# CHAPTER 10

# TARGET DETECTION AND WEAPONS CONTROL

Up to now we have centered our discussion on guns and GMLSs and their operation. However, modern weapons systems rarely, if ever, function independently. A complete weapons system also includes elements that detect and track the target, compute a fire control solution, and generate control orders.

We will begin this chapter by describing some of the equipment and processes used to detect and identify a target. We will then describe the different elements involved in the fire control problem and the major fire control systems now in the fleet. We will introduce the subject of system testing and a very important piece of equipment, a guided missile training round (GMTR).

## THE DETECTION PROCESS

*LEARNING OBJECTIVE:* Describe the major components of Navy fire control systems.

The modern detection process involves more than the location of possible targets by the sensors of the ship. Before sensor information from your ship (or other ships) can be fully used by the weapons system, it must first be processed. Processing involves the extraction of data concerning the course of the target, speed, bearing, range, identity as friend or foe, and type of target (air, surface, or subsurface). This information is called target data and it is processed by the Naval Tactical Data System (NTDS). The NTDS function is central to the modern detection process, so we will describe it first-then we will describe the types of sensors that supply the data to the NTDS.

Many different detection systems are in use today. A discussion of the operation of each one is beyond the scope and intent of this book. Therefore, in this chapter we will not discuss specific systems, only the general characteristics of the different system types. For detailed information on a specific system, consult the system's technical manual(s).

### NAVAL TACTICAL DATA SYSTEM

The NTDS consists of high-speed computers, data display consoles, communication links, and operational computer programs. The total system functions to collect, analyze, and correlate sensor data to obtain a clear picture of the tactical situation. A good tactical picture includes complete target data on all ships, aircraft, and submarines in the area of concern. This picture is then converted to digital format and supplied to the weapon systems of the ship and to other ships over the communications data link

Figure 10-1 is a simple line drawing that shows the NTDS function. The picture supplied by the NTDS is a "real time" display; it is not a projection, but a representation of the tactical situation as it is at that moment, based on available sensor data. Some weapon systems are able to use raw sensor data to engage targets, although this use is not the most effective mode of operation. The use of raw data is normally reserved for casualty mode use.

When two or more ships operate together, one ship will be designated to maintain the communications link network This designation allows ships in the task force to feed target data into the link for use by the entire group. Each ship in the link will be able to use all the processed target data from all the other ships in the link Access to this collective data serves to broaden the tactical picture for the task force commander and for individual commanders as well.

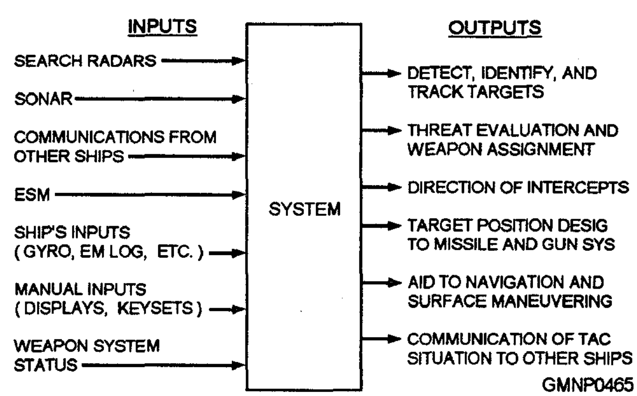


**Figure 10-1.—The NTDS function.**

In the past, as with other systems, the NTDS was considered an individual unit instead of a component of the combat system of the ship. This is no longer true. Older ships are adopting a one-system philosophy. Newer systems are designed as a single system. The NTDS function is now being performed by the same equipment that performs other functions formerly not associated with NTDS. The AEGIS weapon system is the first system designed under the one-system concept. The AEGIS Command and Decision (C&D) system not only performs the NTDS function but also controls the electronic warfare (EW) system, IFF challenges, and several other functions as well.

## SENSORS

The NTDS collects data from each of the sensors of the ship (radar, IFF, ESM, and sonar) as well as other target data of the ship over the data link, We will now provide brief descriptions of the type of information each sensor supplies. Sonar will not be covered in this text.

### Radar

The Navy uses a variety of search radars to detect surface and air targets. However, they can all be classified as either surface search/navigation or two- or three-coordinate air search radars.

**SURFACE SEARCH/NAVIGATION RADARS.—** Radar sets (such as the AN/SPS-65) are short-range, two-coordinate, narrow-beam radars capable of good discrimination in range and bearing for surface search and low-flying aircraft. They are also valuable because of their ability to detect modern low-flying antiship missiles.

**THREE-COORDINATE RADARS.—** Three-coordinate radars (such as AN/SPS-48 or AN/SPY-1) are normally the primary source of air target information. These radars provide precise air search data consisting of range, bearing, and elevation angle to the NTDS or weapons direction system (WDS). These radars also provide IFF (identification, friend or foe) data. IFF is a subsystem that issues an electronic challenge to aircraft. Depending upon the response or lack of response from the aircraft, the aircraft is determined to befriendly or hostile. The air search data and synchronized IFF interrogation information are displayed on operator consoles in the combat information center (CIC) for target engagement evaluation. Electronic counter-countermeasure (ECCM) features improve the display when jamming environments are encountered.

**TWO-COORDINATE RADARS.—** An alternate source of air target information for a weapon system is a two-coordinate radar. These are the primary means for detection of long-range air targets. These radars (such as the AN/SPS-49) provide course range and bearing information and IFF capabilities similar to those of the three-coordinate radars. They do not, however, provide elevation information.

### Electronic Support Measures

Electronic support measures (ESM) is the passive side of the total elecronic warfare capability of the ship. Its function is to detect electronic emissions and aid in the rapid identification of the source platform or weapon. A low-flying antiship cruise missile (ASCM), such as our Harpoon, may not be detected by the radar of your ship. The first indication you might see is the electronic emissions of the missile seeker when it initiates its homing phase. This first indication could give you just 90 seconds, or less, to react before the missile strikes your ship.

Modern ESM not only detects the emission but also supplies the operator with a suggestion regarding the source. The operator must then visually verify the accuracy of the suggestion. If he agrees with the evaluation, the push of a button sends the data to the NTDS. Should he disagree, he inputs his evaluation through a manual keyboard.

The LAMPS III helicopter is also equipped with ESM equipment that further extends sensory range. A single ESM unit can only supply target bearing data. The LAMPS III helicopter, however, can be sent out away from the ship to monitor the same emission, thus allowing a vector of the position of the target and range data. Two ships can perform the same maneuver.

Figure 10-2 shows the configuration of a modern weapon system aboard an AEGIS-equipped ship. Remember that the NTDS function is accomplished by the C&D equipment in the AEGIS system.

## WEAPONS DIRECTION SYSTEM

*LEARNING OBJECTIVE* Discuss the function of the weapons direction system (WDS).

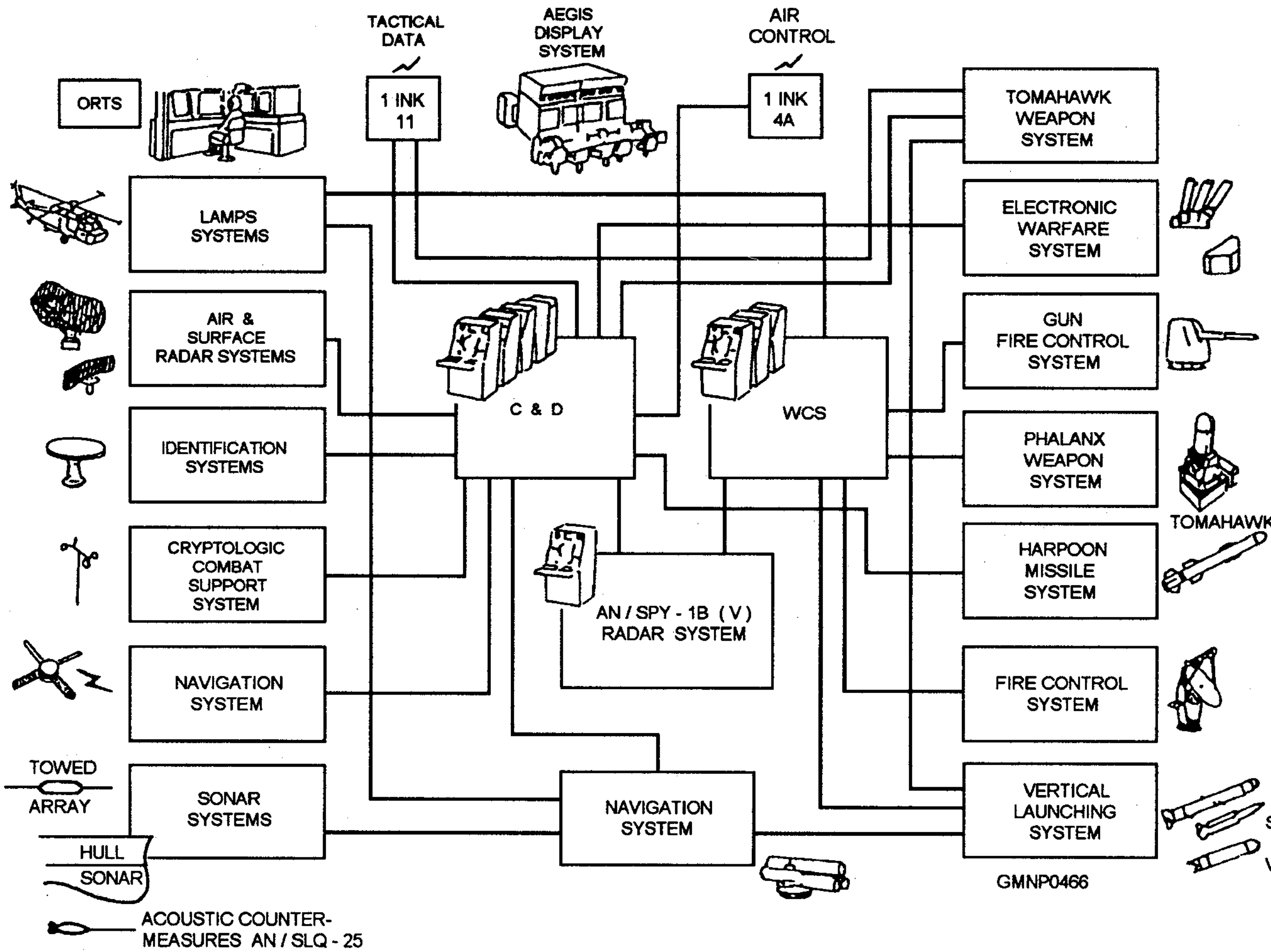


**Figure 10-2.—The AEGIS combat system.**

The weapons direction system (WDS), also referred to as weapons control system (WCS), functions to schedule, control, and assess the engagement of targets with the weapon systems of the ship. WDS consists of a computer set, a computer program, and two or more operator consoles.

WDS receives target data from NTDS. Each target is analyzed and assigned a threat priority. The system then assigns a weapons system to engage the highest priority target. Weapons system assignment includes (in the case of a missile engagement) the selection of the number and type of missiles to be fired, as well as which director will be used to track and illuminate the target. In the case of a fully automatic engagement, the system will also initiate missile firing. However, not all systems are capable of full automatic operation. In all cases, the operator may manually override the system to alter the method of engagement.

Before the advent of WDS, each of these functions was performed by the individual action of system operators. Therefore, response time and accuracy were limited to the speed and skill of the operators. A rapid and accurate response is required to defend against the sophisticated modem weapons currently in the arsenal of the world. WDS enables the entire engagement (or portions thereof) to be executed rapidly and automatically.

The WDS computers programmed to prioritize and engage targets that exhibit certain characteristics. In addition to this programming, the operator consoles can also be programmed to include quick reaction (QR) zones. These zones determine at what range, and from which direction, approaching targets are automatically engaged. These parameters are constantly updated as the tactical situation changes. QR zones may also be used to help make sure friendly ships and aircraft are not mistakenly engaged.

## FIRE CONTROL

*LEARNING OBJECTIVE:* Identify the components of a basic fire control system and discuss the function of each.

A basic fire control system consists of a computer, a director and radar, and a stable element. The following sections will provide a brief description of each of these.

### COMPUTER

The definition of a computer is any device capable of accepting data, applying mathematical operations to that data, and obtaining useful information from those operations. A fire control computer accepts target and own-ship's data, processes it, and provides a solution to the fire control problem. Own-ship's data includes course, speed, pitch, and roll. Also included are other variables, such as wind direction and, in the case of guns, projectile initial velocity. This data will be discussed further as we describe the fire control problem later in this section.

The fire control solution for a gun engagement consists of gun mount train and elevation orders, fuze setting orders, and in some cases, gun sight orders. For a missile engagement, the computer supplies launcher train and elevation orders and missile prelaunch programming.

A guided missile, unlike a gun projectile, can change course in flight. Therefore, the missile fire control computer continuously updates the solution for target intercept after the missile is fired. The updated solution is transmitted to the missile that then corrects its course to intercept the target. These actions are occurring during the midcourse phase of an SM-2 missile engagement. The SM-2 engagement also requires target illumination to be scheduled and ordered (during the terminal phase of missile flight). These two actions are also accomplished by the fire control computer.

### DIRECTOR AND RADAR

The fire control system's director and radar are discussed as a single unit since, once assigned, their combined outputs are the primary source of target information for the fire control computer.

The radar antenna is mounted to the director. Once assigned by the WDS, the director "slews" to the ordered bearing and elevation where the radar conducts a search for the target. The search is controlled by a subsystem that moves the director in a predetermined pattern around the ordered position until the radar "acquires" the target. Once acquired by the radar, a subsystem of the radar unit controls the director to keep the radar "locked on" the target. The system then begins to track the target. While locked on and tracking, the radar and director continuously provide precise target range, bearing, and elevation data to the computer. Radar provides target range, and the director, based on its train angle and the elevation angle of the radar antenna, provides target bearing and elevation data.

### STABLE ELEMENT

A ship, by its very nature, is in constant motion. The weapon systems, especially gun systems, require a stable platform to deliver accurate fire. Since it is impossible to build a ship that is not subject to constant movement, the stable element input is added to the fire control computer. A stable element is a gyroscope mounted to gimbals. Its output provides the computer with a stable horizontal reference from which to compute a fire control solution. Some older systems have their own dedicated stable element, while most newer systems use an input from the gyro of the ship.

## THE FIRE CONTROL PROBLEM

*LEARNING OBJECTIVE:* Discuss the characteristics of the fire control problem and the components involved.

To deliver accurate fire, a fire control system must consider and compensate for own-ship's movement, gun characteristics, natural forces, and target movement. Each compensation involves a different set of variables. Compensating for these variables is the essence of the fire control problem.

Own-ship's movement and characteristics involve platform stabilization (stable element), parallax, and interior ballistic considerations. Natural forces are compensated for as exterior ballistics. Target movement involves considering exact target position in reference to your ship, then predicting its future position.

## PARALLAX

If guns were physically located at the reference point (the director), projectiles fired from the guns would hit the target without further correction. The guns are, of course, not located at the reference point but are some distance forward or aft of this point and below it (the director is located high on the superstructure). This difference in location puts the gun at a different angle from the target than the director, giving each unit a different line of sight to the target. Unless corrected, this difference will result in large errors in accuracy. The parallax correction is normally accomplished in the fire control computer.

## BALLISTICS

Ballistics is the science of projectile motion. It is divided into two branches—interior and exterior ballistics. Interior ballistics is the study of projectile motion while inside the gun. Exterior ballistics pertains to the projectile motion after it leaves the gun.

### Interior Ballistics

The speed at which a projectile is traveling at the instant it leaves the gun bore is known as initial velocity (IV). The initial velocity of a projectile must be known to predict its trajectory. Initial velocity is determined by the gun, the projectile, and the propelling charge. Projectiles and propelling charges are standardized. This standardization means that all size, weight, and shape variations are predetermined. The only variables left to consider are the condition of the gun and the temperature of the propelling charge. The propelling charge temperature is determined by averaging the powder magazine temperatures for the previous 3 days.

Figure 10-3 shows the components of a gun. When a projectile and propelling charge are loaded into the gun, the projectile rotating band engages the rifling in the gun bore. The rotating band forms a seal at the forcing cone. When the gun is fired, the expanding gases from the burning propellant push the projectile through the bore and out the muzzle. As the projectile passes through the bore, the twisted rifling imparts a spin to the projectile that stabilizes it in flight.

Each firing wears on (erodes) the interior surfaces of the gun. This erosion results in a gradual enlargement of the bore. Erosion begins at the rear and extends to the end of the bore as the gun is used. As the bore enlarges, the seal becomes less effective, resulting in a slower initial velocity.

Data from the annual star gauge inspection and from the regular projectile seating and distance gauge (PSDG) tests is used to compute IV The determined IV is then entered into the fire control computer for consideration in the final fire control solution.

### Exterior Ballistics

Exterior ballistics starts with a projectile traveling at a known speed (initial velocity) and in a known direction. This direction, called the line of fire (LOF), coincides with the center-line axis of the gun bore. Once the projectile leaves the gun, you have no further control over its trajectory. Natural forces, such as gravity, air, wind, drift, and the rotation of the Earth, act on the projectile in flight to alter its trajectory. Therefore, to hit a target, it is necessary to compensate for the effects of these forces by offsetting the LOF of the gun before firing. For example, if it is known that a projectile is going to drift right, the gun should be trained to the left. If it is known that a projectile is going to curve downward, the gun should be elevated.

**NOTE**

The ultimate purpose of a gun fire control system is (1) to find the correct position for the gun barrel to make the projectile fall where desired and (2) to put the gun in that position.

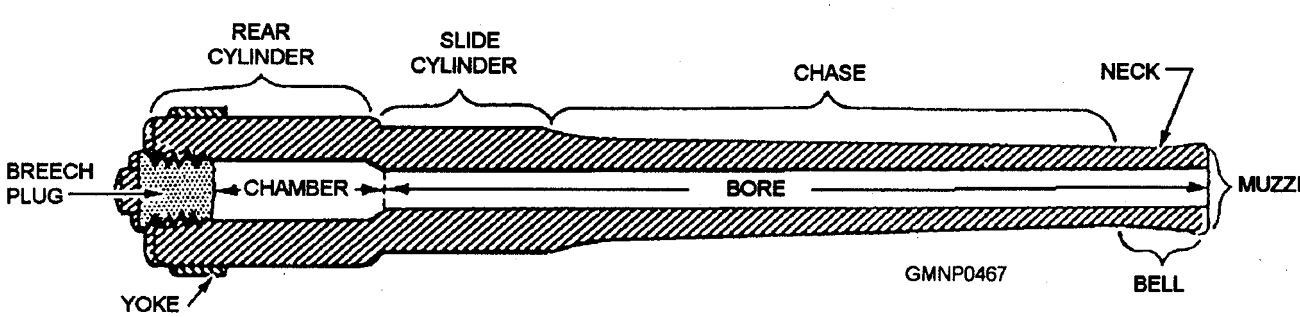


**Figure 10-3.—Cross section of a gun.**

**GRAVITY.—** Gravity is a continuous attracting force, acting perpendicular to the surface of the Earth, that tends to pull all objects toward the Earth. Without gravity, a projectile (fired in a vacuum) would continue to travel in the direction it was fired until something interfered with its flight.

Gravity acts on a fired projectile, causing it to begin to fall as soon as it leaves the muzzle of the gun. The projectile, however, is traveling forward and falling at the same time. The projectile has two forces acting on it: (1) the momentum and (2) the pull of gravity. The path of the projectile, as a result of these two forces, is a curved trajectory.

**AIR.—** When a projectile is traveling through the air, it takes a different path from the one it would follow in a vacuum. In a vacuum, with gravity as the only retarding factor, an angle of departure and an angle of fall of the projectile would be identical (fig. 10-4). The maximum ordinate would be in the exact center of the trajectory.

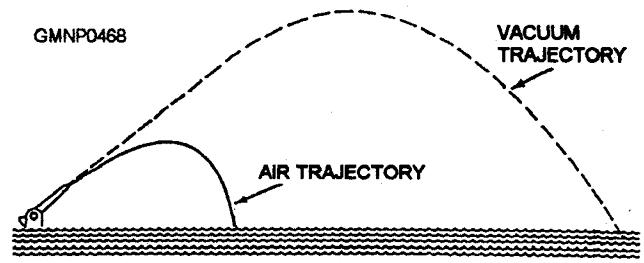


**Figure 10-4.—Vacuum and air trajectories for the same elevation angle.**

Air resists the motion of a body passing through it. This resistance is a form of friction that slows the movement of the body. The result is that a certain amount of velocity is being lost for each second of projectile flight. The longer the projectile travels through the air, the slower it goes. Notice the steepness of the descending curve and the location of the maximum ordinate in the air trajectory. These characteristics, as well as the greatly reduced range, are due to air resistance.

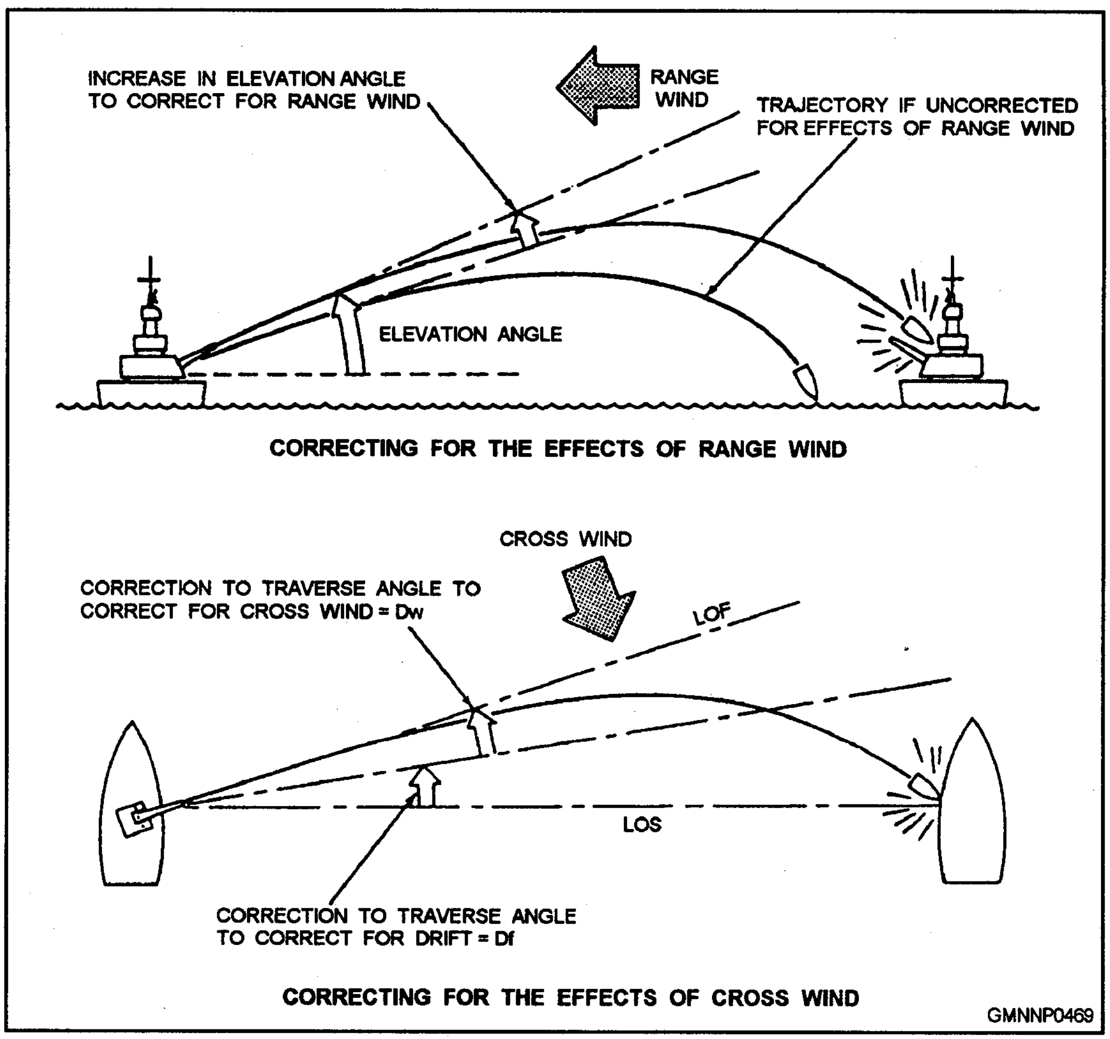


**Figure 10-5.—Correcting for the effects of wind.**

The density of the air determines the amount of resistance the projectile will experience. Air density depends on temperature and barometric pressure, both of which are changing all the time. Dense air will slow a projectile more than thin air. Density also varies at different altitudes, which further complicates the equation.

**WIND.—** The effect of wind on a projectile in flight is obvious. Depending upon its force and the direction it is coming from, wind can cause a projectile to fall short, overshoot, or fall to the left or right of the target. As with air density, the longer a projectile is in flight, the more it will be affected by wind. The size of a projectile is also a factor: the larger the projectile, the more it will be affected.

True wind is used in all fire control calculations. If the wind is blowing along the LOF, either with or against the projectile, it is called range wind (fig. 10-5). If the wind is blowing at right angles to the LOF, it is called cross wind. Range wind is compensated for by increasing or decreasing gun elevation angle. Corrections for cross wind are made to the train angle of the gun. Normally, however, the wind will be at some angle to the LOF. In that case, the true wind must be broken down to the range and cross wind components (fig. 10-6). This calculation allows for the realized effect of the wind in each direction.

**DRIFT.—** Naval guns are rifled to give a spinning motion to the projectile. The spinning projectile assumes the properties of a gyroscope. The gyroscopic actions tend to keep the projectile pointed along the trajectory and prevent it from tumbling. These actions make the projectile almost rigid in its trajectory and ensure it will land point first. This rigidity makes the flight characteristics of the projectile predictable.

In addition to this useful effect, gyroscopic action causes the harmful effect of drift (fig. 10-7). Notice that the effect increases with range. Drift is always to the right in a gun with right-hand rifling (the twist of the rifling is to the right from the chamber to the muzzle).

**EARTH'S ROTATION.—** In our discussion so far we have assumed that the Earth is flat and does not rotate. For ranges up to about 20,000 yards or so, this assumption does not seriously affect our fire control solution. At ranges over 20,000 yards, the rotation of the Earth has a serious affect.

An object in motion above the surface of the Earth tends to turn toward the right in the Northern Hemisphere and toward the left in the Southern Hemisphere. Corrections are made to the left or right

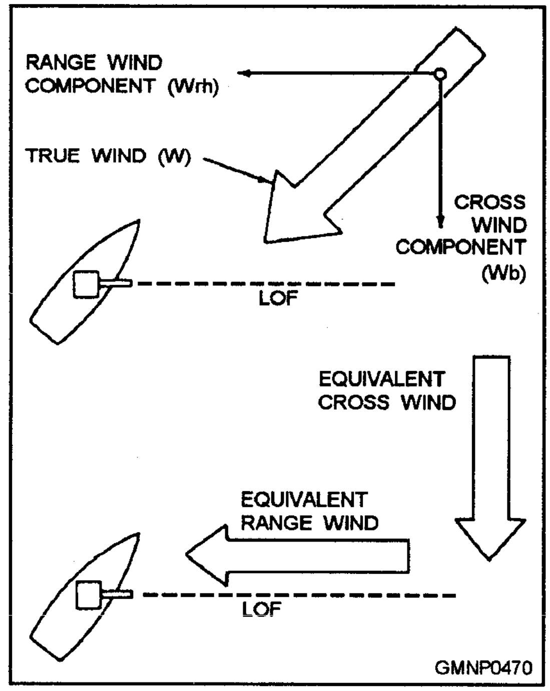


**Figure 10-6.—Readmg true wind.**

accordingly. The correction is only made on guns with bores larger than 5 inches.

### Frames of Reference

A frame of reference is a system of lines, angles, and planes, within which target position can be measured and lead angles computed. A position can be described only by relating it to a known reference point. A reference frame has a point, called the point of origin or reference point, from which all measurements are made.

Two frames of reference are used by fire control systems. One is rigidly attached to the ship, while the other is considered rigidly attached to the surface of the Earth. The frame of reference of the ship has its point of origin built into the fire control system. All measurements are made from this point. This point is unstabilized, subject to the pitch and roll of the ship. The frame of reference of the Earth is a horizontal plane established by the stable element, independent of the pitch and roll of the ship.

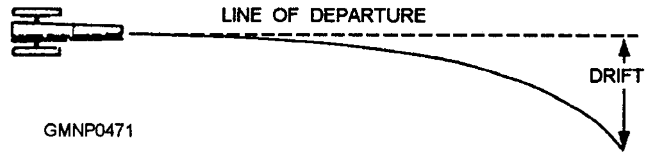


**Figure 10-7.—Effect of drift.**

**LINES.—** Given the effects of exterior ballistics, two lines are required. One line, called the line of sight (LOS), is used to establish the present location of the target; the second line, called the line of fire (LOF), is used to establish the position of the gun bore with respect to the LOS. The LOS is the primary reference from which the offsets are made to establish the LOF.

**LEAD ANGLES.—** Two lead angles are considered in the fire control problem— sight angle and sight deflection (fig. 10-8). Sight angle is the difference between the LOF and the LOS, measured on the plane perpendicular to the trunnion axis. Sight deflection is the angle that the plane through the gun bore is deflected left or right from the LOS.

**REFERENCE PLANES.—** Reference planes are flat surfaces that may extend in all directions to infinity. Normally, these planes are pictured with boundaries equal to the range of the fire control problem, as shown in figure 10-9.

The fire control system establishes target location as a point on a plane using the same three-coordinate system described earlier in this chapter. Once the position, speed, and direction of travel of the target are determined, its future position can be accurately predicted

The steps in the solution of the fire control problem can be described as follows:

- Determining present target location in relation to own ship
- Predicting future target position in relation to own ship
- Stabilizing the system

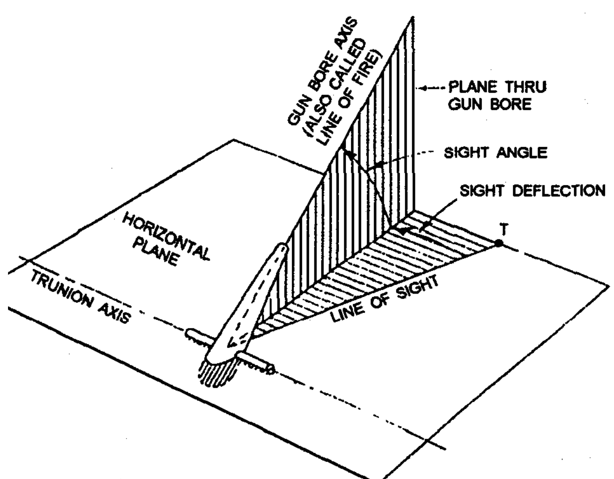


**Figure 10-8.—Lead angles in a surface problem.**

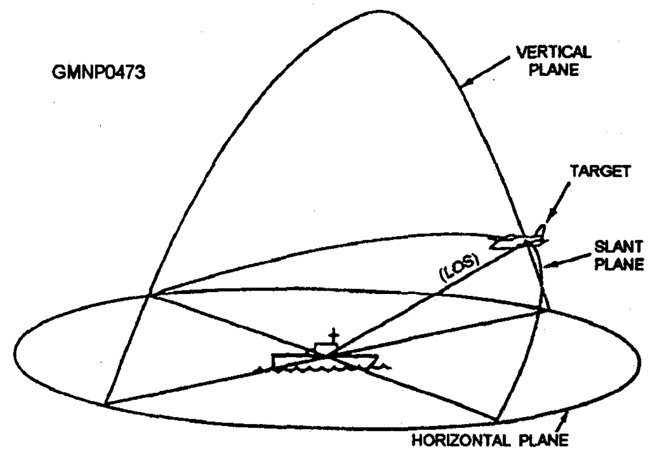


**Figure 10-9.—Reference planes.**

- Calculating the required correction to the gun or launcher train and elevation orders
- Transmitting the data to the delivery device

We have attempted to cover the basic elements involved in the fire control problem. Each element must be compensated for exactly, because once fired, a gun projectile cannot be redirected. The entire problem is, however, much more complex than the general description we have provided. The next section provides a more detailed description of the actual systems used in solving the gunfire control problem.

## FIRE CONTROL SYSTEMS

*LEARNING OBJECTIVE: Describe the fire control systems currently in use.*

Several fire control systems (FCSs) are currently in use aboard U.S. Navy ships. The most modern of these is the AEGIS weapon system. AEGIS is a complete system, incorporating all the elements of a weapon system. It is included here in the control section because of the unique advancements it uses in the integration of control systems. We will provide a basic description of the AEGIS system, the Mk 34 GWS, the Mk 86 GFCS, and the Mk 92 FCS. These systems represent the most modern fire control capabilities in the world and should be in our inventory well into the next century.

### AEGIS WEAPON SYSTEM

The AEGIS weapon system is a fast-reaction, high-performance, computer-controlled system that uses a multipurpose radar to detect contacts in all directions. It is the only system in the free world that can detect, track, and engage multiple threats while maintaining continuous surveillance from horizon to zenith, AEGIS is the first system in the Navy to be capable of a fully automatic reaction to intense air warfare.

AEGIS is equipped with embedded computer-controlled tests that continuously monitor the system to detect equipment failures. When a failure is detected, the system automatically reconfigures using backup systems to keep the system operational. These features make AEGIS the most reliable system in the fleet.

The AEGIS weapon system Mk 7, as shown in figure 10-10, is made up of the following nine elements:

1. AN/SPY-1 Radar
2. Command and Decision (C&D) System
3. Weapons Control System (WCS)
4. Fire Control System (FCS)
5. GMLS Mk 26 or VLS Mk 41
6. Standard Guided Missile
7. AEGIS Display System (ADS)
8. Operational Readiness Test System (ORTS)
9. AEGIS Combat Training System (ACTS)

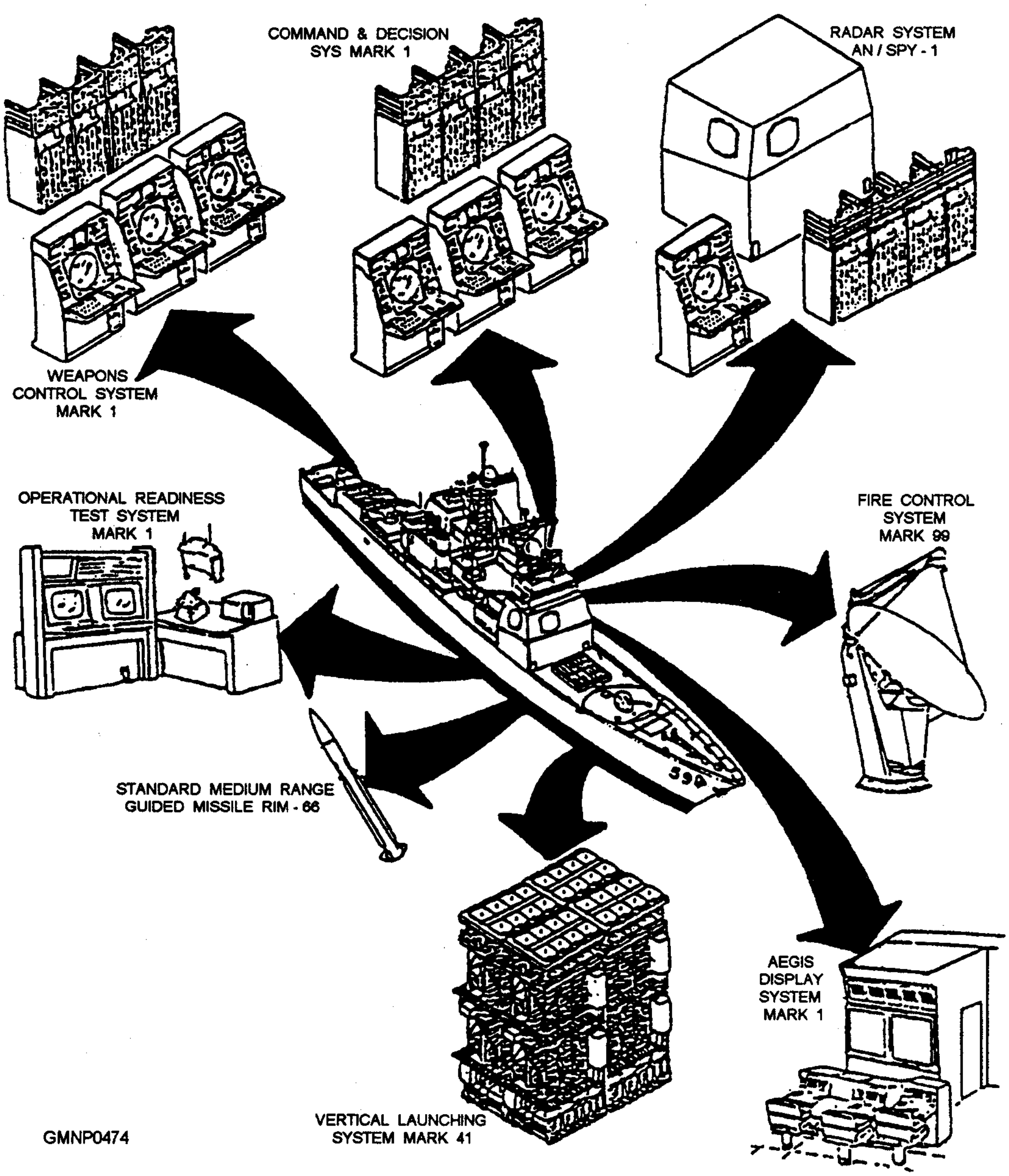


**Figure 10-10.—AEGIS weapon system Mk 7 major elements.**

Of the nine elements, seven have sophisticated computer programs for operation, control, and interface. These are the AN/SPY-1, C&D, WCS, FCS, ADS, ORTS, and ACTS. Operators manage and control the C&D, WCS, and SPY programs with doctrine statements. These statements allow the operator to define parameters that control the computer program for the tactical situation. Doctrine statements define automatic actions for targets meeting specific conditions.

A general description of each of the major elements of the AEGIS weapon system is offered here. The Standard missile and both launchers will not be covered.

### AN/SPY-1 Radar System

The AN/SPY-l radar system is the primary search and track radar for AEGIS-equipped ships. It is a multifunction, phased array radar, capable of three-dimensional surveillance, while simultaneously providing fire control tracking for hundreds of air and surface targets in clear and ECM environments. In addition to search and track, it provides midcourse guidance to the Standard missile (SM-2).

### Command and Decision System

The command and decision (C&D) system is a manned computer and display complex that coordinates and controls the AEGIS mission. C&D operators manage automatic CIC operations related to the following:

- Air, surface, and subsurface engagements
- Electronic warfare system control
- Data link control
- IFF challenges
- User defined information alerts
- Weapon tight zones

### Weapons Control System

The weapons control system (WCS) schedules, controls, and assesses all air, surface, and subsurface engagements. It is the interface between the C&D and the FCS of the delivery system.

### Fire Control System

The fire control system (FCS) provides illumination control for Standard missile engagements. WCS assignment orders and AN/SPY-1 target data make a designation source for the FCS illuminators. The FCS consists of four AN/SPG-62A radar sets. These four sets permit the illumination of multiple targets simultaneously.

### AEGIS Display System

The AEGIS display system (ADS) is a computer-controlled display complex that provides various pictures and information of the tactical environment. With the ADS, commanders can observe and control a graphic representation of selected tracks, coastal maps, weapons release zones, and specific warfare environments. After entry of selected information, the displays are automatically updated in regard to own-ship's position. The ADS receives all track information from the C&D system.

### Operational Readiness Test System

The operational readiness test system (ORTS) is a computer-controlled test and monitor system that performs automatic fault detection, fault isolation, status monitoring, and system reconfiguration. When a fault occurs, the ORTS automatically assesses and displays the highest level of system impact. Through a keyboard, the operator can initiate tests, evaluate system performance, and load programs into the various AEGIS computers. When tests are being conducted the system uses embedded test equipment throughout the system to measure voltages, analyze data, and measure power and phase.

### AEGIS Combat Training System

The AEGIS combat training system (ACTS) enables shipboard personnel to conduct highly integrated multifaceted warfare training scenarios. It also provides the capability to record and print out specific training events for self-evaluation.

All these elements form the core of the AEGIS combat system (ACS). The ACS also integrates and controls the following elements:

- Harpoon weapons system
- Gun weapon system
- LAMPS helicopter

- Electronic warfare system
- sonar
- Air and surface search radars
- Navigation system

The complete integration of all these systems serves to enhance the capability of a ship to engage and defeat numerous multiwarfare threats simultaneously.

## MK 34 GUN WEAPON SYSTEM

The MK 34 gun weapon system (GWS) is a departure from past gun fire control systems. In line with the one-system concept, the Mk 34 GWS is designed as a fully integrated subsystem of the AEGIS Combat System (ACS) to include the fire control computer, gun mount, and sight. The Mk 34 GWS receives target engagement orders from the AEGIS command and decision (C&D) system. It receives target data from shipboard sensors, performs ballistic calculations, and generates gun control orders. Digital target data is provided primarily by the AN/SPY-1 phased array radar system, with the AN/SPS-67 surface search radar serving as the secondary source of target data. Figure 10-11 shows the functional interface of the Mk 34 GWS with other elements of the combat system.

The Mk 34 GWS will be installed on all new construction AEGIS ships beginning with the DDG-51 class destroyer. Several of the later Ticonderoga class cruisers will also be fitted with the Mk 34 GWS. The system consists of a Mk 160 gun computer system (GCS), a 5"/54 Mk 45 gun system, and an EX 46 optical sight. The following is a brief description of each of these components except for the 5"/54 Mk 45 gun that was described in chapter 6.

### Mk 160 Gun Computer System

The Mk 160 gun computer system (GCS) receives target data from shipboard sensors to compute a ballistic

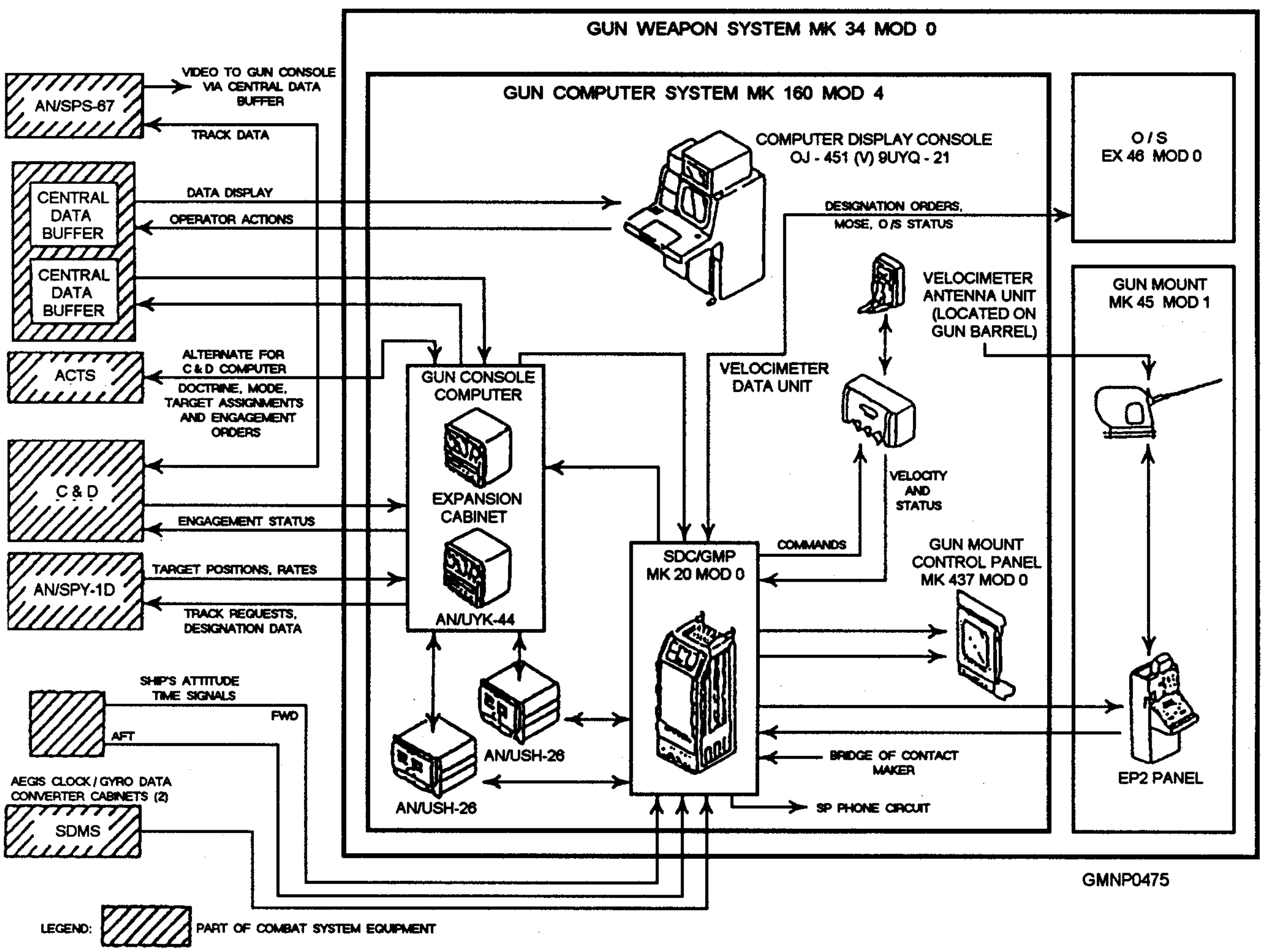


Figure 10-11.—Functional interface of the Mk 34 GWS.

solution. From this ballistic solution, it provides gun orders and selects projectile types. The GCS also generates the fire order to the gun mount. The Mk 160 GCS consists of the following elements:

- Gun console computer (GCC)
- Computer display console (CDC)
- Recorder-reproducer
- Signal data converter/gun mount processor (SDC/GMP)
- Gun mount control panel (GMCP)
- Velocimeter

**GUN CONSOLE COMPUTER.—** The gun console computer (GCC) serves as the primary interface between the GWS and the AEGIS C&D system and combat system sensors. It acts as a falter for target data, passing data for the selected target to the SDC/GMP.

**COMPUTER DISPLAY CONSOLE.—** The computer display console (CDC), also known as the gun console (GC), serves as the operator-to-GCS interface for providing target/system status and data entry displays. It also permits manual selection of the engagement mode and type of ammunition, queuing and engaging targets, entering ballistic data, and adjusting fire.

**RECORDER-REPRODUCER.—** The recorder-reproducer is a standard lightweight digital tape storage subsystem using a tape cartridge medium. The GCS uses two of these units to load operational programs, record, and retrieve system operational data.

**SIGNAL DATA CONVERTER/GUN MOUNT PROCESSOR.—** The signal data converter/gun mount processor (SDC/GMP) consists of two primary segments-the signal data converter (SDC) and the gun mount processor (GMP). Both are contained in a single watertight cabinet located in the gun mount. The GMP computes two ballistic solutions for the target being engaged, based on filtered target data, control commands, and other ship related information. The GMP converts ballistic solutions into gun orders that are transmitted to the gun mount by the SDC.

**GUN MOUNT CONTROL PANEL.—** The gun mount control panel (GMCP) is used to monitor and display GCS and GWS status in the normal modes of operation. The primary function of the GMCP, however, is to provide a casualty mode means of target data entry into the SDC/GMP should data not be available from the GC.

**VELOCIMETER.—** The velocimeter is a Doppler radar system used to measure projectile IV. The IV data is passed digitally to the GMP to update/correct ballistic computations. The velocimeter antenna is mounted directly to the gun above the barrel.

### EX 46 Optical Sight

While still in development at this writing, some information is available on the EX 46 optical sight (OS). The sight is described as a stabilized imaging sensor. The OS will supplement the coverage of the sensors of the ship, allowing the operator to detect and track surface targets, support the engagement of counter-battery threats, and act as a safety check sight during gun operations.

## MK 86 GUN FIRE CONTROL SYSTEM

The Mk 86 gun fire control system (GFCS) is a shipboard, digitally controlled system that directs gunfire against surface, shore, and air targets. The system is designed to control the 5"/54 Mk 45 rapid-free gun mount currently found aboard various platforms, including the DD-963, DDG-993, CG-47, CGN-36, CGN-38, and LHA-1 class ships.

Variations of the system integrate it with the missile FCS of the ship. The ship can use the Mk 86 system to supply air target tracking and continuous wave illumination (CWI) for control of SM-1 missile engagements.

Other improvements enable the system to control SM-2 engagements. In this text, however, we will discuss only the gun control function of the system.

Refer to figure 10-12 as we describe the major components of the Mk 86 Mod 10 GFCS. For ease of discussion, the physical units are grouped into related functions as follows:

- Operator consoles
- Power central
- Computer/peripherals
- Surface search radar
- Air action radar
- Data/video units
- Optical sighting system

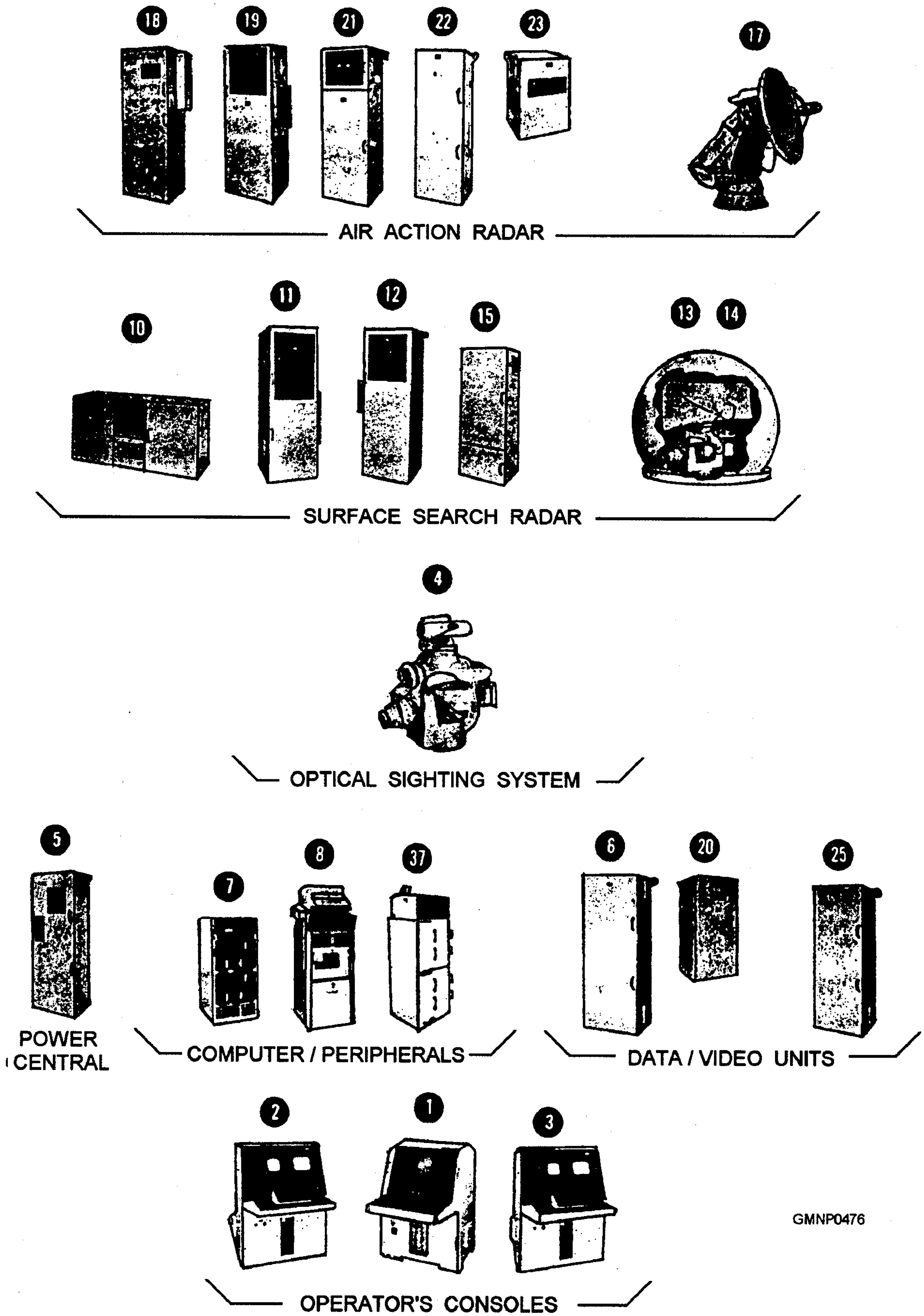


Figure 10-12.—Mk 86 Mod 10 FCS.

### Operator Consoles

The operator consoles consist of the control officer console Mk 67 (COC, unit 1) and two Mk 113 weapons control consoles (WCC1 and WCC2, units 2 and 3). The COC and WCCs are the principal command positions for the Mk 86 FCS.

The COC allows the control officer to control and monitor overall operation of the FCS. From this position he initiates radar tracking of targets and assigns weapons to the WCCs.

An operator may control one or both guns from either WCC, depending on the weapon assignment made by the COC operator. The WCC operator enters tire control data into the computer through his keyboard and associated controls. This data includes ballistics data, ammunition selection, target data, grid coordinates, and spotting data. The WCC also has a TV monitor for visual surveillance and optical tracking.

### Power Central

Power central (Mk 12, unit 5) is the central power control and distribution point for all units except the AN/SPG-60 radar set, the digital computer, and the digital input/output (I/O) console.

### Computer/Peripherals

The systems computer/peripherals group consists of the AN/UYK-7 computer, the digital I/O console, and the magnetic tape recorder-reproducer. (These units are shown as units 7, 8, and 37, respectively, in fig. 10-12.)

**DIGITAL COMPUTER AN/UYK-7.—** The FCS uses the AN/UYK-7 general-purpose computer set. The program, once loaded into the computer memory, contains all instructions and constant data required to perform the computations and functions related to the fire control problem. The computer performs ballistic computations to determine the line-of-fire of the gun and the time-in-flight of the projectile from which gun orders are generated.

**DIGITAL I/O CONSOLE.—** The digital I/O console consists of a paper tape reader and perforator and a teletypewriter (keyboard/printer). The I/O console is primarily used for troubleshooting and for running system diagnostics.

**MAGNETIC TAPE RECORDER-REPRODUCER.—** The magnetic tape recorder-reproducer (MTRR) interfaces with the AN/UYK-7 computer to load the operational and maintenance programs for the system. The MTRR also records all system engagements for future review.

### Surface Search Radar

The surface search radar consists of the AN/SPR-9A radar set that is comprised of units 10 through 15 (fig. 10-12).

Unit 10—Radar receiver

Unit 11—Frequency converter

Unit 12—Transmitter

Unit 13—Antenna

Unit 14—Radome

Unit 15—Control amplifier

The AN/SPQ-9A is the prime sensor of surface targets for the Mk 86 FCS. The radar is also equipped with circuitry for the reception and interrogation of a radar beacon (described later).

### Air Action Radar

The air action radar consists of the AN/SPG-60 radar set and the tracking radar of the system that provides the director/radar inputs to the computer. The system is comprised of units 17 through 19 and 21 through 23 (fig. 10-12).

Unit 17—Antenna

Unit 18—Radar receiver

Unit 19—Radar transmitter

Unit 21—Antenna control

Unit 22—Signal data converter

Unit 23—Power distribution control

The antenna is mounted with a TV sight that allows the WCC operator to track targets visually. The same antenna is used in variations that supply CWI with the addition of a waveguide and feedhorn for CWI transmission.

### Data/Video Units

The data/video units consist of a signal data translator (unit 6), a signal data converter (unit 20), and a video processor (unit 25). The signal data translator interfaces the computer with other units of the Mk 86 FCS. The signal data converter converts gun position synchro signals for use by the signal data translator. The video processor operates in conjunction with the computer system to acquire, track, and develop position and rate data for targets detected by the AN/SPQ-9A radar set. The video processor receives raw data from

**the** radar and correlates it with present and previous radar echoes to provide a high-detection probability and low incidence of false alarms.

### Optical Sighting System

The optical sighting system (unit 4) consists of a gimbal-mounted TV camera (separate from the one mounted to the AN/SPG-60 antenna). The sight permits the WCC operator to monitor and track targets visually. The sight can be positioned automatically by the computer or manually by the WCC operator.

## MK 92 FIRE CONTROL SYSTEM

The Mk 92 fire control system (FCS) is installed primarily on FFG-7 class ships. The system, in conjunction with the Mk 13 Mod 4 GMLS and the 76-mm Mk 75 gun, is capable of simultaneously detecting, tracking, and engaging multiple air and surface targets. Much of the terminology and some of the components, associated with the Mk 92 FCS, are similar or identical to those used in the Mk 86 FCS. Both systems, for instance, use the AN/UYK-7 general-purpose computer set to perform all the fire control calculations. Watch for other similarities as we describe the functions of the major components of this system. The system consists of the following major components:

- Combination antenna system (CAS) and radar
- Separate track and illuminating radar (STIR)
- Weapons control processor (WCP)
- Data exchange auxiliary console (DEAC)
- Planned position indicator (PPI) display console

### Combined Antenna System

The combined antenna system (CAS) consists of search and track antennas mounted on a stabilized platform and enclosed in a radome (fig. 10-13). The search antenna provides air and surface surveillance but can also be used to track a limited number of targets while scanning. The search antenna is also equipped with IFF for target interrogation.

The CAS track antenna is primarily used for three-dimensional (three-coordinate) tracking of air targets. The antenna is also equipped with a continuous wave illumination (CWI) horn to provide target illumination for the guidance of Standard semiactive missiles.

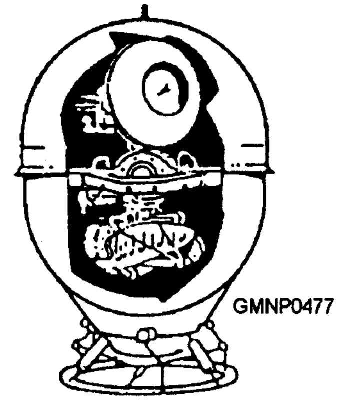


**Figure 10-13.—The combination antenna.**

Both antennas are part of the same radar unit. Both are controlled and operated from the CAS weapon control console (WCC). The CAS WCC is a two-operator console. One operator is responsible for the acquisition, the tracking, and the engagement of air targets by gun or missile. The second operator is responsible for the tracking and engagement of surface targets. The console is interfaced with the weapons control processor (WCP). In the normal mode of operation, the WCP designates targets for engagement by the CAS operators.

### Separate Track and Illuminating Radar

The separate track and illuminating radar (STIR) (fig. 10-14) provides the system with a longer range tracking capability than is possible with the CAS. The STIR is solely a tracking radar with no search capability. The antenna is equipped with CWI for the control of Standard missiles. The STIR is a separate radar from CAS.

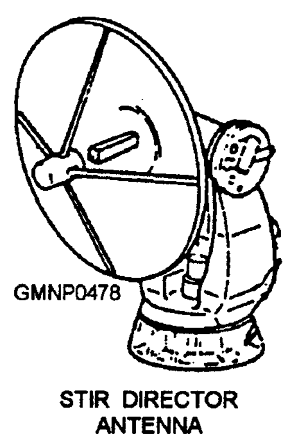


**Figure 10-14.—The STIR director antenna.**

The STIR WCC is a single-operator console. It is identical to the CAS WCC except that the search radar controls have been eliminated. The operator is responsible for the acquisition, the tracking, and the engagement of targets by gun or missile, as ordered by the WCP.

### Weapons Control Processor

The Mk 92 FCS uses the AN/UYK-7 computer set to perform all fire control calculations and threat evaluations. The WCP is the source of gun mount and missile launcher position orders and missile programming.

### Data Exchange Auxiliary Console

The data exchange auxiliary console (DEAC) provides a variety of input and output capabilities for the WCP. The DEAC provides a keyboard and page printer, a paper tape reader and punch, a magnetic tape recorder/reproducer, and an output teletype communications interface. The DEAC is capable of accepting from either the WCP or the weapons support processor (WSP). (The WSP is another AN/UYK-7 computer that is part of the WDS.) The DEAC can exchange data with either the WCP or the WSP.

### Planned Position Indicator Display Console

The planned position indicator (PPI) console, AN/UYA-4, serves as the weapons control officer (WCO) console. It displays selected radar and track data received from external search radars and the CAS search radar. The console may also be used, in the casualty mode, to enter track data into the WCP.

Figure 10-15 shows the equipment layout aboard an FFG-7 class ship.

## WEAPONS SYSTEM MAINTENANCE

*LEARNING OBJECTIVE:* Recall the general requirements and procedures for weapons system maintenance and testing.

In today's SMS fleet, the' name of the game is readiness. Is the weapons system ready IN ALL RESPECTS to engage a target successfully? To achieve the optimum state of readiness, the weapons system must be maintained and tested.

At the equipment level, the gear (i.e., GMLS, computer, radar set, etc.) must be lubricated, aligned, and checked. This routine maintenance ensures individual accuracy and reliability. These general

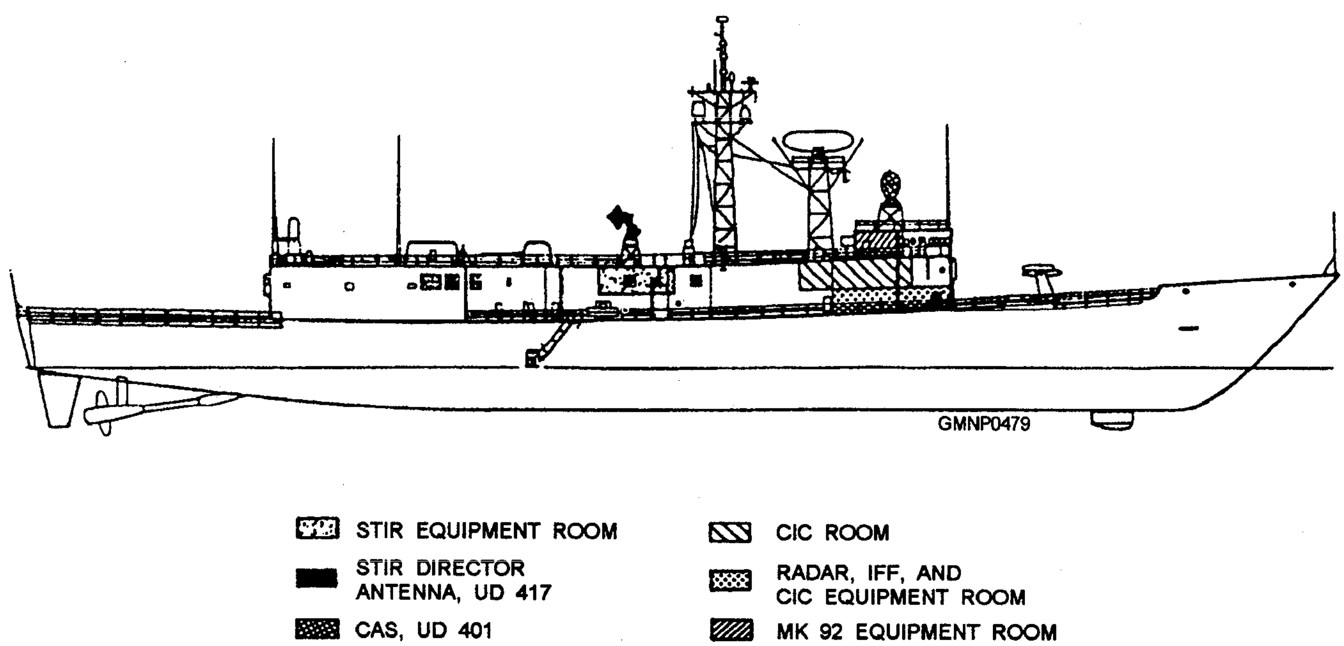


Figure 10-15.—Mk 92 FCS equipment configuration on FFG-7 class ship.

maintenance tasks are performed by the technicians assigned to the various work centers. (Chapter 12 discusses general maintenance in greater detail.)

At the system level, maintenance actions are concerned with alignment and electrical operability testing. The maintenance responsibility shifts to all personnel assigned to the missile division. In short, a team effort is required. Normally, the missile Fire Controlmen assume the lead in system maintenance actions. However, Gunner's Mates are equally involved.

## SYSTEM TESTING

To determine the readiness of the missile weapons system, a series of tests has been developed under the SMS program. These tests are known as system maintenance tests (SMTs). They are used to evaluate the ability of a weapons system to perform effectively. If SMTs uncover a problem, corrective action is required. Quite often troubleshooting must start at the system level. It then works its way down to the individual piece of equipment at fault.

SMTs, in conjunction with separate equipment level tests, provide a thorough check of the entire weapons system. The tests are designed (for the most part) not to overlap each other. In other words, a particular equipment level check is not rechecked by an SMT. Also, SMTs are scheduled at the minimumfrequency or period necessary to ensure reliability.

Since system testing is a form of maintenance, SMTs come under the Navy's planned maintenance system (PMS). Hence SMT scheduling and format are identical to equipment-level maintenance actions. Each SMT is letter-number coded according to its required time interval. The letter *D* stands for daily check, *W* for weekly, *M* for monthly, and so forth.

For certain weapons systems, weekly tests are designed to check different equipment combinations, setups, and modes of operation. This concept requires that these weekly tests be scheduled over a 6-day period, Monday through Saturday. Quite often there will be 12 different weekly tests, identified W-1 through W-12. Depending on how a ship sets up its maintenance schedule, W-1 and W-7 would be held on Monday. On Tuesday, you run W-2 and W-8; Wednesday it's W-3 and W-9; and so forth. In this concept, each GMFCS and guide arm (on dual-arm launchers) is exercised daily with a different problem.

### Testing Requirements

A typical missile system test program normally includes (but is not limited to) the items listed below:

- Daily system operability test (DSOT)
- Search radar readiness
- Supplemental (auxiliary) firing readiness
- Casualty mode operation
- Ship parameters (gyro inputs)
- Radar collimation/correlation
- ECCM capabilities
- Fire control radar parameters
- Live target tracking (AAW)
- Balloon tracking (designation accuracy)
- Surface target tracking

Overall system testing is centered around the daily system operability y test (DSOT), (Actually, a DSOT is one of the 12 weekly scheduled checks, W-1 through W-12, mentioned earlier.) The DSOT is designed to exercise almost all of the functional circuits related to the primary mode of system operation. The DSOT is very important and we'11 examine it in detail shortly.

Other system tests check the areas of the system not covered by DSOT. For example, weapons systems have different modes of operation. Antiair warfare (AAW) is the normal mode, usually. Antiship missile defense (ASMD), surface warfare (SUW), antisubmarine warfare (ASW), and shore modes are optional. There may also be a casualty mode to permit system operation should certain equipments be inoperable. Each mode is tested to ensure its continued reliability. The periodicities of these tests are usually greater, such as monthly, quarterly, or longer.

SMTs check the equipment in two major areas—alignment requirements and electrical operability requirements. Alignment requirements consist of in-space RF alignments and internal (shipboard) alignments. In-space RF alignments verify that RF beams from the search, fire control, and guidance radars all coincide. This coinciding action is very important. Assume a search radar is tracking a target at 180° true bearing. Also assume a fire control radar beam is 10° out of alignment with the search radar. At designation, the fire control radar is searching empty space, 10° off target. Acquisition could be impossible.

Internal or shipboard alignments are mechanical and electrical in nature. They affect individual equipments and the interactions between different equipments. For example, consider a GMLS power drive system with its synchros and receiver-regulators. Synchronization will never be achieved with misalignments between the computer and the GMLS.

Alignment procedures are provided to correct any in-space RF or internal misalignments. However, they are only performed on an as-needed basis, when discovered by faulty test results.

The quality of system test results can be determined by system responses and parameter tolerances. (Parameter-any set of values that determines the normal or desired characteristics and behavior of something.) Test result data may be obtained from indicators, lamps, dials, meters, and computer readouts (printouts). Analyzing the data provides the technicians with a” yardstick for measuring the success or failure of a particular test.

### Testing Procedures

System test procedures are printed on standard maintenance requirement cards (MRCs). Each system test MRC contains the same information as found on any other equipment MRC. Ships' 3-M Manual, Volume I, OPNAVINST 4790.4, explains MRCs in detail.

The actual test procedure is presented in an easy-to-read step-by-step format. Figure 10-16 shows a sample system test MRC page. Note that the information is listed in four columns:

1. Step—a number to indicate the phase or point in the test sequence.

2. Equipment—the equipment of a station/work center that performs the step.

3. Procedure—what action must be accomplished.

4. Response—the “desired” response or result from a particular step.

Also note that pertinent safety warnings and operational notes (special instructions) precede important steps.

Since a system test normally requires the participation of many individual stations/work centers, coordination is a must. DSOT, for example, can include four or five different stations. Each station will have its own copy of the MRC of the test. That way, all involved personnel can follow along with each step as it occurs.

Test procedures are arranged so one individual serves as the test conductor/coordinator. The test conductor controls and directs the performance of the test (keeps it going). Normally, this individual is located at the WDE, but that varies among ships. The test conductor can also call out each step number and record any response data.

Refer to figure 10-16, step 49. The test conductor calls out “Step 49.” You, the EP2 panel operator, must observe the reaction of the ALERT indicator lamp and buzzer of the GMLSs. Knowing how your system operates, you realize the lamp should flash and the buzzer buzz when they are activated. (Step 48 activates them.) If they work properly, you report over the sound-powered phone circuit, “Step 49, flashing and buzzing.” The test conductor acknowledges your verbal response and the test goes on. This procedure may vary from ship to ship, but the idea is the same.

### Test Evaluation and Fault Isolation

Each system test is divided into independent phases where possible. This division helps in conducting the test and is a fault isolation aid. Particular parts of the system may be checked without conducting an entire test.

Selected parameters under test are sampled or measured to specified tolerances. These tolerances, along with the desired responses, are listed on the MRC following the applicable steps. Step 40 on figure 10-16 shows parameters and tolerances.

Fault isolation directories are located in each MRC and keyed to corresponding test steps

PROCEDURE (Contd)

| STEP | EQUIPMENT | PROCEDURE | RESPONSE |
|---|---|---|---|
| 40 (Cont.) | | b. RANGE RATE | 0 yd/sec (10 to -10 yd/ sec) |
| | | c. ELEVATION | 0° (1° to -1°) |
| | | d. BEARING | 0° (359° to 001°) |

NOTE 14: Do not perform steps 41 thru 59 when test is repeated on other MR channel.

| STEP | EQUIPMENT | PROCEDURE | RESPONSE |
|---|---|---|---|
| 41 | LSM | Depress MSL MODE SEL ITR (SMIA (SM1) switch. | Depressed |
| 42 | EP2 | Depress MISSILE TYPE SYSTEM ASSIGNMENT X (Y) (Z) switch. | Depressed |
| 43 | CWI HVPS | Observe IT COMMAND (SMIA COMMAND) (SM1 COMMAND) indicator lamp. | Lit |
| 44 | CWI XMTR | Position MISSILE MODE switch to IT (SM). | Position |
| 45 | LSM | Observe MR ( ) MSL MODE ITR (SM1A) (SM1) indicator lamp. | Lit |

WARNING: Safety observer ensure launcher area is clear.

| STEP | EQUIPMENT | PROCEDURE | RESPONSE |
|---|---|---|---|
| 46 | Safety observer | Ensure launcher area is clear and close safety switch. | Clear |
| 47 | LSM | Observe LS STANDBY indicator lamp. | Lit |
| 48 | LSM | Depress LS ALERT switch. | Depressed |
| 49 | EP2 | Observe ALERT indicator lamp and buzzer. | Flashing, buzzing |
| 50 | EP2 | Position READY SWITCH SMS3 to READY. | READY |
| 51 | LSM | Observe LS READY indicator lamp. | Lit |

WARNING: Only TSAM will be loaded on rail.

| STEP | EQUIPMENT | PROCEDURE | RESPONSE |
|---|---|---|---|
| 52 | LSM | Depress LOAD ORDER CONT switch. | Depressed |
| 53 | LSM | (ITR only) Simultaneously start stopwatch and depress WARMUP ON switch to light WARMUP ON indicator lamp. | Depressed |

PAGE 9 OF 21

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MAINTENANCE REQUIREMENT CARD (MRC)
OPNAV 4700 - 1 ( ) (Rev. )

GMNP0480

Figure10-16.—Sample system test MRC page.

(fig. 10-17). If an out-of-tolerance condition or incorrect response is observed, the fault isolation direction should be consulted. It lists system and equipment OPs that can be referenced to aid in troubleshooting.

Ideally, the test should be completed without pause for fault isolation. Completing the test permits a more accurate evaluation of the fault. It also results in the most efficient use of manpower.

A significant feature of a GMFCS is its general-purpose digital computer. In addition to solving the tactical fire control problem, the computer is also a test instrument. Digital test programs have been designed to enhance system testing.

PROCEDURE (Contd)

| STEP | FAULT ISOLATION PROCEDURE | SFD REFERENCE |
|---|---|---|
| 1 | Para. 10-2.3 | Fig. 11-4.4,2 |
| 2 | Para. 10-2.4 | Fig. 11-4.4,5 |
| 25 | Para. 10-2.5 | Fig. 11-4.6,4 |
| 26 | Para. 10-2.6 | Fig. 11-4.4,8 |
| 27a | Para. 10-2.7 | Fig. 11-4.8,14 |
| 27b | Para. 10-2.7 | Fig. 11-4.8,14 |
| 27c | Para. 10-2.7 | Fig. 11-4.8,14 |
| 27d | Para. 10-2.7 | Fig. 11-4.8,14 |
| 28 | Para. 10-2.8 | Fig. 11-4.4,5<br>Fig. 11-4.6,9 |
| 29 | Para. 10-2.9 | Fig. 11-4.6,9 |
| 30 | Para. 10-2.9 | Fig. 11-4.13,10 |
| 32 | Para. 102.10 | Fig. 11-4.6,12 |
| 33 | Para. 10-2.11<br>Para. 10-2.12 | Fig. 11-4.9,5 |
| 40a | Para. 10-2.13 | Fig. 11-4.8,14 |
| 40b | Para. 10-2.13 | Fig. 11-4.8,14 |
| 40c | Para. 10-2.13 | Fig. 11-4.8,14 |
| 40d | Para. 10-2.13 | Fig. 11-4.8,14 |
| 43 | --- | Fig. 11-4.12,3 |
| 45 | Para. 10-2.14 | Fig. 11-4.12,5 |
| 47 | --- | Fig. 11-4.15,6 |
| 49 | --- | Fig. 11-4.15,2 |
| 51 | --- | Fig. 11-4.15,6 |
| 54 | OP 2665 Vol 3 | Fig. 11-4.15,4 |
| 57 | OP 2655, Vol 3 | Fig. 11-4.15,4 |
| 59 | --- | Fig. 11-4.15,2 |

PAGE 16 OF 21

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MAINTENANCE REQUIREMENT CARD (MRC)
OPNAV 4700 - 1 ( ) (Rev. )

GMNP0481

**Figure10-17.—Sample test fault directory.**

Dynamic digital tests are controlled by the computer complex of the GMFCSs or the computer complex of the NTDS/WDSs. The computer stores special test programs and generates a variety of dynamic target problems. The test program solves the fire control problem to arrive at ideal values. These values are then compared with actual test responses to provide error monitoring. Teletypewriters can be used to print out this information for evaluation.

A new concept in digital system testing uses the computer to isolate a fault. This testing can be performed during or separate from normal computer operations. The advantages are obvious—quicker repair times and increased readiness.

## DAILY SYSTEM OPERABILITY TEST

The purpose of DSOT is to assess missile system readiness in its normal mode of operation. For most systems, this would be the AAW mode, although the specific functions tested may vary between systems. DSOT usually involves testing target detection and/or designation, acquisition, tracking, and missile firing. A typical DSOT is described in the following paragraphs. Figure 10-18 is a simplified block diagram of DSOT data flow.

### Preliminary Setup

Before the test sequence is started, each equipment station prepares for operation. Technicians follow a list of instructions provided at the beginning of the MRC test procedure. Most setups involve equipment turn-on actions and switch positioning. In some cases, the test conductor announces a particular equipment configuration.

### Detection

In systems that test this function, a synthetic (artificial or man-made) target video is inserted in the 3-D search radar. The target is at a predetermined range, bearing, and elevation. These data are routed through normal distribution circuits. The target video is checked at the NTDS/WDS or WDS consoles. The test target is then entered into a WDS tracking circuit.

### GMFCS Assignment

If the detection function is not tested, the NTDS/WDS or WDS operator initiates the test target at the TSTC. A GMFCS is assigned to one of the tracking channels. The accuracy of the designated position is checked at the radar set console. Position repeat back data are checked at the NTDS/WDS or WDS consoles.

### Acquisition and Static Track

A test RF generator provides the fire control radar with a simulated target return signal. Radar jamming signals may also be provided. The scope display of the radar is monitored to see how well the radar can acquire the target. How much of the radar receiver is tested is determined by where the test signal is introduced. The test signal contains information needed for radar tracking, including angle, error, and range. Target

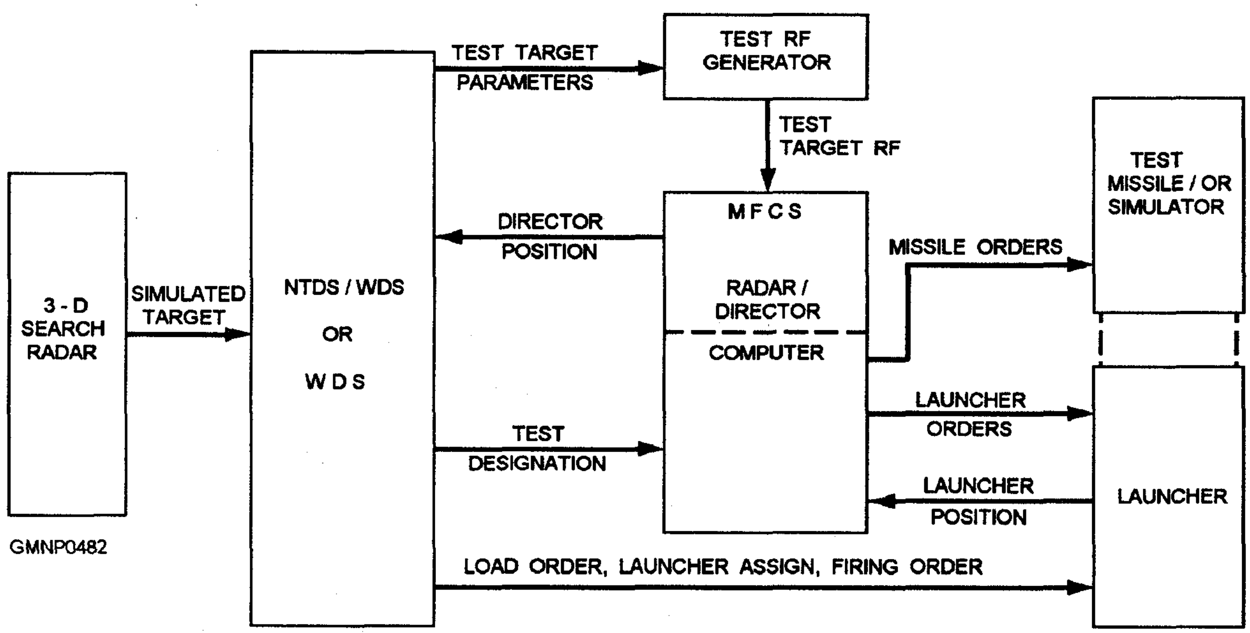


Figure 10-18.—Simplified DSOT data flow.

parameters are usually controlled by a test program, as previously mentioned. Control is also possible from an analog test set.

### Launcher Loading and Missile Selection

After track is attained, the launcher goes through a loading sequence to place a training missile on the rail. SAFETY REMINDER: VERIFY THAT ONLY A TEST MISSILE HAS BEEN LOADED. Otherwise, the DSOT would result in the actual launching of a live missile. (Don't laugh, it HAS happened!)

Missile type and mode selection might also be tested at this time. The simulator of the test missile provides these functions.

### Dynamic Evaluation

During this phase of DSOT, two aspects of system operation are tested. The first is the FCS tracking of a dynamic target. The second is launcher assignment and synchronization to a computer-ordered position.

Target parameters are selected that simulate an incoming enemy aircraft. The fire control system is monitored to ensure smooth and accurate tracking. The launcher is assigned and the fire control problem solution verified by monitoring launcher and missile orders.

Engageability displays are observed at the weapons control area. Displays indicate when the target is within firing range and the launcher is in a clear firing bearing. If all conditions are correct, the firing circuit is closed (ITL). A proper firing indication is monitored at the launcher station and is verified at various weapons stations.

The launcher operator must initiate a missile-in-flight condition. That is usually done by depressing a switch button which simulates the launcher rail is clear/empty. In effect, we electrically "lie" to the system, but it is necessary to continue the test.

### Test Missile Readouts

Certain signals are essential to missile operation but may not be automatically y checked. Visual observations, by means of built-in lamps and dials, are made at the simulator of the test missile. Signals, such as missile orders, are sometimes checked with a multimeter. A serious safety hazard exists when you are making measurements or otherwise approaching the missile while it is on the launcher. ALWAYS ENSURE THAT ALL LAUNCHER MOTORS ARE STOPPED BEFORE APPROACHING THE MISSILE.

After missile readouts are finished, all stations are secured or setup for the next test.

### OCSOT

Another test you may be involved with is the overall combat system operability test (OCSOT). The OCSOT provides a tool to make rapid assessments of ship readiness. It tests the entire combat system as an integrated system. An OCSOT uses normal equipment, software, and interfaces during both simulated and controlled live target phases. As a rule, the following systems are tested:

- Guided missile fire control
- Gun fire control
- Antisubmarine warfare
- Electronic warfare
- Tactical data
- Identification friend or foe (IFF)
- Search radars
- Electronic navigation

The OCSOT has specified parameters, such as range, bearing, and elevation tolerances, for all phases. Proper reaction times for systems and operators are also monitored. As an added benefit, the OCSOT results in training for improvement of operational readiness in a combat environment.

## TRAINING MISSILES

*LEARNING OBJECTIVE:* Recall the general purposes of and the maintenance requirements for the Guided Missile Training Round (GMTR).

A training missile is an integral part of every missile weapons system. A training missile consists of two major subassemblies—a training round and a guided missile simulator. The training round is an inert shape or body that resembles a tactical missile shape. The guided missile simulator is an electronic unit or module that simulates the electrical performance of a tactical missile.

In the SMS community, the primary training missiles are the guided missile training round (GMTR) (pronounced gim-ter) used by the Mk 13 and 26 GMLSs.

Other training rounds and missiles do exist. Examples include the ASROC training round and the (relatively new) training antisubmarine warfare missile (TASWM). Although these items are special-purpose equipments, fictionally they are similar to GMTRs. This discussion will be limited to the GMTRs.

## GENERAL PURPOSES

Training missiles are electrically and mechanically compatible to their launching and fire control systems. Training missiles are also capable of simulating the performance of any tactical missile handled by a particular weapons system.

GMTRs are carried by combatant ships for two purposes-training and testing. GMTRs are used to train personnel in magazine loading, launcher operation, missile firing, and missile handling evolutions. The GMTR is also used during DSOT and as an aid in other system testing/equipment maintenance actions. The training and testing functions are really inseparable operations and greatly contribute to overall system readiness.

Training missiles may also be used as display shapes. As your ship enters/leaves port, the GMTRs will be loaded to the launcher. The same thing applies for public/VIP tour demonstrations. This policy may vary among commands, but it is the general rule.

GMTRs are mandatory items in a magazine loadout. Single-arm GMLSs will carry one training missile; dual-arm launchers will carry two training missiles. Although these missiles are inert rounds (contain no explosive materials), they should always be treated as real tactical weapons.

## STANDARD GMTR

The current version of the GMTR is designated the Mk60 Mod 6, 7. It is capable of simulating ITR, SM-1A (MR), SM-1 (MR), SM-2 (MR), Standard ARM, and Harpoon missiles. Externally, the GMTR is similar to a tactical SSSM round. Although the sections and markings are not the same, the GMTR adequately serves for all general handling and display purposes.

The Mk 60 Mod 6, 7 GMTR is made up of two major subassemblies:

1. Mk 59 Mod 3 guided missile dummy round (GMDR)
2. Mk 63 Mod 5, 6 guided missile simulator (GMS)

The GMDR (fig. 10-19) forms the body of the GMTR. It consists of ballasted dummy sections and is painted blue. Tail control surfaces and dorsal fins are painted white. The Mk 63 Mod 5, 6 GMS is located in a compartment of the dummy rocket motor section. A removable door protects the simulator from the outside elements. The door has a clear plastic window to permit visual observation of switch positions and lamp displays.

A target acquisition console (TAC) source and emitter are mounted in the adapter section of the GMDR. These units are used in testing Standard ARM missile features. The dummy rocket motor igniter assembly is mounted in the forward part of the dummy

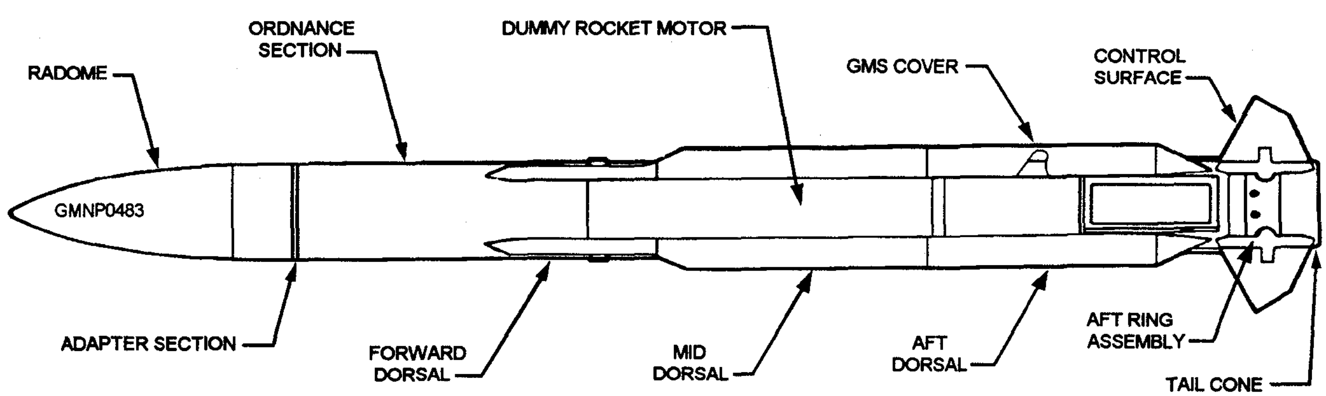


**Figure 10-19.—Mk 60 Mod 6, 7 GMTR for Standard missile systems.**

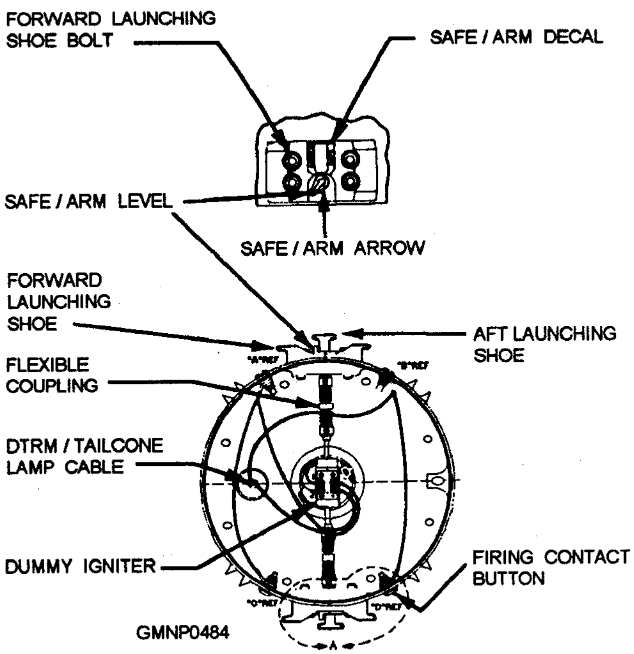


**Figure 10-20.—GMTR dummy igniter and S&A lever.**

DTRM (fig. 10-20). Four firing contact buttons and the S&A (SAFE/ARM) levers are also located here.

The tail cone assembly of the GMDR includes two external electrical connectors (fig. 10-21). The six-pin missile-to-magazine connector provides for round identification and application of warmup power (if applicable). The missile-to-launcher connector (MLC) provides a 23-pin jack receptacle for application of preflight missile orders and simulator power. The MLC is easily removed/replaced and protected by a rubber composition pad.

The tail cone assembly houses a large red light bulb called the tail cone lamp. When a firing circuit is completed, the lamp lights to simulate rocket motor ignition. The aft end of the tail cone is sealed with a clear plastic window. The tail cone lamp is easily observed through this window. Figure 10-21 also illustrates how a GMS is installed and connected (electrical cables) to the GMDR.

The Mk 63 Mod 5, 6 GMS is a very versatile electronic unit. Figure 10-22 shows the front panel of the simulator. The GMS furnishes the electrical loads, voltages, frequencies, and responses for any of the six missile types mentioned earlier. Around identification switch (item 1 in the figure) selects the correct circuits

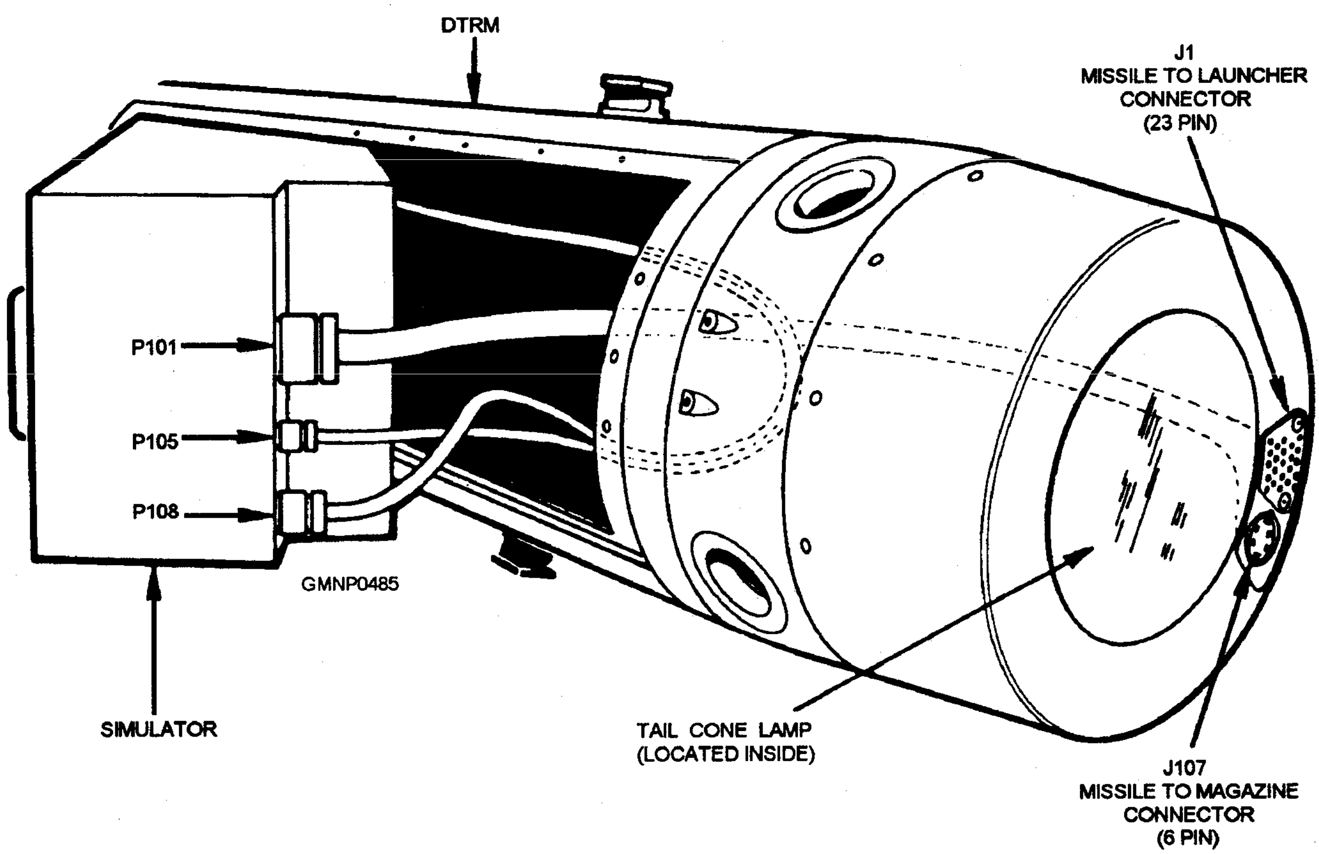


**Figure 10-21.—Tail cone assembly components and simulator removal.**

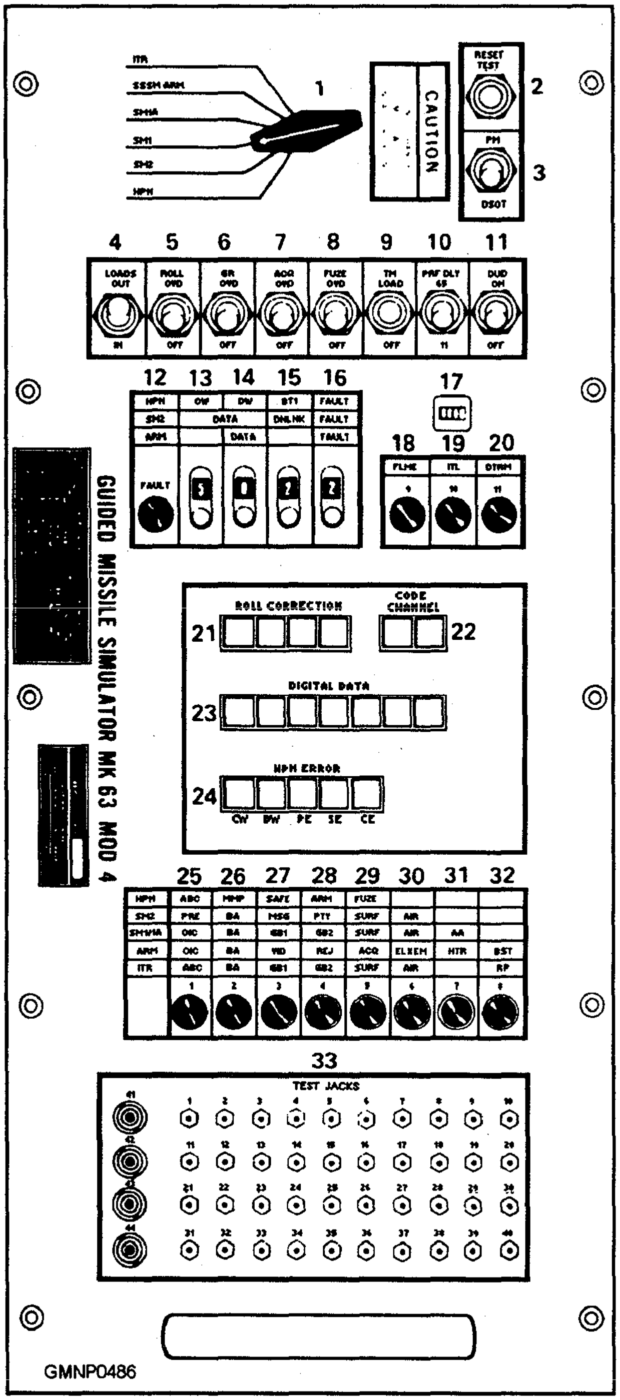


**Figure 10-22.—Mk 63 Mod 5, 6 front panel of the guided missile simulator.**

for simulation of the desired missile type. Lamps, switches, displays, and test jacks on the front panel facilitate DSOT and other system testing.

Most of the major simulator circuits are designed to function independently. They also have associated indicators to display readouts of their operations. The roll corrector circuit includes an LED display (item 21 in the figure) for direct reading in degrees of roll. Visual readout of the selected missile cede or channel number (item 22 in the figure) is also displayed on an LED readout.

## TRAINING MISSILE MAINTENANCE

The importance of maintaining all training missiles in peak condition cannot be stressed enough. If these devices are allowed to deteriorate, the operational readiness of the entire weapons system is in jeopardy. Gunner's Mates are responsible for the proper maintenance and care of the GMTRs. A majority of these maintenance actions come under the headings of inspecting and servicing.

Maintenance requirement cards (MRCs) provide the guidance necessary to maintain the training missiles. The MRCs describe the required periodic and unscheduled maintenance actions applicable to the round. In case of fictional problems or equipment failure, be sure to consult these MRCs.

### Inspections

Inspections include the preventive maintenance procedures required to detect problem areas before they cause equipment failures. Listed below are a few examples of what to look for during a training missile inspection.

1. Examine all painted surfaces for chipping and scratches.

2. Inspect tail control surfaces for hard or rough movement as they are folded/unfolded.

3. Inspect the S&A levers/arming tool socket. Ensure they are in the SAFE position and they offer some tension or resistance to being turned. Also inspect the firing contact buttons or points for wear and cleanliness.

4. Examine all plastic covers/windows for cracks and chips.

5. Examine the front panel items of the simulator. Check for damaged lamp lenses, broken or loose switches, and so forth.

6. Inspect the launching shoes for excessive or uneven wear by using a micrometer or special GO/NO-GO gage tool. Consult the applicable training missile OP or MRC for maximum/minimum wear tolerances.

If possible, correct any deficiencies noted at the time of inspection. If an immediate repair cannot be made, report the problem to proper authority.

### Servicing

Servicing a training missile prevents corrosion and deterioration of the round. While in stowage, training missiles require no external care other than routine cleaning. Gross accumulations of oil, grease, and dirt must not be permitted to remain on the surface of the round. If you are cleaning the sockets, apply the compound liberally to the socket area. Then carefully clean the socket with an LP air supply. Reapply the compound but do not wipe it dry. This point applies to any application of corrosion-preventive compound. If you wipe it dry, you wipe away the effectiveness of the compound

Training missiles are NOT sealed, watertight devices. Excessive exposure to moisture not only affects the external surfaces of the missile but can cause serious internal damage. This problem is particularly acute in the area of the simulator. Remember, a simulator is a very sensitive electronic test instrument.

Training missiles will corrode—that's a fact of life. Therefore, an effective maintenance program is mandatory. Also, DO NOT LET THE GMTR GET WET. If it begins to rain, immediately unload the round to the magazine. If taking this action means interrupting a DSOT, so be it. The DSOT can be setup and rerun in a matter of minutes after the storm passes. It may take you days to thoroughly dry a "soaked training missile and its simulator. In the long run, it is better to keep the round dry.

## SUMMARY

In this chapter we covered the weapons system processes of detection and control. We described how raw data is gathered by the various types of sensors, then processed by the NTDS for use by the WDS. You saw how the WDS functions as an information gatherer and engagement controller. We then examined some of the compensations in the fire control problem required to deliver accurate fire. We then looked at the three most modern fire control systems currently in the fleet. Finally, we described system testing and the characteristics/uses of a guided missile training round (GMTR). Remember to refer to the within text references for more specific information about these subject areas.