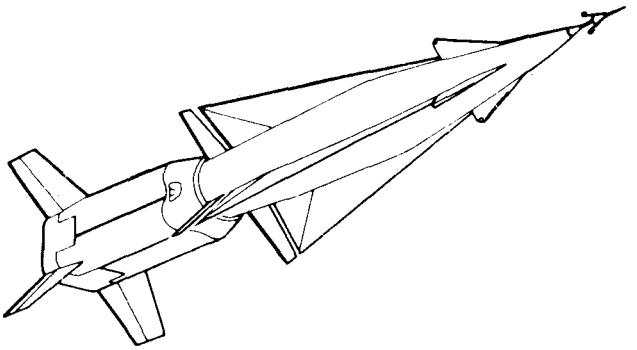


## LESSON 1. INTRODUCTION TO THE IMPROVED NIKE HERCULESE MISSILE SYSTEM

**MMS Subcourse No 150** . . . . . **Nike Radars and Computer**

**Lesson Objective** . . . . . **To give you a general knowledge of the history, missions, and purpose of the improved Nike Hercules missile system and relationship of its major items.**

**Credit Hours** . . . . . **Two**

## TEXT

1. **GENERAL.** This lesson presents an overall description of the improved Nike Hercules air defense guided missile system. This description is intended to provide information for personnel requiring only a general knowledge of this missile system.

2. **PURPOSE.**

a. The purpose of air defense guided missile systems is to deter or minimize the effects of enemy attacks by detecting and destroying enemy aircraft and missiles approaching a defended area. These systems must be capable of defending strategic areas against attack from high altitude, high speed enemy aircraft capable of taking evasive action while performing precision bombing. Therefore, to intercept targets that can take evasive action, the system must be capable of trajectory corrections after missile launch. In addition, it is desirable that the system be capable of self-defense against tactical surface targets.

b. The improved Nike Hercules system and the Nike Hercules antitactical ballistic missile (ATBM) system can be used in support of other service groups. For example, both systems may contain a bomb scoring system that tracks an aircraft during a simulated bomb run, from the start of the run until the bomb release point. Then, using predetermined data, the theoretical impact point of the bomb can be calculated. Thus, bomb-drop accuracy can be measured without actually expending a bomb.

3. **SEQUENCE OF EVENTS.**

a. The improved Nike Hercules air defense guided missile system and the Nike Hercules ATBM system both use integrated radar systems to detect and track targets approaching their defended areas. Another radar system is used to guide missiles to intercept and destroy the hostile target. Early warning facilities provide information on the approach of hostile targets, and either of two acquisition radar systems provide constant long-range detection and surveillance of the targets. The acquisition radar supplies azimuth and range data to the target tracking radar which then acquires and tracks the target. A missile tracking radar system acquires a missile while it is still on the launcher, tracks the missile in flight, and transmits steering and warhead burst orders to the missile.

b. The target and missile track radars continuously supply target and missile position data to a computer system. From this data, the computer supplies the necessary information to the battery control officer for launching the missile, and it sends steering and warhead burst orders to the missile tracking radar system

for transmission to the missile during flight. Both high explosive (HE) and nuclear warheads can be used with the Nike Hercules system. (Nuclear warheads would be used against large formations of aircraft, tactical ballistic missiles, or selected surface targets.)

## 4. HISTORY OF DEVELOPMENT.

**a.** The development of offensive missiles and the increases in the capabilities of modern aircraft have rendered conventional antiaircraft weapons ineffective. The need for a new defense became apparent as fundamental changes in existing defensive weapons seemed unlikely. After an extensive investigation, it was decided that a guided missile system would be the most effective defense.

**b.** There were three types of missile guidance systems from which to choose: the homing system, the beam rider system, and the command guidance system. These three guidance systems are briefly described in (1) through (3) below.

(1) The homing system guides the missile by locking in or "homing" on energy emission or reflections from the target. This energy may be either light, heat, radio signals, or radar reflections. Since the homing system locks in on energy coming from the target, the amount of received energy increases as the missile approaches the target and accuracy increases.

(2) With the beam rider system, the missile must be launched and then captured by a radar beam pointing at the target. The missile must then follow the beam to the target. Although the narrow radar beam makes it difficult to capture the launched missile, a number of missiles can be controlled at the same time with this system.

(3) The command guidance system guides the missile by steering commands transmitted from ground guidance equipment to the missile while in trajectory. Although complex and precise ground guidance equipment is required for this type of guidance system, the expendable missile guidance equipment is normally less complex than that required for the homing or beam rider systems.

**c.** After analyses of the three missile guidance systems, it was decided that the command system would provide the best guidance for the needed defense. The command guidance system promised to be the most effective against fast and highly maneuverable aircraft and to have capabilities for greater range. A government research and development program was initiated that resulted in the Nike Ajax air defense guided missile system utilizing a command guidance system.

**d.** Although the Nike Ajax system was capable of destroying aircraft at ranges up to 50,000 yards, by 1952 the increased speed and maneuverability of modern aircraft made it apparent that the Nike Ajax system would soon cease to be an effective defense. A new guided missile system was needed which could, with a single missile, destroy entire formations of high altitude, high speed aircraft at greater ranges. After extensive studies, it was determined that this new system would require the use of a nuclear warhead in a new missile with a greater range and speed than the Nike Ajax.

**e.** Studies were made concerning the feasibility of incorporating a nuclear warhead in the Nike Ajax missile to give it the required destructive capabilities. Consideration was also given to modifying the Nike Ajax ground guidance equipment to get the greater range and accuracy required. It became apparent that adaption of the Nike Ajax missile would necessitate extensive missile redesign, but only minor changes in the ground guidance equipment. In addition, it was determined that the ground guidance equipment could be altered so that it would be capable of launching and controlling the new missile as well as the Nike Ajax missile. This would allow the Nike Ajax missile to be retained for use against single aircraft at shorter ranges.

**f.** Surface to surface capability for the new system was included as a secondary requirement. Engagement of surface targets at long ranges was desired, and the missile used must be capable of delivering nuclear warheads.

**g.** In 1954, after studies were completed, contractors were authorized to proceed with the new system - designated the Nike Hercules air defense guided missile system. This system would provide the additional capabilities needed, including an intercept range far in excess of the Nike Ajax.

**h.** By 1956, it was again apparent that further improvement in the Nike Hercules system would be necessary to keep pace with advancements in aircraft, air to surface missiles, and electronic countermeasures (ECM) techniques. Extension of Nike Hercules capabilities was needed to maintain an effective defense against smaller, faster targets operating at higher altitudes and equipped with improved ECM systems. From inception, the Nike system was designed to afford maximum performance flexibility with minimum system modification. Studies showed that the basic Nike

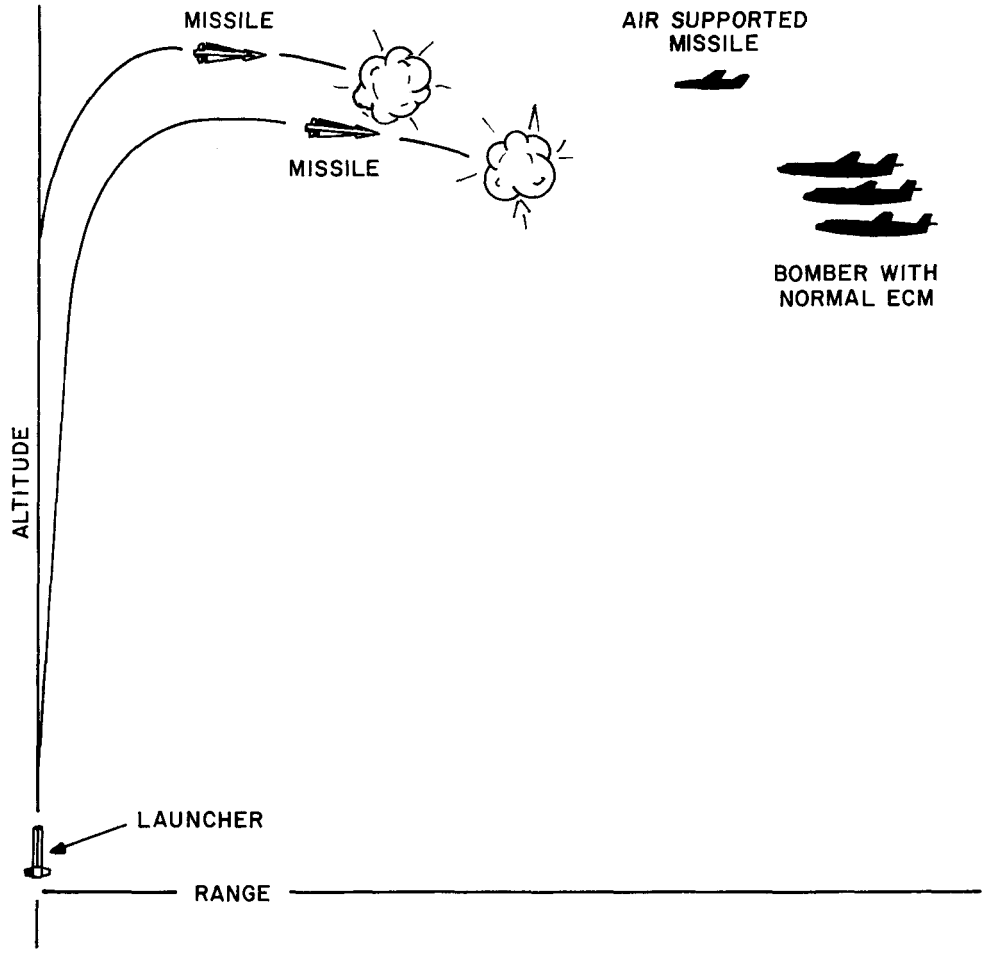



*Figure 1. Surface to air mission.*

Hercules system could again be improved to meet the anticipated post-1960 threat. With no change in the missile, the effective range could be increased by the addition of a new high power acquisition radar (HIPAR) system. The HIPAR system, plus a new target ranging radar system (TRR), could provide electronic counter countermeasure (ECCM) capabilities to contend with anticipated enemy ECM techniques. In 1958, after studies were completed, contractors were authorized to proceed with development of the new system - designated the improved Nike Hercules air defense guided missile system. The improved systems were to be deployed in two configurations within the continental United States, with or without HIPAR. Sites without HIPAR will have an auxiliary acquisition radar (AAR) which is supplied by modifying existing acquisition systems to improve their ECCM and power capabilities.

i. Later studies were begun on the feasibility of adapting existing guided missile systems for use in countering the threat to the field army by enemy tactical ballistic missiles. The studies of the Nike Hercules system revealed that if appropriate changes were made in the HIPAR, computer, presentation system, and plotting boards, the improved Nike Hercules system could be used for defense against tactical ballistic missiles, as well as manned aircraft and air supported missiles. After these studies were completed, contractors were authorized to proceed with the development of the Nike Hercules ATBM air defense guided missile system.

## 5. APPLICATION.

a. The improved Nike Hercules air defense guided missile system is primarily designed to combat air to surface missiles and fast, high altitude formations of modern aircraft with ECM capabilities. It can be most effectively employed to defend military installations, industrial centers, large cities, and as a first line of defense in areas such as the distant early warning (DEW) line and the eastern and western seaboards of the continental United States.

b. An improved Nike Hercules battery can be

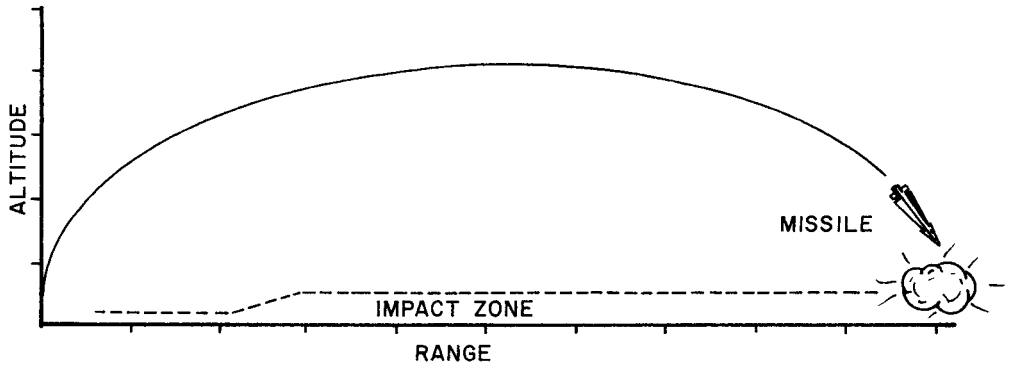



*Figure 2. Surface to air low altitude mission.*

employed as an individual defense unit or in combiation with other air defense units. A number of improved Nike Hercules batteries can also be employed as units of an integrated air defense system, with each system monitored and controlled by the Army Air Defense Command Post (AADCP).

c. The Nike Hercules ATBM system is primarily designed to combat aircraft, air supported missiles, and tactical ballistic missiles, but it can be conditioned to operate against surface targets.

## 6. MISSIONS.

a. The improved Nike Hercules system is capable of performing three types of missions: surface to air, surface to air low altitude, and surface to surface. An effort to support the Air Force has been made by providing selected systems with the capability for radar scoring of simulated bombing runs. The general capabilities of the improved Nike Hercules system are described in (1) through (4) below.

(1) Surface to air mission (SA-AA)(fig 1). The improved Nike Hercules system is designed to combat high altitude bombers or air supported missiles. The system can detect missiles traveling at supersonic speeds. Bombers with normal ECM capabilities and with a typical radar reflecting surface can be detected at greater ranges than the air supported missile. The Nike Hercules missile can attain a maximum velocity which surpasses the speed of known manned aircraft or aerodynamically supported missiles.

(2) Surface to air low altitude mission (SA-LA)(fig 2). The improved Nike Hercules system has provisions for intercepting and destroying low altitude targets. A delayed start of the missile rocket motor is employed to achieve a shorter turning radius of the missile. This permits the missile to attain a low altitude much faster; therefore, the low altitude corridor (fig 2) becomes the impact zone in the surface to air low altitude mission.

(3) Surface to surface mission (SS)(fig 3). The improved Nike Hercules system can deliver a nuclear warhead to a surface target. The missile is guided to a space reference point above the target, then a dive order

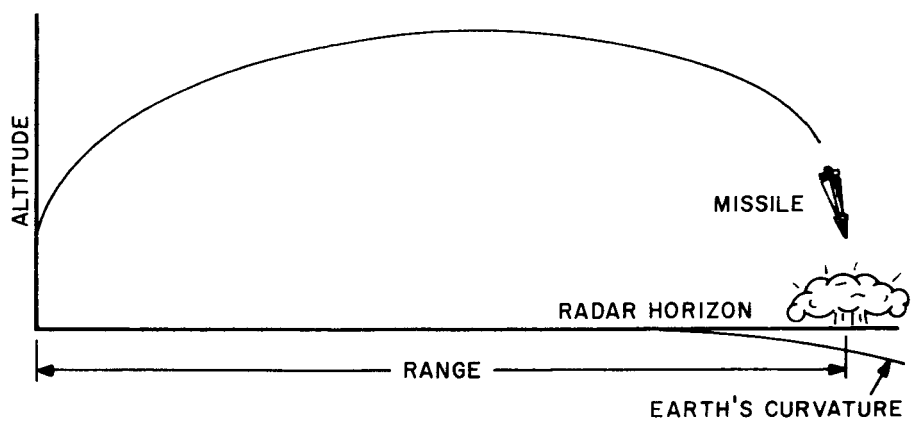



*Figure 3. Surface to surface mission.*

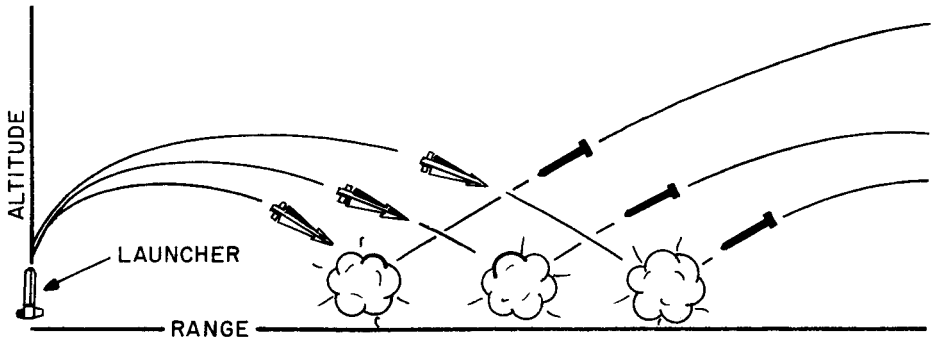



*Figure 4. Surface to air mission against ballistic missile.*

is issued causing the missile to approach the target vertically.

(4) Bomb scoring mission. The improved Nike Hercules system, when used in a bomb scoring mission, accurately plots the course of a bomber making a simulated bombing run and marks the point of the simulated bomb release. From this plot, the theoretical impact point is calculated and the accuracy of the bombing run can be determined.

**b.** The Nike Hercules ATBM system is also capable of performing three types of missions: surface to air antiaircraft (A-A), surface to air antimissile (A-M), and surface to surface (S-S). This system can also be used for radar bomb scoring of simulated bombing runs as described in paragraph (4) above. The missions of the ATBM system are the same as the improved system with one exception. The ATBM system has a surface to air antimissile mission instead of a surface to air low altitude mission. When the antimissile mission is

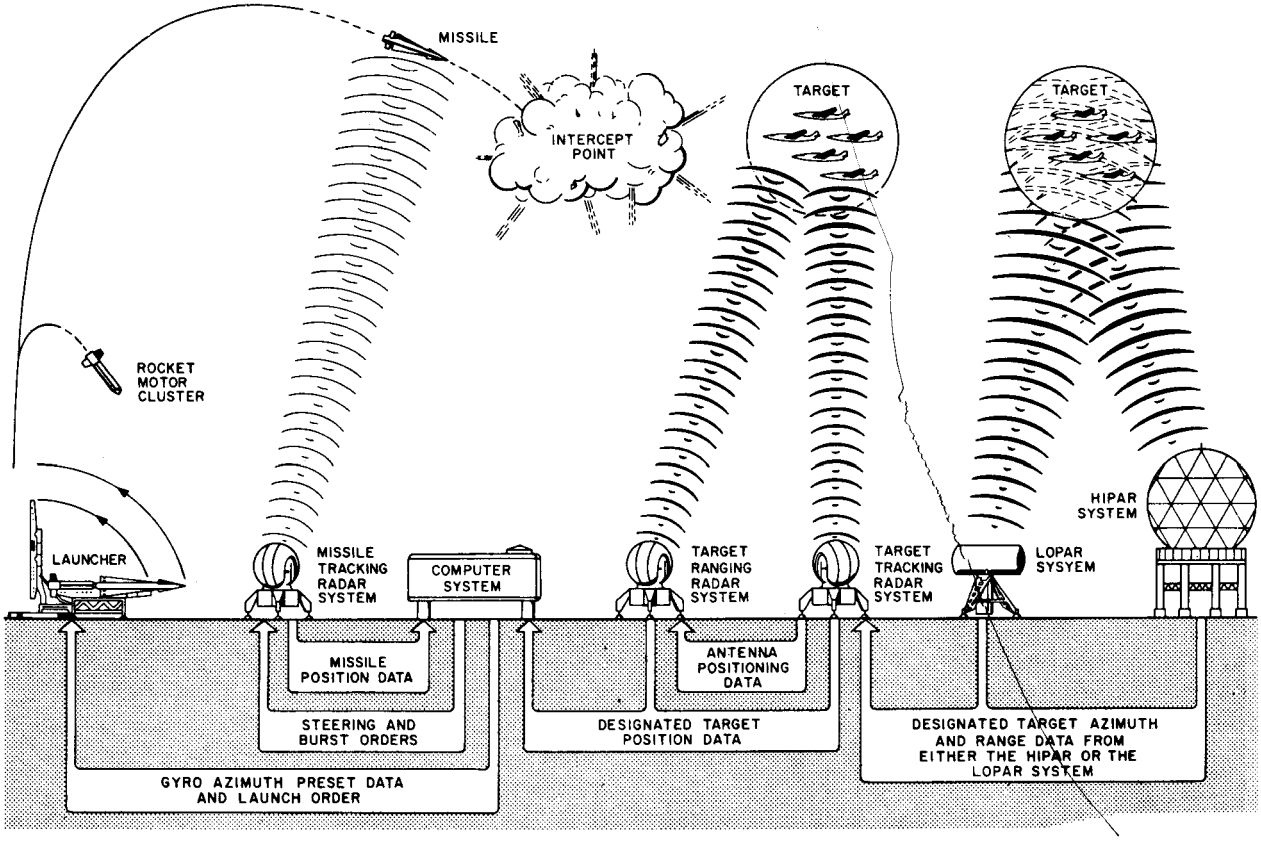



*Figure 5. Surface to air mission - functional diagram.*

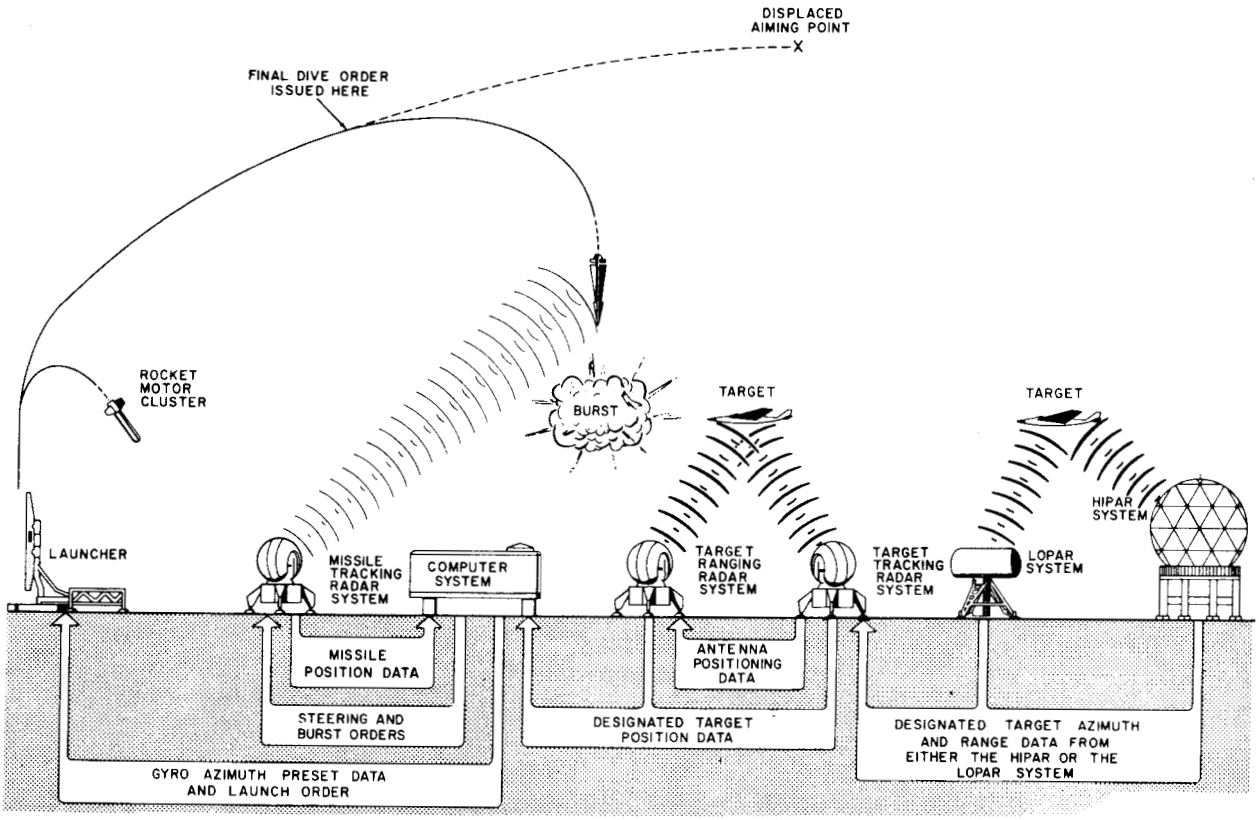



*Figure 6. Surface to air low altitude mission - functional diagram.*

selected, the computer is conditioned for ballistic prediction. The system is capable of guiding a Nike Hercules missile to intercept and destroy a tactical ballistic missile, as illustrated in figure 4. It should be noted that the effective destruction range is shorter for a longer range ballistic missile.

## 7. FUNCTIONAL DESCRIPTION.

### a. Improved Nike Hercules system.

(1) Surface to air mission.

(a) In a surface to air mission (fig 5), either of two acquisition radar systems detects and identifies incoming targets. The HIPAR system operates at a greater range than the lower power acquisition radar (LOPAR); therefore, it provides more time for target evaluation. The HIPAR also provides more altitude coverage for detecting a tactical ballistic missile. Acquisition radar azimuth and range data of a designated target are electronically transferred from either acquisition radar to a target tracking radar system. These data are used by the target tracking radar operators to acquire the target. After acquiring the designated target, the target tracking radar (TTR) system continuously supplies target position data (elevation, azimuth, and range) to a computer system. When enemy countermeasure activity is adverse, target azimuth data can be attained by using the strobe line feature of either the HIPAR or LOPAR antijamming display (AJD). The target azimuth can then be transferred to the TTR and target ranging radar (TRR) which provide the computer with enemy target range, azimuth, and elevation data. From the target position data, the computer system continuously calculates a predicted intercept point. The azimuth of the predicted intercept point is sent to a previously designated missile as gyro azimuth preset data. This data orients a gyro in the missile so that after launch, the missile automatically rolls to the correct attitude with respect to the predicted intercept point. A missile tracking radar system is electronically locked on the designated missile while the missile is still on the launcher, so that, after launch, the radar system can supply uninterrupted missile position data to the computer system. At the same time, the computer system continuously supplies data to two plotting boards which enable the battery control officer to determine the optimum time to launch the missile.

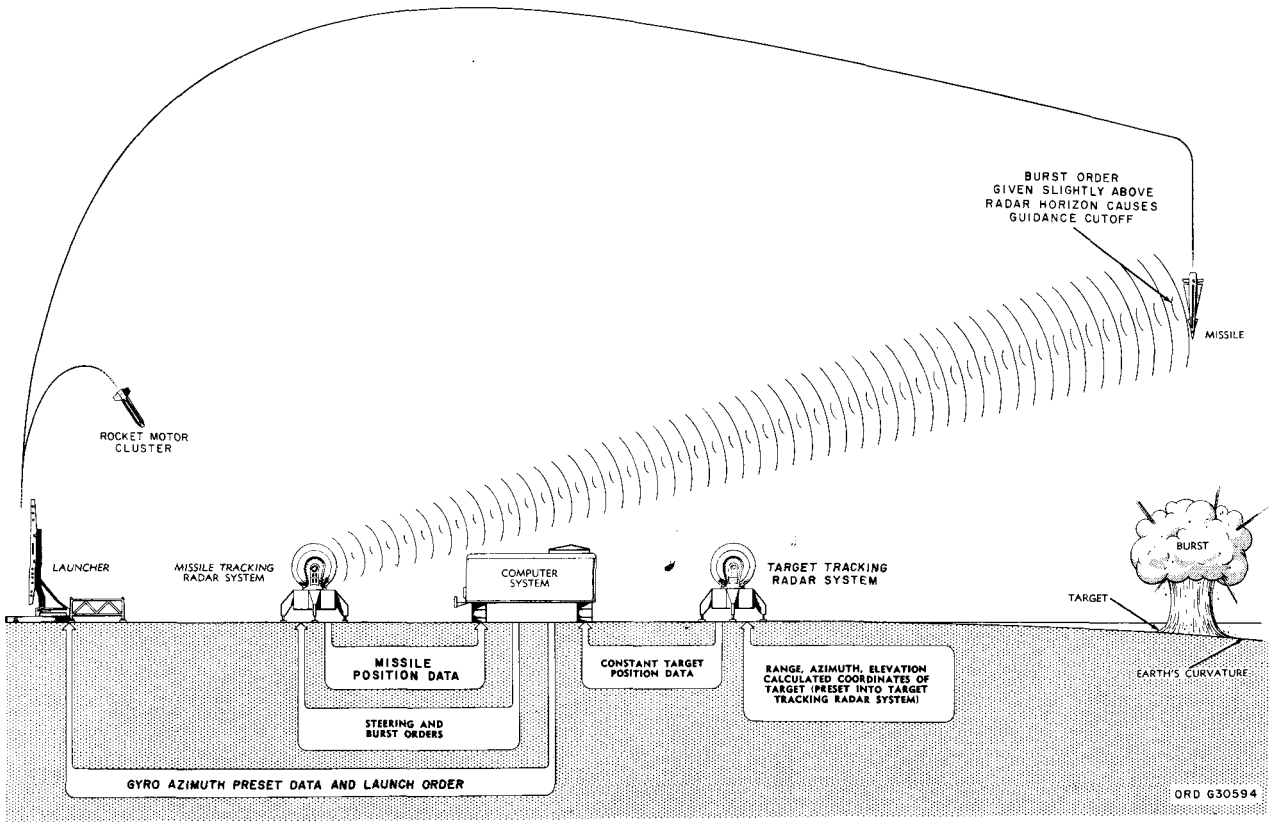



*Figure 7. Surface to surface mission - functional diagram.*

(b) When the missile is launched, a booster motor cluster provides the initial thrust, then separates from the missile. As determined by the designated target and missile position data being supplied by the tracking radar systems, the computer system continuously calculates the proper missile trajectory. The computer system guides the missile by sending appropriate steering orders by way of the missile tracking radar system. At a predetermined time before intercept, the computer system automatically sends a burst order by way of the missile tracking radar system. The burst order causes the missile warhead to detonate within a lethal radius of the target. Detonation of the missile warhead shortly before intercept provides the most effective burst coverage.

(2) Surface to air low altitude mission. In a surface to air low altitude mission (fig 6), the functions of the acquisition radar systems, the tracking radar systems, and the computer system are similar to those described for a normal surface to air mission (a(1) above), with the exception of the climb-and-dive trajectory used. Use of this trajectory minimizes the effects of ground clutter in the missile tracking radar system. In order to achieve the climb-and-dive trajectory, the computer system continuously calculates a displaced aiming point above the target, as determined by the designated target position data. When the time required to reach the displaced aiming point and the final dive time to the actual intercept point become equal, the computer system issues a final dive order to the missile so that the missile dives toward the actual intercept point. The computer system continues to monitor the missile, issues steering orders as necessary, and sends a burst order that causes the missile warhead to detonate a fraction of a second before intercept. The most effective burst coverage is achieved by using the overhead approach.

(3) Surface to surface mission. In a surface to surface mission (fig 7), the acquisition radars are not used because the target position is known. The range, azimuth, and elevation coordinates of the target are calculated and manually set into the TTR system, therefore, the TTR supplies constant target position data to the computer. Although the function of the computer system is similar to that described for a normal surface to air mission (a(1) above), the missile trajectory data must be manually set into the computer. This will, in turn, cause the missile to be guided toward a point in

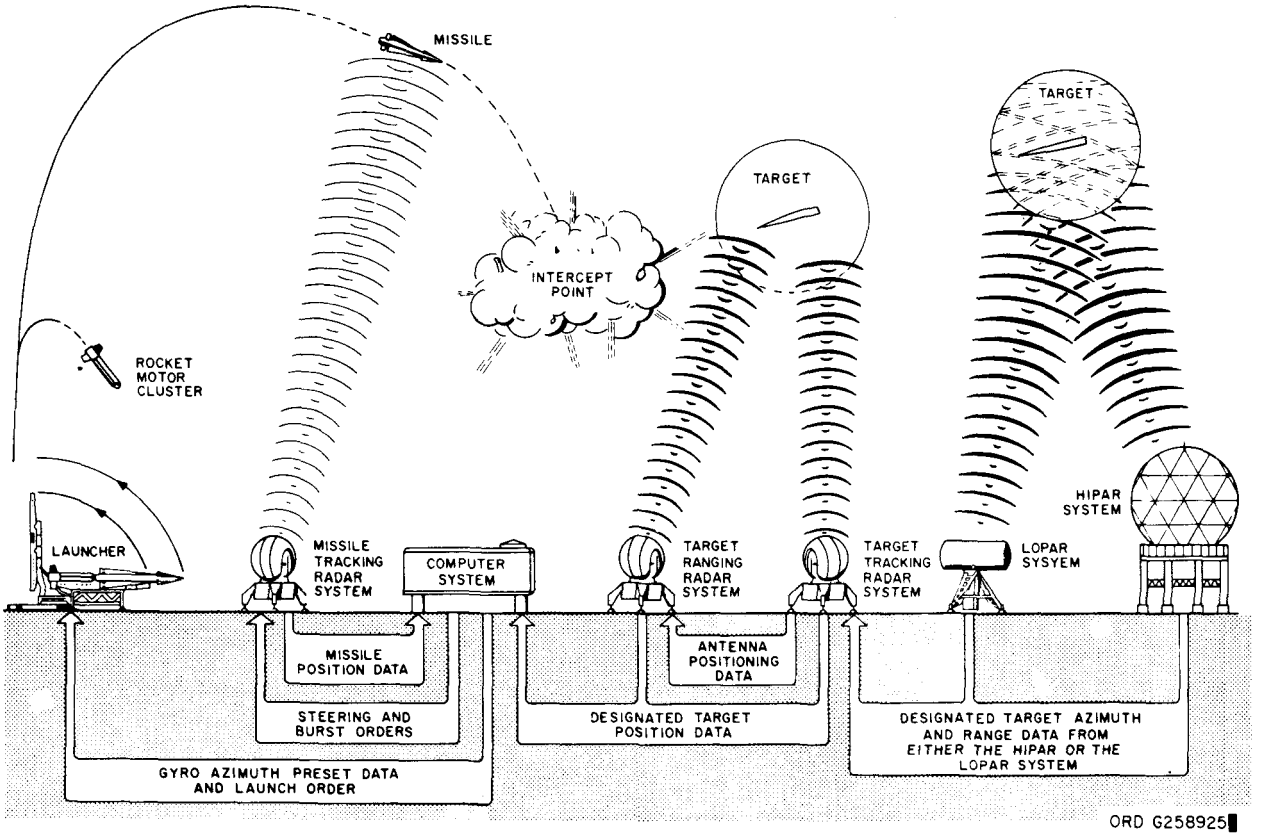


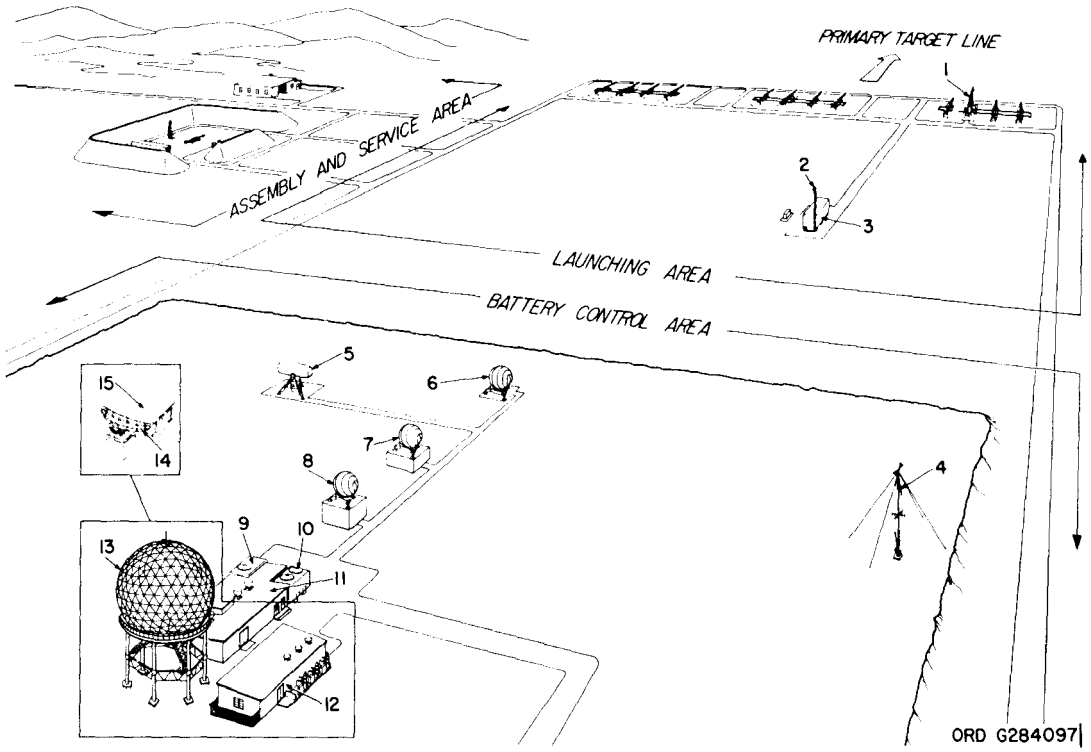

*Figure 8. Surface to air antimissile mission - functional diagram.*

space above the desired point of impact. When the missile reaches the space reference point, the computer system issues a dive order that will cause the missile to approach the ground target vertically. As the missile approaches the ground, the computer sends a burst order by means of the missile tracking system. Due to special missile preparation in a surface to surface mission, however, the burst order does not cause the missile warhead to detonate. Instead, the burst order disables the missile fail-safe mechanism and causes guidance cut-off by disabling the missile receiver. The burst order also arms a preset barometric fuze in the missile warhead and rolls the missile 180 degrees to compensate for any possible control surface misalinement. The missile then follows a vertical trajectory until the barometric fuze causes the nuclear warhead to detonate at a predetermined altitude above the target.

**b. Nike Hercules ATBM system.**

(1) Surface to air mission.

(a) In a surface to air antiaircraft (fig 5) or antimissile mission (fig 8), either of the two acquisition radar systems can be selected for detecting and identifying oncoming targets, although the HIPAR is preferred. Azimuth and range data of a designated target are electronically relayed from either acquisition system to a target tracking radar system. This data is then used to acquire the target. After acquisition, the target tracking radar system continuously supplies target position data (elevation, azimuth, and range) to a computer system. When enemy countermeasure activity is adverse, the target azimuth is also obtained by using the strobe line feature of either HIPAR or LOPAR. When the target azimuth is transferred to TTR and TRR, the target can be tracked in range, azimuth, and elevation. The primary function of the TRR is to supply the computer with target range data when countermeasures are intense. Target azimuth and elevation data are supplied to the computer by the TTR. From the target position data, the computer system continuously calculates a predicted intercept point. The azimuth of the predicted intercept point is sent to a previously designated missile as gyro azimuth preset data. This data orients a gyro in the missile so that after launch, the missile automatically rolls to the correct attitude, with respect to the predicted intercept point. The missile tracking radar system is electronically locked on the designated missile while it is still on the launcher so that, after launch, the radar system can supply uninterrupted missile position data to the computer system. At the




1. Erected missile on launcher
2. Flight simulator group and radar target simulator
3. Trailer mounted launching control station
4. Radar test set group
5. LOPAR antenna-receiver-transmitter group
6. Missile track antenna-receiver-transmitter group
7. Target ranging antenna-receiver-transmitter group
8. Target track antenna-receiver-transmitter group
9. Trailer mounted director station
10. Trailer mounted tracking station
11. HIPAR building
12. Power building
13. HIPAR antenna radome-supported-tripod
14. AAR antenna
15. AAR shelter

*Figure 9. Battery layout - typical consolidated site.*

same time, the computer system continuously supplies data to two plotting boards that enable the battery control officer to determine the optimum time to launch the missile.

(b) When the missile is launched, a rocket motor cluster provides the initial thrust, then separates from the missile. As determined by the designated target and missile position data being supplied by the tracking radar systems, the computer system continuously calculates the proper missile trajectory. The computer system then sends appropriate steering orders to the missile by way of the missile tracking radar system. Moreover, at a predetermined time before intercept, the computer system automatically sends a burst order by way of the missile tracking radar system. The burst order then causes the missile warhead to detonate within a lethal radius of the target.

(2) Surface to surface mission. The functional analysis of the Nike Hercules ATBM system surface to surface mission is the same as that discussed in paragraph a(3) above.

## 8. OVERALL PHYSICAL DESCRIPTION AND SITE LAYOUT.

a. **Operational areas.** Equipment incorporated in the improved Nike Hercules or ATBM system is located in three operational areas: the battery control area, the launching area, and the assembly and service area (figure 9). The functions of these areas are briefly described in (1) through (3) below.

(1) Battery control area. The battery control area contains the radar course directing central (RCDC) which basically consists of the following: the acquisition radar systems; the target tracking, target ranging, and missile tracking radar systems; the computer system; and other associated equipment. The purpose of the RCDC is to detect, acquire, and track the

target; furnish the necessary information to the battery control officer for determining when a missile should be fired; track the missile during trajectory; and issue steering and burst orders to the missile. The battery control officer determines the type of mission, missile, and warhead to be used; supervises selection of the target to be engaged; and issues orders to ready the missile for firing and to fire the missile.

(2) Launching area. The launching area contains the guided missile launching set which consists of Nike Hercules and Nike Ajax launchers and launching control equipment or only Nike Hercules equipment. Personnel in this area are required to maintain a supply of ready missiles.

(3) Assembly and service area. The assembly and service area is a support area that provides equipment and facilities for assembling, testing, fueling, and storing missiles.

**b. Physical layout.** The improved Nike Hercules system and the Nike Hercules ATBM system described below is the continental United States. (CONUS) emplacement. Spacing and siting characteristics of a typical battery layout are described in (1) through (5) below and illustrated in figure 9. Emphasis is placed on the mandatory locational requirements.

(1) The site for the battery control area requires a minimum of 3.8 acres. This area is preferably situated on high ground so that the best possible radar coverage is obtained. The launching area is preferably located in front of the battery control area, with respect to the primary target line. Although an intercept can be made in any direction from the battery, the primary target line is the direction in which most intercepts are likely to be made. The location of the launching area is flexible, however. For example, due to terrain characteristics or real estate availability, it may be necessary to locate the launching area behind or to the side of the battery control area.

(2) Due to interarea cable limits, the launching area normally cannot be located further than 5,200 yards from the battery control area. However, if additional cables are employed, or if the system uses a radio-link instead of cables, the interarea separation can be extended to 6,000 yards. Separation distances in excess of 6,000 yards are possible with modification of the computer system parallax circuits. Because of the angular tracking rate limitations of the missile tracking radar system, the minimum distance between the battery control area and the launching area is approximately 1,000 yards.

(3) The launching area must be emplaced so that a line of sight exists between the missile track antenna-receiver-transmitter group (6, fig 9) in the battery control area and the flight simulator group and radar target simulator (2, fig 9) in the launching area. A line of sight must also exist between the missile track antenna-receiver-transmitter group and each erected missile (1, fig 9) in the launching area.

(4) The launching area should be fairly level and easily accessible by roads from the battery control area and the assembly and service area. Moreover, to minimize damage from falling burned out boosters, an unpopulated area forward of the launching area is required as a drop zone.

(5) The assembly and service area is a support area that provides equipment and facilities for assembling, testing, fueling, and storing of missiles; therefore, it should be located near the launching area. Army Materiel Command Regulation (AMCR) 385-224, formerly ORDM 7-224, is used as a guide for determining the minimum safe distance between the launching area and the assembly and service area. This distance will vary according to the type explosives and protective barriers employed.

(6) The auxiliary acquisition radar performs the same functions as the HIPAR and will not be discussed in this subcourse.

## EXERCISES FOR LESSON 1

1. Why was the Nike Hercules system developed?

   A. To extend system range and altitude capability
   B. Because of the tactical ballistic missile threat
   C. To counter advances in ECM techniques
   D. For employment against surface targets

2. During countermeasures activity, which radar furnishes the computer with target range data?

   A. HIPAR
   B. LOPAR
   C. TTR
   D. TRR

3. What is the primary function of the missile tracking radar (MTR)?

   A. It furnishes the computer with missile and target positions and transmits steering and burst orders
   B. It presets the missile gyro and transmits steering and burst orders
   C. It furnishes the computer with differences in target and missile positions and transmits steering and burst orders
   D. It furnishes the computer with missile positions and transmits steering and burst orders

4. Which are the mission capabilities of the Nike Hercules ATBM system?

   A. SA, SA-LA, SA-AM
   B. SA-AA, SA-AM, SS
   C. SA, SA-LA, SS
   D. SA-AA, SA-AM, SA-LA

5. What type of guidance is employed by the Nike Hercules missile system?

   A. Inertial
   B. Homing
   C. Command
   D. Beam rider

6. Which radar or radars in the improved Nike Hercules system can furnish initial target range and azimuth data?

   A. HIPAR and LOPAR
   B. TTR and TRR
   C. HIPAR, LOPAR, and TTR
   D. TRR only

7. What additional radars were added to the basic Nike Hercules system to create the improved Nike Hercules system?

   A. HIPAR and AAR
   B. TRR and HIPAR or AAR
   C. TRR and LOPAR
   D. ATBM and AAR

8. Why is there a minimum distance between the battery control and launcher areas?

   A. To minimize damage from falling boosters
   B. To satisfy line of sight requirements
   C. To prevent exceeding the MTR tracking rate
   D. To limit land required to a minimum of 3.8 acres

9. What determines the minimum safe distance between the launching and the assembly and service areas?

   A. Area of land available
   B. ORDM 7-224
   C. Type explosives and revetments used
   D. Battery commander's policy

10. What are the operational areas of an improved Nike Hercules site?

    A. Block house, launching, and assembly and service
    B. RCDC, launching, and block house
    C. Battery control, RCDC, and launching
    D. Battery control, launching, and assembly and service