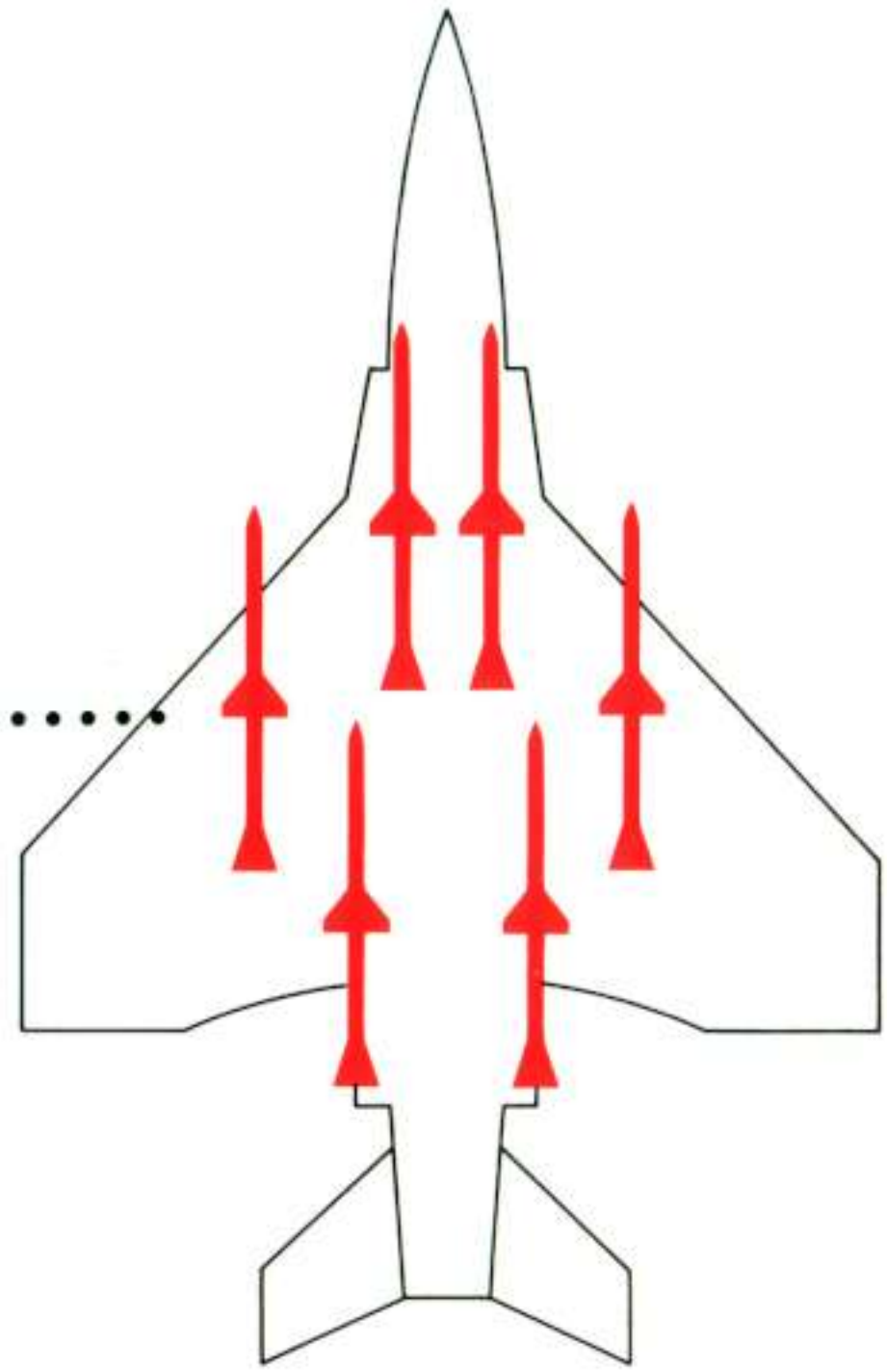
SPARROW III

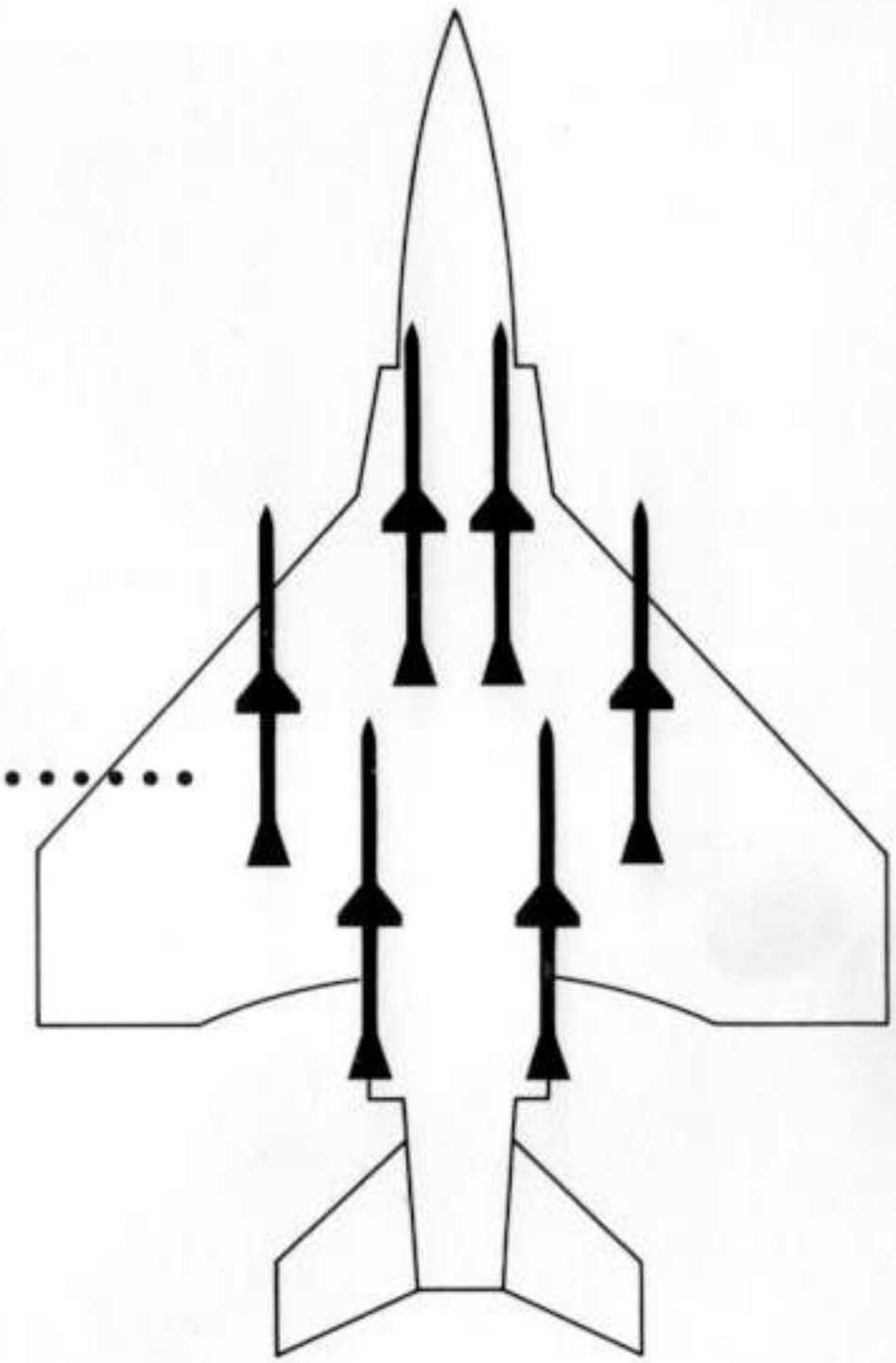


RAYTHEON COMPANY

MISSILE SYSTEMS DIVISION

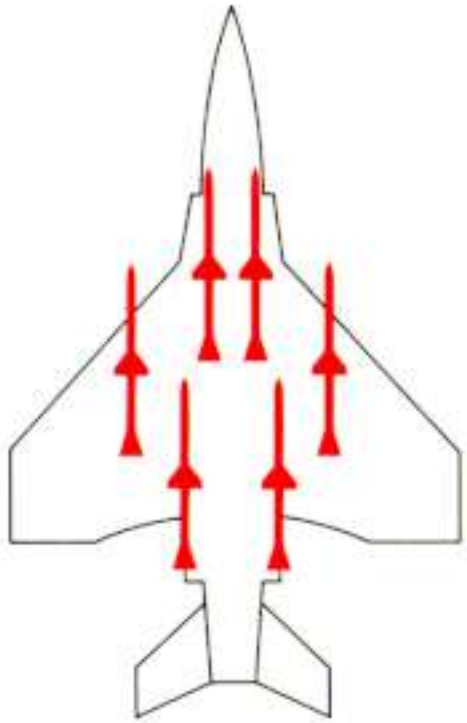
UNCLASSIFIED

SPARROW III



RAYTHEON COMPANY

MISSILE SYSTEMS DIVISION



THE SPARROW III MISSILE SYSTEM

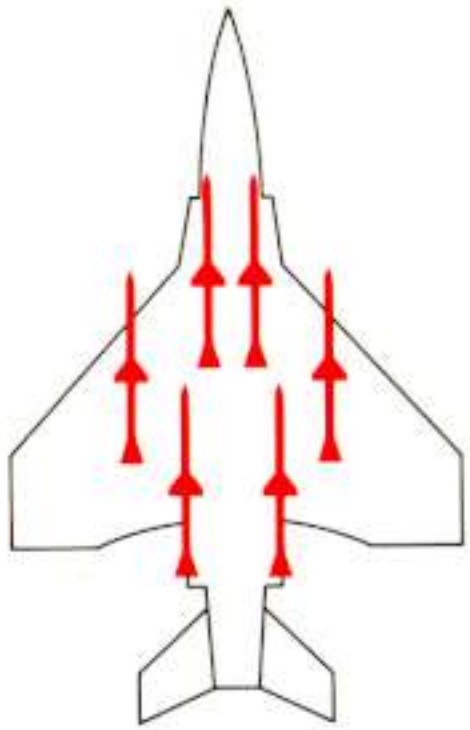
The SPARROW III Missile System is designed to intercept and destroy airborne targets and consists of an interceptor aircraft, SPARROW III missiles and their launchers, and a fire control system. The SPARROW III Missile System uses radar homing.

The fire control system consists of this radar and the computers, controls, and displays required by the interceptor pilot to follow a proper missile-attack sequence.

This reliable, highly accurate, all weather system is sufficiently automatic to relieve the pilot of many of the problems present in air-to-air attacks by conventional weapons such as guns, rockets, or unguided missiles, while still permitting him to make the target selection and attack decision.

The SPARROW III Missile can attack from any direction 360 degrees around the target. Because of the missile's range and self-guidance capability the launching aircraft is allowed great latitude in range and in aiming when firing the missile from this circle. Thus, the pilot is provided with a flexibility in maneuvering his aircraft into an effective attack position heretofore unobtainable with previous air-to-air weapons.


R-1060

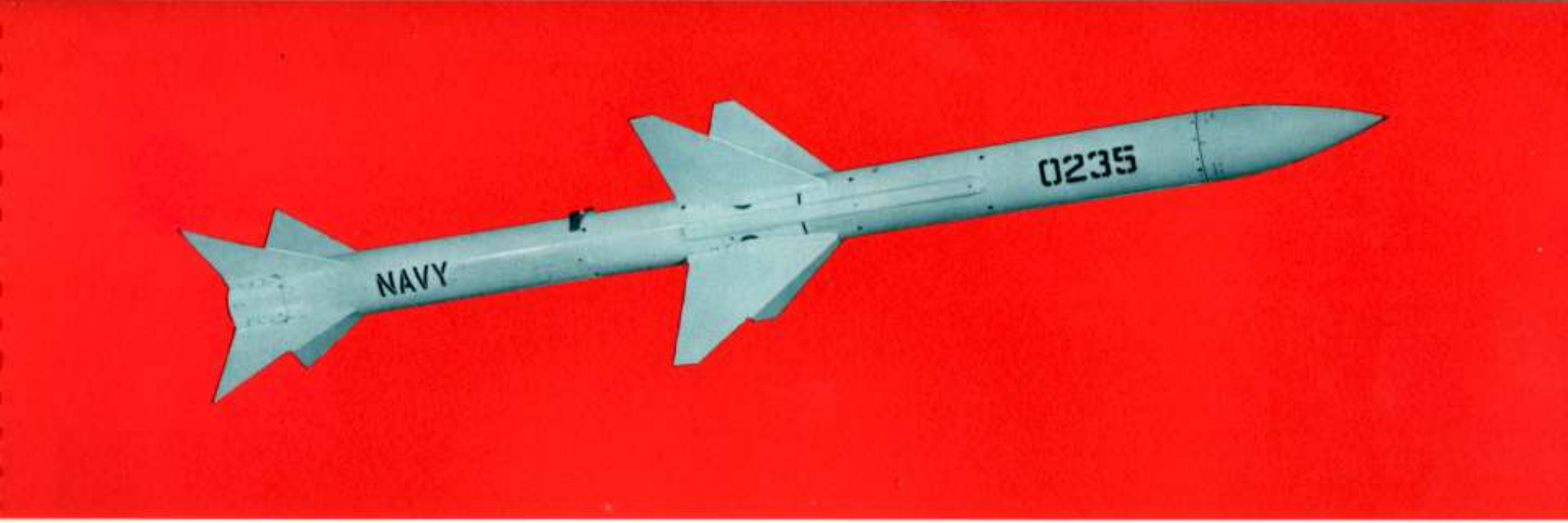


THE MISSILE

The SPARROW III Missile is 12 feet long, has a body diameter of 8 inches, and weighs approximately 400 pounds. It has four controlled wings and four fixed tails. The missile design has evolved from many years of research, development, and actual flight test. The components used in this design have been carefully selected to insure the utmost reliability over the widely varying environment that the missile encounters. The missile is divided into six major sections as follows:

TARGET SEEKER — This section contains the radome, the radar receiver and antenna, and associated electronic circuits and electromechanical parts. It receives the radar reflections from the target and extracts the information required to direct the missile on its proper course.

AUTOPILOT — This section combines the target information obtained by the target seeker with measured missile data to provide the control signals necessary to guide the missile on an optimum path to the target. The electric power unit for the missile is also contained in the autopilot section. It is designed for a long reliable life under the extreme variations of the missile environment.



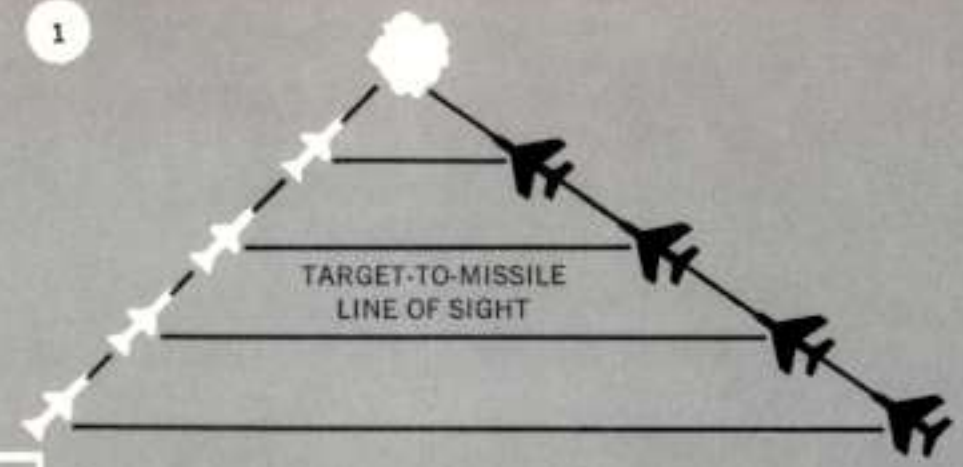
WING HUB — This section supports the four wings and also contains the hydraulic system which actuates the wings.

WARHEAD — This unit is designed to have an efficient destruction pattern and detonates at the optimum position in relation to the target when used with the SPARROW III's fuzing system. A telemetering unit can be substituted in this section when the warhead is not required. A limited amount of telemetering is provided when the warhead is used.

ROCKET MOTOR — Both solid-propellant and sealed liquid-propellant rocket motors have been designed to give the SPARROW III the thrust required to meet the requirements of the system. Careful design enables motors to perform satisfactorily over the wide range of temperatures to which the missile is subjected.

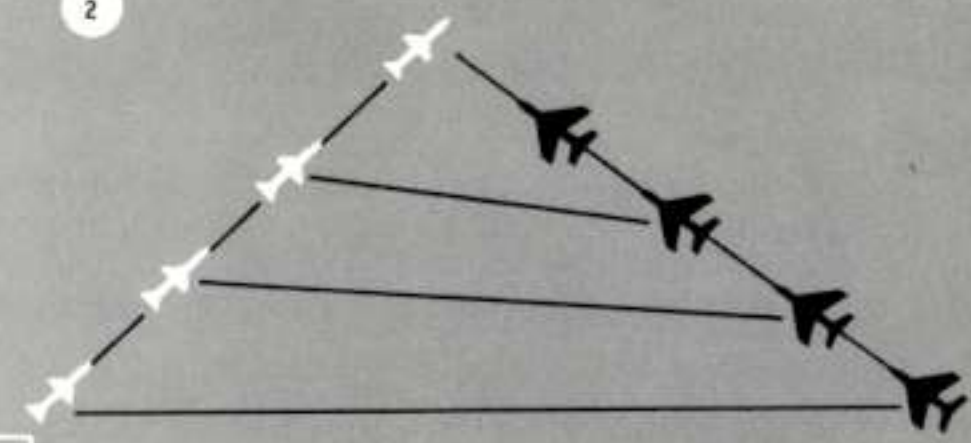
STABILIZER ASSEMBLY — This unit is attached to the end of the motor and serves as a support for the tail fins.

1



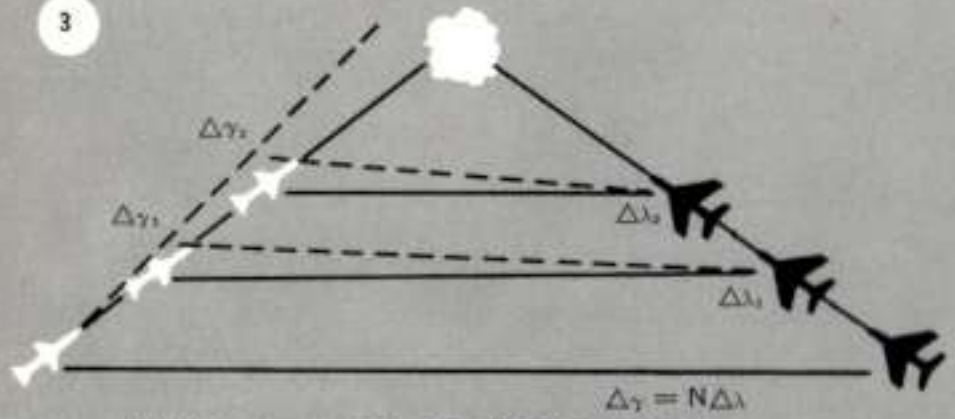
PERFECT COLLISION COURSE REQUIRING
NO MISSILE COURSE CORRECTION

2



INCORRECT MISSILE HEADING RESULTING IN LARGE MISS. (NO MISSILE CORRECTION IN RESPONSE TO CHANGING TARGET-TO-MISSILE LINE OF SIGHT.)

3

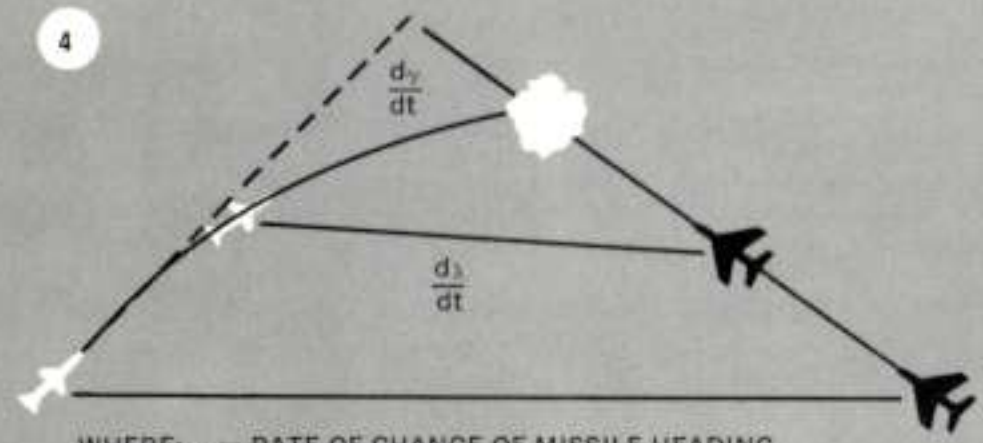


WHERE: $\Delta\gamma$ = CHANGE IN MISSILE HEADING
N = NAVIGATION RATIO
$\Delta\lambda$ = CHANGE IN LINE OF SIGHT TO TARGET.

THE CHANGE IN γ IS MADE PROPORTIONAL TO A CHANGE IN λ. THE CONSTANT OF PROPORTIONALITY IS THE NAVIGATION RATIO.

MISSILE COLLISION COURSE CORRECTED AT DISCRETE INTERVALS

4



WHERE: $\dot{\gamma}$ = RATE OF CHANGE OF MISSILE HEADING
N = NAVIGATION RATIO
$\dot{\lambda}$ = RATE OF CHANGE OF LINE OF SIGHT TO TARGET.

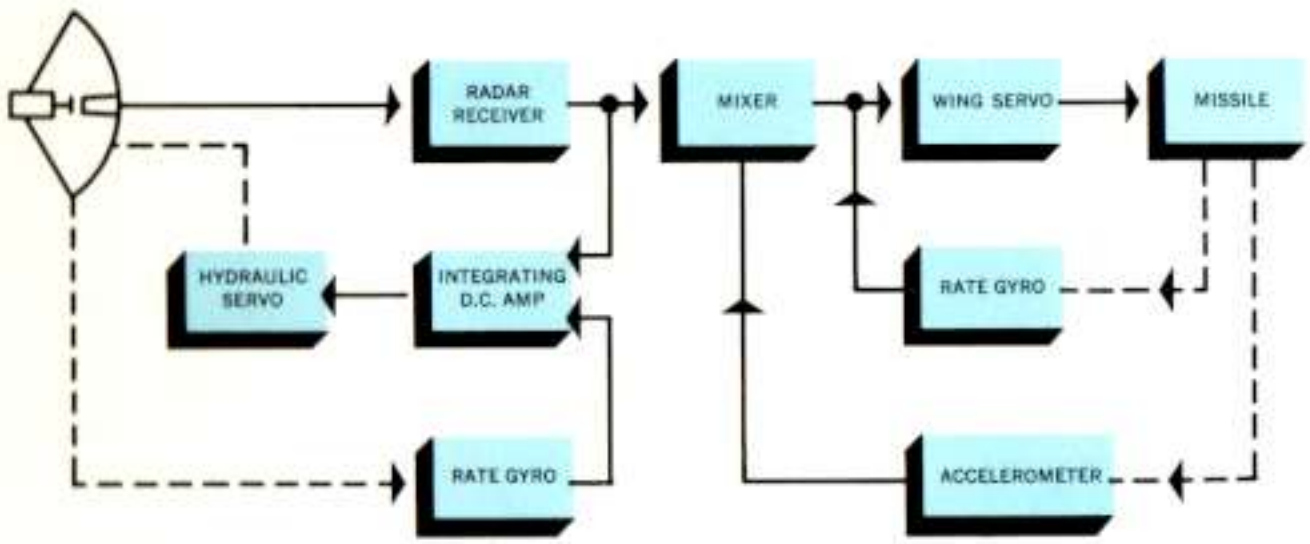
RATE OF CHANGE OF γ IS PROPORTIONAL TO RATE OF CHANGE OF λ. THE CONSTANT OF PROPORTIONALITY IS THE NAVIGATION RATIO.
MISSILE COLLISION COURSE CORRECTED CONTINUOUSLY

PROPORTIONAL NAVIGATION

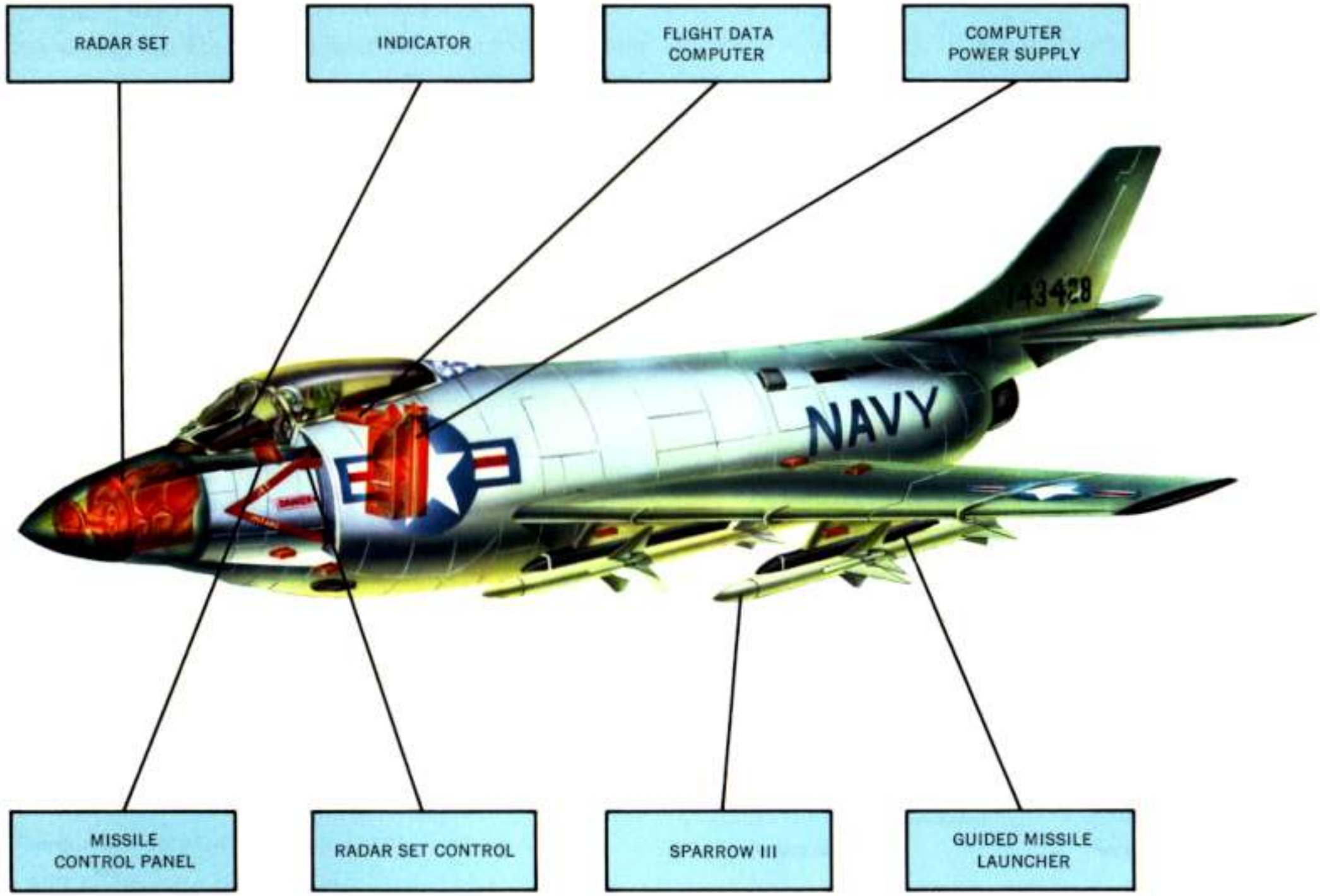
The SPARROW III Missile uses proportional navigation in its flight to a target; that is to say the missile's turning rate ($\frac{d\gamma}{dt}$) is made proportional to the rate of change of line-of-sight between the missile and the target ($\frac{d\lambda}{dt}$). In actual practice the SPARROW III achieves this condition by measuring $\frac{d\lambda}{dt}$ and the closing velocity between the target and itself (Vc), and by applying a compensating lateral acceleration (Am) through the appropriate movement of its wings. The quantity $Am = Vm \frac{d\gamma}{dt}$, where Vm is the missile velocity. The equation describing the measuring and accelerating action may be written as follows: $Am = N' Vc \frac{d\lambda}{dt}$.

The constant N', which is called the equivalent navigation ratio, sets the stiffness of the trajectory loop and is selected to give the best missile performance possible for all altitudes and aspects of attack. The figures on the opposite page show the advantages of a proportional navigation trajectory over a constant bearing course.

GUIDANCE AND CONTROL



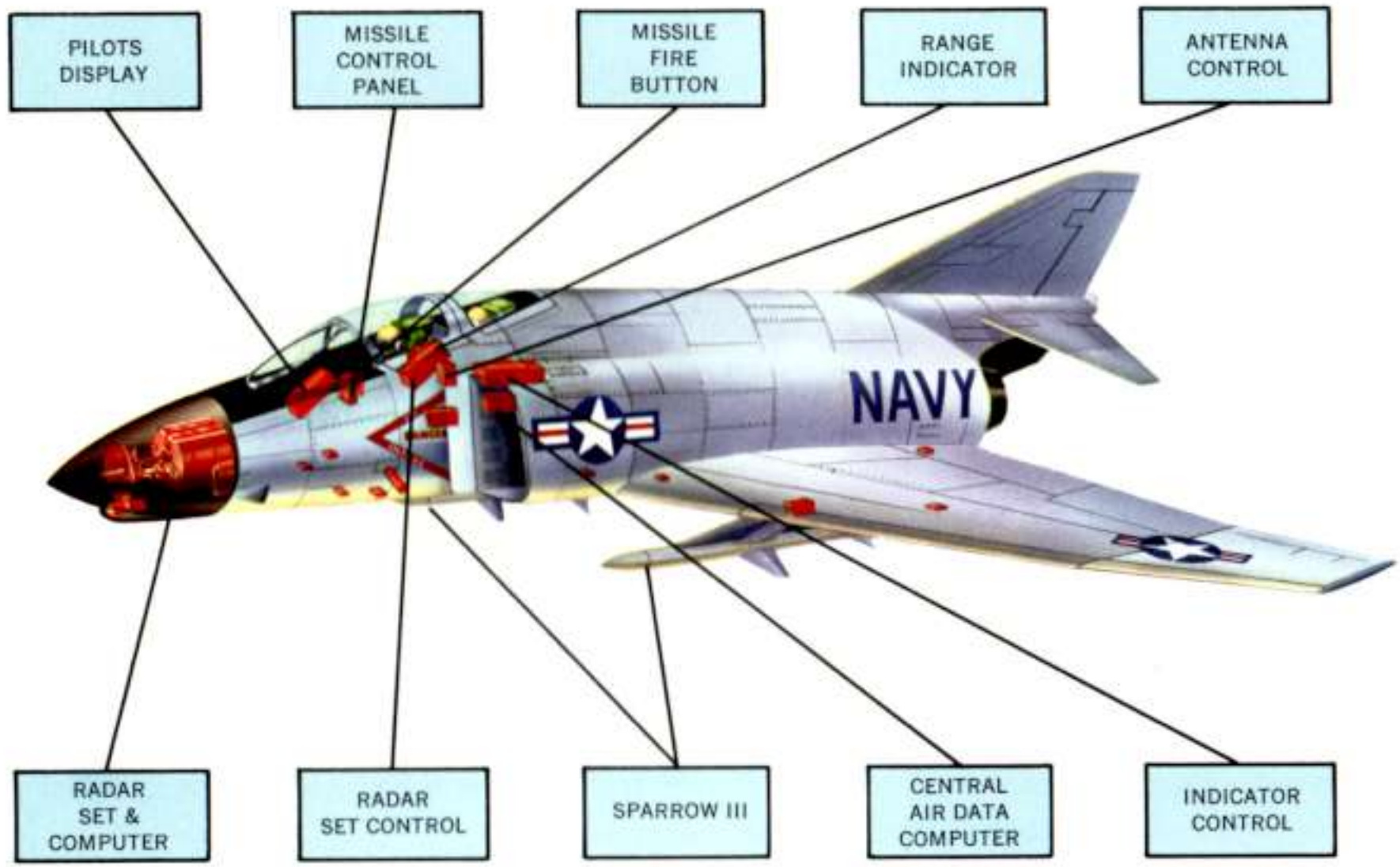
To mechanize the proportional navigation equation, the missile is provided with a radar target seeker which extracts line-of-sight and closing-velocity information from energy reflected from the target. The information is mixed proportionately in the autopilot with the missile lateral acceleration measured by the autopilot accelerometers. The proportion of the mixture is determined by the equivalent navigation ratio. The combined information is fed to the wing servo system to actuate the missile wings. The gyros are provided to stabilize the missile during these maneuvers.


RADAR SET
INDICATOR
FLIGHT DATA COMPUTER
COMPUTER POWER SUPPLY
NAVY
MISSILE CONTROL PANEL
RADAR SET CONTROL
SPARROW III
GUIDED MISSILE LAUNCHER

THE FIRE CONTROL SYSTEM

The fire control system arrangement for a single place aircraft is exemplified by that installed in the U. S. Navy's F3H-2 interceptor. It consists essentially of a radar in the nose of the aircraft, a fire control computer, displays and controls, and launchers on the wings. The radar searches for, acquires, tracks, and illuminates the target. The information obtained by the radar is supplied to the fire control computer where it is combined with interceptor data (such as True Air Speed) to generate signals that will enable the interceptor pilot to attack targets successfully.

These signals show the pilot, through his display, the maximum and minimum ranges at which he can launch the SPARROW III, the optimum angle of attack, the speed at which he is closing on the target, and the relative altitude of the target. Once the display indicates that the interceptor is within range of the target and maneuvered into the proper position for missile launch, the pilot may fire the missile by the simple operation of a switch on the missile control panel. Lights on the panel indicate the missiles ready to be fired and those that have been fired. If desired, the firing sequence can be made automatic. The display will also show the pilot the proper direction in which to maneuver his aircraft after the SPARROW III has been launched.


PILOTS DISPLAY
MISSILE CONTROL PANEL
MISSILE FIRE BUTTON
RANGE INDICATOR
ANTENNA CONTROL
NAVY
RADAR SET & COMPUTER
RADAR SET CONTROL
SPARROW III
CENTRAL AIR DATA COMPUTER
INDICATOR CONTROL

In addition to supplying signals for the pilot's display and controls, the fire control computer also supplies signals to the missile guidance and control section prior to launch. These signals enable the missile to acquire a target after launch without prior acquisition on the launcher, as well as assisting it in attaining the most efficient course to the target. Before target engagement, the fire control system supplies the missile with signals for tuning its receivers and testing its readiness.

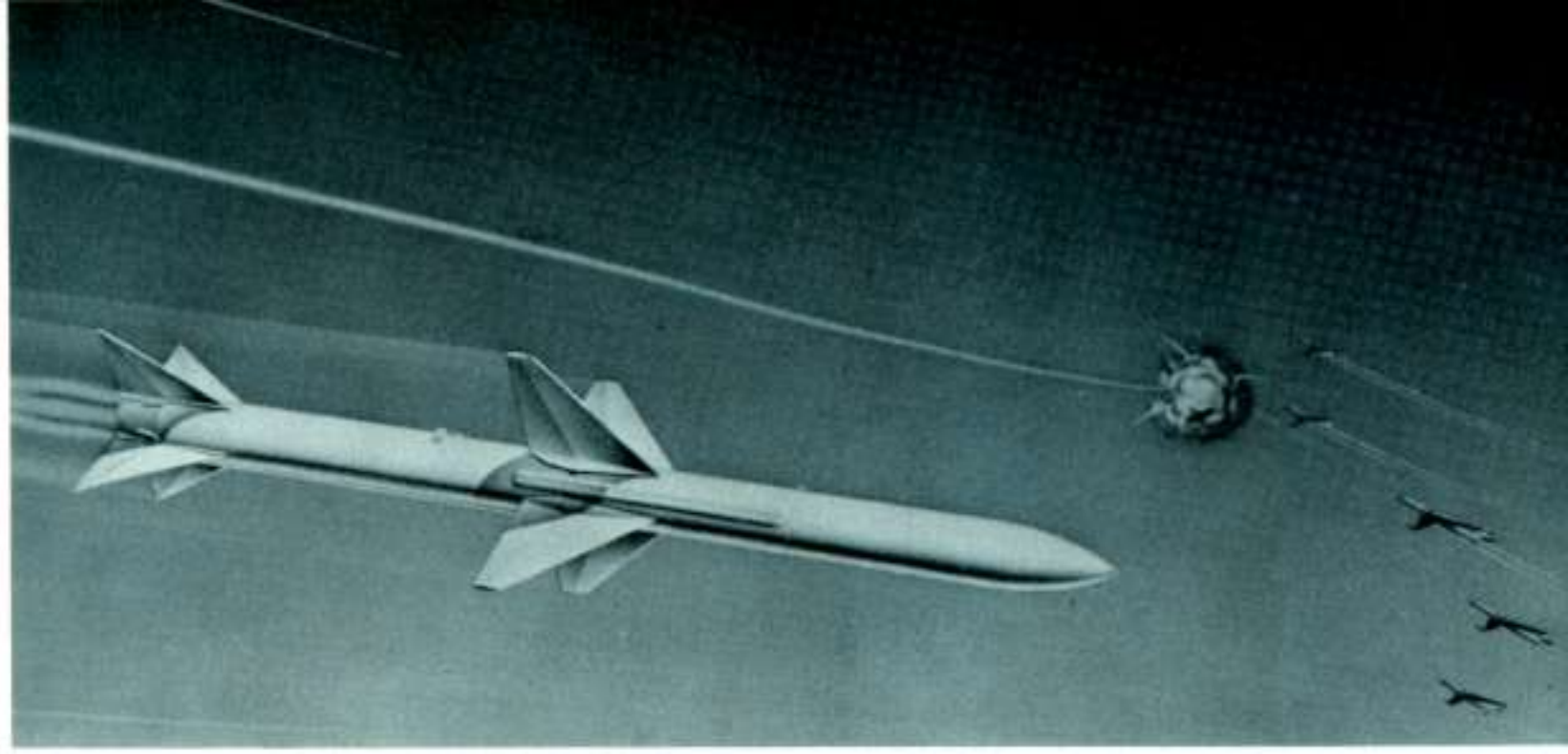
This feature of the system prepares the missiles for launching prior to acquisition of the targets by the fire control system; therefore, the time delay between acquisition of the target and firing of the missile is minimized.

The fire control system for the F4H-1 interceptor aircraft is much like that of the F3H-2. It contains the same basic group of units; a radar, a fire control computer, controls and displays, and a launching system. The improved capability of the system makes full use of the superior performance of the F4H-1 and the presence of a radar operator in the aircraft. System improvements include more radar range, greater data handling capacity in the computer, and a launching system that allows the missiles to be carried in a semi-submerged position on the aircraft.

In addition, the system improvements are intended to contend with the improved performance of future target aircraft.

TACTICAL EMPLOYMENT

The SPARROW III Missile System can be tactically employed under the control of airborne or surface based early warning centers. These centers, using long-range radar data, direct the interceptors to the target intercept area, the fire control system of the interceptor is used to locate the target and maneuver the aircraft to a suitable position for launching the missile.

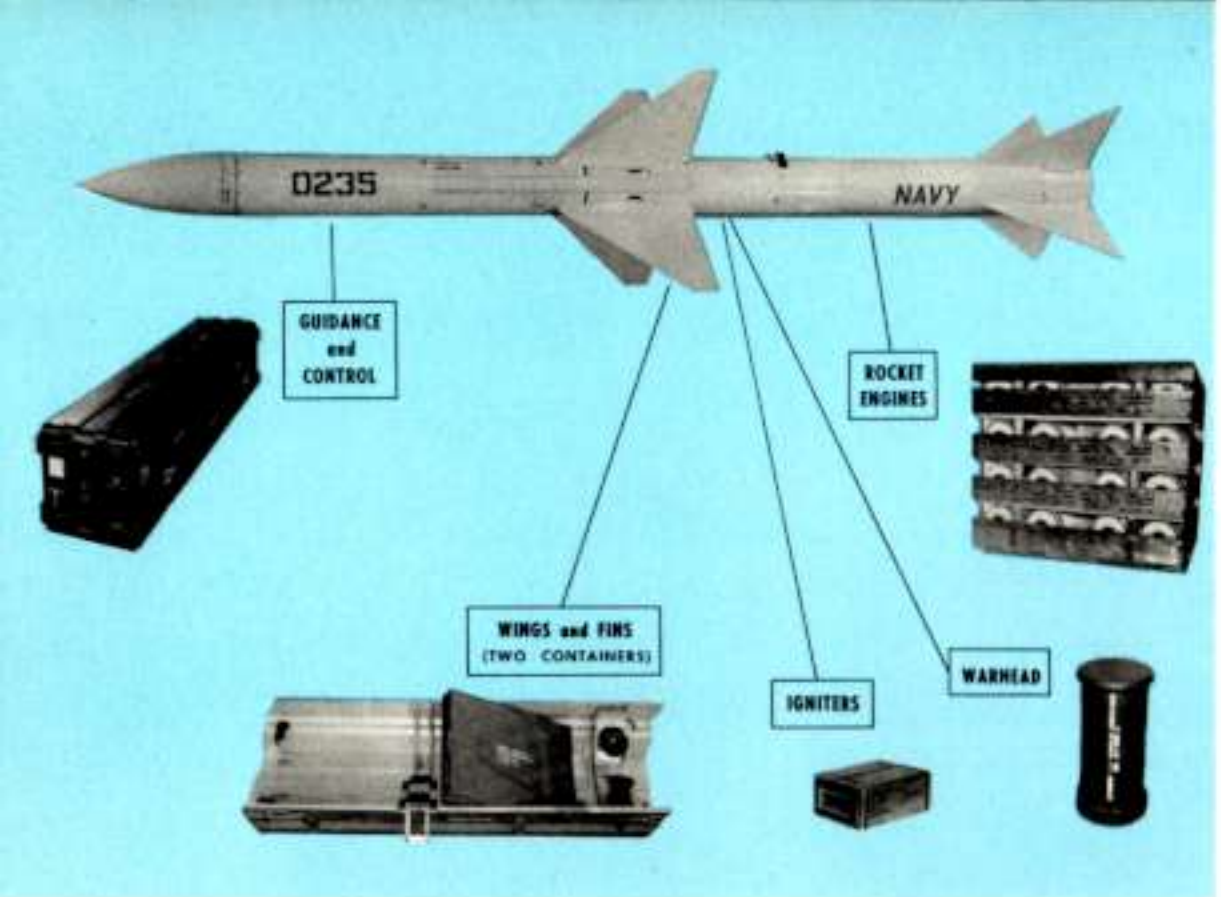


CAPABILITY

The SPARROW III Missile System has been designed to include certain capabilities that are becoming increasingly important as the speed and altitude of aircraft increase. The time available for an attack on a target is becoming too short to allow any elaborate maneuvering by the interceptor; thus the interceptor pilot, if he is to make a successful attack under all conditions, must have a weapon system that has substantial range, high speed, flexibility, reliability, and accuracy. Furthermore, the weapon system must have these characteristics under all weather conditions.

The SPARROW III Missile System provides the interceptor pilot with these characteristics. The SPARROW III can be fired at a target from any aspect from head-on to directly on the tail. It has considerably more range than conventional weapons. It can be fired very quickly without loss of accuracy either automatically when in range of the target or at the pilot's discretion by the simple operation of a switch. Because of the missile's ability to correct its course while in flight and to home directly on a target, the pilot does not have to aim the missile accurately prior to launch. The interceptor does not have to be at the same altitude as the target, since the missile can climb up or dive down at the target. More than one missile can be fired at a target during the same approaches.

An in-flight check out feature permits the pilot to insure himself that the missile he has selected is ready for successful launching.



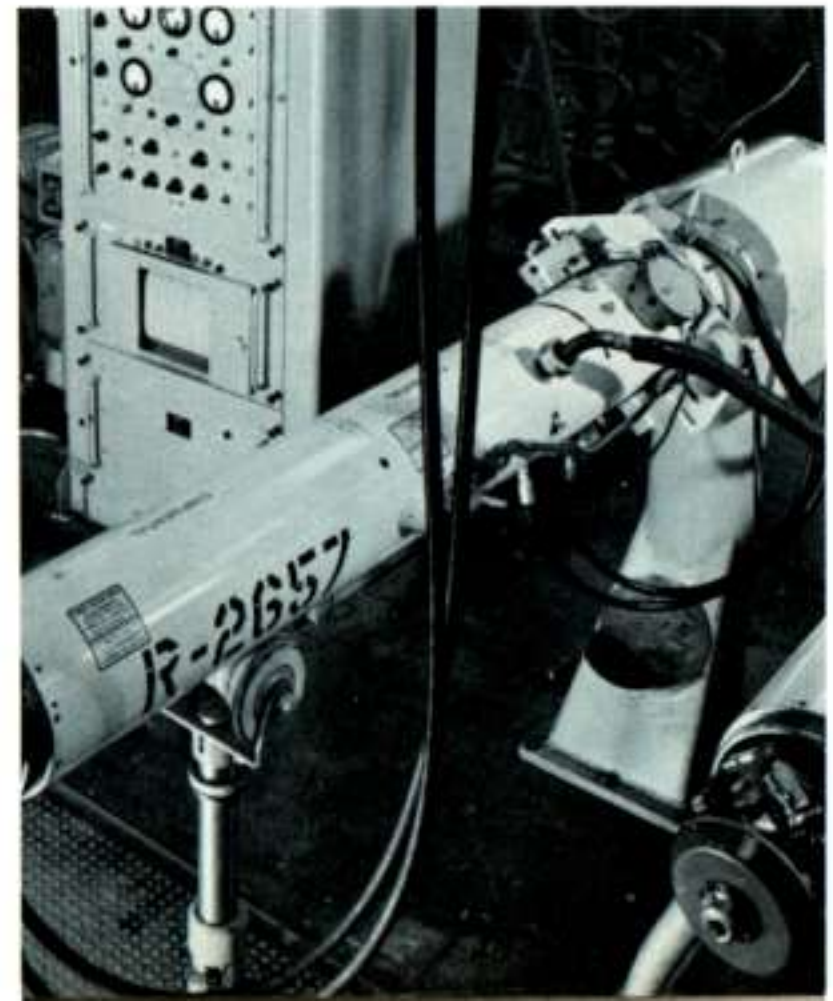
LOGISTICS

The SPARROW III Missile has been designed for easy handling and storage, both on board aircraft carriers and on land. The missile can be broken down into several interchangeable sections which can be quickly assembled or disassembled. The guidance and control sections which are usually handled and stored separately from the warhead and rocket motor sections, can be given a periodic electronic check-out without being joined to the remaining sections. The wings and fins can be installed immediately before the missile is attached to the launcher.

TRAINING — Fire control system simulators have been used effectively to train pilots in the use of SPARROW III. Because of the simplicity and flexibility of the system, pilots quickly become proficient. Precise control of the aircraft is not necessary in order to achieve destruction of the target. The tasks performed by tactical base personnel are relatively simple, and can be quickly mastered by trained personnel.

MAINTENANCE

MISSILE — A missile testing concept has been adopted to provide for missile operational readiness while permitting sectional stowage, keeping tactical base test equipment and maintenance simple. The guidance and control section of the missile, which is the only one that requires periodic checkouts (at 3 month intervals) is stored as one unit. The missile test equipment is designed to check out all elements of one system by simulating flight problems. It provides the proper electrical and mechanical inputs and monitors the response. Test equipment is available to provide a permanent recording or to display the response on a cathode ray tube. The test equipment isolates major units of the guidance and control section which are faulty. The faulty units are replaced and returned to completely equipped and staffed shore-based depots where repairs are made. This procedure offers the advantages of conserving desk space, which would be otherwise needed for elaborate test equipment, eliminating the need aboard ship for highly trained personnel required to repair the missiles, and simplifying the spare parts inventory aboard ship.



FIRE CONTROL SYSTEM — To facilitate maintenance, the fire control system test equipment is designed to isolate and replace a defective unit without removing the system from the aircraft. Testing and maintenance are divided into four levels as follows:

(1) Preflight check to determine system readiness. This check is made with test circuits built into the equipment. The only auxiliary equipment required is that needed to provide hydraulic power, cooling air, and electrical power.

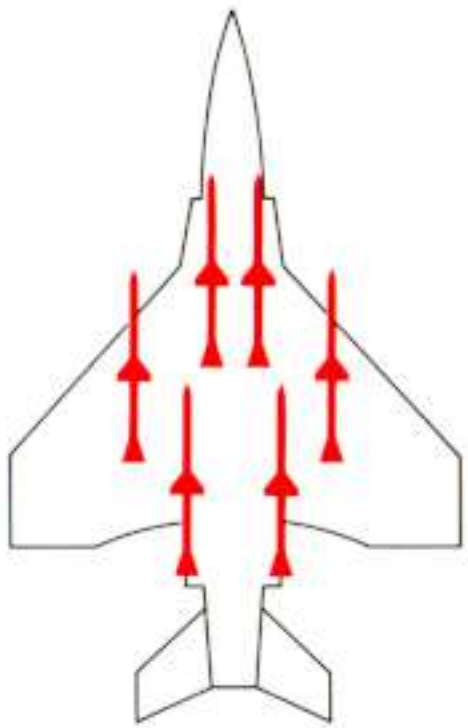
(2) Thirty-hour check to provide a periodic check of the equipment or locate faults discovered in the preflight check. In this check the faulty unit is identified and replaced. Test equipment is portable for the F3H-2 aircraft and carried on a hand cart for the F4H-1 aircraft.

(3) Bench Test and maintenance to locate and correct the defect. The system test concept is used at this level; that is to say the defective unit is installed in a fire control system mounted on a bench, and faults are located to specific components which can then be repaired or replaced as required. Equipment used at this level includes a complete operable system as well as various pieces of test equipment.

(4) Depot repair to overhaul the fire control system completely. After a definite period of use, each system is removed from its aircraft and is sent to an overhaul and repair shop where it is dismantled, thoroughly checked, and rebuilt. The overhauled system will pass the production line tests normally given to newly manufactured systems. Test and maintenance equipment used at this level include that found in a manufacturing plant.

OPERATIONAL EMPLOYMENT

On 13 January 1959, the U. S. Navy announced that the SPARROW III Missile System was in use on carrier-based jet interceptors of the Seventh Fleet in the Western Pacific. Since then, the SPARROW III has also been deployed with the Sixth Fleet in the Atlantic. Pilots on board the aircraft carriers Midway and Bon Homme Richard were among the first to get operational experience with this missile. The missiles are being manufactured in plants at South Lowell, Massachusetts, and Bristol, Tennessee. SPARROW III is becoming the U. S. Navy's prime air-to-air defense weapon.



TOMORROW'S WEAPON

The basic concept of the SPARROW III Missile System does not limit growth of its capabilities. Continuing research and development are improving components and sub-systems. As a result, advanced fire control systems and SPARROW III missiles can be produced to match the capability of the most modern interceptor aircraft. At the same time, compatibility between the various versions of the system is being maintained. It is confidently felt that the SPARROW III Missile System will be able to match the growth rate of potential targets for years to come.

SPARROW III

- ALL WEATHER
- ALL ALTITUDE
- ALL ASPECT
- CLIMBS OR DIVES TO ATTACK
- PROVEN IN OPERATIONAL USE
- DEMONSTRATED RELIABILITY
- ECONOMICAL
- SIMPLE TO EMPLOY

RAYTHEON

RAYTHEON COMPANY

MISSILE SYSTEMS DIVISION

MSM 1502