## TA-ENG: SESC - FFG DIVISION

# FFG COMBAT SYSTEM LEARNERS GUIDE

**VERSION 2.01, DATED 10 Dec 2014**

## SECTION 5 – Effectors

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# Chapter 1. Mk 75 Mod 0 76mm Gun

**Figure 1-1: Mk75 Mod 0 76mm Gun**

## Characteristics

1. The table below outlines some of the important characteristics of the Mk 75 Mod 0 Gun.

| | |
|---|---|
| RATES OF FIRE | 10, 20, 40, 60 and MAX rounds per minute (rpm).<br>(Note: The MAX setting is approximately 85 rpm). |
| FIRE CONTROL | Mk 92 FCS, TDT or EOTS (BB3). |
| READY SERVICE | 70 rounds in the revolving magazine<br>+ 6 rounds in the screw feeder<br>(+4 rounds in the loader drum possible but not safely practical) |
| ELEVATION LIMITS | -6º(approx), +85º<br>(Gun Drive is electrically limited as it approaches the lower limit to prevent the gun driving into physical stops). |
| TRAIN LIMITS | Unlimited. |
| TRAIN/ELEVATION DRIVE | Train & Elevation solid state electrical motors in the upper gun housing<br>(2 x 4.5KW Train , 1 x 4.5KW Elevation) |
| LOADING MECHANISM DRIVE | Hydraulic power |
| RANGE | 16, 459 yards. (limited by ballistic weight of round) |
| MAX EFFECTIVE RANGE | AA: 5,700 yards<br>SU: 16000 yards (approx)<br>NGS: 16000 yards (approx) |
| POWER | 440 V 60 Hz 3 phase<br>115 V 400 Hz 1 phase |
| COOLING | Barrel Cooling: 13 gpm salt water (with 150 gallon fresh water for flushing)<br>76mm Magazine is air conditioned. |
| ALIGNMENT | Within 3' tolerance to Mk 92 FCS. Gun is the reference for in service Combat System Alignment.<br>Gun Bore Camera and Borescope available. |

**Table 1: Mk75 76mm Gun Characteristics and Specifications**

## Introduction

2. The Mk 75 Mod 0 Gun is a fully automated, remotely controlled gun mount which stows, aims and fires 76mm / 62 calibre ammunition. Automatic water cooling of the barrel allows sustained operation at high firing rates.

3. The Gun is primarily a defensive weapon used against aircraft and missile threats, however, it is able to be used against surface and shore targets.

4. The Mk 75 Gun is mounted on the 02 weather deck of an FFG but extends below decks into a compartment which combines the roles of 76mm Magazine, Mk 75 Gun equipment room, ready-use stowage and Local Control Station. This compartment, 01-231-0-M, is normally referred to by the first of its roles, the *76mm Magazine*.

## *Major Components*

5. The following are the major components of the Mk 75 gun:

a. Gun Carriage;

b. Slide Assembly;

c. Hydraulic System;

d. Train and Elevation System;

e. Gun Barrel and Weather Shield;

f. Upper Gun Loading system;

g. Lower Gun Loading System;

h. Equilibrator and Compensator Assembly; and

i. Gun Control Panel.

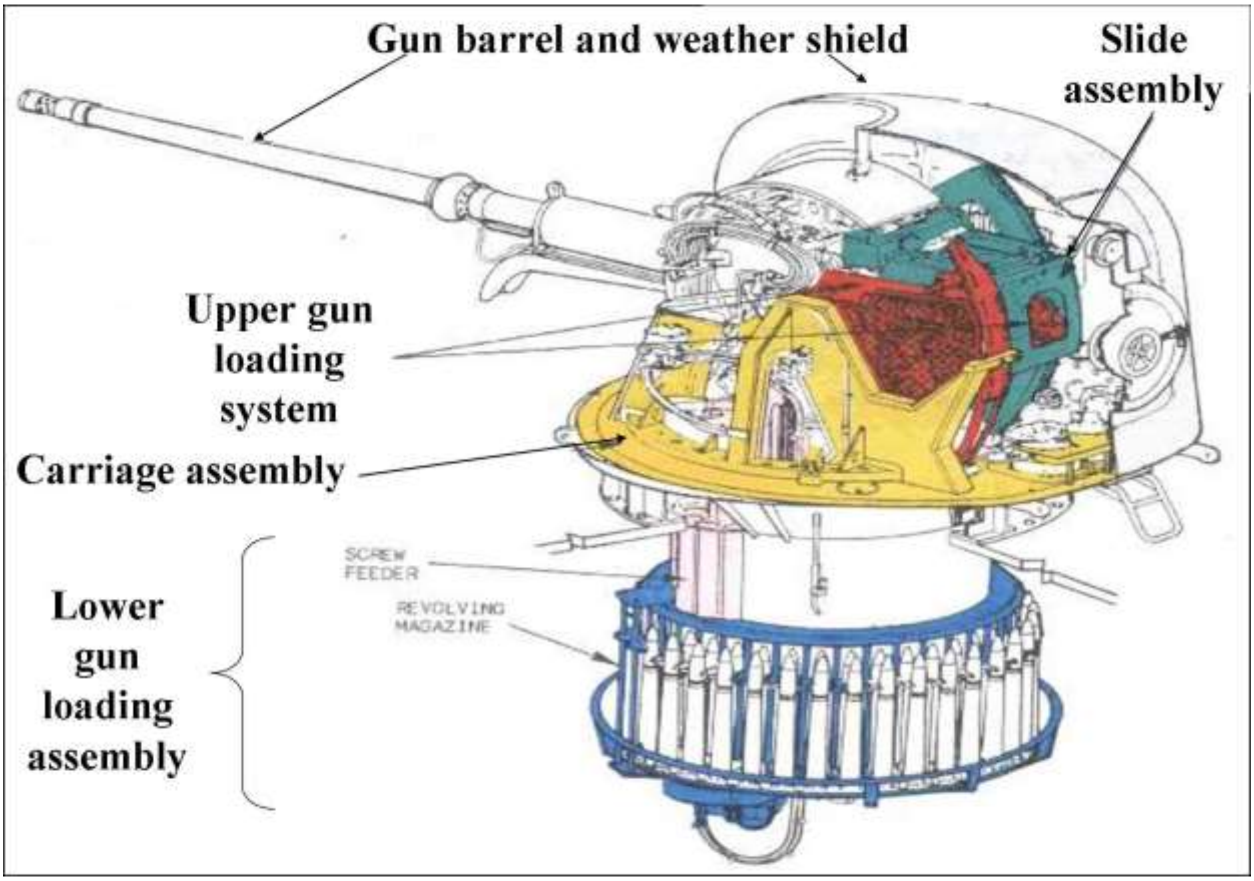


**Figure 1-2: 76mm Gun Major Components**

## Gun Carriage

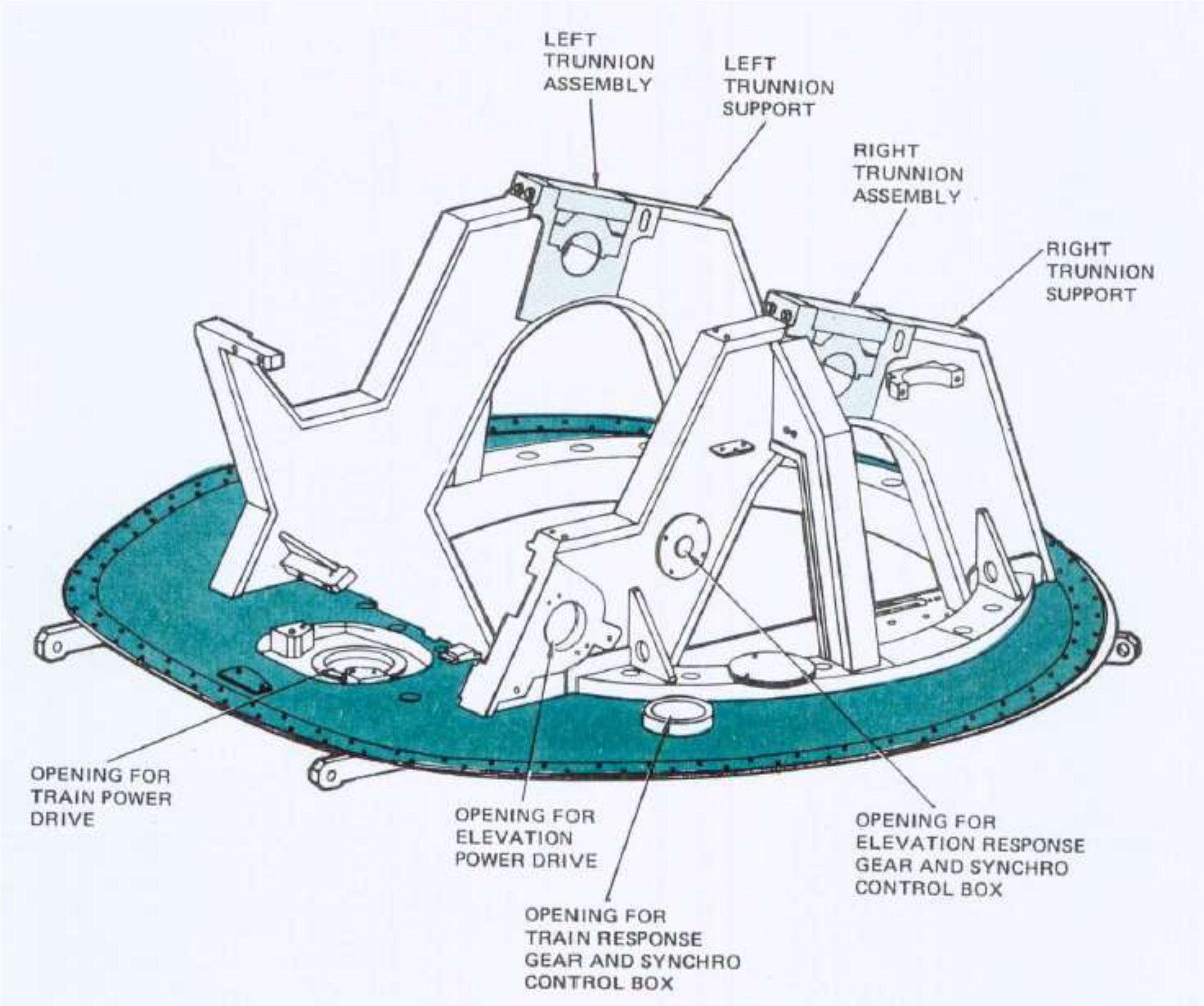


**Figure 1-3: Carriage Assembly Layout**

6. The carriage assembly supports the gun, the weather shield assembly and the rotating components of the gun mount.

7. Two trunnion supports on the carriage support the slide assembly. This assembly is bearing mounted in the right and left trunnion assemblies in the top of the trunnion supports. The mounting arrangement allows elevation and depression movements.

## Slide Assembly

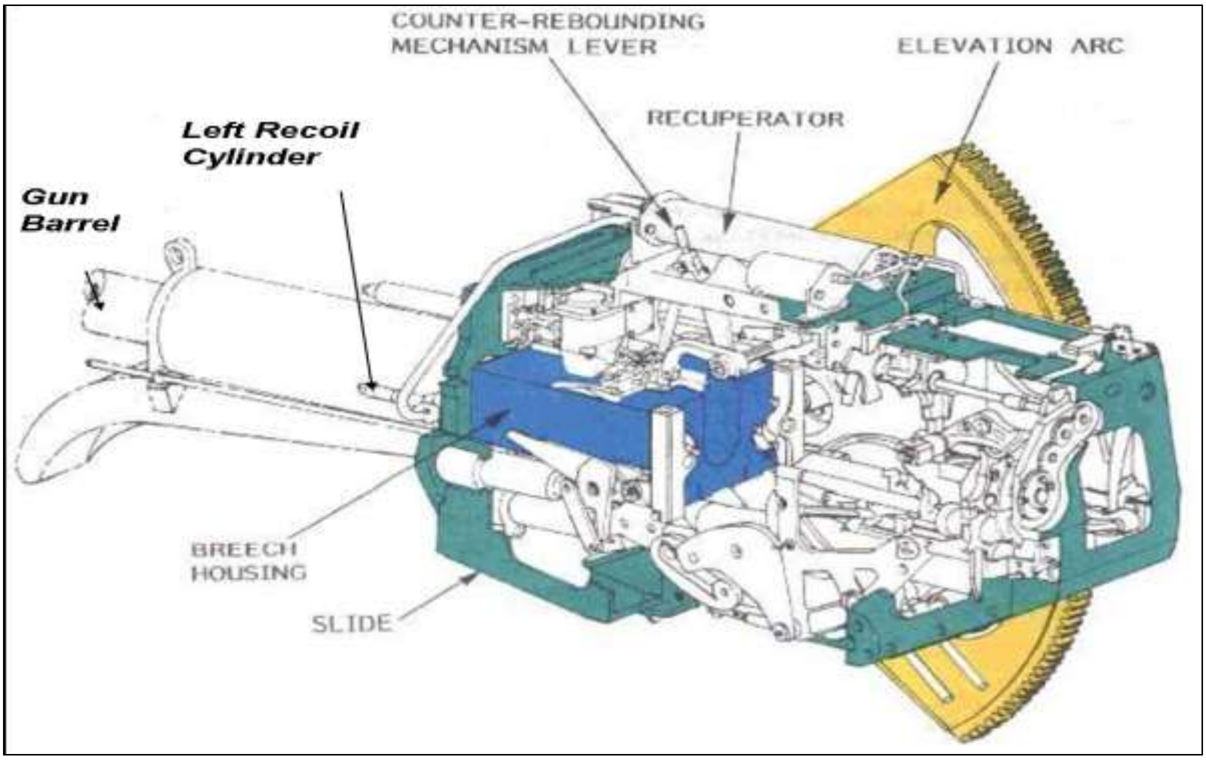


**Figure 1-4: Slide Assembly**

8. The slide assembly is suspended between the two trunnion supports. The slide serves as a support structure for the gun mount components that elevate and depress. The main components of the slide are the following:

a. Breech mechanism;

b. Recoil/counterrecoil system;

c. Recoil/counterrecoil dampers;

d. Cold recoil jacks;

e. Gun port shield;

f. Elevation arc;

g. Trunnions; and

h. Firing cutout mechanism

i. Counterrebounding Mechanism

## Breech Mechanism

9. This consists of a breech housing, which secures the gun barrel tube, and a breechblock assembly, which rides in guideways of the breech housing to open and close the breech end of the barrel.

10. During a firing sequence, the breechblock seals the breech end of the barrel when the gun is in battery to confine the gases generated by the burning propellants behind the projectile. It also positions the firing mechanism in line with the powder case primer.

11. During recoil, movement of the breech assembly operates the opening mechanism, which lowers the breechblock, which in turn recocks the firing mechanism and operates the empty case extractor arms. These eject the empty case from the barrel chamber to the empty case tray.

## Recoil/Counterrecoil System

12. The recoil/counterrecoil system controls movement of the gun during the recoil and counterrecoil strokes. The system consists of two recoil cylinders, connected hydraulically to a recuperator, and performs five functions:

a. Absorbs gun recoil force to ensure prescribed recoil lengths;

b. Maintains a nearly constant recoil force throughout the recoil stroke;

c. Stores energy to return the gun to battery;

d. Regulates the counterrecoil stroke to keep it within the prescribed rate-of-fire limits; and

e. Brakes recoil and counterrecoil movement at the end of their strokes.

13. The recuperator is a hydropneumatic device having separate chambers for hydraulic fluid and nitrogen. During the recoil stroke, the energy developed by the recoiling gun is absorbed by the recuperator and the recoil cylinders. The energy absorbed by the recuperator is stored as pressure by compressing the nitrogen. The energy absorbed by the recoil cylinders is dissipated by the resistance to the flow of hydraulic fluid through throttling grooves between the stationary and moving parts of the cylinders.

14. During counterrecoil, the energy, stored in the recuperator as pressure, moves the gun from its maximum recoil position to the gun-at-hooks position. When the gun is released by the gun releasing mechanism, the pressure stored in the recuperator moves the gun to the in-battery position. In this phase of counterrecoil, the recoil cylinders act as stroke regulators and release energy stored by the recuperator at a regulated rate.

## Recoil/Counterrecoil Dampers

15. The recoil dampers absorb shock at full recoil and as the gun stops at hooks position. The counterrecoil dampers provide a cushioning surface between the slide and the breech housing as the gun counterrecoils to the battery position.

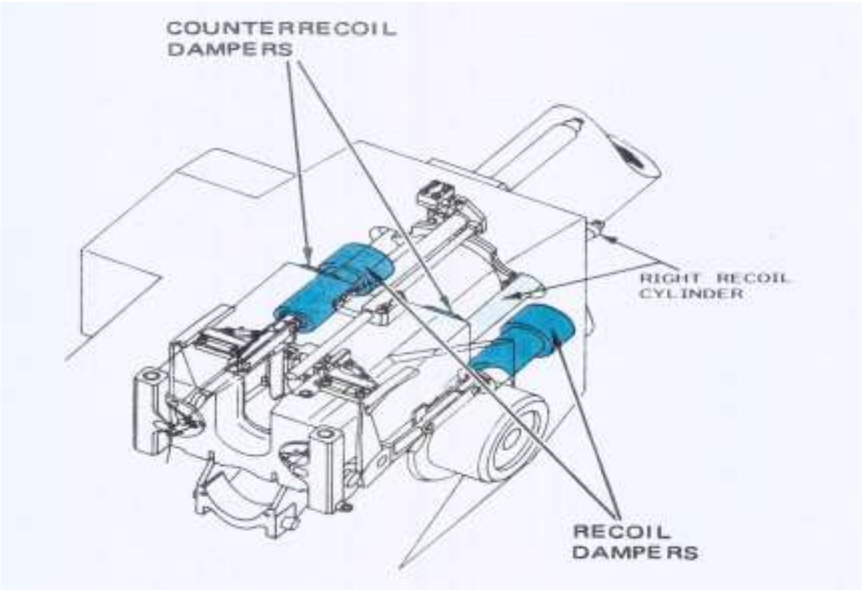


**Figure 1-5: Recoil and Counterrecoil Dampers**

## Cold Recoil Jacks

16. Two hydraulic cold recoil jacks are on the forward part of the slide. The recoil jacks are primarily for maintenance work to move the gun in and out of battery. They also move the gun to the hooks position in preparation for firing.

## Gun Port Shield

17. The gun port shield covers the gun port opening at the front of the weather shield. It provides vertical clearance for elevation and depression movements of the gun barrel and provides a protective closure for the gun port regardless of the gun barrel elevation.

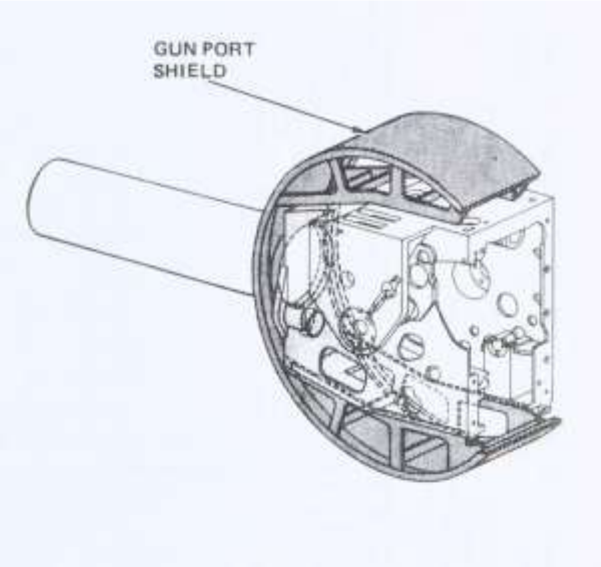


**Figure 1-6: Gun Port Shield**

## Elevation Arc

18. The elevation arc is driven by the elevation drive pinion and elevates and depresses the gun barrel in response to local or remote signal orders. The buffer pad acts as a physical stop to prevent the barrel from exceeding its prescribed elevation/depression limits. The elevation response sector gear provides a mechanical input to the elevation synchros.

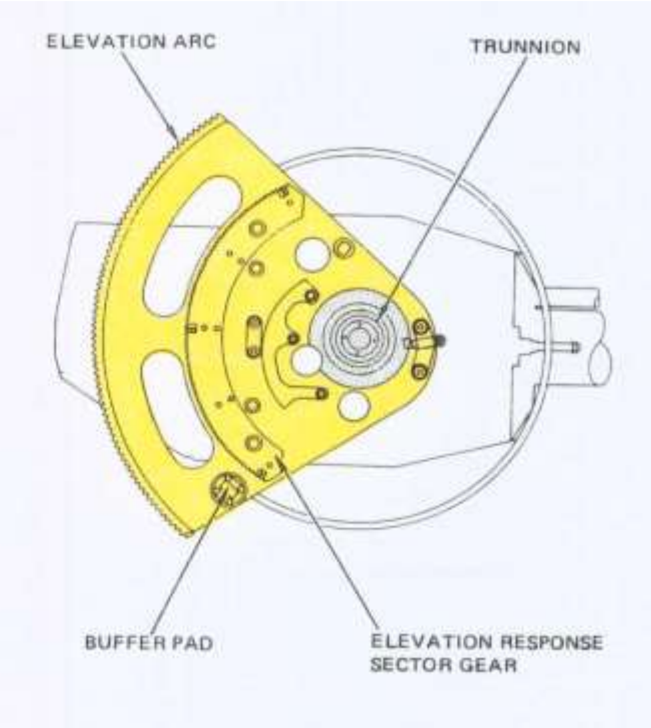


**Figure 1-7: Elevation Arc**

## Trunnions

19. There are two trunnions – one on either side of the slide (see Figure 1-3). These allow the slide and gun barrel to swing between the trunnion supports for elevation and depression movements.

## Firing Cutout Mechanism

20. The firing cutout mechanism serves two purposes:

a. Prevents firing of the gun when the barrel is not pointing in a safe to fire zone; and

b. Prevents firing when the gun mount is not synchronised with the train and elevation signals from the Mk92 Fire Control System

21. The firing cutout mechanism is operated by a solenoid. When the firing cutout solenoid de-energises, operation of an attached mechanical linkage and cam prevents operation of the firing pin.

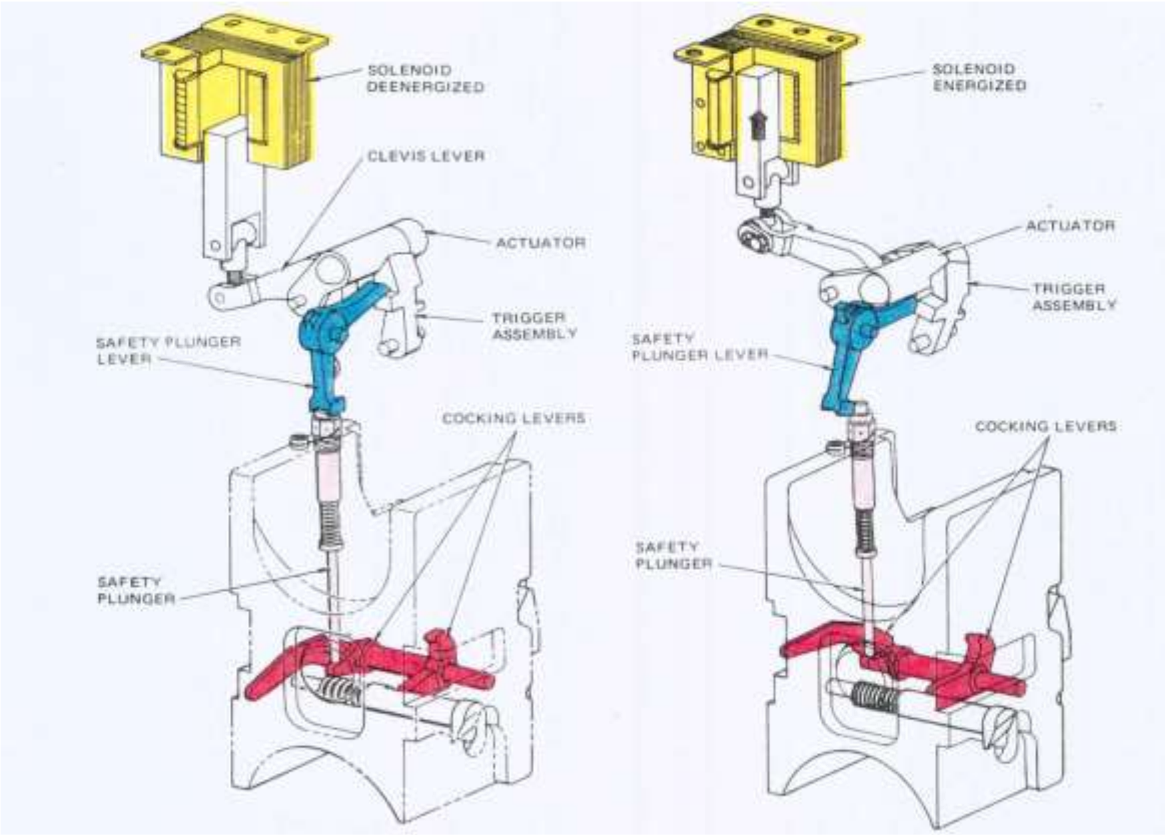


**Figure 1-8: Firing Cutout Mechanism**

## Counterrebounding Mechanism

22. The Counterrebounding mechanism ensures that the round rammed into the barrel chamber remains seated until the breech block closes. The round is held in the chamber by a spring loaded lever assembly which releases when the gun recoils. The manual release lever (see Figure 1-4) is used to override the operation to remove misfired or rammable rounds.

## Hydraulic System

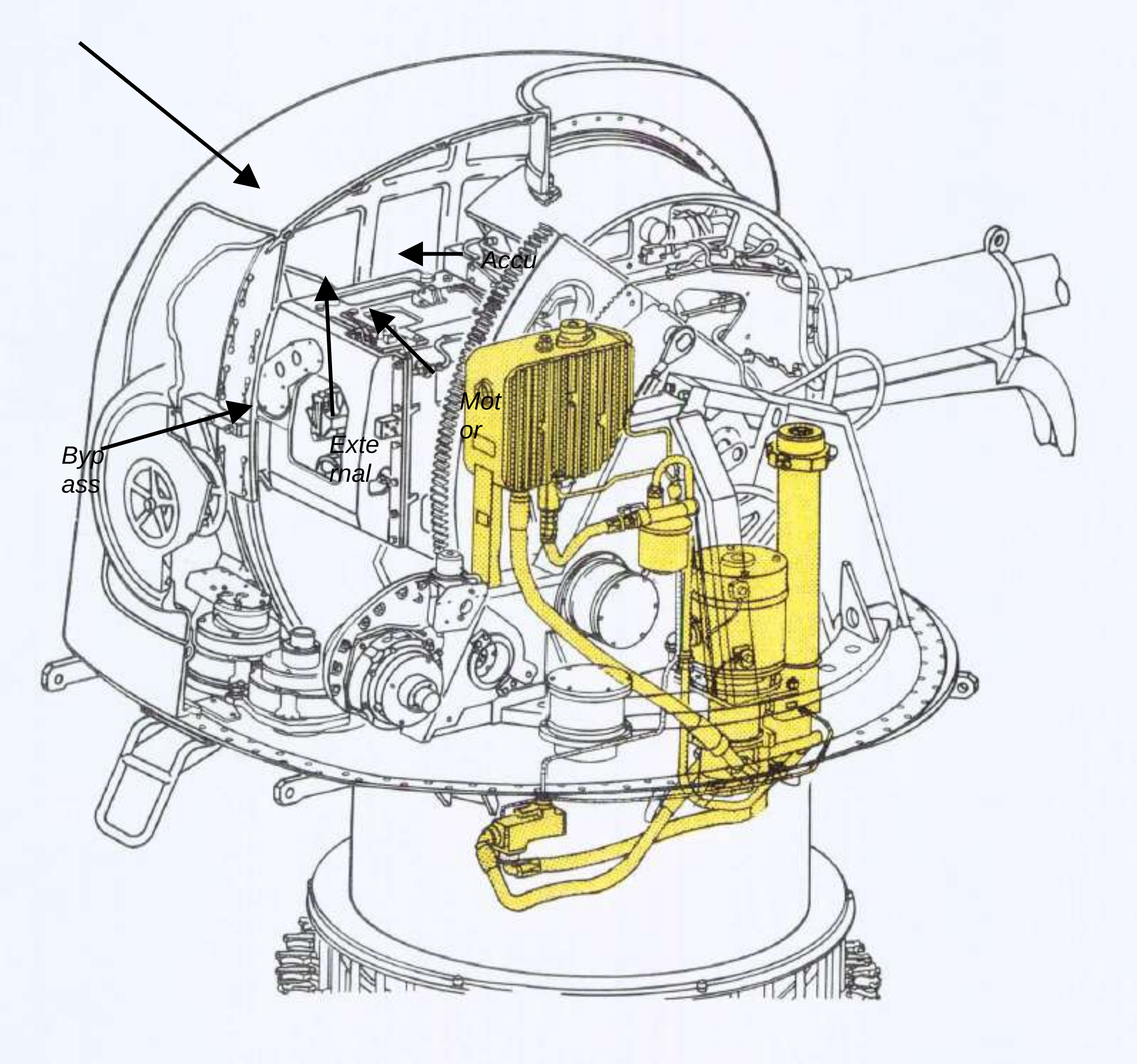


**Figure 1-9: Upper Gun Hydraulic System**

23. The hydraulic system is comprised of the following components:

a. Tank Assembly – Acts as a 40L reservoir and also provides for heat dissipation;

b. Accumulator – stores pressurised fluid to maintain system pressure and to cushion system pulsations;

c. Pump/Motor – Supplies oil pressure to the system;

d. External Filter – Removes contaminants from the system; and

e. Bypass Valve – Reduces the starting load on the pump/motor assembly

## Train and Elevation Drive Systems

### Train Drive

24. The train drive system rotates the gun mount in a horizontal plane relative to the deck. Two low inertia DC motors drive a reduction gear assembly which produces a maximum train rate of 65° per second.

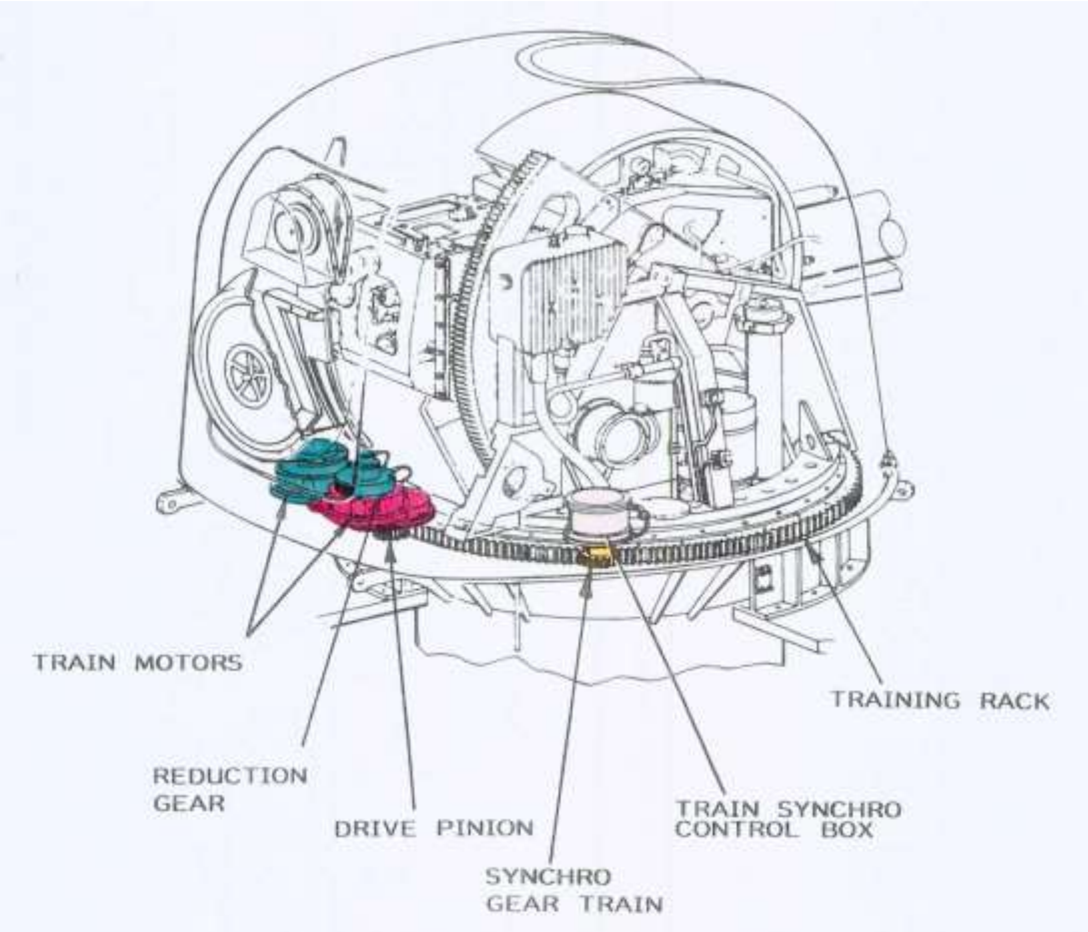


**Figure 1-10: Train System locations**

25. As the gun moves, a train response shaft rotates synchros by way of gearing at the base of the synchro control box.

26. Two Control Transformers (CTs) receive signals from the FCS and generate error signals which regulate the current applied to the train motors.

## Elevation Drive

27. A single low inertia DC motor (identical to the train motors) drives the elevation arc, connected to the slide, in order to elevate or depress the barrel. Similar to the train drive system, the motor is connected to a reduction gear assembly. The output of this assembly produces a maximum elevation rate of 40° per second.

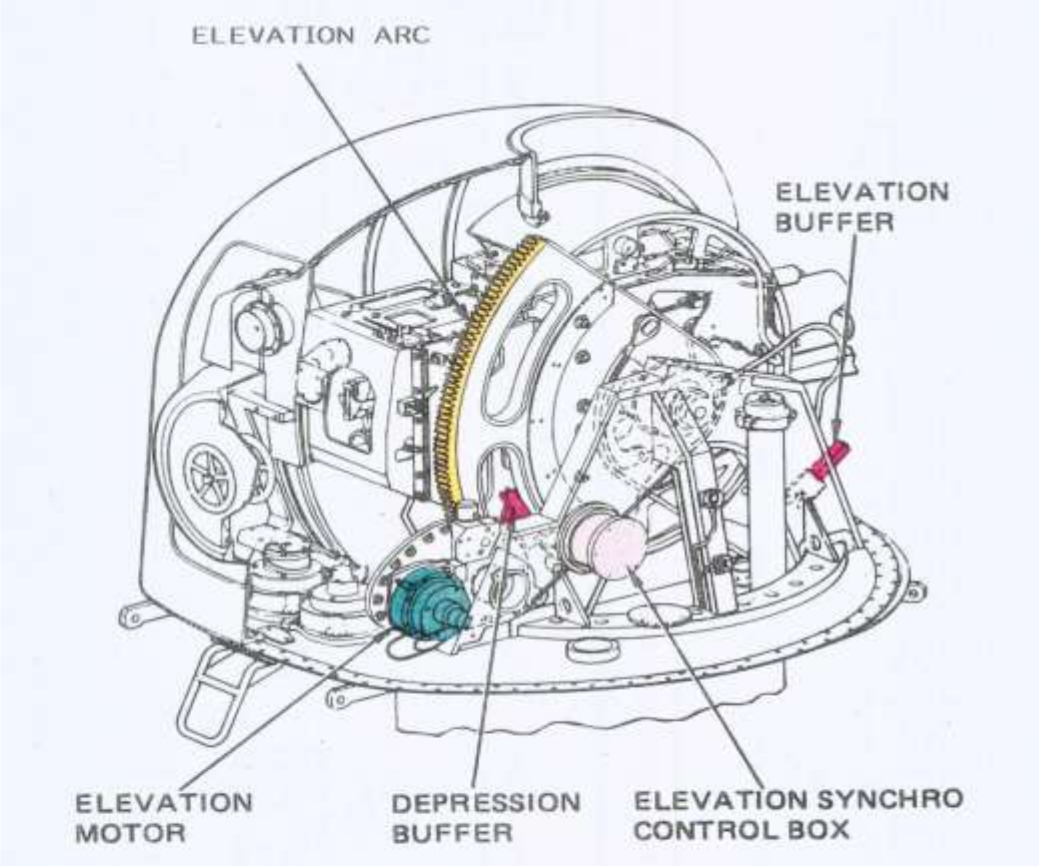


**Figure 1-11: Elevation System locations**

28. Two Control Transformers (CTs) receive signals from the FCS and generate error signals which regulate the current applied to the train motors.

29. Elevation and depression buffers (hydraulic) and an electrical limit stop system restrict elevation and depression movements to between -15° and +85°.

# Gun Barrel and Weather Shield

## Gun Barrel

30. The main components of the gun barrel are:

   a. Barrel liner;

   b. Barrel Tube;

   c. Bore Evacuator;

   d. Water Jacket;

   e. Muzzle Brake; and

   f. Associated barrel components

### *Barrel Liner*

31. The barrel liner contains a chamber for the round rammed into the breech. A rifled bore imparts a stabilising rotational movement to the fired projectile.

32. It has 20 longitudinal grooves which form passageways between the liner and the tube for the flow of cooling water. It also has 6 vent holes which pass through the liner to the bore evacuator.

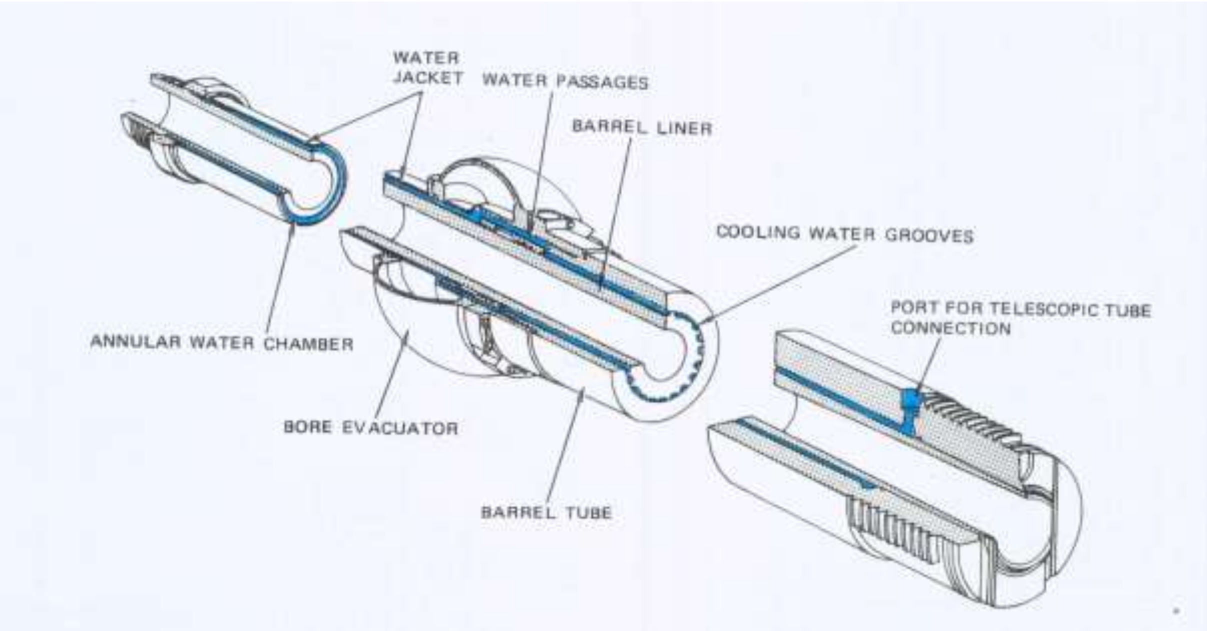


**Figure 1-12: Gun Barrel cutaway view**

### *Barrel Tube*

33. The breech end of the barrel liner fits into the barrel tube. The liner is retained by a coupling ring and an interrupted thread section secures the barrel to the breech housing.

### *Bore Evacuator*

34. The bore evacuator expels propellant gases from the barrel liner. As the projectile passes the six vent holes of the bore evacuator, gases under pressure from the burning propellant enter the spherical chamber via the vent holes. As the projectile leaves the barrel, the propellant gases are no longer confined to the bore. As a result, the pressure in the bore rapidly drops. The pressure built up in the chamber of the bore evacuator jets out of the six vent holes angled towards the muzzle end of the barrel. This jetting action carries any propellant gases remaining in the bore out through the muzzle.

## *Water Jacket*

35. The water jacket extends from the bore evacuator to the muzzle brake. Cooling water is discharged through an outlet at the muzzle end of the water jacket..

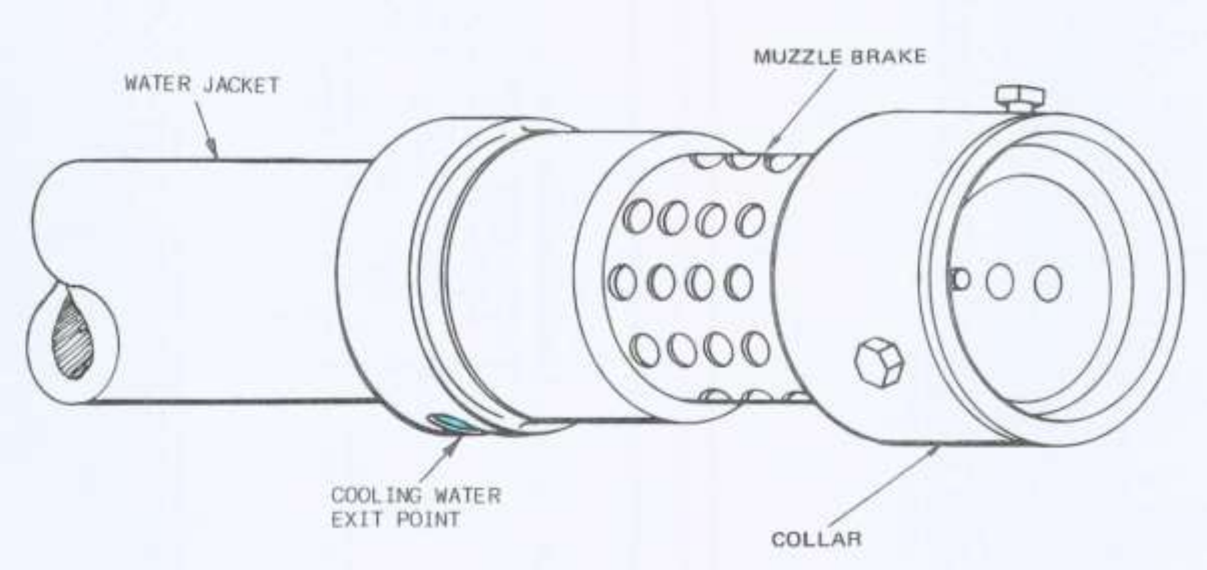


**Figure 1-13: Muzzle brake**

## *Muzzle Brake*

36. The muzzle brake has two primary purposes:

a. Reduce gun recoil; and

b. Reduce muzzle blast.

37. Propellant gases jetting out of the angled ports in the muzzle brake create a counteracting force to recoil. The collar is positioned to cover a desired number of ports to obtain the optimum counteracting force.

## *Associated Barrel Components*

38. A thermistor is mounted on the coupling ring behind the bore evacuator. It provides a warning of excessive barrel temperatures. It is electrically connected to two warning lamps on the Gun Control Panel (GCP).

39. A ground strap is connected between the bore evacuator and the slide to provide continuity of radio frequency (RF) shielding.

## Upper Gun Loading System

40. The delivery path through the upper gun will take a round from the last station screwfeeder through the following components:

a. Rocking Arms

b. Loader Drum

c. Transfer Tray

d. Rammer Assembly

## Rocking Arms

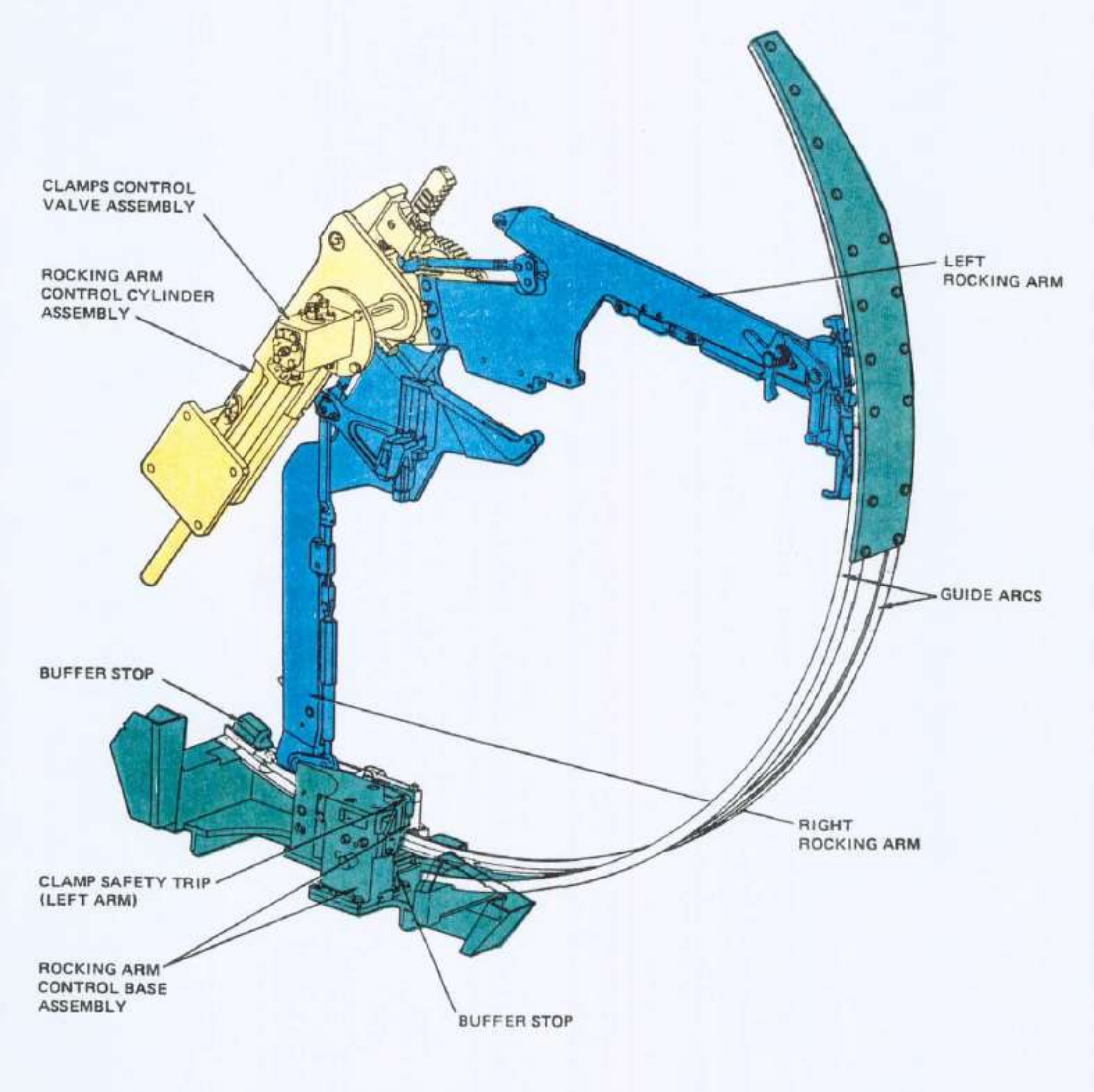


**Figure 1-14: Rocking Arm Assembly**

41. The hydraulically operated rocking arms transfer ammunition from the last station screw feeder to the loader drum. The rocking arms have a swinging motion and move alternately in opposite directions. When an arm is at the end of its upward travel to deliver a round to the loader drum, the other is at the end of its downward travel to take a round from the last station screwfeeder.

42. Hydraulically and mechanically operated clamps at each end of the rocking arms hold ammunition while in transit between the screw feeder and the loader drum. At the start of a rocking arm cycle the clamps on the raised arm open to release a round to the loader drum. Simultaneously, the clamps on the lowered arm close to take a round from the last station screw feeder. The rocking arm cycle speed when empty is between 110-120 cycles per second.

## Loader Drum

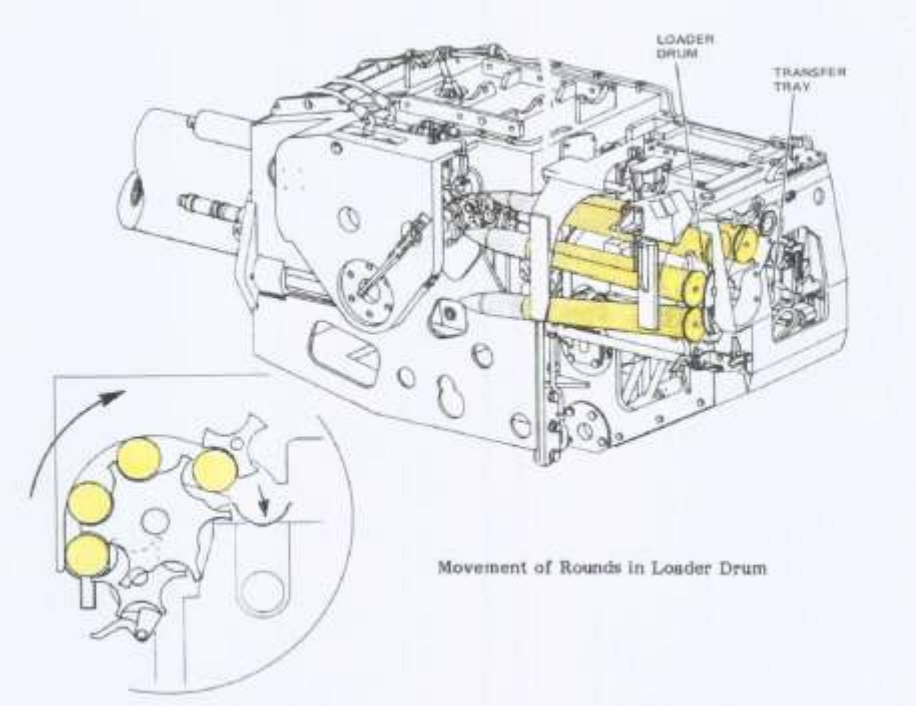


**Figure 1-15: Loader Drum**

43. The hydraulically operated loader drum assembly is synchronised with the operation of the rocking arms. The loader drum has two shaft mounted disks (star wheels) with u-shaped cutouts to receive ammunition from the Rocker Arms. A round received by the Loader Drum is moved one position at a time, through 4 stations. From the last station, upon completion of the firing circuit, a round is deposited in the transfer tray for ramming into the gun barrel chamber.

## Transfer Tray

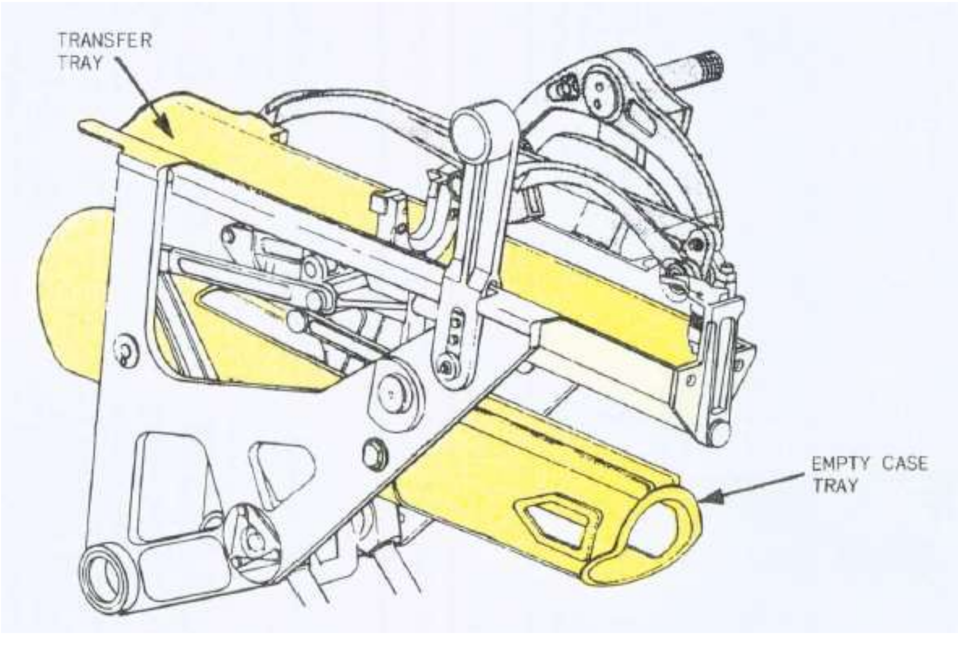


**Figure 1-16: Transfer Tray Mechanism**

44. The transfer tray is connected to the recoiling mass and pivots on two supports which are fixed to the slide. During recoil and counter-recoil actions of the gun, the transfer tray moves in an up and down swinging arc.

45. In the up position the transfer tray is positioned to accept a round from the loader drum and the empty case tray, which is attached to the lower part of the transfer tray, is aligned with the chamber in order to receive the spent cartridge case. As the tray moves to the down position the rammer assembly extends, performing two functions:

a. It rams a round into the chamber , and

b. It pushes the empty case of the previously fired round out of the empty case tray into the empty case ejector chute. The spent case then ejects through the chute and out of the gun mount.

## Rammer Assembly

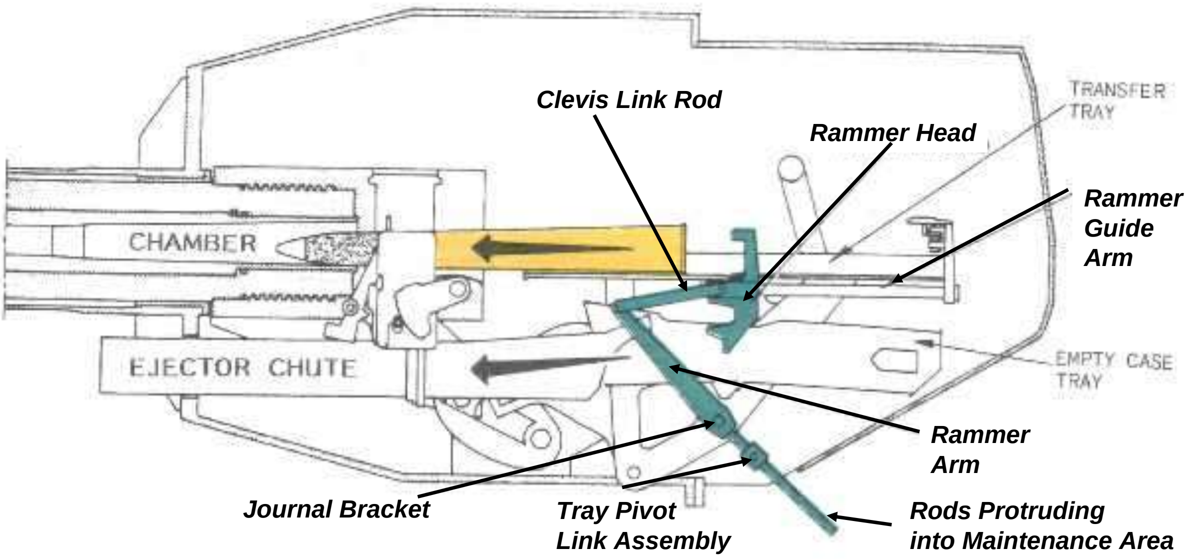


**Figure 1-17: Rammer Assembly**

46. Before the gun release mechanism can free the linkage holding the gun at the hooks position, two mechanical interlocks, which are called *consents*, need to be made. The first is the 'empty case consent'. This consent ensures that the spent cartridge has been extracted and is sitting in the empty case tray. Prior to the shoot this consent is made manually by the gun maintainers but after each round is fired the spent case must be in the empty case tray to make the consent.

47. The second consent is the 'round on tray consent' which is satisfied by the round dropping on the transfer tray. With both consents made the two roller arms drop onto their respective hooks which frees the angled levers.

48. As the gun leaves the hooks the transfer tray lowers to align the round with the chamber. The rammer assembly operates like a catapult. As the tray swings down force is applied on the rammer arms through the journal brackets. As the rammer arms pivot forward the rammer head travels forward to ram the round into the chamber. At the same time the lower part of the rammer head pushes the empty case into the ejector chute and onto the weather deck.

## Lower Gun Loading System

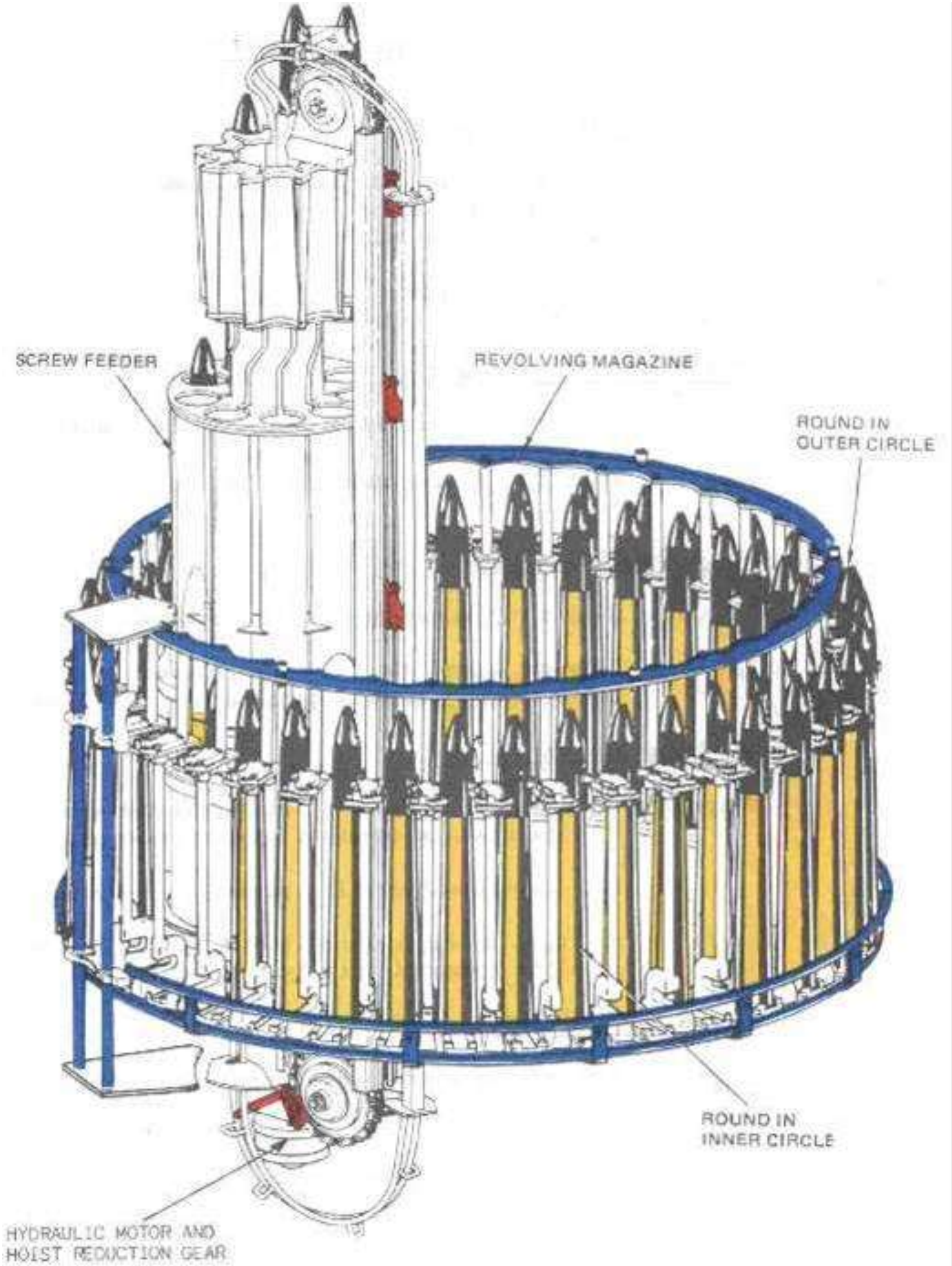


**Figure 1-18: Lower Gun Assembly**

## Revolving Magazine

49. The revolving magazine is able to hold a maximum of 70 rounds in the inner and outer circles. As the magazine rotates, rounds are fed into the screwfeeder where they are raised to the upper gun assembly.

## Screwfeeder

50. The screwfeeder is driven by a hydraulic motor and is geared to the revolving magazine. It holds up to six rounds. After a round leaves the last station of the screwfeeder it enters the upper gun assembly.

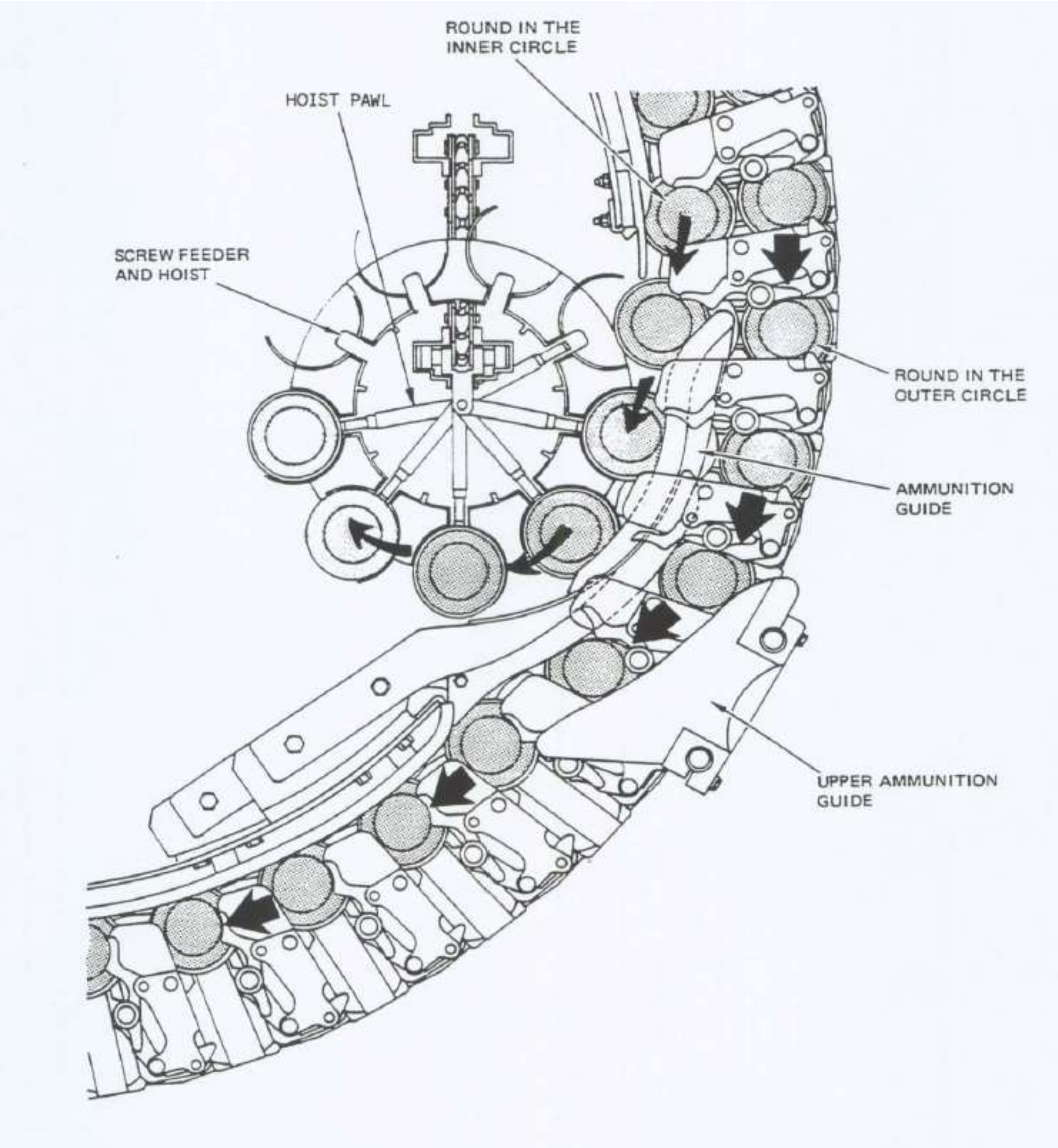


**Figure 1-19: Transfer of Rounds from Outer Ring to Inner Ring to Screwfeeder**

## Equilibrator and Compensator Assembly

51. The equilibrator and compensator assemblies operate together to perform three functions:

a. Counterbalance the gun;

b. Compensate for the shifting center of gravity of the barrel and breech assemblies that occurs during recoil/counterrecoil and during elevation/depression movements.

c. Stop counterrecoil movement of the gun if a short recoil fails to eject the empty powder case from the gun barrel.

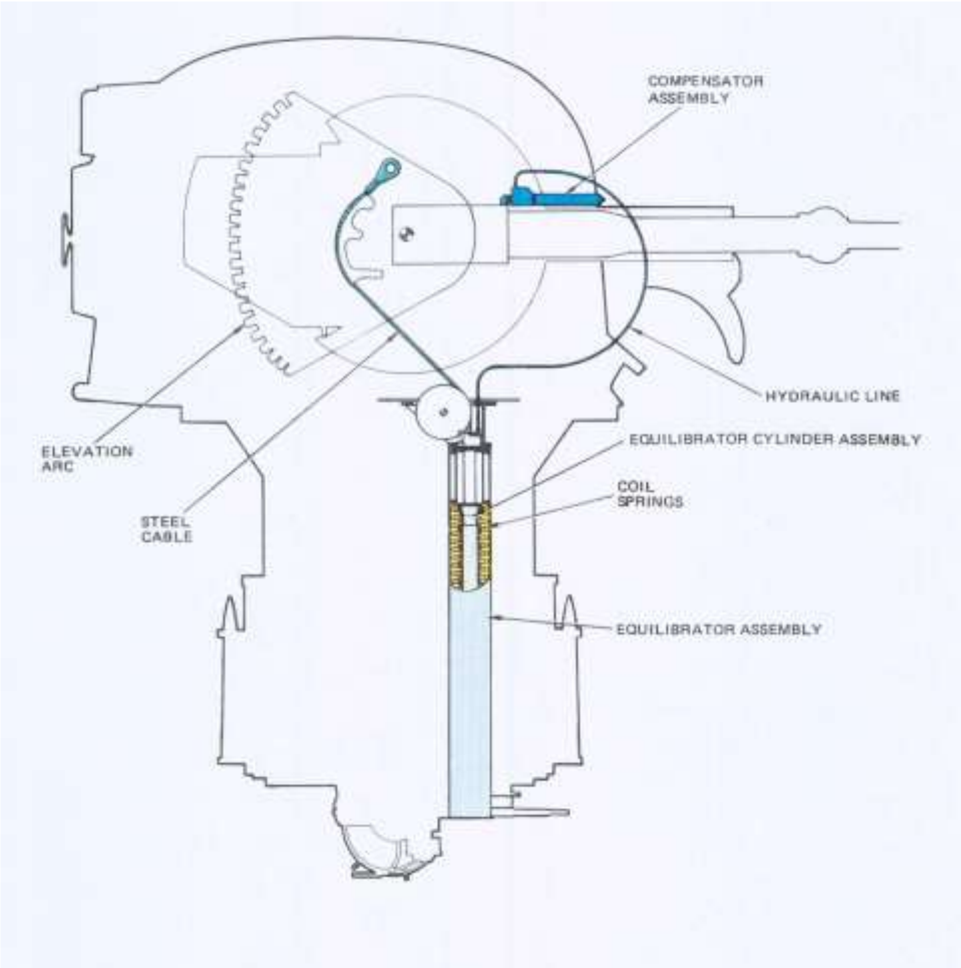


**Figure 1-20: Equilibrator and Compensator Assemblies**

52. The equilibrator is attached to the bottom of the carriage and extends down inside the revolving magazine assembly. It consists of an equilibrator cylinder assembly and two sets of coil springs. A steel cable extends from a spring seat at the bottom of the equilibrator to the elevation arc. In operation, the coil spring tension pulls on the steel cable to counterbalance the gun as it elevates and depresses.

53. The compensator assembly is a hydraulic cylinder attached to the slide above and parallel to the gun barrel. A hydraulic line connects the compensator assembly to the equilibrator cylinder assembly in the equilibrator. As the gun recoils and counterrecoils, the porting of hydraulic fluid between the compensator assembly and the equilibrator cylinder assembly changes the position of the upper spring seat in the equilibrator. This, in turn, varies the counterbalancing spring tension on the steel cable attached to the elevation arc. As the gun moves back in recoil, less counterbalancing force is needed; conversely, when the gun moves forward in counterrecoil, more counterbalancing force is needed.

54. The compensator assembly prevents the flow of hydraulic fluid into the equilibrator cylinder if a short recoil fails to bring the gun back to the hooks position (or if the hooks fail to engage the gun). This prevents counterrecoil of the gun.

## Gun Control Panel (GCP)

55. The GCP is located within the 76mm Magazine and allows the gun to be controlled in 'Local' mode. When the system is in 'Remote', the gun is under the control of the FCS operators.

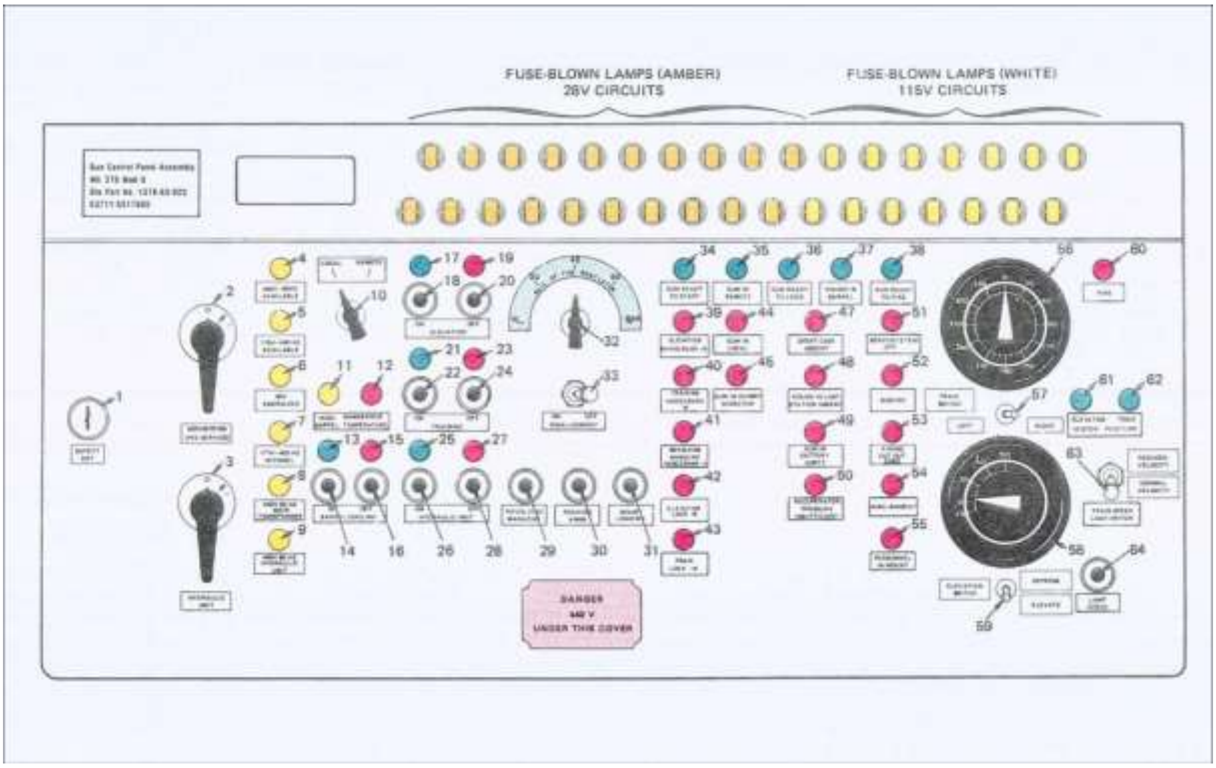


**Figure 1-21: Gun Control Panel**

## *Periodic Inspections*

| Inspection | Period | Conducted By |
|---|---|---|
| Upper Series Inspection (USI) | Conducted every 400 Effective Full Charges (EFC) and/or six monthly, which ever occurs first | Contractor |
| Lower Series Inspection (LSI) | Conducted every 400 Effective Full Charges (EFC) and/or six monthly, which ever occurs first | Contractor |
| Refit Series Inspection (RSI) | Conducted at a three yearly cycle – generally programmed to coincide with a SRA/DSRA and in conjunction with either a LSI or USI | Contractor |
| In-Service Mechanical Adjustment and Timing (ISMAT) | Conducted Annually | FSU |
| In-Service Motor Evaluation Program (ISMEP) | Conducted Annually | FSU |

**Table 2: Mk75 Periodic Inspections**

## Ammunition

56. The Mk 75 Gun fires 76 mm ammunition which comes in a number of types as detailed below:

| Designation | Description | Purpose |
|---|---|---|
| HEPD | High Explosive Point Detonating | SU/NGS |
| HEIR | High Explosive Infra-Red | AA |
| HEVT | High Explosive Variable Time | AA |
| TP-S | Target Practice - Spotting | Exercise AA |
| TP | Target Practice | Exercise AA/SU |

**Table 3: 76mm Ammunition Types**

57. In addition, clearing charges (a modified cartridge without a projectile), a gauge round used for system alignment checks and a rammable drill round are available.

58. The Rammable Round is used to prove the loading, ramming and firing initiation mechanism and test round extraction. It is also used for pre-fire checks and misfire drills. Eight rounds are issued per ship.

59. The ammunition consists of a cartridge and projectile, but unlike many other ammunition types, the cartridge and projectile are assembled during manufacture to form a single 'bullet'.

60. The ammunition is stored horizontally in protective casings or tanks which are designed to protect the rounds from excessive moisture and physical blows. The tanks have a removable base permitting the round to be removed from the tank while leaving the tanks secured in the rack. Rounds are usually loaded directly from the racks to the Revolving Magazine: a process which normally requires two loading personnel, but may be accomplished with one, albeit more slowly.

61. The ammunition is percussion fired, which requires a firing pin to strike the base of the round, hence the requirement to prevent inadvertent striking of the round.

62. Each of the types of rounds fired has a different mass and mass distribution, which will affect its trajectory on being fired. Therefore, ballistic corrections, calculated in WCP, will be different for each round type. Furthermore, the round type must be entered at the WCC prior to firing, to enable WCP to make the appropriate ballistic corrections. Currently, the program only contains accurate ballistic coefficients for HEIR and HEPD rounds.

## Hot Gun

63. The barrel cooling system is designed to facilitate the gun's high firing rate and maintains the barrel at a suitable temperature to maintain safety of any round. In a casualty mode (no barrel cooling) the gun will normally achieve a hot gun condition after 50 rounds in 4 hours.

## Misfire

64. The definitions and procedures for a misfire in the 76mm gun are laid down in **SW300-BC-SAF-010.** The steps to be taken are as follows:

a. GCP operator to identify that the MISFIRE indicator is illuminated.

b. Wait 30 secs for possible hangfire;

c. GCP operator to take mount into LOCAL control;

d. Train mount to safe bearing as directed by PWO/AWO and depress barrel to 0° elevation;

e. If a ‘hot gun’ situation existed at the time of the misfire, the round needs to be cleared within 10 minutes otherwise the potential for ‘cook off’ exists. If the round cannot be removed in this time frame, internal barrel cooling needs to be established and the mount kept clear for two hours. This situation would only exist if barrel cooling was not operating during the firing.

f. In a normal ‘cold gun’ situation, a two-man team will enter the gun and follow the relevant procedures to remove the misfired round.

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# Chapter 2. Guided Missile Launching System (GMLS) Mk 13 Mod 4

## *Introduction*

1. The Guided Missile Launching System (GMLS) Mk 13 Mod 4 is one of the major subsystems of the Mk 92 Fire Control System. Its purpose is to load and fire Surface to Air Missiles (SAMs) and Surface to Surface Missiles (SSMs). It stows, selects, loads, initialises and fires missiles in response to orders from the Mk 92 Fire Control System or Harpoon Ship Command Launcher Control System (HSCLCS).

## *System Inputs*

2. The GMLS requires the following inputs from the ship:

   a. 440V 60Hz 3$\phi$

   b. 115V 400Hz 1$\phi$

   c. 440V 400Hz 3$\phi$

   d. Zdo (for remote dud jettison stabilisation)

   e. FCS (Mk 92 or HSCLCS) control and order signals

   f. Chilled Water for the magazine AC plant

## *System Outputs*

3. The GMLS provides the following outputs:

   a. status signals to the FCS

   b. SM2 missiles at a continuous rate of up to approximately one every 10 sec

   c. Harpoon missiles at a rate of approximately 3 per minute.

## *Physical Description*

4. The Guided Missile Launching System (GMLS) Mk 13 Mod 4 consists of three main components:

   a. Missile Launching System Control consisting of:

      i. Power Panel EP1;

      ii. Control Console EP2; and

      iii. Electronics Panel EP3,

   b. The Launcher, and

   c. The Missile Magazine

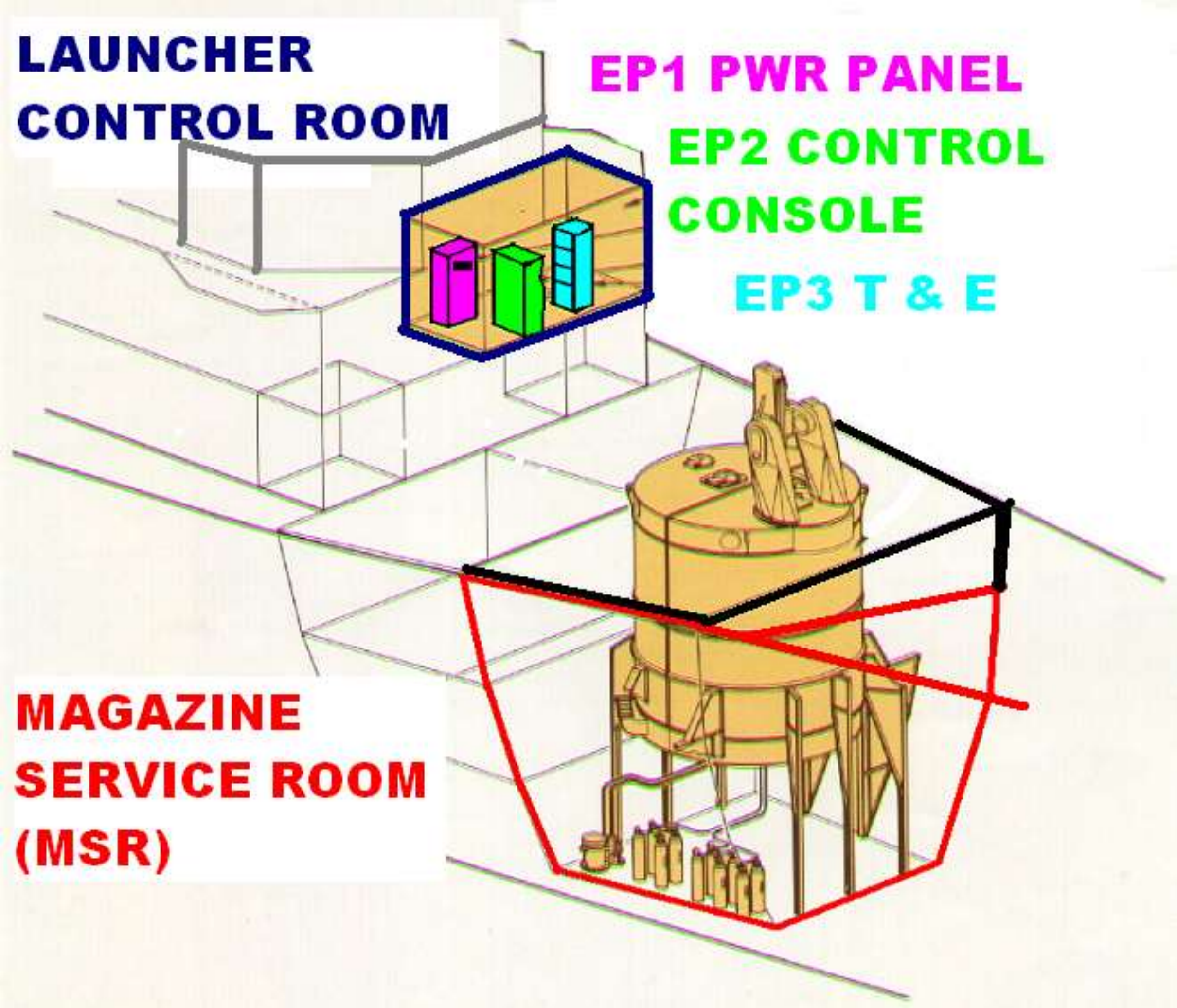



**Figure 2-1: Major GMLS Components**

## Launching System Control MARK 162 MOD 0

5. The Launching System Control electronically directs and monitors operation of the GMLS. It includes:

a. EP1 Power Panel,

b. EP2 Control Console, and

c. EP3 Electronics Panel.

## Power Panel

6. The Power Panel (EP1) is the primary distribution panel for electrical power from ship supplies. The panel contains circuit breakers, contactors, overload relays and switches for the power supplies.

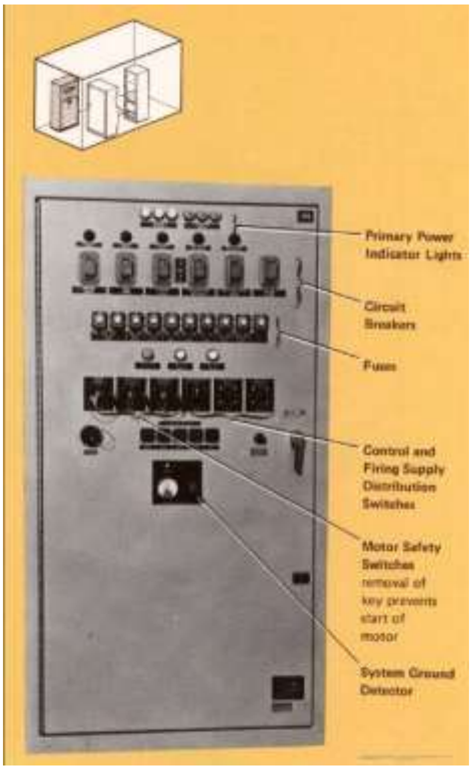



**Figure 2-2: EP1 - Power Panel**

## Control Console

7. The Control Console (EP2) is the operational control panel for the GMLS. This panel contains the switches, PCBs, DC power supplies and other electrical components that select and control the type of operation performed by the launcher. Indicators on the panel constantly display system status so that all phases of system operation can be monitored.

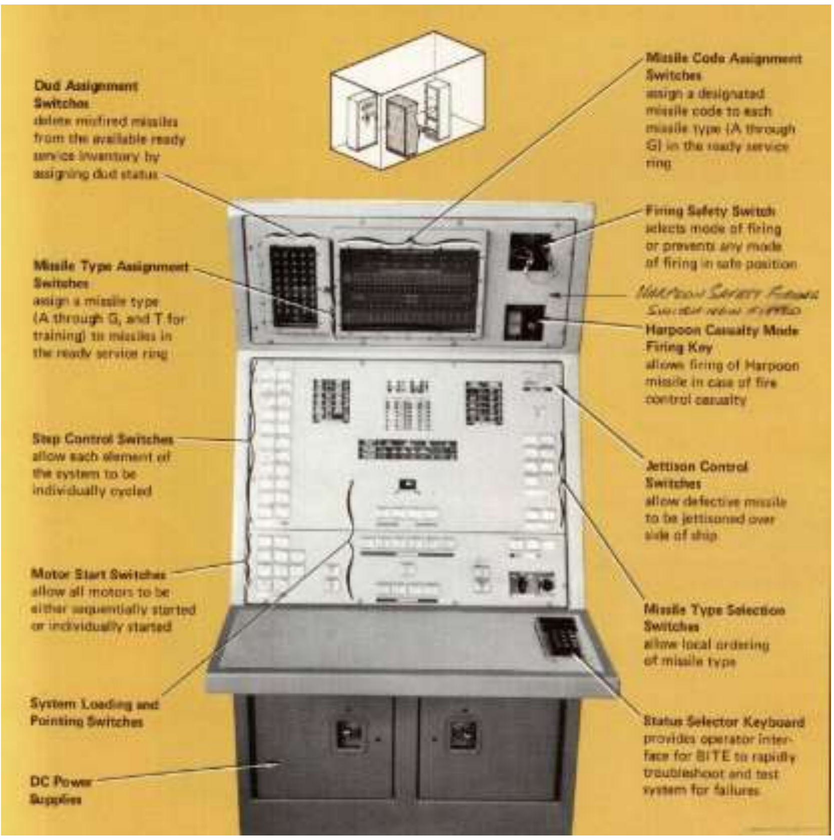



**Figure 2-3: EP2 - Control Console**

## Electronics Panel

8. The Electronics Panel (EP3) is a combination of a local control panel and a test panel. The EP3 panel contains the electronic servo control unit, the digital director, switches, indicators, jack plug connections and various electronic components. The electronic servo control unit is the electrical control portion of the train and elevation power drives. The digital director controls the operation of the launcher train and elevation systems in local, load/unload, dud jettison, strikedown and test operations.

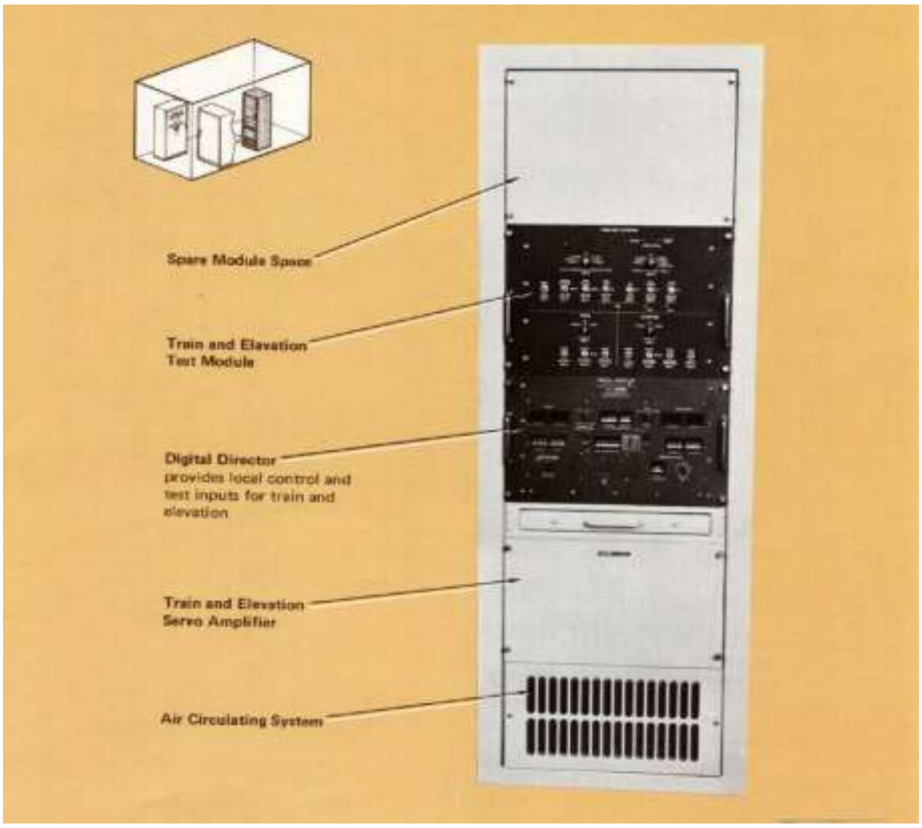



**Figure 2-4: EP3 - Electronics Panel**

## Guided Missile Launcher MARK 116 MOD 2

9. The single arm launcher receives missiles from the ready service ring (RSR). The major components of the launcher are:

a. Train Power Drive

b. Elevation Power Drive;

c. Guide Arm; and

d. Carriage.

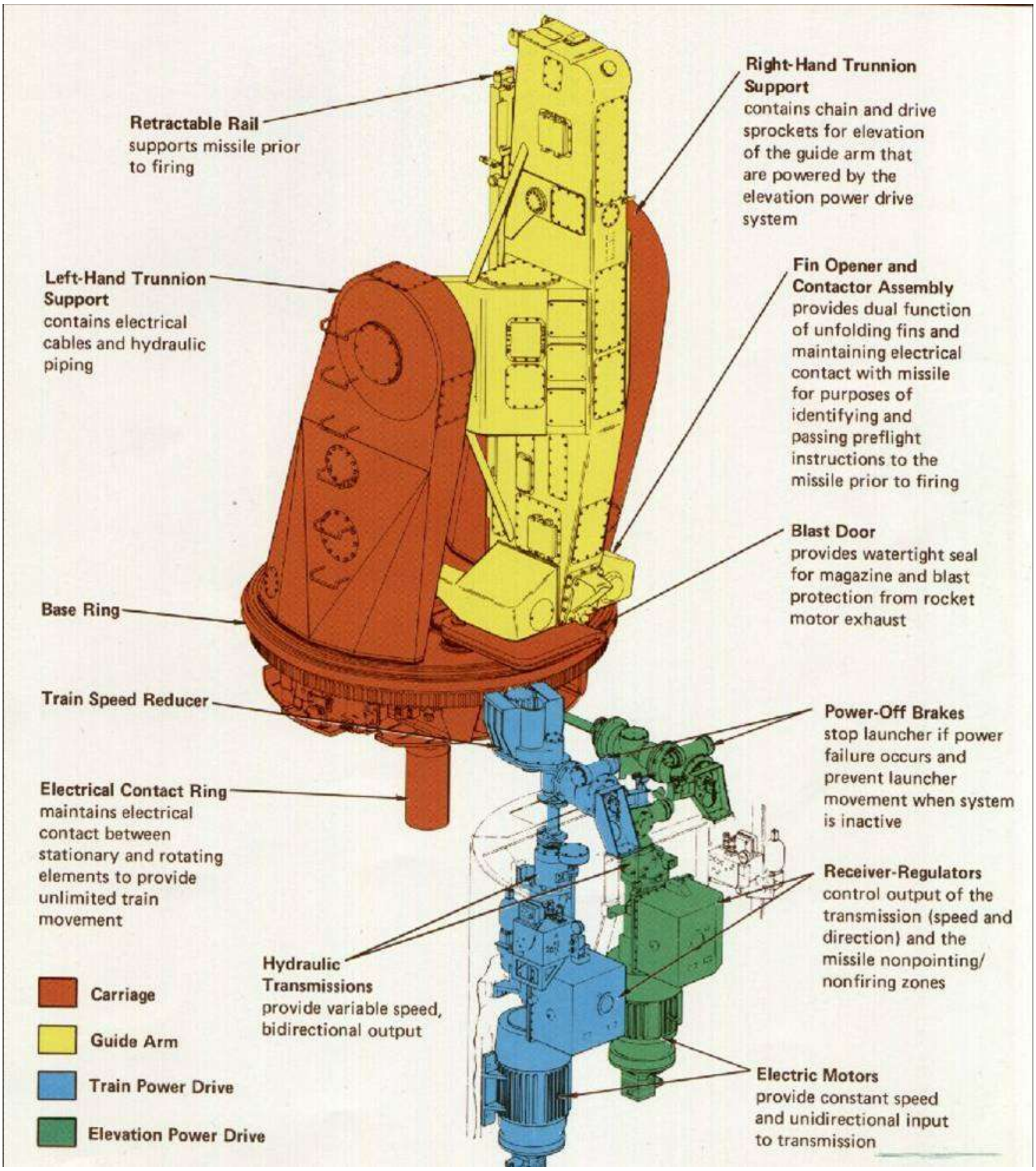



**Figure 2-5: GMLS Major components**

## Guide Arm

10. The guide arm elevates and depresses on its lateral axis between the trunnion supports. Slack cables provide electrical connections between the carriage and the guide arm to allow movement of the guide arm. Major components are:

a. Missile Identification Probe;

b. Jettison System;

c. Retractable Rail;

d. Forward and After Motion Latches; and

e. Fin Opener and Contactor

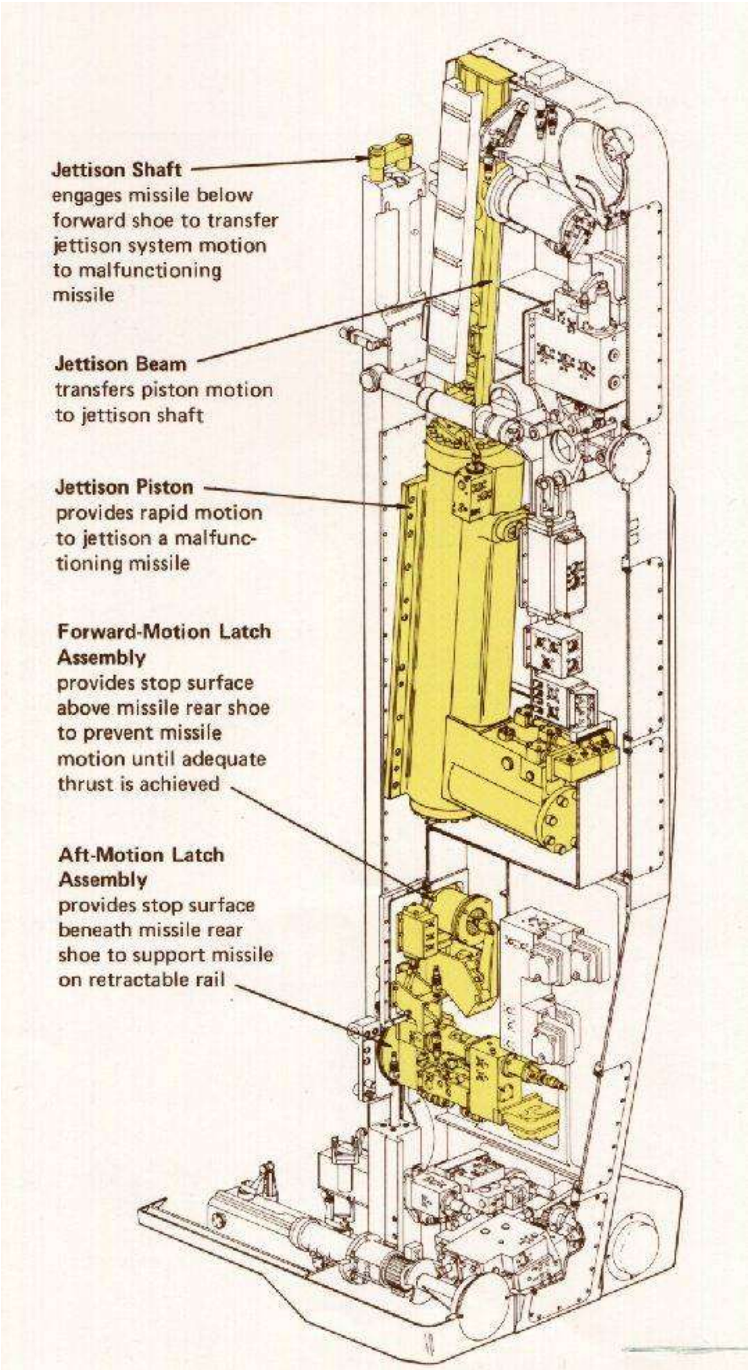



**Figure 2-6: GMLS Guide Arm Assembly**

## Carriage

11. The structural units of the carriage include the base ring and two trunnion supports. A blast door, which is part of the base ring assembly, covers the opening through which missiles pass from the magazine to the guide arm. Mounted below the base ring is a planetary differential gear assembly for the elevation drive that allows the system to elevate properly regardless of train movements.

## Train and Elevation Power Drives

12. Train and Elevation Power drives position the launcher in response to orders from either the FCS or the local launching system control. The train power drive rotates the carriage in a horizontal plane; the elevation power drive elevates or depresses the guide arm in a vertical plane.

13. The major components of the Elevation and Train Power Drives are:

a. Power Off Brakes;

b. Receiver Regulators;

c. Electric Motors;

d. Hydraulic Transmissions; and

e. Train Speed Reducer

## Guided Missile Magazine MARK 109 MOD 0

14. The Magazine contains the major structural components used to support the launcher and missile complement. The main components of the Magazine are:

a. Magazine Structure - includes base, inner structure, outer shell and stand;

b. Ready Service Ring (RSR) - rotatable structure that contains an inner and outer ring which stores a maximum of forty (40) missiles in ready service; it occupies the space between the inner structure and outer shell.

c. Power Drive - a single electric motor and hydraulic pump (located in the inner structure) to drive either the hoist or RSR.

d. Hoist - raises a missile from the RSR to guide arm or, conversely, lowers a missile from the guide arm to the RSR.

15. The base not only adds lateral strength to the outer shell, but also contains all service connections. It serves as a plenum chamber for containing and venting missile blast gases from accidental ignition of a rocket motor in the magazine. The train and elevation power drives and the power drive for the RSR and hoist are in the cylindrical cavity inside the inner structure. The stand is both a cover for the magazine and a mounting platform for the launcher.

16. The hoist consists of an opened roller chain that moves in a track and is driven by a hydraulic power drive system. The hoist system raises/lowers missiles in either inner or outer cells of the RSR by connecting the end of the roller chain to either the inner hoist pawl or the outer hoist pawl, respectively.

17. The RSR rotates in either a clockwise or counter clockwise direction, corresponding to the shortest travel distance from the selected missile to the hoist position. Since one power drive serves both the hoist and the RSR, interlocks prevent their simultaneous operation.

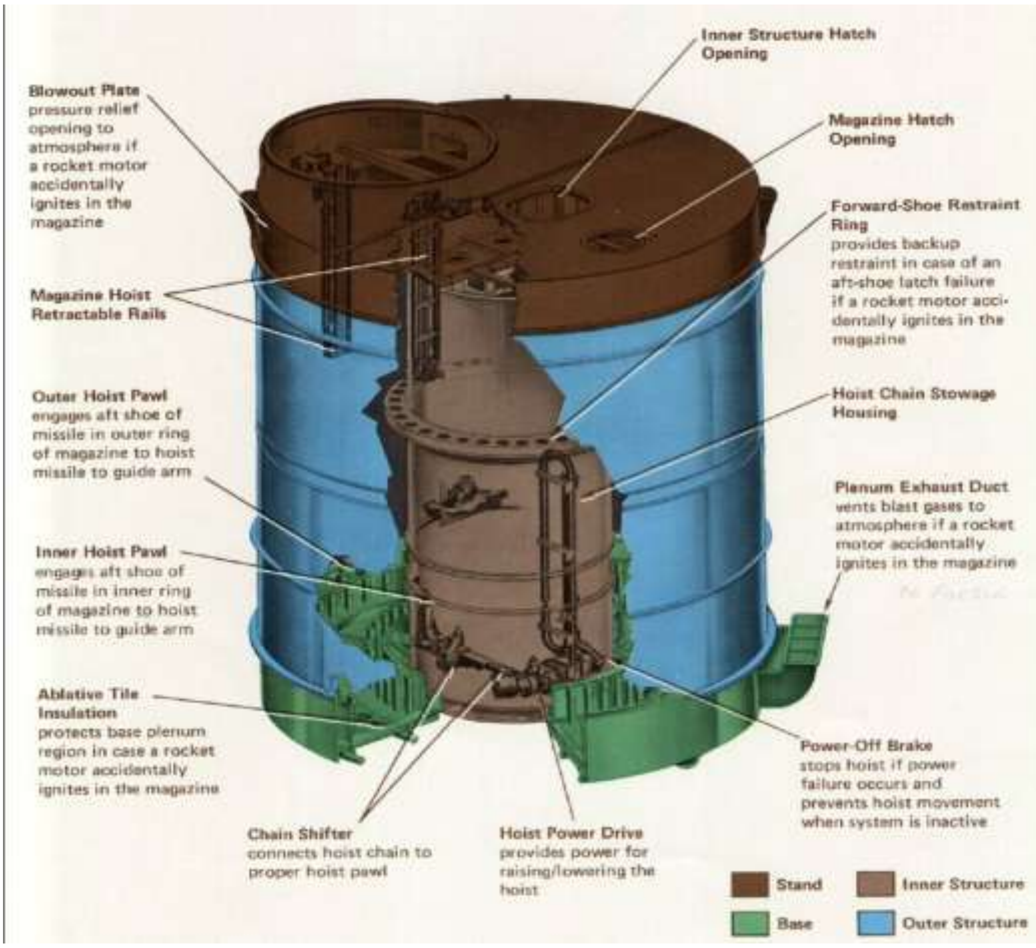



**Figure 2-7: GMLS Magazine**

## Auxiliary Equipment

18. The Mk 13 Mod 4 has several auxiliary systems to ensure safe and proper GMLS operation. These systems are:

a. Sprinkling system that automatically provides direct spray to suppress fire and heat and cool missile warheads in the magazine under control of heat sensing devices;

b. Water injection system that directs high pressure water directly into the rocket motor exhaust if a rocket motor accidentally ignites in the magazine;

c. Anti-icing system that prevents ice formation on moving components of the guide arm, carriage, and stand to ensure proper launcher operation at low temperatures. The system ensures the launcher will operate when subjected to -20° F with a 40 knot wind and sea spray equivalent to an ice build up of 6"/hr;

d. Magazine ventilation system that maintains proper temperatures and humidity in the magazine using the ship air conditioning system;

e. Two independent carbon dioxide systems that automatically discharge $CO_2$ to suppress fire in the magazine or the inner structure machinery space under control of heat sensing devices. Also, the system can be manually actuated, either locally or remotely; and

f. Nitrogen system that supplies pressurised nitrogen for charging hydraulic accumulators and the nitrogen tank of the jettison system.

## *Modes of Operation*

19. The GMLS has two modes of local launcher control, Auto and Step.

## Auto Control

20. Auto Control provides automatic sequencing and operation of system components to select, load and ready the missile for firing without any manual switching. Auto control is the normal mode for loading a missile onto the guide arm and for unloading a missile from the guide arm to the magazine.

21. When the launcher is loaded, it trains and elevates to synchronise with the remote order signals from the FCS or HSCLCS. When the launcher position is within 1° of its ordered position, and other ready to fire conditions are satisfied, the missile can be fired.

## Step Control

22. Step Control provides step by step sequencing and operation of GMLS components by manual switching at the Control Console (EP2). The GMLS can be operated in step control to load and launch missiles in a tactical situation.

## *Capabilities*

23. The GMLS stows missiles in the Ready Service Ring (RSR) cells of the magazine. In operation the RSR rotates between the outer shell and the inner structure to put the selected missile at the hoist station. The missile is hoisted onto the guide arm of the launcher. The launcher, mounted on the magazine stand, receives missiles from the magazine for firing. The launcher also strikes down missiles to the magazine during replenishment.

24. As the missiles on the guide arm are readied for flight, the launcher trains and elevates (or depresses) in response to order signals from the FCS to aim the missile in the required direction. When the launcher is synchronised with the orders, FCS can initiate firing of the missile. After the missile is fired, the launcher automatically returns to the load position to receive the next missile selected for loading from the magazine.

25. A Launching Control Station contains controls and indicators to control and monitor GMLS operation. Under normal operating conditions, the launcher is remotely operated from the Operations Room under Mk 92 control. The LCS is manned at all times during operations for safety reasons and so that the operator can take local control in the event of system or missile casualty

26. An automatic pointing cutout system prevents pointing a missile at any part of the ship. A firing cutout mechanism prevents firing missiles in areas hazardous to the ship's structure.

27. A dud jettison unit is an integral part of the launcher guide arm. The dud jettison unit ejects missiles overboard when the missile cannot be launched normally.

28. A water injection system functions if accidental missile rocket motor ignition takes place in the magazine. The system discharges a high pressure stream of water into the rocket motor expansion cone to help confine the fire to a missile cell.

29. A sprinkling system cools the missile warhead in the event of fire in the ready service area of the magazine. The ready service area is the area between the inner structure and the outer structure.

30. The GMLS can also strikedown missiles. Strikedown is the operation used to move missiles from the deck to the magazine during replenishment of the magazine or to move missiles from the magazine to the deck during unloading of the magazine. Strikedown equipment includes an air operated chain drive fixture, a strikedown hand control and associated missile handling equipment.

31. The GMLS stows up to 40 missiles in the RSR cells of the magazine. The outer ring stows 24 missiles and the inner ring stows 16 missiles. Usually one of the cells is used for a Guided Missile Test Round (GMTR) Mk 60 Mod 4/6/8. The missiles can be any mixture of STANDARD or HARPOON.

## *Load and Fire Sequence*

32. In response to a *missile select* order from the Mk 92 Fire Control System (FCS) or local order from the EP2, the RSR indexes to bring a missile of the ordered type to the hoist position for loading to the guide arm.

33. In response to a *load* order from the FCS/EP2 with the launcher at the load position, the blast door opens and the elevation positioner extends. The hoist raises to the intermediate position, where the hoist pawl engages the missile. At the same time, the hoist retractable rail extends into alignment with fixed rails in the magazine and the launcher carriage. These rails, along with a track selection on the blast door, form a continuous track for the movement of the missile from the RSR to the guide arm.

34. With the continuous track between the RSR and the guide arm, the hoist raises the missile onto the guide arm. When the missile is in the proper position on the guide arm, an aft motion latch extends to hold the missile on the guide arm.

35. With the missile secured, the contactor engages the missile to provide the interface to the internal missile circuits. When the missile is secured in position on the guide arm, the empty hoist lowers to the magazine position. When the hoist is lowered sufficiently to clear the track section of the blast door, train and elevation positioners retract, the launcher trains and elevates in response to FCS pointing orders, and the blast door closes.

36. When the aft motion latch extends and while the hoist is lowering, a contactor and a missile identification probe engage the missile, and a set of fin openers cranks engage (but don't open) the missile fins. When the hoist is down and the hoist retractable rail retracts, the RSR indexes if a missile select order is present to bring the next missile to the hoist position.

37. The contactor engages the missile to provide the interface to the internal missile circuits. The missile identification probe engages the missile to complete circuits that identify the missile type. When the missile is properly identified, pre-flight data is applied to the missile through the contactor.

38. When the FCS initiates missile firing, the missile batteries are activated, the fin opener cranks open the folded missile fins, the missile is armed, and the forward motion latch unlocks. With these actions complete, the contactor disengages, the missile rocket motor ignites, and the missile is fired.

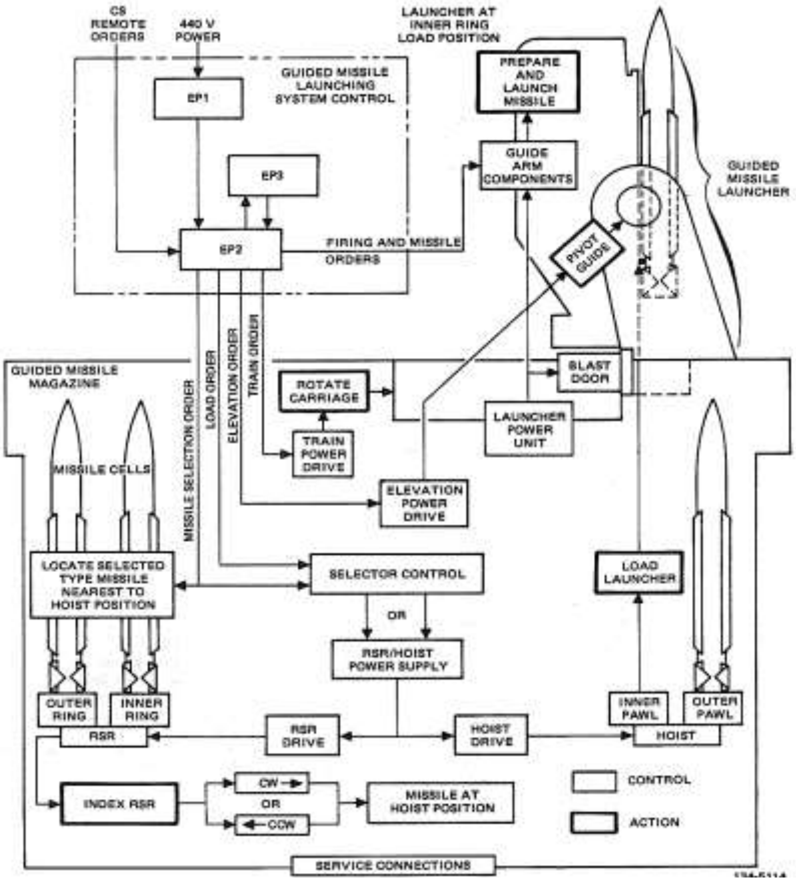



**Figure 2-8: Launcher Load Sequence**

## *Strikedown*

39. Using the strikedown equipment, GMLS personnel can on-load missiles to the guide arm from the Missile Transfer Dolly Mk 6. Using the dolly, missiles can also be off-loaded from the guide arm. The personnel control the movements of the launcher with a portable strikedown hand control.

40. A chain drive fixture attaches to the front of the guide arm for strikedown operations. To secure the chain drive fixture to the guide arm, two quick release pins attach the chain housing to the guide arm. Also, a lever controlled latch engages a block on top of the launcher retractable rail.

41. To load a missile, a hoist chain is driven out of the chain drive fixture through the retractable rail into the dolly. When the chain engages a missile, a pair of latches on the open end of the chain spring latches onto the missile forward shoe. The chain then pulls the missile onto the aft end of the guide arm during onloading or pushes the missile off during off-loading.

42. An air motor (powered by ship's LP air) drives the chain through a gear reduction connected to the chain drive sprocket. An air throttle valve regulates the speed and direction of motor rotation. A pressure regulator causes the air motor to rotate slowly to prevent the chain from buckling when the chain latches engage the missile.

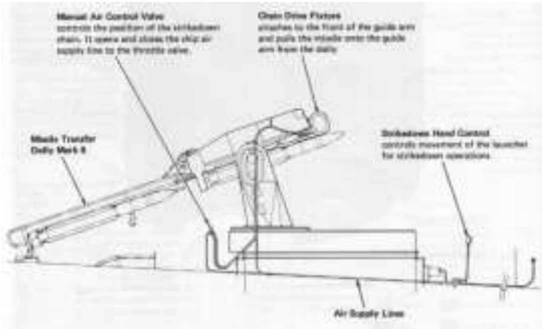



**Figure 2-9: Strikedown Equipment with Mk 6 Dolly**

**Figure 2-10: Strikedown fail**

## *GMLS Normal Operation*

43. The GMLS Mk 13 is manned at all times during operations for safety reasons and in the event of system or missile casualty. There is, however, no requirement for a local operator to do anything, if the system is functioning normally and has been correctly remoted to the Operations Room.

44. There are three selections that must be made at the GMLS EP2 panel to fully remote the GMLS to the Ops Room. They are:

a. System status control;

b. Pointing orders; and

c. Operational control.

45. Firstly, the system status selection must be switched to AUTO. This allows a single command, eg. *load (with Type B selected)*, either from local or remote control, to invoke all prerequisite steps before executing the commanded step. For example, if the launcher is in the outer-RSR load position, the order *load* will lock the launcher in position, open the blast door, move the hoist chain, and so on. In local control, each of these functions can be executed singly in STEP control.

46. Secondly, the GMLS must know whether to use pointing orders generated by the thumbwheel inputs at the digital director at the EP3 panel (LOCAL), or remote orders from the FCS, that is, either WCP or HWCC (REMOTE). Selecting REMOTE ensures FCS pointing orders will be used.

47. Finally, the operational control of the launcher should be transferred from the EP2 panel (LOCAL LAUNCHER CONTROL) to the WCC (REMOTE LAUNCHER CONTROL). This enables, for example, remote selection of LS STANDBY or LS READY ALERT.

48. At this point the GMLS operator becomes a safety number and the standby operator in the event of a misfire, system or missile casualty. He may regain full control of the GMLS at any time by reversing the selections above.

## *Operator Exercising Local Control*

49. There are several events that will normally warrant the GMLS operator to take control:

a. Misfire;

b. Dud;

c. Missile ID mixup or failure;

d. System casualty; and

e. Loss of WCP/HWCC.

### Misfire

50. A misfire occurs when the missile fails to leave the rail after the firing voltage for the DTRM has been passed. The GMLS operator will observe the MISFIRE indication at the EP2 panel (echoed at the WCC) and take the launcher to local control. If he observes no smoke from the DTRM, and if the tactical situation permits, the missile will be left on the rail, on a safe bearing, for the statutory waiting period. After this period expires, and if there is no reason to believe the missile is otherwise dangerous, it may be returned to the magazine for eventual return to EO Depot Orchard Hills. If black smoke is visible, indicating that the DTRM is burning, or if the tactical situation demands that the launcher be made available immediately, the GMLS operator will conduct a Local Jettison, unless he has been otherwise instructed (for example, during an AAW policy broadcast). The jettison process will probably occupy the launcher for 25 - 30 seconds.

## Dud

51. A dud missile does not respond correctly to missile orders within the prescribed time, ie. a DUD indication is received during the launch sequence, but *before* the firing voltage is passed. The GMLS operator will observe the DUD indication at the EP2 panel (echoed at the WCC) and wait for a second attempt to fire the missile tactically. If a second firing attempt fails, the options are to conduct a Dud Firing, Emergency Firing, Jettison or to download the missile. If the tactical situation permits, the best option is to download the missile for eventual return to EO Depot Orchard Hills. Clear instructions should be given (for example, during an AAW policy broadcast or an exercise briefing) if the GMLS operator is to carry out any particular procedure.

## Missile ID mixup or failure

52. This may occur either from ID probe, other GMLS or missile failure. The GMLS operator will enable visual missile ID via the MISSILE VISUAL IDENT ENABLE button, and Type selection (normally carried out without orders, unless otherwise briefed). An alternative is to force missile ID to the type *that has been loaded* by pressing the corresponding SEL/LOADED pushbutton at the WCC, which will generate a Missile ID Override signal. This method is faster but less flexible. If a QR Target is being engaged, Missile ID Override is generated automatically by WCP.

## System Casualty.

53. The nature of a casualty cannot be predicted in advance, but if a firing cannot be completed, the GMLS operator would take the launcher to local control, either download or jettison a missile on the rail, as appropriate, and shut down. On reporting the defect to the AWO, rectification action will commence.

## Loss of WCP/HWCC.

54. During an SM-2 engagement, WCP provides remote pointing orders, therefore loss of WCP will result in the launcher losing train and elevation orders, and an inability to fire the SM-2. The GMLS operator will take the launcher to local control and await restoration of WCP. If the tactical situation permits, he/she may also download the missile. During a Harpoon engagement, loss of the HWCC will result in a similar loss of train and elevation orders and the ability to fire the missile in Range Bearing Launch (RBL) mode. A Harpoon Casualty Firing can still be conducted, ie. in Bearing Only Launch (BOL) mode only, or the missile may be downloaded.

# Chapter 3. Standard Missile 2 Block IIIA

## *Introduction*

1. The SM-2 missile provides medium range surface to air defence for Navy's Adelaide Class FFG ship and the new Hobart Class DDG (SEA 4000 Air Warfare Destroyer (AWD) Program).

2. The SM-2 is primarily used for fleet area air defence and ship self defence, but it also has an extended air defence capability and has a secondary anti-surface ship mission. The Adelaide Class FFG's Mk 13 Launcher and Mk 92 Fire Control System are used to fire the SM-2.

3. The SM-2, which is extensively used by the US Navy, has consistently demonstrated its effectiveness against targets from surface ships to helicopters and manned aircraft. It can also be used against in-coming missiles, from very low to very high altitudes and from stationary to supersonic speeds, under a variety of weather conditions, and across a spectrum of electronic countermeasure environments.

4. The SM-2 uses tail controls and a solid fuel rocket motor for propulsion and manoeuvrability, and in addition, extended range missiles have a booster with thrust vector controls.

## *Characteristics*

| SM2 Block IIIA (RIM-66L-2) Characteristics | |
|---|---|
| **Function:** | Surface to air missile |
| **Manufacturer:** | Raytheon Missile Systems |
| **Propulsion:** | Dual thrust, solid fuel rocket |
| **Thrust:** | 272kg |
| **Weight:** | 708kg |
| **Diameter:** | 34.3cm |
| **Length:** | 4.7 m |
| **Range:** | >166km (90 nM) |
| **Speed:** | >Mach 3 |
| **Usage:** | Adelaide Class (FFG)<br>Hobart Class (DDG) |

**Table 4: SM-2 Characteristics**

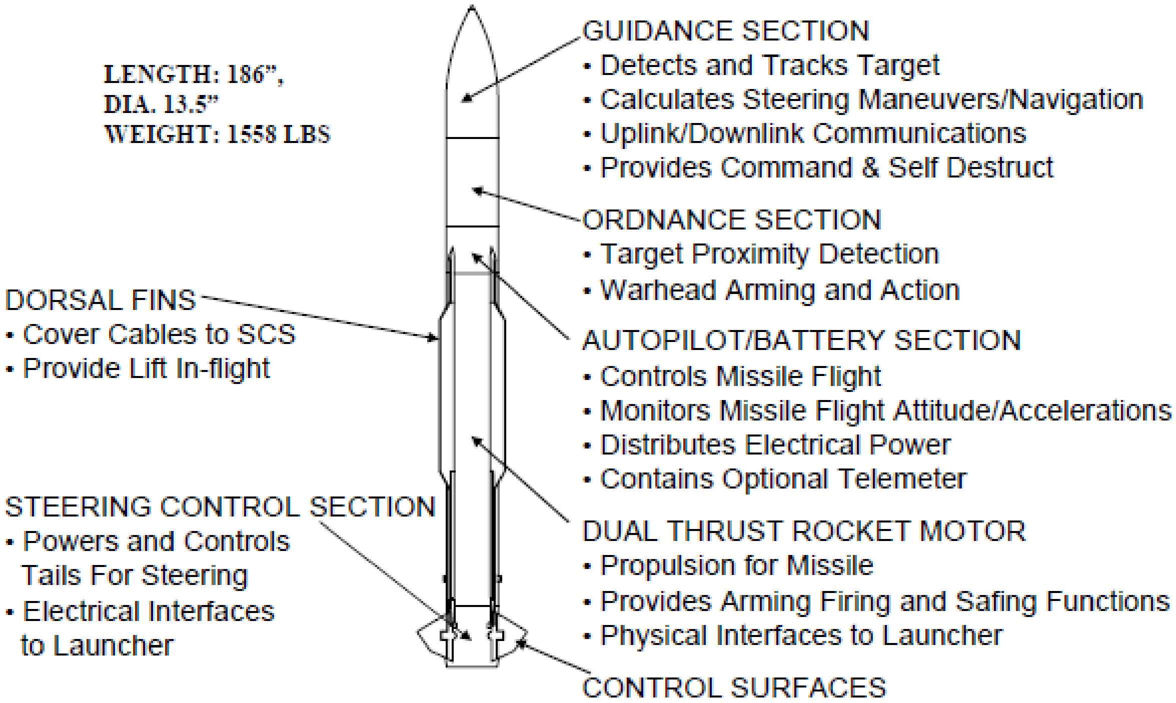
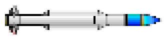



**Figure 3-1: SM-2 Block IIIA**



## *Guidance Section*

5. The guidance section consists of the Radome and shroud and, internally, the seeker head assembly and four electronics 'plates'.

6. The Radome allows transmission and reception of signals from the seeker assembly, while the shroud encapsulates the plates and also houses the link (for Mid Course guidance) and reference (for rear reference during HAW mode) antennae.

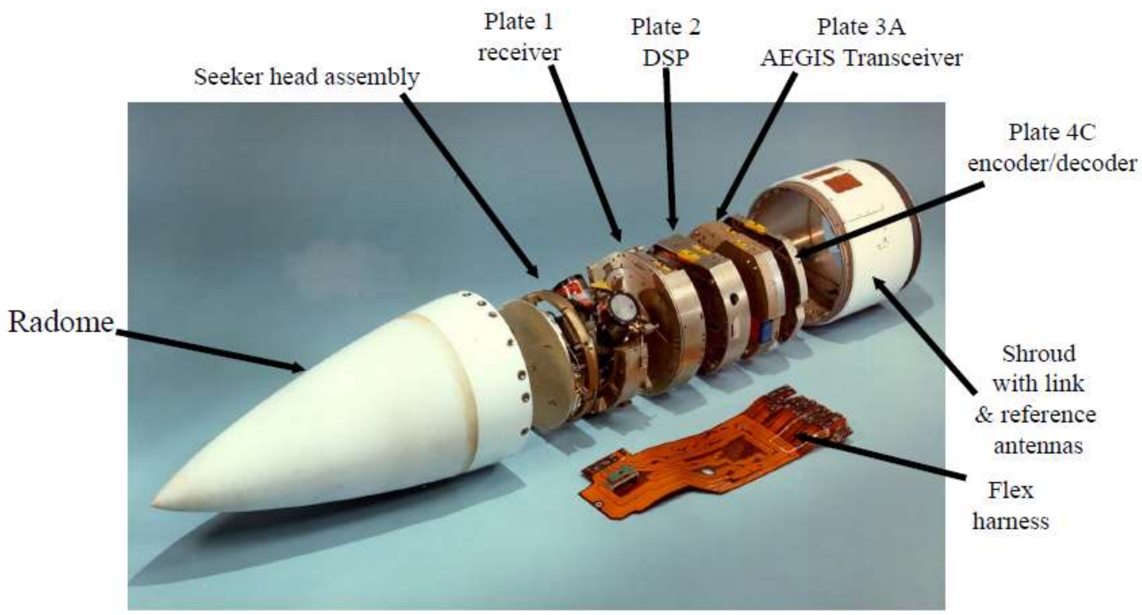



**Figure 3-2: SM-2 Guidance Section**

## Seeker Head Assembly

7. The seeker consists of a monopulse antenna, microwave receiver and control electronics. Signals from the Ship, control instruments and electronics serve to point the antenna beam toward the target and sense the rate of change in space.

8. The seeker has two modes of operation:

a. Position Mode;

b. Rate mode

9. Prior to launch, the seeker is initiated in position mode and aligned with the missile's longitudinal axis. Approximately three seconds after launch, the seeker head is slewed in position mode towards the expected line of the target. Once the target is acquired, the seeker switches to rate mode which allows the seeker head to be driven to maintain the target in the antenna's electrical boresight.

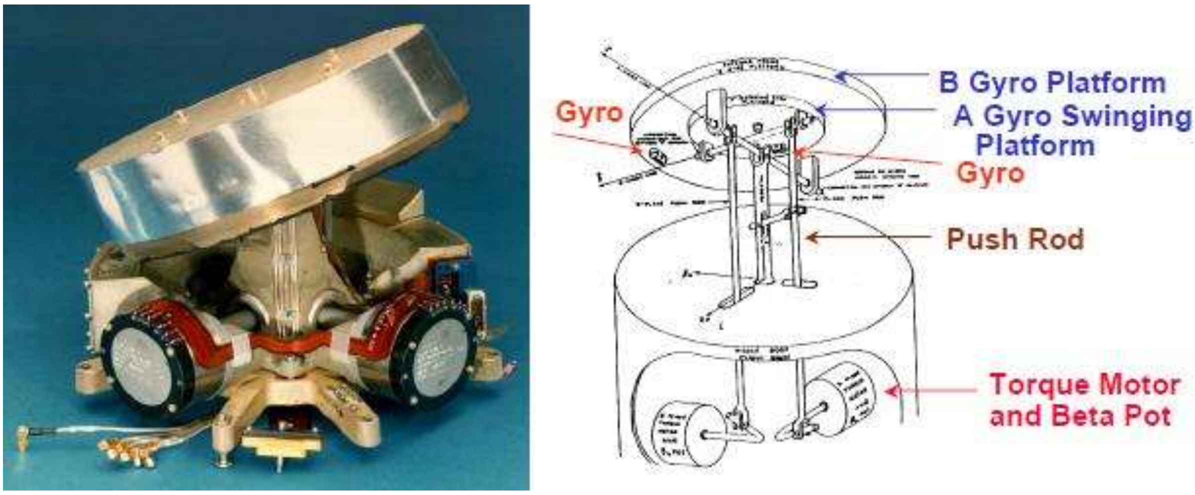



**Figure 3-3: SM-2 Seeker Head Assembly**

10. The electronic plates contain the circuitry to process signals and control functions such as:

a. RF rear reference signal from the Ship;

b. Self Destruct and Command destruct logic;

c. Safety arming firing signals;

d. MCG uplink signals;

e. Digital signal processing and guidance control;

f. Encoding and decoding of initialisation and uplink messages

## *Ordnance Section*

11. The major components in the ordnance section are:

  a. the warhead;

  b. the safety-arming device; and

  c. the target detection device (TDD).

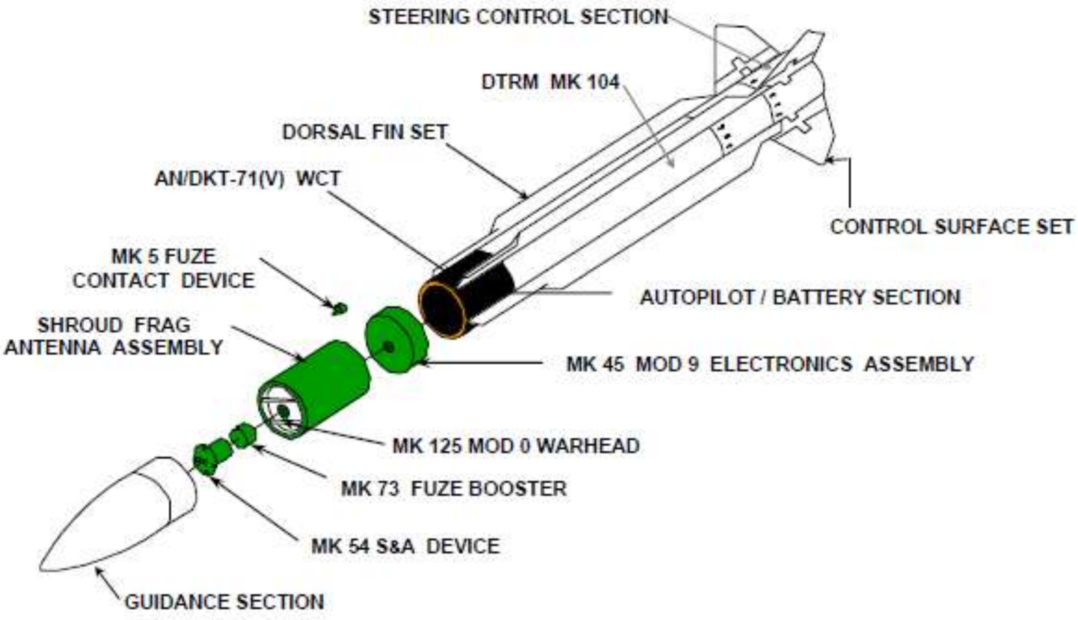



**Figure 3-4: SM-2 Ordnance Section**

## Warhead

12. The Mk125 Mod 0 warhead is a focused blast fragmentation warhead. It is designed to be detonated within close proximity to the target and the force of the detonation directs the fragments with sufficient velocity to destroy the target. Figure 3-5 shows the SM-2 warhead approaching the target from above. Upon detonation, the fragmentation is directed down and intercepts the target.

**Figure 3-5: SM-2 Warhead Detonation**

## Safety-Arming Device (S&A)

Prior to launch the S&A is latched SAFE. At battery power up, the solenoid latch is released but the device is still SAFE.

The S&A becomes armed due to the axial acceleration of the missile post launch. This allows time for a safe separation distance from the Ship prior to arming. The S&A detonates the warhead after receiving a command from either the guidance section (Command destruct/Self destruct) or from the target detecting device (TDD) which is part of the ordnance section electronics assembly.

## Target Detecting Device

The function of the TDD is to maximise the kill probability of a target given the capability of the missile's own guidance system. To do this, the TDD processes input signals from the guidance section such as TDD enable/arm, range rate, look angle and self destruct or command destruct orders. It also provides terminal target detection and warhead fusing.

The TDD utilises a dual beam radar target detection system which allows it to determine the precise target location at intercept. From this information, it is able to predict the optimum warhead burst point in order to inflict maximum damage to the target.

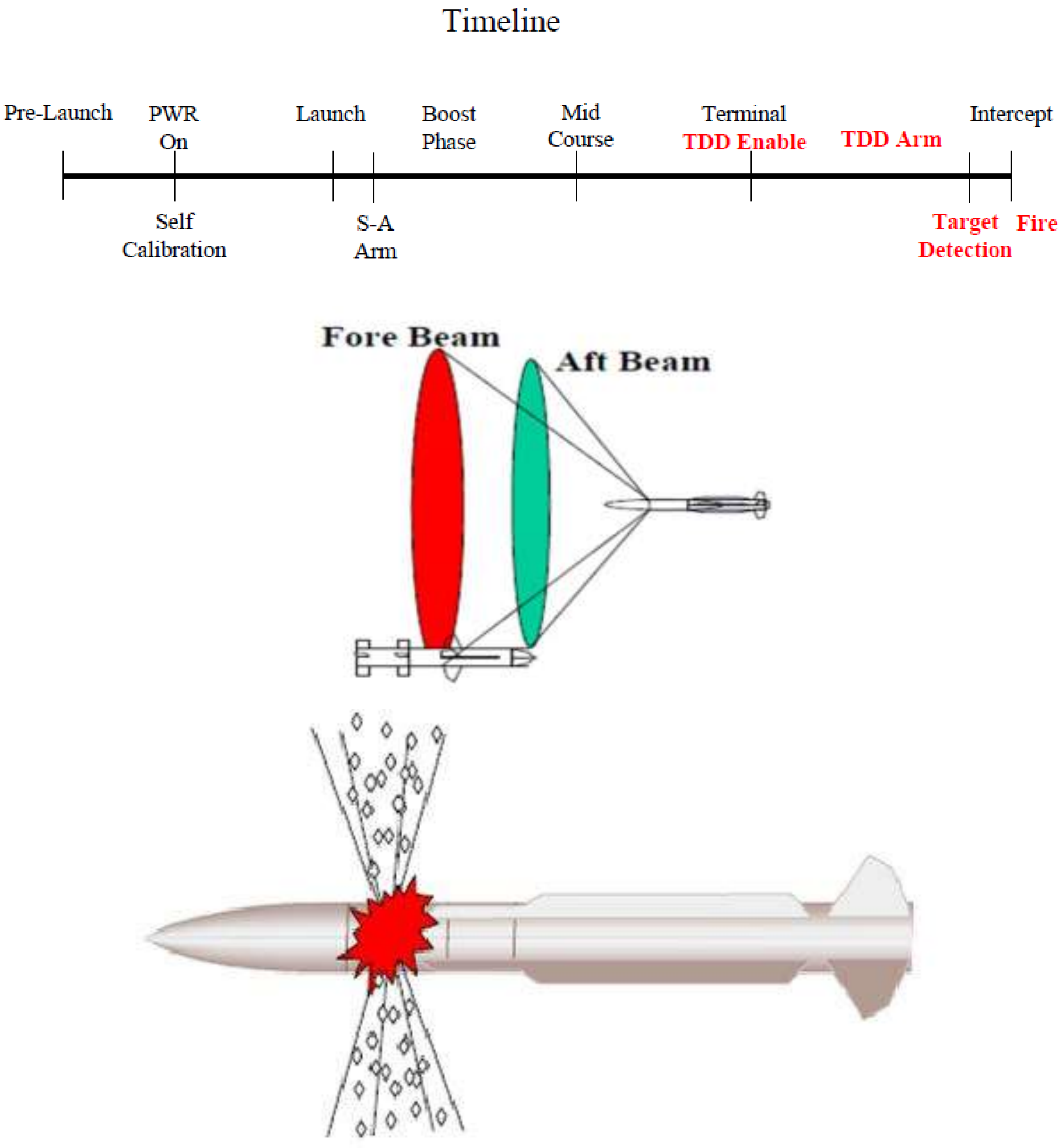



**Figure 3-6: SM-2 Sequence of Operation**

## *Autopilot Battery System*

13. The purpose of this system is to:

a. Provide power distribution;

b. Provide a functional interface to the launching system;

c. Maintain a stable airframe in flight; and

d. Achieve a reasonably uniform Speed of Response to variations in flight conditions.

14. The main components in the Autopilot battery section are:

a. Power Changeover Unit;

b. Battery; and

c. Autopilot System.

## Power Changeover Unit (PCU)

15. The PCU:

a. Distributes prelaunch power to inertial instrument gyros in the Autopilot;

b. Provides round identification;

c. Routes electronics and digital supply power to Autopilot and Guidance sections after battery up;

d. Applies Guidance Sequence Start (GSS) after rocket motor pressure build-up due to ignition; and

e. Activates the Autopilot 0.7 seconds after GSS

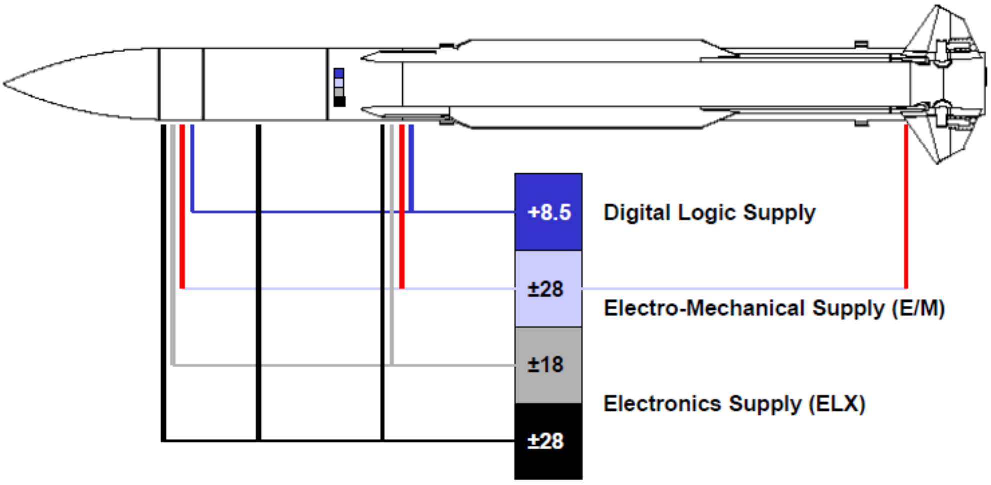



**Figure 3-7: SM-2 Power Distribution**

## Battery

16. The Ag-Zn battery supplies power for digital logic circuits, electro-mechanical systems and electronics systems. It has a 215 second lifetime.

## Autopilot System

17. The autopilot system utilises an inertial instrument unit (IIU) to sense any missile movement about the pitch, roll and yaw axes. It also detects acceleration changes. These changes generate error signals which are used to drive the control surfaces of the missile in order to maintain the desired heading and attitude stabilisation of the missile.

## *Dual Thrust Rocket Motor*

18. The dual thrust rocket motor (DTRM) is fuelled by a solid grain propellant which provides the boost phase and sustain phase thrust levels. The boost grain burns at a higher rate than the sustainer grain. The DTRM includes an arming system designed to prevent inadvertent ignition.

19. The DTRM ignition sequence is as follows:

a. Autopilot battery section provides -28VDC Arming Current to energise the arming solenoid;

b. 28 Vdc From Autopilot rotates solenoid arm fire device (A/FD) to close the safe and arm firing contactor;

c. Launcher Applies Firing Signal To Firing Squib Via Contact Buttons;

d. Squib Ignites thin layer explosive (TLX) Train;

e. TLX Ignites Igniter Inside DTRM;

f. Igniter Initiates Motor Burn

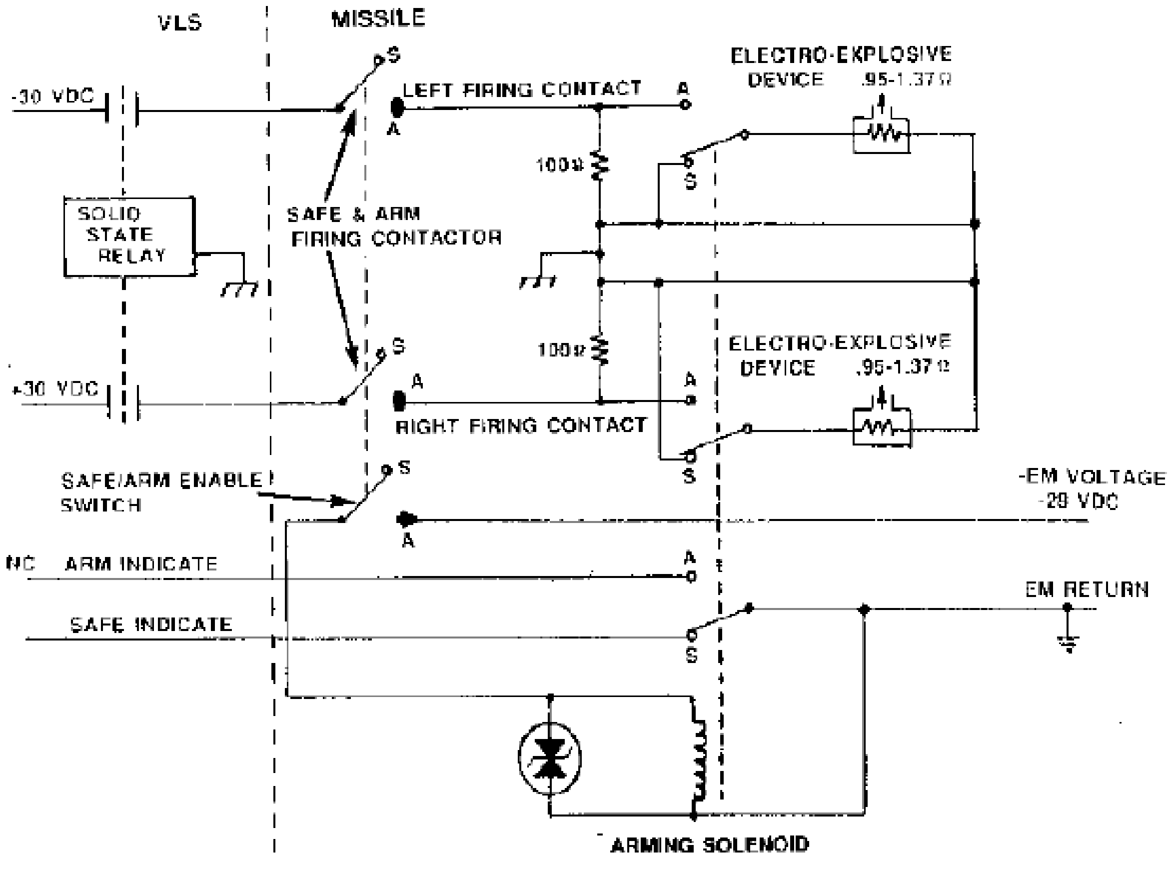
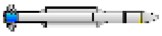



**Figure 3-8: DTRM Electrical Schematic**

## *Steering Control Section*



20. The steering control section:

a. Provides for attachment and actuation of control surfaces;

b. Accepts actuator drive commands from autopilot battery section to implement missile control/stability;

c. Provides control surface position indications to autopilot/battery section; and

d. Provides missile-to-launcher electrical interface connection.

21. It contains four identical steering control actuators which drive the external flight control surfaces. Each actuator consists of an electric DC motor, a torque motor, two clutches and signal conditioning circuitry.

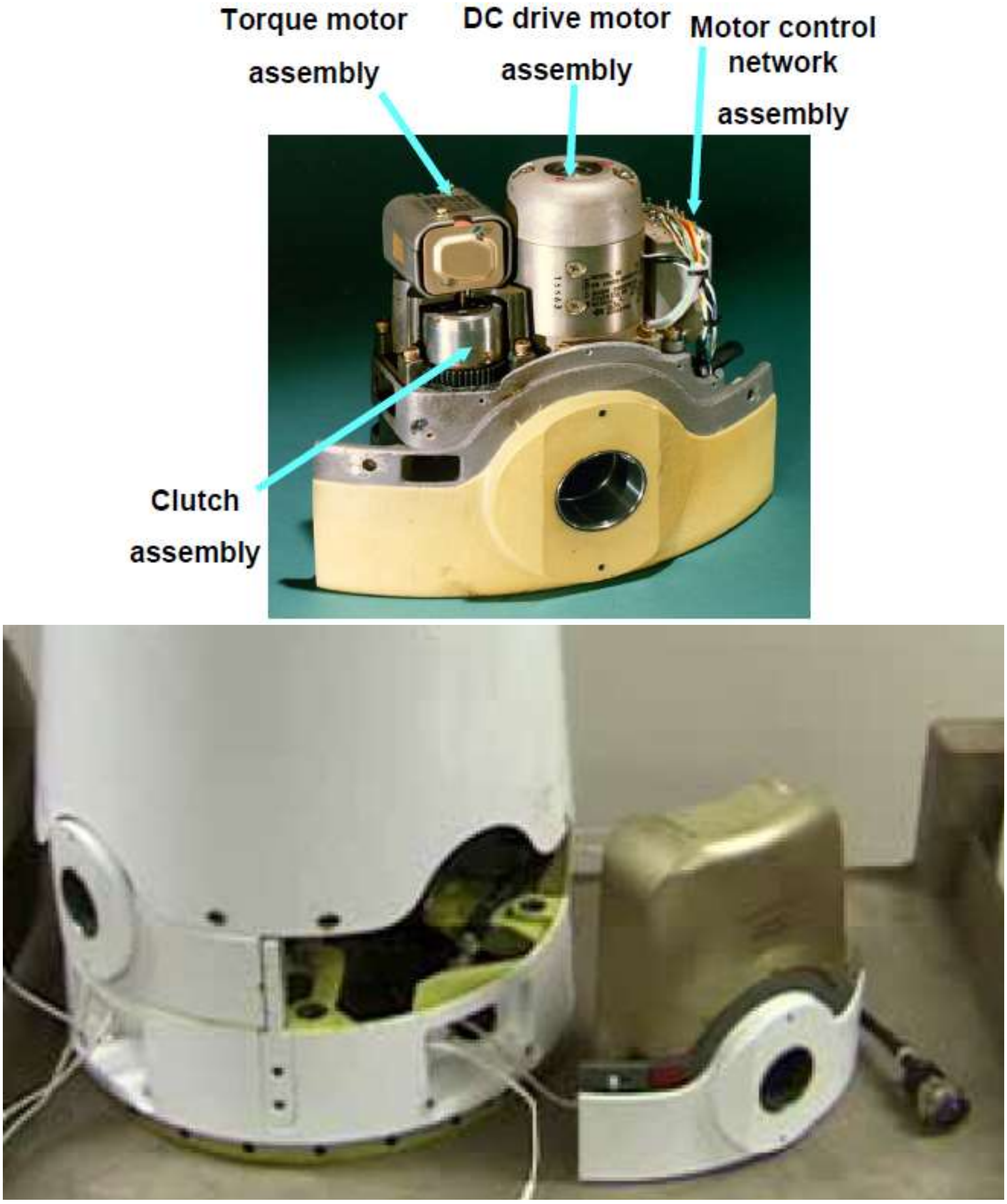



**Figure 3-9: SM-2 Steering Control Actuator**

## *Dorsal Fins and Control Surfaces*

22. The dorsal fins provide aerodynamic lift and also cover electrical cabling.

23. The control tail fins are stowed in a folded position until immediately before launch. In flight, they are driven by the steering control actuators to adjust missile heading and maintain stabilisation.

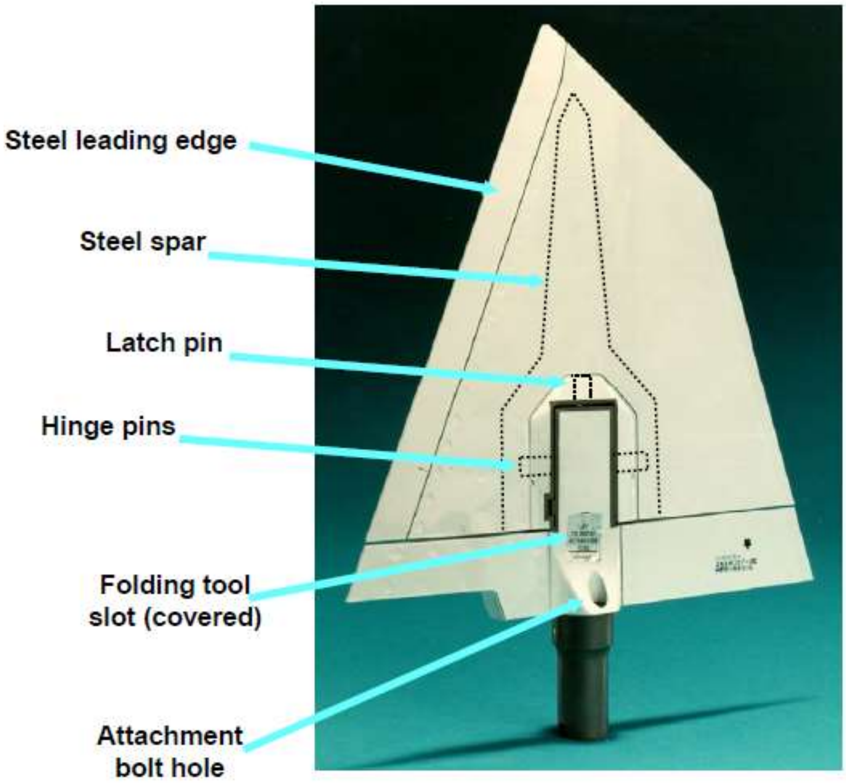



**Figure 3-10: SM-2 Control Tail Fin**

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# Chapter 4. Harpoon Missile

## *Introduction*

1. The Harpoon is an all-weather, over-the-horizon, anti-ship missile system. It uses active radar homing, and a low-level, sea-skimming cruise trajectory to improve survivability and lethality. The current version of missile being used on FFG platforms is the RGM-84 J Block 1-L.

### Specifications

| | |
|---|---|
| **General** | |
| Type: | Anti-ship cruise missile |
| Targets: | Ships |
| Platforms: | Airplanes (AGM-84), Surface Ships (RGM), Submarines (UGM-84) |
| Manufacturer: | Boeing Integrated Defense Systems |
| **Technical Data** | |
| Guidance: | Sea-skimming cruise monitored by radar |
| Air Launch Weight: | 519kg |
| Surface/Sub Launch Weight: | 628kg |
| Air Launch Length: | 3.8m |
| Surface/Sub Launch Length: | 4.6m |
| Diameter: | 340mm |
| Range: | Over-the-horizon |
| Speed: | High Subsonic, 850 km/h |
| Warhead: | 221kg, penetration high explosive blast |
| Propulsion: | Teledyne Turbojet/solid-propellant |

**Table 5: Harpoon Missile Characteristics**

## *Missile Breakdown*

2. The Harpoon missile consists of five sections that are outlined below.

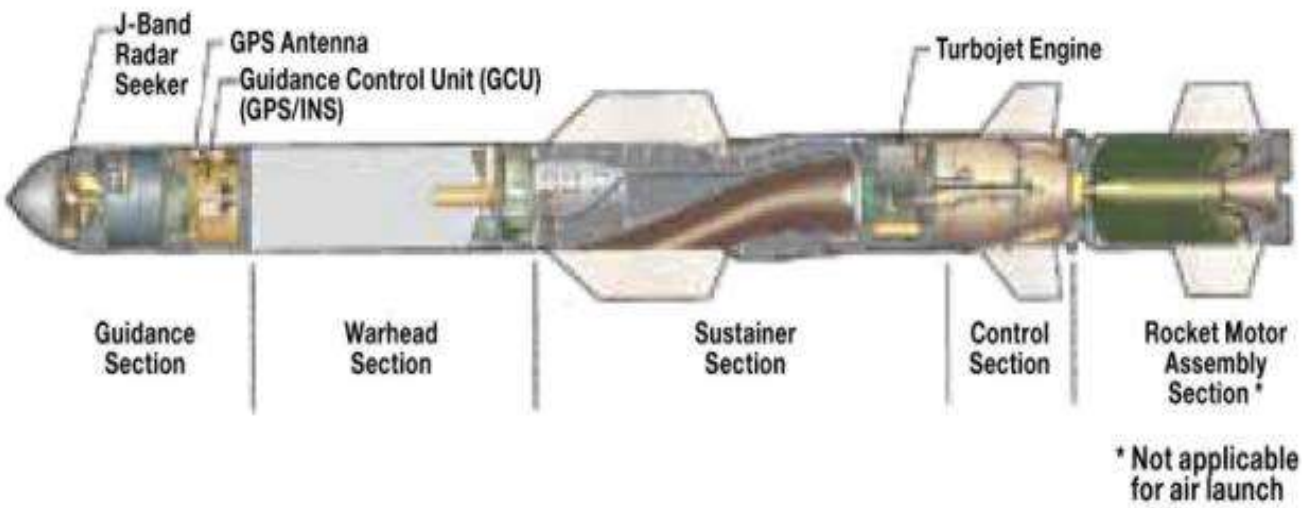


**Figure 4-1: Harpoon Missile Section Breakdown**

## Guidance Section

3. The guidance section contains four major components:

   a. seeker;

   b. radar altimeter;

   c. midcourse guidance unit (MGU); and

   d. power converter.

4. The *Seeker_Assembly*, which includes a radar antenna and a radome, is mounted in front of the guidance section with the radome housing the radar antenna. It is a frequency agile, two-plane, monopulse, active radar seeker which is controlled by the MGU. The Seeker operates in the Ku frequency band and performs range / angle search and tracking.

5. The Radar_Altimeter is a short-pulse active radar. It is primarily used for mid-course and terminal guidance and its accuracy is tailored to this application. Its transmitter and receiver antennas are located on the undersides of the guidance section and the warhead respectively.

6. The seeker. The radar altimeter system includes two antennas mounted on the missile: one (transmitter) on the guidance section, and one (receiver) on the warhead section. The altimeter and MGU provide missile stabilisation and midcourse guidance. Before missile launch the power converter provides conversion from external AC power to DC power. After launch power is supplied to missile sections from a dual battery.

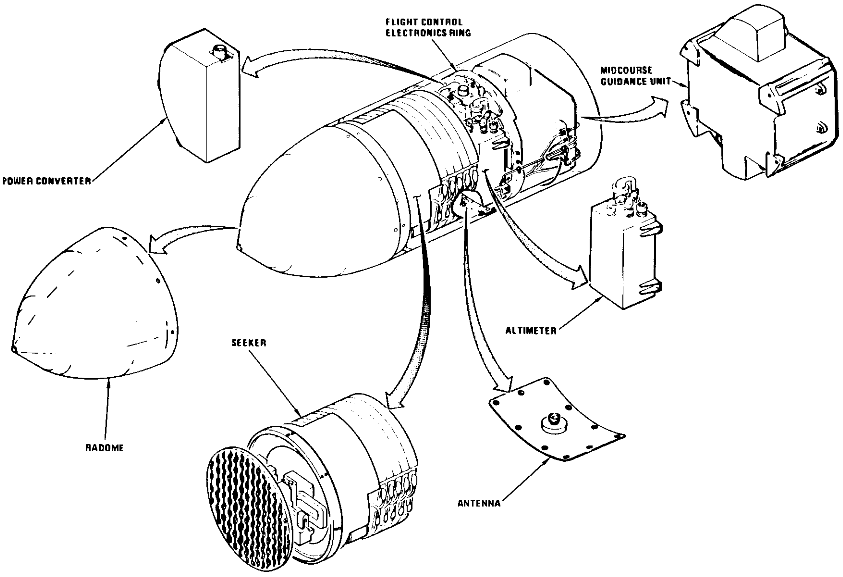


**Figure 4-2: Guidance Section**

## Warhead Section

7. The Warhead section contains the bulk of the missile's explosive ordnance and the related fusing components. The forward bulkhead of the warhead is reinforced to aid penetration of the target

8. The warhead section contains the following components:

   a. Wire bundle;

   b. Booster fuse well;

   c. Pressure probe assembly;

   d. Safe / Arm contact fuse;

   e. Altimeter receiver antenna; and

   f. Crush sensors.

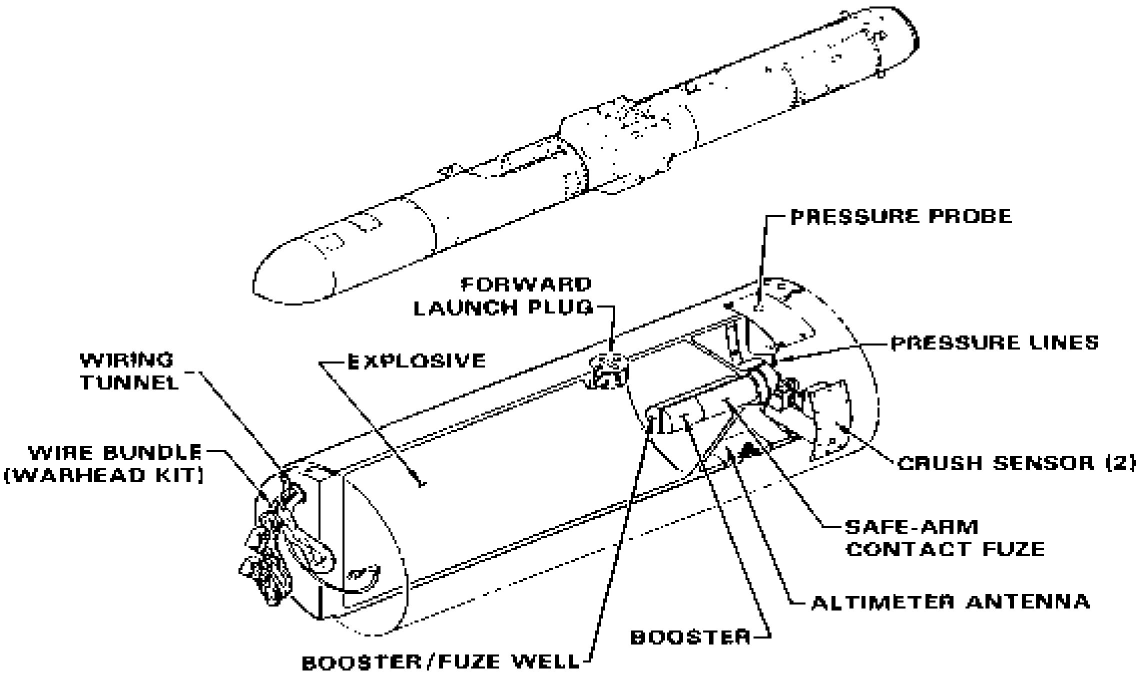


**Figure 4-3: Warhead Section**

9. The wire bundle electrically interconnects the guidance section with the warhead and the sustainer and control sections.

10. The booster fuse well houses the safe / arm contact fuse and its booster.

11. The pressure probe assembly is situated on the top of the warhead at the rear. It provides the safe / arm contact fuse with the arming energy (air pressure) after engine start command. The pressure probe assembly, refer Figure 4-4, consists of an erectable probe, an initiator housing and initiator, and a switch assembly.

12. The safe / arm contact fuse housed in the booster well is connected to the pressure probe by pressure lines and provides the initiation sequence for warhead detonation.

13. The receive altimeter antenna is located on the underside of the warhead at the rear.

14. .The crush sensors (two of) located on either side of the warhead at the rear, permit operation of the safe / arm contact fuse under certain conditions.

15. Safety features of the warhead include a stress relief riser and a hot melt internal liner. The stress relief riser is a longitudinal groove machined into the underside of the warhead casing. It acts as a pressure relief mechanism should the warhead under go an elevated temperature rise as in the case of a fire. The hot melt liner inside the shell of the warhead provides thermal protection to the explosive filling.

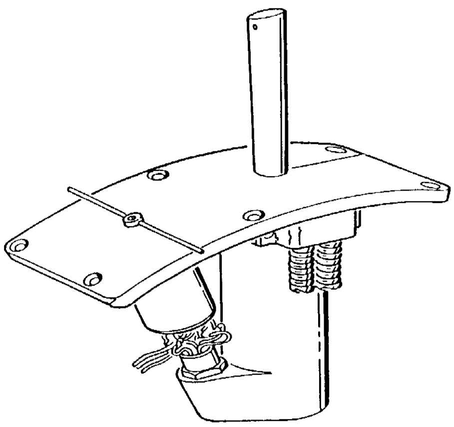

**Figure 4-4: Pressure Probe Assembly**

## Sustainer Section

16. The sustainer section consists of five major components: servo-drive assembly, battery, pyro relay panel, fuel and fuel tanks, and a 600-pound thrust turbojet engine. The sustainer section also has four spring-loaded wings.

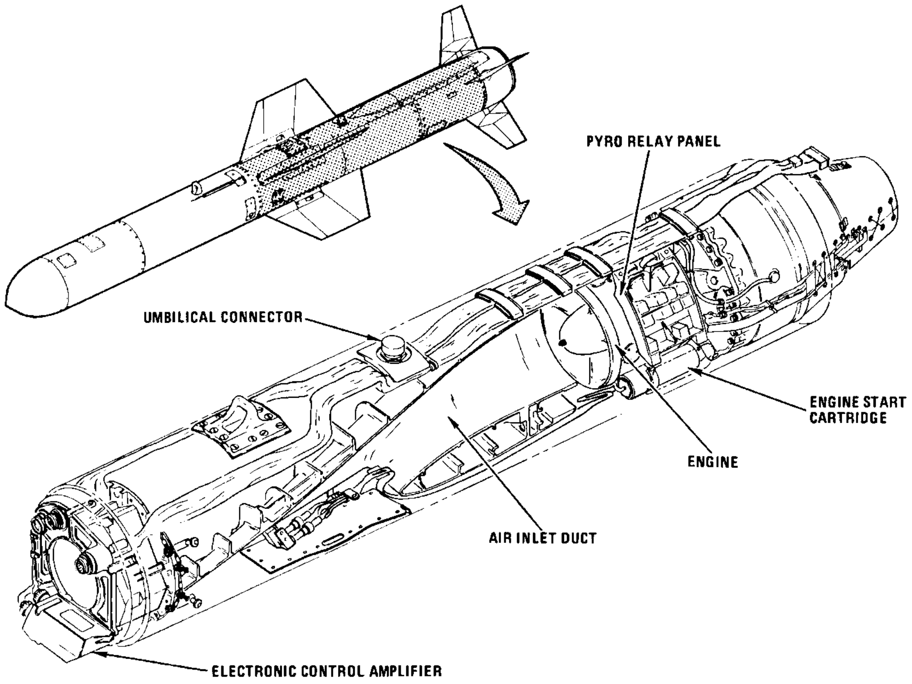


**Figure 4-5: Sustainer Section**

## Control Section

17. The control (or boattail) section contains flight control fins and four electromechanical actuators. The actuators control missile fin movement over a deflection range of 60°. The boattail section is attached to the booster section by a split-clamp ring with pyrotechnic bolts, which provide for separation.

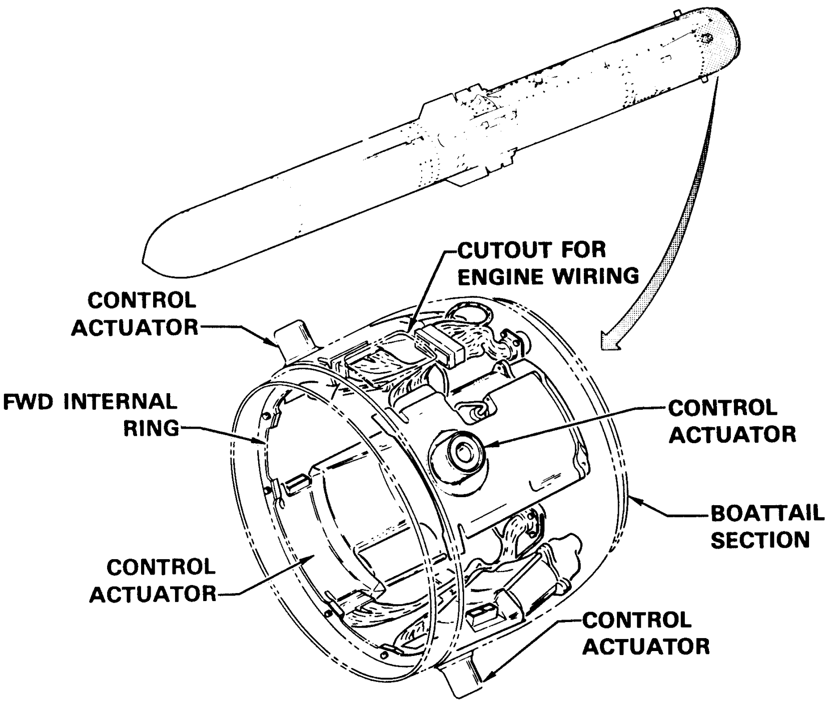


**Figure 4-6: Control Section**

## Booster Section

18. The booster section consists of a booster motor, an interstage assembly, flight stabilising fins, and an arming and firing device. The arming and firing device is electrically activated to permit booster firing and making-safe. All wings and fins are hinged and are mechanically unfolded, while on the launcher, during the *firing* cycle.

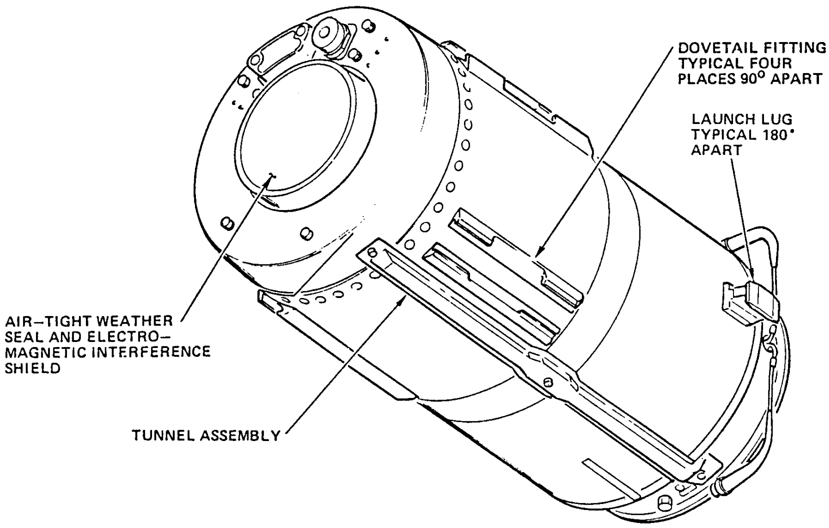


**Figure 4-7: Tartar Configured Booster Section**

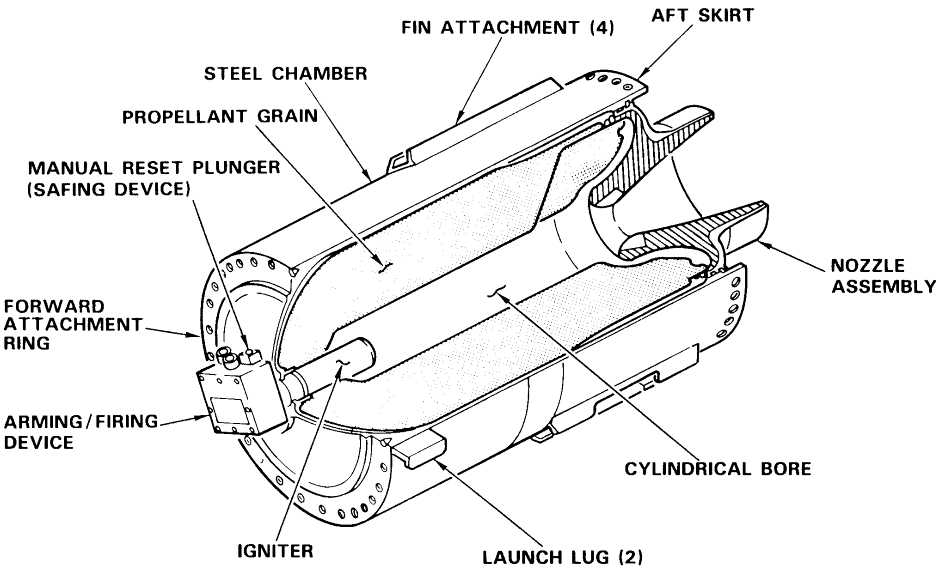


**Figure 4-8: Rocket Motor**

## *BIT Requirements*

19. The Harpoon missile is fitted with a Built-in-Test (BIT) facility which must be performed:

a. Within two weeks of missile on-load;

b. Not greater than two weeks prior to missile off-load; and

c. Every 6 months, in accordance with the Planned Maintenance System.

20. Harpoon BIT is initiated from the HWCIP, which returns a simple GO/NO GO status. A time limit is applicable, and for a BIT pass to be recorded, GO must be received within 16 to 18 seconds of test initiation only.

21. Harpoon missile BIT is usually performed in concert with a physical inspection of the missile (specifically checking for fuel leaks), which otherwise is performed monthly. Both physical inspection and BIT require loading the live missile to the launcher rail, and therefore neither can be performed alongside a normal berth. When performed, the launcher must be trained on a "safe bearing" as well as taking other safety precautions.

## *Harpoon Flight Characteristics*

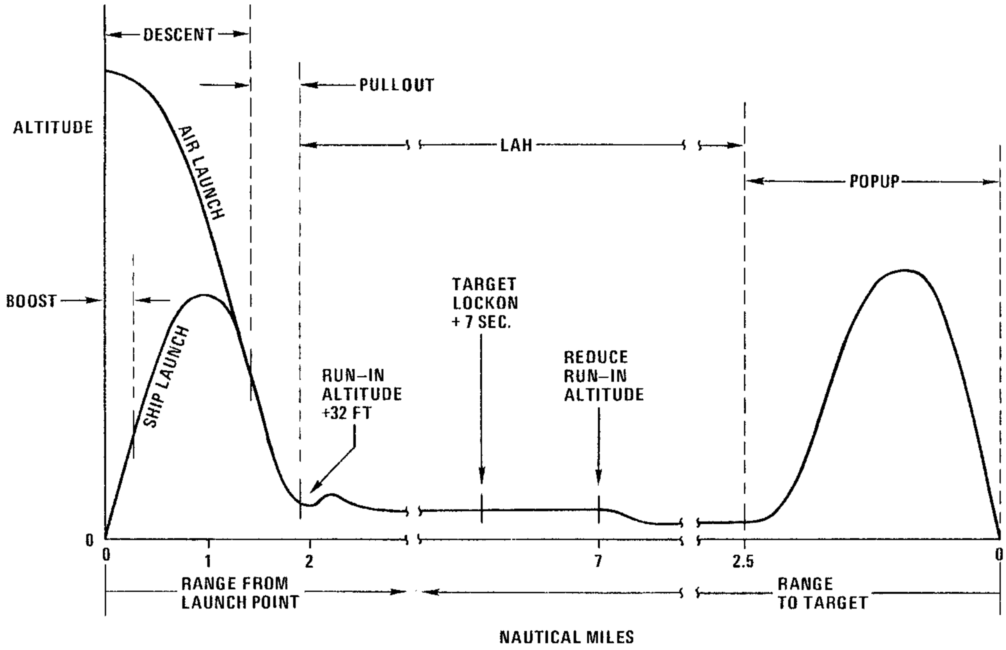


**Figure 4-9: Harpoon Mission Profile/Trajectory**

## Launch Modes

### Simultaneous Time on Top (STOT)

22. In this mode, the firing Ship plans for all missiles launched from that Ship to hit the target at the same time. To achieve this, missiles will take separate routes and use different waypoints with the end goal of a simultaneous strike on the target.

### Designated Time on Top (DTOT)

23. In this mode, all launched missiles will hit the target at a specified time. This mode is used when co-ordinating strikes with Ships in company.

### Ripple Fire

24. In this mode, all selected missiles will be launched in sequence with minimal time between launches.

## Operation

25. The normal operating mode, Range and Bearing Launch (RBL) mode, includes three search patterns (large, medium and small). The search is initiated at a specific range based on expected target location, as can be seen in Figure 4-10.

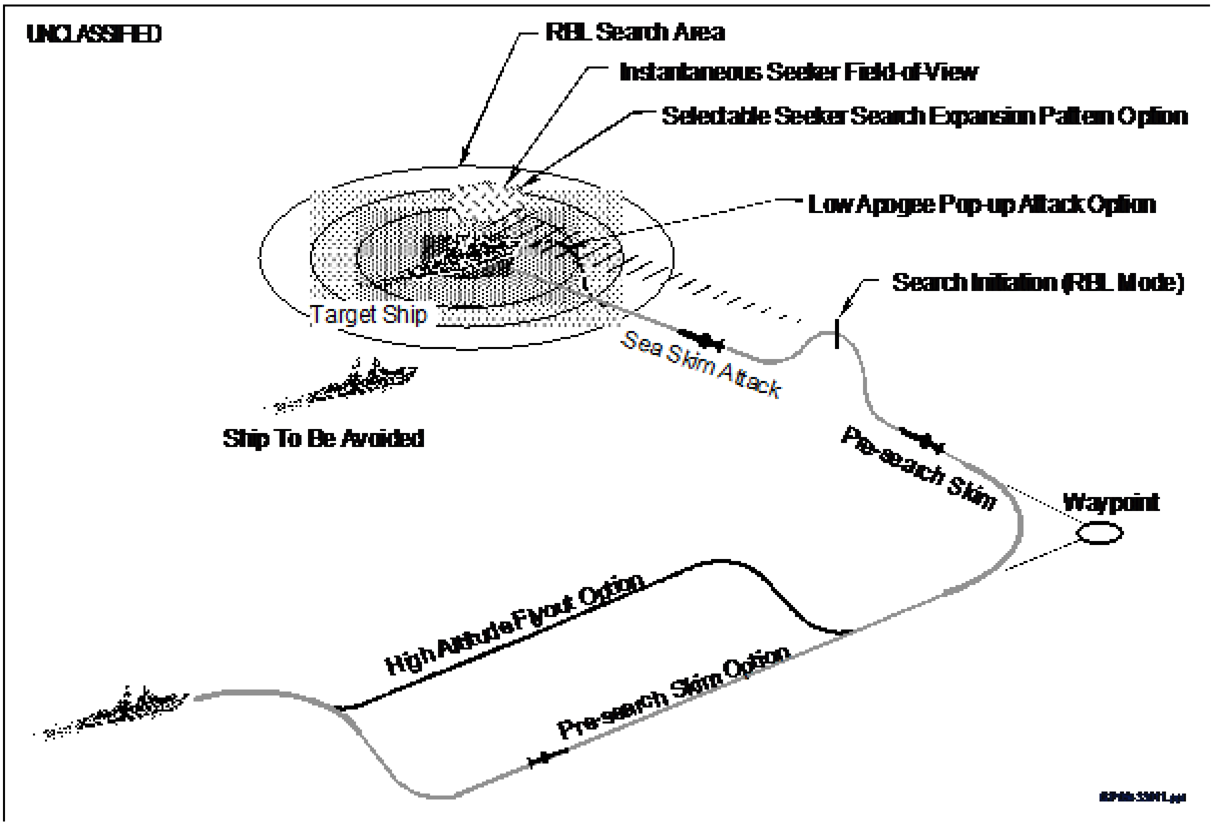


**Figure 4-10: RBL Mode Search Procedure**

26. A Bearing Only Launch (BOL) mode is available when only the target bearing is known and not the range to target. The seeker search pattern increases in width and depth as the missile travels down range to the target. The BOL terminal search is initiated at a range selected by the launch platform.

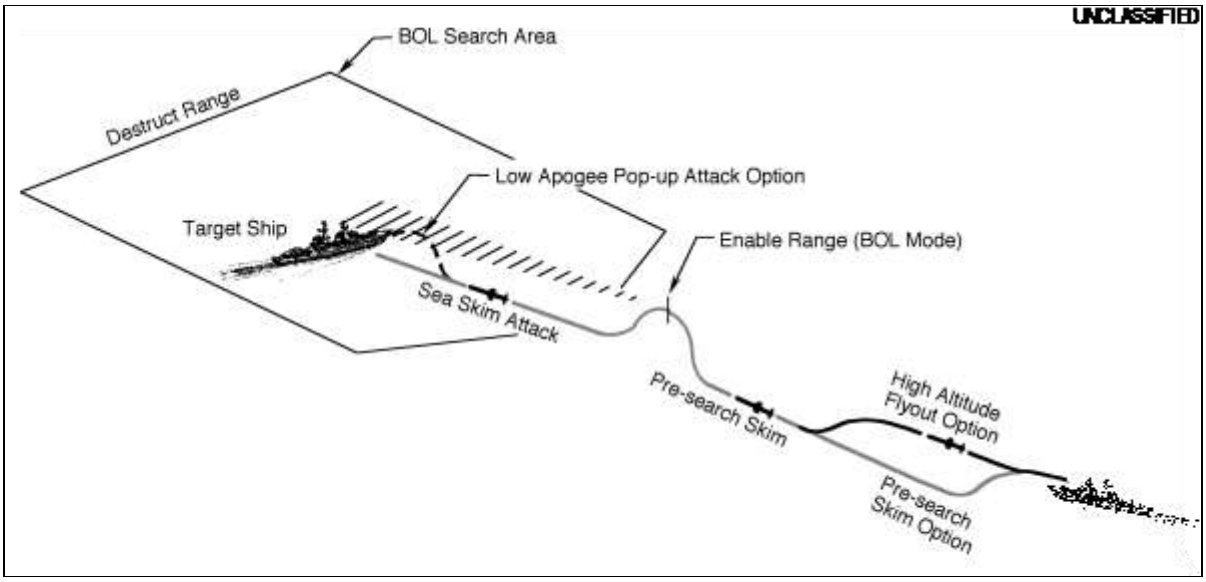


**Figure 4-11: BOL Mode Search Procedure**

27. A Line Of Sight (LOS) or Casualty mode is available when support equipment is damaged or target information is unable to be input to the missile.

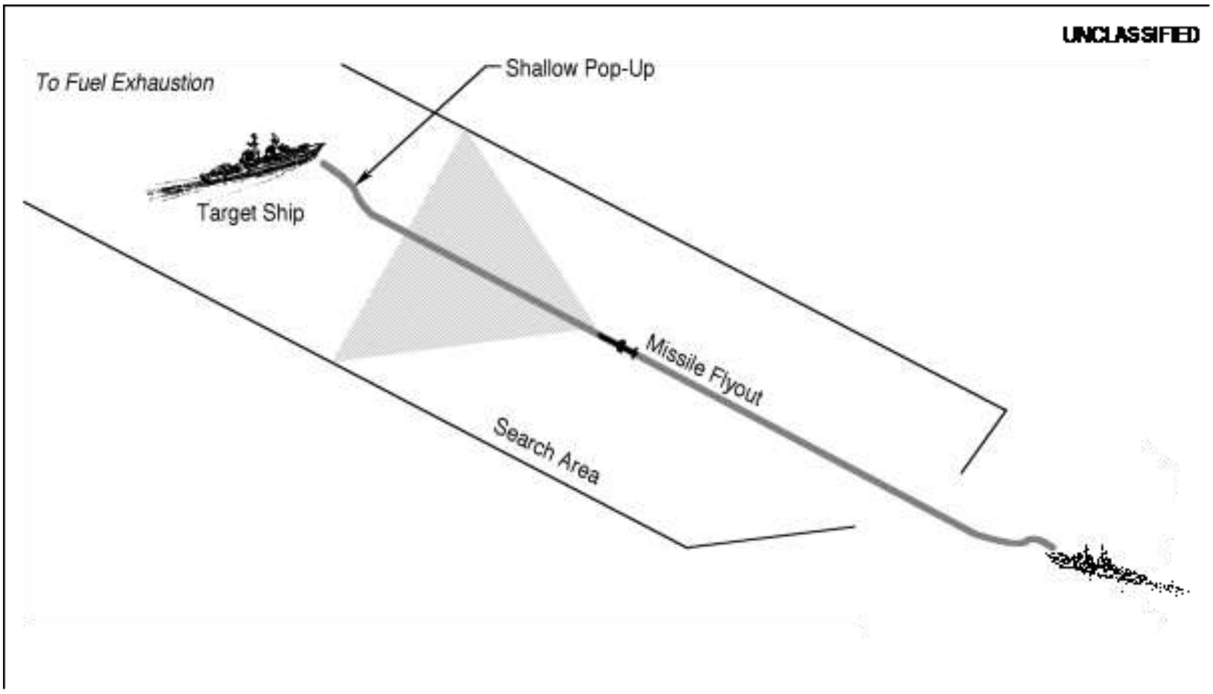


**Figure 4-12: LOS Launch**

28. Harpoon BIT is initiated from the HWCIP, which returns a simple GO/NO GO status. A time limit is applicable, and for a BIT pass to be recorded, GO must be received within 16 to 18 seconds of test initiation only.

29. The basic operation of the Harpoon is as follows:

## Launch Phase

13. The decision is made to launch the missile. Target data is fed to the missile along with flight profile, ie. way points, terminal manoeuvre.

14. Missile does a Built In Test (BIT) and battery squib fires, charging battery, and control actuators are energised.

15. Missile released, inlet cover removed, engine started. (The missile can have the engine started then released or engine start after launch)

16. Engine start cartridge is ignited to assist start up of the sustainer engine, and the pressure probe is extended.

17. The pressure probe in the warhead senses Harpoon speed and activates the Safe-Arm/Contact Fuse (S-A/CF) to arm the warhead approx 10 seconds after separation.

## Descent, Pullout and Cruise.

18. After the sustainer engine starts, the Harpoon roll stabilises with the flight axis up and the altimeter antennas underneath beamed towards the sea surface.

19. The Harpoon performs a dive and pullout at cruise altitude and the radar altimeter continually updates the guidance computer to maintain the cruise altitude to target.

20. During the cruise phase the guidance seeker activates and begins searching for the designated target. The seeker employs an active radar system. Radar returns are received and processed to determine the presence and location within the target area.

21. The size and location of the search area is preselected prior to launch. Depending on the quality of the target data available the missile is programmed to one of two modes: Bearing Only Launch (BOL) or Range and Bearing Launch (RBL). BOL is used when target range data is unknown or uncertain; RBL is used for all other situations. A Casualty Line of Sight (CLS) can be used when systems are degraded.

### Termination

22. The Harpoon reaches a prescribed distance from the target and performs the final manoeuvre as per the preselected mode (pop up or straight in).

23. The target is impacted and the Harpoon penetrates the target. A minimum of two indicators must be crushed before the warhead can be detonated by the S-A/CF. This is met, by at a minimum any combination of at least two of the crush sensors and pressure probe being crushed, ie pressure probe and a crush sensor crushed, two crush sensors crushed or all three crushed.

## Harpoon Missile Safety:

24. **DUD.** A missile that fails to give a missile ready indication within a predetermined interval after the normal firing key has been closed.

25. **MISFIRE.** A missile in which ignition did not occur when voltage was applied to the rocket motor.

26. **HANGFIRE.** Any undesired delay in firing the round after the firing key has been closed.

27. All missiles that fail to fire are to be treated as a hangfire. The missile may not be approached for 2.5 hours after the last attempt to fire. Following a misfire where the battery has activated, the missile must be maintained on a safe bearing for 4 hours.

28. In the event of a report of 'Black Smoke' the missile will be Dud Jettisoned. If black smoke is reported the missile will be jettisoned after 10 seconds unless Launcher Safety number receives an order NOT to jettison from CO/AWO/WEEO. The missile will be jettisoned immediately if the Launcher Safety number observes rapidly increasing black smoke.

29. A misfired missile can only be returned to the magazine by order of the Commanding Officer.

30. Figure 4-13 details the hazard prone areas of the Harpoon missile.

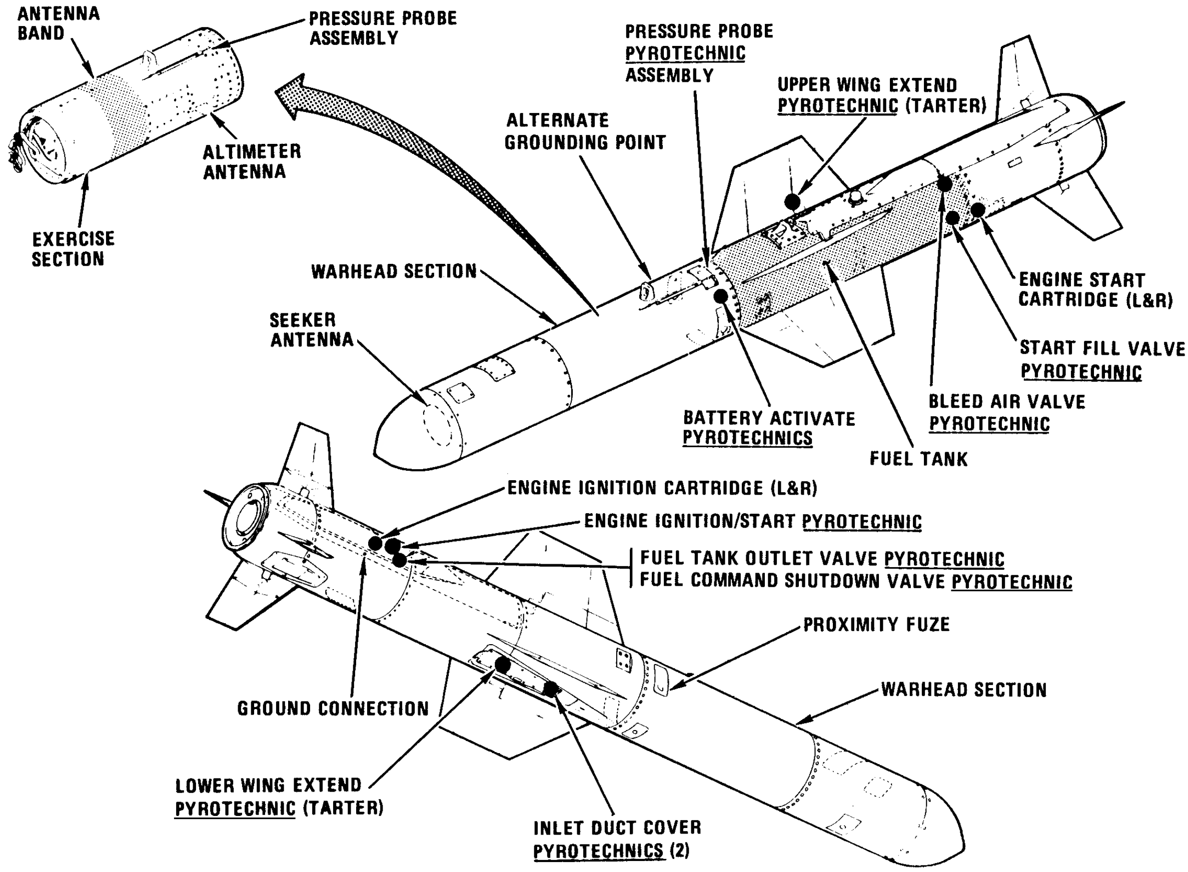


**Figure 4-13: Harpoon Missile Hazard Prone Areas**

31. The hazard prone areas of the Harpoon missile are as follows:

a. Radome made of Lexan material - fragile.

b. Seeker antenna - Does not transmit prior to flight.

c. Altimeter antenna on underside of Guidance section - fragile.

d. Warhead - explosive charge / safe / arm contact fuse.

e. Pressure probe assembly and crush sensors - erection of probe and sensors.

f. Altimeter antenna on underside of warhead / exercise sections - fragile.

g. Wraparound antenna on exercise head section - fragile.

h. Wing extend pyrotechnic (Tartar missile) - explosive.

i. Fuel tank JP 10 fuel - flammable.

j. Inlet duct cover initiator - explosive.

k. Rear fins - spring loaded.

l. Battery - electrolyte, gas generator.

m. Engine and fuel tank initiators and pyrotechnics - explosive.

n. Booster separation explosive bolts - explosive.

o. Booster motor and Arm / Fire Device - propellant and initiator

# Chapter 5. Mk 41 Vertical Launcher System

**Reference:** VL15–TECH–0001/090

## *Introduction*

1. The VLS provides ships with multiple missile capacity, improved launcher system flexibility, and fast combat reaction times. The VLS Mk 41 Mod 16 is capable of launching the Evolved Sea Sparrow Missile (ESSM).

2. All missiles in the VLS are in a ready–to–launch position at all times. Safety features designed into the VLS prevent the inadvertent launch of a missile or a dangerous fly-out condition if proper maintenance procedures are followed.

### VLS Cardinal Rules

3. The VLS operation and maintenance philosophy is based on a US Naval Sea Systems Command (NAVSEA) policy as defined by the following safety precepts known as the VLS Cardinal Rules of Safety:

a. The VLS Mk 41 is operated and maintained only by trained personnel using authorised procedures.

b. A dead electrical missile interface is always maintained until a missile is intended to be launched.

c. No simulators of any type will be mixed with live ordnance except during highly controlled special test and evaluation scenarios.

d. No Developmental Test (DT) ordnance, programs, or Weapons Control Systems (WCSs) shall be mixed with tactical VLS ordnance or programs.

4. The missiles, while in the launcher, are 100–percent electrically deadfaced until selected for launch. Canister Mk 25 Mod 0 has four subcells and each subcell is loaded with one ESSM. Canister Mk 25 Mod 0 has a deluge water system that protects each missile in the event of a subcell overtemperature condition. If an overtemperature condition occurs in one or more subcells, the deluge system sprays water on all four subcells simultaneously.

5. Multiple manual and electronic methods are provided for missile safing. When a missile is in a safe condition, it is incapable of receiving the electronic signals that fire the missile rocket motor. The missiles stored in the VLS canisters are kept in the safe condition until there is an intent to launch. The canister has a Canister Safe/Enable Switch (CSES). One CSES is used for all four subcells. The CSES is set and lockwired to SAFE during handling, transportation, storage, and training exercises to prevent accidental activation of the missile. When the canister is stored in the VLS in a ready–to–launch condition, the CSES is positioned to ENABLE; electronic safeguards in the VLS are then used to prevent electrical connections to the missile rocket motor.

6. All data to, from, and within the launcher undergo validity tests. Extensive analyses for isolation of faults within the VLS are conducted. Missile safing procedures are provided for missile misfire/dud situations.

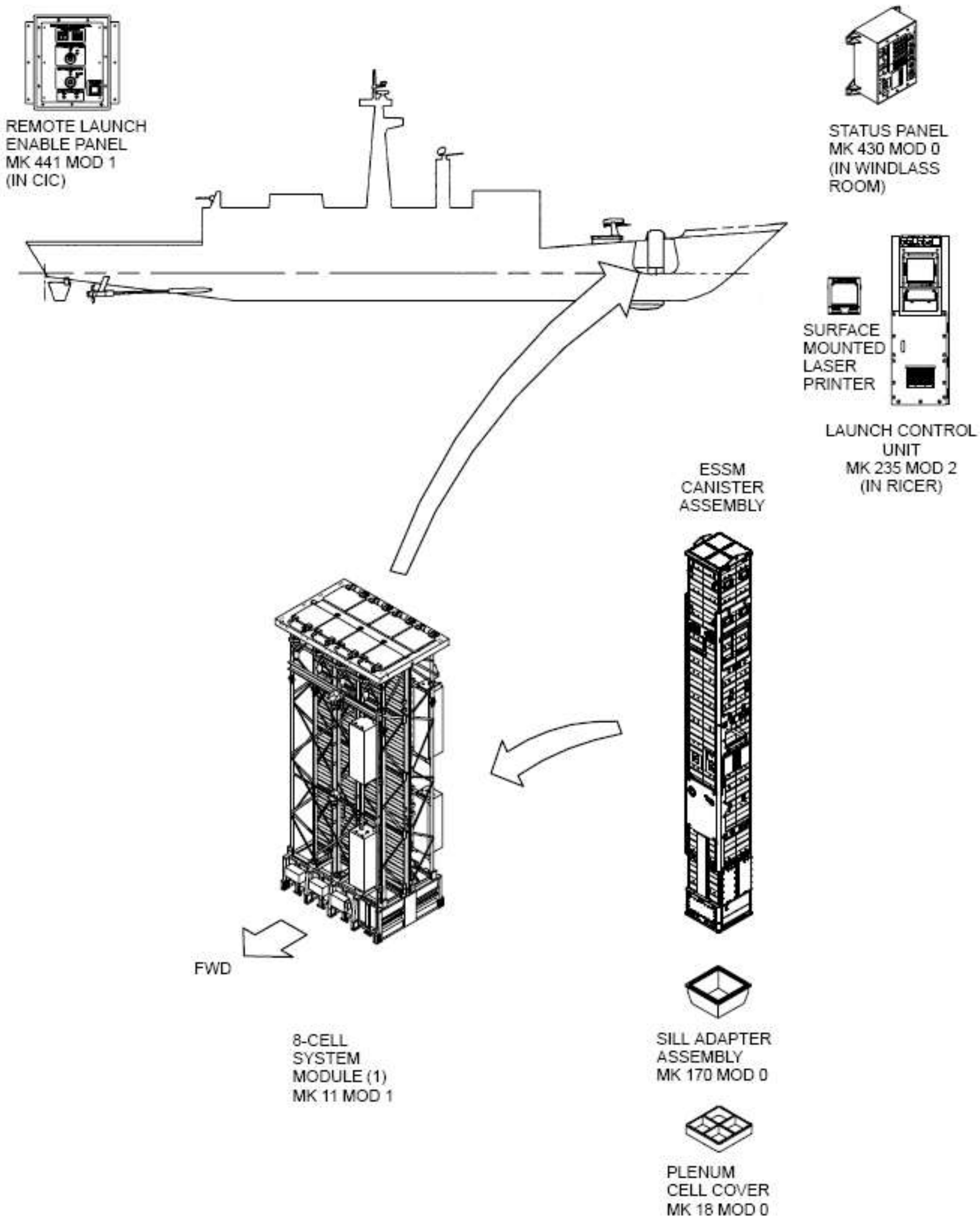


**Figure 5-1: Mk41 VLS Installation**

7. The Launch Enable signal is controlled by either of two manually operated key–switches. One key–switch is located at the status panel and the other at the Remote Launch Enable Panel (RLEP) in the Combat Information Center (CIC). During normal operation, the status panel CONTROL key–switch is positioned to REMOTE. In this mode, CIC controls the Launch Enable signal from the RLEP. When the status panel CONTROL key–switch is positioned to LOCAL for maintenance or strikedown operations, the Launch Enable signal is controlled at the launcher status panel.

8. The separate power supply and electronic component sets for each half–module limit the effect of most component failures to a half–module. Failures affecting the entire module include an uptake hatch failure or failures in the module electronic controls, power supplies, or interfaces. The separate

power supply and electronic component sets for each half–module make it possible to simultaneously prepare a missile for launch in each half–module. The launches will have a small forced–time separation to avoid collisions.

9. All missiles within the launcher are contained in separate, sealed canister subcells. The canisters are installed vertically below deck in cells within the launcher. The RAN FFGs have a single, forward launcher capable of containing up to eight missile canisters and up to four missiles in each canister.

## *System Description*

10. The VLS Mk 41 Mod 16, installed in RAN FFGs is controlled by the Mk92 WCP FCS. The Mk92 WCP interfaces directly with the VLS to integrate the VLS launcher capability into the ship's combat system. Figure 5-2 shows the VLS and its integration into the ship weapons system via the Launch Control Unit (LCU).

11. Missile select orders, target related data, and missile launch orders are sent to the VLS to control launch operations. In turn, the VLS supplies and updates missile availability and inventory data to the Mk92 WCP.

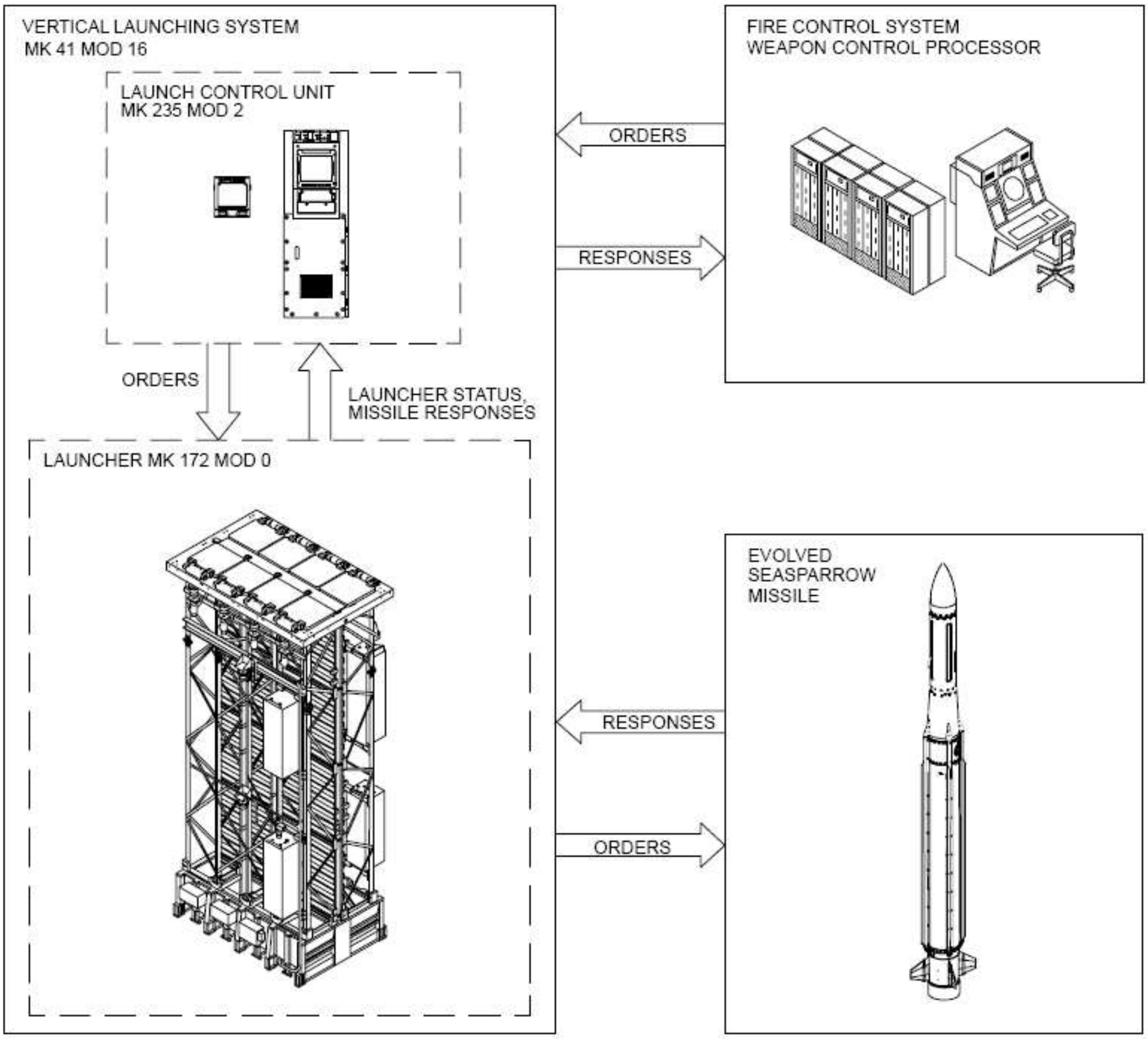


**Figure 5-2: MK41 VLS Interconnections**

## *Launch Control Unit*

12. The Mk 235 Mod 2 LCU provides the digital link and interface to the Mk92 FCS, manages VLS operations, and interfaces with VLS weapons for hazard monitoring and to select, prepare, and launch missiles. The LCU is located in RICER.

13. Communications between the LCU and the Mk92 are via the NTDS Type E low - level serial interface. The LCU receives launch orders from Mk92 WCP and in response, selects and issues prelaunch and launch commands to the Launch Sequencer (LSEQ). The LCU provides Input/Output (I/O), memory, and data processing capabilities for the VLS. The LCU has a direct interface with the LSEQ and transmits and receives serial data messages via Ethernet fibre optic interface cables. (Refer to VL15–TECH–0001/020, Chapter 2, Description, Section III, Detailed Functional Description, for a detailed description of this interface.)

14. The LCU provides the communications link for the VLS operating personnel. It processes the Launch Control Computer Program (LCCP), stores VLS operating history, and records data for fault isolation and data analysis. The LCU cabinet includes a power control panel, 20–inch (51–centimetre) flat panel display, magnetic media storage drawer containing two magneto–optical disk drives, retractable keyboard with trackball, switch router (inside cabinet), Versa Module European (VME) chassis (inside cabinet), and power subsystem (inside cabinet).

15. The LCU primary operator interface is via the keyboard with a trackball. The LCU provides a direct connection to a dedicated laser printer. The DmC 2180 laser printer provides a hard copy of the selected operator and computer interface messages and reports.

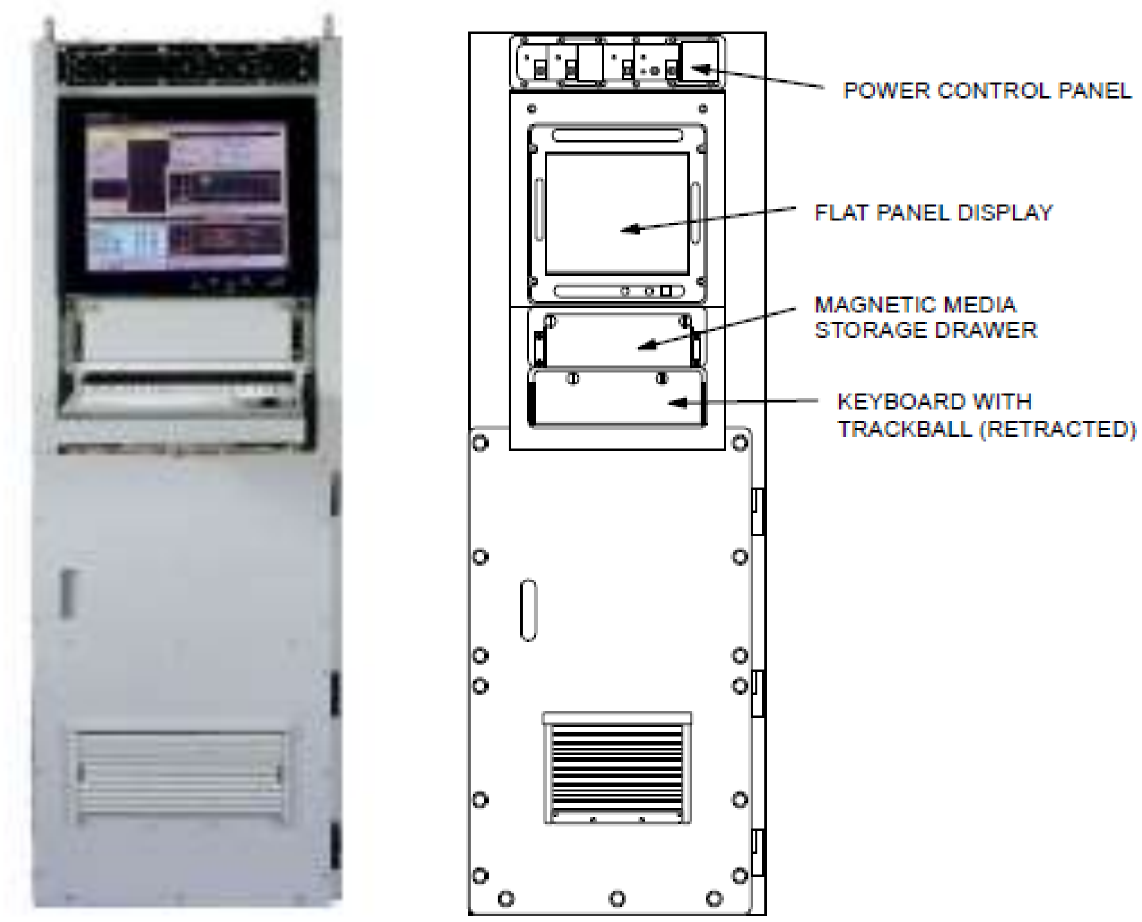


**Figure 5-3: Launcher Control Unit**

## Status Panel

16. Status Panel Mk 430 Mod 0 (fig. 1–5) is mounted on a bulkhead in the windlass room outside the launcher. The status panel houses indicators and key–switches. It monitors hazards and continuous power, controls launcher power, enables strikedown and anti-icing, and provides the launcher hazard status to the Integrated Monitoring Control System (IMCS). The status panel maintains communication with the RLEP in CIC and with the IMCS.

17. The status panel has five colour–coded key–switches. Each key–switch is used for control of a specific function. The key–switches are not to be used to control functions other than their intended use. The key–switch functions are:

a. CONTROL – LOCAL/REMOTE. When positioned to REMOTE, magazine power and launch enable are controlled from the RLEP (REMOTE is the normal operating position). When positioned to LOCAL, control of magazine power and launch enable is maintained from the status panel (LOCAL is used only for launcher maintenance and strikedown).

b. LOCAL OPERATION – LAUNCH ENABLE. This key-switch inhibits or permits launch enable when launcher is in local control.

c. LOCAL OPERATION – MAGAZINE PWR. This key–switch inhibits or permits magazine power when the launcher is in local control.

d. POWER – ANTI-ICING. This key-switch, permits selective activation of the anti-icing system for any module in the launcher.

e. POWER – STRIKEDOWN. This key-switch provides power to permit opening and closing of the cell hatches in strikedown mode. When this key-switch is turned on, it inhibits specific power to the magazine and Motor Control Panel (MCP). This key-switch is effective when the launcher is in local or remote control.

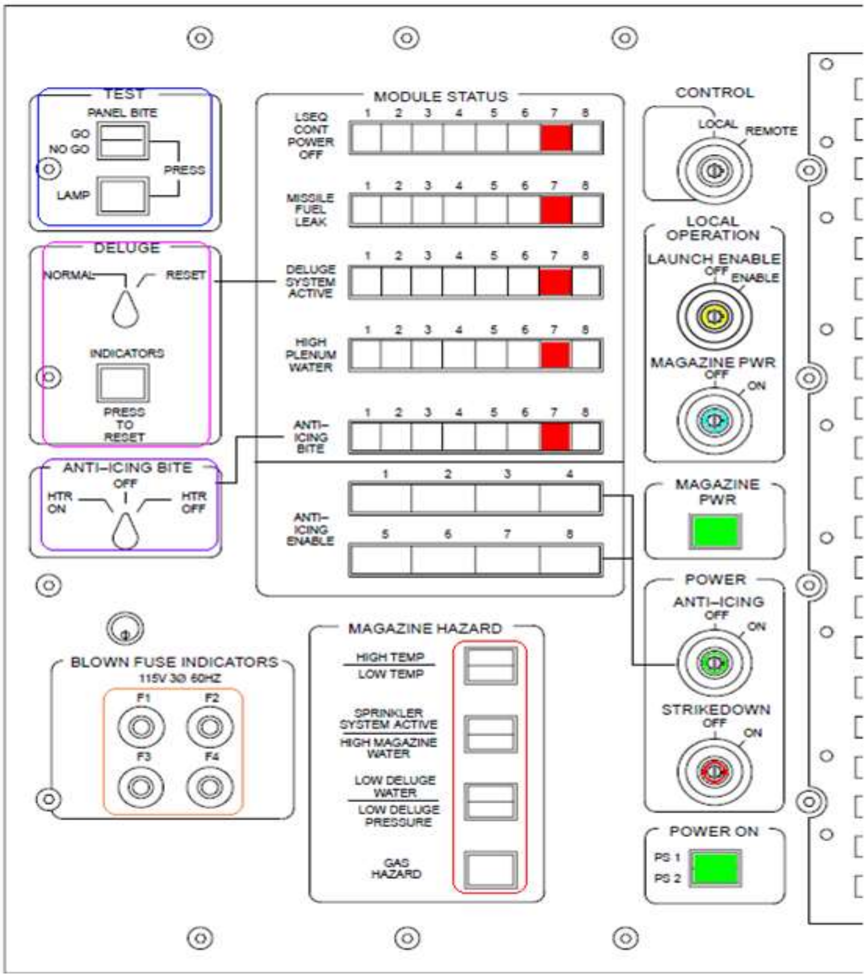


**Figure 5-4: Mk 430 Mod 0 Status Panel**

18. The status panel also includes a relay that is controlled by the safety observer's safety switch on deck. The switch is used during strikedown operations. If the safety observer's safety switch is released, power to the cell and uptake hatch motors is interrupted.

## *Remote Launch Enable Panel*

19. The Mk 441 Mod 1 RLEP, located in the CIC, interfaces directly with the status panel to display the source of launcher control (either local [MAGAZINE] or remote [CIC]), launch enable status, and launcher (magazine) power on status. The RLEP also provides control of the Remote Magazine Power and Remote Launch Enable signals to the launcher under normal conditions.

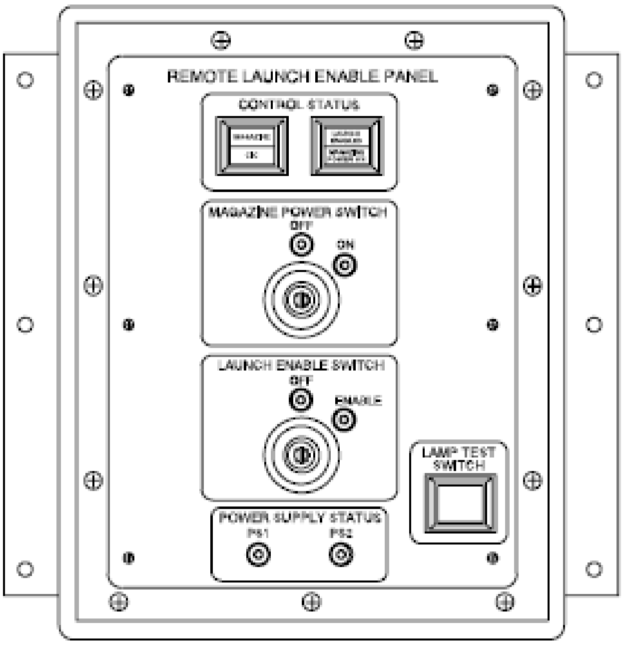


**Figure 5-5: Remote Launch Enable Panel**

## *Vertical Launcher*

20. The Vertical Launcher is the Mk 172 Mod 0. The launcher is housed in a watertight compartment that extends vertically from between the first platform and the second deck to above the main deck. Access to the launcher is through a watertight entrance door on two deck. Upper and lower launcher walkways provide access to VLS equipment.

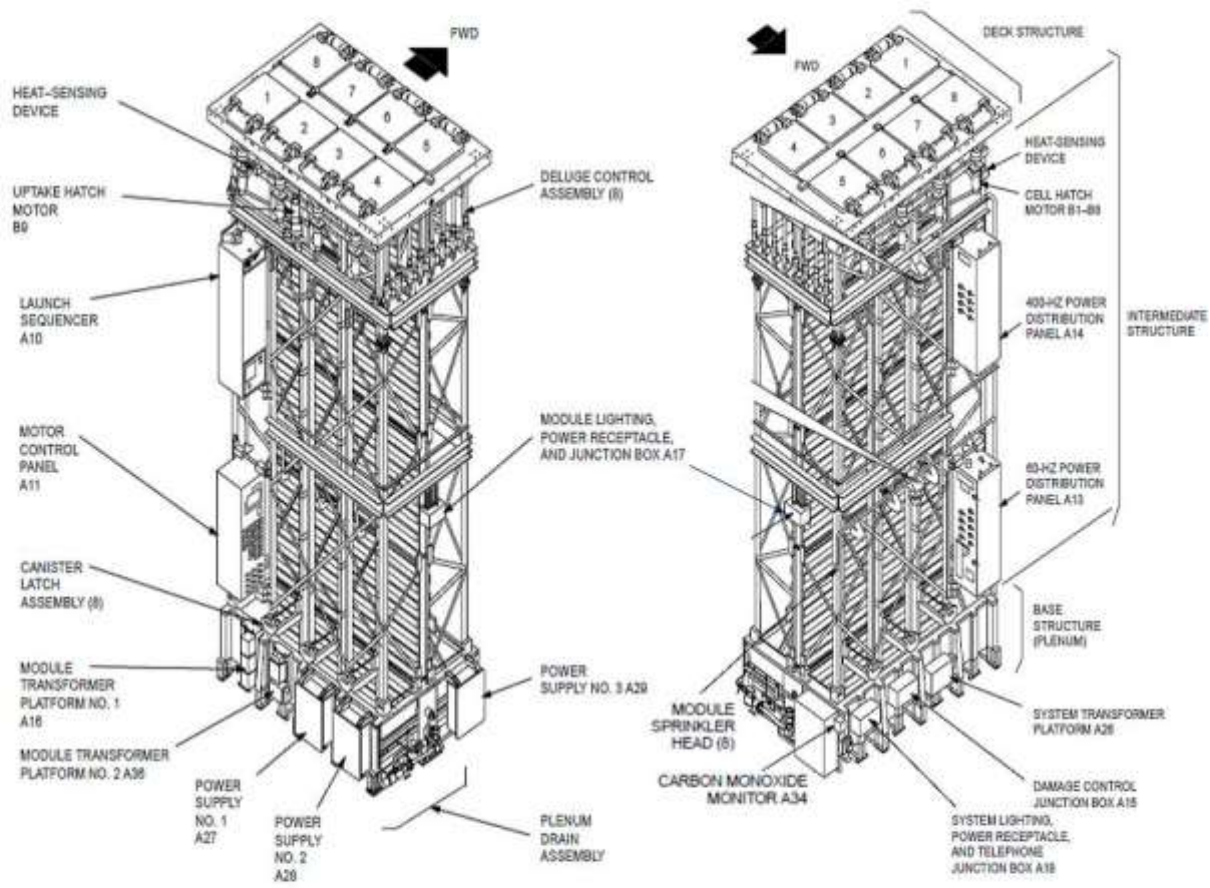


**Figure 5-6: Mk 172 Mod 0 Launcher**

21. The module is the primary structural component of the VLS launcher. It consists of the deck structure, intermediate structure, and base structure.

22. The **deck structure** on the 8–cell module consists of eight cell hatches and an uptake hatch. The deck structure provides ballistic protection equivalent to 3/4 inch (19 millimetres) of HY–80 steel. The deck structure also supports the upper ends of the canisters and is part of the gas management system that prevents rocket motor exhaust gases from escaping into the open launcher area.

23. The cell hatches and the uptake hatch are automatically opened by individual drive motors prior to a missile launch. Following a launch, the cell hatch is automatically closed. After the last missile in a firing sequence is launched from a module, the uptake hatch closing is automatically delayed 10 seconds to permit a substantial amount of gases from the launcher to vent. The cell hatches are manually activated from the motor control panel (MCP) for strikedown. All hatches contain heating elements to prevent icing.

24. The **intermediate structure** forms the midsection of the module and is part of the gas management system. The intermediate structure consists of four uptake sections bolted together (bottom to top) and the outboard structures. The uptake sections form a flue–like structure for venting missile exhaust gases above deck during a launch.

25. The **outboard structures** connect to the sides of the uptake sections and the top of the base structure to form four cells on each side of the uptake. The upright structure beams that form the corners of each cell serve as canister guide rails during installation and removal of canisters.

26. The canister latch assemblies are mounted above the lower walkway between the exterior of the uptake and canister guide rails. The latch assemblies engage grooves in the canister or plenum cell cover to secure them to the plenum and provide a tight seal for gas management of rocket motor exhaust.

27. The **base structure** serves both as a base for the module and as a plenum for the gas management system. The intermediate structure mounts directly to the base, which supports the weight of the module and canisters. A seal between each canister and sill adapter assembly and between the sill adapter assembly and the base structure prevents exhaust gases from escaping into the launcher. The interior surface of the plenum and uptake are protected with ablative material to prevent the heat blast from overheating the VLS structure or the ship structure.

28. The allowable number of firings per cell is calculated based on a formula that includes the missile type (ESSM) and launches in adjoining cells. The ablative is capable of withstanding one restrained firing in the module, even when the module is approaching its maximum number of firings. During a restrained firing, the entire module is taken offline until the ablative can be removed from the launcher for depot level repairs/ refurbishment of the ablative and any other damage.

## 8–Cell System Module

29. The 8–Cell System Module Mk 11 Mod 1 contains all of the major electrical assemblies along with control panels and circuitry to support operation of the associated VLS launcher.

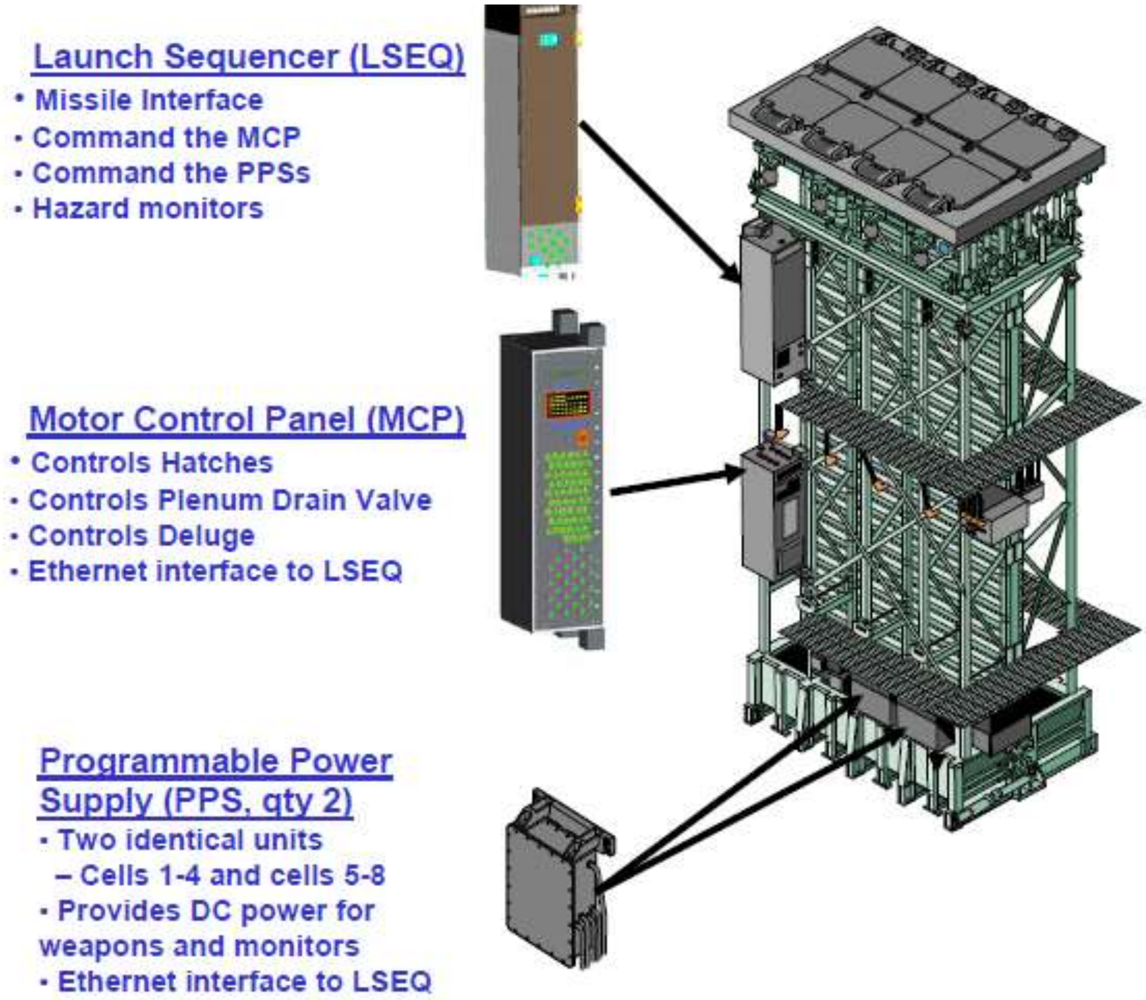


**Figure 5-7: 8-Cell System Module**

## Launcher Sequencer (LSEQ)

31. The LSEQ Mk 4 Mod 6 is mounted to the module structure at cell 1 above the upper walkway. It is attached by four brackets (two at the top and two at the bottom). The two sides of the cabinet are double–walled to allow cooling air to flow between them. Heat sinks and two blowers provide cooling for the LSEQ. Connector jacks are mounted on the top and bottom of the cabinet and on the lower part of the front. The front panel consists of a display panel, hinged cabinet access panel, and connector panel. The circuit card file access cover and eight relay module assemblies are located behind the cabinet upper access panel. The card file contains slots for 43 plug–in circuit cards of which 26 are used. The cards have keyed connectors to prevent incorrect circuit card installation.

32. The LSEQ power supply is behind the lower access panel. The display panel and access covers have electromagnetic interference/watertight seals. The LSEQ is the interface unit between the controlling LCU, other module equipment, and the missiles. The LSEQ monitors the status of the module and the cells within the module.

a. LCU interface

b. Control

c. Monitor

d. Missile interface

e. Hazard function

### *LCU Interface*

33. The LCU interface provides a two–way fast Ethernet fiber optic interface between the LSEQ and LCU. The LCU information consists of commands or data for the module. In return, the LSEQ provides the LCU with module status and BITE data. This function also maintains a two–way digital communication link with the other LSEQ functional areas.

### *Control*

34. The control function provides the primary data routing within the LSEQ. It performs automatic BITE to verify correct operation of the other LSEQ functions and provides temporary storage for status and BITE responses to the LCU. This information includes status of the LSEQ module power supplies, Motor Control Panel (MCP), deluge, and LSEQ mode check.

### *Monitor*

35. The monitor function collects both individual cell and overall module status. This information is stored and provided to the control function upon request.

### *Missile Interface*

36. The missile interface receives enabling inputs from the control function. These inputs control the routing of prelaunch and launch data and commands from the LCU interface function and the reporting of missile status and BITE data to the control function. This function decodes commands, reformats data, and routes information to the commanded cell.

### *Hazard Function*

37. The hazard function detects and reports hazard conditions in the module/cell areas to the status panel and to the missile interface and control functions. The hazard function contains circuitry that monitors sensors within the canister and controls the operation of the deluge system. Deluge occurs if the temperature inside a missile canister is greater than 190 °F (88 °C).

38. When a hazard condition exists, a hazard message is sent to the LSEQ control function and front panel lamps (deluge activated is lit) or deluge activated indicator (numeric indicator of deluged cell[s] is lit). The hazard function also monitors LSEQ temperature. If an LSEQ overtemperature is detected, the LSEQ power is commanded off if in the standby mode.

### Motor Control Panel

39. The MCP receives input commands from the LSEQ and converts them into discrete outputs to open and close the uptake and cell hatches, deluge control valve, and plenum drain valve. The MCP also provides monitoring and power control for the VLS module. Switches on the front panel of the MCP allow it to perform these functions independently of the LSEQ, when necessary.

40. Sensor switches on the hatch mechanisms and on the drain valve report status to the MCP. The status responses are used to turn off motor drive power when open or close limits are reached. The status responses are also routed to the LSEQ.

41. The MCP controls the distribution of power to module equipment upon receipt of a System Enable signal from the status panel. The MCP contains control relays, dc power supplies, command processing and control circuits, and fuses for protection of power distribution circuits. Indicators on the front panel display the status of power in the module. When the System Enable signal is removed, the MCP removes power from all module equipment except the anti–icing system and the continuous 24 Vdc to the LSEQ for hazard monitoring functions.

42. The MCP disables the anti–icing system upon receipt of a Strikedown Enable signal from the status panel or open cell hatch command from the LSEQ. The Strikedown Enable signal also enables the MCP for manual control of the cell and uptake hatch motors in a slow speed (pulsed) mode. When installed during strikedown operations, the safety observer’s safety switch is used to interrupt the cell and uptake hatch motors.

43. In the standby mode of operation, the LSEQ can send the MCP a BITE on command. Receipt of this signal disables the hatch motor drive circuits and enables an internal MCP self–test. The results of the self–test are reported back to the LSEQ.

## *Hazard Monitoring and Damage Control System*

44. The hazard monitoring and damage control system uses sensors to monitor and control hazards in the launcher. The hazard monitoring and damage control system consists of:

a. Hazard monitoring system

b. Deluge system

c. Sprinkler system

d. Plenum drain

e. Plenum relief valve

f. Launcher sump

### Hazard Monitoring System

45. The VLS hazard control monitoring system monitors for abnormal environmental and operating conditions. If an abnormal condition occurs, a sensor detects the condition and causes a hazard indicator on the status panel to light. Also, a signal indicating the abnormal condition is sent to the IMCS. The primary power for the monitoring system is supplied by the 440/115Vac 60Hz normal transformed supply. The ship supplied 115Vac 60Hz continuous power is used if the 440–/115–Vac 60–Hz normal transformed supply fails so the system can continue to monitor launcher hazards.

46. Major components of the hazard monitoring system are the sensors, DCJB, status panel, and interconnecting wiring.

47. There are two high temperature sensors, a low temperature sensor, a launcher high–water–level sensor, a low deluge pressure switch, a deluge low water level switch, a Carbon Monoxide (CO) monitor, four Heat–Sensing Devices (HSDs), and a sprinkler system flow sensor.

#### High Temperature Sensors

48. The two high temperature sensors detect high temperature conditions in the launcher environment. These two sensors close with increasing temperature of 85 to 95 °F (29 to 35 °C) and open with decreasing temperature of 85 to 75 °F (29 to 24 °C). When the sensors close, the MAGAZINE HAZARD–HIGH TEMP indicator on the status panel lights.

### Low Temperature Sensor

49. The low temperature sensor detects any under temperature condition in the launcher environment. The low–temperature sensor closes with decreasing temperature of 55 to 45 °F (13 to 7 °C) and opens with increasing temperature of 55 to 65 °F (13 to 18 °C). When the sensor closes, the MAGAZINE HAZARD–LOW TEMP indicator on the status panel lights.

### Launcher High Water Level Sensor

50. The launcher high–water–level sensor detects the presence of water at or above allowable level and is located 6 inches (15 centimetres) below the top of the sump. The sensor lights the MAGAZINE HAZARD–HIGH MAGAZINE WATER indicator on the status panel.

### Low Deluge Pressure Switch

51. The low deluge pressure switch is located on the deluge system manifold bleeder valve. The switch monitors the water pressure in the deluge water system. When it detects a drop in the deluge water system pressure to below 190 psi (13 bar), the switch closes to light on the MAGAZINE HAZARD – LOW DELUGE PRESSURE indicator on the status panel.

### Deluge Low Water Level Switch

52. The deluge low–water–level switch activates when the volume of freshwater inside the accumulator falls below 14 gallons (53 litres). When the switch is activated, the MAGAZINE HAZARD––LOW DELUGE WATER indicator on the status panel lights.

### Carbon Monoxide Monitor Sensor

53. The CO monitor sensor detects the presence of CO in the launcher at or above 50 Parts Per Million (ppm). The CO monitor receives ship power through the 60–Hz PDP. It sends a hazard signal to the status panel where it lights the MAGAZINE HAZARD—GAS HAZARD indicator on the front panel and sends a signal to the IMCS and to the ship alarm when CO in the launcher exceeds 50 ppm.

### Heat Sensing Devices (HSDs)

54. The four HSDs are temperature sensors used to detect any unacceptable rise in temperature in the launcher. The HSDs activate the sprinkler system after detecting a temperature in excess of 160 °F (71 °C). The HSDs are connected pneumatically to the Pneumatically Released Pilot Valve (PRPV) in the sprinkler control station.

### Sprinkler System Flow Sensor

55. The sprinkler system flow sensor is an inline sensor in the dry side of the launcher sprinkler valve that detects water flowing through the sprinkler system. When the sensor is activated, the MAGAZINE HAZARD–SPRINKLER SYSTEM ACTIVE indicator on the status panel lights.

## Damage Control

56. Damage control consists of the deluge system and the sprinkler system. Each cell has its own deluge system. The sprinkler system consists of eight sprinkler heads, four HSDs, and various control valves. Six sprinkler heads are located on the module and two are located on the starboard bulkhead. The sprinkler system is always in automatic (active) operating mode except during maintenance. If a casualty occurs in the canister deluge system, the sprinkler system becomes the primary fire fighting component and the entire launcher becomes the magazine. A casualty in the launcher sprinkler system requires a firewatch be posted.

### Deluge System

57. The deluge system applies water directly to the missile when a canister subcell overtemperature is detected. An overtemperature condition is defined as an internal canister temperature of 190 °F (88 °C) or above with a missile present. When a canister subcell overtemperature condition exists, a sensing device in the canister subcell sends the appropriate signal to the deluge control circuits in the LSEQ. The affected cell is taken offline and the LSEQ sends a deluge system on command to the MCP. The MCP determines which cell requires deluging and issues a Deluge On signal to cause deluging of that particular cell. Each deluge lasts 90 to 110 seconds and is terminated automatically by

signals from the LSEQ. If the overtemperature condition still exists after deluge, the canister is deluged again.

58. The two water sources the deluge system uses are freshwater and seawater. Normally, the system is filled with freshwater, which minimizes corrosion to pipes, valves, and other deluge system components during extended non-deluge conditions. However, seawater is the main water source for the system. When a deluge starts, freshwater in the system is used for initial canister cooling, but is expended quickly. Seawater from the ship firemain automatically fills the system as the freshwater is expended and used until deluge activation stops.

59. The deluge system contains 60 to 90 gallons (227 to 341 liters) of freshwater. A 28–gallon (106–liter) accumulator contains approximately 15 gallons (57 liters) of the freshwater supply, which is pressurized to 225 psi (15.5 bar). The accumulator maintains constant pressure in the deluge system. A level switch monitors the water level inside the accumulator. If the water level drops below approximately 14 gallons (53 liters), a signal is sent to the status panel, lighting the LOW DELUGE WATER indicator at the status panel and to the IMCS, causing an alarm to sound.

60. When a deluge condition is detected in a cell, any previously deluged cells/subcells with Canister Mk 25 Mod 0 present, the umbilical still connected, and the missile still present within the module will also be deluged. This continues until the spent canisters are removed or replaced. When no further deluge is required, the system is drained of seawater, flushed and filled with freshwater, pressurized, and returned to standby condition. Flushing of the system can only be performed when instructed by authorised personnel. Water from the deluged canister(s) is drained to the ship sump through the plenum. The ship eductor system is used to remove the expended water from the ship sump.

61. The deluge can be stopped manually by using the DELUGE–NORMAL/RESET switch on the status panel. The deluge can also be stopped by using the two–way deluge control valve, located in the local control station, which secures the seawater supply.

62. The deluge control assembly includes a deluge valve manual override mounted on each deluge control assembly in each cell. Personnel can use the manual override to selectively deluge an individual cell. In addition, a quick disconnect valve, located above and upstream from the deluge control assembly, can be used to isolate the cell from the deluge system water supply during maintenance (e.g., deluge control assembly replacement).

### Sprinkler System

63. The sprinkler system is part of the overall VLS hazard monitoring damage control system. The sprinkling system is normally maintained in active automatic operating mode. The sprinkler system is designed to extinguish fires within the launcher. Since the launcher is unmanned, the sprinkler system also provides redundancy if the canister deluge system fails. When the hazard monitoring deluge systems are operational, the VLS is treated as a launcher. If the deluge system is taken offline, the launcher space is treated as a magazine and the sprinkler system becomes the primary source of fire fighting.

64. The sprinkler system is a dry system. Prior to use, water is not present at the sprinkler heads. Water pressure is applied to the sprinkler heads when the sprinkler control valve is opened. The control valve opens when one of the HSDs activates. When the control valve opens, seawater from the ship firemain is applied to the sprinkler system and is sprayed from each sprinkler head.

### Damage Control Junction Box

65. The DCJB functions as a tie point between the status panel and the other launcher/module VLS equipment. Connections between the launcher sensors, MCP, and status panel are made through the DCJB. Signals from launcher sensors and from MCP are applied to the status panel from the DCJB.

66. The DCJB also applies +24 Vdc continuous power from the MCP to the status panel and applies status panel output signals to the MCP. The output signals consists of:

a. System Enable (power)

b. Launch Enable

c. Anti–Icing Enable

d. Strikedown Enable

## Plenum Drain Assembly

67. The plenum drain assembly is part of the sealed gas management system. It is a motor–driven valve controlled by logic circuits in the MCP. The plenum drain valve is normally open and driven closed during a launch sequence or deluge operation. The normally open drain valve allows water to be drained from the plenum whenever water is present.

## Plenum Relief Valve

68. The plenum relief valve admits launcher air into the plenum uptake when pressure in the plenum drops to approximately 14.4 psi (1 bar) atmospheric pressure. This prevents a vacuum from developing in the plenum after a missile launch. The plenum relief valve also functions as a check valve to prevent missile exhaust from entering the launcher during missile launches.

## Launcher Sump

69. The launcher sump is located in the space below the launcher. Water accumulated in the launcher sump is removed by the launcher main eductor and discharged overboard. The main eductor automatically opens when the sprinkler system is operating. If the main eductor fails to operate automatically, it can be operated manually by opening a bypass valve. The space below the launcher also contains a housekeeping eductor. The housekeeping eductor is manually operated and used to drain small amounts of water from the launcher sump and lowest level of the launcher area during launcher maintenance.

70. Water accumulates in the launcher sump when the deluge and/or sprinkler system is activated. The deluge control assembly is located adjacent to cells 4 and 5 above the upper walkway of each module. The deluge control assembly automatically delivers water flow to the missile warhead when a critical temperature is detected by a heat sensor located inside the canister. Water from a deluge accumulates in the module plenum and is drained into the launcher sump. The sprinkler system is automatically activated when a critical temperature is detected in the launcher. Water from the sprinkler system drains directly into the launcher sump. The main eductor is capable of handling water discharged into the launcher sump even if the launcher sprinkler and deluge systems are activated simultaneously.

# *Ancillary Systems*

## Anti–Icing System

71. The anti–icing system prevents a build up of ice or snow that could prevent the cell or uptake hatches from opening during launching. The anti–icing system is not a de-icing system. Use of the anti–icing system is required to ensure the hatches operate in cold weather. To avoid overloading the electrical system of the ship, the anti–icing system cannot be used continuously. Hatch heater elements may burn out if the anti–icing system is left on indefinitely. To reduce the possibility of a failure, the anti– icing system should only be enabled when the outside temperature is 38 °F (3.3 °C) or below. Anti–icing must be manually enabled at the status panel. Power to operate the heater elements is supplied by the 60–Hz Power Distribution Panel (PDP).

## Blowout System

72. The blowout system removes toxic fumes from the launcher by opening vent lines and activating the vent fans motor controller. After a missile launch, restrained firing, or strikedown operation, the ship launcher blowout system must be operated for a minimum of 20 minutes prior to entering the launcher. The blowout system must also be operated for 1 minute each hour that personnel remain in the launcher with air replenishment system off, to ensure adequate air. After a restrained firing, the blowout system must be operated continuously when personnel are in the launcher or environmentally attached spaces until the affected canister is offloaded.

## *Launcher Support Equipment*

### Sill Adapter

73. The ESSM Canister Mk 25 Mod 0 and Training Canister Mk 19 Mod 0 use Sill Adapter Assembly Mk 170 Mod 0 to form a gas–tight system to capture, contain, and vent the rocket motor exhaust gases to the atmosphere. The inside of the adapter is lined with ablative block. The upper and lower seals provide gas management.

### Plenum Cell Cover

74. Plenum Cell Cover Mk 18 Mod 0 is used with the sill adapter assembly to cover an empty cell. The cover plate seats over the opening of the sill adapter assembly and is secured in the cell at the latching surfaces by the canister latches.

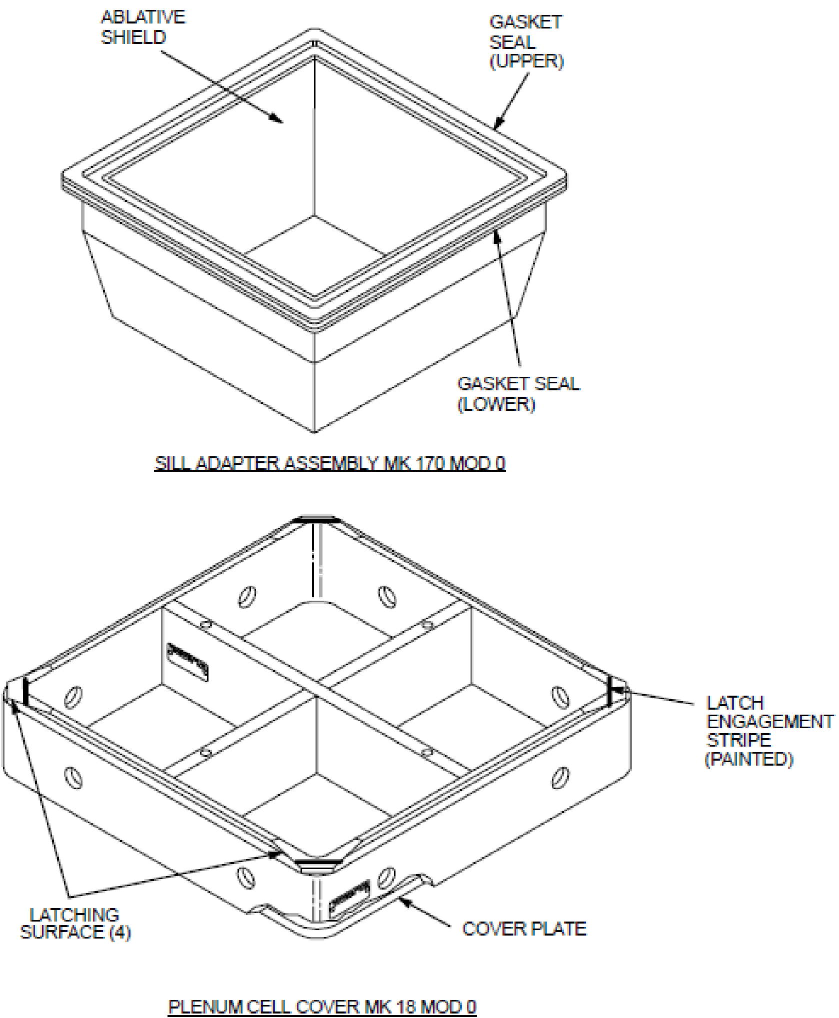


**Figure 5-8: Launcher Support Equipment**

### Seal Monitoring Circuit

75. A canister or plenum cell cover and sill adapter assembly must be in place and latched down in each cell before a rocket motor can be ignited in the module. A series switch circuit sends a signal through the MCP to the LSEQ to indicate a canister or cell cover and sill adapter assembly is in place in each cell and the latches are tightened. The canister present switches are closed when a canister or cell cover and sill adapter assembly is in place over a cell plenum opening. The latch sensor switches are closed when the latches are tightened. The signal is sent through the MCP to the LSEQ when all 10 latch switches and all 8 canister present switches are closed.

## *Operating Modes*

76. The VLS Mk 41 is designed to operate continuously. It does not require periodic shutdown and reinitialisation. Once the VLS is successfully initialised, it can receive missile preparation and engagement orders from the WCP and simultaneously prepare one missile for launch in each half–module of the launcher. The system can also prepare one missile for launch in a half–module while launching another missile from the other half–module. The three operating modes of the VLS, in priority order, are **ready alert, simulation, and standby**. The WCP provides mode control by ordering the VLS in any of the three operating modes. When a mode change order is received from the WCP, the LCU issues mode change orders to the Launch Sequencer (LSEQ).

## Initialisation

77. This consists of loading the Launch Control Computer Program (LCCP) into the LCU and the FCS WCP putting VLS in standby. After initialisation is successfully completed with VLS in standby, power is applied to the launcher equipment and the VLS is under FCS WCP control.

## Ready Alert Mode

78. Ready alert mode is the firing mode. The VLS responds to all orders from the FCS WCP managing the engagement, including missile select and launch. The VLS is capable of continuous operation in the ready alert mode. Ready alert mode is the highest priority mode for VLS. In the ready alert mode, the system does not perform routine Built–In Test (BIT/BITE) functions, but does report launch–related faults and performs status collection.

79. When the order is received from the FCS WCP, the LCU commands the LSEQ into the ready alert mode. Before a missile can be launched, the Canister Safe/Enable Switch (CSES) must be set to ENABLE and the status panel must provide a Launch Enable signal. This is normally in response to a command from the Combat Information Center (CIC) via the Remote Launch Enable Panel (RLEP). The status panel forwards the Launch Enable signal to the Motor Control Panel (MCP), which routes it to the LSEQ. The LSEQ then enables the Missile Launch signal interface between the LSEQ and the missile.

## Simulation Mode

80. Simulation mode supports combat system training and testing. In this mode, the VLS can perform all the functions of standby mode except BITE. In simulation mode, the VLS accepts simulated launch orders from FCS WCP and provides responses to support training and testing. The VLS does not provide the system with a missile interface during simulation mode. All communication to the LSEQ, other than normal protocol status, is disabled. The missile interface circuitry is maintained in a safe state.

81. In simulation mode, the LSEQ is in standby mode and the LCUs perform normal status collection. Fault detection and status and hazard reporting are not affected. The simulation mode consists of:

- a. Missile simulation preparation
- b. Missile inventory reporting
- c. Message validation
- d. Missile selection
- e. Evolved Sea Sparrow Missile (ESSM) launch sequence processing

82. In the simulation mode, either the actual inventory or a simulated inventory may be used. If a simulated inventory is desired, the LCU stores the actual missile inventory and sends the selected simulated missile inventory to WCP. A simulated Launch Enable signal is generated when the VLS is in simulation mode. Personnel must not generate a Launch Enable signal from the RLEP or status panel when the VLS is in simulation mode. When the VLS is placed in simulation mode for an extended period of time, the VLS must be returned to standby mode every 2 to 4 hours to allow BITE to be initiated.

## Standby Mode

83. In standby mode, the VLS is fully functional except that missile select and launch functions are inhibited. The VLS performs missile inventory management and equipment and hazard fault detection and reporting. These functions are performed through system BITE and status collections.

84. Following successful system initialisation and configuration by WCP, the VLS is placed into standby mode and the LCU establishes communication with the LSEQ. Within 30 seconds, the LCU commands a system BITE check on the module, provided Launch Enable signal is off. System BITE runs for about 3 minutes; the results are displayed at the LCU and, if desired, can be printed via the laser printer.

85. Subsequent automatic BITE is conducted every 2 hours, while the VLS is in standby mode with Launch Enable signal off. Providing the 2–hour timer has not elapsed, mode order changes that command VLS out of standby mode and back into standby mode do not cause a system BITE to be executed. However, if the 2–hour timer has elapsed while the system is not in standby mode, a mode order that returns the system to standby causes a system BITE to be initiated. Subsequent automatic BITE is initiated every 2 hours from the completion of the last automatic BITE. The LCU BITE is conducted every 10 minutes.

86. Operator–initiated all modules or single-module system BITE may be initiated from the LCU if the VLS is in standby mode and Launch Enable signal is off. Completion of operator–initiated BITE does not reset the 2–hour automatic BITE timer.

87. Cell/subcell and module status collection checks are also performed along with BITE to isolate faults in the VLS. Status collection is performed every 30 seconds on each module regardless of the mode.

88. All faults detected during system BITE or status collection are reported to WCP. Fault information is also displayed at the LCU and may be printed at the printer if requested at the LCU. Faults are recorded once, unless the LCU is reinitialised. If the fault affects the availability of a module, half–module, or a particular cell, WCP is notified. The VLS then declares the module, half–module, or cell/subcell unavailable for use until the fault is corrected or an override (for those faults that are overrideable) is ordered from WCP.

89. **VLS Tactical State** – is the default state for operation. In this state, all Missile Rounds (MRs) are automatically authorised and cannot be made unauthorised. If the CSES is enabled, the missile is ready for firing. The launch proceeds normally, unless the MR is taken offline for another reason.

## *Launch Sequence*

90. The VLS ESSM launch sequence functions are:

a. Cell/subcell/missile selection

b. Cell/subcell/missile preparation

c. Missile/module ready

d. Missile initialisation and rocket motor ignition

e. Missile away

f. Missile safing

g. At–sea ventilation

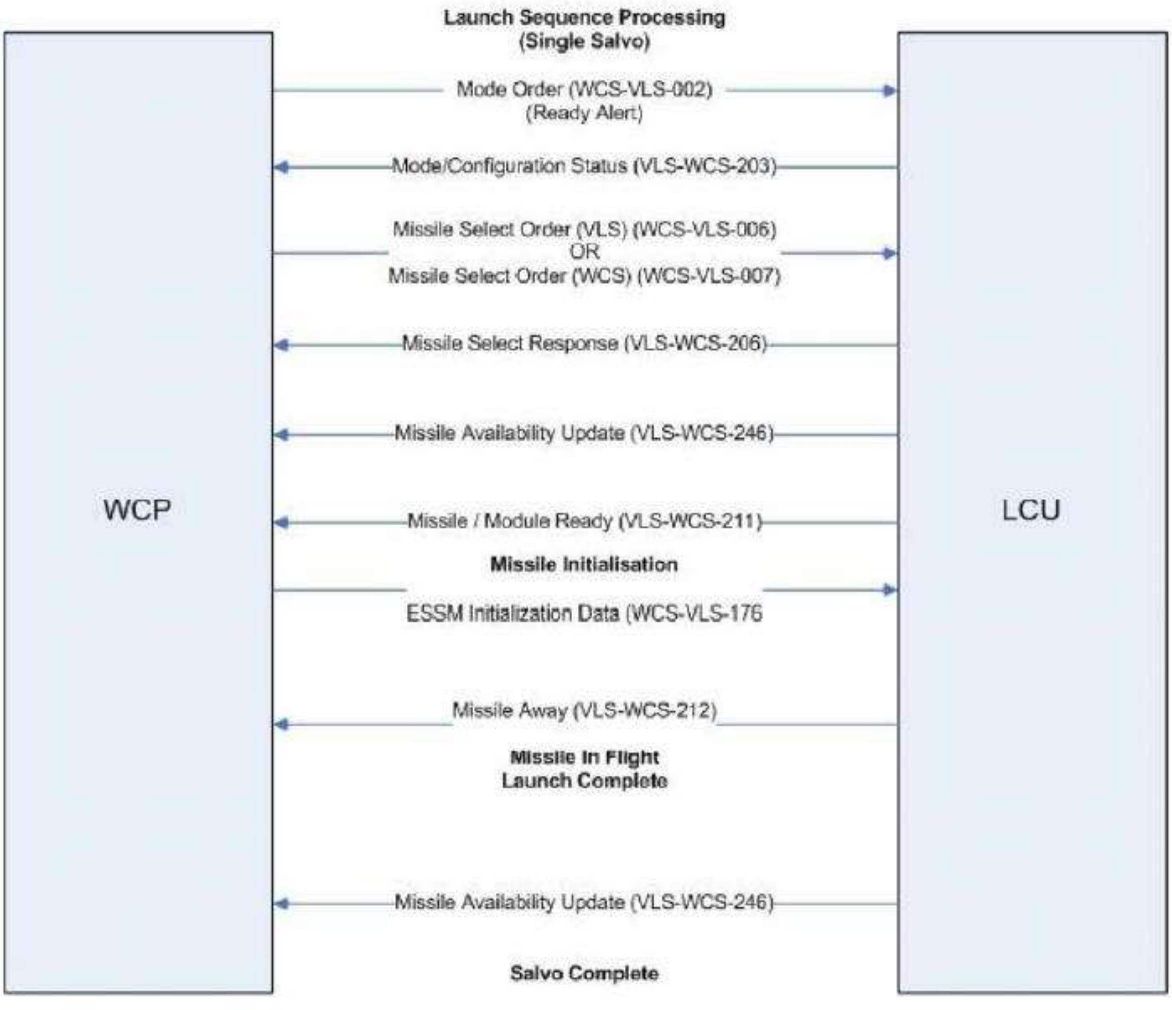


**Figure 5-9: ESSM Launch Sequence**

## Cell/Subcell/Missile Selection

91. During cell/subcell/missile selection, the WCP selects the cell, subcell, and ESSM. Selection can be made in one of two ways. The WCP either designates the specific cell/subcell that a specific missile is located in, or just selects the missile type and allows the VLS to select the best missile from the available cells/subcells. The missile can be selected from subcells A, B, C, and D of cells 1 through 8. Once a missile is selected for launch, other missiles in the same half–module cannot be selected until the selected missile is launched or the safing and deselection process is completed.

## Cell/Subcell/Missile Preparation

92. With Intent–To–Launch (ITL) present, the cell and uptake hatches are opened and the plenum drain valve is closed to begin cell/subcell/missile preparation. The +28–Vdc ITL signal is applied to a series of internal missile contacts (firing interlocks) which, when closed, indicate the missile is ready for flight. Then the ESSM warhead identification is verified and voltage is applied to the battery squibs. Target selection is made provided launch enable and the CSES are enabled.

## Missile/Module Ready

93. The system monitors cell and missile status and reports to the FCS WCP that the cell and missile are ready for the digital data message. If no failure messages are received, the WCP transmits a digital data message for the missile to the system.

## Missile Initialisation and Rocket Motor Ignition

94. Missile initialisation occurs when the digital data message is successfully received by the missile. Then the rocket motor ignition function verifies the Launch Enable signal is present from the RLEP in CIC and the CSES is enabled. The system then ignites the rocket motor and verifies the missile has been successfully launched.

## Missile Away

95. As the missile moves upward, a wire in the shear connector of the missile umbilical connect plug breaks to indicate the missile is leaving the canister/subcell and provides the Missile Away signal to the LSEQ. The cell hatch closes after a short delay. The uptake hatch remains open longer before closing to vent rocket motor gases. Missile away time is reported to WCP and the system records the firing count and remaining missile inventory.

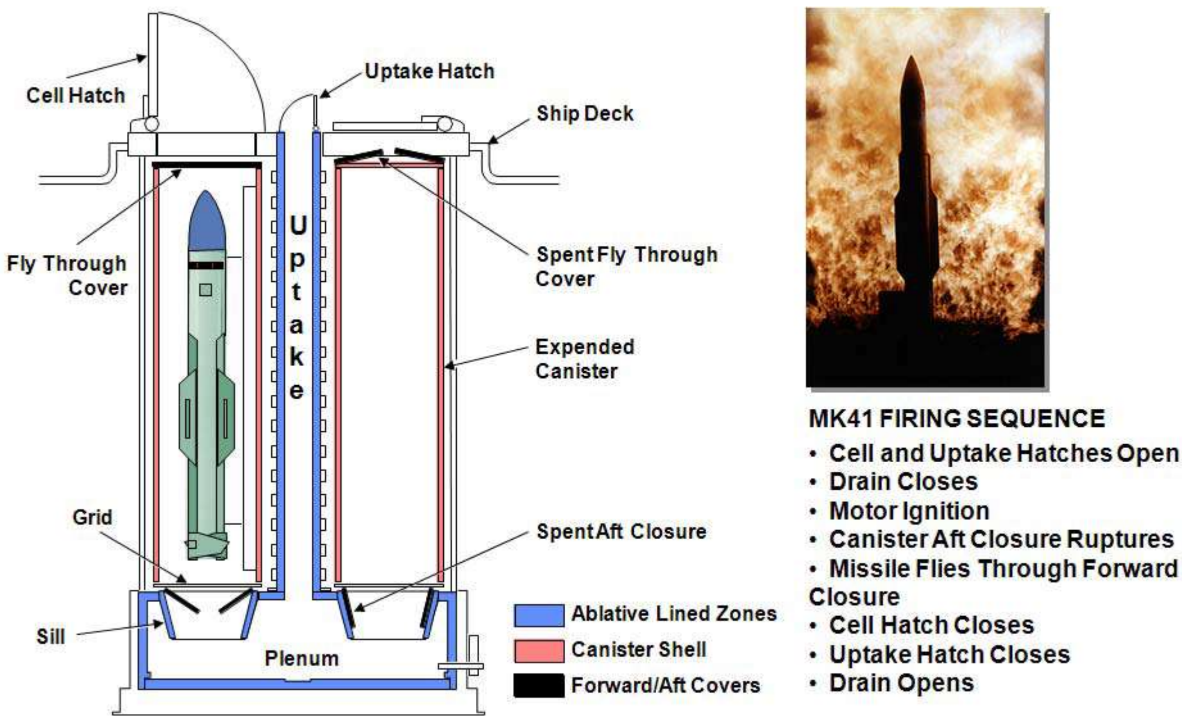


**Figure 5-10: VLS Firing Sequence**

## Missile Safing

96. This can occur during any part of the launch sequence prior to rocket motor ignition to safe, deselect, and terminate a launch attempt. If the rocket motor is not safe, the missile safing function is completed to disarm and safe the missile. The cell hatch closed status is verified and a missile cool–down period is initiated if the battery was not activated. If the battery was activated before safing, the missile is no longer available for selection.

## At–Sea Ventilation

97. When launches are completed, the launcher blowout system is activated to remove any latent toxic gases. The launcher blowout system must be operated for a minimum of 20 minutes before personnel are allowed to enter the launcher or environmentally attached spaces. After a restrained firing, operate blowout system continuously when personnel are in the launcher or environmentally attached spaces until the affected canister is offloaded. Personnel entering the launcher must use toxic gas sensors to ensure carbon monoxide in the launcher or environmentally attached spaces is below the specified Parts Per Million (ppm), normally established at 50 ppm. If the carbon monoxide levels are above 50 ppm, personnel must exit the launcher and reactivate the launcher blowout system for another 20 minutes. This procedure continues until carbon monoxide levels are below 50 ppm.

98. Once inside the launcher, personnel open the hatches (cell and uptake) from the MCP for all cells from which missiles have been fired. The ship may need to manoeuvre to create a minimum of 5 knots of relative wind, preferably athwartships across the deck. The hatches must remain open for a minimum of 20 minutes and then be closed.

## *Restrained Firing*

99. Unlike GMLS, dud or misfired missiles cannot be jettisoned. Instead, they are physically restrained within their cell until a safe opportunity to remove the canister is presented. During a normal firing, the restraining system is released via explosive bolts. In a restrained firing, the missile fails to be released and is held inside its cell throughout the rocket motor burn, with the exhaust vented in the normal manner. The deluge system will initiate once the temperature in the cell rises above 88°C.

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# Chapter 6. Evolved Sea Sparrow Missile

30. The VLS Mk 41 Mod 16 launches the ESSM. The ESSM is a short–range surface–to– air missile with a solid–propellant rocket motor. The ESSM consists of a radome, guidance section, warhead section, transition section, dorsal fins, rocket motor, control actuation assembly, control surfaces, and Thrust Vector Control (TVC). The TVC controls pitchover and guidance during the initial portion of the flight.

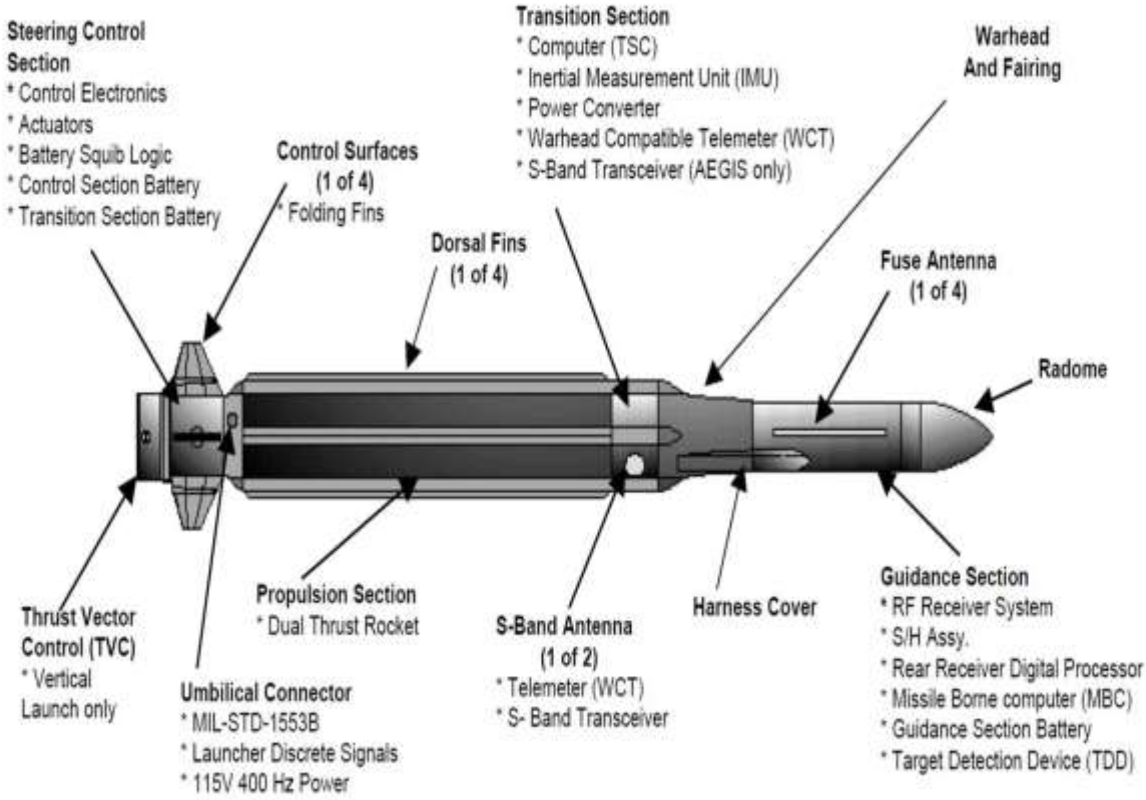


**Figure 6-1: Evolved Sea Sparrow Missile**

## Missile Flight Phases

31. The ESSM has seven operational missile phases:

a. Ready/Storage;

b. Pre-Launch/Launch;

c. Transition Phase;

d. Mid-Course Guidance and Acquisition;

e. Homing Phase;

f. Terminal Phase

g. Intercept

### Ready/Storage

32. While in this phase, the missile conducts rear reference tuning and a BIT in order to generate a ‘missile ready’ signal. The missile sits dormant in this state until required.

## Pre-Launch/Launch

33. The Pre-Launch/Launch Phase, is started when the external power and battery activate signals are applied by the launcher via the Launcher Umbilical Interface (LUI). The missile will conduct BIT to verify missile readiness. Upon successful BIT results and battery activation, the missile will send a Latch Command to the launcher. The launcher then sends the missile an initialisation message which consists of two types of data: Missile data message, and target data message. The missile error-checks the digital message and if it is proper, the missile will send the launcher a Ready to Launch signal. The launcher will subsequently provide the firing command to ignite the rocket motor. After a successful rocket motor ignition, the missile will exit the launcher and a break wire signal will provide a Launch Indicate to the transition section computer (TSC) indicating missile launch.

## Transition Phase

34. Transition Phase is defined as the period between missile first motion and homing guidance. During transition phase, the TSC guides the missile safely away from the ship and directs the missile on an intercept course towards the target. Missiles launched from vertical launchers, will have a vertical flight period and a pitchover period. During the vertical flight period, the aerodynamic control surfaces and the thrust vector control (TVC) vanes are not moved until the launcher is cleared and then activated to achieve the roll orientation desired for pitchover. The control surfaces and the TVC vanes perform the pitchover manoeuvre to place the missile on the desired flight path. Once the missile is on the desired flight path, is stable, and has achieved a desired air speed, the TVC is jettisoned to reduce aerodynamic drag. The transition phase is then completed.

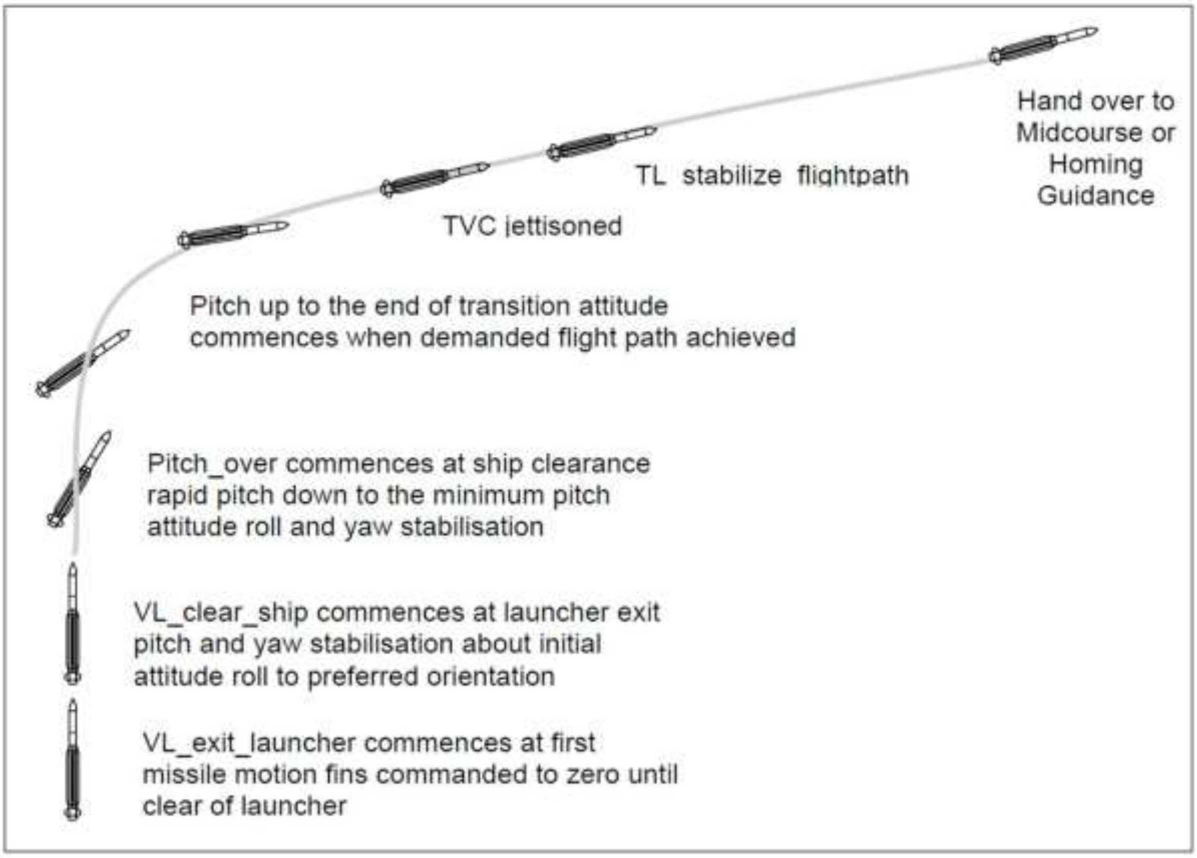


**Figure 6-2: ESSM Transition Phase**

## Mid-Course Guidance and Acquisition

35. The ESSM variant currently in use with the RAN is not capable of mid-course guidance and instead operates in True Home All the Way (THAW) mode.

36. Upon completion of Transition Phase, the missile establishes an interim midcourse trajectory based on the Inertial Measurement Unit (IMU) output and on the predicted intercept point (PIP) provided to the TSC during pre-launch initialisation. Since the seeker head is directed toward the

predicted target position during Transition Phase, the target search and acquisition process can start immediately during Transition.

37. If rear reference acquisition does not occur during Transition and consequently front lock is delayed, the missile will continue to search for these entities. If rear reference does not occur within an allotted 8 seconds including a 3 seconds hold off after launch, or is lost for 5 seconds after being acquired, and the pre-launch data has enabled Self-Destruct functionality, the Self-Destruct sequence will be initiated. In the case where rear reference RF is acquired but the reflected illumination is never acquired, the missile will not transition to the terminal homing phase; it will continue to fly the energy efficient trajectory to the PIP and beyond.

38. Once both rear reference and reflected illumination RF are acquired, the missile transitions directly to the terminal homing phase, irrespective of the time until intercept. In THAW mode the missile is in Homing Guidance Mode for the maximum percentage of missile flight duration with tail control surfaces responding to seeker angle tracking signals. The trajectory is not expected to be energy efficient.

## Homing Phase

39. The Homing Phase for the missile is when the target is acquired and target return signal is sufficient for the seeker head / receiver to track the target. The target acquisition / homing commences on the occurrence of 5 seconds Time to go depending on the TSG Mode. The guidance section missile borne computer (GS/MBC) will perform signal processing algorithms and provide line-of-sight rates to the TSC which uses them to calculate command accelerations to steer the missile to intercept the target.

40. Homing guidance is accomplished by continuous wave illumination (CWI) from either the CAS or STIR director.

## Terminal Phase

41. In Terminal Phase, the missile transitions to terminal mode homing guidance upon receipt of Low Altitude Flag from the MBC. The TSC continues to guide the missile to an intercept course towards the target. Critical information is calculated and sent from the target detection device (TDD) to the TSC via the MBC. The TSC adds corrections to terminal guidance for special scenarios such as low altitude intercept. The missile guidance is modified by a Low Altitude Guidance (LAG) algorithm for adjustment to missile aerodynamics and TDD characteristics. The objective of the missile guidance and control is to intercept the target (physical contact) or obtain a specified miss distance to optimize target kill from warhead detonation.

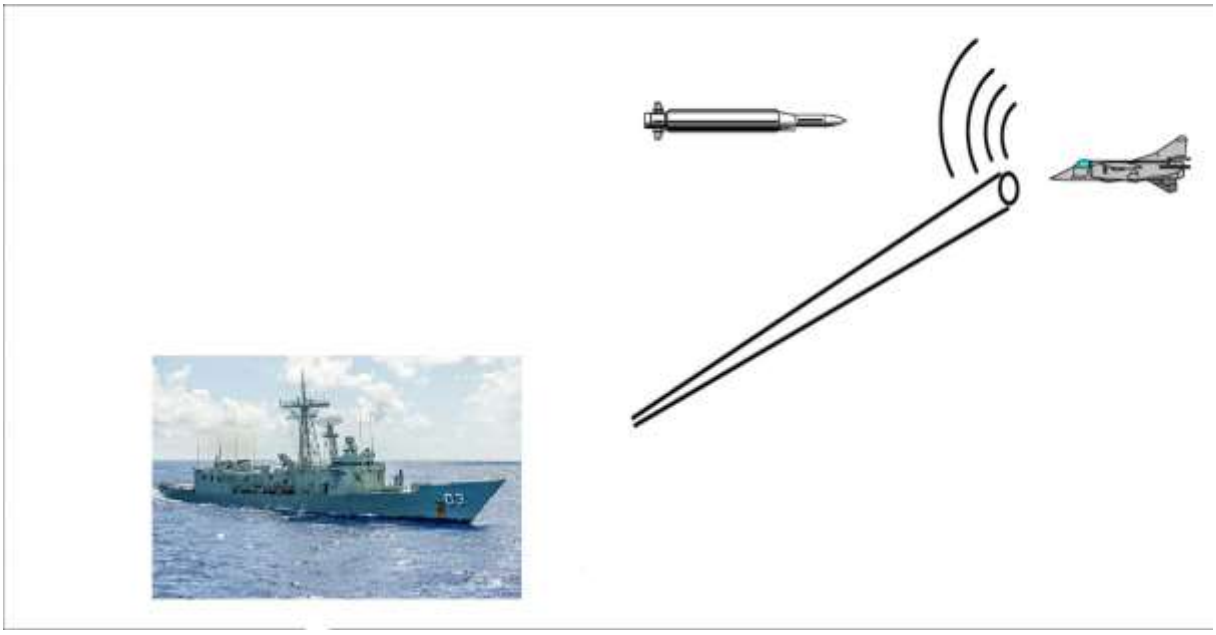

**Figure 6-3: ESSM Terminal Phase**

## Intercept Phase

42. The Intercept Phase is accomplished when the TDD has successfully detected the target at intercept-Closest Point of Approach (CPA). A fire pulse will be generated causing the warhead to detonate, unless the TDD inhibit function has been enabled. Another method of warhead detonation is when the fuse triggering device senses physical target impact, the contact fuse fire pulse signal will cause the warhead to detonate.

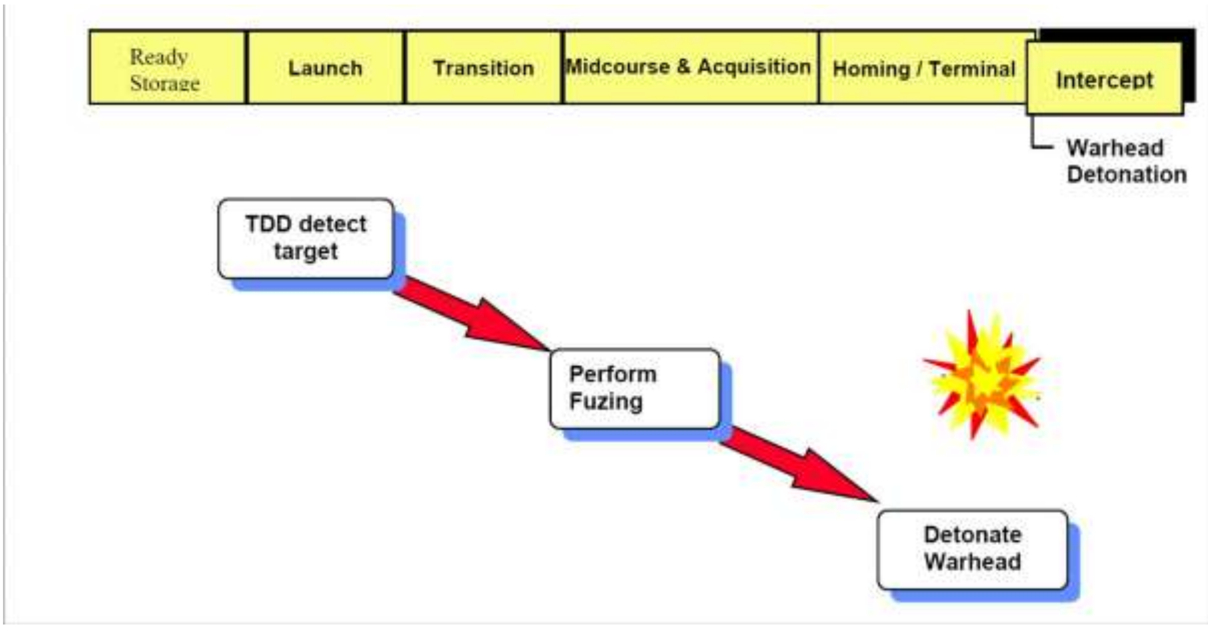


**Figure 6-4: ESSM Intercept phase**

# Chapter 7. CIWS MK 15 MOD 11

**Reference**: SW221-BF-MMO-010/020/030(CONF)


**Figure 7-1: Phalanx CIWS Mk15 Mod 11**

## *Overview*

1. The Phalanx Close-In Weapons System (CIWS) was designed and manufactured by the General Dynamics Corporation, Pomona Division (now owned by Raytheon). Its primary purpose is to act as the last line of automated weapons defence (terminal defence or point defence) against anti-ship missiles (ASMs), including high-g and manoeuvring sea-skimmers.

2. Due to its design criteria, its effective range is very short relative to the range of modern ASMs, from 1 to 5 nautical miles (9km). The gun mount moves at a very high speed and with great precision. The system takes minimal external inputs, making it capable of functioning despite potential damage to the ship.

3. The following inputs are provided to the system:

   a. Power:

      i. 440V, 60Hz, 3Φ to the Weapons Control Group (WCG) and the Local Control Panel (LCP)

         1. Search Radar transmitting = 10kW (16.4A)

         2. Worst case (gun firing) = 70kW (100A)

      ii. 115V, 60Hz, 1Φfor the Remote Control Panel (RCP) and Parameter Analysis Storage System (PASS)

   b. Chilled Cooling (from A/C's, 7 gpm @ 150 psi @ 40degF) - required for cooling of the internal cooling fluid (glycol based) that is used in cooling the Klystron (Tx), and aids in keeping the waveguide dehumidified.

   c. Cqo (Ship's heading from Ship's Parameter distribution system)

4. The system provides the following outputs:

   a. RF (J band).

   b. SW overboard discharge. (Emergency Cooling Only)

   c. Mk149, 20mm Tungsten tipped ammunition (Australian made).

## *Functional Characteristics*

| CHARACTERISTIC | LIMITATION/CAPABILITY |
|---|---|
| Search/Track Radar<br><br>Maximum Search Range<br>Track Slant Range<br>Track Elevation Coverage (deg) | J-Band Coherent Pulse-Doppler (4 Search Antennas used for search ($0.5^0$-$10^0$, $10^0$-$30^0$, $30^0$-$50^0$ & $50^0$-$72^0$ - antenna zones)<br>SEE SW221-BF-MMO-030 (CONFIDENTIAL)<br>SEE SW221-BF-MMO-030 (CONFIDENTIAL)<br>SEE SW221-BF-MMO-030 (CONFIDENTIAL) |
| Mount Elevation Coverage (swing) - WRT deck plane | SEE SW221-BF-MMO-030 (CONFIDENTIAL) |
| Engageability Requirements (software controlled) | SEE SW221-BF-MMO-030 (CONFIDENTIAL)<br>a. speed within limits<br>b. NOT in a No-Engage Sector |
| Termination Requirements (software controlled) | a. Gun in firing cut-out zone (determined by cams configured on installation of mount)<br>SEE SW221-BF-MMO-030 (CONFIDENTIAL) |
| Rate of Fire | 4500 rpm (approx 75 rounds per second) |
| No-Engage Sectors | Up to 2 non-overlapping sectors, either RELATIVE or TRUE.<br>A target within the sector will NOT be fired upon UNLESS firing was initiated OUTSIDE the sector. **Set at the LCP only**. |
| Target Speed | Minimum and maximum speed setting selectable from the LCP only. |

**Table 6: CIWS Characteristics**

## *Major Components*

5. CIWS Mk 15 Mod 11 is built from four major components:

   a. UNIT 1 – Local Control Panel (LCP) – located in the CIWS Local Control Station.

   b. UNIT 2 – Electronics Enclosure (ELX) – located on 02 Deck at the base of the Weapon mount.

   c. UNIT 3 – RADAR Weapon Assembly and Unit – located on 02 Deck Aft; and

   d. UNIT 4 – Remote Control Panel (RCP) – located in the Ops Room beneath the Harpoon console.

6. UNITs 2 & 3 are collocated and together are referred to as the Weapon Group.

7. Unit 1 – Local Control Panel (LCP) and Parameter Analysis Storage System (PASS) located in the CIWS control room

   a. Direct interface to the WCG computer via the PASS computer / LCP

   b. Lower section houses Power Supply and Primary Load device for loading of operational software (there is no casualty load device)

   c. Sole position for input of threat/engagement data

   d. Has mode selection/maintenance panel

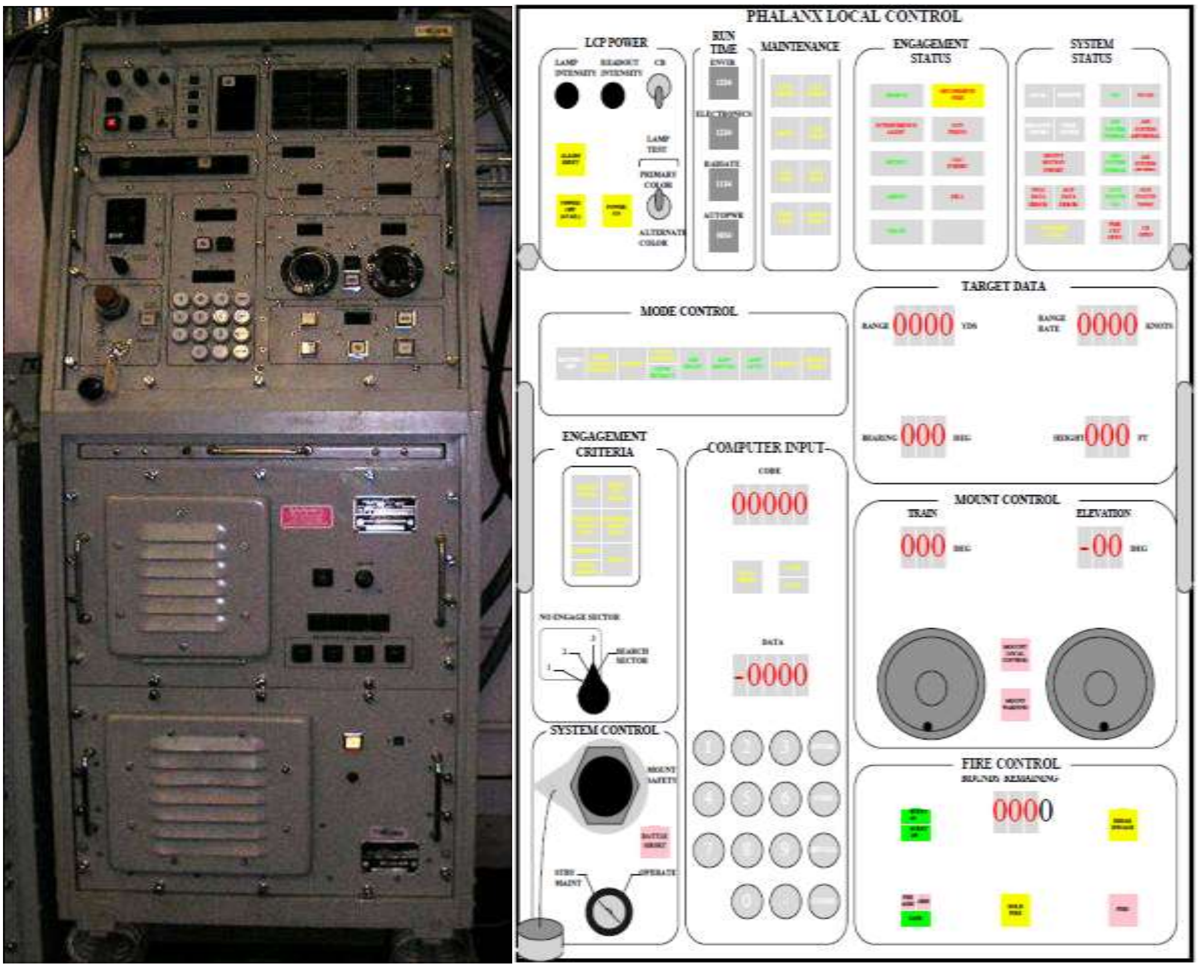


**Figure 7-2: CIWS LCP**

8. Unit 2 – The Electronics Enclosure (ELX) houses the majority of the system electronics, contained on replaceable circuit card assemblies mounted in pull-out drawers


**Figure 7-3: CIWS Electronics cabinet**

9. Unit 3 – The Radar Weapon assembly consists of the:

a. radar/servo fire control assembly;

b. gun sub-system;

c. elevation drive assembly;

d. train drive platform assembly; and

e. barbette.

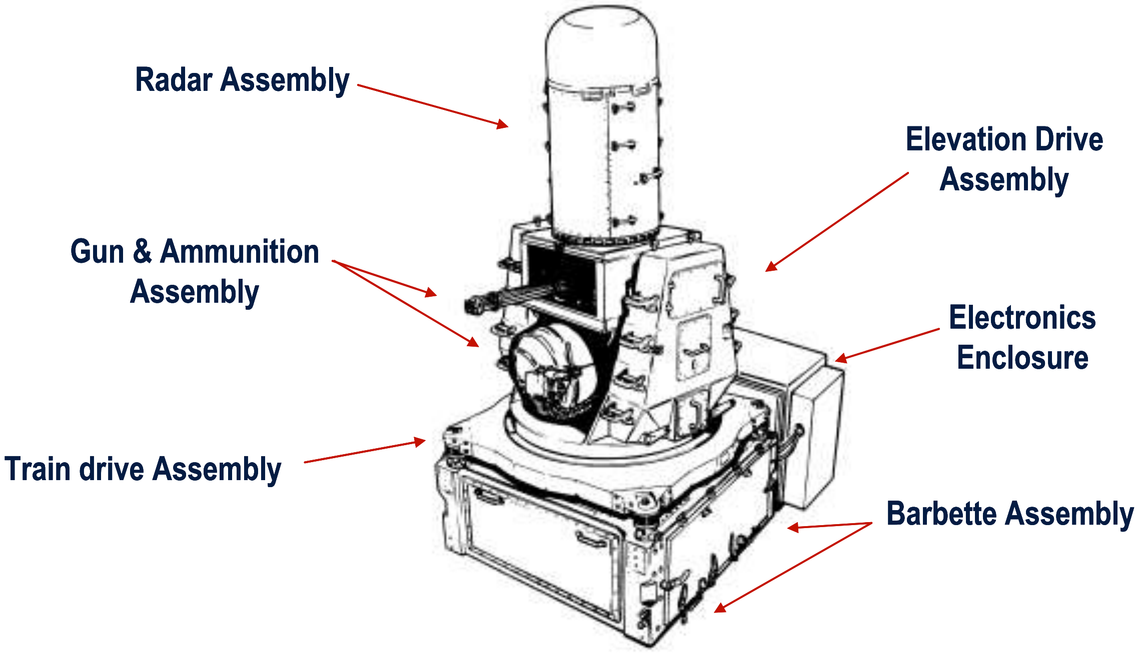


**Figure 7-4: CIWS Mount Major Components**

**Figure 7-5: CIWS Track (left) and Search Radars**

10. Unit 4 – Remote Control Panel (RCP) located in the Ops room.

   a. Normal position for operation

   b. Indications/Controls for MAJOR functions only

   c. Controls Inoperative when RCP/LCP key switch is in LCP position except for BREAK ENGAGE. This button functions irrespective of the key switch and allows the Command to force an engagement to be broken (any time after lock on) even if the LCP is in control.

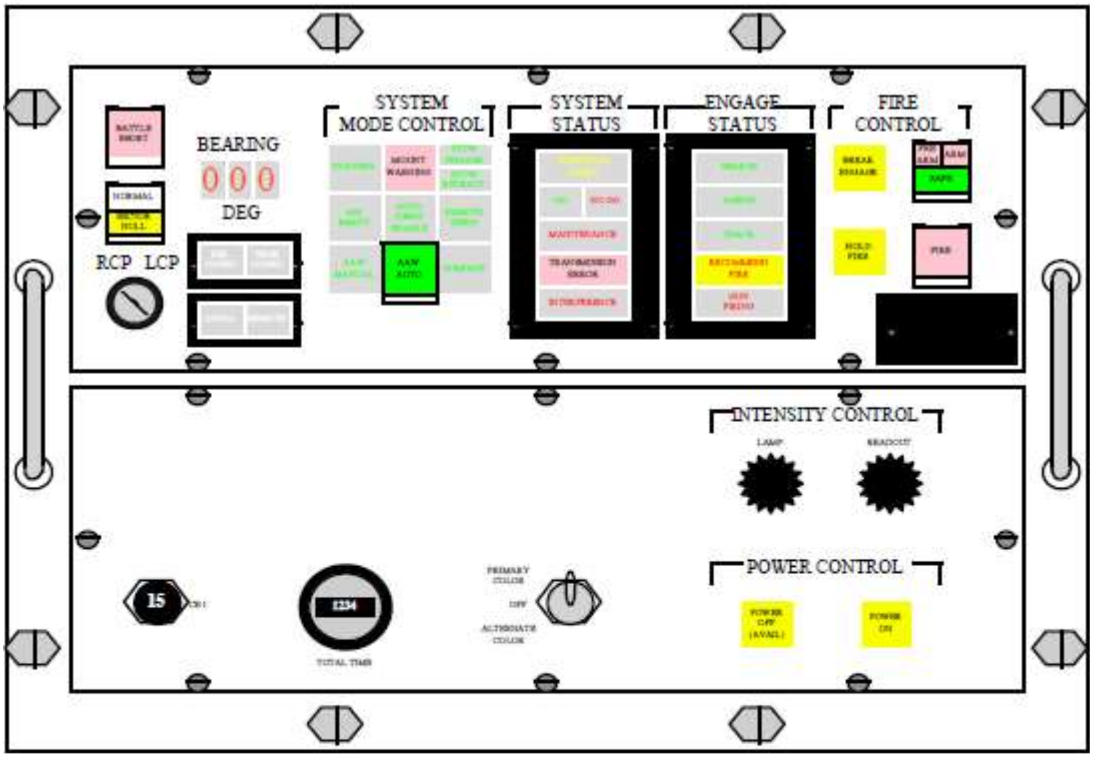


**Figure 7-6: CIWS Remote Control Panel**

## *Modes of Operation*

11. The major operating modes of CIWS Mk 15, in order of activation, are:

| | |
|---|---|
| Battery OFF/ECG | Environmentals activated only (NOT an operational mode) |
| STANDBY Mode | When selected, takes □5.6 minutes from Battery OFF (fixed). Warms up Klystron. |
| AIR READY Mode | When selected takes □ 5 seconds from STANDBY. |
| AAW MANUAL Mode | System searches for, detects, assigns to and recommends fire upon the target. Will only fire if operator presses FIRE (when HOLD FIRE is deselected and SAFE/ARM has been switched to ARM) |
| AAW AUTO Mode | System searches for, detects, assigns to and fires (provided HOLD FIRE deselected and SAFE/ARM is switched to ARM at the LCP or RCP) WITHOUT operator intervention. |

**Table 7: CIWS Modes of Operation**

12. Other (non-operational) modes include:

a. AIM-CALIBRATE, used for calculating initial aim point corrections based on measured deviations during a Pre-Action Calibration (PAC) firing. Note that this is a Firing mode;

b. MAINTENANCE mode - used for DSOTS (i.e. SOTS, PSOTS & FITS); and

c. SEARCH ONLY (does not hand over to the Track Radar).

## *CIWS Engagement Sequence*

13. As it is a stand alone system, CIWS follows a modified combat system engagement sequence:

a. Search

b. Detection

c. Target Declaration (ID and Classify)

d. Evaluation

e. Scheduling

f. Acquire Target

g. Track Target

h. Engage Target

i. Target Destruction Evaluation

### Search and Detection

14. The Search Radar operates in either MTI or pulse Doppler fashion, and the antenna system comprises a phased array four beam constant rotational device (rotates at 90rpm). The antenna platform is stabilized to the horizon, and target bearing is indicated as a function of antenna position. Range is either measured or derived as a function of time; range rate is computed using range changes between the zones; i.e. (0.50-100 (array 1), 100-300 (array 2), 300-500 (array 3) & 500-720 (array 4) - Max. range 0.50).

15. The search function can Track-While-Scan up to 128 targets (up to 12 on the same bearing) tracks simultaneously.

16. A permanent radiation cut-out exists for the FFG's superstructure arcs; the cut-out bearings being resident in the Operational program.

17. Tuning - 6 pre-tuned channels are selectable from the LCP (max. time to retune = 1 min). Note that there are actually 70 possible frequencies, but the RAN has only 6 frequencies designated by the equipment sponsor, the USN. (The Tx frequencies are generated by a crystal fitted to a CCA).

18. When a sufficient number of target RADAR returns have been received and processed by the dual mode DMTI signal processor, a "TARGET DETECT INDICATE" condition is generated.

### Target Declaration

19. Each target detection will be classified as one of the following:

a. Valid target

b. Interference

c. CW jammer

## Target Evaluation

20. Before a target can be designated for engagement, it must be evaluated for the following criteria:

a. The target must measure up to the operator pre-set "THREAT CRITERIA". The targets closing velocity must be within the minimum and maximum range rate;

b. Target must be on a course that is threatening to (will intercept) the ship; and

c. Target must not be in a "NO ENGAGE SECTOR" (also called a friendly sector)

## Scheduling

21. After the target is determined to fall within the THREAT CRITERIA, the Weapons Control Group (WCG) will select one target for engagement. Target selection is determined by highest range to range rate ratio (of all targets, this is the first that will intercept the ship's protective volume). The WCG will also determine the second highest threat and store the information to improve system response in stream attack scenario

## Acquire and Track Target

22. Once a target has been assigned, the computer will command the mount to slew to the bearing of the incoming threat, and elevate to the approximate target elevation.

a. Mount slew rate in train = 126 degrees per second

b. Mount slew rate in elevation = 92 degrees per second

23. After the mount has achieved its commanded position in elevation and azimuth, the following major events occur:

a. High power RF radiation is disabled and the signal path is diverted from the search antennas to the monopulse track antenna.

b. The track antenna is positioned to search the ambiguous area determined by the search RADAR.

c. High power RF radiation is enabled to the track antenna. The track antenna and mount are driven to give a modified figure eight search pattern.

d. When the target is detected, the mono-pulse error signals are used to keep the target at beam center. The mount is continually updated in both train and elevation to maintain proper track antenna to target position.

## Engage Target

24. Target lock is achieved when both the traverse and elevation tracking errors between the target and track antenna bore sight are less than 6 milliradians for more then 50 milliseconds. After target lock has been achieved, tracking mode is entered and target range rate can be computed.

25. The CIWS fire control equation is simplified through the use of Pre-action Aim Calibration (PAC). PAC is a gun firing performed using the type and lot of ammunition that is to be used in a tactical environment. The track RADAR is used and the following mean information is derived:

a. Ballistic errors. Mean muzzle velocity is calculated. This number is unique for every gun.

b. Gun to track antenna parallax error (offset error). This number is unique for every system.

26. Once the target tracking (calculation of range rate) has been achieved, the WCG computer will solve the fire control equation to determine when to commence firing.

27. The following items will be considered in calculation of the fire control equation:

a. Target range and velocity (from track RADAR);

b. Projectile muzzle velocity (from PAC);

c. Target first hit range (from operator input);

d. Computed 6.5 seconds of firing time (time taken to empty the drum) before target impacts ship; and

e. Mount position

28. As the target approaches the computed "FIRST HIT RANGE", the computer will position the gun/mount to allow for any necessary lead angle or super elevation. The computer must predict where in space the target will be when the computed projectile time of flight to the target has elapsed.

29. When the firing command is issued from the WCG computer, the system will open fire and continue to track the designated target for as long as it measures up to the threat criteria.

### Continuous Aim Correction

30. RADAR data is returned from both the target and CIWS own rounds that have been fired (through time multiplexing). The WCG then calculates the angular difference (or miss angle) between the target and projectile stream. Using this angle as an error term, the mount is commanded to move to reduce the error term to zero. This angle results in increased kill probability and minimum expenditure of ammunition per engagement

## Target Destruction Evaluation

31. The system will continue to fire on the designated target until one of the following break engage conditions occurs:

a. Rapid decrease in targets velocity

b. Target within 300 feet of the ship

c. Target has reached the 8g point

32. An assessed KILL is a condition of rapid decrease in the targets velocity after the gun has started firing and the projectile computed time of flight has elapsed.

33. After break engage:

a. The mount will return to the initial bearing of the target;

b. Search mode will resume with emphasis on the bearing of the last target; and

c. After several seconds of intensified search, the system will return to the last search mode function and the mount will return to the air ready position

## *CIWS Ammunition.*

34. CIWS Mk 15 uses specialised rounds of 20mm sub-calibre ammunition (Mk 149) which are Australian made. Characteristics of the ammunition and stowage's are:

a. Heavy metal (tungsten) penetrator with an aluminium pusher and a nylon (discarding) sabot.

b. Safety zones for SABOTS and PUSHERS are: 10° elevation: to 300 feet. and 2° elevation: to 900 feet respectively.

c. Ammunition is HERO susceptible, and must remain in RADHAZ links until transfer from the transfer unit to the exit unit (i.e. during loading).

d. Magazine:

i. Max. safe stowage is approximately 10,000 rounds

ii. Emergency escape to 02-Deck fitted

iii. Salt Water Fire-Fighting Spray System

iv. Air-conditioned.

e. Two or three CIWS Ready-Use stowage lockers are fitted close to the mount on 02-Deck. The correct configuration is two lockers, however during the upgrade to Block 1, some ship's retained their third locker. Dummy rounds are stowed in the RU stowage lockers. Approximately 600 dummy rounds are required for effective maintenance, training and loading drills.

# *Safety*

## Firing cut-outs

35. Each mount contains 7 pre-set physical firing cut-out stops set IAW measurements taken during each mount's installation and rechecked during subsequent Safe-to-Fire Zone checks.

## Gun Mount Safety Precautions

36. Before approaching the CIWS mount to perform ANY maintenance functions you must ensure:

a. The system is in STANDBY mode or lower;

b. The LCP MOUNT SAFETY connector (rubber plug) is removed and held by the maintainer on the mount.

c. The LCP key switch is in STBY/MAINT position and the key removed and held by maintainer on the mount.

d. The MOUNT SAFETY SWITCH on the barbette is set to SAFE.

37. Hot Gun - CIWS gun system ensures that a hot gun situation should never eventuate by routing the last few rounds of the burst into the clearing sector of the breech. If 300 rounds are fired in 5 minutes, the barrels should be allowed to cool for 30 minutes before handling is attempted.

38. Toxic Gases - Toxic gases are produced on firing and 10-15 minutes are required for dispersion after firing ceases. Potentially toxic gases are also present from gas turbine exhaust (via the stack) which is a hazard for personnel particularly during CIWS maintenance and loading.

39. Noise Level - All personnel within 80 feet of the mount during firing will require hearing protection.

40. Gun Control Unit (GCU) Key & Sector Holdback Tool - To ensure maximum safety when carrying a loaded magazine, a Gun Control Unit (GCU) Key (also called a firing circuit integrity key) is required to be removed from the GCU section. The GCU Key is necessary for the firing circuit to close. The Sector Holdback tool, which inhibits rounds passing into the firing sector of the breech, is inserted to ensure inadvertent firing cannot occur.

## Alarms Fitted

41. The CIWS Mk 15 Mod 11 is fitted with the following alarms:

a. Low Flow Alarm - One provided for each mount to monitor SW flow into the ECG group. Alarms are located in the CIWS LCS, CIC (Summary Alarm) and DCC (Summary Alarm).

b. Assign Mount Alarm - During the engagement sequence, an audible alarm will ring for 1-2s in the CIC to indicate that the Mount has been assigned or designated for Tracking.

c. Audible Warning at LCP - Provided to operator to indicate hard/soft faults monitored by the internal BITE (can be RESET).

d. Magazine High Temp Alarm - Two alarms fitted in DCC only, at the main alarm panel.

# *Inter-System Interfaces*

42. There currently exists no physical interface between ADACS and CIWS. This may change if the RAN acquires CIWS Mark 15 Mod 11 Block II. The combat system is cabled for the interface to be enabled however at this stage ADACS has not been configured for CIWS designation. Note that Multi-Weapons Coordination is available between mounts, but is obviously not used in RAN FFG's.

# *Parameter Analysis Storage System (PASS)*

43. The Parameter Analysis and Storage System (PASS) consists of a PC with a CD Drive, a printer and an interface card to the LCP. PASS replaced the teletype (TTY) previously found in Block '0' CIWS installations.

44. PASS provides the following menu driven functions: CIWS Parts Database; TTY Emulation (allowing input of commands directly to the WCG computer from the keyboard); and, real-time graphical display of engagements on a synthetic PPI. PASS also provides a FULL recording capability (CD ROM) for analysis at a later time. For example, PAC firings and live firing exercises may be recorded and replayed onboard, or the tape used for post exercise analysis. Hardcopies of engagement data may be produced for firing records or slow time analysis of a firing.

## Casualty Modes

45. The following casualty modes are considered:

a. PASS Failure

i. Does not effect System operation, revert to LCP keyboard input.

b. RCP Failure

i. Loss of comms between RCP and the LCP will be indicated by an RCP data error on the LCP and TRANSMISSION ERROR on the RCP. The system will revert to LCP control upon the operator turning the key-switch at the LCP to OPERATE. The system will remain in its LAST operating mode during transition from RCP to LCP control. If target engagement is in progress then subsequent actions will depend on the mode and failure:

1. AAW AUTO (cable still intact). Gun will remain armed for 17s. Gun will automatically be made safe after this time. NIL operator action is required here.

2. AAW Manual (cable still intact). Gun remains armed for 17s. RCP cannot fire. LCP operator to push FIRE button on verbal recommendation.

3. AAW AUTO or MANUAL (severed cable). Gun will be made safe immediately if no engagement is progressing; or engagement in progress will continue until completed. LCP operator MUST press PRE-ARM/ARM to ARM to ensure gun will fire.

ii. ECG Failure

1. Loss of coolant to klystron from failure of coolant pump will result in mount not being able to cycle above BATTERY OFF mode.

iii. Cqo Failure

1. Cqo can be input directly from LCP if required (this is only used for no-engage sectors)

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# Chapter 8. Active Missile Decoy

## Introduction

1. The Active Missile Decoy (AMD) (referred to as either Nulka, AMD or decoy) system is designed to counter radar-homing anti-ship missiles (ASM's). The AMD system provides the capability of an automatic or semi-automatic response to detection of an ASM threat. Protection of the ship is achieved by launching one or more AMD's along a calculated flight path based on a fire control solution. The fire control solution is calculated based on threat characteristics and converted into flight demands, which are programmed into the AMD immediately prior to launch. There are two main classes of Nulka tactical rounds, the Mk 234 mod 1 (Baseline) round which is used on the FFG's and the Mk 234 mod 1 EMC lite round (ANZACs). The Mk 234 mod 2 rounds are Telemetry rounds configured either as a Baseline or as an ECM lite round. The Mk 250 rounds are Practice rounds and contain a dummy payload.

**Figure 8-1: Nulka Round in Flight**

## Mission Profile

2. The intended mission profile for the Nulka is as follows:

   a. Weapon Type: Active Missile Decoy for shipboard use to decoy incoming, radar homing anti-ship missiles,

   b. Launch Method: Automatic or Semi-Automatic,

   c. Weather dependence: All Weather Operation,

   d. Guidance Principle: Pre-programmed ship characteristics (dependant on launch platform type),

   e. Target Data: Obtained from search radar, and

   f. Temperature Limits: -14 to +40 Celsius.

## *Characteristics*

3. The Nulka general characteristics are:

   a. Designation - NULKA

   b. Round - Mk 234 Mod 1 or 2

   c. Weight - Approx 69kg

   d. Length - 2304mm

   e. Width - 235mm

   f. NEQ - 18 Kg EA

   g. HCC - 1.3 C

4. AMD requires the following inputs from the ship and combat system:

   a. Power:

      i. 115V 60Hz 1$\phi$ (Primary Power)

      ii. 28VDC (Backup Power with battery backup)

   b. Ship Motion & Wind Data (synchro format):

      i. Own Ship's Heading (Cqo)

      ii. Own Ship’s Speed (Dmho)

      iii. Own Ship’s Pitch (Eio)

      iv. Own Ship’s Roll (Zdo)

      v. Relative Wind Speed (Wha)

      vi. Relative Wind Direction (Bwda)

   c. ADACS to AMD:

      i. ADS data and control

      ii. Gyro

      iii. Horizon reference

      iv. Wind speed and direction

      v. Own Ship’s Speed (Dmho)

5. The AMD system outputs the following data:

   a. AMD to ADACS:

      i. Operating and control data

      ii. Engagement status reports

      iii. AMD System status

## *Equipment*

6. The AMD System consists of the equipment listed in Table 8.

| Equipment | Location |
| --- | --- |
| Primary Fire Control Panel (PFCP) | EWconsole |
| Secondary Fire Control Panel (SFCP) | Bridge |
| 2 x Memory Interface Module (MIM) | 1 in each FCP |
| Data Recording Device (DRD) | EW console |
| Command Interface Module (CIM) | Between AWO & PWO consoles |
| AMD Casualty Control Switch (AMDCCS) | EW console |
| Remote Interface Module (RIM) | RICER |
| 4 x Processor Power Supplies (PPSs) | 2 in RICER and 2 in (main) passage 1-212-0-L |
| 4 x launchers with 4 Nulka rounds in each | Port & Stbd 1 deck |
| **Note: PPS 4 and Launcher 4 (STBD Aft) not fitted on FFGs 04, 05 & 06** | |

**Table 8: AMD Equipment**

## *Operation*

7. Normal operation of the AMD system is via the PFCP in Local Semi-Automatic Condition with the CIM used to monitor the engagement. The CIM displays both threat data and engagement data and has the ability to Break Engage on any threat. The SFCP eavesdrops on the ADACS to PFCP messages only and does not actually communicate with the PFCP. The SFCP is able to display ADACS/EW threats but does not display any engagement information and is unable to interact with the PFCP ie no Break Engage functionality. The SFCPs functionality is also limited to one touch display only.

**Error! Objects cannot be created from editing field codes.**

**Figure 8-2: Primary Fire Control Panel (PFCP)**

8. The following operating conditions are available:

a. Local Semi-Automatic - fire control solutions are generated by the PFCP and firings are initiated from the PFCP via an operator selected ‘Fire’ softkey.

b. Automatic – fire control solutions are generated by the PFCP and the appropriate round fired automatically.

c. Remote Semi-Automatic - fire control solutions are generated by the PFCP and firings are initiated from the CIM via an operator selected ‘Fire’ softkey.

d. Casualty – If the Fire Enable Key is moved to Fire on the SFCP then casualty firings are enable where the SFCP generates a fire control solution and the firing is initiated at the SFCP via an operator selected ‘Fire’ softkey.

9. Both the PFCP and SFCP communicate with all four PPSs. When a firing sequence is initiated the PPS for the selected round enters an ‘Armed’ condition that locks out communication with the other FCP (ie SFCP if firing was initiated from PFCP) until the firing is complete.


**Figure 8-3: Nulka Processor Power Supply (PPS)**

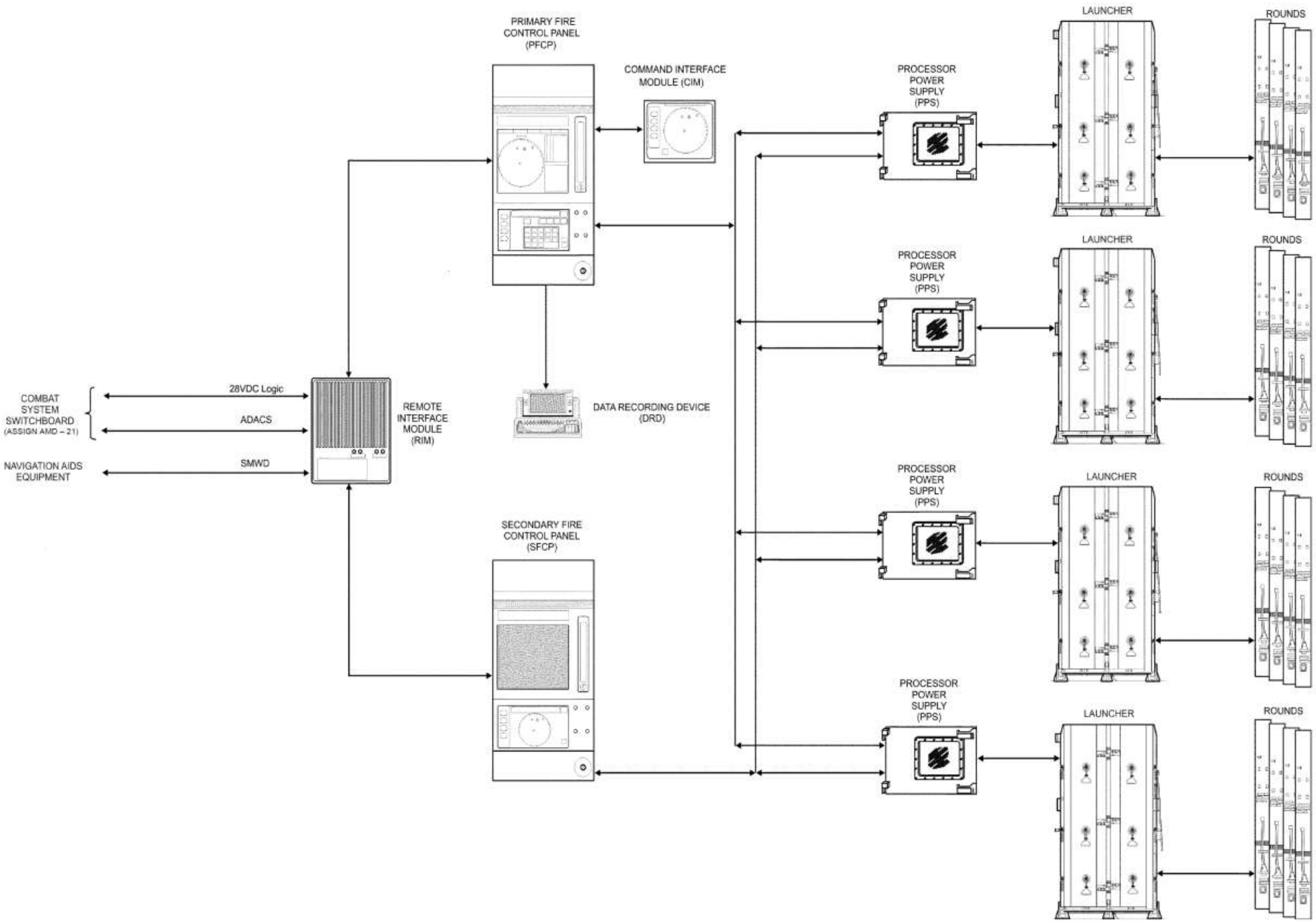


**Figure 8-4: AMD System Interfaces**

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## Phases of Operation

10. The basic operation of the Nulka is as follows:

### Pre - Launch Phase.

11. The launcher is moved from the stowed (vertical) position to the operational (deployed) position (15 deg from the vertical) via a hand operated deployment mechanism. This also operates the Launcher Stowage Interlock (LSI) which arms the PPS.

12. The Safe To Load (STL) switch is set to combat, a return path to the PPS is now made and data can be transferred from the FCP via the PPS to the round.

13. The PPS issues the command to fire the thermal batteries and after power becomes available the payload and the flight vehicle perform a BIT, the results are sent to the FCP via the PPS. At the same time the PPS will arm and lock out non-firing FCP, sound the launcher warning horn, initialise comms with decoy and energise firing ccts.

14. When the payload and flight vehicle have successfully finished BIT the pre-flight alignment checks are completed and flight demands are sent to the AMD by the FCP via the PPS.

### Launch Phase.

15. When the decoy is ready the PPS under control of the FCP sends a signal that causes the detonation cord in the top cap of the canister to ignite and sever the top cap which then flips back.

16. The PPS sends a firing pulse to the PIU which ignites and fires the propulsion unit.

17. When the propulsion unit ignites the decoy begins to exit the canister and as the decoy passes up through the canister a de-connector mechanism disengages the electrical and data interface from the decoy. This is known as Instant of Move (IOM) and is reported back to the FCP. Once this interface is extracted the decoy receives no further data from the ship.

### Target Counter

18. The decoy follows its predetermined flight path.

19. The flight vehicle orientates the decoy toward the target.

20. The payload transmits a false/stronger ship image to seduce the ASM away from the ship, setting itself as the target. If successful the ASM will select the decoy as its target and home in on it not the ship.

## *Decoy.*

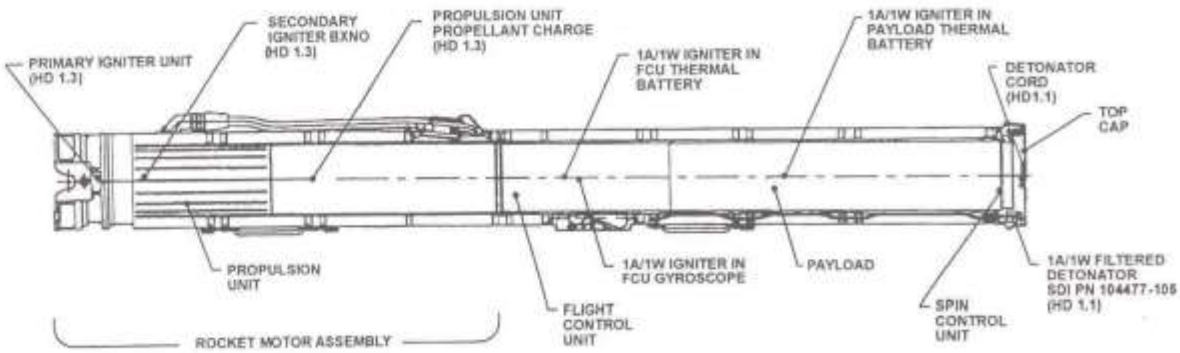


**Figure 8-5: AMD Components**

21. The decoy consists of a body structure housing the Payload and the Flight Vehicle consisting of Spin Control Unit, Flight control Unit and Propulsion Unit.

## Payload

22. The payload influences incoming ASM to lock on to it rather than a ship. When the ASM is locked-on the pre-programmed flight path of the decoy will seduce the ASM'(s) away from the ship.

## Flight Vehicle

23. The spin control unit, flight control unit and propulsion unit collectively form the flight vehicle. These units are integrated into a feedback loop that controls vehicle speed, height and direction, and ensures that the decoy maintains the correct orientation for successful seduction.

### Spin Control Unit

24. The spin control unit is mounted at the uppermost section of the decoy and is used to maintain the orientation of the decoy along a longitudinal axis. That is, the spin control unit keeps the payload emitter pointing down the bearing of the incoming threat. The spin control unit receives signals from the flight control unit which, it applies to the spin control motor to change the orientation of the decoy.

### Flight Control Unit

25. The flight control unit receives the flight profile data from the Fire Control Panel (FCP) to control the flight path of the decoy. During flight the flight control unit transmits data to the spin control unit and thrust control unit to maintain vehicle speed, height and orientation.

### Propulsion Unit

26. The propulsion unit provides the thrust to manoeuvre the decoy during flight. Thermal batteries fitted to the flight control unit and payload provide decoy electrical power. The Processor Power Supply (PPS) issues the command to ignite the thermal batteries and after the power becomes available the payload, and flight vehicle perform a BIT, results of which are sent to the FCP via the PPS.

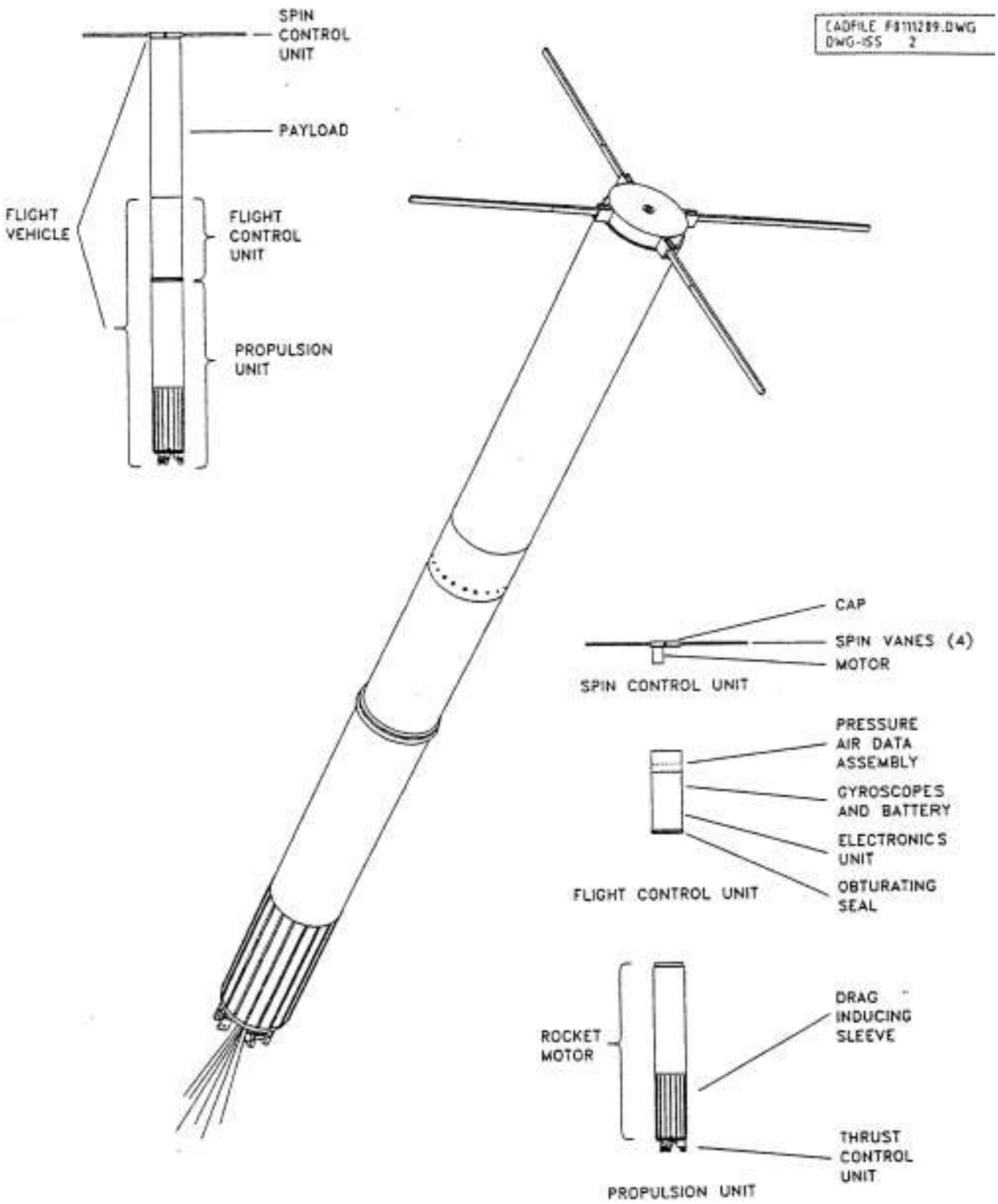


**Figure 8-6: Deployed Nulka Round**

## Safe/Arm Conditions

27. There are no safety devices fitted to the Nulka Round. For example there is no safe arming switch to short the Squib lines. Safety while fitted to the launcher is achieved through the LSI, and the STL set to the safe position, both of which prevent an FCP command signal to the PSS to generate a firing pulse reaching the round.

***Canister.***

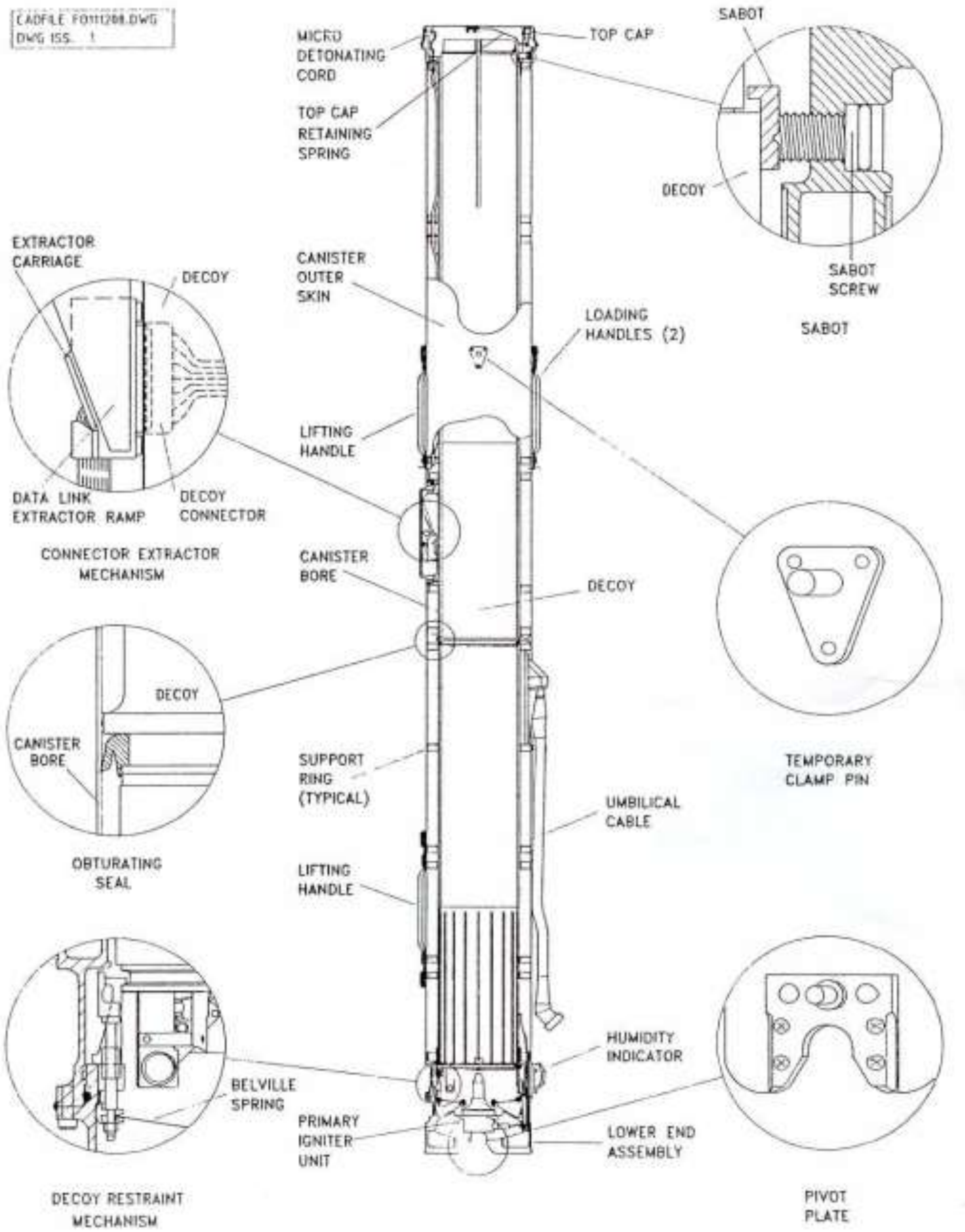


**Figure 8-7: AMD Canister**

28. The canister provides protection from the external environments including humidity, temperature, shock and EMI/ECM. The canister acts as the launch tube for the decoy and also provides the electrical and data interface between the decoy and the Processor Power Supply (PPS). The canister has five main assemblies, the Canister Sleeve Assembly, Lower End Assembly, Primary Igniter Unit, Top Cap Assembly and Humidity Indicator (see figure 1).

## Canister Sleeve Assembly

29. The canister sleeve assembly has an inner and outer wall, support rings, and end rings. The outer skin of the canister forms a faraday cage to protect the decoy from EMI/ECM. Polycarbonate sabots are used to position the decoy in the canister and are thrown from the canister on launch of a decoy. The umbilical cable provides data and electrical connectivity between decoy, canister and the PPS.

## Lower End Assembly

30. The bottom of the lower end assembly has a pivot plate to fit the canister correctly into the launcher. It contains a decoy restraint mechanism that aligns and holds the decoy in the canister prior to decoy ignition. Pre-tensioned latches restrain the decoy within the canister until pressure from the ignited propulsion unit is sufficient to activate the spring-operated mechanism that releases the latches. The latches are designed to fail at high pressure in the event that the spring does not operate. The lower end assembly also houses the Primary Igniter Unit (PIU) and humidity indicator.

## Primary Igniter Unit

31. The PIU contains an explosive squib and a small amount of rocket motor propellant. When ignited by the squib this propellant sends a spurt of flame into the base of the decoy propulsion unit to ignite the unit.

## Top Cap Assembly

32. The canister is sealed at the top by a cap, which is opened just before launching. When the decoy reports that it is ready the PPS commanded by the Fire Control Panel (FCP) sends the signal that's causes the micro detonating cord in the top cap to detonate and sever the top cap. When the top cap is severed the caps flips back.

## Humidity Indicator

33. At final assembly each round is purged and pressurised with dry nitrogen, and desiccant sachets are installed in the top cap, and lower end of the canister. To indicate internal moisture content a humidity indicator is mounted on the exterior of the canister. The humidity indicator is a colour change indicator that indicates if the relative humidity levels of 20%, 40% and 60% exist within the round. As the humidity increases the colour in a sector changes from blue (dry) through lavender to a pink (humid). For example, when the humidity reaches 20% the 20 segment will be completely pink and the 40% segment will have a touch of lavender, but will be predominantly blue. When the humidity indicator is completely pink it indicates that there is 60% or greater relative humidity within the canister. It should be noted that this does not render the round unserviceable. Rounds delivered to a ship from an armament depot should have a dry humidity indication (all Blue). A round that gives a humidity indication is not deemed unserviceable, it merely indicates that some water vapour may have entered the canister. A round that passes testing using the round test set can be considered serviceable regardless of humidity indications (on board only).


**Figure 8-8: Humidity Indicator**

## *Casualty Modes*

34. **Power**. The AMD System normally operators using the 115V AC input. In the event 115V is lost the system automatically uses the battery backed 28V DC supply. The entire system needs approx. 17 amps to operate on 28V DC. The 28V DC power supply has a battery backup that is specified to supply 40A for 1.5 hrs. At 17 amps the battery backup should last for approx. 3.5hrs.

35. **ADACS/AMD Interface.** If the primary interface between ADACS and AMD is lost then ADACS automatically switches directly to the other ADS server for its AMD LAN connection.

36. **Ship Motion & Wind Data (SMWD).** The default source of SMWD is in synchro format from the relevant equipment. If this input isn't available the source defaults to operator controllable preset values. An option is also available to source the information from ADACS via the normal AMD-ADACS interface.

37. **PFCP.** If the PFCP fails then SFCP can be used to launch decoys. In this mode the SFCP does not receive any threat warning data. Fire control solutions are generated on manually entered threat bearings only.

38. **PFCP Display.** If one of the two display panels on the PFCP fails then a display casualty mode can be enabled at the PFCP that results in the PFCP using only one touch screen and having a look and feel similar to the SFCP.

## *Hangfire / Misfire / Restrained Firing*

39. A hangfire is declared if:

a. An ignition pulse is applied to the round and the top cap fails to separate;

b. After a top cap fires and the decoy fails to move;

c. An ignition pulse is applied to the primary igniter unit but the propulsion unit does not ignite.

40. If any of the above occurs, a wait time of 30 minutes is to be observed. After this time has elapsed, the launcher is to be made safe by utilising procedures IAW ABR 6294 Vol 1 Para 2-9.

41. A misfire is declared if:

a. An ignition pulse is sent to the decoy battery, but the Decoy fails to initialise;

b. A decoy does not establish comms after the battery ignition pulses have been sent, or

c. "Decoy fail" message is received by the Fire Control Panel (FCP) at any time prior to top cap ignition.

42. If a misfire condition is declared the FCP displays a "misfire" message to alert the operator. The system will attempt to select and launch another decoy (if other decoys are available) and the Active Missile decoy (AMD) system automatically declares a round has been misfired as "Failed Decoy". No further operator action is necessary and unlike a Hang Fire, the decoy is considered safe. Procedure is to be followed IAW ABR 6294 Para 2-10.

43. A restrained firing occurs when a decoy is restrained in a canister and the rocket motor ignites. In the event of a restrained firing the following procedure is to be followed by ships staff:

a. Conduct checks for "hot spots" on the ships bulkhead and deck head adjacent to the launcher;

b. Boundary cool the Ship's superstructure if necessary, but do not approach the launcher for 30 minutes. This allows the launcher to cool and remove the danger of re-ignition should any unburnt propellant remain.

c. Handle the round as for a hang fire taking care to avoid touching efflux residue with bare hands

# Chapter 9. Mk32 Surface Vessel Torpedo Tubes (SVTT) and Torpedoes

## *Overview*

1. The MK 32 SVTT System is a quick reaction, short range, anti submarine weapon launching device. The weapons housed within the MK 32 SVTT are primarily used for self-defence after a short range submarine detection. Torpedoes can be fired from the two triple tube mountings. Fire control is provided by the Shipborne Presetter System (SPS) (for MK 46 Lightweight Torpedoes (LWT) only and MK 46/MU90 LWT respectively).

2. The characteristics of the MK 32 SVTT system are shown below. Note that in addition to being fitted with the SPS system for torpedo fire control, minor modifications need to be made to the torpedo tube mountings in order to make them capable of loading and firing MU 90 LWT.

| | |
|---|---|
| Optimum Firing Angle | Red or Green 45° (one position micro–switch) |
| Firing Possible | Red or Green 45° only |
| Firing Pressure | 1500 psi |
| Minimum Firing Pressure | Local 1200 psi Remote 1350 psi |
| Ready Light Actuating Pressure | 1275 psi (± 75 psi) |
| Maximum Flask Pressure | 2000 psi |

**Table 9: Mk32 SVTT Capabilities and Limitations**

3. Each mounting can be trained from right ahead through 180 degrees. The optimum firing angle is Red or Green 45 degrees respectively for Port and Starboard tubes. A retractable stop is provided at these positions. Firing circuits are only completed when the tubes are trained at 45° +/- 1°.

4. Tube numbering conventions are standard throughout the RAN surface fleet, regardless of ship class. Each barrel of the mounting is assigned a number according to its side. Even numbers indicate the port tubes and odd numbers the starboard tubes. To minimise confusion, when referring to tubes they are to be called by side and number (eg ‘Port tube 6’). The numbering of tubes are as follows:

a. Top barrels—1 and 2;

b. Inner barrels—3 and 4; and

c. Outer barrels—5 and 6

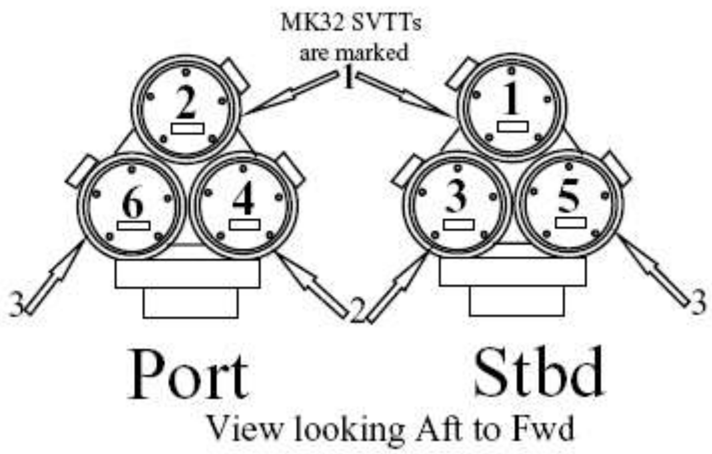


**Figure 9-1: Mk32 SVTT**

5. The MK 32 SVTT have two states of readiness:

   a. Harbour/Cruising State:

      i. Tubes trained inboard.
      ii. Tubes unloaded (if possible).
      iii. Muzzle cover ON (PVC cover at Sea).
      iv. Torpedo access ports secured.
      v. Air flask's fully vented (In the peace time cruising state the air flasks are not to be charged without the permission of the Anti-submarine Warfare (ASW) Officer).
      vi. Air control lever Forward.
      vii. 'Ready to Fire' indicator OFF.
      viii. Emergency fire lever LOCKED.

   b. Action State:

      i. SVTT Trained 45 degrees outboard in the firing position (PVC cover removed).
      ii. Tubes Loaded (in accordance with SW395–AC–MMO–010, OP3355).
      iii. Muzzle cover ON.
      iv. Access ports secured.
      v. Air flask's charged and inserted.
      vi. Air control levers Aft.
      vii. 'Ready to Fire' indicator ON.
      viii. Emergency fire lever UNLOCKED.
      ix. WARNING notices on mounts.

6. SVTT are to be manned and checked regularly when the ship is at Action Stations. Particular attention is to be paid to the air flasks to ensure the firing pressure is maintained. In defence watches, a routine to check the state of the tubes is to be maintained.

7. Reaching the designated state is to be achieved in accordance with the MK 32 SVTT Pre-firing check list and all Practice Firings are to be prepared for and conducted in accordance with this document. MK 32 SVTT Airshots are to be conducted in accordance with current planned maintenance routines.

8. Specific guidance on modifications of the above states for implementation during WUPE/Unit Readiness Evaluation (URE)/Seacheck evolutions and in order to avoid inadvertent firings are detailed in Australian Fleet Tactical Publication 1, chapter 24, annex J.

9. Only one barrel can be fired at a time either electrically or manually. Manual firing is for emergency use only after electrical firing failure. Manual firings can be conducted automatically during Minimum Level of Operational Capability/continuation peacetime firings if a failure occurs. However, during an ASW Combat System Ship Qualification Trial, the firing is to be aborted until the defect has been identified and rectified. Only one instance will override this situation and that is where the weapon gyro is uncaged during the firing sequence (misfire), if this occurs then the weapon should be fired from the local position without delay.

10. When fired electrically a solenoid valve is actuated (also in manual firing) and air is vented to a plug pulling mechanism that withdraws an electrical plug connection (umbilical) and results in air being ported to a puller mechanism to unlock the torpedo securing mechanism jaws. This actuates a spring-loaded lever which opens the firing valve and releases HP air to fire the torpedo.

11. The MK 46 squib is fired 100ms before launch to uncage the gyro.

12. To fire tubes manually in an emergency the 'Emergency Fire Lever' must be actuated (this uncages the MK 46 gyro and then expels the weapon). This Lever is normally padlocked to prevent accidental firing.

13. The barrel ready light indicates there is sufficient air pressure to fire the tube (at least 1200 psi) and the operator has put the 'Ready: Light Latch' to the 'on' position. This will be indicated on the MK 309 panel.

14. The ready light will not burn when:

a. there is insufficient air pressure to activate the pressure switch;

b. the 'Ready Light Latch' is in the 'off' position;

c. the mounting is trained outside the firing arc.

**Note**

The 'Emergency Fire Lever' bypasses the firing arc and cuts out the 'Ready Light Latch'.

15. Failure to fire could be caused by:

a. No power to the 309 panel.

b. Air lever is not aft.

c. Ready light latch is in the 'off' position.

d. Tubes are trained outside the firing arcs.

e. There is insufficient pressure in air flask.

16. **Misfire.** If an electrical failure occurs in the firing circuit it is possible to fire the tube locally using the Emergency Fire Lever. If the warning bell sounds (Standby) and then stops without a torpedo leaving the tubes the Surface Launched Torpedo (SLT) crew is to report 'Misfire' to the Operations Room. This may indicate a failure or that a decision was made not to fire. If it was a misfire the Operations Room will order the tube fired in local using the Emergency Fire Lever. SVTT then reports 'Port tube 2 fired in local'. Caution must be exercised in emergency firings as the safe firing arc cut-outs are overridden. Misfire drill may be conducted during exercise firings if a safe and valid FCS is maintained.

17. **Local firing.** If the MK 309 Torpedo Fire Control Panel (TFCP) or SPS fails, torpedoes can be fired locally as in the case of a misfire. Torpedo settings (Gyro angle and ISD), however, will be those set before the failure and cannot be changed until the TFCP/SPS is repaired. Local firing may be exercised in peacetime firings if a failure occurs. It may also be exercised for a small percentage of continuation firings if desired. If a misfire occurs the MK 46 gyro can be uncaged which requires the weapon be fired without delay. This is due to the gyro spinning up under it's own inertia. Sufficient power is provided by the gyro to maintain the inertia for about 30 seconds without power supplied from the weapon alternator. Under normal circumstances, when the weapon starts up after water entry, the weapon will provide power to the gyro to maintain and sustain the inertia initially generated by the gyro. However, if there is a substantial delay in discharging the weapon (longer than 30 seconds) after the gyro is uncaged, then the gyro may lose sufficient inertia to make it unstable to the point it cannot be recovered no matter how much power is supplied by the weapon. Firing a weapon that has an unstable gyro will result in unpredictable in water performance and increase the possibility of weapon loss.

18. Air shots are conducted as required at sea or in harbour. The maintainers must ensure:

a. OOW/Officer Of the Day (as appropriate) permission is granted,

b. tube to be fired is confirmed empty,

c. muzzle cover is removed, and

d. Warning pipes are made and danger signs are placed.

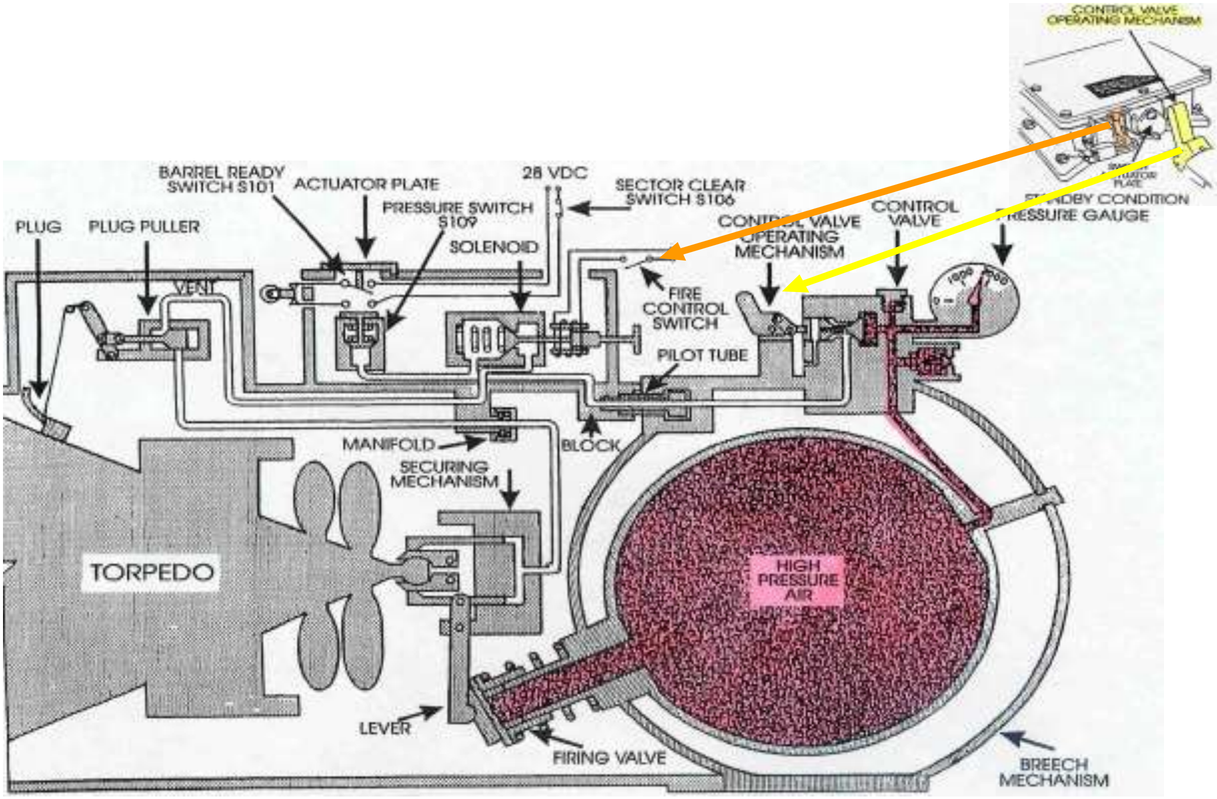


**Figure 9-2: SVTT at Standby**

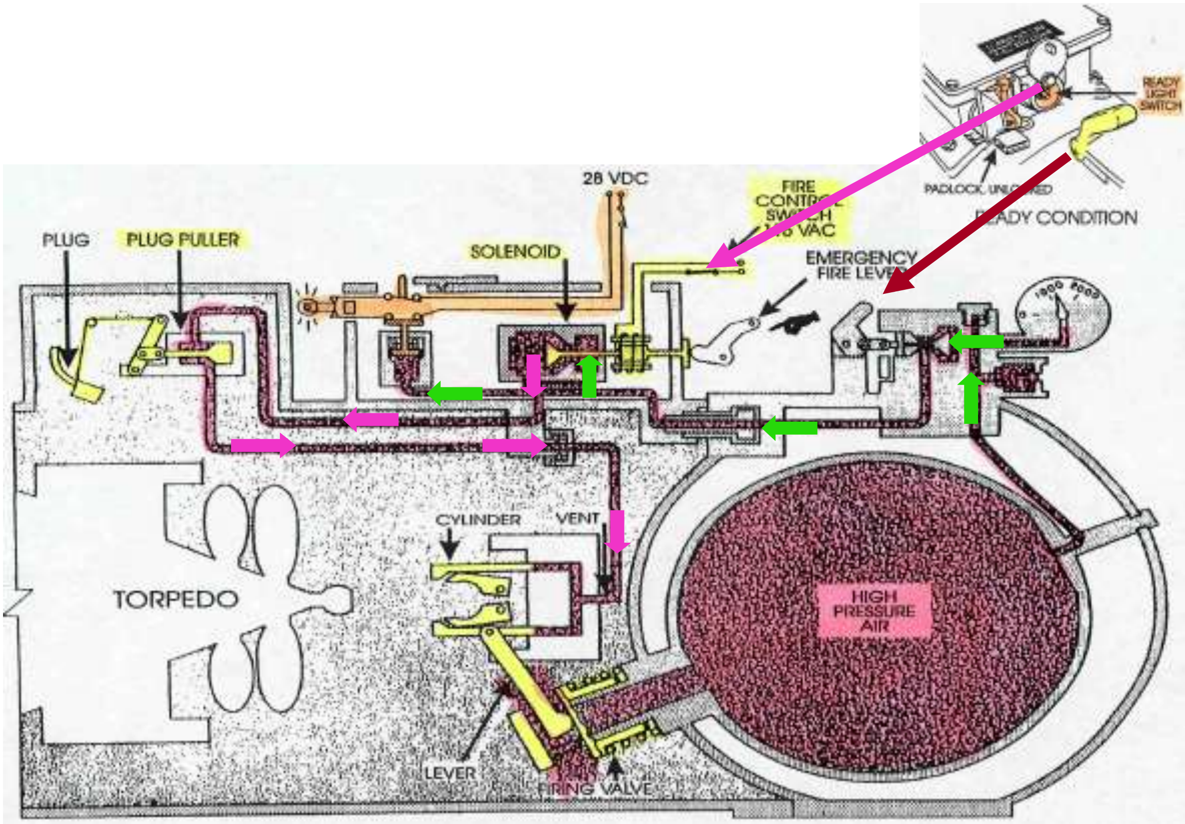


**Figure 9-3: SVTT Firing**

## *MU90 Torpedo*

19. The MU90 is designed to be a fire-and-forget Lightweight Torpedo (LWT) able to counter any type of nuclear or conventional submarine. It is able to be deployed from surface vessels and aircraft.

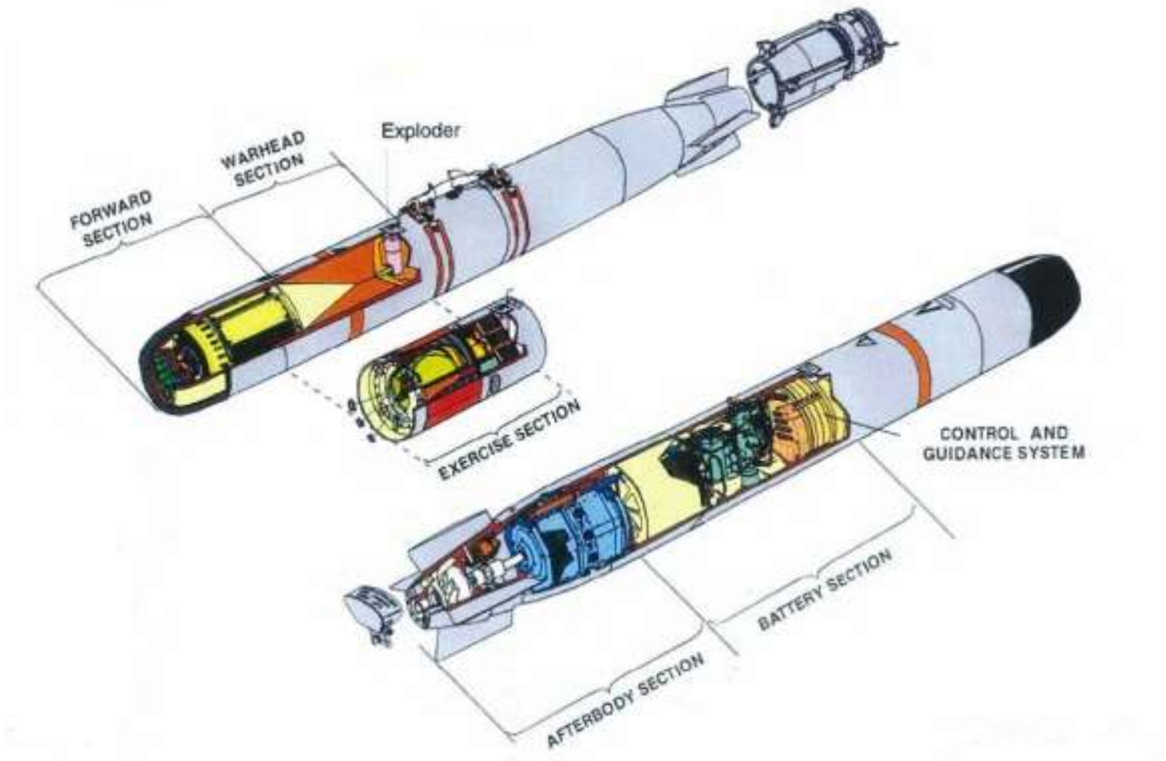


**Figure 9-4: MU90 Torpedo**

| General characteristics, MU90 Torpedo: | |
|---|---|
| **Power Plant** | Powered through an Aluminium-Silver Oxide (AgO-Al) sea water battery using dissolved sodium-dioxide powder as electrolyte |
| **Length** | 2.85m |
| **Weight** | 304kg |
| **Diameter** | 323.7mm +/- 0.3mm |
| **Range** | >12,000m at full speed<br>>25,000m at min speed |
| **Depth** | 3m to >>1000m |
| **Speed** | Variable between 29 knots and >50 knots |
| **Guidance System** | Homing: Active, passive or combination |
| **Acoustic Coverage** | 120° horizontal, 70° vertical |
| **Warhead** | 32kg highly compressed TATB explosive |

**Table 10: MU90 Torpedo Characteristics**

## Forward Section

The forward section contains the acoustic seeker array and the associated electronics. The acoustic seeker is made up of 30 transducers which provide 120° horizontal and 70° vertical coverage. It can operate in passive, active or combined mode, automatically selected by the operational phase of the weapon.

**Figure 9-5: Forward Section with front view of Transducers**

## Warhead Section

20. The warhead is a direct energy, shaped charge type. It is composed of 32kg of highly compressed TATB explosive (equivalent to 120kg of TNT).

21. The explosive chain works on a similar basis to the Mk46. Nose-mounted impact sensors initiate activation of the exploder which in turn causes the detonation of the warhead.

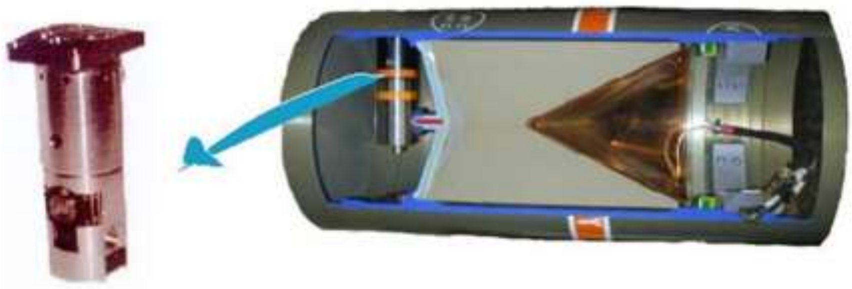

**Figure 9-6: Warhead - Exploder and Charge**

22. The exploder device itself incorporates 2 mechanical and 6 electrical independent safety measures.

## Control and Guidance System

23. The control and guidance section accommodates the operational and tactical software, including the signal processing, data processing and torpedo guidance rules. The torpedo guidance and control is based on an inertial system of 'strap down' technology.

**Figure 9-7: Control and Guidance Section**

## Battery Section

24. The MU90 is an electrically propelled torpedo. It is powered through an Aluminium-Silver Oxide (AgO-Al) sea water battery using dissolved sodium-dioxide powder as electrolyte.

25. It houses three thermal batteries. The first one – PTH1 – is initiated during the launch sequence. Once the torpedo becomes submerged, the salt water reacts with PTH1 allowing a second thermal battery – PTH2 to activate. This battery activates the weapon guidance and control section and also the electrolyte recirculation pump. It continues to provide power until the main battery takes up the load.

## Afterbody Section

26. This area houses the propulsion components of the torpedo. The MU90 is propelled through an electronically controlled, high-RPM brushless motor. It allows a variable speed range between 29-55 knots. The torpedo speed is automatically selected by the weapon depending on the scenario, environment and operational phase.

27. The MU90 has an 'X fin' configuration which differs from most conventional torpedos. This configuration is designed to enable better manoeuvrability in all conditions.

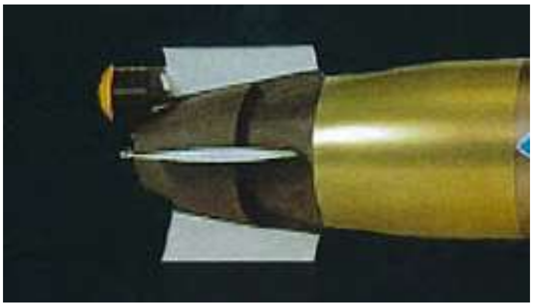

**Figure 9-8: X-fin Control Surface**

## *Mk 46 Torpedo*

44. The Mk 46 torpedo is a deep-diving, high speed torpedo fitted with active/passive acoustic homing and is intended mainly for use against submarines. After water entry it starts a helical search pattern, acquires and attacks its target. If it misses the target it is capable of multiple re-attacks. Two search modes are available: snake or circle. It has two operating speeds 36 and 45 kt (for the Mod 5A version). The torpedo uses a five-cylinder liquid monopropellant (Otto fuel II) motor. The Mk 46 can be launched by surface vessels or by fixed- and rotary wing aircraft.

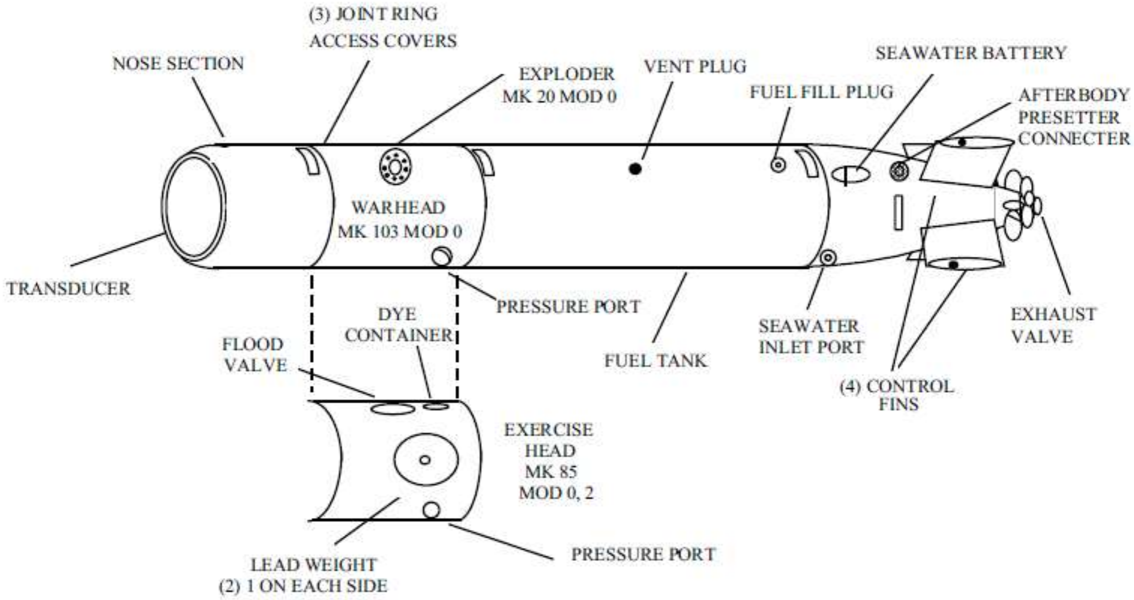


**Figure 9-9: Mk46 Torpedo**

| General characteristics, Mark 46 Mod 5: | |
|---|---|
| **Power Plant** | Two-speed, reciprocating external combustion; Mono-propellant (Otto fuel II) |
| **Length** | 8 ft 6 in (2.59 m) tube launch configuration (from ship), |
| **Weight** | 508 lb (231 kg) (warshot configuration) |
| **Diameter** | 12.75 in (324 mm) |
| **Range** | 12,000 yd (11 km) |
| **Depth** | > 1,200 ft (365 m) |
| **Speed** | > 40 knots (46 mph, 74 km/h) |
| **Guidance System** | Homing mode: Active or passive/active acoustic homing |
| **Launch/search mode** | Snake or circle search |
| **Date Deployed** | 1967 (Mod 0); 1979 (Mod 5) |
| **Warhead** | 96.8 lb (44 kg) of PBXN-103 high explosive (bulk charge) |

**Table 11: Mk46 Torpedo Characteristics**

## Otto Fuel II

45. This distinct-smelling, reddish-orange, oily liquid is a mixture of three synthetic substances. Although the fuel can be made to explode, this requires extreme conditions (such that it can be regarded as practically stable). The vapour pressure of the fuel is low (i.e., it is not volatile), minimising toxic hazards. Finally, the fuel's energy density far surpasses the capacity of the electric battery used in other torpedoes, maximising range.

46. Exposure to OTTO Fuel II is an uncommon occurrence on board ships, but could occur on rare occasions due to a torpedo defect, or the accidental rupture of a torpedo fuel tank caused by rough handling or an accident.

47. OTTO Fuel II becomes a hazard to health when ingested, absorbed through the skin or inhaled as a vapour. The ingestion of OTTO fuel II byproducts also represents a hazard to health. Ingestion of contaminated food or direct exposure at worksites can cause headaches, poor eye–hand coordination, eye irritation, congested noses, nausea, dizziness, and difficulty breathing. Fresh air and black coffee are used to relieve exposure symptoms. No fatal cases of overexposure have yet been reported.

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# Chapter 10. Soft Kill Weapon System

## *Introduction*

1. The Soft Kill Weapon System (SKWS) as fitted on FFGs provides a manually controlled and operated decoy launching system. It delivers the capability of off-board countermeasures against anti-ship missiles and torpedoes using either Radio Frequency, infrared or acoustic decoy systems. The 130 mm countermeasure or decoy rounds are mortar type and launched from the Mk137 Launcher. Two Control Units provide the operator with system control and indication. The system provides automatic round identification of loaded decoys, and a Load / Empty status indication for each of the launchers during operation.

**Figure 10-1: FFG SKWS Firing**

## *Components*

2. The SKWS consists of the following:

a. Two Control Units (CU) which provide the main HMI. One of the CUs is located on the Bridge and the other is located in the CIC adjacent to C&Di console number six.

b. One Launcher Interface Unit (LIU). The LIU is the central distribution unit of the SKWS. The LIU interfaces between the Launchers and CU. The main power switch for the SKWS; the Standby / On Switch is located on the bottom panel of the LIU.

c. Four Mk137 Launchers. The Mk137 is a 130 mm, deck mounted launcher incorporating an assembly of six fixed launch tubes mounted on a base assembly. The launch tubes are mounted in two rows with an elevation of 45 degrees.

d. Two Warning Horns that alert personnel prior to a firing. They are located on the main mast and are activated by the hardware safety chain and / or manually activated from the CU.

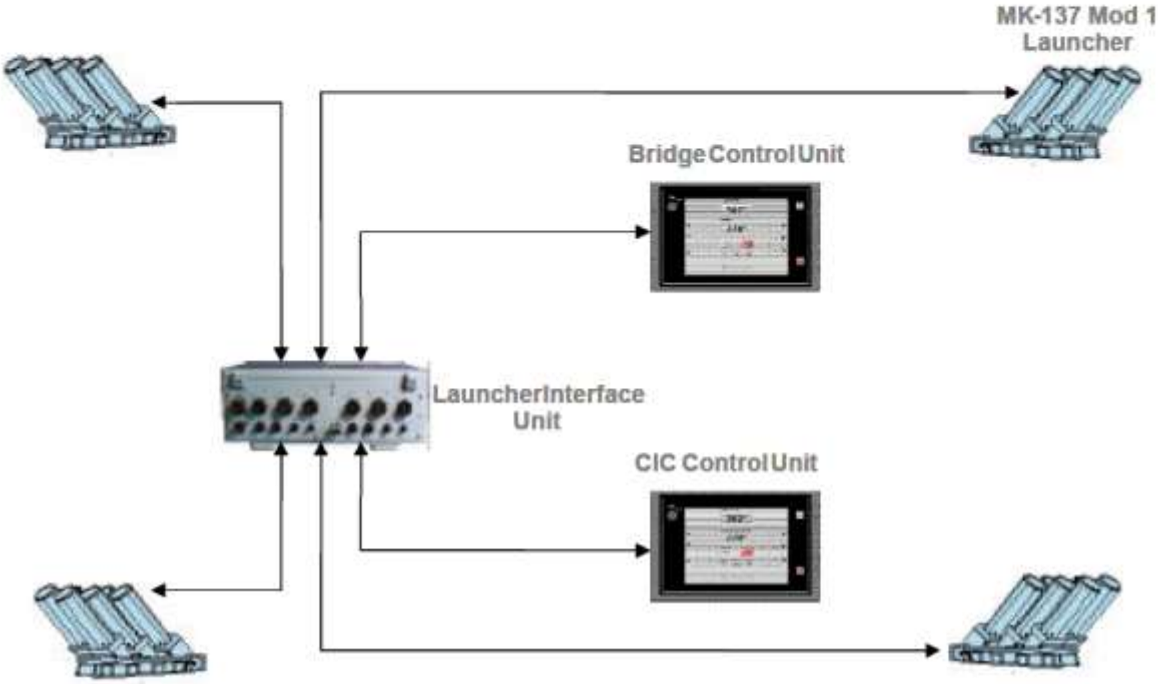



**Figure 10-2: FFG SKWS Major Components**

## Control Units

3. The Control Unit (CU) is the operator interface to the SKWS. The CU contains a graphics VGA colour display with a touch sensitive screen, two mechanical push buttons and a key switch. The CU has the following main functions:

a. Manual firing of decoys (software selection of decoys).

b. Optional: Control in automatic and semi-automatic modes.

c. Monitoring of the SKWS status.

d. Communication with the LIU.

e. View of maintenance statistics (stored in the LIU).


**Figure 10-3: SKWS Control Unit**

4. One CU is placed in the CIC and one on the bridge.

## Launcher Interface Unit

5. The Launcher Interface Unit (LIU) is the central distribution unit in the system and it provides power for the Control Unit, firing coils and Warning Horns. Access to the LIU is from the front. The LIU is normally supplied from the ship's of 115 VAC 60 Hz supply, but option exists to connect a 24 VDC backup supply in case of emergency.

**Figure 10-4: Launcher Interface Unit**

## Mk137 Launcher

6. The 130mm Launcher MK137 is deck mounted equipment incorporating an assembly of six fixed launch tubes mounted on a base assembly. The launch tubes are mounted in two rows with elevation of 45 degrees. At the rear of the base assembly is mounted a Junction Box which has a launcher safety switch and an indicator lamp, and contains all electrical connections from the LIU and Round Identification System (RIS).

7. The launcher fires a round on receipt of a firing pulse from the LIU. The launcher excitation coil triggers the round for firing.

8. One Warning Plate is mounted on the Launchers Junction Box beside the Launcher Safe Indicator Lamp. The text on this plate alerts the user regarding the launcher safety. The other warning plate is mounted nearby the launcher. This plate alerts the deck personal regarding the launcher safety clearance.

**Figure 10-5: Mk137 Decoy Launcher**

## Round Identification System

9. The Round Identification System (RIS) Sensors are located on top of each tube, probing the round for an identification number. The round is fitted with an identification chip mounted on the barrel extender. The response (or lack of) is communicated to the LIU and combined with the information from the load status sensor located in the bottom of the tube providing a load/empty tube status. RIS control unit installed in the Launcher Junction Box handles the ammunition detection and communicates over a RS-485 serial data bus with the LIU.

## *Operation*

10. When the Fire button is pressed and the CU Safety Switch is in the 'ARM' position, a software command is sent to the LIU via the Interface Board and the LAN (Local Area Network) communication. The On / Off Switch will only affect the display.

11. The Power Supply Module accepts 115V AC 60Hz and converts this to a regulated and filtered +28V DC output to the relay boards mounted within the LIU. The power supply module also provides signals to the LED board to provide indication on the LIU top cover of; 115V AC Main Power and Power Fail.

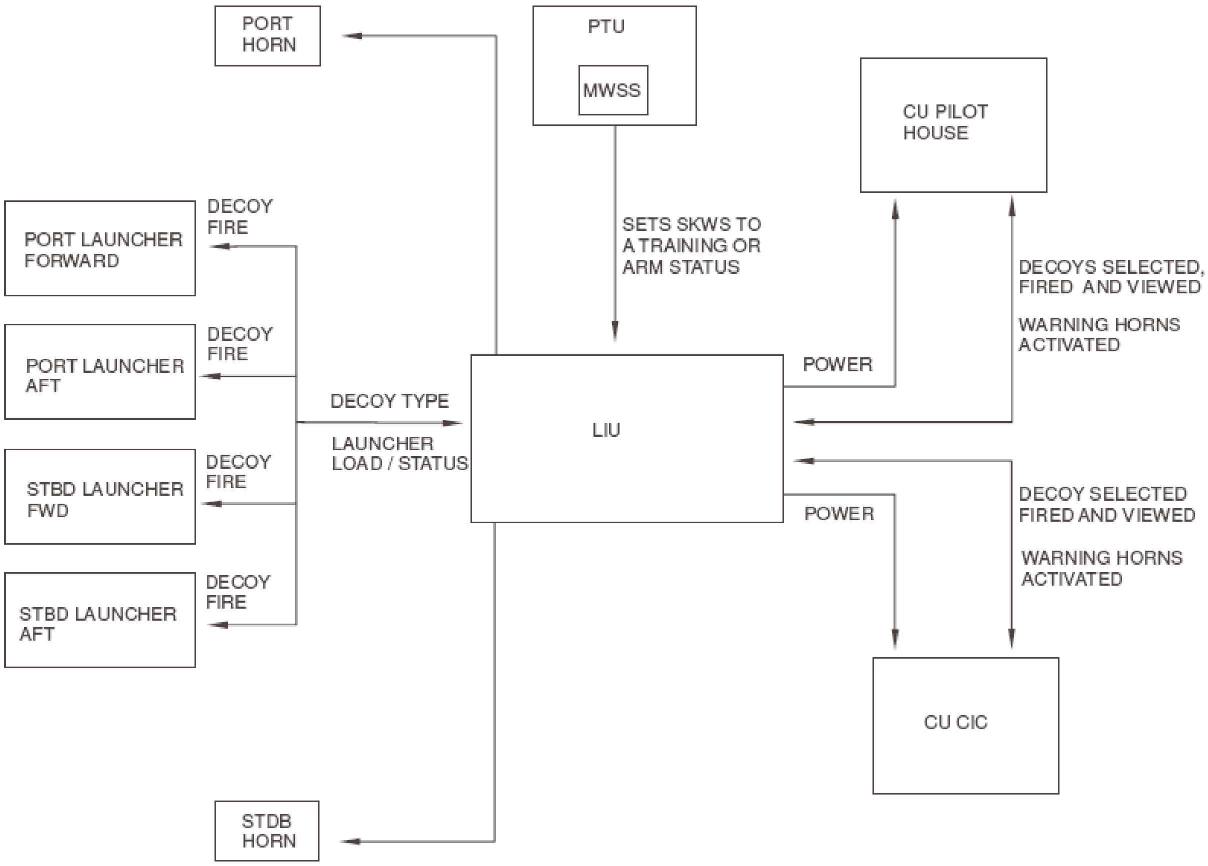



**Figure 10-6: SKWS Functional Block Diagram**

12. The Relay Boards receive +28V DC from the Power Supply Module and distributes it via the Standby / On switch to the LIU sub-units; CIC and Bridge Control Units and the Port and Starboard Launchers and Warning horns. The Relay Boards also provide the hardware safety control for the firing circuit, it accepts manually controlled signals from the Master Safety Switch (MSS), Main Weapon Safety Switch (MWSS), Launcher Safety Switches and the software controlled; fire and arm relay signals. The relay signals allow the firing circuit to initiate the generation of a firing pulse.

13. The LIU CPU provides the communication between the LIU sub-units and the 2 CU's.

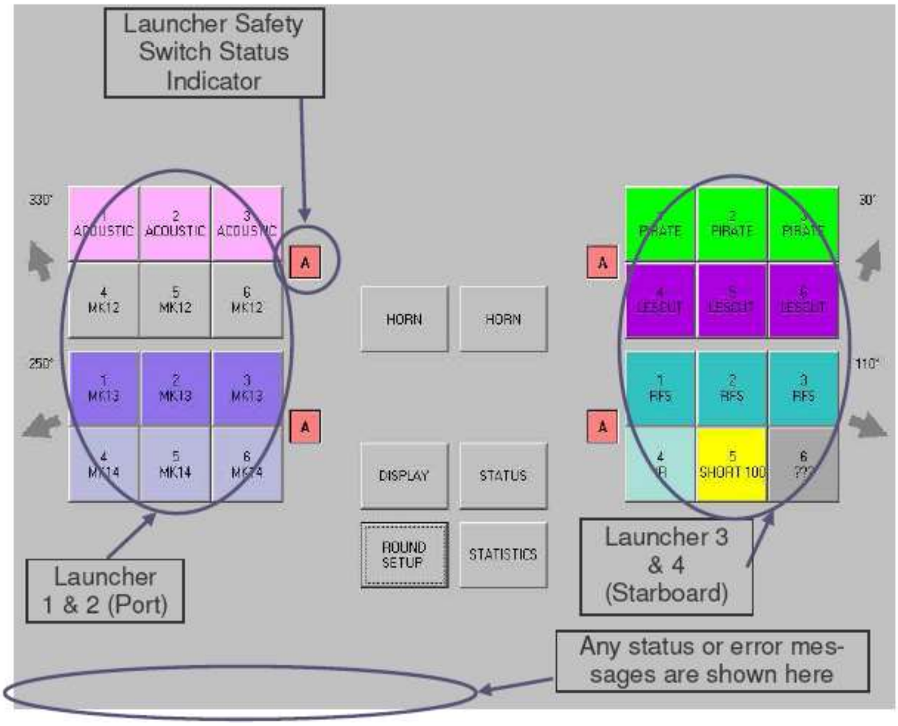



**Figure 10-7: Control Unit Manual Fire Screenshot**

14. The Manual Fire Screen is the default screen which is displayed when the system is powered up. The screen consists of twenty four individual touch-screen cells. Each group of six cells represents a launcher and each individual cell represents a decoy type. The screen displays the following:

a. Launcher Safety Switch Status Indicators,

b. Decoy type and Launcher Tube,

c. Status of error messages,

d. System Status,

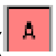
e. Safety Switch Indicators,

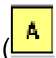
f. System Statistics,

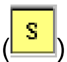
g. Horn for the Warning Horn, and

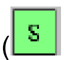
h. Display.

15. The Launcher Safety Switch Status Indicators on the 'Manual Fire' screen show the combined status of the Safety Switches. They can have the following states:

a. Red 'A' () indicates that all Safety Switches connected to this platform are set in their 'ARMED' state,

b. Yellow 'A' () indicates that the Main Weapon Safety Switch and/or the Master Safety Switch is set to their 'SAFE' state, while the Launcher Safety Switches are in their 'ARMED' state,

c. Yellow 'S' () for a platform indicates that the Launcher Safety Switch for that platform is set to 'SAFE' and

d. Green 'S' () for a launcher means that all Safety Switches connected to the platform is 'SAFE'.

16. There are three status or error messages that can be shown on the Manual Fire Screen

17. Some Tubes Not Fired - Indicates that a firing of a decoy has been initiated from a CU without success, due to the LSS, MSS or MWSS in a 'SAFE', 'SAFE' or 'TRG' position respectively.

## *Decoys*

## SEAGNAT

18. The Seagnat Cartridge is a mortar launched chaff store designed to be launched from the Mk 137 launcher on board HMA Ships and to burst near the apogee, dispensing its chaff payload, confusing and seducing an RF Guided Missile in its terminal phase by the deployment of chaff clouds. The cartridge consists of three sections; Propulsion Assembly, Safety and Arming Mechanism, and Chaff Payload all contained within a 130mm diameter outer metal cylinder.

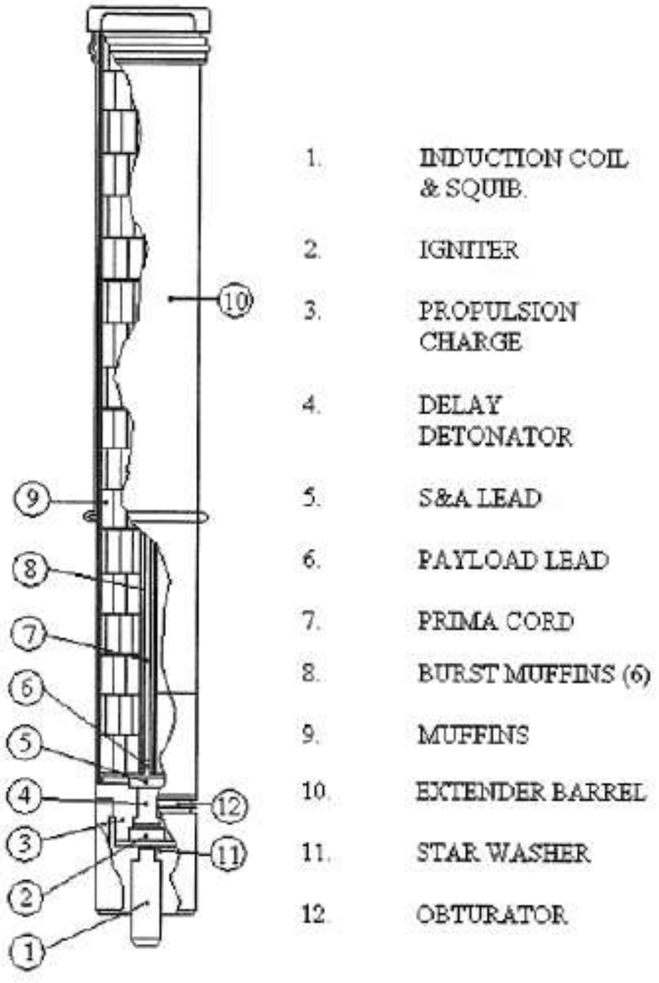



**Figure 10-8: Seagnat Cartridge Mk214 Mod 1**

19. The cartridge is designed for deployment from a 45°-quadrant elevation and all performance requirements apply when fired from the 45° barrel. However, the cartridge may also be fired from a 60° barrel resulting in a higher trajectory and shorter range.

### Ignition and Propulsion Assembly

20. The Seagnat Cartridge Ignition and Propulsion Assembly consists of:

a. an Ignition coil;

b. Squib;

c. Propellant; and

d. Delay Detonator.

### Safe and Arming Mechanism

21. The Safety and Arming Mechanism, Figure 10-9, requires two criteria to enable alignment of the explosive train and subsequent initiation of the explosive lead:

a. sufficient gas pressure; and

b. cartridge to be clear of the launcher tube,

22. The Safe and Arming Mechanism does not prevent the propellant from initiating.

## Payload Assembly

23. The Payload Assembly consists of strands of aluminised glass fibre chaff of various lengths, called dipoles, bundled together in packages referred to as muffins. The muffins are wrapped in polymide film to form clusters called soft packs. The soft packs are packaged in layers around a central burster charge, all contained within a frangible fibreglass outer casing.

## Operation

24. The cartridge is loaded into one of the barrels of the launcher. An application of 30 volts supplied to the primary induction coil (within the launcher tube) induces a current within the ignition coil of the War-shot and Practice Seagnat round. The induced current in the igniter initiates the fuse head, igniting the propellant and propelling the cartridge out of the launcher tube.

25. The activation of the propulsion system initiates a pyrotechnic delay ensuring that the cartridge is clear of the ship prior to dispelling the payload.

26. During initial propulsion, the Safe and Arming Mechanism commences its function to move the Explosive Lead into alignment and completing the firing train. The plunger mechanism keeps the Explosive Lead out of alignment on the ‘x’ axis. To prevent the Safe and Arming Mechanism to function whilst loading and unloading the store, the plunger mechanism is locked into position by use of a ‘locking ball’.

27. The following criteria are required to occur to complete the explosive train:

a. When sufficient gas pressure is produced, at launch the bellows expand to allow the locking ball to drop free. This action unlocks the plunger mechanism.

b. The Seagnat Cartridge needs to clear the launcher tube before allowing the plunger mechanism, held back by it’s contact with the inside wall of the launcher tube, to ‘pop out’ of the side of the cartridge under spring action. The Explosive Lead slides along the ‘x’ axis to complete the explosive train.

28. Upon satisfaction of the Safe and Arming Mechanism the output of the pyrotechnic delay is permitted to initiate the central burst charge. The central burst charge propels the soft packs radially outwards through the frangible outer case.

29. The soft packs and muffins unwrap, dispersing the individual chaff dipoles, forming a radar effective cloud.

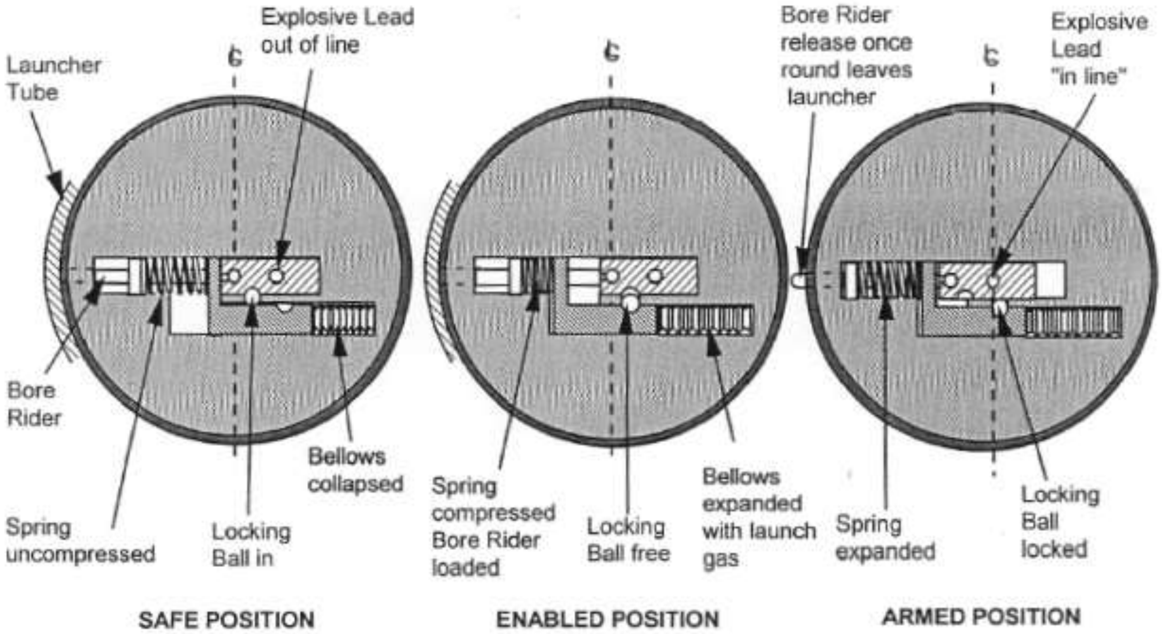



**Figure 10-9: Safe and Arming Mechanism Operation**

## PIRATE

30. PIRATE stands for **P**ains Wessex **I**nfra **R**ed **A**nti **T**hreat **E**xpendable.

31. The 130mm ‘PIRATE’ Naval Decoy is an infra-red (IR) countermeasure round, producing an obscurant and emissive smoke cloud which produces infra-red emission in the mid and long wavebands. The round is the culmination of a series of development programmes for various customers since 1985 and currently represents a ‘state of the art’ Naval IR ‘fire and forget’ countermeasure deploying both air burst and floating pot submunitions to provide both fast rise time and long duration IR response from a single round firing.

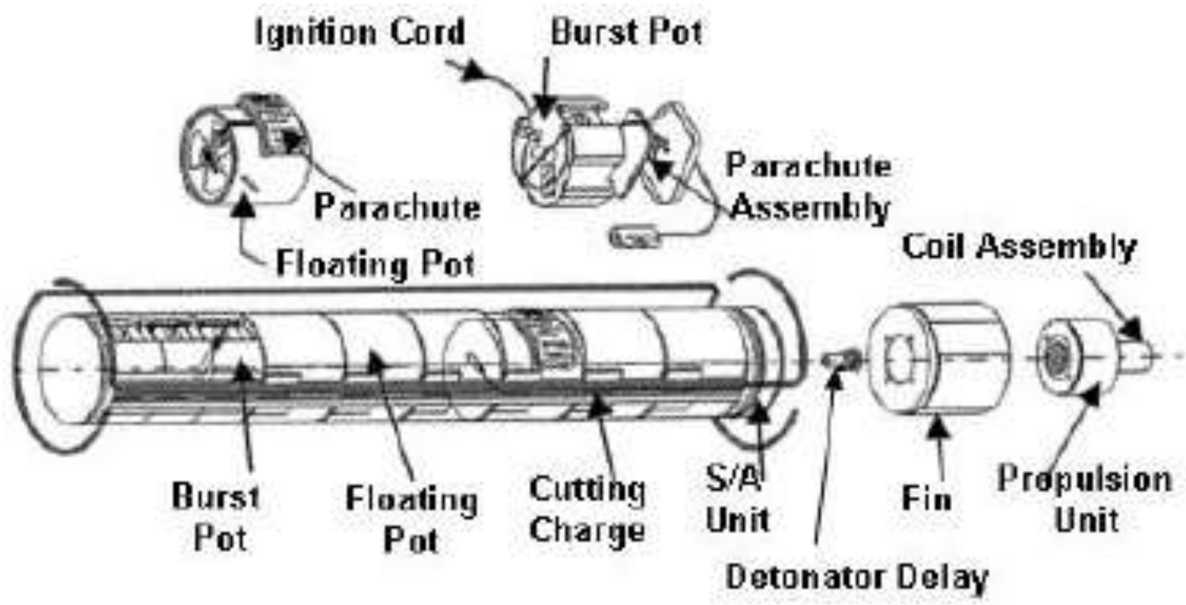



**Figure 10-10: PIRATE Decoy**

32. The PIRATE decoy is a mortar launched decoy, fully enclosed within its own metal cartridge. It is launched from the existing MK137 launchers in exactly the same way the SEAGNAT RF decoy is launched. The complete cartridge weighs approximately 19kg, including 6kg of red phosphorous composition, six individual floating smoke pots and three air burst pots.

### Operation

33. When launched, the PIRATE round is propelled away from the ship and after two seconds begins to detonate. The detonation process is made up of a number of separate detonations that effectively provide a highly active and persistent IR signature designed to attract any missile with an IR seeker head, thus seducing it away from the ship.

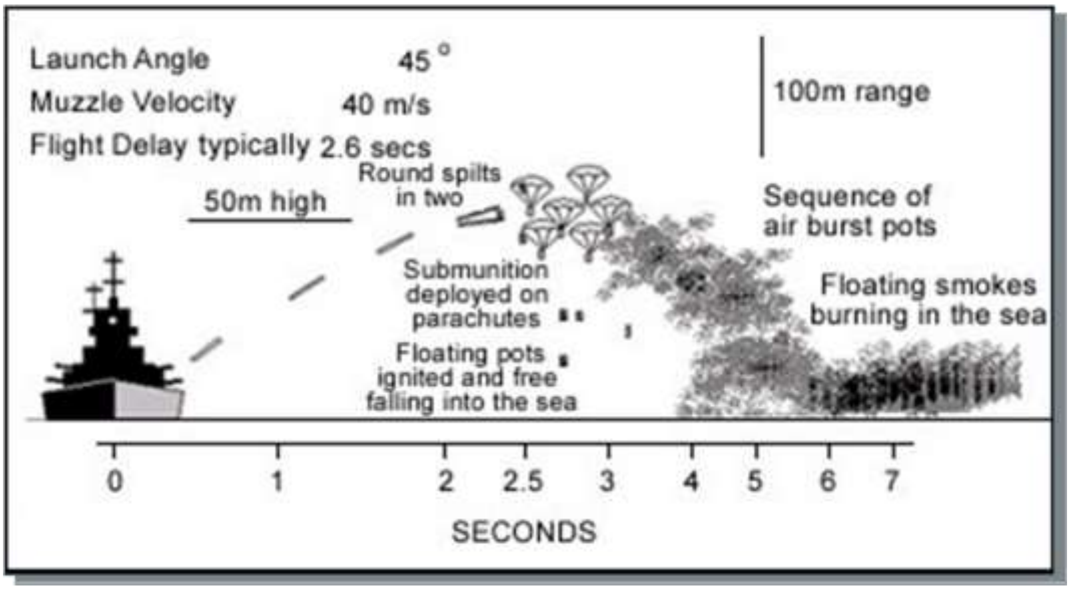



**Figure 10-11: PIRATE Decoy Operation**

## LESCUT

34. The LESCUT MR (A) Acoustic Decoy is an expendable mortar launched decoy system that enables a surface ship to seduce and evade incoming active or passive acoustic homing torpedoes. The attacking torpedo is decoyed by soft-kill acoustic signals transmitted into the water via the LESCUT MR (A) Acoustic Decoy transducers. The LESCUT MR (A) Acoustic Decoy round consists of a flight package (including tether and float) and a Reactive Expendable Acoustic Module (REAM).

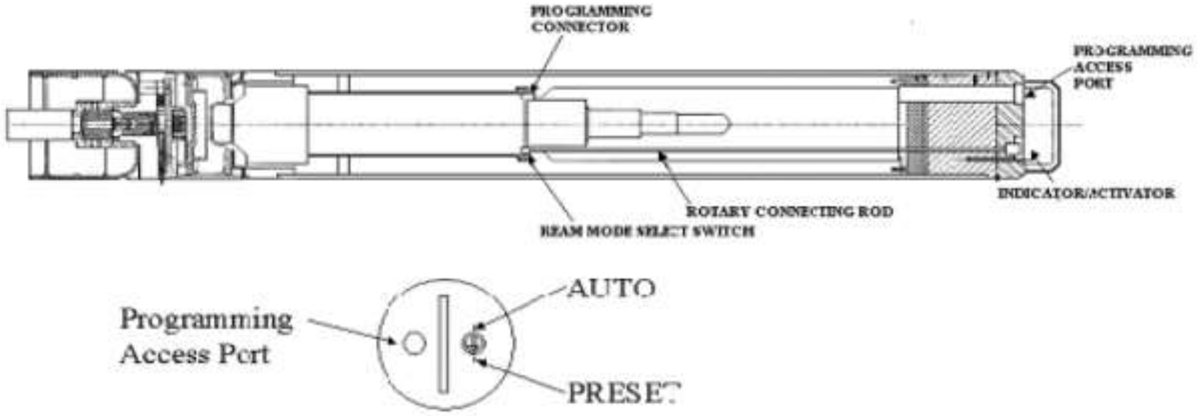



**Figure 10-12: LESCUT Acoustic Decoy Cross Section View**

**Reactive Expendable Acoustic Module**

35. The LESCUT MR(A) Acoustic Decoy round uses the REAM to seduce the homing torpedo away from its intended target by soft-kill techniques. On water entry the REAM's lithium thermal battery is activated within five seconds to allow the REAM to automatically perform its seduction mission.

**Figure 10-13: LESCUT Reactive Expendable Acoustic Module**

## Operation

36. The LESCUT Acoustic Decoy is a mortar launched acoustic decoy. It is fully enclosed within its own outer metal tube and loaded as an all up round into the standard Mk 137 launcher. A coil in the base of the Mk 137 barrel is energised, causing an induced current in the squib assembly firing coil to initiate the electric squib. The squib's output initiates the propellant charge and the resultant rapid expansion of gas launches the round. A bore rider pin in the Safe and Arm (S&A) assembly is held back by its contact with the inside wall of the launcher tube. After the LESCUT Acoustic Decoy leaves the tube the bore rider pin is allowed to extend under spring pressure to complete the arming sequence.

37. At water impact, a firing pin, in the S&A assembly strikes a stab detonator that initiates a primer and ignites the separation charge. The separation charge generates enough pressure inside the outer case to separate this from the S&A Assembly allowing the float and acoustic device to be deployed. The pressure generated by the separation charge drives two pistons into two $CO_2$ bottles inflating the float. The float assembly contains two porous plugs that allow air to slowly escape. The float and acoustic device scuttle after a pre-set duration.

38. The round is fired by the Mk 36 Decoy Launch System by application of 30 volts supplied to the primary induction coil (within the launcher tube) inducing a current within the ignition coil of the flight package. On firing, a coil in the base of the Mk 137 barrel is energised, causing an induced current in the squib assembly firing coil to initiate an electric squib. The squib's output initiates the propellant charge and launches the round. At the same time the output pressure of the propellant charge expands a bellows in the Safe and Arm (S&A) section. The charge assembly unlocks an inertial firing pin in the S&A assembly and cocks a bore rider pin. Upon leaving the barrel, the bore rider fully extends, aligning the safe and arm assembly. The pressure generated in the bottom of the launch tube propels the cartridge out of the launch tube at approximately 45 meters/second.

39. As the round exits the launcher the Payload Separation Charge Initiator is armed and four foldout fins open to ensure flight stability. When launched from the Mk 137 launcher within the Ship Launch Envelope, the mortar propelled round will gain an average separation of approximately 150 meters from the platform.

40. At water impact, the Separation Charge is initiated by a firing pin in the S&A assembly to separate the acoustic payload from the remainder of the cartridge. The separation charge generates enough pressure inside the outer case to separate this from the S&A assembly allowing the float and REAM to be deployed. The pressure generated by the separation charge drives two pistons into two CO2 bottles inflating the Surface Float. The float assembly contains two porous plugs that allow the CO2 to slowly escape over a 24 hour period. The sequence completes as the payload assembly descends in the water to a predetermined operational depth by deploying a tether attached to the float.

41. When the LESCUT MR(A) Acoustic Decoy's payload assembly reaches the end of the tether, the housing continues to fall away, extracting the REAM from the housing. A salt water battery in the acoustic module is activated upon contact with the water and provides electrical energy to a match initiated thermal battery. The thermal battery powers the acoustic output (jamming/seduction) of the REAM within five seconds of water impact and continues transmissions for over 10 minutes. Note that the LESCUT MR(A) Practice Round will follow the same deployment sequence without any transmissions as the practice round contains a weighted dummy REAM for drill and training purposes.

42. While the LESCUT MR(A) Acoustic Decoy's REAM is operating, CO2 gas is continually being released from the surface float so that, after the REAM ceases operation, the float and REAM payload will scuttle to the seabed within 24 hours.

# Chapter 11. AN-SLQ-25(C) Nixie Towed Torpedo Decoy System

## *Overview*

1. The AN/SLQ-25C System is a surface ship towed torpedo countermeasures system designed to provide enhanced ship survivability while presenting minimum interference with own ship's sonar. The AN/SLQ-25C NIXIE employs an underwater acoustic projector housed in the towed body which is streamed astern of the vessel by means of a combination of a tow-signal cable and a streaming winch. The main electronic console selects, generates, and amplifies electrical signals, which are then transmitted through the cable to the acoustic projector in the towed body. The acoustic projector transforms the electrical signals into acoustic output energy. During operation, the Remote Control Unit (RCU) can be used to control and monitor the system performance.

2. The AN/SLQ-25C System is a follow-on to the AN/SLQ-25 and AN/SLQ-25A systems and is significantly different operationally than the previous systems. The AN/SLQ-25C incorporates improved torpedo countermeasure modes greater than those provided by the AN/SLQ-25A system. New hardware items have been added to support the incorporation of the improved torpedo defence capabilities. A longer more functional Tow Cable is included in the AN/SLQ-25C configuration which supports Surface Ships Torpedo Defence operations in littoral waters. Electronic components are now included in the mechanical winch to assist with the performance of the torpedo countermeasure modes. The AN/SLQ-25C configuration contains electronic components in the mechanical winch and the Electronic Console.

3. The major system components are:

   a. Remote Control Unit;

   b. Electronics Cabinet;

   c. Motor Controller;

   d. Winch Assembly; and

   e. the Towed Body.

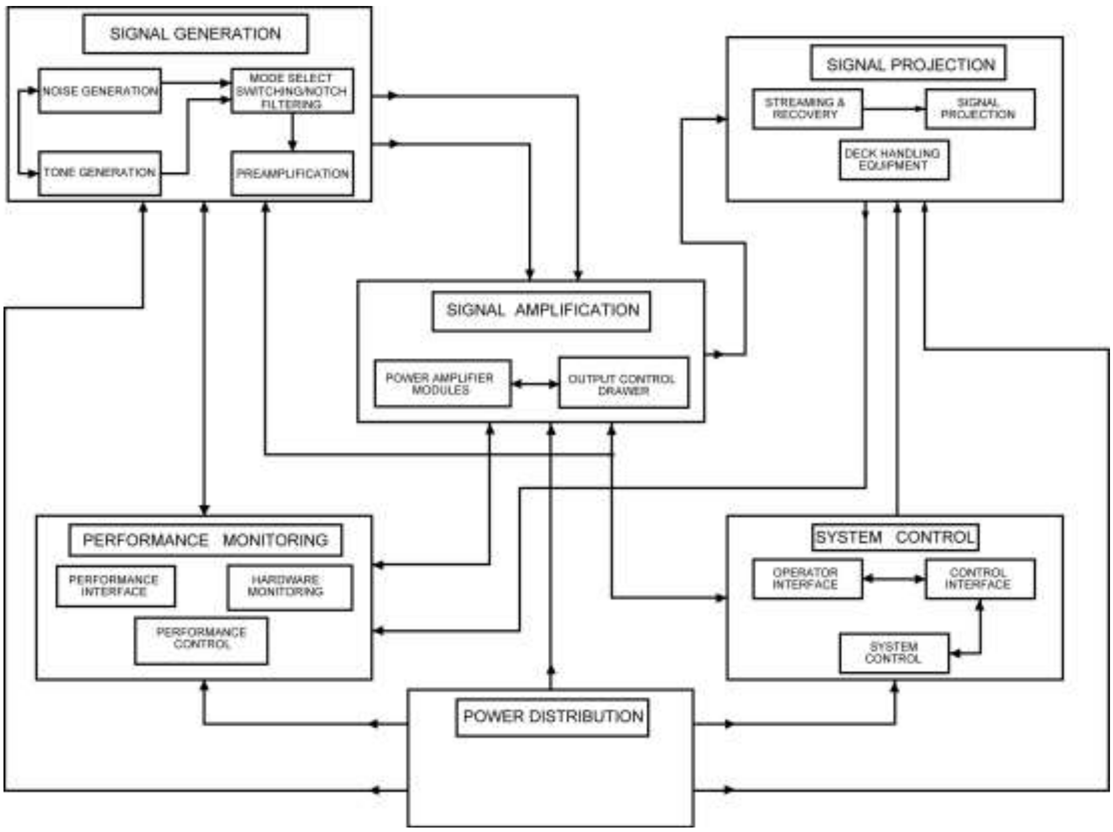



**Figure 11-1: Nixie System Functional Block Diagram**

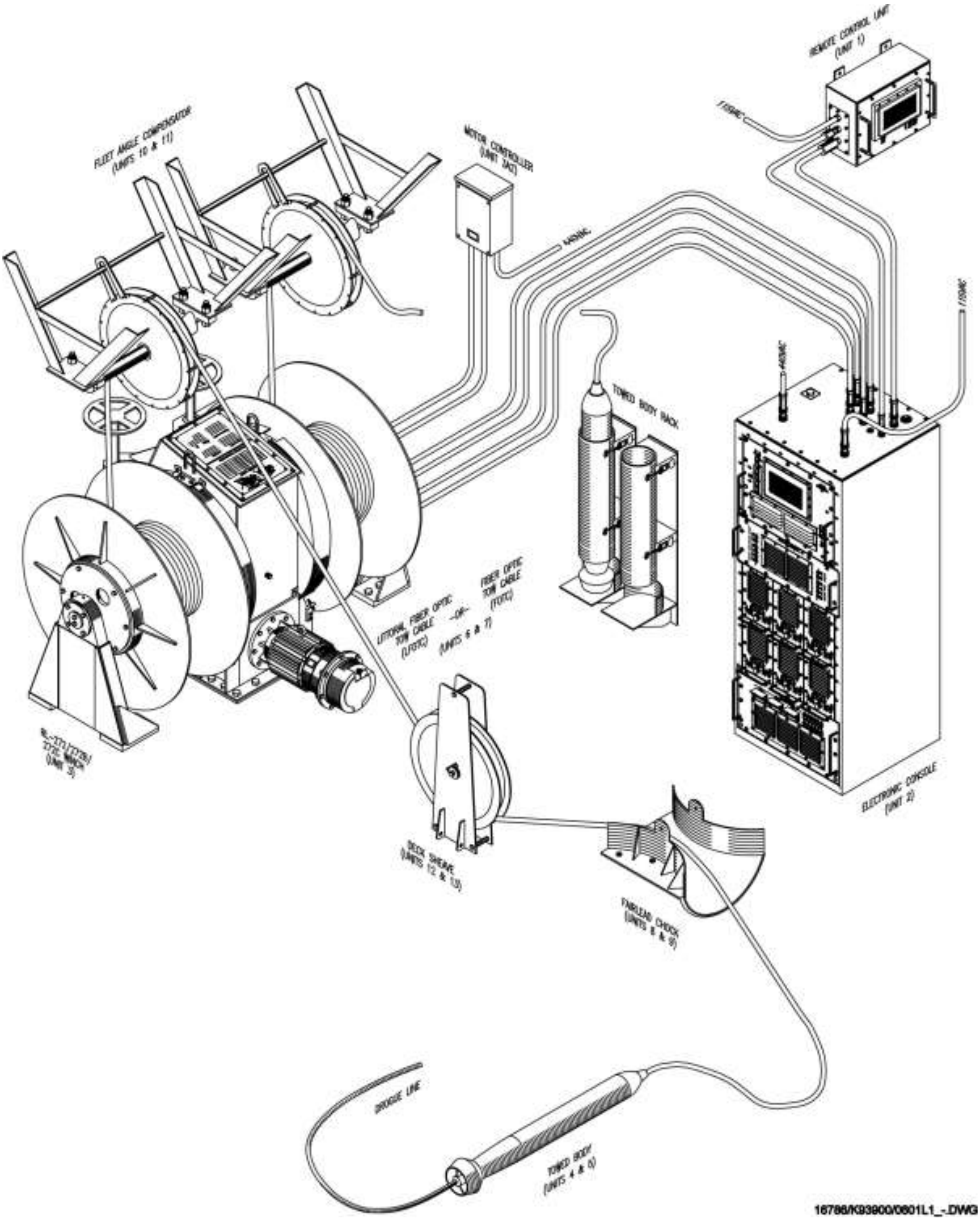



Figure 11-2: Nixie System Equipment