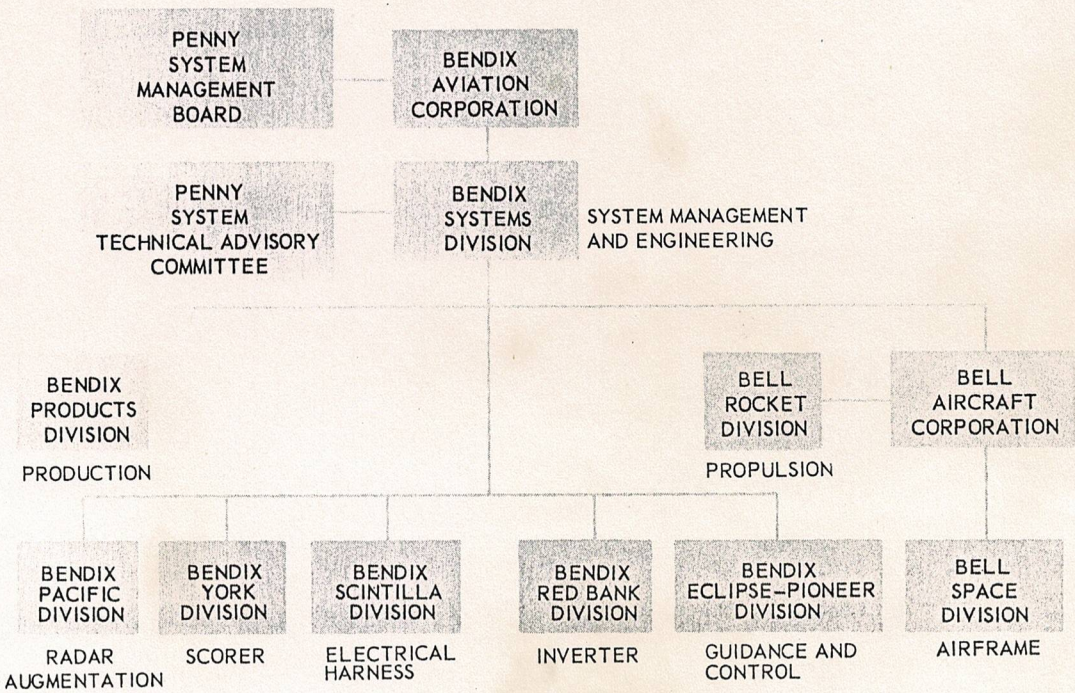
Three different Bendix lenses are used for passive and bistatic radar augmentation. These lenses, plus a tracking beacon and three-inch corner reflectors, are used for the seven required augmentation situations. Flares are used for infrared augmentation in the required spectra. These items have been developed by Bendix.

*electrical*

The electrical system includes the battery, transistorized static inverter, cabling, and launch circuitry. The non-spill lead acid battery provides 300 watts at 28 volts DC. Cabling is molded harness and pygmy connectors. The total aircraft power requirement is 175 watts at 28 VDC.



development team



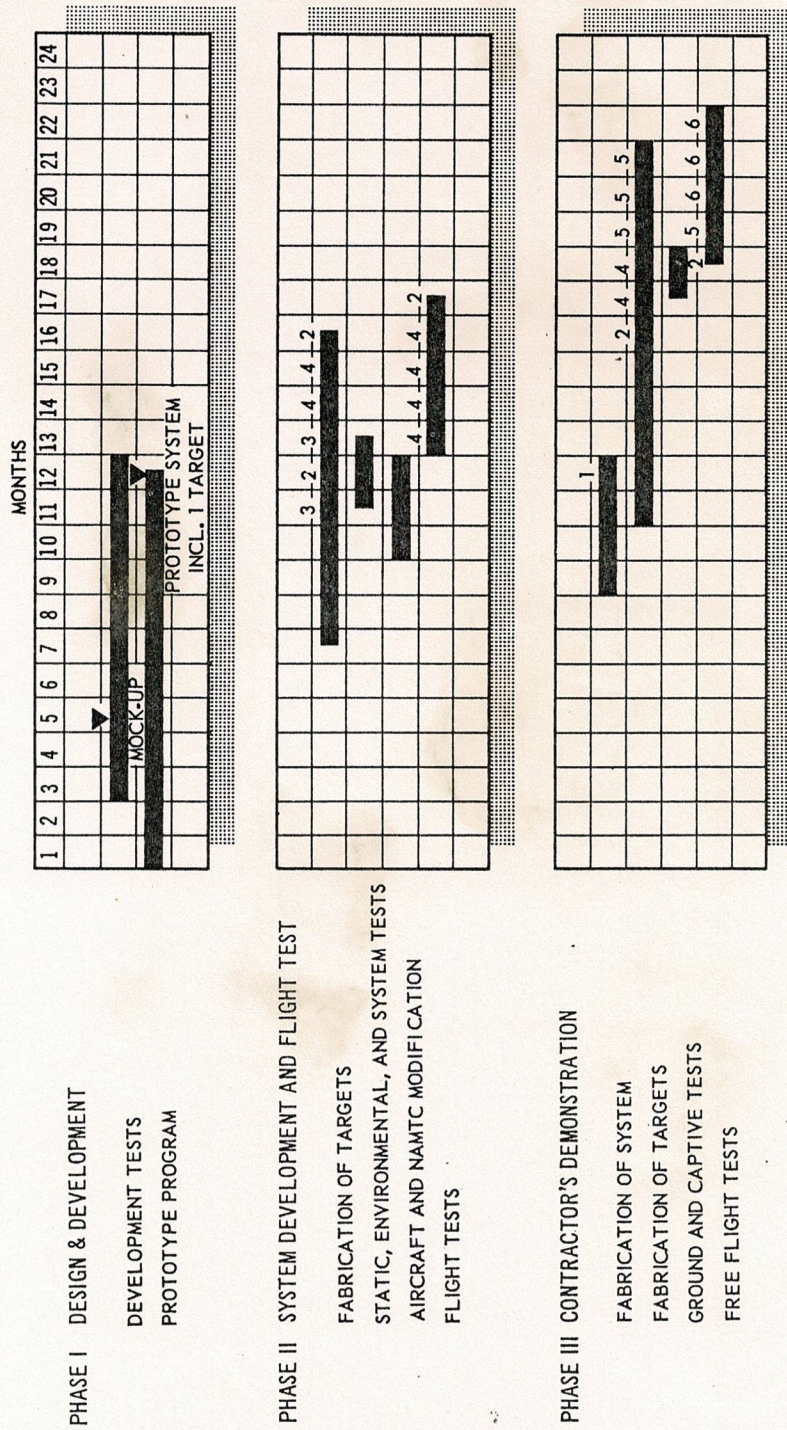
The Bendix-Bell PENNY 1C Team is in being, and has already carried out an extensive company-sponsored development for a low-cost, expendable powered target drone. The team includes seven divisions of Bendix and the Bell Aircraft Corporation.

This team has adequate existing facilities for the PENNY 1C development and production programs.

A strong Project Management organization exists at the Bendix Systems Division. Supporting management groups are at the Bendix Products Division and the Bell Aircraft Corporation.

The development of the PENNY 1C system is within present-day state of the art. Much development and test has already been carried out at no cost to the Government.

schedule

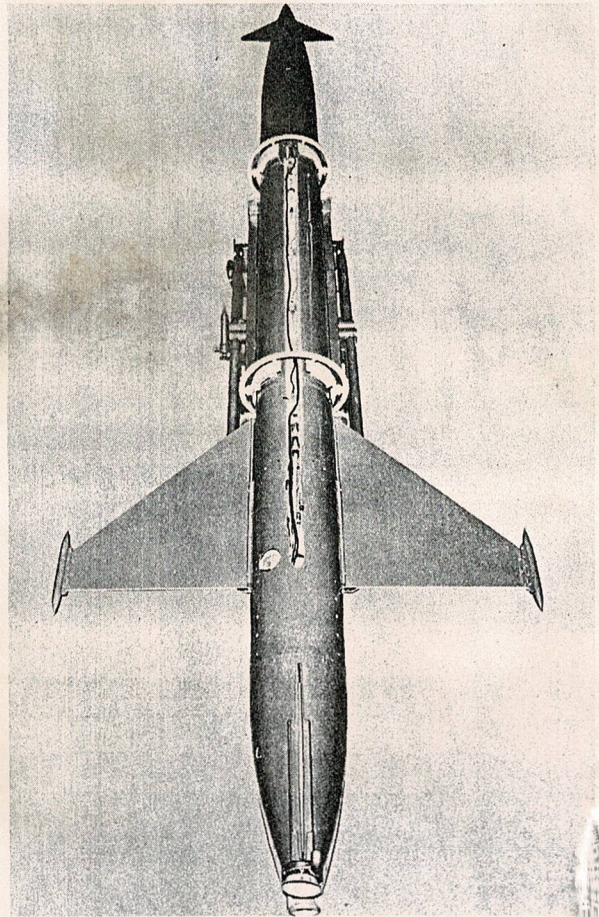


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economics

The PENNY 1C system, during the more than two years of its development, has included extensive and detailed economic analysis specifically aimed toward a low-cost expendable target. All system and subsystem designs were, from the start, aimed at meeting performance objectives with minimum unit cost. Design compromises and revisions, normally required in any such development, have already been completed at no cost to the government. In the PENNY 1C system Bendix-Bell offers the results of this effort - a drone system using developed subsystems tailored from the start to the objectives of the program.



PROTOTYPE TARGET PENNY 1A

For example, our experience permits full confidence in our estimated average airframe cost of about \$14.60 per pound, which is between 30% and 50% of the accepted average for missile systems.* We are equally confident of our estimated average cost of the electronics subsystems of \$144 per pound, significantly lower than the average for similar high-density missile electronics subsystems.

**Based on a production quantity of 1,000 targets.*

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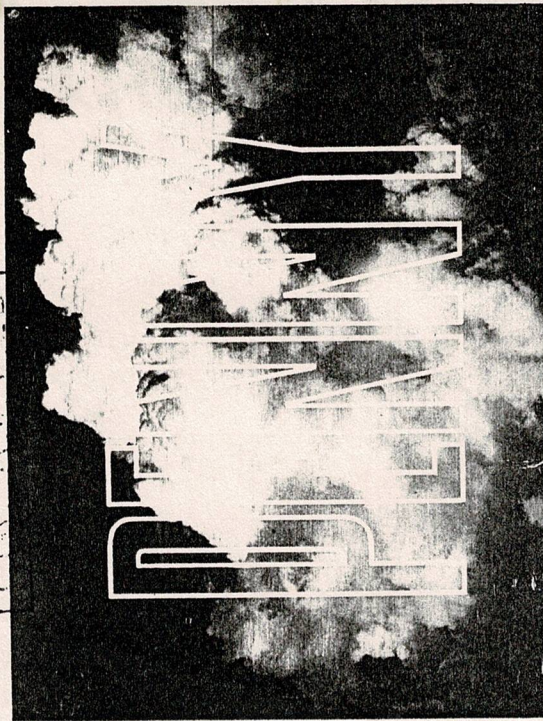
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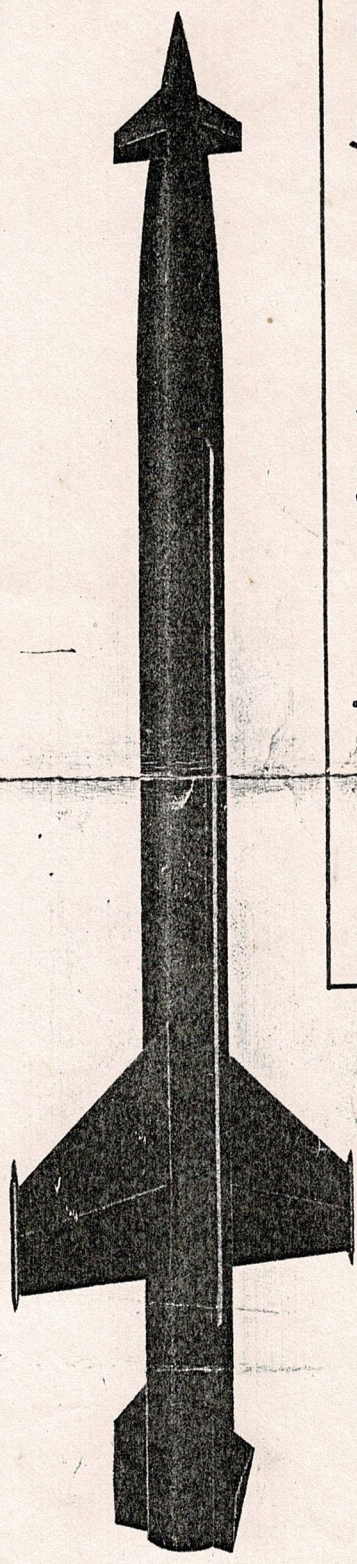
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Low Cost Target System

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