SW820-AP-MMI-010

REVISION 15

TECHNICAL MANUAL
TOMAHAWK CRUISE MISSILE RGM/UGM-109
SYSTEM DESCRIPTION

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FOREWORD

SCOPE: This document consists of four volumes which provide information, data and procedures for operations and support of the TOMAHAWK Weapon System (TWS).

a. Volume 1 - SW820-AP-MMI-010 - TOMAHAWK CRUISE MISSILE SYSTEM DESCRIPTION - This volume presents information pertinent to the submarine and surface launch TOMAHAWK Weapon System (TWS) to include physical and functional descriptions of system components, safety and security considerations, and operations aboard platforms employing the TWS.

b. Volume 2 - SW820-AP-MMI-020 - TOMAHAWK CRUISE MISSILE GENERAL HANDLING PROCEDURES - This volume contains Procedural Guides (PGs), Operating Procedures (OPs) and Standard Inspection Procedures (SIP) to permit afloat and ashore activities to perform receipt, handling, inspection, transfer, and reconfiguration processes for TOMAHAWK Cruise Missile (TCM) configurations. This volume does not include procedures for combatant onload/offload or submarine tender unique on board handling. Combatant onload/offload procedures are contained in NAVSEA OD 44979 for Torpedo Tube Launch (TTL) variants; in NAVSEA OD 44979 and SW820-AD-WHS-010 for Capsule Launching System (CLS) variants; and in SW394-EE-PRO-010 for Vertical Launching System (VLS) variants. Processes unique to handling TCM configurations on board submarine tenders are contained in SW820-AA-WHM-010 for TTL and in SW820-AD-WHS-030 for CLS and VLS on AS 39 Class.

c. Volume 3 - SW820-AP-MMI-030 - TOMAHAWK CRUISE MISSILE MAINTENANCE PROCEDURES - This volume contains PGs, OPs, SIPs, and Repair Parts Breakdown (RPB) to permit afloat and ashore activities to perform authorized maintenance on TCM configurations.

d. Volume 4 - SW820-AP-MMI-040 - TOMAHAWK CRUISE MISSILE UGM 109A-1 WARHEAD INSTALLATION/REMOVAL AND AIR VEHICLE MAINTENANCE - This volume contains PGs, OPs and RPBs to handle and prepare UGM 109A All-Up-Rounds for installation or removal of the warhead and to perform authorized maintenance on the UGM 109A Air Vehicle.

PURPOSE: This document provides information, data and procedures for operations and support of the TOMAHAWK Weapons System (TWS).

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CHAPTER 1 INTRODUCTION
SECTION I. DOCUMENT ORGANIZATION

1.1 SCOPE.

This document presents information pertinent to the submarine-launched and surface-ship-launched Tomahawk Weapon System (TWS) to include physical and functional descriptions of system components, safety and security considerations, and operations aboard platforms employing the TWS.

1.1.1 Chapter 1. Chapter 1 discusses the TWS mission and physical descriptions of system components and equipment required to support the system; identifies the types of documentation and documentation terminology associated with TWS operations and support; describes TOMAHAWK Cruise Missile (TCM) mission profiles from prelaunch to target engagement; and provides TWS reference data. Section I of this chapter provides an outline of this document's organization and content. Section II provides an overview of the TWS to include a discussion of the TWS mission, the TCM All-Up-Round, support equipment, and documentation and documentation terminology. Section III provides a description of the TCM without regard to launch configuration and discusses targeting and the typical missile profile for each TCM variant. Section IV discusses the submarine Torpedo Tube Launch (TTL) launch configuration and provides information and data unique to the TTL system. Section V discusses the submarine Capsule Launching System (CLS) launch configuration and provides information and data unique to CLS. Section VI discusses the surface Vertical Launching System (VLS) launch configuration and provides information and data unique to VLS.

1.1.2 Chapter 2. Chapter 2 discusses TWS security and safety requirements, regulations and general policies relating thereto.

1.1.3 Chapter 3. Chapter 3 discusses functional descriptions of TWS components and interfaces between the TCM and its launch platforms. Section I provides an outline of the organization and content of the chapter. Section II discusses the TCM electrical power system and type commands and requests for status issued to the TCM and TCM responses to those commands and requests for status. Section III discusses unique interfaces between TTL TCMs and the submarine. Section IV discusses unique interfaces between CLS TCMs and the submarine. Section V discusses unique interfaces between VLS TCMs and the surface ship.

1.1.4 Chapter 4. Chapter 4 discusses TWS operations aboard launch platforms to include a description of the launch platform and on board equipment used to load, store and launch TCMs; TCM onload scenarios; and launch operations. Section I provides an outline of the organization and content of the chapter. Section II discusses TTL unique operations. Section III discusses CLS unique operations. Section IV discusses VLS unique operations.

SECTION II. TOMAHAWK WEAPON SYSTEM

1.2 TWS DESCRIPTION.

The TWS consists of the submarine TTL system employed aboard SSN 688, SSN 21, and SSN 774 Class submarines; the submarine CLS employed aboard selected SSN 688 Class submarines, SSN 774 Class submarines and SSGN Class submarines; and the surface VLS employed aboard DD 963 Class, CG 47 Class, and DDG 51 Class ships. Each system employs a unique All-Up-Round (AUR) configuration to launch a TCM. In addition to tactical TCM variants, each system also includes applicable exercise, certification, and training variants as well as related support, test, handling and training equipment. Within the broad definition, each system also includes those ship systems necessary to stow and launch TCMs.

1.3 MISSION.

The mission of the TWS is to provide theater and force commanders with a capability to use surface and sub-surface platforms to employ, either independently or in coordination with other strike capabilities, highly accurate, all-weather TOMAHAWK Cruise Missiles (TCM), armed with a variety of highly destructive payloads, against land targets at stand-off ranges.

1.4 ALL-UP-ROUND.

An AUR consists of a TCM installed in a capsule or canister configuration. For a TTL AUR, the separate pneumatic and electrical umbilicals are considered part of the AUR. For horizontal submarine launch, the depot installs an appropriately configured TCM into a Capsule, Mk 1 Mod 0 (for UGM-109A/C/D-1) or a Capsule, Mk 3 Mod 0 (for UGM-109E-1). For vertical submarine launch, the depot installs an appropriately configured TCM into either a Capsule Launching System (CLS), Mk 45 Mod 1 (SSN use only), or a CLS, Mk 45 Mod 2. CLS, Mk 45 Mod 1 assemblies are being converted to the Mod 2 configuration which can be used on both SSN and SSGN platforms. For surface launch, TCMs are encanistered at the depot into the Mk 10 Canister and then subsequently encanistered into the Mk 14 Canister at designated intermediate maintenance activities to permit surface vertical launch. The capsules/canisters provide protection during handling, storage, and transportation. The capsules and Mk 14 Canister also serve as launching devices for TCMs. Tactical and exercise AURs are delivered to the launch platform fueled and ready for launch. Tactical AURs are warheaded. Exercise AURs may be equipped with a depot-installed Range Safety System (RSS) and a live or inert warhead, or a depot-installed Recovery Exercise Module (REM) without warhead. Tactical and exercise AURs with conventional explosive warheads are classified as Class 1 Division 1 explosives. UGM-109A is classified as Class 1 Division 3. AURs with inert, or without warheads, are classified as Class 1 Division 3 explosives.

1.4.1 Tactical AURs. Tactical AURs are used for land-attack missions to strike high-value or heavily defended targets. Tactical AURs are configured for either surface launch (RGM) or submarine launch (UGM). Anti-ship TOMAHAWK is no longer employed. Each TCM is equipped with various devices for launch, a rocket motor to boost it to a specified altitude after launch, a sustaining engine for cruising to the target, wings and fins to affect course changes, a guidance section, and an explosive warhead.

1.4.2 Exercise AURs. Exercise variants are classified as either REM- or RSS-equipped TCMs and provide the capability to launch TCMs for testing or training. REM- and RSS-equipped TCMs are identified by a ’J’ prefix in the missile designator. A REM-equipped TCM (JUGM-109A or JRGM/JUGM-109C only) has a parachute system that permits recovery upon test flight completion. REM-equipped TCMs are identified by an "M" suffix in the missile designator. An RSS-equipped TCM (JRGM- or JUGM-109C or D) or MRSS-equipped Block IV TACTOM (JRGM- or JUGM-109E) is used for an exercise flight involving a target hit and may have a ’W’ (live warhead) or an ’S’ (inert warhead) suffix in the missile designator.

1.5 MISSILE IDENTIFICATION SYSTEM.

The Missile Identification System (MIS) is a method of differentiating between operationally significant features within a weapon type. Digital data can be electronically read from TCM variants containing a Programmable Read Only Memory in the Mission Control Module or from data stored in the protected memory of the guidance set. The MIS code consists of a series of digital data words followed by a checksum. These data are transmitted to the submarine/ship launch control system upon request. Matching data plates, containing the AUR serial number and MIS code, are mounted in the Record Book for TOMAHAWK Cruise Missile (TRB), PEO(W) PUB 4440, and on the AUR. A removable data plate is provided for VLS variants for attachment to the Mk 14 Canister. The MIS data plate may also contain canister code plug values which are applicable only to surface launched variants. Refer to PEO(CU)INST 8800.1 for complete identification of AUR nomenclatures, National Stock Numbers, Navy Ammunition Logistics Codes, discriminators, and MIS codes.

1.6 SUPPORT EQUIPMENT.

TOMAHAWK Weapon System planning identified requirements for support, test and handling equipment aboard submarines, surface ships, submarine tenders, shore bases, and training activities. Requirements include equipment already in the Navy inventory as well as peculiar equipment designed and developed for TWS unique application. Table 1-1 "Support Equipment Description"⇒ consolidates and provides identifying data for equipment required for TWS evolutions at submarine and surface launch operational and support activities. Table 1-2 "Shipboard Equipment Used for TOMAHAWK Support"⇒ identifies on board submarine tender and surface ship equipment that is used to support TWS evolutions.

1.7 LOADING AND HANDLING TRAINING EQUIPMENT.

The CLS Missile Tube Loading and Handling Trainer Assembly (Figure 1-21 "CLS Missile Tube Loading and Handling Trainer Assembly"⇒) is a facsimile of an SSN 688(I) submarine missile tube that is used to train submarine tender and shorebase personnel in all facets of CLS onload and offload evolutions. This trainer can be used to simulate the SSN-774 Class platform as well as the SSN-688(I).

For SSGN-726 class, the Submarine Missile Tube Trainer (SMTT) Assembly (Figure 1-37 "CLS Submarine Missile Tube Trainer Assembly"⇒) emulates MAC AUR cells for onload and offload training evolutions. Installation of an SSN top plate over the SSGN platform, transforms the trainer assembly from SSGN to SSN use.

A SMTT training shape (Figure 1-38 "SMTT Training Shape"⇒) is required to handle and train on the SMTT . The SMTT training shape is a modified version of the CLS capsule, shortened to approximately 15 inches. The SMTT training shape includes a Capsule Loading Cover.

1.8 DOCUMENTATION.

1.8.1 Record Books. Record books form an integral part of maintaining inventory and historical data on TWS variants. Each variant's record book accompanies the variant at all times throughout the logistics cycle and is returned to the depot with the variant at the time of recertification or unscheduled maintenance. The record book identifies the variant configuration and determines the data necessary for Fleet use; provides a log for tracking and recording security seal data; provides a history of movement, maintenance, and significant events between initial acceptance and return to the depot; and provides a record of authorized waivers and deviations to technical manual acceptance/rejection criteria. PEO(W) PUB 4440, Record Book for TOMAHAWK Cruise Missile, is used to record data pertinent to tactical and exercise AURs and specific trainers. PEO(W) PUB 4440 has been structured to accommodate both surface and submarine launched variants. Therefore, some forms contained in the record book are not applicable to some launch configurations. Instructions for use, forms completion, and disposition are contained in the record book and in PEO(W) INST 4440.2 .

1.8.2 Procedural Documentation. To perform TWS handling, maintenance and warheading evolutions, procedural documentation utilizes Procedural Guides (PG), Operating Procedures (OP) and Standard Inspection Procedures (SIP). All requirements, equipment, tools, material and procedures necessary for the safe and efficient handling, maintenance and warheading of weapons are contained in those PGs, OPs and SIPs. The PGs and OPs are self-explanatory and only require personnel be familiar with ship/shore base facility weapons systems. The SIPs are used by inspection personnel, when applicable. Inspection steps are indicated in the OPs by the following line '***IP STOP***' centered prior to a sequence of IP steps. The check line will be marked with 'IP' on the right edge. All paragraphs, steps and sub-steps are of equal standing when determining if there is a sequence break requiring IP stop markings.

1.8.2.1 Figures. Figures are provided in procedural documents to visually supplement procedural information in the OPs and, except for certain assembly sequences, provide typical views of events. Illustrations are not intended to restrict operations. Interpretation of visual depictions of events and variance from these same depictions are within the scope of the Weapons Officer/Weapons Repair Officer/Civilian Counterpart's authority and should only be governed by standard safety procedures and proper performance of equipment/operation being performed with no degradation of mission/weapon effectiveness.

1.8.2.2 Evolutions. Procedural documents contain only the PGs, OPs and SIPs required for the performance of pertinent evolutions. The combination of PGs and OPs/SIPs provides procedural documentation for an overall task. Evolutions are controlled by the PGs which will refer the user to the appropriate OPs or other external references. The PGs are presented in order of use and in a general to specific type sequence. OPs are arranged in a step-by-step sequence which allows personnel to read a procedural step, perform the work and check off the accomplishment of the work in the space provided. The procedures stand alone to the extent that referral to other steps, procedures or documents is minimized. The SIPs are used with their corresponding OPs whenever IP is involved as indicated in the OPs by the IP stops. SIPs are numbered to track with the OP with which they are used (i.e., SIP 3 is used with OP 3). There will be gaps in the numbering sequence of the SIPs because every OP does not have a SIP.

1.8.3 Procedural Documentation Terminology. The following paragraphs discuss terminology used in TWS procedural documentation.

1.8.3.1 Procedural Guides. PGs are used to coordinate major evolutions. Accomplishment of OPs may be prescribed. Appropriate steps for the evolution in process should be selected and all non-selected steps can be disregarded. Non-selected steps should be appropriately marked, i.e., 'N/A'. Selected steps should be accomplished in the sequence listed unless a deviation has been authorized by the Weapons Officer/Weapons Repair Officer/Civilian Counterpart. When deviating from the listed sequence and/or illustrations, the Weapons Officer/Weapons Repair Officer/Civilian Counterpart must evaluate the broad task to ensure that the deviation is both safe and correct. Referral to the PG during the evolution is mandatory and status of steps accomplishment shall be indicated by a physical check-off of PG steps or 'N/A' type indication. The Reader-Worker Method is not mandatory, but is recommended. When not using the Reader-Worker Method, reading aloud or making oral reports at the end of each step is not required. The terms 'as required', 'as necessary', etc. indicate a choice of action is required within the step, usually as a result of actions taken within the step, such as test results, presence of varying conditions, etc.

1.8.3.2 Operating Procedures. OPs are used where the rigid method required for Checklists is not necessary, and where specific tasks may be completed in other than the listed sequence. OPs may include steps which refer to other procedures and documents when it is not practical to include all the required steps in one procedure. Steps may be performed in any correct sequence or concurrently. A correct sequence results in safe and reliable operations and is determined by the person in charge of the evolution. Illustrations supporting an event are considered typical. Deviation from depicted events is allowed under the same guidelines used when deviating from procedural text. Referral to the OP during the evolution is mandatory and status of steps accomplishment shall be appropriately indicated by a physical checkoff of the OP steps or 'N/A' type indication. The Reader-Worker Method is not mandatory, but is recommended. When not using Reader-Worker Method, reading aloud or making oral reports at end of each step is not required. The terms 'as required', 'as necessary' etc. indicate a choice of action is required within the step, usually as a result of actions taken within the step, such as test results, presence of varying conditions, etc.

1.8.3.3 Inspection Table Specifics. Some OPs contain Inspection Tables to be used as references during the performance of the OP steps. These tables list the specific items and features to be inspected, describe unacceptable conditions for these items and prescribe a disposition for items which are not acceptable. An Inspection Table has four columns with headings of Inspection Point, Inspection Criteria, Action and Check Off. The Inspection Point column identifies the specific item, or subassembly, being examined. Inspection Criteria describes the particular conditions or items to be assessed at the Inspection Point. The Action column indicates actions to be taken to resolve any problems associated with the specific Inspection Point. The Check Off column allows monitoring the Inspection Table status. Three terms are used in the "Action" column: Repair; Replace; and Reject. In the cases of Repair or Replace, the prescribed action applies to the Inspection Point only, not to the higher assembly. For TOMAHAWK AUR processing, "Reject" indicates the Inspection Point discrepancy is neither replaceable nor repairable at the IMA level. The "Reject" action "flows up" and results in rejecting the AUR unless a waiver is requested and approved. "Repair" indicates the Inspection Point discrepancy can and should be repaired at the IMA level in accordance with procedures contained in SW820-AP-MMI-030 or other applicable documentation. "Replace" indicates the Inspection Point discrepancy is a replaceable component at the IMA level, however the component is not repairable at the IMA.

1.8.3.4 Standard Inspection Procedures. The SIPs can be reproduced and used and/or retained by QA personnel as records and check sheets. They contain each and every IP step from the referenced OP rephrased for QA requirements. Warnings, cautions, notes, figures and tables are not repeated in the SIP.

1.8.3.5 Supervisors. The responsibility of the supervisor is to define handling team roles and operational requirements based on appropriate local directives and controls team actions. He acknowledges all verbal statements of completion from the team members.

1.8.3.6 Readers. The responsibility of the reader is to ensure the procedure has been verified; read aloud all warnings, cautions, and notes as they occur; read aloud the complete step verbatim; observe the worker's performance as a double check to ensure proper execution of the step (when physically possible). In some situations, it may be more efficient to have a second worker or observer perform this double check observation, providing this individual reports satisfactory completion of the step; and check off the step when it is completed (it is considered completed when reports are received from all workers). A verbal acknowledgement shall be made upon completion of each step. Ensure all steps are performed in proper sequence; and report completion of the procedure by appropriate checkoff in the PG, completion of the certification form or by continuation to the next procedure.

1.8.3.7 Workers. The responsibility of the worker is to verbally acknowledge all warnings, cautions, and notes (after they are read), perform the step and report completion of the step using the standard term 'check'.

1.8.3.8 Observers. The responsibility of the observer is the same as that of the worker except that the observer observes the step instead of performing the step.

1.8.4 Quality Assurance (QA). Within procedural documents, certain OPs have procedural check-off steps followed by 'IP'. These steps are procedures which should be witnessed by QA personnel and are repeated in a modified form for QA use on the SIPs. The SIP can be used for record purposes by QA, if required.

1.8.4.1 Philosophy and Scope. The policy and practice of designating steps for inspection/verification is not intended to provide solutions for training deficiencies, operation tempo, variations in personnel performance, or other hardware/system features susceptible to procedural error. Neither do they cover all facets involved in administering a total QA program. Inspection verification points generally create a record that significant operations were accomplished by or in the presence of specific personnel. The record may be useful in a failure investigation, suggesting candidates for interview, and the involvement of a QA function may heighten worker attentiveness at affected steps, however the record is not a guarantee of compliance. Safety of operations and reliability of product are dominated by the training, proficiency, and professionalism of the personnel accomplishing the tasks. In the limit, record worthy steps are those which, if not performed correctly, may create a hidden condition that may, in turn, cause a post-launch mission failure. Steps meeting this "record-worthy" criteria from a standpoint of AUR design features are designated as Inspection Points in the technical manual products. Technical manual user activities may designate additional steps as Inspection Points to support local safety, production management, quality assurance or administrative processes, as prescribed by local command/activity policies and procedures.

1.8.4.2 QA Functions and Responsibilities. Responsibility for quality and safety is not restricted to QA and safety organizations, but extends to every person. The worker's task assignment is to perform all operations in order displayed or as directed by the supervisor and to honor all IP hold points. Verification of significant operations at IP stop points should be performed by personnel qualified and designated by the command QA program.

1.8.4.3 IP Stop Points. IP stop points are located at the highest level of assembly possible which will allow inspections to be performed. These points are preceded by banners '***IP STOP***' in the body of the steps. Check-off lines for affected steps are marked with 'IP' at the end of the line. These indications require QA witness/approve (signature/stamp/verbal approval) before production personnel may continue. The assembler will notify the QA representative whenever such notations are encountered in the course of an operation. Upon QA approval of a marked step, production will continue with the next step. QA representatives will follow the operations by using SIPs and OPs, when necessary.

1.8.5 Reference Documentation. Table 1-3 "Reference Documentation"⇒ provides a consolidated list of TWS unique documentation, as well as directives, instructions and technical and general reference documents applicable to the TWS.

1.8.6 Abbreviations and Acronyms. Table 1-4 "Abbreviations and Acronyms"⇒ provides a consolidated list of abbreviations and acronyms applicable to the TWS.

1.9 REPORTS.

Table 1-5 "Summary of Reports"⇒ provides a consolidated list of reports applicable to the TWS. Requirements for report submission are contained in the applicable submarine and surface ship User's/Operational Logistics Support Summary.

SECTION III. TOMAHAWK CRUISE MISSILE

1.10 GENERAL.

This section provides a physical description of tactical and exercise TCM variants and presents a typical mission profile for each variant.

1.11 TACTICAL VARIANTS.

The following paragraphs describe the sections and components that make up tactical TCM variants. Table 1-6 "Common Descriptive Data"⇒ provides data common to multiple TCM variants. Table 1-7 "Variant Unique Descriptive Data"⇒ provides variant unique data common to multiple launch configurations.

1.11.1 Land-Attack 109A. The land-attack 109A (Figure 1-1 "Land-Attack 109A"⇒) is a long range missile which carries a non-conventional W80 Warhead with guidance provided by Terrain Contour Matching (TERCOM) techniques. The missile measures 243.33 inches long by 20.375 inches in diameter. The missile has a modular construction aluminum airframe. The unique body sections are the guidance section, forward body payload section and forward body fuel section. Each section is described in the following paragraphs.

1.11.1.1 Guidance Section. The guidance section, extending from station 0.00 to station 18.35, includes the positive retention nose cone and the Cruise Missile Guidance Set (CMGS) (Figure 1-2 "Cruise Missile Guidance Set (CMGS)"⇒). The positive retention nose cone is made of an aluminum alloy and threads onto the missile forward body payload section. The CMGS provides missile navigation, guidance and control functions and consists of a Reference Measuring Unit and Computer (RMUC), a Rate Gyro/Accelerometer Package (RGAP), a Missile Radar Altimeter (MRA), an Analog Filter Assembly (AFA), a Warhead Interface Unit (WIU), a DC-DC Converter Module (DCM) and a Battery Power Unit (BPU). The CMGS attaches to the payload section via a mechanical hinge and link assembly using five mounting bolts. This arrangement permits the CMGS to be swung aside after positive retention nose cone removal for access to the warhead cavity in order to install and remove the warhead without having to break electrical connections between the airframe and CMGS.

1.11.1.2 Forward Body Payload Section. The forward body payload section, extending from station 18.35 to station 52.45, houses a W80 Warhead (Joint Test Assembly (JTA) or Launch Test Payload (LTP) in the REM-equipped missile), with the remaining section volume serving as a fuel tank. Two flush-mounted radar altimeter antennas (one a transmitter and the other a receiver) are installed on the bottom centerline to provide altitude and terrain inputs to the CMGS.

1.11.1.3 Forward Body Fuel Section. The forward body fuel section, extending from station 52.45 to station 99.80, contains fuel and an expansion bladder to accommodate changes in fuel volume due to fuel expansion and contraction. For test and exercise flights, the forward body fuel section is replaced by a REM section.

1.11.2 Land-Attack 109C. The land-attack 109C (Figure 1-3 "Land-Attack 109C"⇒) is a medium range missile armed with a WDU-25/B or WDU-36/B conventional warhead with guidance provided by Terrain Contour Matching (TERCOM) techniques and Digital Scene

Matching Area Correlation (DSMAC) or DSMAC IIA and a Global Positioning System Subsystem (GPSS) to increase terminal accuracy. Time of Arrival (TOA) and Time on Target (TOT) software are also used to enhance coordination with other strike capabilities. The missile has a modular construction aluminum airframe with a diameter of 20.375 inches. The length is 243.33 inches with the Mk 106 Mod 0 Rocket Motor or 246.06 inches with the Mk 111 Mod 0 Rocket Motor. The unique body sections are the forward body guidance section and the forward body payload section which are described in the following paragraphs.

1.11.2.1 Forward Body Guidance Section. The forward body guidance section extends from station 0.00 to station 52.45. Major components are the positive retention nose cone, the Cruise Missile Guidance Set (CMGS) (Figure 1-2 "Cruise Missile Guidance Set (CMGS)"⇒), the Digital Scene Matching Area Correlation (DSMAC) (Figure 1-4 "Digital Scene Matching Correlation (DSMAC)"⇒) or DSMAC IIA and Global Positioning System Subsystem (GPSS) sets and an illuminator assembly. Also included are a junction box in a well on the right side and two radar altimeter antennas on the bottom centerline. The positive retention nose cone, made of an aluminum alloy, threads on to the payload section. The CMGS provides missile navigation, guidance and control functions and consists of a Reference Measuring Unit and Computer (RMUC), a Rate Gyro/Accelerometer Package (RGAP), a Missile Radar Altimeter (MRA), an Analog Filter Assembly (AFA), a Warhead Interface Unit (WIU), a DC-DC Converter Module (DCM) and a Battery Power Unit (BPU). The CMGS attaches to the payload section via a mechanical hinge and link assembly using five mounting bolts. This arrangement permits the CMGS to be swung aside after positive retention nose cone removal in order to install and remove the warhead without having to break electrical connections between the airframe and CMGS. The DSMAC or DSMAC IIA set mounts aft of the CMGS. The GPSS Receiver Processor Unit (RPU) mounts aft of the RMUC. A window for the DSMAC lens is provided on the bottom centerline, along with a pyrotechnically jettisoned cover. Shields protect the DSMAC set from electromagnetic interference (EMI). The illuminator assembly (strobe), which lights the DSMAC scenes for night flights, also mounts on the bottom centerline. Two fuel lines run through the section for CMGS cooling. A fuel tank is also provided.

1.11.2.2 Forward Body Payload Section. The forward body payload section, extending from station 52.45 to station 99.80, houses the warhead, the warhead fuze-booster assembly and a pyrotechnically activated dual air valve to arm the warhead. On WDU-36/B warhead configurations, this section also houses the GPSS Antenna Module and additional fuel for extended flight. Warhead support is provided by a series of adjustable wedges and bolts. Two fuel tube assemblies run through the section for CMGS cooling. Quick-disconnect couplings at each end of the tube assemblies permit removal and installation of the payload section without having to defuel the missile. For test and exercise flights involving Recovery Exercise Module (REM)-equipped missiles, the forward body payload section is replaced by a REM section.

1.11.3 Land-Attack 109D. The land-attack 109D (Figure 1-5 "Land-Attack 109D"⇒) is a medium range missile armed with BLU-97/B combined effects bomblets with guidance provided by Terrain Contour Matching (TERCOM) techniques and Digital Scene Matching Area Correlation (DSMAC) or DSMAC IIA and Global Positioning System Subsystem (GPSS) to increase terminal accuracy. Time of Arrival (TOA) and Time on Target(TOT) software are also used to enhance coordination with other strike capabilities. The missile has a modular construction aluminum airframe with a diameter of 20.375 inches. The length is 243.33 inches with the Mk 106 Mod 0 Rocket Motor or 246.06 inches with the Mk 111 Mod 0 Rocket Motor. The unique body sections are the forward body guidance section and the forward body payload section which are described in the following paragraphs.

1.11.3.1 Forward Body Guidance Section. The forward body guidance section extends from station 0.00 to station 52.45. Major components are the positive retention nose cone, the Cruise Missile Guidance Set (CMGS) (Figure 1-2 "Cruise Missile Guidance Set (CMGS)"⇒), the Digital Scene Matching Area Correlation (DSMAC) (Figure 1-4 "Digital Scene Matching Correlation (DSMAC)"⇒) or DSMAC IIA and Global Positioning System Subsystem (GPSS) sets and an illuminator assembly. Also included are a junction box in a well on the right side and two radar altimeter antennas on the bottom centerline. The positive retention nose cone, made of an aluminum alloy, threads on to the payload section. The CMGS provides missile navigation, guidance and control functions and consists of a Reference Measuring Unit and Computer (RMUC), a Rate Gyro/Accelerometer Package (RGAP), a Missile Radar Altimeter (MRA), an Analog Filter Assembly (AFA), a Warhead Interface Unit (WIU), a DC-DC Converter Module (DCM) and a Battery Power Unit (BPU). The CMGS attaches to the payload section via a mechanical hinge and link assembly using five mounting bolts. This arrangement permits the CMGS to be swung aside after positive retention nose cone removal in order to install and remove the warhead without having to break electrical connections between the airframe and CMGS. The DSMAC or DSMAC IIA set mounts aft of the CMGS. The GPSS Receiver Processor Unit (RPU) mounts aft of the RMUC. A window for the DSMAC lens is provided on the bottom centerline, along with a pyrotechnically jettisoned cover. Shields protect the DSMAC set from electromagnetic interference (EMI). The illuminator assembly (strobe), which lights the DSMAC scenes for night flights, also mounts on the bottom centerline. Two fuel lines run through the section for CMGS cooling. A fuel tank is also provided.

1.11.3.2 Forward Body Payload Section. The unique payload section (Figure 1-6 "Land-Attack 109D Payload Section"⇒) extending from station 18.35 to station 99.80, houses four submunition dispenser modules, 24 submunition packs, two fuel modules, electrical harnesses, pyrotechnic transfer lines, initiators and detonators. Each submunition pack consists of an ejection system and a separator assembly. Two submunition packs contain six combined effects bomblets (CEB) and the remaining 22 packs contain seven CEBs each, for a total of 166 CEBs. The payload section incorporates a longitudinal avionics trough on the top centerline for electrical harnesses, pyrotechnic transfer lines and pyrotechnic initiators and detonators. On GPSS equipped configurations, an avionics cover, which covers the trough, houses the GPSS Antenna and antenna electronics. Also housed in the payload section is the DSMAC set, a sensor window for the DSMAC lens, the DSMAC illuminator unit electronics assembly, the DSMAC illuminator unit reflector and two radar altimeter antennas. The radar antennas, illuminator reflector (strobe), which lights the DSMAC scenes for night flights, and the sensor window, with its pyrotechnically jettisoned cover, are all mounted on the bottom centerline. Two payload covers are installed on the right and left sides of the payload section and are pyrotechnically jettisoned in the target area before the submunitions are ejected.

1.11.4 Block IV Tactical TOMAHAWK. The Tactical TOMAHAWK (TACTOM) Cruise Missile (Figure 1-7 "Block IV Tactical TOMAHAWK Missile General Arrangement"⇒) is part of the Baseline IV upgrade to the TOMAHAWK Weapon System. The Block IV TACTOM carries the WDU-36/B warhead. The Navigation Processor provides navigation solution updates to the Mission Control Processor (MCP) using multiple onboard sensors. These sensors include the improved DSMAC IV system, Radar Altimeter, TERCOM System, Inertial Measurement Unit, Air Data Module, GPS Subsystem, and Anti-Jam GPS Receiver.

During flight, target relocation to alternate land targets may be selected by the Strike Controller through communications with the Satellite Data Link Transceiver. The Block IV TACTOM has a "loiter" function used for post launch Time Of Arrival adjustments to ensure precise timing of diversionary and suppressive strikes. In addition, the Block IV TACTOM can be re-targeted while enroute or in a loiter pattern. The MCP is the central executive during all phases of the mission including flight control management and warhead detonation.

The Block IV TACTOM uses the existing WDU-36/B warhead, thermal battery, and many of the electro-explosive devices used in other TOMAHAWK missiles. However, the composition of each of the body sections is considerably different from other TOMAHAWK configurations, and is described in the following paragraphs.

1.11.4.1 Forward Body Section. The forward body section (Figure 1-8 "TACTOM Forward Body Section"⇒) extends from Sta. 0.00 to Sta. 74.0 and consists of the nose and payload structure. It provides the necessary brackets and configuration to support the WDU-36/B warhead. Fuel is distributed throughout the entire missile including the forward section. There is approximately 455 lb. of JP-10 fuel located in the forward section.

1.11.4.2 Midbody Section. The midbody section (Figure 1-13 "TACTOM Midbody Section"⇒) extends from Sta. 74.0 to Sta. 148.0 and contains four access doors, tactical mission cover, RSS mission cover, wing plugs and wing doors, three fuel tanks, and other electrical components. The midbody section structure is a machined A357-T6 casting. The skin of this missile is thicker than that of Block III TOMAHAWK. The Block IV TACTOM wings are slightly larger than previous generations of TOMAHAWK and measure approximately 40 in. in length and 14 in. in width.

The midbody section contains three fuel tanks. The lower midbody tank is the largest with a capability of 357 lbs. and is actually built into the structure of the midbody. The gravity tank, which is a sealed part of the midbody structure, similar to the lower midbody tank, contains 64 lbs. of fuel. The hopper tank is the smallest with a capacity of 15 lbs. The midbody section houses a fuel metering pump used to send the fuel to the engine, and a ullage bladder filled with air that is submerged in the fuel connected to a relief line that passes through the exterior of the missile. This system allows for expansion and contraction of fuels and other components.

The midbody section also houses the following three electrical components for the missile: the Inertial Monitoring Unit (IMU), the DSMAC Illuminator Unit (DIU), and the radar altimeter antennas.

The IMU measures linear acceleration and rotational angular rates to assist in the navigation of the missile to the intended target. It uses three gyros and three accelerometers positioned on three axes as sensors. All data is output to the Navigation Processor for navigation aiding.

The DIU provides lighting for the DSMAC IV System for use during night flights. The DIU is a camera flash device that is optimized for coverage, uniformity, and spectral output. The unit is designed to produce twice the optical energy of IIA Illuminator used on Block III Missiles.

There are two identical radar altimeter antennas on each Block IV TACTOM Missile. These antennas provide the radar altimeter the ability to transmit (rear) and receive (forward). The radar altimeter system transmits RF signals to the ground and receives the reflected signals to determine altitude based on timing. The updated altitude data is then provided to the Mission Control Processor.

1.11.4.3 Aftbody and Tailcone Section. The aft body (Figure 1-18 "TACTOM Aftbody and Tailcone Section"⇒) extends from Sta. 148.0 to Sta. 196.0 and contains the cruise engine, flush inlet, inlet cover, and aft body cover. The aftbody and tailcone section runs from Sta. 194.75 to Sta. 219.16. The aftbody and tailcone section structure is machined from A357-T6 castings. The aft portion of the tailcone is designed to mate with the rocket motor. In the case of the submarine configurations, the missile also contains continuity shrouds. The Block IV TACTOM has three fins, vice four, which are made of foam core sheet composite that deploy 134 degrees in approximately 0.25 seconds. The fins are used by the vehicle to provide stability and control.

The cruise engine is started by means of a single pyrotechnic start cartridge. The engine is controlled by an engine control module integrated in the air vehicle's mission control system and an in-the-loop fuel metering pump. An alternator powers direct current sources, which are used by the missile during cruise flight. The engine is equipped with an Alternating Voltage Control and Converter (AVCC). The AVCC provides two sources of power and an engine speed signal to the missile.

The major features of the cruise engine include:

- the Model XF415-WR-400 engine, which includes an internal 4 kw alternator,
- a separate power conditioner - AVCC, a single pyrotechnic start cartridge,
- one ignition cartridge,
- an exhaust extension, and
- an exhaust extension thermal covering.

Fuel is distributed throughout the entire missile, including the aftbody and tailcone section. There is approximately 106 lbs. of JP-10 fuel located in the aft body. The aftbody and tailcone section houses the majority of the electrical components for the entire missile. The components contained within the aftbody and tailcone section are:

- Air Data Module
- Alternator Voltage Control Converter (AVCC)

- Anti-Jam Global Positioning System Antenna
- Anti-Jam Global Positioning System Receiver (AGR)
- Cruise Missile Airframe (CMA) Battery
- Digital Scene Matching Area Correlator Processor Subsystem
- Digital Scene Matching Area Correlator Sensor Assembly
- Fin Control System
- Guidance Electronics Unit (GEU)
- Mission Control Input/Output (MCIO)
- Mission Control Processor (MCP)
- Navigation Processor (NP)
- Power Filter Unit (PFU)
- Pyro and Power Control Assembly (PPCA)
- Radar Altimeter (RA)
- Satellite Data Link (SDL) Antenna
- Satellite Communications (SATCOM) Data Link Terminal
- Secondary Power Unit (SPU)

1.11.4.3.1 Air Data Module (ADM). The ADM is used to determine altitude and air temperature using two pressure sensors. Analog data is converted to a digital format, which compensates for sensor characteristics. The ADM provides the Mission Control Input/Output (MCIO) with pressure and temperature data as requested. This unit resides in the GEU.

1.11.4.3.2 Alternator Voltage Control Converter (AVCC). The AVCC converts alternator high frequency AC power into two DC voltage outputs used by the missile electrical system during cruise and terminal flight. The DC power is filtered by the Power Filter Unit (PFU) before distribution to missile components.

1.11.4.3.3 Anti-Jam Global Positioning System Antenna. The Anti-Jam GPS Antenna is tuned for reception at 1227 MHz and 1575 MHz for military GPS signals. The antenna is made using multi-layer micro-strip technology and comprised of five crossed slot elements with integrated frequency selective surface design.

1.11.4.3.4 Anti-Jam Global Positioning System Receiver (AGR). The AGR is used to assist in directing the missile to the intended target. It is a single-channel sequencing, dual frequency, P(Y) Code, Military GPS Receiver with high anti-jam capability. The AGR has nulling and beam steering processing using a five-element antenna to distinguish the GPS signals from various jamming sources. The AGR provides line of sight measurements, position, velocity, and time to aid the Navigation Processor.

1.11.4.3.5 Cruise Missile Airframe (CMA) Battery. The CMA Battery provides missile electrical power during mission boost. It is a pyro activated lithium thermal battery. The pyro activates iron/potassium perchlorate (heat pellets), and melts the ternary electrolyte. This process provides an electrical path between the lithium silicon anode and iron disulfide cathode. Within the battery are two independent cell stacks to power missile CM regulated and unregulated busses. The CMA Battery outputs DC power to the PFU before distribution to missile components.

1.11.4.3.6 Digital Scene Matching Area Correlator Processor Subsystem. The Digital Scene Matching Area Correlator (DSMAC) Processor Subsystem is part of the DSMAC IV System, which also includes the DSMAC Sensor and the Illuminator. There are two processor cards within the subsystem, DSMAC Control Processor (DCP) and DSMAC Signal Processor (DSP). Both of these cards reside within the Guidance Electronics Unit. The DCP provides interfaces to the sensor, illuminator, Mission Control Subsystem, and telemetry. The chief function of the DSP is to process the DSMAC video data from the sensor and compares it with the reference maps stored in its memory.

1.11.4.3.7 Digital Scene Matching Area Correlator Sensor Assembly. The Digital Scene Matching Area Correlator (DSMAC) Sensor is part of the DSMAC IV System, which also includes DSMAC Processors and the Illuminator. The Sensor is an optical device (camera) that captures digital grayscale images for the DSMAC IV System. Images are processed in the DSMAC Processor Subsystem against reference images for missile navigation assistance. DSMAC images of pre-planned locations can be obtained and transmitted as part of midcourse Health and Status messages for use as Battle Damage Indication Imagery (BDII).

1.11.4.3.8 Fin Control System. The Fin Control System controls all three missile fins (right, left, and vertical) located at the rear of the missile. The system consists of one controller and three actuators and ballscrew assemblies. The FCS is controlled by the MCP and returns feedback and status data to the MCP.

1.11.4.3.9 Guidance Electronics Unit (GEU). The GEU provides centralized housing of various electronic cards for guidance, pyro and power control, mission control, and secondary power. The GEU motherboard provides interconnections among the cards and with the rest of the missile.

1.11.4.3.10 Mission Control Input/Output (MCIO). The MCIO provides the interface between the Mission Control Processor and other missile subsystems. These subsystems include the Fin Control System, Thrust Vector Control, Air Data Module, Radar Altimeter, Satellite Data Link Terminal, Engine, and Mid-body Range Safety System. Collectively, these interfaces are referred to as Mission Control I/O Low Priority (MCIOLP). This unit resides in the GEU.

1.11.4.3.11 Mission Control Processor (MCP). The MCP is the central executive for the Block IV TACTOM missile during all phases of the mission and functions as the manager of all other elements. The MCP provides the computational functions necessary to enable autonomous vehicle flight from launch to mission completion. The MCP also provides control of SATCOM Data Link Terminal communications. MCP is the hardware host for TACTOM mission control operational flight software. This unit resides in the GEU.

1.11.4.3.12 Navigation Processor (NP). The NP is a single board computer that provides a navigation solution to the MCP for directing the missile to the intended target. The NP takes in AGR, IMU, DSMAC, Radar Altimeter, and TERCOM inputs. The outputs are passed to the

MCP in the form of position, velocity, acceleration, and attitude. The NP is considered a highly critical item. This unit resides in the GEU.

1.11.4.3.13 Power Filter Unit (PFU). The PFU provides DC power filtering and protection features and distributes electrical power throughout the missile. It receives power inputs from the surface launch platform (prelaunch), AC/DC Converter (pre-launch phase, submarine only), the CMA Battery (boost phase), and the AVCC (cruise phase). The PFU will isolate all power, until commanded, before distribution to missile components during the pre-launch phase. The PFU will apply launch platform power to the TVC, FCS, and FMP to perform self-tests when commanded. The PFU incorporates a deadface to the TVC just prior to booster jettison, and incorporates a positive disarming mechanism to isolate launch platform power from the pyro circuits during the prelaunch phase.

1.11.4.3.14 Pyro and Power Control Assembly (PPCA). The PPCA consists of three circuit cards located within the GEU. It controls and monitors designated missile avionics and pyrotechnic (pyro) devices. PPCA functions are performed under control of the launch platform or the missile Mission Control Processor (MCP) or both.

1.11.4.3.15 Radar Altimeter (RA). The Radar Altimeter, also referred as the Single Card Altimeter (SCA), resides inside the GEU. The RA determines the altitude of the missile in relation to the ground below. The RA transmits RF signals to the ground via the rear RA Antenna and processes return signals received from the forward RA Antenna. The updated altitude data is provided to the Mission Control Processor and forwarded to the Navigation Processor. The altitude data is also used for TERCOM navigation.

1.11.4.3.16 Satellite Data Link (SDL) Antenna. The SDL Antenna provides the SDLT the ability to transmit and receive RF signals. It is designed around center frequencies of 256 MHz and 296 MHz for 5 kHz and 25 kHz channel SATCOM coverage. The conformal antenna is made using multi-layer micro-strip technology and is comprised of a single crossed slot element (dual-tuned for transmit and receive frequencies) with an integrated frequency selective surface.

1.11.4.3.17 Satellite Communications (SATCOM) Data Link Terminal. The SDLT is a UHF SATCOM terminal that operates on DOD Demand Assigned Multiple Access channels. It is used for data communications between the missile and missile/strike controller via satellite. The SDLT uses half duplex encrypted data communications and is interoperable with standardized DOD protocols for UHF SATCOM.

1.11.4.3.18 Secondary Power Unit (SPU). The SPU receives +28 VDC power from the PFU and provides +15 VDC, -15 VDC, +5 VDC, and +3.3 VDC power to the GEU and other avionics sub-assemblies. This unit resides in the GEU.

1.11.5 TCM Body Sections Common to 109A/C/D. The midbody, aft body and propulsion sections are common to the 109A/C/D TCM variants and are discussed in the following paragraphs.

1.11.5.1 Midbody Section. The midbody section, extending from station 99.80 to station 155.20, consists of a standard mission cover and an upper and lower fuel tank section separated by a lateral through-slot. The through-slot contains the wings, one stowed above the other, in scissor fashion, and the wing pneumatic actuator and associated control valves. Two pneumatically actuated doors, one on each side of the missile, open to permit wing deployment, then close again to provide aerodynamic smoothness. The midbody lower fuel tank section contains an expansion bladder to accommodate fuel expansion and contraction and to provide the initial fuel pressure for engine start. The lower section also contains the fuel hopper that supplies fuel to the sustainer engine. The Cruise Missile Airframe (CMA) thermal battery is located in a dry well on the right side. A single-point fuel/defuel panel is provided on the left side. A coolant pump, used to circulate missile fuel through the CMGS, mounts on the aft side of the forward bulkhead.

1.11.5.2 Aft Body Section. The aft body section, extending from station 155.20 to station 182.50, consists of an integral dry well and a domed housing. The upper half also serves as the missile aft fuel tank for the 109C. Inside the dry well is the Mission Control Module (MCM) which interfaces the airframe electrical systems with the CMGS. Inside the domed housing is the airframe pneumatic storage bottle that is used to erect the fins and to deploy the wings and the engine inlet. The aft body lower half contains the molded fiberglass/epoxy engine inlet and its pneumatic actuator and associated control valve. The aft body lower half also contains the pilot-static system air data package which provides barometric and differential pressure inputs to the CMGS to determine altitude, dynamic pressure and flight Mach number and supplies air pressure to arm the conventional warhead.

1.11.5.3 Propulsion Section. The propulsion section, extending from station 182.50 to station 219.16, includes the tail cone structure, the turbofan sustainer engine and four pneumatically erected, fiberglass/polycarbonate stabilizer fins. The lower fin is fixed, while the other fins move to provide pitch, roll and yaw control. An engine-driven dc generator-regulator, three electrically driven servo-actuators (one for each movable fin) and the fin Power Switching Amplifier are also housed within the propulsion section.

1.11.6 Rocket Motor Assemblies. RGM-109C and RGM-109D variants are configured with the Mk 106 Mod 0 Rocket Motor. UGM-109A variants are also configured with Mk 106 rocket motor assemblies. UGM-109C and UGM-109D variants are configured with the Mk 111 Mod 0 Rocket Motor. RGM/UGM-109E (Block IV TACTOM) is configured with the Mk 135 Rocket Motor Assembly. Each rocket motor assembly is described in the following paragraphs.

1.11.6.1 Mk 106 Mod 0 Rocket Motor. The Mk 106 Rocket Motor (Figure 1-9 "Mk 106 Rocket Motor"⇒) is a single-chamber, fixed-nozzle assembly that extends from station 219.16 to station 243.33. The major components are an insulated steel case containing solid-grain propellant, a safe/arm igniter assembly, a fixed nozzle, pneumatic/hydraulic thrust vector control (TVC) tabs and a pyrotechnic separation assembly. The nozzle is fitted with a moisture-tight plug that includes a pressure relief valve to prevent rocket motor collapse in the event of a submarine torpedo or missile tube over-pressure condition. The nozzle plug blows out upon rocket motor ignition. The rocket motor aft cover supports the electrical connector and the missile retention devices.

1.11.6.2 Mk 111 Mod 0 Rocket Motor. The Mk 111 Rocket Motor (Figure 1-10 "Mk 111 Rocket Motor"⇒) is mounted on the missile tail cone at station 219.16 through a separation ring and extends to station 246.06. The rocket motor has a pneumatically actuated, hydraulically operated movable ball and socket nozzle which directs the rocket motor exhaust and controls the directional movement of the missile during the boost phase of the missile flight. The rocket motor consists of a heat treated steel case containing solid grain propellant, insulation, movable nozzle and thrust vector actuator system, arming-firing device and igniter assembly, and aft cover assembly. The nozzle comes equipped with an aluminum nozzle seal plug fitted with a flood valve. The nozzle plug blows out upon rocket motor ignition. The rocket motor aft cover supports the electrical connector and the missile retention devices.

1.11.6.3 Mk 135 Rocket Motor Assembly. The Mk 135 Rocket Motor Assembly consists of an air melt 4330 steel, cadmium plated motor case, loaded with 322 pounds of Arcadene 360B HTPB, a high performance, aluminized composite propellant. Arcadene 360B HTPB has been assigned a Department of Defense (DOD) hazard classification of 1.3C. The propellant is cast into and bonded to the insulated steel case. Other major subcomponents include the Arm-Fire Device (AFD) and a fixed nozzle to which the TVC is attached. The TVC employs electrically actuated jet tabs. The rocket motor assembly is approximately 19.9 inches in diameter and 24.5 inches in length. The total weight of the assembly is approximately 600 pound

1.11.7 TCM Components Common to 109A/C/D. The following components are common to the 109A/C/D variants.

1.11.7.1 Missile Retention Devices. Two retention devices are installed between the rocket motor and capsule or canister to restrain the missile in the capsule/canister during storage, shipping and handling. Each device consists of a stud and nut that releases at launch to permit egress of the missile from the launching device.

1.11.7.2 Underwater Protection Devices. Submarine launch variants employ underwater protection devices consisting of two wing slot plugs, an engine inlet cover and a continuity shroud (Figure 1-11 "Underwater Protection Devices"⇒). The devices are described in the following paragraphs.

1.11.7.2.1 Wing Slot Plugs. Jettisonable wing slot plugs cover the wing cutouts on each side of the missile to prevent the entry of seawater during underwater launch. Each consists of a plug that is shaped to fit the wing cutout, an integral vent valve and a pyrotechnic thruster. The thruster, which also attaches to the wing pivot fitting, provides the means to jettison the plug. The vent valves prevent possible structural damage due to overpressure by venting the through-slot cavity pressure during underwater ascent. The wing slot plugs are jettisoned immediately following broach.

1.11.7.2.2 Engine Inlet Cover. An engine inlet cover is installed on the underside of the missile to cover the inlet cavity and prevent the entry of seawater during underwater launch. The cover includes seven vent valves and two vent holes to vent the engine inlet and propulsion section cavities during underwater ascent. The cover is jettisoned by a pyrotechnic thruster immediately following broach.

1.11.7.2.3 Continuity Shroud. The continuity shroud consists of two shroud halves that bolt together to form a watertight closure around the propulsion section. A dual differential pressure transducer is installed in the upper shroud half to monitor differential pressure between the shroud cavity and the sea. A pressure relief valve is installed in the lower shroud half to prevent overpressurizing the missile. Also installed in the lower shroud is an ac-dc converter that converts ship wye power to dc to power the missile during prelaunch operations. Linear-shaped pyrotechnic charges, assisted by leaf springs, jettison the shroud halves following broach.

1.12 EXERCISE VARIANTS.

The following paragraphs describe the components of the REM and RSS kit which may be installed for use in test and exercise flights of the TCM.

1.12.1 Recovery Exercise Module Equipped Missile. TCMs used for test and exercise flights and subsequent recovery/reuse are equipped with a depot-installed REM (Figure 1-12 "Recovery Exercise Module"⇒). The compartmentalized REM body section replaces the 109A forward fuel tank section, or the forward body payload section of the 109C TOMAHAWK variant. A housing assembly replaces the standard mission cover on the upper midbody. The various REM compartments and equipment are described in the following paragraphs.

1.12.1.1 Parachute Compartment. The REM parachute compartment houses the main parachute pack and a drag parachute pack. The compartment also contains the forward attachment fitting for the main parachute Y-harness. A jettisonable cover, held by two pyrotechnic thrusters, covers the compartment. The compartment is vented through two tubes to an orifice plate located on the top of the forward body section.

1.12.1.2 Riser Stowage Compartment. The parachute Y-harness and risers are routed along two shallow channels in the top of the missile midbody. Excess harness is stowed in the riser compartment. Additionally, the compartment contains two pyrotechnically released riser attachment fittings and the attachment fitting for the aft leg of the main parachute Y-harness. It also contains the recovery beacon antenna and its flotation assembly. Rubber-impregnated cloth strips, held by aluminum retainers, cover the riser channels. A jettisonable cover, held by a single pyrotechnic thruster, encloses the riser compartment.

1.12.1.3 Flotation Equipment Compartment. The flotation equipment compartment houses the flotation equipment used for water recovery. The equipment consists of a pneumatically inflated flotation bag, two pyrotechnically activated pressure bottles, and the tubing and fittings to route pneumatic pressure to the flotation bag. The compartment contains lead ballast to compensate for the differences in weight between the REM and the forward body section it replaces. Fuel lines for the land-attack REM-equipped variants are also provided for the transfer of fuel between the CMGS, the payload section fuel tank and the midbody.

1.12.1.4 Instrumentation/Avionics Compartment. The instrumentation/avionics compartment makes up the aft one-third of the REM. The equipment mounts on a removable shelf as well as on the REM body structure. Equipment mounted on the shelf includes two pyrotechnically activated batteries, two lithium active batteries, an inertia switch, a test control module, an auxiliary relay unit, a digital delay module, a telemetry support package, an electronic support package, a relay enclosure, a dual Range Safety Command (RSC) receiver/decoder, a Pulse Code Modulation (PCM) encoder, a recovery beacon transmitter, an S-band telemetry transmitter, a C-band transponder, a hybrid antenna coupler and an RSC test oscillator. REM body-mounted equipment includes two RSC antennas, two S-band antennas and two C-band antennas. Two inertia switches are mounted on the compartment forward bulkhead. A saltwater sensor switch is mounted near the bottom centerline. Two acoustic pingers (one 9 kHz and one 45 kHz) are flush-mounted on the sides. The REM antennas consist of two S-band, two C-band and two RSC antennas. The S-band antennas are flush-mounted on the REM top and bottom centerline. The C-band and RSC antennas are flush-mounted on the sides.

1.12.2 Range Safety System Equipped Missile. The land-attack TCMs used for test and exercise flights with live or inert warheads/submunitions are equipped with a depot-installed RSS kit. The J-109C has the RSS equipment installed primarily on a vertically mounted plate in the aft portion (fuel tank) of the guidance section (Figure 1-14 "Range Safety System (109C)"⇒). The J-109D has the RSS equipment mounted on two shelf assemblies in the payload section and an RSS antenna nose cone installed in place of the positive retention nose cone (Figure 1-15 "Range Safety System (109D)"⇒). RSS instrumentation consists of a dual RSC receiver/decoder, a PCM encoder, an FM multiplexer (J-109C/D), an RSC test oscillator, a power monitor unit, a thermal battery, a C-band transponder (J-109C/D), an S-band telemetry transmitter and associated antennas (J-109C/D) and a squib-activated thermal battery.

1.12.3 Midbody Range Safety Subsystem (MRSS). Block IV TACTOM missiles used for test or exercise flights are equipped with MRSS. The MRSS provides the missile with a communications link with test ranges during flight tests. This subsystem is only present during such exercises and comprises of a Range Safety Electronics Unit (RSEU) and a Tri Band Antenna. The RSS provides telemetry data at a rate of 2.5 megabits per second. The communications includes missile instrumentation data, range command and control, flight termination, position tracking, and underwater telemetry data transmission (submarine launch only). Major Subcomponents include: Tri-band Antenna; Command Control Decoder; C-Band Transponder; Flight Termination Battery; Flight Termination CCA; Flight Termination Receivers (2); Harnessing; I/O CCA; Power Monitoring Unit; Pulse Control Modulation Encoder; S-Band Transmitter; Test Oscillator; OTL payload cover.

1.13 LAND-ATTACK TCM TARGETING.

The capabilities and special employment considerations of the land-attack TCM makes it necessary to limit the access to mission data and displays presented. This is accomplished by requiring the use of mission codes to access data. Only when the correct code is entered, can data be displayed and evaluated. The evaluation of mission data is generally concerned with the establishment of flyout routes and introducing waypoints which define specific latitude and longitude intersections along the flight path to the target (Figure 1-16 "Typical Land-Attack TCM Pre-landfall Flyout Route"⇒).

1.13.1 Mission Data. Route, map and target data for the land-attack variants are stored on disks. Access is gained by entering the disk serial number and correct mission number. The data consist of trajectory segment data, TERCOM maps, DSMAC scenes (109C, 109D and 109E only) and mission definition data.

1.13.2 Terrain Contour Matching (TERCOM). The guidance system is periodically corrected and updated in flight through TERCOM. The process (Figure 1-17 "Terrain Contour Matching (TERCOM) Process"⇒) compares a set of digital maps stored in the CMGS with ground elevation readings supplied by the missile radar altimeter. The digital maps consist of several TERCOM maps used to maintain the missile on flight path to the target. Correlation and position updating parameters include the latitude and longitude of map center, map heading (centerline), length, width, cell size, altitude data and estimated fix accuracy. Although maps may overlap, the data for each map are stored separately for software efficiency. Predetermined waypoints define specific latitude and longitude intersections along the flight path to the target. Enroute to target, TERCOM is updated upon reaching each waypoint. Since distance traveled is measured from the last waypoint, not total distance flown, terminal accuracy is very high. TERCOM is also relatively insensitive to weather, season and ground cover.

1.13.3 Digital Scene Matching Area Correlation (DSMAC). Stored digitized images or scenes are used by the TCM 109C, 109D and Block IV TACTOM to perform terminal updates. A sensor in the DSMAC set takes a visible wavelength image of ground features, digitizes the images, and compares them with the stored digitized images. Since the DSMAC scenes are smaller and contain more detail than TERCOM maps, they result in more accurate position updates. With Block IV TACTOM, DSMAC images of pre-planned locations can be obtained and transmitted as part of midcourse Health and Status messages for use as Battle Damage Indication Imagery (BDII)

1.13.4 Global Positioning System Subsystem (GPSS). A GPSS is used by the TCM 109C, 109D and Block IV TACTOM to perform periodic navigational updates. A GPSS receiver receives signals from GPS satellites, processes the signals, and provides navigational data for the missile. This GPSS navigational data can be used in lieu of, or in combination with, TERCOM/DSMAC fixes to provide more flexibility and higher reliability in accomplishing mission objectives

1.13.5 Block IV Tactical TOMAHAWK Targeting. The Tactical TOMAHAWK Cruise Missile is part of the Block IV upgrade to the TOMAHAWK Weapon System. The Block IV upgrade also includes improvements to the planning and launch control systems that, coupled with improvements to the Tactical TOMAHAWK Cruise Missile, provide increased capabilities to the operational forces.

The Block IV TACTOM combines the capabilities of the current system with faster response time and more flexibility. Multiple outcome missions can be created at shore-based planning centers or the Afloat Planning System installed on aircraft carriers. Each mission can have up to 15 outcomes. The default outcome may be reset prior to launch or via communication with the missile while in flight. Mission data for Block IV TACTOM can also be created onboard launch platforms. Launch platform planned missions are GPS-only with a single outcome.

During flight, the Block IV TACTOM can report Health and Status (H & S) at predetermined intervals or when requested by the Strike Controller. Near the end of the mission, the missile can transmit a Battle Damage Indication (BDI) message that contains its estimate of navigation error as it approaches the target. In addition, the Block IV TACTOM can transmit compressed images taken by the DSMAC Sensor as part of a H & S message. The locations for acquiring BDI images are part of a preplanned mission. The Block IV TACTOM can also be redirected in-flight. The Strike Controller (at a Command and Control facility) or the Missile Controller (on a launch platform, for a missile launched by the launch platform) can command the missile to execute a new preplanned mission outcome. The Strike Controller or Missile Controller can also send the missile a newly planned terminal segment to direct the missile to an emerging target. Target coordinates are supplied external to the TWS. The controller can also send an aimpoint update message to allow the missile to autonomously navigate a direct GPS route to the target.

The Block IV TACTOM GPS receiver provides increased ESM resistance compared to TLAM Block III. The GPS Receiver is tightly coupled with inertial navigation and several other sensors to provide robust navigation performance. In the terminal area, the Block IV TACTOM is capable of dive angles between five and 85 degrees. The expanded range of dive angles removes the need for a Horizontal Attack Mode, and provides greater resistance to vertical errors in targeting data

1.14 TYPICAL MISSION PROFILE.

The typical mission is divided into six phases: prelaunch, launch, boost, transition to cruise, cruise, and either a terminal phase for 109A/C/Block IV (Figure 1-19 "Typical Mission Profile (109A/C)"⇒) or a target attack phase for 109D (Figure 1-20 "Typical Mission Profile (109D)"⇒). A REM-equipped missile also includes a seventh or recovery phase in which, the REM-equipped missile, instead of detonating a warhead, continues on to a pre-determined recovery site. Typical mission profiles are described as having either a lo-lo and hi-lo penetration of the general target area. Maximum protection from detection is provided by a lo-lo penetration. A hi-lo penetration provides maximum range. The missile is programmed to fly at a specific altitude and speed, which may or may not include a terminal maneuver prior to warhead detonation. Flight path altitude also depends on the roughness of terrain, evasive maneuvers to avoid enemy defenses, and climb and dive rates of the missile. The various mission phases are described in the following paragraphs.

1.14.1 Prelaunch Phase. The prelaunch phase begins with the decision to launch a TOMAHAWK Cruise Missile against a predetermined land target. It covers preparation of the missile and launching device, weapon power-up, guidance set initialization and alignment and loading target data. The prelaunch phase is described in detail in Chapter 4 for each launch configuration.

1.14.2 Launch Phase. Following the closing of various preset firing interlocks and verification of firing status ready, Intent to Launch (ITL) is signaled. The final firing sequence occurs automatically. The missile batteries activate and the essential electrical power buses are isolated. A status check is then performed by the CMGS using battery power. If the status check is go, a MISSILE ENABLED signal is sent. Upon receipt of this signal, launch equipment separate and eject the TCM from its launcher. The launch phase is described in detail in Chapter 4 for each launch configuration.

1.14.3 Boost Phase. After 1.5 to 4 seconds from first motion, the rocket motor pull switch actuates. With CMGS concurrence of safe eject velocity and distance, the CMGS initiates signals that activate the rocket motor TVC system and ignite the rocket motor. The CMGS also enables the anti-circular run (ACR) system. At the same time that rocket motor ignition occurs, a momentary pitchup command is sent to deflect the exhaust, causing the missile to pitch up as it begins to accelerate. Should the missile deviate from the planned trajectory, or the CMGS fail to reset the MCM timer, the ACR system will automatically terminate the mission by jettisoning the continuity shroud and rocket motor which stops the uncontrolled acceleration of the missile and prevents it from turning back toward the launch platform. The fins deploy and active roll control is initiated. After a velocity test is passed, the engine inlet and wings are deployed and a pushover command initiated.

1.14.4 Transition to Cruise Flight. The transition to cruise flight begins about 14 seconds after first motion and coincides with rocket motor thrust decay. As the thrust decays, the ACR enable is turned off and the TVC nulled. The rocket motor is then jettisoned and the sustainer engine started. As the sustainer engine comes up to speed, the engine-driven generator/regulator comes on-line to supply the electrical power needs. The transition to cruise flight continues at maximum engine thrust until the missile descends or climbs to the commanded cruise altitude and accelerates to the commanded Mach number.

1.14.5 Cruise Phase. The cruise phase commences with the descent or climb to cruise altitude and acceleration to cruise speed. For a land-attack variant, it includes pre-landfall inertial plus GPSS aiding navigation; crossing the initial TERCOM field and making altitude corrections for terrain following; overland inertial plus GPSS aiding navigation to the programmed mission waypoints; and performing enroute or midcourse position fixes using TERCOM maps plus GPSS aiding. For REM- or RSS-equipped variants, radio frequency (RF) carrier is continually sent by the chase aircraft. If the missile loses RF carrier, the missile will climb or descend to a predetermined altitude. After a prescribed time, if the carrier remains lost, a REM-equipped missile will initiate recovery; a RSS-equipped missile will terminate flight (throttle is driven off and the vertical fin is driven hard-over). Additionally, if electrical power is lost, or the CMGS fails in a REM-equipped missile, a zoom command may be initiated to enhance the probability of missile recovery. Emergency flight termination by chase aircraft command is also provided wherein the vertical fin is driven hard-over, the throttle is driven off, and the parachute recovery sequence (REM-equipped missile only) is initiated.

1.14.6 Terminal Phase (109A/C). The terminal phase covers the terminal flight events which consist of a final position fix(es) by TERCOM (109A) or DSMAC/DSMAC IIA/GPSS (109C), terrain following, warhead arming, and determining final target range and bearing. These events also include the terminal maneuver and warhead detonation or missile impact. The exact sequence of events will depend on the mission data loaded into the CMGS.

1.14.7 Target Attack Phase (109D). The target attack phase consists of five position fixes by DSMAC or multiple periodic updates by DSMAC IIA/GPSS before attacking the first target, payload cover jettison, submunition pack ejection over the first target and additional navigation fixes and submunition pack ejection for subsequent targets. As each submunition pack is ejected, door assemblies in the dispenser module close, allowing the missile to maintain an aerodynamic surface. A submunition separation system is used to separate the submunition pack after ejection from the payload section. The submunition pack combined effects bomblets are armed when exposed to the airstream, allowing the primary or secondary firing mechanism to detonate the explosive upon impact.

1.14.8 Block IV TACTOM Terminal Phase. The Block IV TACTOM terminal phase begins with Terminal BDI image acquisition and ends with the missile impacting the target. The terminal subphase of the Block IV TACTOM mission differs from the Block III mission in several respects. If the mission is autonomous strike, the Block IV TACTOM will proceed to target after the DSMAC update and function the same as Block III. If an alternate target has been designated during enroute navigation or in the loiter pattern, the remainder of the navigation will be GPS only. The Block IV TACTOM missile will use a pushover maneuver that will induce negative Gs.

The Block IV TACTOM Missile can be programmed to attack targets with either a Programmed Warhead Demolition (PWD) maneuver or a Variable Dive Attack Maneuver (VDA) with a terminal dive angle from five to 85 degrees. The PWD attack is the same as that used for the Block III TOMAHAWK Land Attack Missile. The range of angles available for a VDA is significantly wider than that used in Block III and also serves to replace the Horizontal Attack Maneuver used in Block III.

The Block IV TACTOM Missile uses an elliptical steering algorithm to determine its terminal maneuver. The ellipse is sized to provide impact at the target with the programmed terminal dive angle. Depending on the ingress altitude, either a Low-Approach Ellipse or High-Approach Ellipse is selected.

For a Low-Approach Terminal maneuver, the missile executes a pull-up maneuver to put it in position to transition to the selected ellipse. The ellipse is sized to be the minimum flyable size that meets the terminal dive requirements. At the apex of the ellipse, the missile executes a pushover, and then enters proportional navigation for the terminal dive. For a High-Approach maneuver, the ellipse is sized to intersect with the missiles current trajectory. Upon reaching the ellipse, the missile executes a pushover, and then enters proportional navigation for the terminal dive.

1.14.9 Recovery Phase (REM-equipped variants). REM-equipped missiles are pre-programmed to fly to a designated recovery site. Normal recovery is initiated by on board pre-programmed signals, chase aircraft command, or by loss of RF signal - a function of range safety. The programmed recovery events include initiation of the recovery sequence, transfer of telemetry and tracking systems to REM battery power, parachute deployment, and engine and CMGS shutdown. Also included are radio beacon activation, flotation bag inflation (water recovery only), main parachute jettison and REM power shutdown. Figure 1-22 "Typical Parachute Recovery of REM-Equipped Missile"⇒ shows a typical parachute recovery of a REM-equipped missile.

SECTION IV. TORPEDO TUBE LAUNCH CONFIGURATION

1.15 AUR IDENTIFICATION.

Each tactical and exercise AUR is identified by a unique numeric, six digit serial number. The serial number for all configurations is located on a nameplate in the wing slot but is inaccessible to activities below depot level. At the depot, the AUR configuration and serial number are printed in the upper right-hand corner of the Record Book for TOMAHAWK Cruise Missile (TRB), PEO(W) PUB 4440, which accompanies each AUR. Additionally, an MIS data plate is placed on the AUR and a matching data plate is placed in the TRB. Activities below depot level verify AUR identity by comparing TRB data with data contained on an identification washer installed on the TCM electrical connector or identification plate placed on the TCM near the electrical connector; an identification plate on the capsule aft end; and an MIS data plate on the capsule aft end. A UGM-109A-1 TCM with W80 Warhead installed will have a warhead identification decal on the capsule aft end to reflect the seven digit W80 Warhead serial number. The decal is applied when the warhead is installed and is removed when the warhead is removed.

1.16 CAPSULES.

1.16.1 Capsule Mk 1 Mod 0. The UGM-109A/C/D-1 is protected by the Capsule Mk 1 Mod 0 (Figure 1-23 "TTL Capsules (2 Sheets)"⇒) measuring 248.17 inches long (including the nose cover and loading button) by 20.97 inches in diameter. Capsule components are described in the following paragraphs.

1.16.1.1 Nose Cover. The capsule nose cover, which is made of forged aluminum alloy or a fabric-reinforced composite material, protects the capsule nose diaphragm and the nose of the missile during stowage and handling. Each cover measures 14.48 inches long by 20.95 inches in diameter. The aluminum nose cover weighs about 27 pounds and the composite cover weighs about 13.5 pounds. Attachment to the capsule barrel is provided by seven screws. The cover uppermost screw hole is stencilled TOP to indicate the proper position for installation. The nose cover must be removed prior to launch. The TCM must be fully depressurized prior to removing or installing the cover.

1.16.1.2 Nose Diaphragm. The nose diaphragm consists of a neoprene-impregnated, nylon cloth diaphragm, a capsule-to-diaphragm seal, four leashes and a steel attachment ring. The nose diaphragm is shaped to match the contour of the missile. The diaphragm attaches to the capsule barrel with 24 screws.

1.16.1.3 Capsule Barrel. The capsule barrel is a seamless, corrosion-resistant steel tube 232.88 inches long by 20.97 inches in diameter. Four rows of 12 flow slots each are located at about three-quarters of the length of the barrel to permit the entry of torpedo tube launch pulse pressure. Another single row of nine flow slots is provided around the aft end of the barrel. Bonded to the barrel inside surface are a number of Teflon-coated rubber strips to absorb shock and reduce missile drag during ejection. Also located inside the barrel is a seal that butts against the missile continuity shroud to provide a water-tight seal.

1.16.1.4 Alignment and Retention Provisions. Capsule alignment and retention provisions consist of two guide studs, mounted on the top centerline of the barrel, and two spring-loaded latches, located at the aft end of the barrel. The guide studs engage the guide slot in the top of the torpedo tube. The forward guide stud is engaged by the torpedo tube stop bolt (depending on the stop bolt position). The two spring-loaded latches engage slots in the torpedo tube aft circumferential land and are held extended by two spring-loaded plungers mounted on the aft end of the capsule sleeve. Release of the latches is accomplished either by pneumatically actuating the capsule sleeve to close the flow slots, or by manually depressing the spring-loaded plungers and raising the latches. The latches are held retracted by pins for tube loading/unloading. The pins must be removed to release the latches and stowed in holes provided in the barrel closure prior to TCM launch.

1.16.1.5 Sleeve. The capsule sleeve, measuring 60.80 inches long by 20.50 inches in diameter, consists of a machined, corrosion-resistant steel sleeve and a sleeve ring. The sleeve contains flow slots that match the flow slots in the barrel. It also includes a number of Teflon-coated rubber strips to absorb missile shock and reduce drag. The sleeve ring attaches to the aft end of the sleeve and supports the two spring-loaded plungers used to lock the capsule latches.

1.16.1.6 Barrel Closure. The barrel closure is a machined, corrosion-resistant steel plate 20.97 inches in diameter. It supports the sleeve pneumatic actuator that moves the capsule sleeve to close the flow slots and the pneumatic coupling used to pressurize the TCM and actuate the actuator. A loading button is installed in the center of the barrel closure to permit torpedo tube loading or unloading of the weapon. On TCM configurations with the Mk 106 Mod 0 Rocket Motor, the button supports a nozzle plug retainer to prevent the rocket motor nozzle plug from being dislodged prior to launch. Holes are provided in the barrel closure to access the two missile holdback assemblies, rocket motor pull switch lanyard and TCM electrical umbilical connector.

1.16.1.7 Slot Covers. Slot covers are installed over the capsule flow slots to prevent the entry of foreign matter into the flow slots. Tension latches are provided for cover retention. The covers must be removed prior to tube loading.

1.16.1.8 Protective Covers. Capsule protective covers consist of two molded polyethylene plates. The electric connector access protective cover covers the upper shipping nut, the electrical connector access opening and the lanyard attachment on the barrel closure. The pneumatic coupling protective cover covers the capsule pneumatic coupling. Captive thumbscrews attach the protective covers to the barrel closure. The electrical connector access protective cover is replaced with a security plate after loading aboard the submarine (UGM-109A-1 only). The plate and/or cover(s) must be removed to permit connection of umbilicals to the missile prior to launch.

1.16.2 Capsule Mk 3 Mod 0. The UGM-109E-1 is protected by the Capsule Mk 3 Mod 0 (Figure 1-23 "TTL Capsules (2 Sheets)"⇒) measuring 248.17 inches long (including the nose cover and loading button) by 20.97 inches in diameter. Capsule components are described in the following paragraphs.

1.16.2.1 Nose Cover. The capsule nose cover, which is made of forged aluminum alloy, protects the capsule nose diaphragm and the nose of the missile during stowage and handling. Each cover measures 14.48 inches long by 20.95 inches in diameter. The nose cover weighs about 27 pounds.

Attachment to the capsule barrel is provided by seven screws. The cover uppermost screw hole is stenciled TOP to indicate the proper position for installation. The Mk 3 Mod 0 nose cover has the words BLOCK IV stenciled to distinguish it from the Mk 1 Mod 0 capsule nose cover. The nose cover must be removed prior to launch. The TCM must be fully depressurized prior to removing or installing the cover.

1.16.2.2 Nose Diaphragm. The nose diaphragm consists of a neoprene-impregnated, nylon cloth diaphragm, a capsule-to-diaphragm seal, four leashes and a steel attachment ring. The nose diaphragm is shaped to match the contour of the missile. The diaphragm attaches to the capsule barrel with 24 screws.

1.16.2.3 Capsule Barrel. The capsule barrel is a seamless, corrosion-resistant steel tube 232.88 inches long by 20.97 inches in diameter. A single row of twelve flow slots is provided at about three-quarters of the length of the barrel to permit the entry of torpedo tube launch pulse pressure. Another single row of twelve flow slots is provided around the aft end of the barrel. Bonded to the barrel inside surface are a number of Teflon-coated rubber strips to absorb shock and reduce missile drag during ejection. Also located inside the barrel is a seal that butts against the missile continuity shroud to provide a water-tight seal.

1.16.2.4 Alignment and Retention Provisions. Capsule alignment and retention provisions consist of two guide studs, mounted on the top centerline of the barrel, and a capsule retention fixture, a separate piece of shipboard equipment. The guide studs engage the guide slot in the top of the torpedo tube. The forward guide stud is engaged by the torpedo tube stop bolt (depending on the stop bolt position). The capsule retention fixture engages slots in the torpedo tube aft circumferential land and secures the capsule via an access hole on the barrel closure.

1.16.2.5 Barrel Closure. The barrel closure is a machined, corrosion-resistant steel plate 20.97 inches in diameter. A loading button is installed in the center of the barrel closure to permit torpedo tube loading or unloading of the weapon. The barrel closure provides access to the pressure transducer arrangement, electrical umbilical connector, two missile holdback assemblies, retention fixture latch locking hole, pneumatic umbilical connector, and rocket motor pull switch lanyard attachment.

1.16.2.6 Slot Covers. Two universal slot covers are installed on the capsule. One covers the forward capsule slots and another covers the aft capsule slots. The slot covers prevent entry of foreign matter. There are two straps on each slot cover for cover retention. The covers must be removed prior to tube loading.

1.16.2.7 Protective Covers. The electrical access protective cover is on the starboard side of the barrel closure. The pneumatic coupling protective cover is on the port side. These two covers are also referred to as shipping covers. Both covers provide protection to a separate missile holdback assembly. Additionally the pneumatic coupling protective cover protects the rocket motor pull switch lanyard attachment. The transducer protective cover protects the transducer arrangement including the transducer pneumatic and electrical connectors.

1.17 UMBILICAL ASSEMBLIES.

Separate electrical and pneumatic umbilicals (Figure 1-24 "Electrical and Pneumatic Umbilicals"⇒) are supplied to interface with the submarine launch and pressure/vent control systems. The umbilicals are described in the following paragraphs.

1.17.1 Electrical Umbilical. The electrical umbilical measures 40.50 inches long and consists of a multiconductor electrical cable with quick-release connectors on each end. One end connects to the breech door inside Y-connector. The other end connects to the electrical connector on the aft end of the missile. The connector at the missile end of the umbilical has a hand-pull lanyard to aid manual release.

1.17.2 Pneumatic Umbilical. The pneumatic umbilical measures 30 inches long and consists of a hose assembly, two pneumatic couplings, a lanyard, and a shackle and PIP pin. One end of the umbilical connects to the breech door penetrator. The other end connects to the capsule pneumatic coupling. The lanyard secures to an eyebolt on the inside of the breech door via the shackle and PIP pin.

1.18 INERT VARIANTS.

The paragraphs below discuss certification, training, and other inert variants provided to Fleet and shorebase operational and support activities to conduct TTL training, maintain technical proficiency, and complete personnel, crew, and ship certifications.

1.18.1 TOMAHAWK Test Missile (TOTEM) UTM-109-1. The TOTEM is an encapsulated, launchable, inert test vehicle having the same general configuration as a tactical TTL AUR that, when used with the Digital Missile Simulator Mk 75, is able to simulate the launch sequence of any TTL TCM variant. The electrical umbilical issued with the TOTEM may be a used AUR electrical umbilical or the TOTEM Umbilical Cable Assembly (P/N 1553AS120). The pneumatic umbilical will be a used tactical umbilical. (Use of unused tactical umbilicals with TOTEM is not authorized.) Used tactical umbilicals are readily identified by an orange identification band.

1.18.2 Encapsulated No-Launch No-Wet TOTEM (NL TOTEM). The NL TOTEM is a modified, non-launchable TOTEM that is used to train submarine crews in TTL operations and to verify operability of the TTL pressure/vent system aboard the submarine. The electrical umbilical issued with the NL TOTEM may be a used AUR electrical umbilical or the TOTEM Umbilical Cable Assembly (P/N1553AS120). The pneumatic umbilical will be a used tactical umbilical. (Use of unused tactical umbilicals with NL TOTEM is not authorized.) Used tactical umbilicals are readily identified by an orange identification band.

1.18.3 Crew Training Shape (CTS) UTM-109-1A. The CTS is a modified, non-launchable TOTEM used to train and certify submarine crews in TTL loading and handling procedures for the UGM-109A-1 variant. At Type Commander discretion, the CTS may be used aboard submarine tenders and at shore bases to train personnel in UGM-109A-1 handling procedures.

1.18.4 Warhead Installation Trainer (WIT) Mk 35 Mod 0. The WIT is an inert, non-launchable facsimile of the UGM-109A-1 that is used to train and certify designated personnel in all aspects of W80 Warhead installation and removal.

1.18.5 TOMAHAWK Fitment Shape (TOMFISH) Mk 1 Mod 0. The TOMFISH is an inert, non-functional, ballasted shape that duplicates the physical dimensions, weight, and center of gravity (CG) of a TTL AUR. The TOMFISH is used by shipyards and Fleet activities to test and certify TTL handling, loading and stowage capabilities aboard submarines and submarine tenders.

1.18.6 Commercial Off The Shelf TOMAHAWK Test Missile (COTS TOTEM). The COTS TOTEM is a non-launchable assembly comprised of an inert Pressure Vent Test Vehicle (PVTV) within a capsule. The assembly simulates the appearance, mechanical interface, pressure/vent control (PVC) transducer and PVC ullage characteristics of a Block III AUR. It can be used in a dry torpedo tube for flow rate testing or it can be connected as a NL TOTEM with the BBY adapter and Missile Simulator for PVC/FCS testing or training in a flooded torpedo tube.

1.18.7 Pressure Vent Test Vehicle TOMAHAWK Test Missile (PVTV TOTEM). The PVTV TOTEM is a non-launchable assembly comprised of an inert Pressure Vent Test Vehicle (PVTV) within a capsule. The assembly simulates the appearance, mechanical interface, pressure/vent control (PVC) transducer characteristics and PVC ullage characteristics of a Block IV AUR. It can be used in a dry torpedo tube for flow rate testing or it can be connected as a NL TOTEM with the BBY adapter and Missile Simulator for PVC/FCS testing or training in a flooded torpedo tube.

1.19 CNU-308/E SHIPPING CONTAINER.

The CNU-308/E Shipping Container (Figure 1-25 "CNU-308/E Shipping Container"⇒) is a reusable, stackable container to provide protection for TCMs and capsules during handling, storage, and transportation. The basic design functions of the container are to:

a. Attenuate shock and vibration.

b. Permit handling by forklift, handlift truck, or sling/crane arrangement.

c. Provide a means to stack containers during transport or storage.

1.19.1 Function. The function of the container is to handle, store, and transport TTL tactical and exercise AURs; and handle and transport TTL certification and training variants, post-launch REM-equipped TCMs and TOTEM test vehicles with an adapter (76Z7908-1) installed, and TTL capsules.

1.19.2 Description. The container consists of a fiberglass lower and upper shell, the latter in two sections. Thirty-two quarter turn fasteners are located around the upper edge of the lower shell with matching slots located on the mating edges of the upper shell. Shock mounts, integral supports, and internal straps attenuate the shipping and handling stresses to safe levels. Four handles on each upper shell and five tie-down rings on each side of the lower shell are used for lifting and tie-down. The container has integral skids having fittings for use with forklifts. Also built into the container are fork pockets and hoisting fittings. Small, non-steerable, retractable wheels on the aft end of the container permit limited fore and aft movement. An access door on the container aft end permits activities to check for fuel leaks and gain access to the record book. The empty container weighs 1709 pounds. Container dimensions are provided in Table 1-8 "Container Weights and Dimensions"⇒.

1.20 RECORD BOOKS.

1.20.1 PEO(W) PUB 4440, Record Book for Tomahawk Cruise Missile. PEO(W) PUB 4440 is utilized to maintain data for tactical and exercise TTL AURs. PEO(W) PUB 4440 is also utilized to maintain data for the Crew Training Shape and Warhead Installation Trainer Mk 35 Mod 0. Instructions for use, forms completion, and disposition are contained in PEO(W) INST 4440.2 and the record book.

1.20.2 CMP PUB 4440/2, Record Book for TOMAHAWK Test Missile (TOTEM). CMP PUB 4440/2 is a tailored version of PEO(W) PUB 4440 that is used to record data pertinent to launchable and non-launchable TOTEMs. Instructions for use, forms completion, and disposition are contained in the record book.

1.21 WEIGHTS AND CENTERS OF GRAVITY.

Weights and centers of gravity of TTL variants and related material are contained in Tables 1-9 "Weights of TTL Variants and Related Material"⇒ and 1-10 "Centers of Gravity for TTL Variants"⇒ respectively.

SECTION V. CAPSULE LAUNCHING SYSTEM CONFIGURATION

1.22 AUR IDENTIFICATION.

Each tactical and exercise AUR is identified by a unique numeric, six digit serial number. The serial number for all configurations is located on a nameplate in the wing slot but is inaccessible to activities below depot level. At the depot, the AUR configuration and serial number are printed in the upper right-hand corner of the Record Book for TOMAHAWK Cruise Missile (TRB), PEO(W) PUB 4440, which accompanies each AUR. Additionally, an MIS data plate is placed on the AUR and a matching data plate is placed in the TRB. Activities below depot level verify AUR identity by comparing TRB data with data contained on two identification plates and two MIS data plates placed inboard and outboard on the upper end of the electrical umbilical.

1.23 CAPSULE LAUNCHING SYSTEM MK 45.

The Capsule Launching System (CLS) Mk 45 (Figures 1-26 "Capsule Launching System (CLS) Mk 45"⇒ and 1-27 "Capsule Launching System (CLS) Components"⇒) is a pressurizable cylindrical enclosure that encapsulates, supports, protects, and launches a TOMAHAWK Cruise Missile. There are two configurations of the CLS; the Mk 45 Mod 1 and Mod 2. The Mk 45 Mod 1 is used on SSN class submarines. In order to accommodate the unique requirements of the SSGN launch platform (Figure 1-41 "SSGN (Prototype) Multiple All-Up-Round Canister (MAC)"⇒), the Mk 45 was redesigned to Mod 2 and will be used interchangeably between SSN and SSGN platforms, without the requirement for Intermediate or Depot Level maintenance or reconfiguration. All Mod 1 capsules will eventually be modified to Mod 2. Except for differences in the positioning of handling equipment necessitated by changes in the center of gravity between the two configurations, CLS operations are the same for both configurations.

Paragraphs 1.23.1 through 1.23.1.13 describe the CLS Mk 45 Mod 1; paragraphs 1.23.2 through 1.23.2.12 describe the CLS Mk 45 Mod 2.

1.23.1 CLS Mk 45 Mod 1. The CLS Mk 45 Mod 1 uses a filament wound composite capsule with titanium flanges mounted on each end for attaching CLS forward and aft components. The CLS accepts a specified amount of reflood water after missile launch to preclude the necessity for a missile compensation system. The Mk 45 Mod 1 configuration has a nominal weight of 2,121 pounds.

1.23.1.1 Capsule. The capsule is a tube, 243 inches in length, which forms the main structural member of the CLS. The capsule increases in diameter from 24 inch at the aft end to 26.61 inches at the upper flange. The capsule is sealed on the forward end by the capsule closure assembly and at the aft end by the aft closure assembly. Within the capsule shell is mounting space for the lateral support group and six lip type circumference seals which protect the exterior surface of the missile and constrain eject gases. External mounting arrangements are provided for lateral support pads and an umbilical guard and cable. The capsule has provisions for attaching the vertical support assembly (VSA) and capsule extension as well as handling and support equipment.

The upper flange has penetrations for the pressure/vent port, the annular space vent line, and a slot which allows the flat umbilical cable to pass through the flange. There are two lip seal grooves around the circumference of the upper flange to provide a seal at the upper end of the missile tube. There are two alignment slots, located at 53° and 233° azimuth, which engage pins at the upper end of the missile tube. The alignment slots serve to align the AUR in the missile tube as it is seated.

When installed in the missile tube, the AUR is supported and secured by eight retention segments on its upper flange. Three of the retention segments provide mounting for cable clamps. The segments secure the capsule by exerting downward pressure on the upper closure ring while exerting upward pressure in a groove on the inside surface of the missile tube upper flange.

The aft closure is located below the VSA and capsule extension. The aft closure assembly encloses the lower end of the capsule and provides a mounting surface for the gas generator mechanism and electrical components. The umbilical cable attaches to a through-connector which is installed in the aft closure assembly. The cable is unbonded 24 ± 1 inches forward of the end of the composite capsule. The capsule has a stripe at the expended capsule CG location.

1.23.1.2 Capsule Closure Assembly. The capsule closure assembly (CCA) is attached to the flange at the upper end of the capsule. The closure consists of a nylon cloth-reinforced rubber diaphragm with an internal stainless steel band around the outer edge; a low-permeance mylar dome installed over the diaphragm; and an upper and lower retaining ring. A diaphragm bead is clamped between the two retaining rings in a compression fit to form a seal between the rings. A barrier flange is adhesively bonded to the bottom of the upper closure ring. The rings are bolted together. Bolts pass through both rings to attach the closure to the capsule. An O-ring fits in a groove in the capsule forward flange and provides an air-tight seal between the closure assembly and the capsule upper flange while in the missile tube. The rings also provide mounting for the pressure-sensing line.

The low-permeance dome is made up of six triangular sections, a flange section and a split polar cap assembled with a foil laminate tape. The dome material is a three layer laminate of mylar, tin foil, and mylar (MTM). The tin foil makes the dome nearly impermeable to water vapor. The foil laminated tape forms a separation line across the dome which extends between segments and the hemispheres of the polar cap. This separates at launch to allow the missile to pass through unimpeded.

The diaphragm membrane is purposely weak along a diametrical line called the "tear line". Yet it is strong enough to withstand maximum external pressure at launch depth and maximum prelaunch internal over-pressure. Perpendicular to the membrane tear strip are two peel strips which initiate the tearing of the membrane to reduce the loads on the missile nose. The ends of each peel strip are attached to under-side of membrane at apex near tear line and to lower retaining ring. Between attachment points, two peel strips hang free. As capsule is pressurized before launch, the nylon cloth in the diaphragm allows diaphragm to stretch and grow slightly. The fabric in the peel strips does not stretch because it is kevlar reinforced; thus, peel strips are placed under tension. This tension is transmitted to the apex of the tear line. When launched, the missile nose contacts the tear strips increasing tension until tearing of the membrane is initiated.

1.23.1.3 Sabot. CLS Mk 45 1 capsules containing a UGM-109C/D or JUGM-109C/D variant of the TCM with a Positive Retention (Chine) Nosecone, have a sabot assembly installed between the nosecone and capsule closure assembly (CCA). The sabot is used to prevent damage to the CCA during shipping, handling, loading and prelaunch pressurization activities. The sabot consists of two closed-cell foam halves attached together with plastic tie wraps. The foam material is negatively buoyant due to the inclusion of iron particles within each molded foam half. The sabot is coated with a zinc-rich primer and a polyurethane top coat to provide a corrosion resistant surface compatible with the CCA and the missile nosecone. The sabot assembly weighs approximately 26 pounds.

When launched, the missile nose pushes the sabot against the CCA tear strips. As the CCA tears and the missile leaves the launch tube, the sabot is broken into several small pieces by the ejection forces. These pieces will gradually sink to the bottom away from the launch tube. Some pieces may sink to the bottom of the capsule. This is an acceptable condition.

1.23.1.4 Lateral Support Group. The lateral support group is bonded to the inner surface of the capsule. The lateral support group has thirteen rows of elastomeric liner pads. There are four separate liner pads in each circumferential row. Each liner pad consists of an inner and outer wall jointed by chevron-shaped struts. Teflon is bonded to the inside surface of each pad to reduce friction against the missile surface. Dual plateau pads, with a corrugated inside surface, are incorporated into the lateral support group to further reduce friction during encapsulation and decapsulation of the missile and during launch.

The design of the elastomeric pads provides necessary lateral support and protects the missile from shock and vibration. In this function, the lateral support group acts in concert with the interface support pads which are bonded to the exterior of the capsule and capsule extension. The lateral support group also serves to provide in-tube guidance for the missile during launch.

1.23.1.5 Launch Seals. There are six circumferential launch seals adjacent to the bands of liner pads which are bonded to the inner surface of the capsule. The seals have a projecting lip which bears against the surface of the missile. The surface of the seal lip which contacts the missile surface is coated with Teflon to minimize friction. Also, the Teflon coating eliminates seal lip inversion. Seal lip inversion may result from upward forces acting upon lip from launch gas pressure under the lip and from missile motion against the lip.

During launch, the launch seals minimize gas pressure buildup in the space between the capsule inner wall and the missile skin. The seals also enhance eject performance by minimizing gas leakage from the volume pressurized by the gas generator. By reducing asymmetric pressure forces during the in-tube travel of the missile, the seals serve to reduce launch vibrations. Holes spaced around the circumference of the seal lip allow air to flow between the compartments during capsule pressurization.

1.23.1.6 Separation Nuts. Two separation nuts attach to two hold-down studs on the missile aft end to position the missile before launch and secure the missile to the VSA. Each separation nut has two explosive initiators which, when fired just prior to missile launch, cause the nut to separate from the hold-down stud thus permitting missile egress.

1.23.1.7 Vertical Support Assembly (VSA). The VSA consists of a vertical shock and vibration mitigation device, a metal bellows anti-rotation device, two missile retention devices, a gas generator gas deflector, two missile-away switches, and a capsule extension. The VSA mitigates shock and vibration to the missile in the axial direction, positions the missile vertically and azimuthally in the capsule, provides a flow path for gases from the gas generator to the missile during launch, and provides for mounting electrical control components.

1.23.1.8 Capsule Extension. The capsule extension provides a watertight connection between the VSA and the aft closure assembly. It also provides attachment for the aft closure assembly.

1.23.1.9 Aft Closure Assembly. The aft closure assembly has provisions for mounting the gas generator and the electrical cabling and controls. It also provides through access for electrical cabling and ensures a watertight barrier at the capsule aft end. An aft cover attaches to the aft closure to provide a closed environment for the gas generator and electrical cabling and controls.

1.23.1.10 Gas Generator. The gas generator is contained in a cylindrical steel case approximately 15 inches long and 12 inches in diameter. An integral flange at the gas generator's CG attaches to the aft closure with a spigot fit. The flange seals the capsule from the upper end of the aft closure. The ends of the cylinder are fitted with flat, steel plate closures. The closures are sealed with O-rings and retained in the assembly with threaded rings. The forward closure provides mounting for an electrical bridgewire initiator on the outside and an ignitor housing on the inside. The gas generator aft closure has a nozzle.

A polyester resin inhibitor is molded on the outer surface and forward end of the propellant grain to form a propellant cartridge. Two circular, molded-rubber gaskets are bonded to the grain spacer to provide shock isolation for the cartridge. Four tapped holes in the aft closure provide attachment for the thrust neutralizer. The thrust neutralizer is a safety device installed on the gas generator when it is not installed on the AUR.

The gas generator is a component of the AUR, rather than the CLS, because it is installed during missile encapsulation. It is described because of its close physical and functional relationship to major components described above.

1.23.1.11 Aft Cover. An aft cover attaches to the aft closure to provide a closed environment for the gas generator and electrical cabling and controls.

1.23.1.12 Aft Fairing Device. The aft fairing is a cylindrical urethane elastomer which attaches to the aft end of the CLS capsule by eight bolts. The aft fairing protects the aft end of the AUR during installation into the missile tube. Because of its tapered shape, the aft fairing also serves to guide the AUR into the missile tube.

1.23.1.13 Instrumentation and Controls. The main electrical umbilical cable runs from a through-connector at a penetration in the upper missile tube wall, through a slot in the capsule upper flange, down the outside of the capsule wall to another through-connector in the aft closure. The umbilical cable is a flat, low-profile cable which is bonded to the outside surface of the capsule.

Three cables are installed within the capsule: one cable from the missile, one cable from the two separation nuts, and one cable from the departure switches. The three cables pass through the VSA and connect to three penetration connectors in the aft closure. There are three additional cables on the aft side of the aft closure: one cable connects the firing unit to the gas generator; one cable connects the firing unit to the separation nuts; and one cable connects the umbilical cable to the firing unit, the missile cable, the departure switches, liquid sensors, and the interconnecting box.

1.23.2 CLS Mk 45 Mod 2. The CLS Mk 45 Mod 2 incorporated new designs to successfully integrate the existing SSN class AUR configuration, as cost effectively as possible, for use with SSGN. The three primary areas of concern in achieving this were: 1.) at the aft end connection, the Multiple All-Up-Round Canister (MAC) was unable to connect the existing P130A connector with the umbilical cable installed, 2.) there was possible interference from the sabot with the hatch closure and there existed the possibility of damage to adjacent AURs due to post-launch sabot debris, and 3.) there was concern over the CCA and umbilical cable performance in the SSGN environment over the AUR life cycle.

Solutions to these three areas were to install a new CCA, umbilical cable, and aft end components. The major components of the CLS Mk 45 Mod 2 are discussed in the following paragraphs.

1.23.2.1 Capsule. The capsule is a tube, 243 inches in length, which forms the main structural member of the CLS. The capsule increases in diameter from 24 inch at the aft end to 26.61 inches at the upper flange. The capsule is sealed on the forward end by the capsule closure assembly and at the aft end by the aft closure assembly. Within the capsule shell is mounting space for the lateral support group and six lip type circumference seals which protect the exterior surface of the missile and constrain eject gases. External mounting arrangements are provided for lateral support pads and an umbilical guard and cable. The capsule has provisions for attaching the vertical support assembly (VSA) and capsule extension as well as handling and support equipment.

The upper flange has penetrations for the pressure/vent port, the annular space vent line, and a slot which allows the flat umbilical cable to pass through the flange. There are two lip seal grooves around the circumference of the upper flange to provide a seal at the upper end of the missile tube or AUR cell. There are two alignment slots, located at 53° and 233° azimuth, which engage pins at the upper end of the tube/cell. The alignment slots serve to align the AUR in the tube/cell as it is seated.

When installed in the tube/cell, the AUR is supported and secured by eight retention segments on its upper flange. Three of the retention segments provide mounting for cable clamps. The segments secure the capsule by exerting downward pressure on the upper closure ring while exerting upward pressure in a groove on the inside surface of the tube/cell upper flange.

The aft closure is located below the VSA and capsule extension. The aft closure assembly encloses the lower end of the capsule and provides a mounting surface for the gas generator mechanism and electrical components. The umbilical cable attaches to a through-connector which is installed in the aft closure assembly. The cable is unbonded 6 ± 1 inches forward of the aft end of the composite capsule. The capsule has a stripe at the expended capsule CG location.

1.23.2.2 Capsule Closure Assembly. The CCA (Figure 1-40 "CLS Mk 45 Mod 2 Capsule Closure Assembly"⇒) is compatible with both, the Block III and Block IV AUR configurations. The CCA is attached to the flange at the upper end of the capsule. The closure consists of a nylon cloth-reinforced rubber diaphragm with an internal stainless steel band around the outer edge. Incorporated within the underside of the diaphragm are four sabots. The intent of the sabots is to reduce the stress in the diaphragm at maximum launch pressures. Upper and lower retaining rings are utilized for diaphragm assembly. A diaphragm bead is clamped between the two retaining rings in a compression fit to form a seal between the rings. The rings are bolted together. The bolts pass through both rings to attach the closure to the capsule. An O-ring fits in a groove in the capsule forward flange and provides an air-tight seal between the closure assembly and the capsule upper flange while in the AUR cell/missile tube. The rings also provide mounting for the pressure-sensing line. The diaphragm membrane is purposely weak along a diametrical line called the "tear line". Yet it is strong enough to withstand maximum external pressure at launch depth and maximum prelaunch internal over-pressure. As the capsule is pressurized before launch, the nylon cloth in the diaphragm allows diaphragm to stretch and grow slightly.

1.23.2.3 Lateral Support Group. The lateral support group is bonded to the inner surface of the capsule. The lateral support group has thirteen rows of elastomeric liner pads. There are four separate liner pads in each circumferential row. Each liner pad consists of an inner and outer wall jointed by chevron-shaped struts. Teflon is bonded to the inside surface of each pad to reduce friction against the missile surface. Dual plateau pads, with a corrugated inside surface, are incorporated into the lateral support group to further reduce friction during encapsulation and decapsulation of the missile and during launch.

The design of the elastomeric pads provides necessary lateral support and protects the missile from shock and vibration. In this function, the lateral support group acts in concert with the interface support pads which are bonded to the exterior of the capsule and capsule extension. The lateral support group also serves to provide guidance for the missile during launch.

1.23.2.4 Launch Seals. There are six circumferential launch seals adjacent to the bands of liner pads which are bonded to the inner surface of the capsule. The seals have a projecting lip which bears against the surface of the missile. The surface of the seal lip which contacts the missile surface is coated with Teflon to minimize friction. Also, the Teflon coating eliminates seal lip inversion. Seal lip inversion may result from upward forces acting upon lip from launch gas pressure under the lip and from missile motion against the lip.

During launch, the launch seals minimize gas pressure buildup in the space between the capsule inner wall and the missile skin. The seals also enhance eject performance by minimizing gas leakage from the volume pressurized by the gas generator. By reducing asymmetric pressure forces during the in-tube/cell travel of the missile, the seals serve to reduce launch vibrations. Holes spaced around the circumference of the seal lip allow air to flow between the compartments during capsule pressurization.

1.23.2.5 Separation Nuts. Two separation nuts attach to two hold-down studs on the missile aft end to position the missile before launch and secure the missile to the VSA. Each separation nut has two explosive initiators which, when fired just prior to missile launch, cause the nut to separate from the hold-down stud thus permitting missile egress.

1.23.2.6 Vertical Support Assembly (VSA). The VSA consists of a vertical shock and vibration mitigation device, a metal bellows anti-rotation device, two missile retention devices, a gas generator gas deflector, two missile-away switches, and a capsule extension. The VSA mitigates shock and vibration to the missile in the axial direction, positions the missile vertically and azimuthally in the capsule, provides a flow path for gases from the gas generator to the missile during launch, and provides for mounting electrical control components.

1.23.2.7 Capsule Extension. The capsule extension provides a watertight connection between the VSA and the aft closure assembly. It also provides attachment for the aft closure assembly.

1.23.2.8 Aft Closure Assembly. The aft closure assembly has provisions for mounting the gas generator and the electrical cabling and controls. It also provides through access for electrical cabling and ensures a watertight barrier at the capsule aft end. An aft cover attaches to the aft closure to provide a closed environment for the gas generator and electrical cabling and controls.

1.23.2.9 Gas Generator. The gas generator is contained in a cylindrical steel case approximately 15 inches long and 12 inches in diameter. An integral flange at the gas generator's CG attaches to the aft closure with a spigot fit. The flange seals the capsule from the upper end of the aft closure. The ends of the cylinder are fitted with flat, steel plate closures. The closures are sealed with O-rings and retained in the assembly with threaded rings. The forward closure provides mounting for an electrical bridgewire initiator on the outside and an ignitor housing on the inside. The gas generator aft closure has a nozzle.

A polyester resin inhibitor is molded on the outer surface and forward end of the propellant grain to form a propellant cartridge. Two circular, molded-rubber gaskets are bonded to the grain spacer to provide shock isolation for the cartridge. Four tapped holes in the aft closure provide attachment for the thrust neutralizer. The thrust neutralizer is a safety device installed on the gas generator when it is not installed on the AUR.

The gas generator is a component of the AUR, rather than the CLS, because it is installed during missile encapsulation. It is described because of its close physical and functional relationship to major components described above.

1.23.2.10 Aft Cover. The aft cover (Figure 1-39 "CLS Mk 45 Mod 2 Aft Cover"⇒) attaches to the aft closure to provide a closed environment for the gas generator and electrical cabling and controls. The Mod 2 aft cover configuration is a one-piece design cast from Passivated 316 stainless steel. The aft cover incorporates a pressure test port, and also allows for the use of the redesigned P1130/J1130 connector and for stowage of the P1130 connector.

The design of the aft cover allows for loading and unloading on both the SSN and SSGN platforms. An umbilical clamp has been added to provide protection for the umbilical. An ordnance ground has been added, as well as a vent/pressure test port.

1.23.2.11 Aft Fairing Device. The aft fairing is cylindrical urethane elastomer which attaches to the aft end of the CLS capsule by eight bolts. The device protects the aft end of the missile. Because of its tapered shape, the aft fairing also serves to guide the AUR into the tube/cell.

The aft fairing device for the Mod 2 is a slightly modified version of the Mod 1 configuration. The new device accepts the new aft cover and allows for the redesigned umbilical and the umbilical cable clamp. The revised aft fairing device will still work on the Mod 1 capsule.

1.23.2.12 Instrumentation and Controls. The only umbilical cable required for application use in the SSGN is located at the bottom of the MAC cell. With the CLS AUR loaded into the MAC cell, SSGN personnel remove the P1130 connector from the J1130, and install it in its stowage position. The ship's umbilical is then installed in the J1130. Each AUR requires one of these umbilical cables; seven umbilical cables for each fully loaded MAC. These umbilical cables plug into the ship's control interface cable and to a connector located at the bottom of the AUR.

Three cables are installed within the capsule: one cable from the missile, one cable from the two separation nuts, and one cable from the departure switches. The three cables pass through the VSA and connect to three penetration connectors in the aft closure. There are three additional cables on the aft side of the aft closure; one cable connects the firing unit to the gas generator; one cable connects the firing unit to the separation nuts; and one cable connects the umbilical cable to the firing unit, the missile cable, the departure switches, liquid sensors, and the interconnecting box.

The AUR umbilical cables are not used on the SSGN for umbilical cable applications. The umbilical cable at the top of the AUR is strapped to the MAC cell wall and plugged into a dummy connector. The long electrical umbilical cable that runs from a through-connector at a penetration in the upper MAC cell wall, through a slot in the capsule upper flange, down the outside of the capsule wall to another through-connector in the aft closure. This flat low-profile umbilical cable is bonded to the outside surface of the capsule and plugs into a dummy connector at the bottom of the AUR.

Onboard SSN class, the umbilical can be connected to the same through-connector in the upper missile tube wall as is done with the Mod 1 capsule.

1.24 INERT VARIANTS.

The paragraphs below discuss certification, training, and other inert variants provided to Fleet and shorebase operational and support activities to conduct CLS training, maintain technical proficiency, and complete personnel, crew, and ship certifications.

1.24.1 All-Up-Round Simulator (AURS) Volumetric Shape. The AURS (Figure 1-28 "All-Up-Round Simulator (AURS) Volumetric Shape"⇒) is an inert, non-launchable volumetric shape that is used for pre- and post-delivery test programs, crew certification trials, and at-sea testing. Its design permits simulation of the CLS AUR to allow for pressurization/venting and flood/drain system operations aboard the submarine. Its design also provides a watertight, pressure-proof enclosure for installing the All-Up-Round Electronic Simulator (AURES) (Figure 1-29 "All-Up-Round Electronic Simulator (AURES) Mk 101"⇒) on a hoisting frame. This permits the AURES to be raised without electrical disconnection so that topside operators have access to the AURES front panel controls and indicators (Figure 1-30 "AURES/AURS Interface"⇒). The AURES is a testing and training device used to simulate land-attack CLS variants thereby permitting the submarine launch control system to operate through the complete CLS launch cycle in single or salvo launch modes. The AURES Mk 101 and Mk 112 are presently in use in the fleet.

1.24.2 CLS Loading and Handling Training Shape Mk 3 Mod 0. The CLS Loading and Handling Training Shape Mk 3 Mod 0 is an inert CLS MK 45 containing a non-launchable, ballasted training vehicle that is used by submarine tender and shorebase personnel to train for, and maintain proficiency in, all facets of CLS AUR handling and submarine onload/offload operations.

1.24.3 Ballast Can Variants. The Missile Tube Ballast Can (Figure 1-31 "Missile Tube Ballast Can"⇒) is an inert, non-launchable, enclosed steel cylinder that may be loaded in SSN CLS missile tubes to enhance launch platform buoyancy control when a full complement of CLS AURs is not carried aboard the SSN. Missile Tube Ballast Cans may be loaded in SSGN MAC cells to close cells against water intrusion during non-deployed underway periods if AURs are not carried. The All-Up-Round Ballast, Grade B (AURBb) is a ballast can which may be carried in MAC cells during SSGN deployment.

1.24.4 Missile Tube Bore Gage. The Missile Tube Bore Gage is a cast iron facsimile of the CLS AUR that is used to verify the proper missile tube clear bore to ensure compatibility with the AUR.

1.25 CLS SHIPPING CONTAINERS.

Reusable, stackable shipping containers have been designed to provide protection for the CLS AUR, AUR Simulator and empty CLS during handling, storage, and transportation. The basic design functions of the containers are to:

a. Attenuate shock and vibration.

b. Permit handling by forklift, handlift truck, or sling/crane arrangement .

c. Provide a means to stack containers during transport or storage.

1.25.1 Shipping and Storage Skid Mk 30. The Shipping and Storage Skid Mk 30 (Figure 1-32 "Shipping and Storage Skid Mk 30"⇒) is used to handle, store, and transport CLS tactical and exercise AURs; and to handle and transport CLS Loading and Handling Trainers and spent CLSs. The skid is also used for loading CLS weapons aboard submarines, and may also be used to perform weapon maintenance, by installing the Uprighting Fixture Mk 26 and Forward Support Mk 167 in the skid. The main body of the skid is constructed of aluminum and consists of an inner frame assembly, saddles, restraint straps, lifting eyes, and forklift slots. Lightweight plastic covers, fore and aft, are provided to cover the AUR or capsule during shipment or storage. The forward cover contains an access door. Pins secure the covers to the outer frame assembly. Stacking posts are provided to permit stacking of containers. The Mod 1 configuration includes a storage location for the Closure Protective Cover Mk 19 Mod 0. Skid dimensions are provided in Table 1-8 "Container Weights and Dimensions"⇒.

1.25.2 AUR Simulator Shipping Skid. The AUR Simulator Shipping Skid (Figure 1-33 "AUR Simulator Shipping Skid"⇒) is used to handle and transport the AURS. The skid consists of a steel frame with two aluminum covers secured to the frame with capscrews. A cradle and restraining straps are provided to secure the shape in the skid. Hardwood skids attached to the bottom of the frame allow lifting straps to be used to move the skid. Lifting rings on the covers facilitate use of a sling/crane arrangement to remove the covers. Skid dimensions are provided in Table 1-8 "Container Weights and Dimensions"⇒.

1.25.3 Shipping and Storage Skid Mk 34. The Shipping and Storage Skid Mk 34 (Figure 1-36 "Shipping and Storage Skid Mk 34"⇒) is also used to handle, store and transport the AURS. With the installation of the Uprighting Fixture and Forward Support, this skid can be used for uprighting/lowering the AURS during loading/unloading. The main body of the skid is constructed of aluminum and consists of an inner and outer frame assembly, saddles, restraint straps, lifting eyes, and forklift slots. Lightweight plastic covers, fore and aft, are provided to cover the AURS during shipment or storage. Pins secure the covers to the outer frame assembly. Stacking posts are provided to permit stacking of containers.

1.26 RECORD BOOKS.

1.26.1 PEO(W) PUB 4440, Record Book for TOMAHAWK Cruise Missile. PEO(W) PUB 4440 is used to record data pertinent to the CLS Loading and Handling Trainer Shape Mk 3 Mod 0 as well as tactical and exercise CLS AURs. Instructions for use, forms completion, and disposition are contained in PEO(W) INST 4440.2 and the record book.

1.26.2 Record Book All-Up-Round (AUR) Simulator Volumetric Shape. The AURS record book is used to record data pertinent to the AURS. Data recording requirements are similar as those required for PEO(W) PUB 4440. Instructions for completing required records are contained in the record book.

1.26.3 Record Book Missile Tube Ballast Can (MTBC). The ballast can record book is used to record data pertinent to the CLS ballast can. Data recording requirements are similar as those required for PEO(W) PUB 4440. Instructions for completing required records are contained in the record book.

1.27 WEIGHTS AND CENTERS OF GRAVITY.

Weights and centers of gravity of CLS variants and related material are contained in Tables 1-11 "Weights of CLS Variants and Related Material"⇒ and 1-12 "Centers of Gravity for CLS Variants"⇒ respectively.

SECTION VI. VERTICAL LAUNCHING SYSTEM CONFIGURATION

1.28 AUR IDENTIFICATION.

Each tactical and exercise AUR is identified by a unique numeric, six digit serial number. The serial number for all configurations is located on a nameplate in the wing slot but is inaccessible to activities below depot level. At the depot, the AUR configuration and serial number are printed in the upper right-hand corner of the Record Book for TOMAHAWK Cruise Missile (TRB), PEO(W) PUB 4440, which accompanies each AUR. Additionally, an MIS data plate is placed on the AUR and a matching data plate is placed in the TRB. Activities below depot level verify AUR identity by comparing TRB data with data contained on an identification plate and an MIS data plate on the aft end of the Mk 10 Canister prior to encanisterization of the RGM-109-2 variant into the Mk 14 Canister. A detachable MIS data plate is removed from the TRB and placed on the bottom of the Mk 14 Canister near the deluge connector after encanisterization to identify the VLS configured RGM-109-4 variant. RGM-109C-2, RGM-109D-2, and RGM-109E-2 as well as their corresponding exercise variants are employed in VLS configurations after encanisterization in the Mk 14 Canister.

1.29 CANISTERS.

1.29.1 Mk 10 Canister. The Mk 10 Canister (Figure 1-34 "Mk 10 Canister"⇒) is used to encanister RGM-109-2 variants and measures 253.5 inches long and 21.2 inches in diameter. Canister components are described in the following paragraphs.

1.29.1.1 Canister Fly-Through Cover Assembly. The canister fly-through cover assembly measures about 22.85 inches in diameter and about 0.18 inch thick. The assembly consists of eight frangible segments and a flange and attaches to the canister barrel with 36 bolts.

1.29.1.2 Canister Barrel. The canister barrel is a seamless aluminum tube measuring 247.35 inches long and 21.2 inches in diameter. The barrel provides environmental and physical protection for the missile and rocket motor and serves as the launch tube.

1.29.1.3 Canister Baseplate Assembly. The canister baseplate is a machined, aluminum alloy plate measuring 21.2 inches in diameter. It supports the cable and conduit assembly and its associated connector, a nitrogen servicing pneumatic quick-disconnect coupling, and the umbilical adapter. It also contains three rupture disks for thrust augmentation and for the exit of rocket motor exhaust. Two loading bracket assemblies can be mounted on the baseplate for alignment of the canister.

1.29.2 Mk 14 Mod 1/Mod 2 Canister. The Mk 14 Mod 1 and Mod 2 Canisters (Figure 1-35 "Mk 14 Canister (2 Sheets)"⇒) are thermally lined, rectangular shells with 16 lateral supports to allow longitudinal movement of the encanistered TCM for shock isolation. The canisters provide environmental protection and structural and alignment support for the encanistered TCM as well as a mounting platform for various command, control and safety devices. The canisters also serve as shipping and storage containers and launch tubes for TCMs. Canister components, safety/security devices and canister circuits are discussed in the following paragraphs.

1.29.2.1 FWD Closure Assembly. The FWD Closure Assembly consists of two vertical lift lugs, a cover seal that ruptures during TCM egress and a closure with a breakwire to indicate missile away during TCM launch.

1.29.2.2 AFT Closure Assembly. The AFT Closure Assembly consists of a grid closure, a closure with breakwire and a support ring that provides an exhaust gas seal.

1.29.2.3 Umbilical Connector. The umbilical connector is the exterior interface to connect the Mk 14 Canister cable assembly. The cable assembly connects the code plug, FWD and AFT closure breakwires, temperature sensor, cable and conduit assembly connector and umbilical connector adapter.

1.29.2.4 Deluge Connector. The quick-disconnect deluge connector provides the means of activating the three-piece deluge manifold surrounding the warhead in the canister should a signal be received over the deluge circuit that canister conditions indicate that detonation of a warhead in a canister is imminent. The manifold, with its 22 equally spaced holes, provides an even distribution of water on the warhead area.

1.29.2.5 Antenna Connector. The antenna connector provides the means for data to be transmitted from telemetry monitoring equipment to the encanistered TCM.

1.29.2.6 Canister Safe Enable Switch (CSES) (Mk 14 Mod 1/Mod 2). The CSES provides two-position manual control of the booster ignition circuit for encanistered TCMs in the Mk 14 Mod 1/Mod 2 Canisters. The CSES status (safe or enable) is continuously monitored by the VLS weapon control system.

1.29.2.7 Canister Code Plug. The canister code plug electrically identifies the type of missile in the canister and the type of payload. It is attached to the canister cable assembly, near the forward cover, when the encanistered TCM is placed in the Mk 14 Canister.

1.29.2.8 Nitrogen Supply Valve. The nitrogen supply valve, located near the antenna connector, provides a means of pressurizing the Mk 10 Canister via a nitrogen line inside the Mk 14 Canister.

1.29.3 Mk 14 Mod 2 Canister. The Block IV TACTOM AUR is encanistered in the Mk 14 Mod 2 VLS Canister and interfaces mechanically and electrically with the Mk 41 VLS launcher. The Mk 14 Mod 2 Canister serves as the launch tube support for the missile when installed in the Mk 41 VLS, and as the Packaging, Handling, Storage, and Transportation (PHS&T) container for the Block IV TACTOM AUR when installed with PHS&T equipment. The major difference between the Mk 14 Mod 1 and the Mk 14 Mod 2 canister is the new Mechanical Longitudinal Shock Mitigation Devices (Mechanical Springs). The Mk 14 Mod 2 canister configuration also includes ablative blocks and burn through protection plates that are affixed to the aft end of the canister to protect against canister sidewall burn through during a restrained firing.

1.30 INERT VARIANTS.

The paragraphs below discuss certification, training, and other inert variants provided to Fleet and shorebase operational and support activities to conduct training, maintain technical proficiency, and complete personnel, crew, and ship certifications.

1.30.1 Canister Trainer Mk 17. The Mk 17 Canister is an inert facsimile of the Mk 10 Canister used to train personnel to handle RGM-109-2 variants and the Mk 10 Canister.

1.30.2 Mk 14 Canister Trainer. The Mk 14 Canister Trainer is an inert unit used to train personnel to handle the Mk 14 Mod 1/2 Canister and to encanister and decanister RGM-109-2 variants using the Mk 17 Trainer.

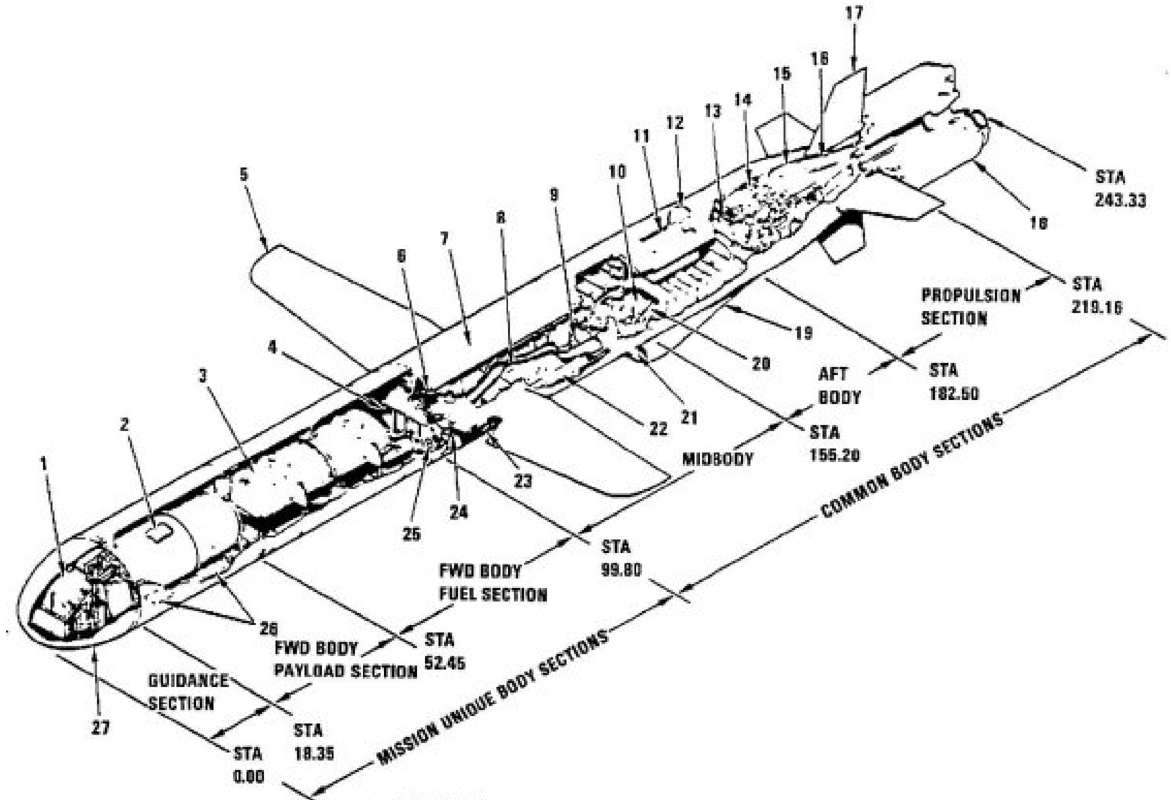
1.31 RECORD BOOK.

PEO(W) PUB 4440, Record Book for the TOMAHAWK Cruise Missile is used to record data pertinent to the RGM-109-2 variant and the VLS AUR. Instructions for use, forms completion, and disposition are contained in PEO(W) INST 4440.2 and the record book. PEO(W) PUB 4440 is not used to record data applicable to the Mk 14 Canister without an encanistered RGM-109-2 variant.

1.32 WEIGHTS AND CENTERS OF GRAVITY.

Weights and centers of gravity of RGM-109-2 variants and related material are contained in Tables 1-13 "Weights of RGM-109-2 Mk 10 Variants and Related Material"⇒ and 1-14 "Centers of Gravity for RGM-109-2 Variants"⇒ respectively. Weights of VLS variants are contained in Table 1-15 "Weights of VLS Variants"⇒.

Figure 1-1. Land-Attack 109A



1. GUIDANCE SET
2. W80 WARHEAD
3. FUEL EXPANSION BLADDER
4. CMA THERMAL BATTERY (DRY WELL, RH SIDE)
5. WING
6. WING ACTUATOR
7. STANDARD MISSION COVER
8. LATERAL THROUGH-SLOT
9. DOOR ACTUATOR
10. AIR DATA PACKAGE
11. MISSION CONTROL MODULE
12. PNEUMATIC STORAGE BOTTLE HOUSING
13. DC GENERATOR-REGULATOR
14. SUSTAINER ENGINE
15. FIN POWER SWITCHING AMPLIFIER
16. FIN SERVOACTUATOR (3)
17. FIN (4)
18. ROCKET MOTOR
19. ENGINE INLET
20. INLET ACTUATOR
21. PITOT HEAD
22. FUEL EXPANSION BLADDER
23. FUEL/DEFUEL PANEL
24. FUEL HOPPER
25. COOLANT PUMP (GUIDANCE SET)
26. RADAR ALTIMETER ANTENNA (2)
27. NOSE CONE KIT OR NOSE FAIRING

Figure 1-2. Cruise Missile Guidance Set (CMGS)

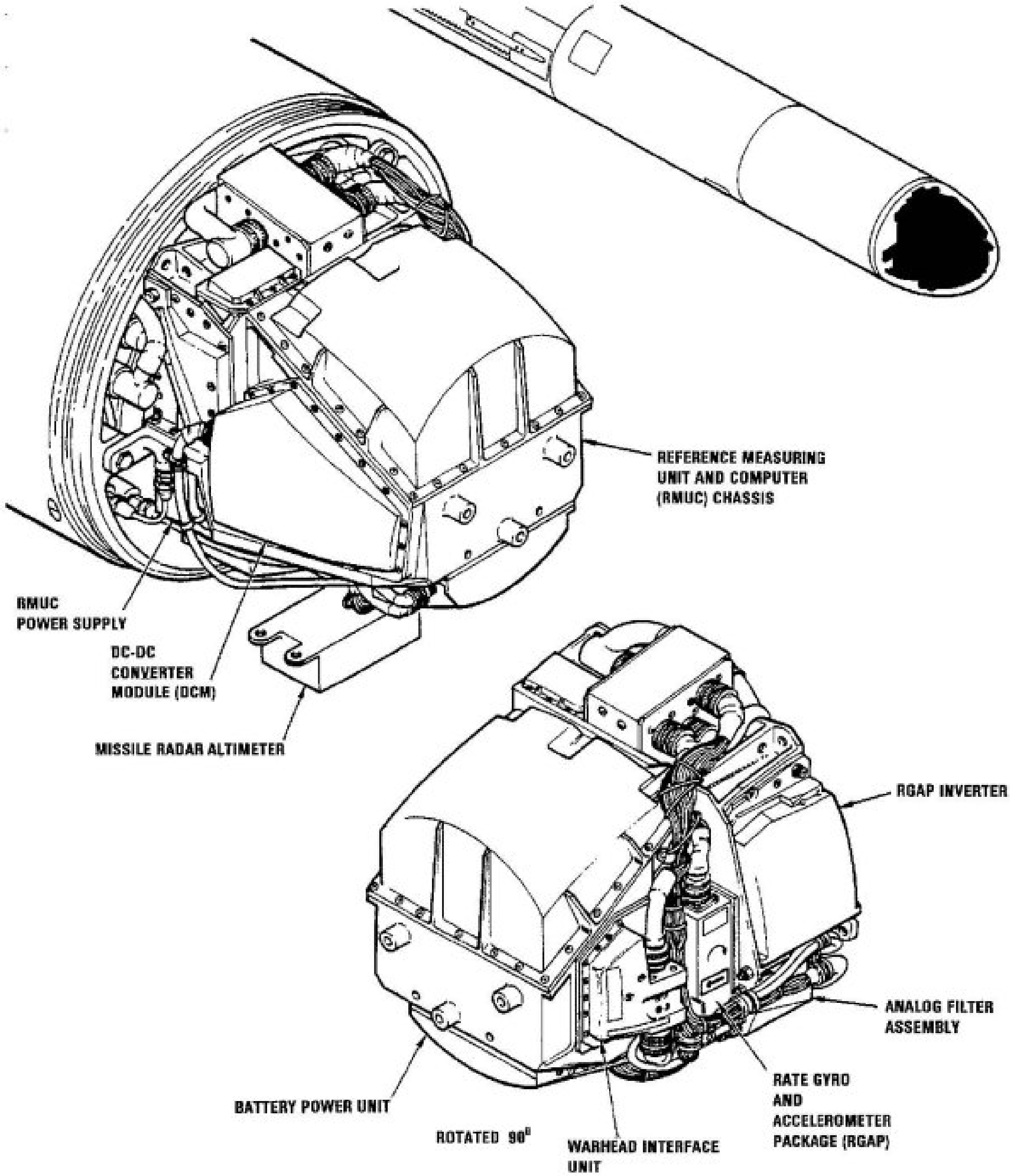
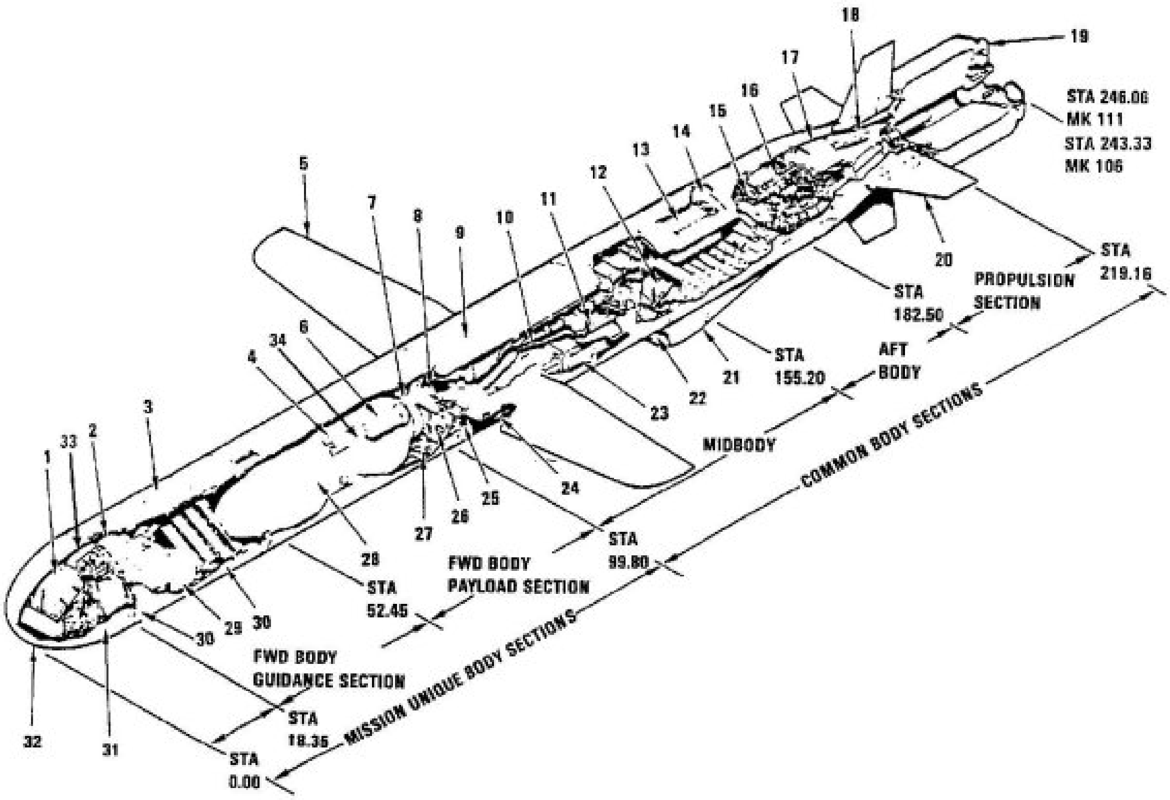


Figure 1-3. Land-Attack 109C



1. GUIDANCE SET
2. DSMAC OR DSMAC II A SET
3. JUNCTION BOX
4. WARHEAD SUPPORT WEDGE (4)
5. WING
6. WARHEAD FUZE-BOOSTER
7. CMA THERMAL BATTERY (DRY WELL, RH SIDE)
8. WING ACTUATOR
9. STANDARD MISSION COVER
10. LATERAL THROUGH-SLOT
11. DOOR ACTUATOR
12. AIR DATA PACKAGE
13. MISSION CONTROL MODULE
14. PNEUMATIC STORAGE BOTTLE HOUSING
15. DC GENERATOR-REGULATOR
16. SUSTAINER ENGINE
17. FIN POWER SWITCHING AMPLIFIER
18. FIN SERVOACTUATOR (3)
19. ROCKET MOTOR
20. FIN (4)
21. ENGINE INLET
22. PITOT HEAD
23. FUEL EXPANSION BLADDER
24. FUEL/DEFUEL PANEL
25. FUEL HOPPER
26. COOLANT PUMP (GUIDANCE SET)
27. DUAL AIR VALVE (WARHEAD FUZE PREARM)
28. WDU-25/B OR WDU-36/B WARHEAD OR TEST PAYLOAD
29. ILLUMINATOR ASSEMBLY
30. RADAR ALTIMETER ANTENNA (2)
31. SENSOR WINDOW COVER & THRUSTER
32. NOSE CONE KIT OR NOSE FAIRING
33. GPSS RECEIVER PROCESSOR UNIT
34. GPSS ANTENNA MODULE

Figure 1-4. Digital Scene Matching Correlation (DSMAC)

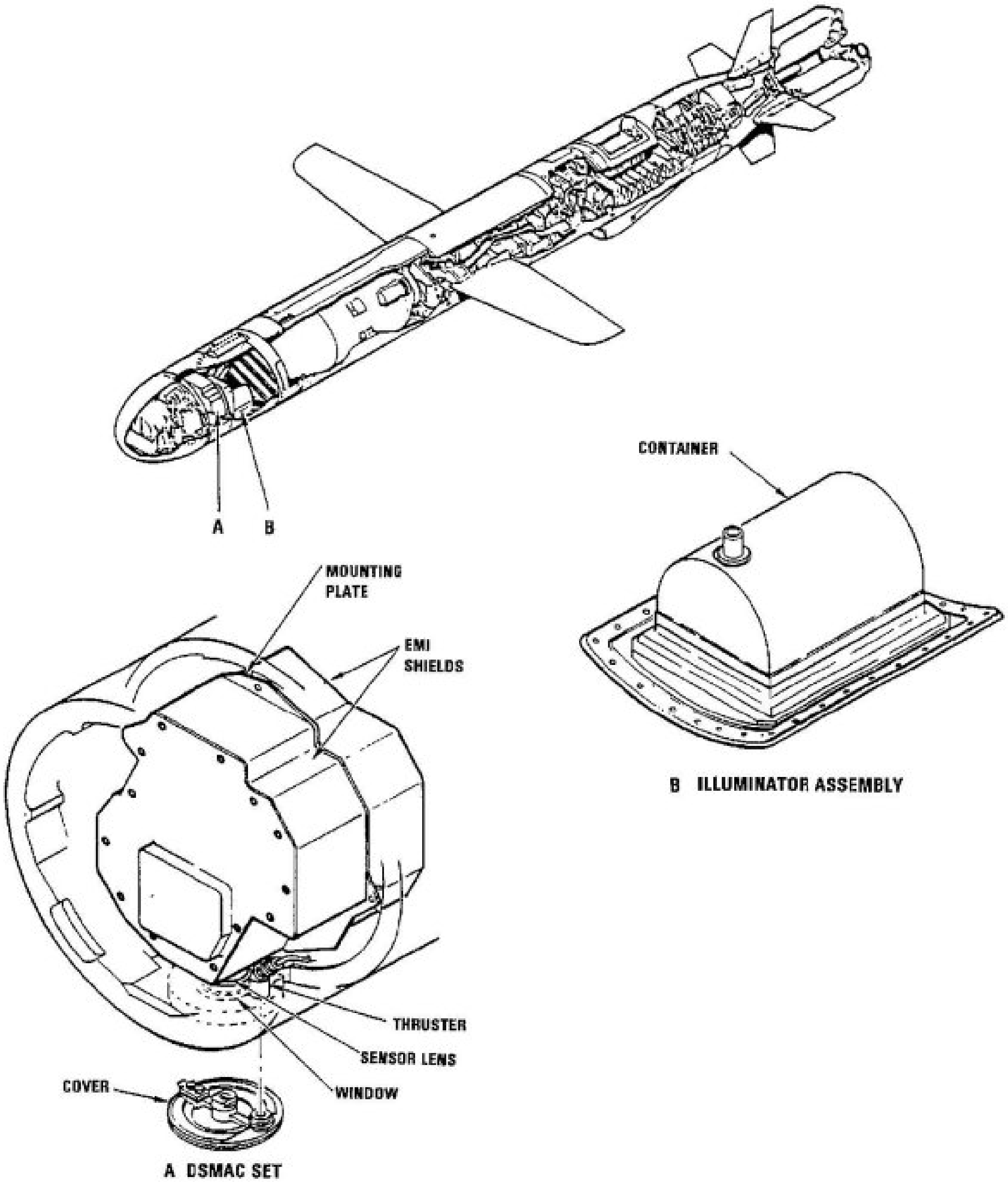
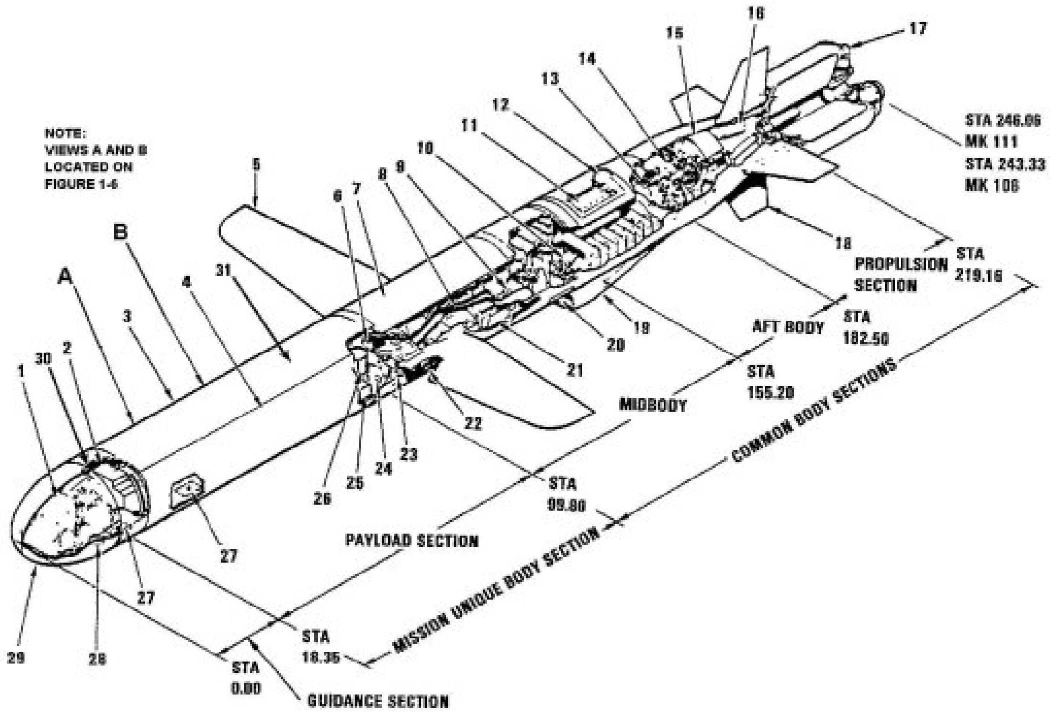


Figure 1-5. Land-Attack 109D



1. GUIDANCE SET
2. DSMAC OR DSMAC II A SET
3. AVIONICS THROUGH ACCESS COVER
4. PAYLOAD COVER (2)
5. WING
6. WING ACTUATOR
7. STANDARD MISSION COVER
8. LATERAL THROUGH-SLOT
9. DOOR ACTUATOR
10. AIR DATA PACKAGE
11. MISSION CONTROL MODULE
12. PNEUMATIC STORAGE BOTTLE HOUSING
13. DC GENERATOR-REGULATOR
14. SUSTAINER ENGINE
15. FIN POWER SWITCHING AMPLIFIER
16. FIN SERVOACTUATOR (3)
17. ROCKET MOTOR
18. FIN (4)
19. ENGINE INLET
20. PITOT HEAD
21. FUEL EXPANSION BLADDER
22. FUEL/DEFUEL PANEL
23. FUEL HOPPER
24. COOLANT PUMP (GUIDANCE SET)
25. DSMAC ILLUMINATOR UNIT REFLECTOR
26. DSMAC ILLUMINATOR UNIT ELECTRONIC ASSEMBLY
27. RADAR ALTIMETER ANTENNA (2)
28. SENSOR WINDOW COVER & THRUSTER
29. NOSE FAIRING
30. GPSS RECEIVER PROCESSOR UNIT
31. GPSS ANTENNA MODULE

Figure 1-6. Land-Attack 109D Payload Section

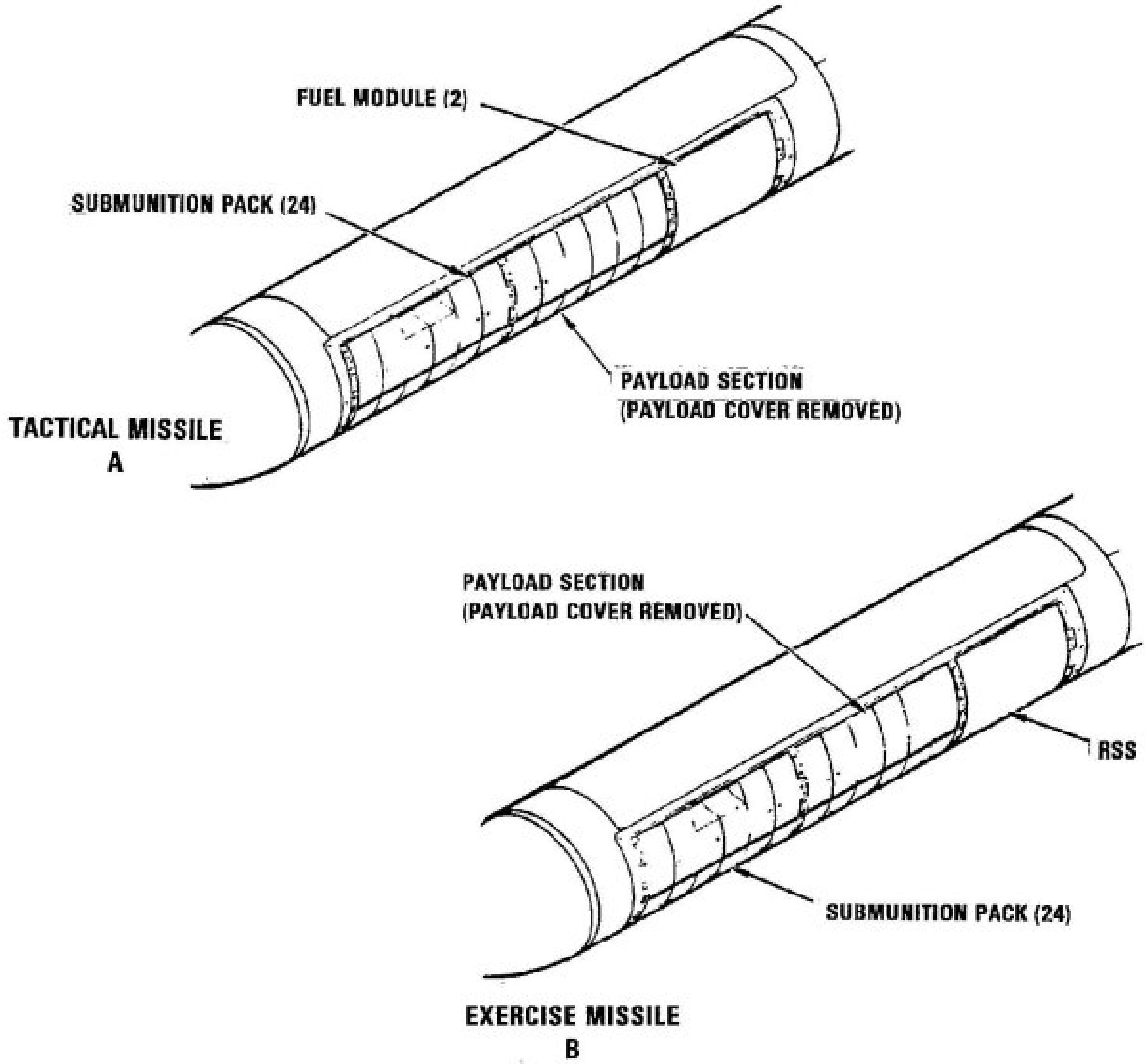


Figure 1-7. Block IV Tactical TOMAHAWK Missile General Arrangement

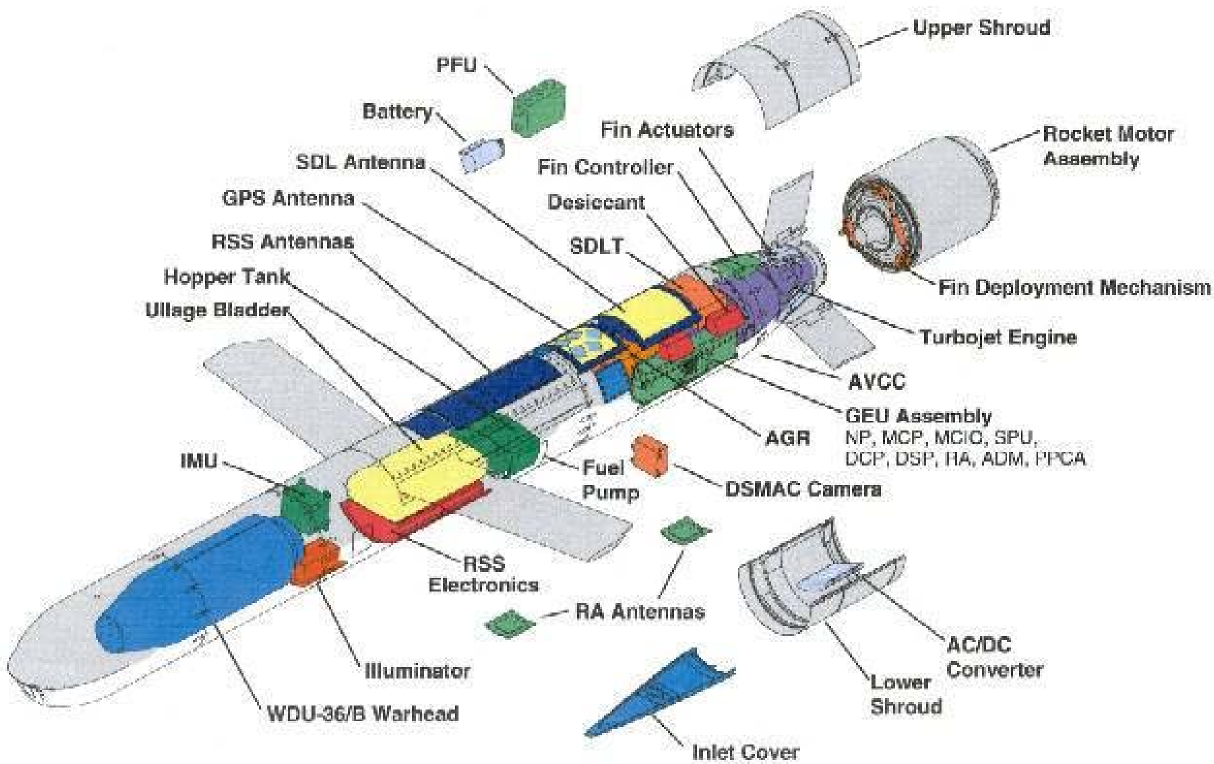


Figure 1-8. TACTOM Forward Body Section

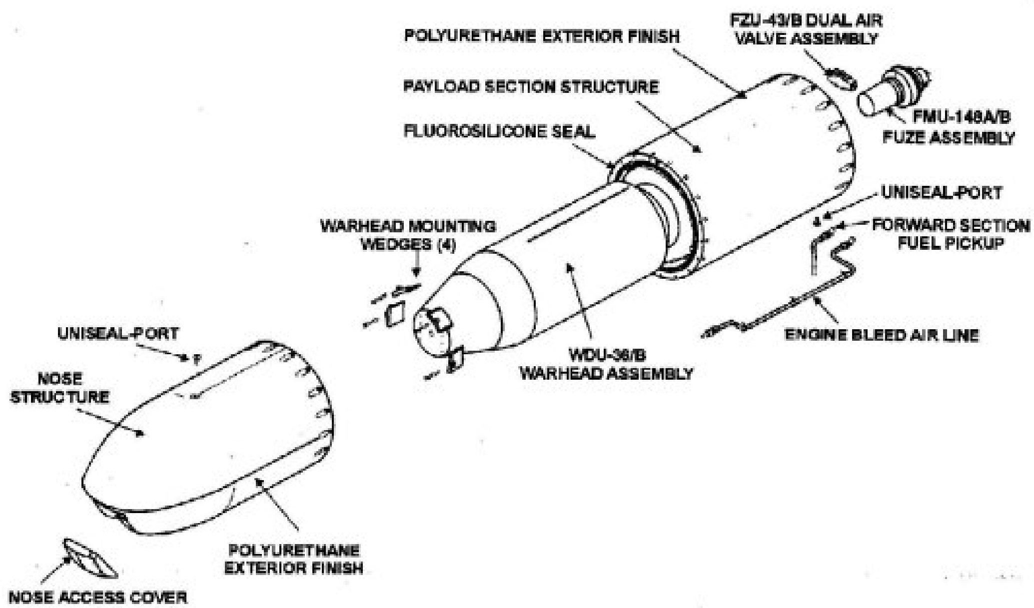


Figure 1-9. Mk 106 Rocket Motor

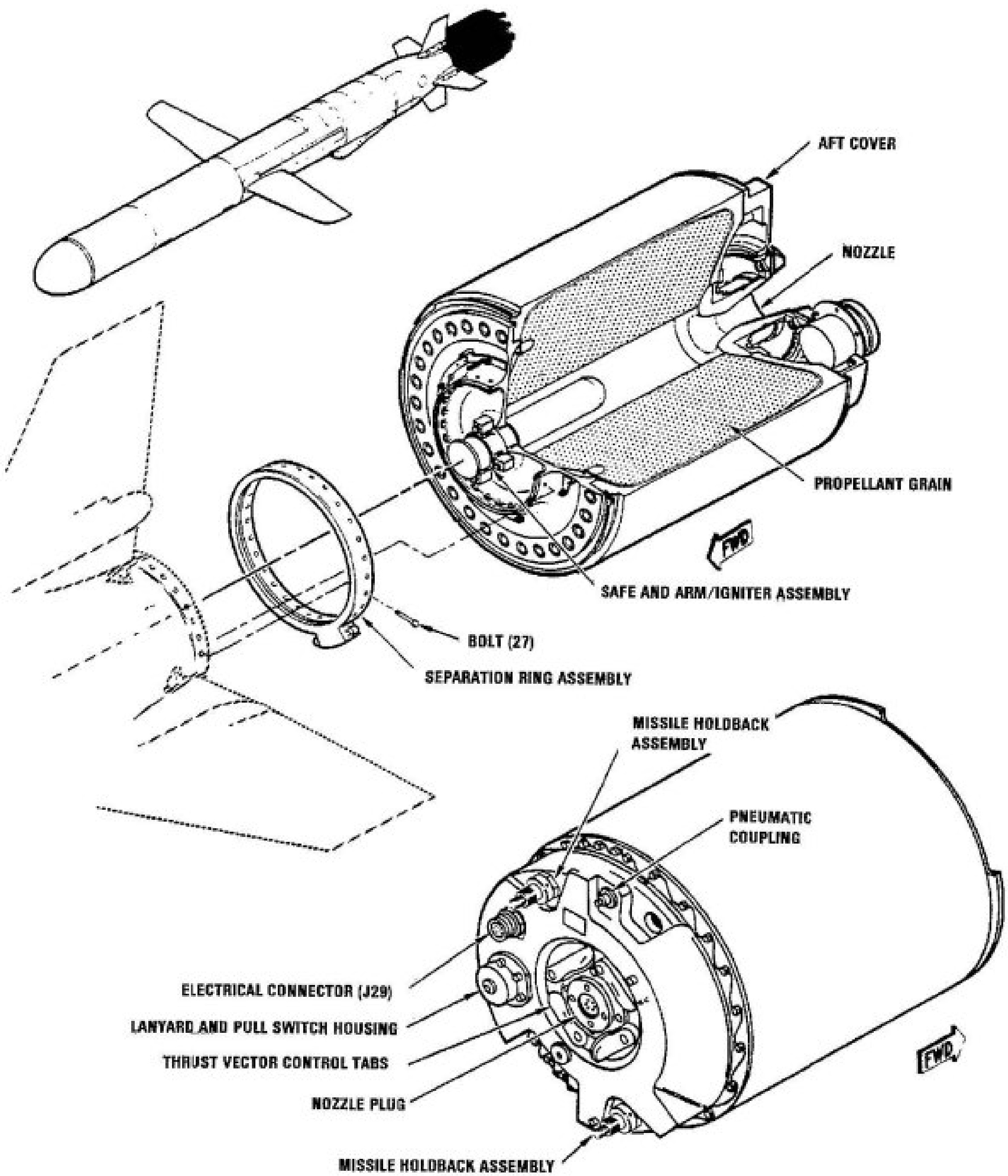


Figure 1-10. Mk 111 Rocket Motor

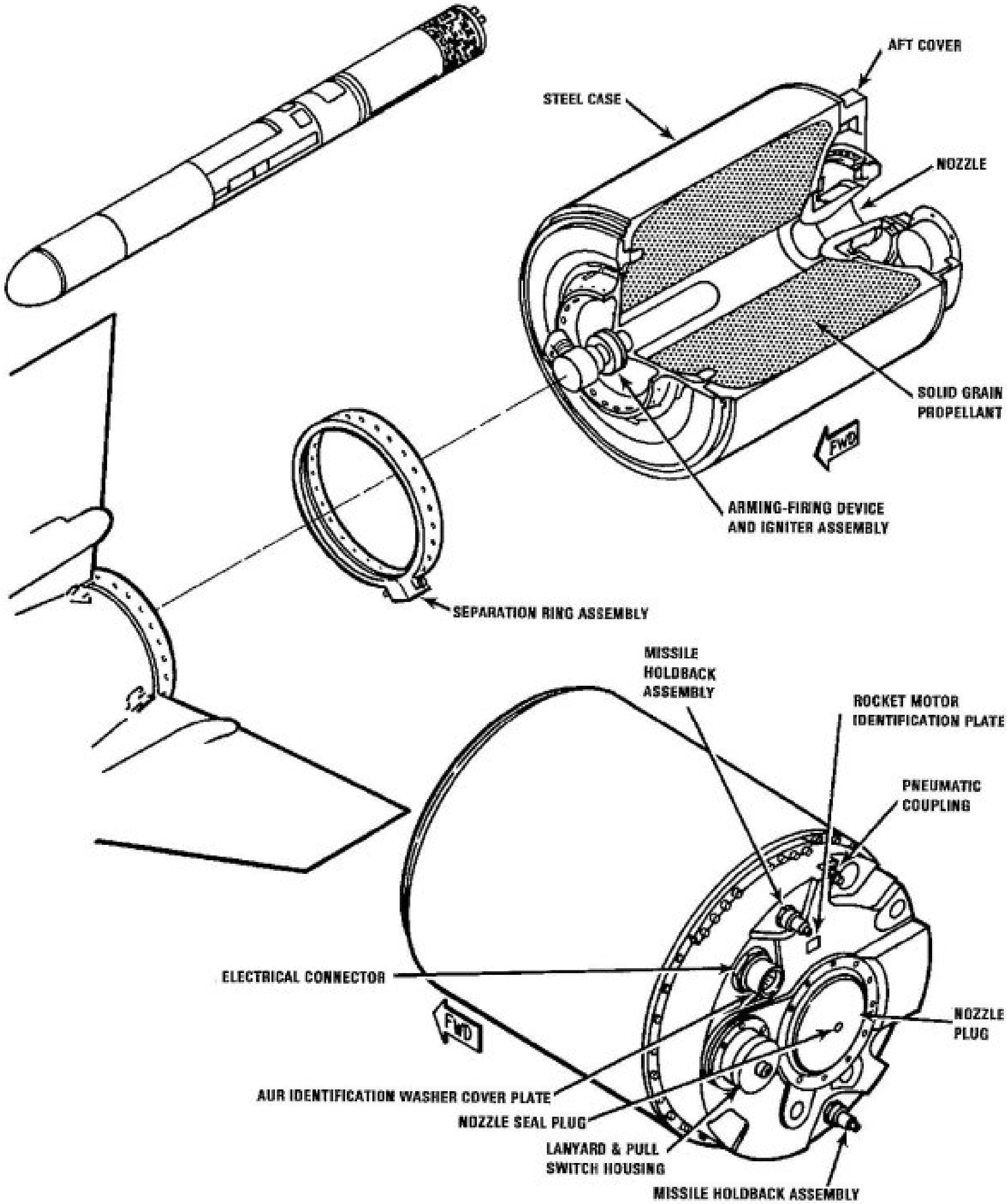


Figure 1-11. Underwater Protection Devices

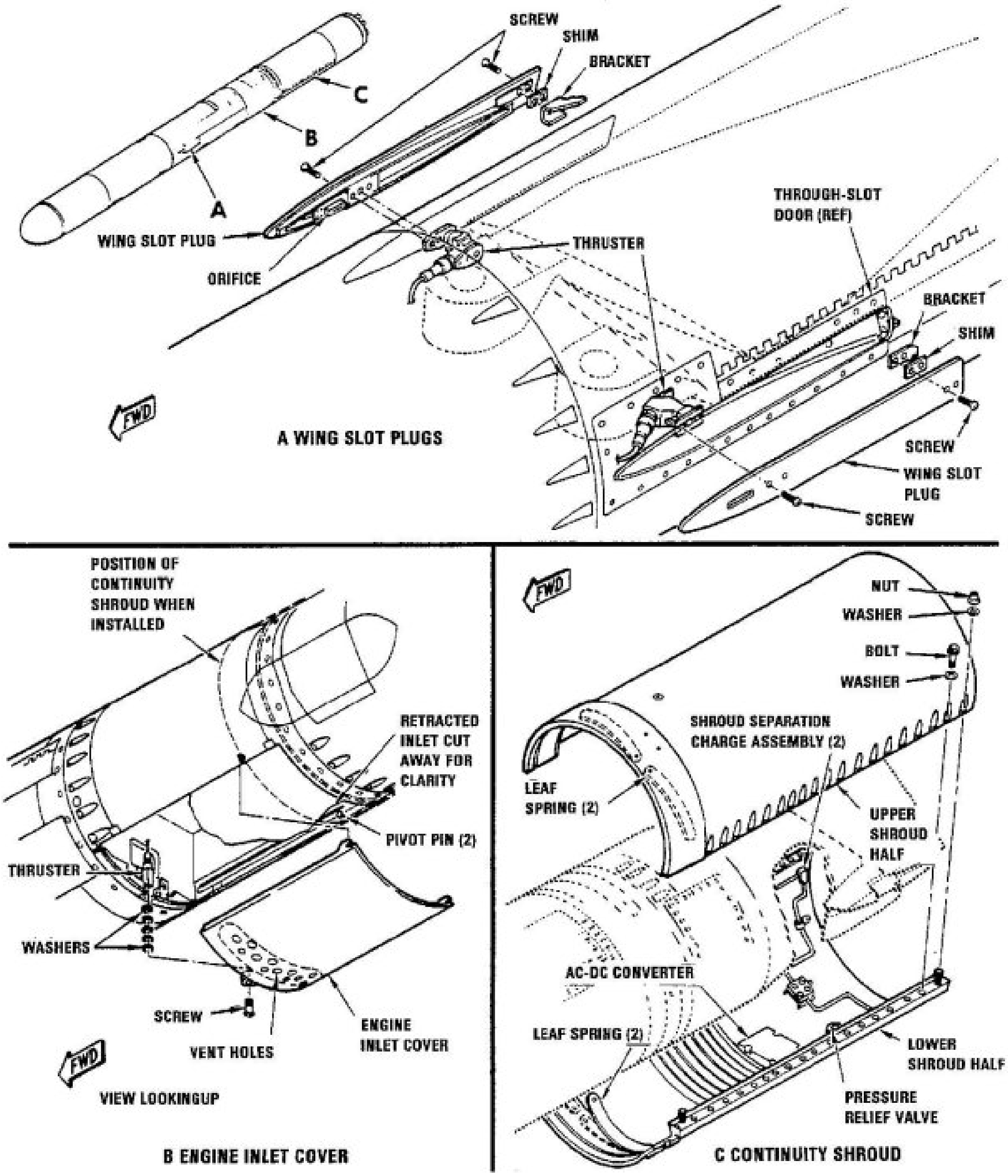
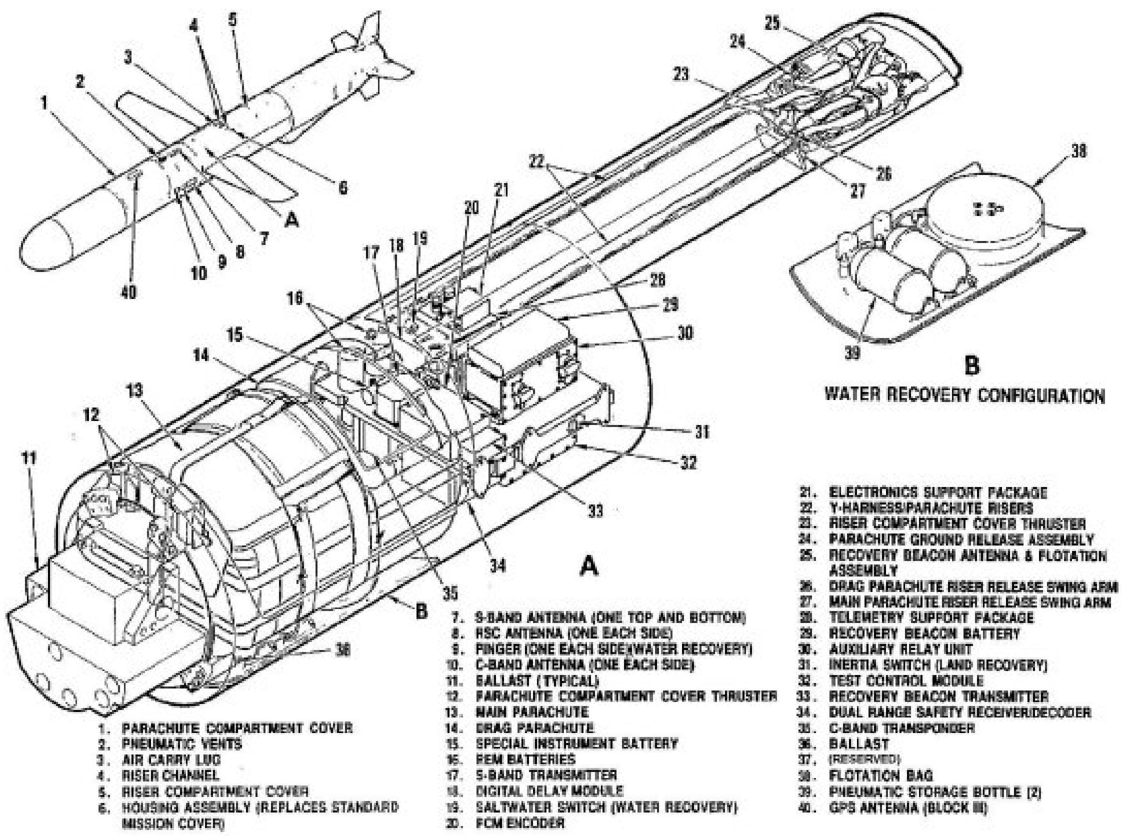
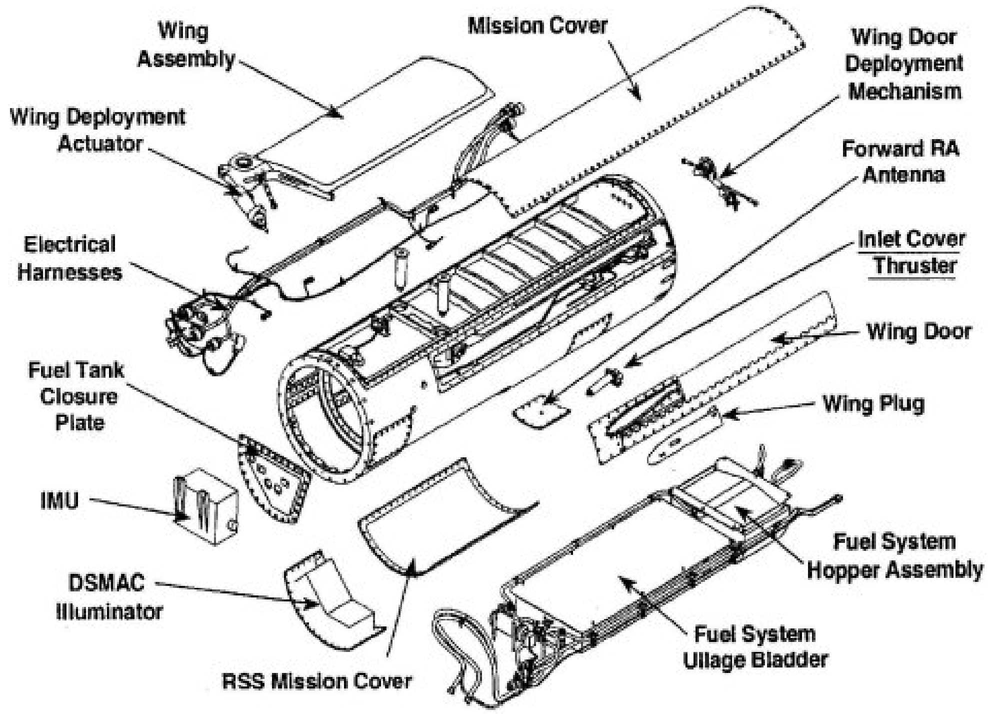


Figure 1-12. Recovery Exercise Module



6008 REM CONFIGURATION

Figure 1-13. TACTOM Midbody Section



Note: Pyrotechnic components are underlined.

Figure 1-14. Range Safety System (109C)

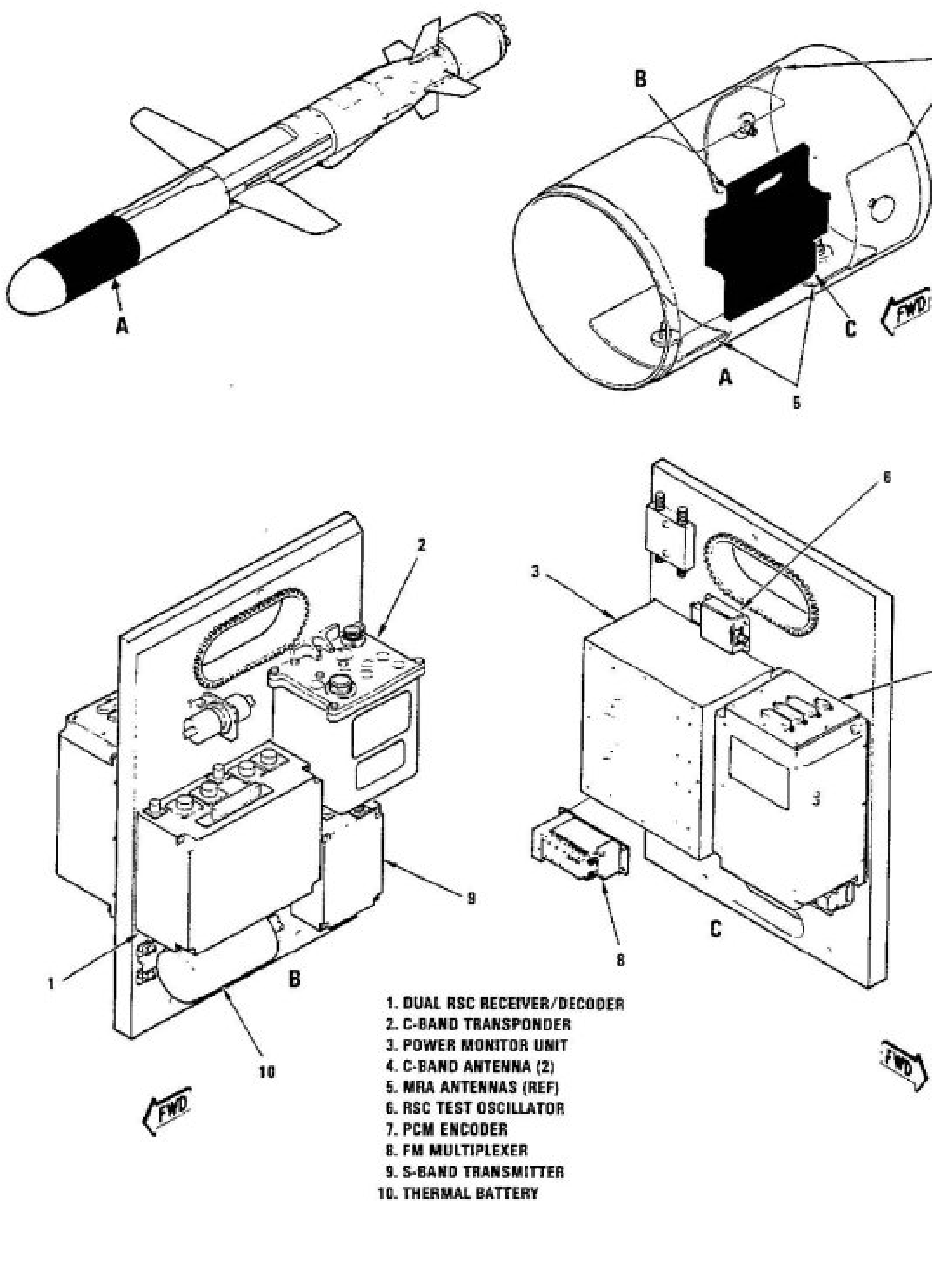


Figure 1-15. Range Safety System (109D)

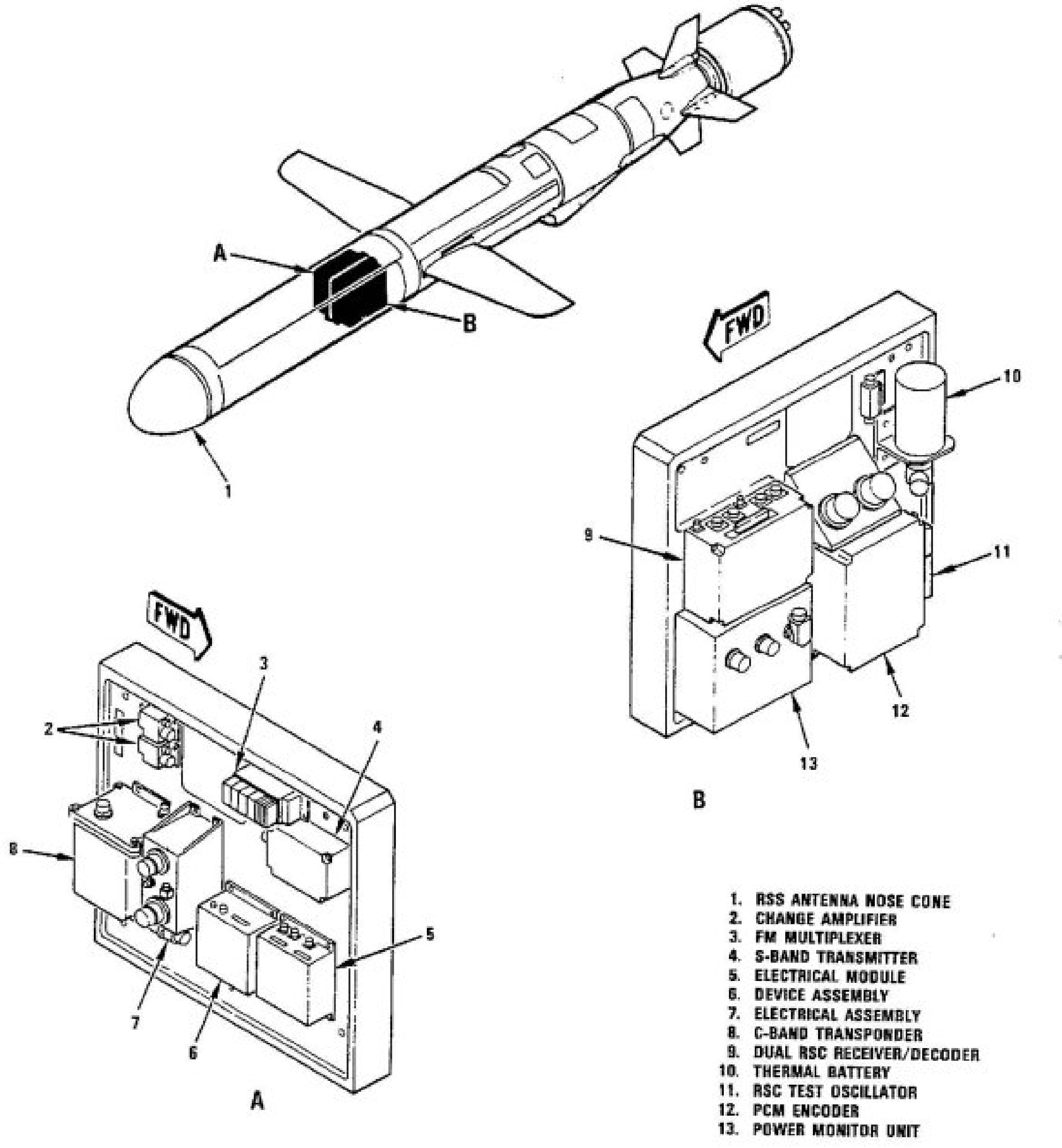


Figure 1-16. Typical Land-Attack TCM Pre-landfall Flyout Route

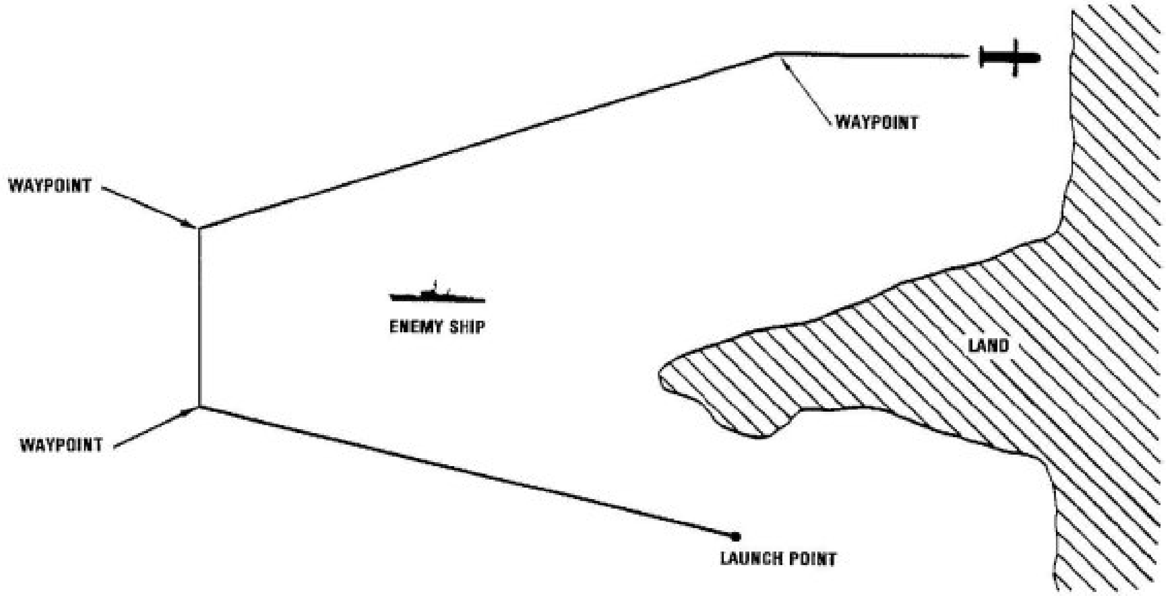


Figure 1-17. Terrain Contour Matching (TERCOM) Process

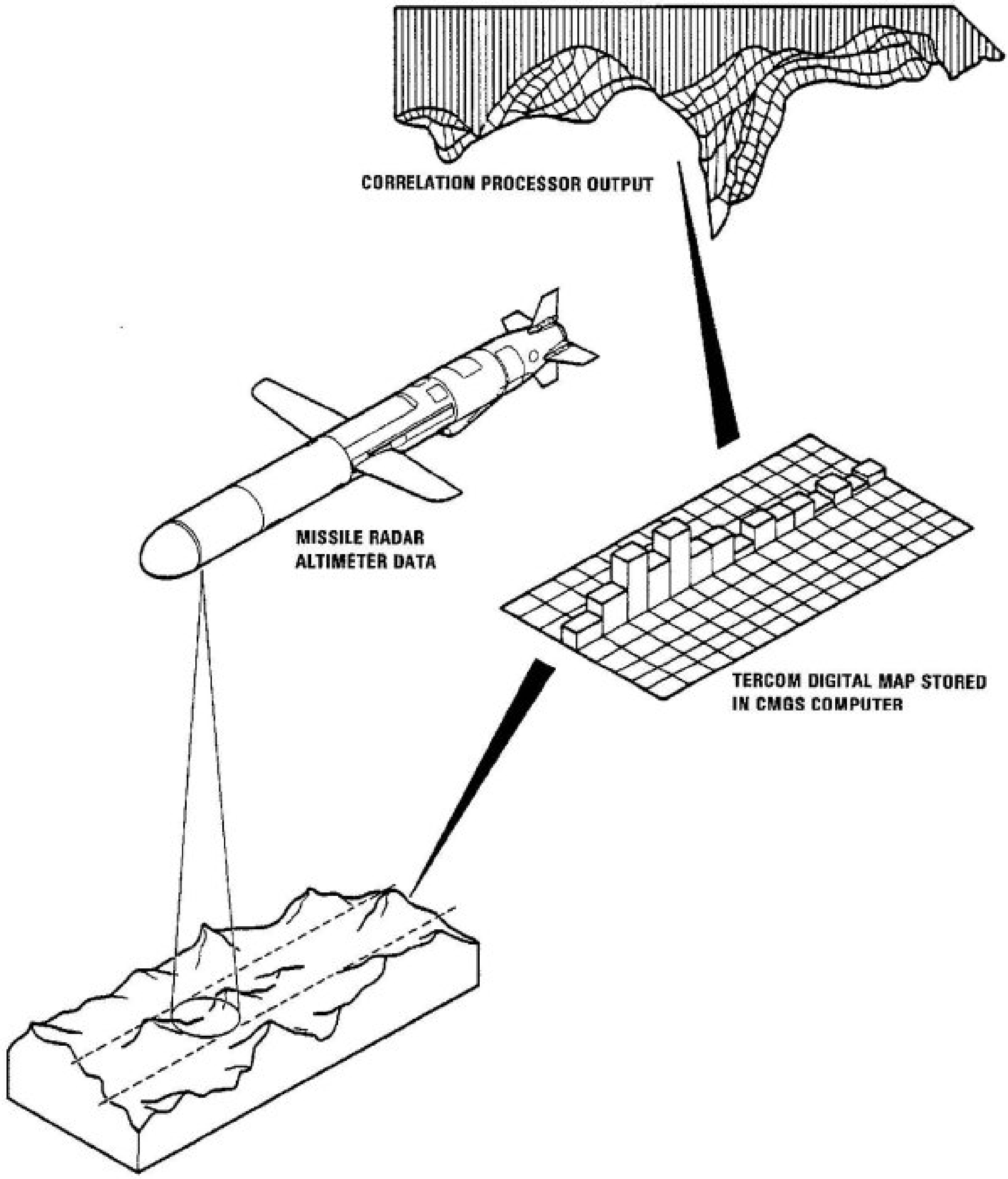


Figure 1-18. TACTOM Aftbody and Tailcone Section

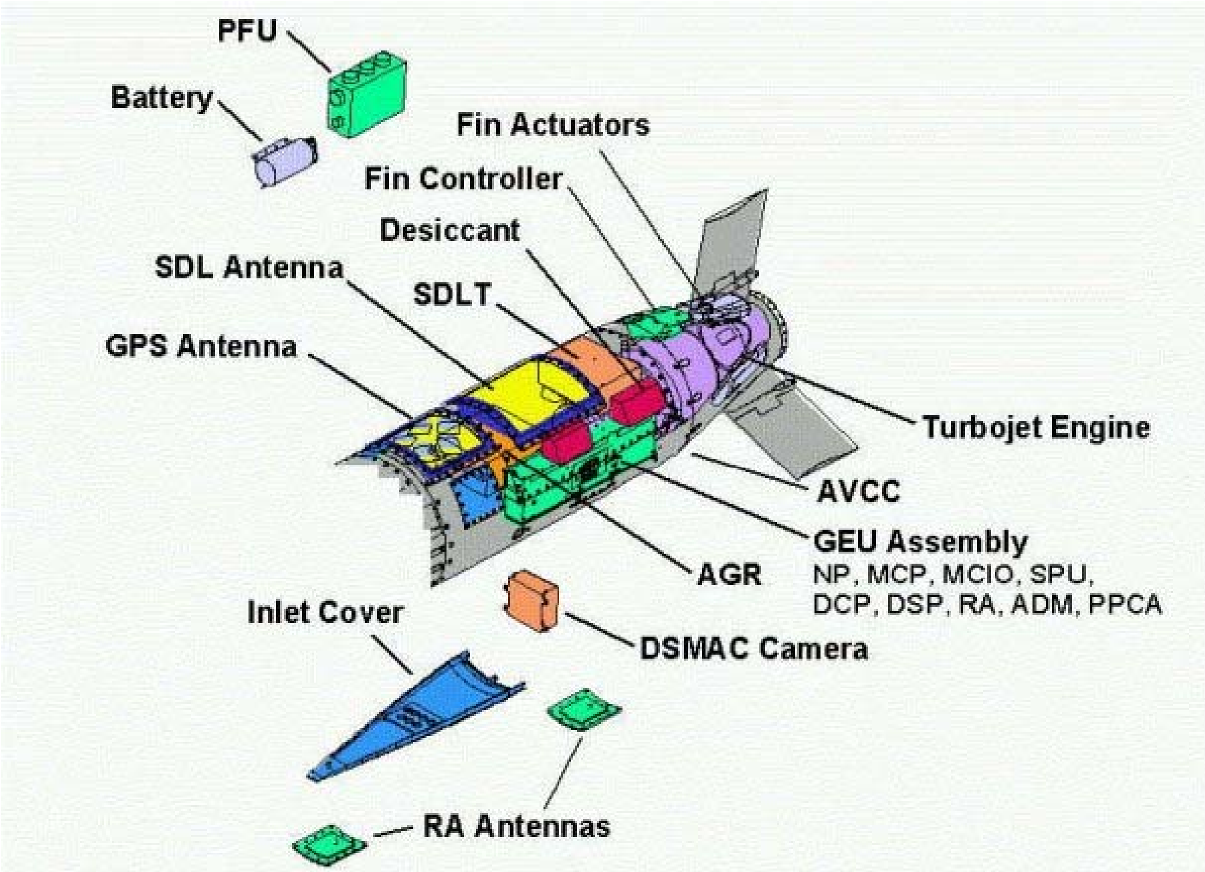


Figure 1-19. Typical Mission Profile (109A/C)

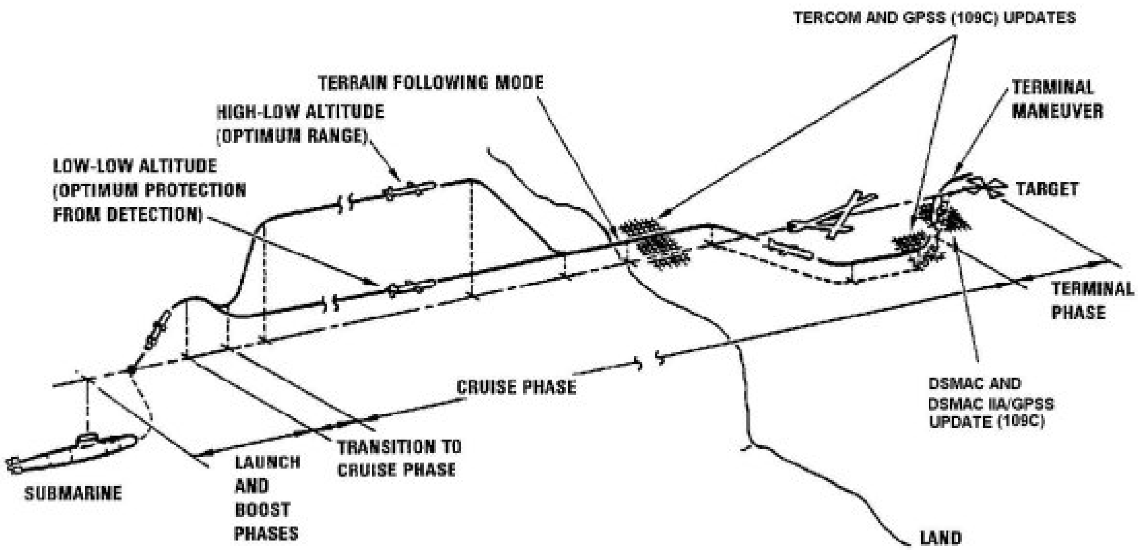


Figure 1-20. Typical Mission Profile (109D)

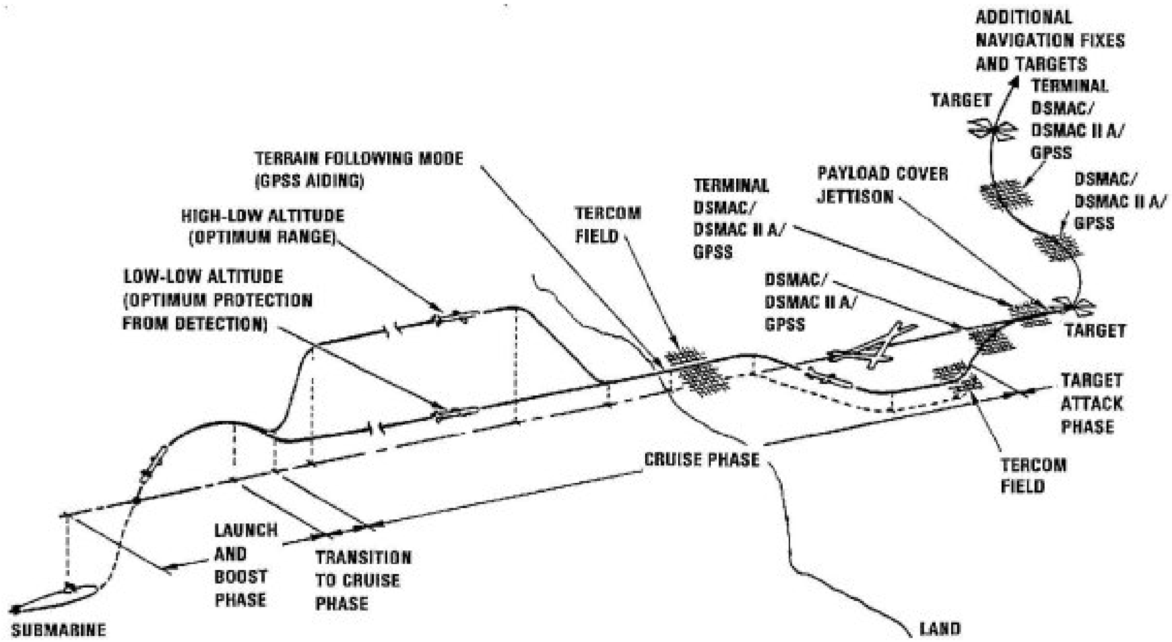


Figure 1-21. CLS Missile Tube Loading and Handling Trainer Assembly

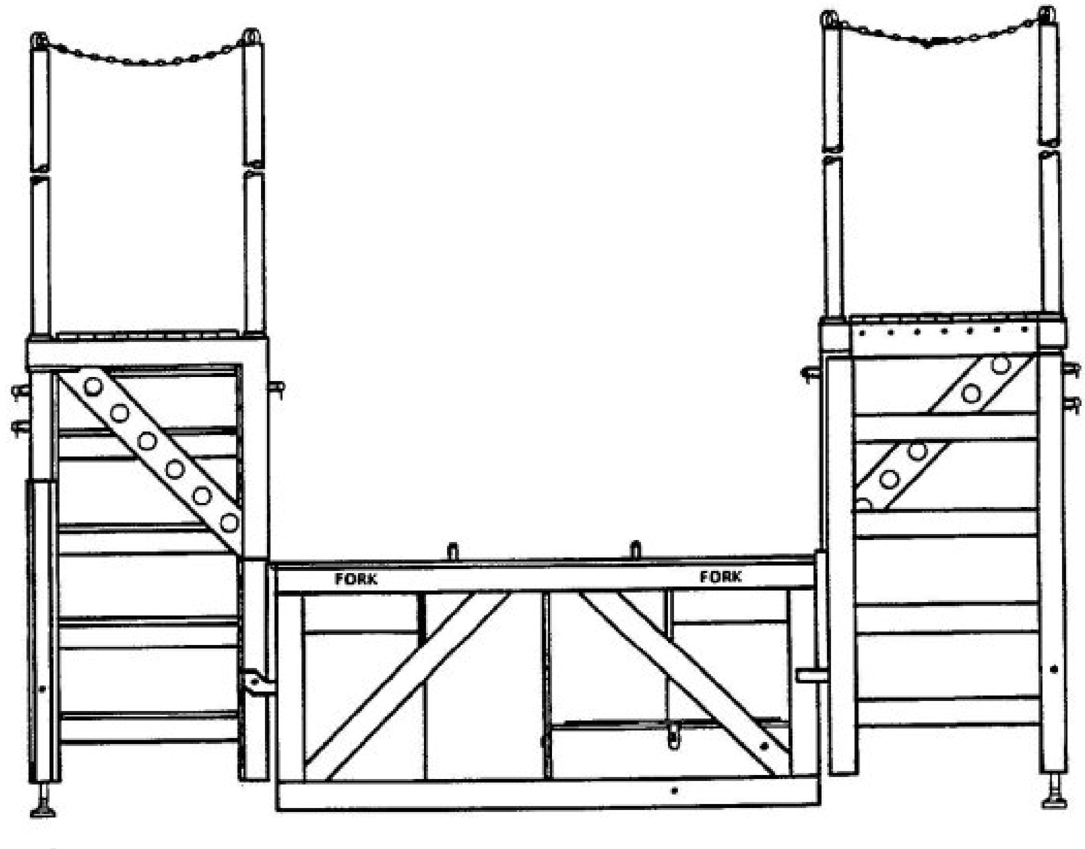


Figure 1-22. Typical Parachute Recovery of REM-Equipped Missile

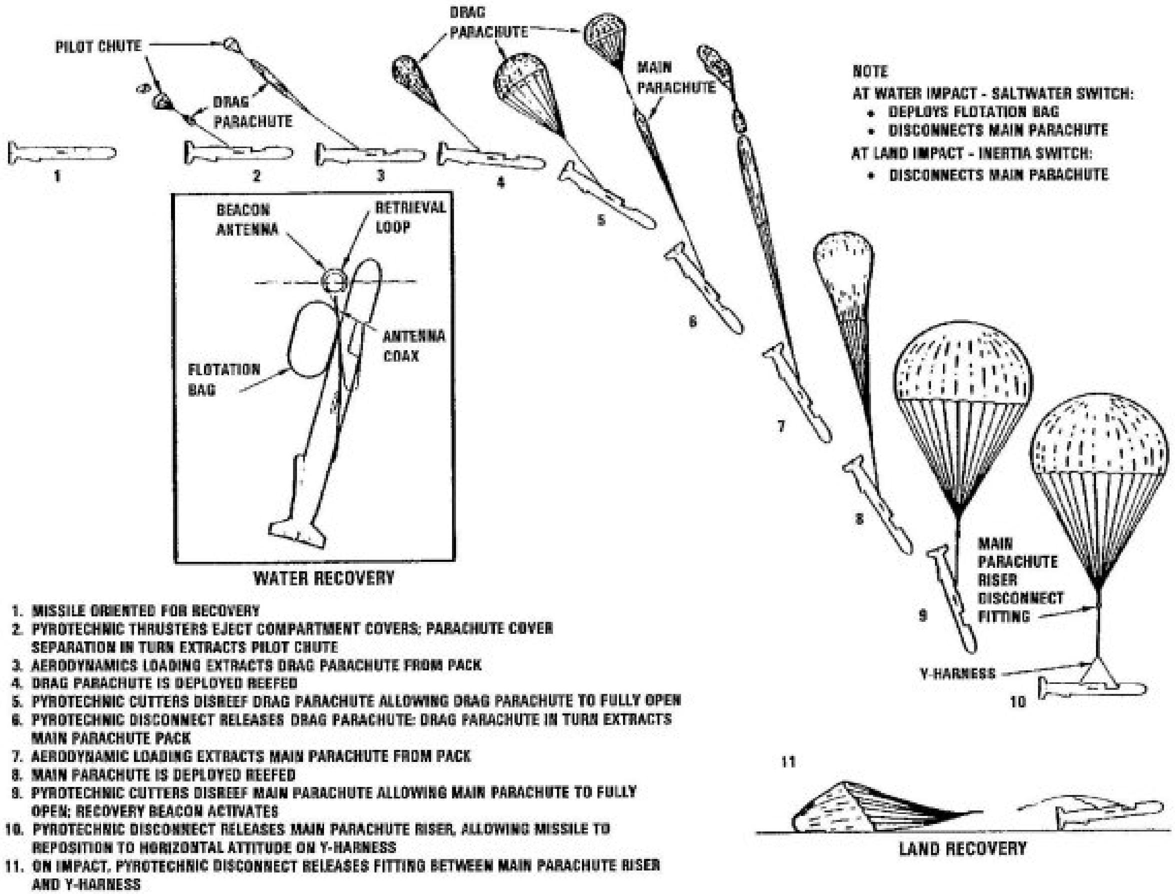
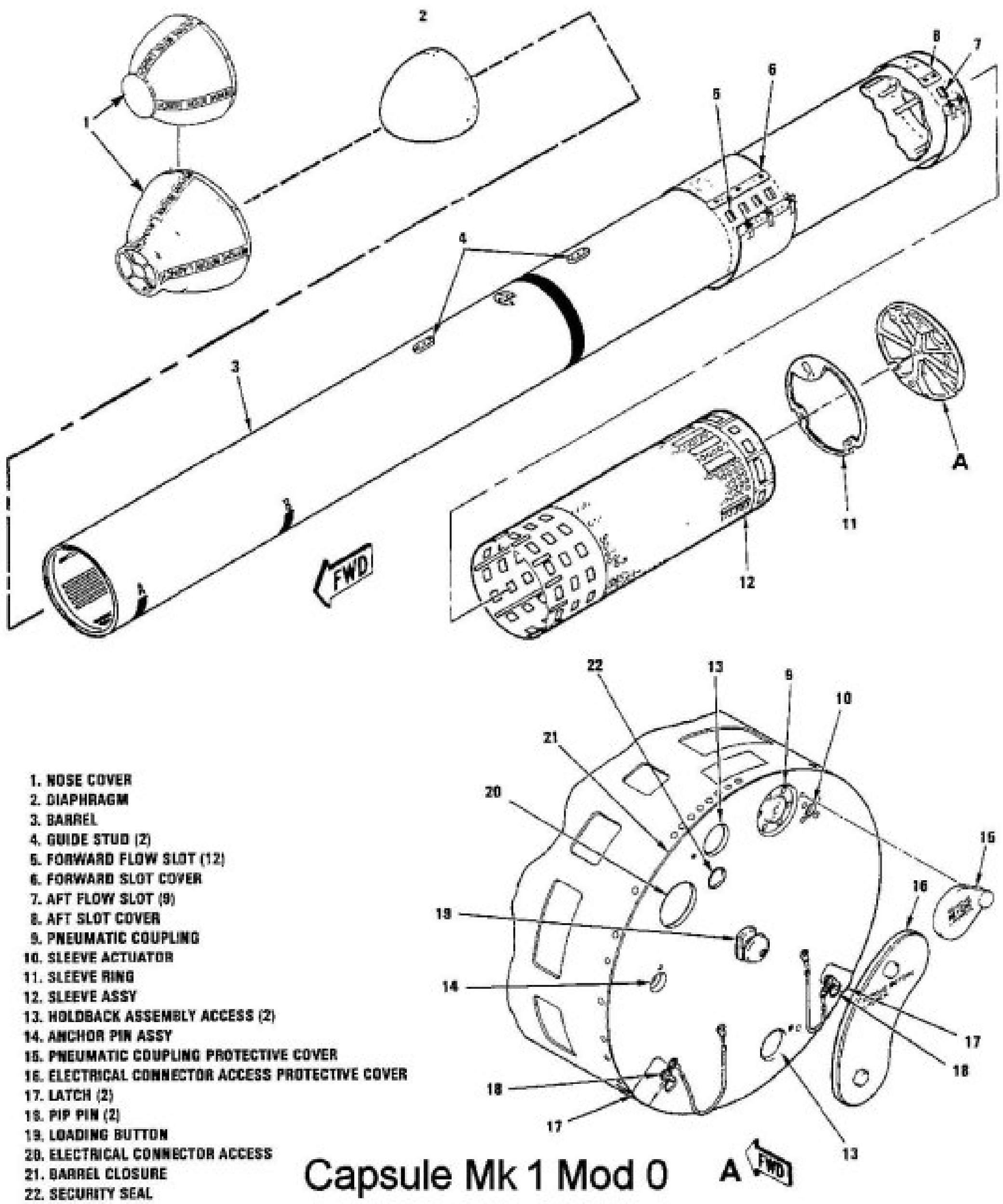


Figure 1-23. TTL Capsules (2 Sheets)



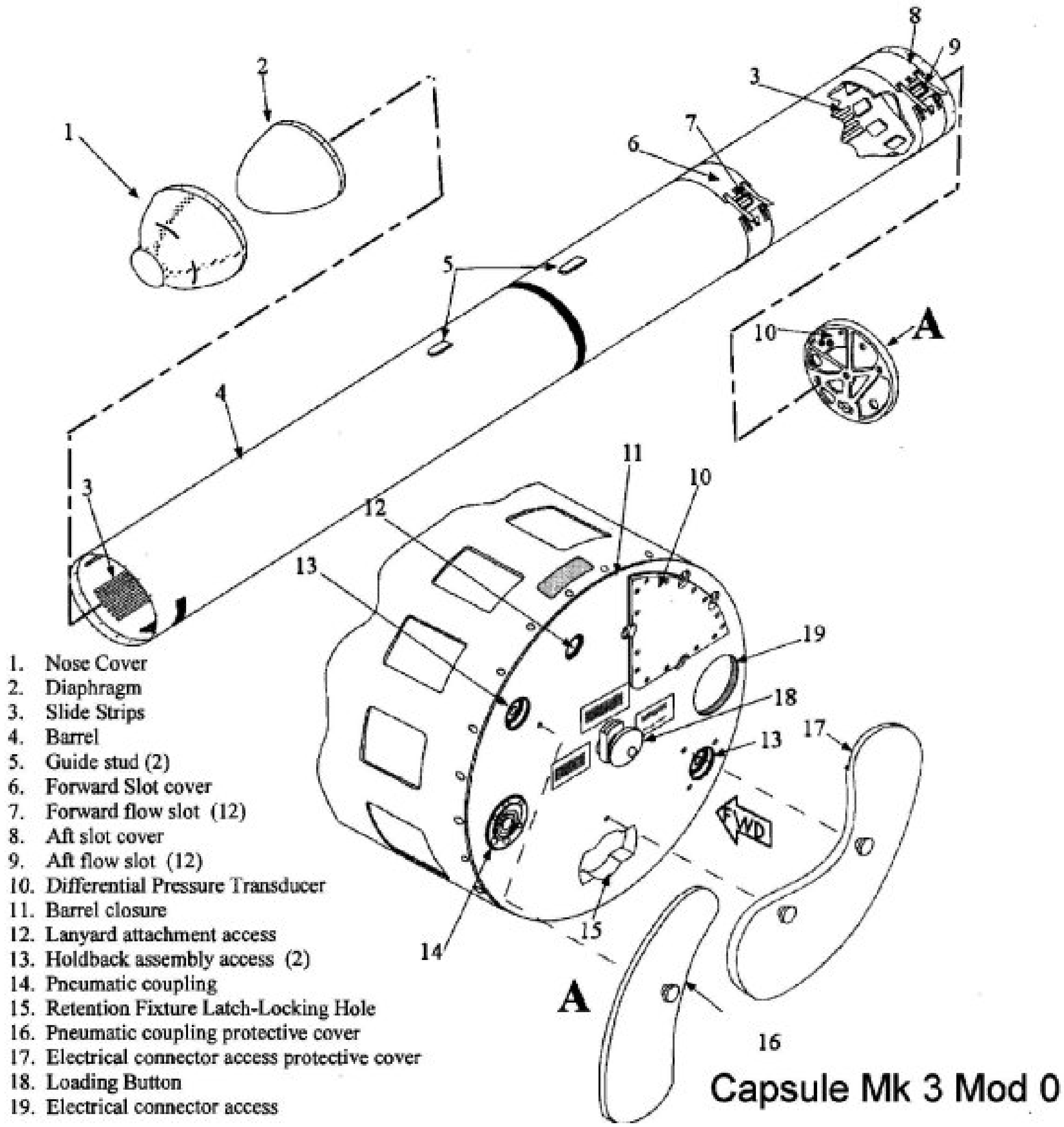

1. Nose Cover
2. Diaphragm
3. Slide Strips
4. Barrel
5. Guide stud (2)
6. Forward Slot cover
7. Forward flow slot (12)
8. Aft slot cover
9. Aft flow slot (12)
10. Differential Pressure Transducer
11. Barrel closure
12. Lanyard attachment access
13. Holdback assembly access (2)
14. Pneumatic coupling
15. Retention Fixture Latch-Locking Hole
16. Pneumatic coupling protective cover
17. Electrical connector access protective cover
18. Loading Button
19. Electrical connector access
A
FWD
Capsule Mk 3 Mod 0

Figure 1-24. Electrical and Pneumatic Umbilicals

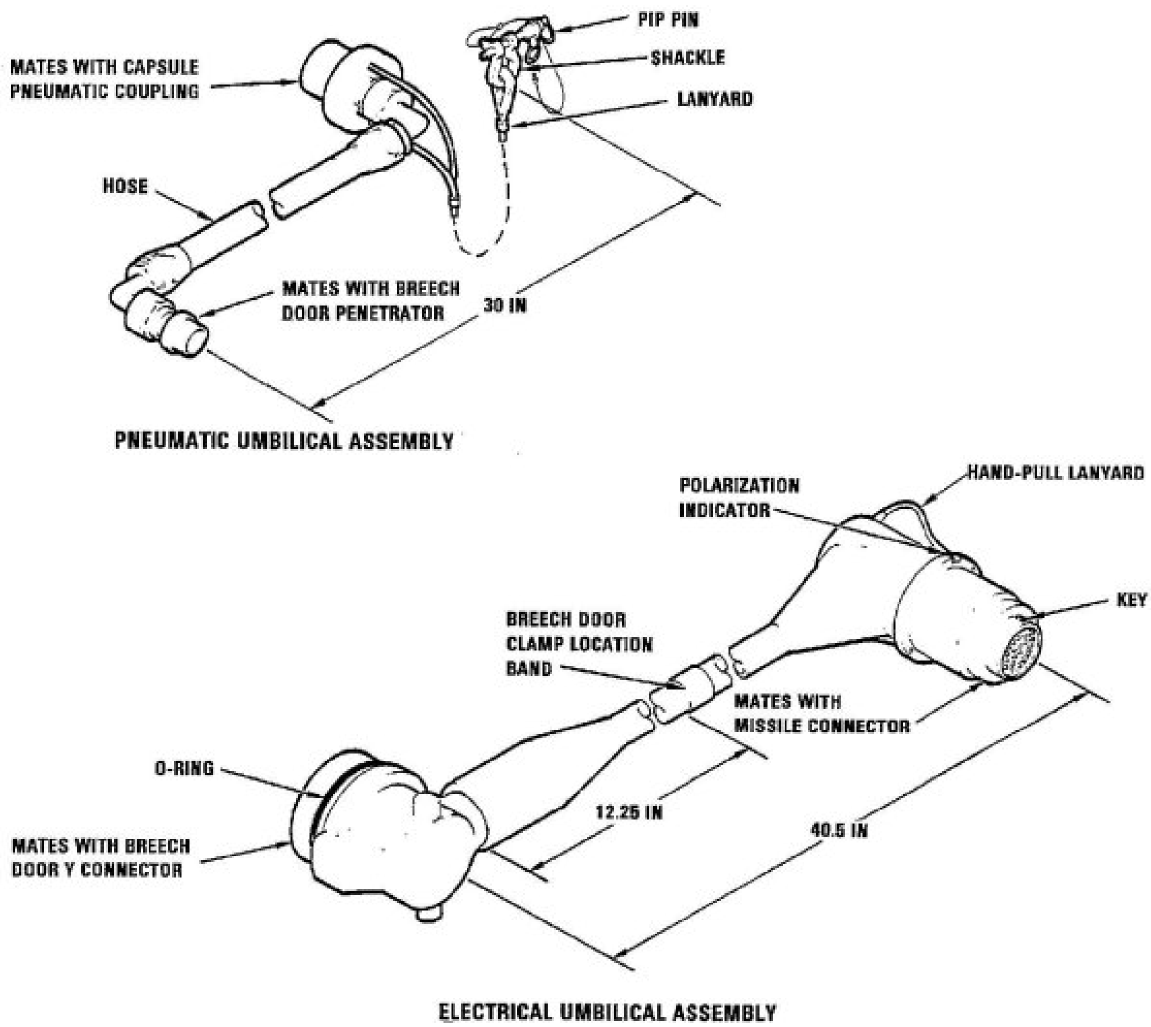


Figure 1-25. CNU-308/E Shipping Container

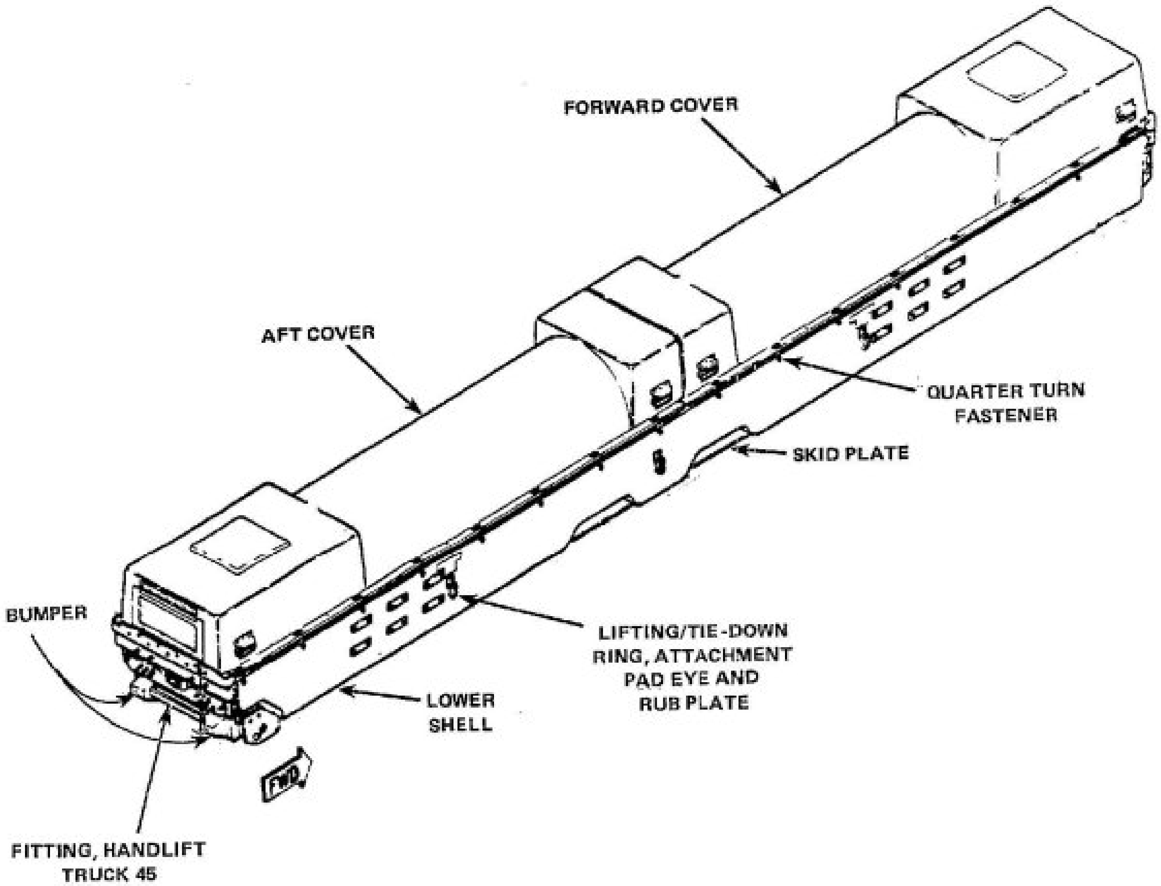


Figure 1-26. Capsule Launching System (CLS) Mk 45

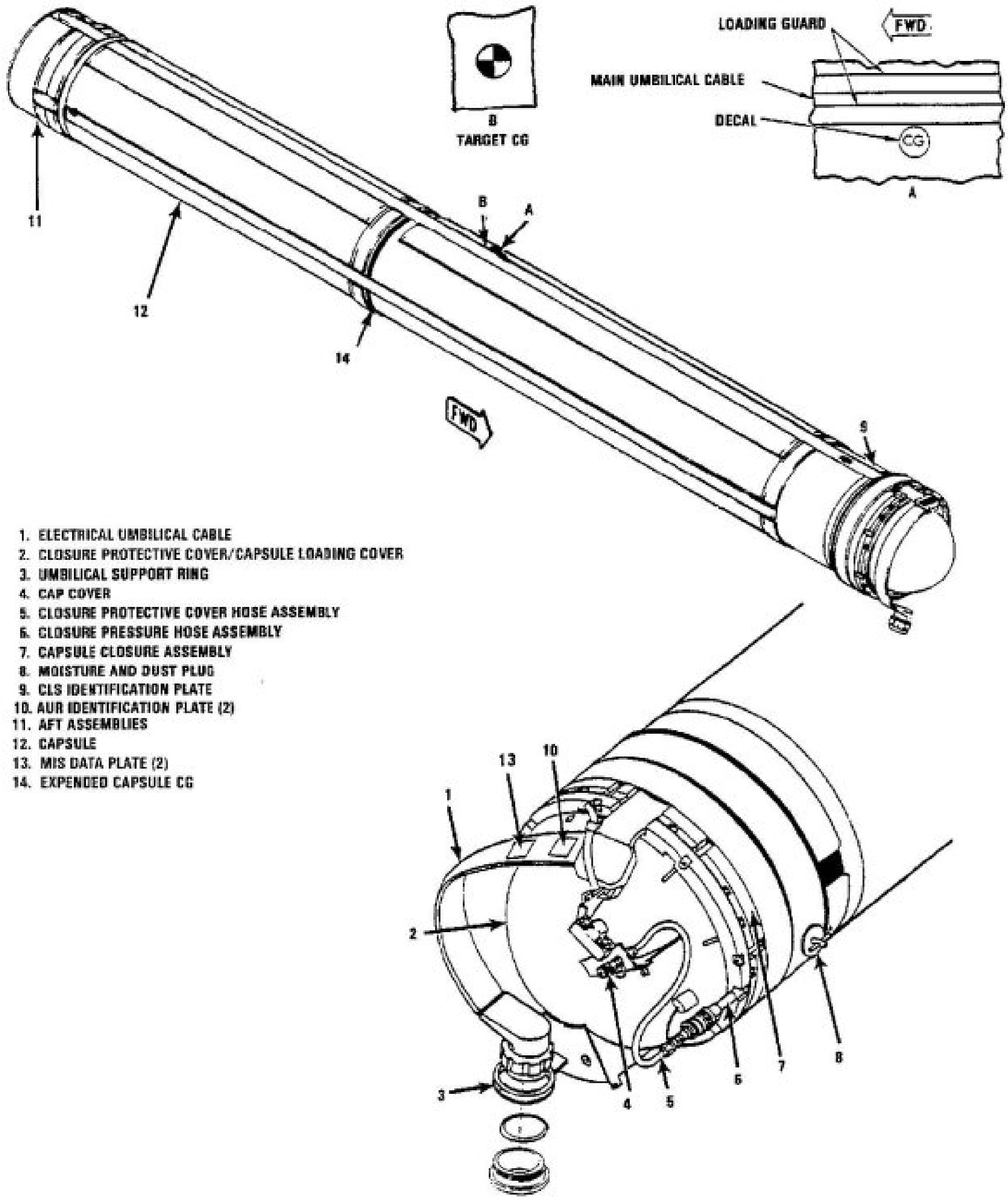


Figure 1-27. Capsule Launching System (CLS) Components

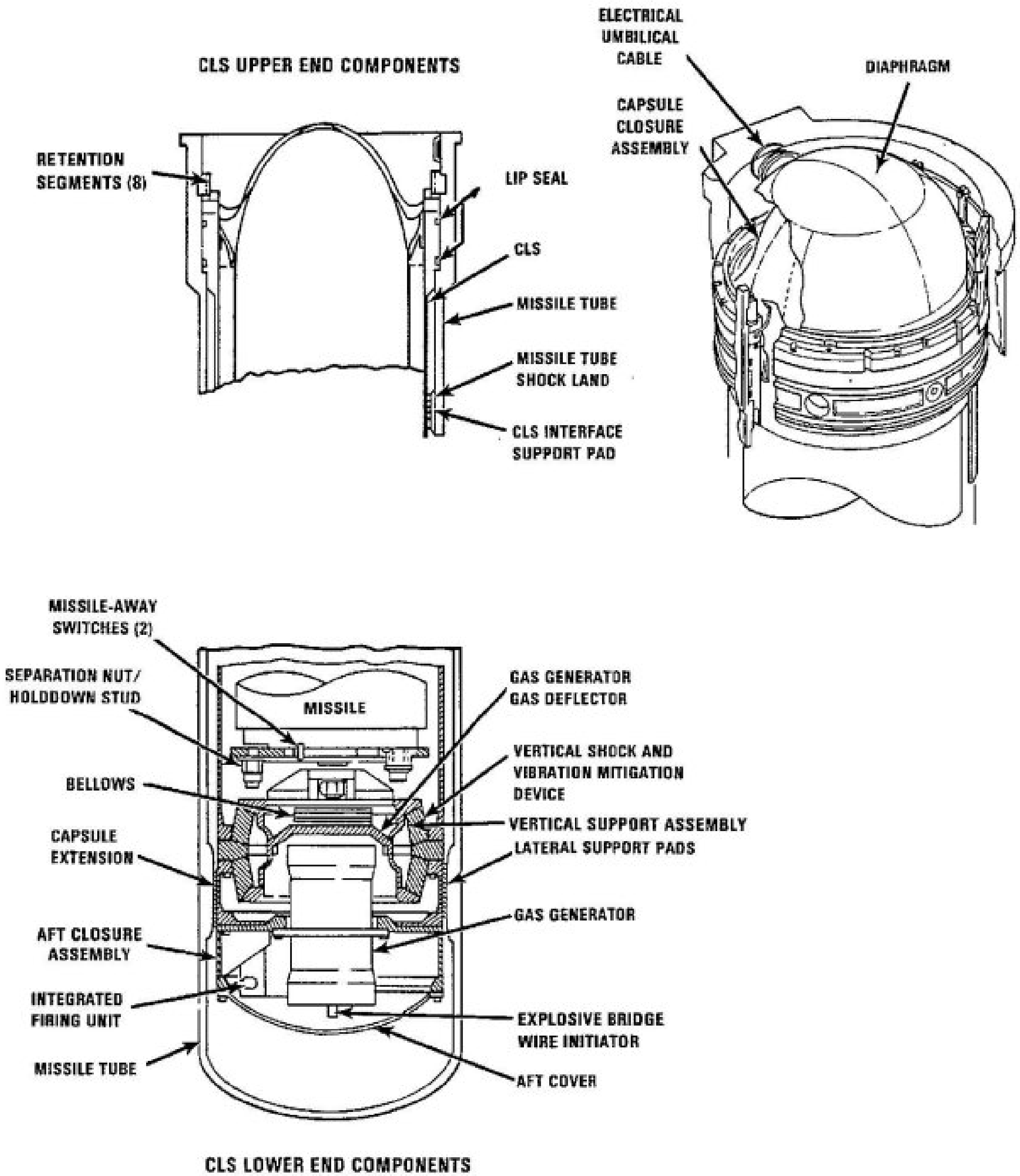


Figure 1-28. All-Up-Round Simulator (AURS) Volumetric Shape

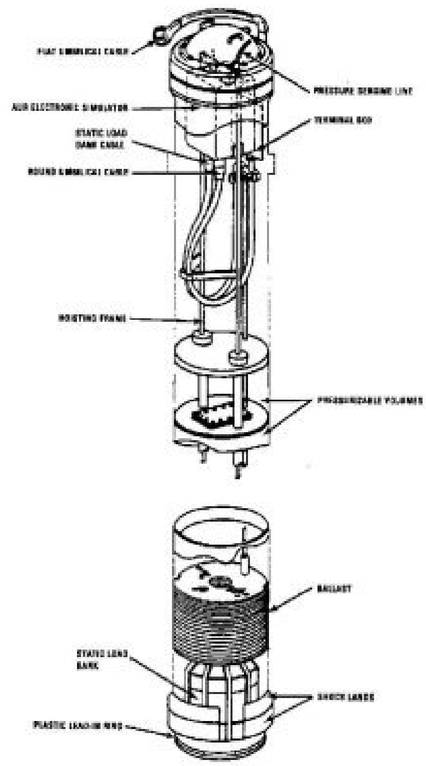


Figure 1-29. All-Up-Round Electronic Simulator (AURES) Mk 101

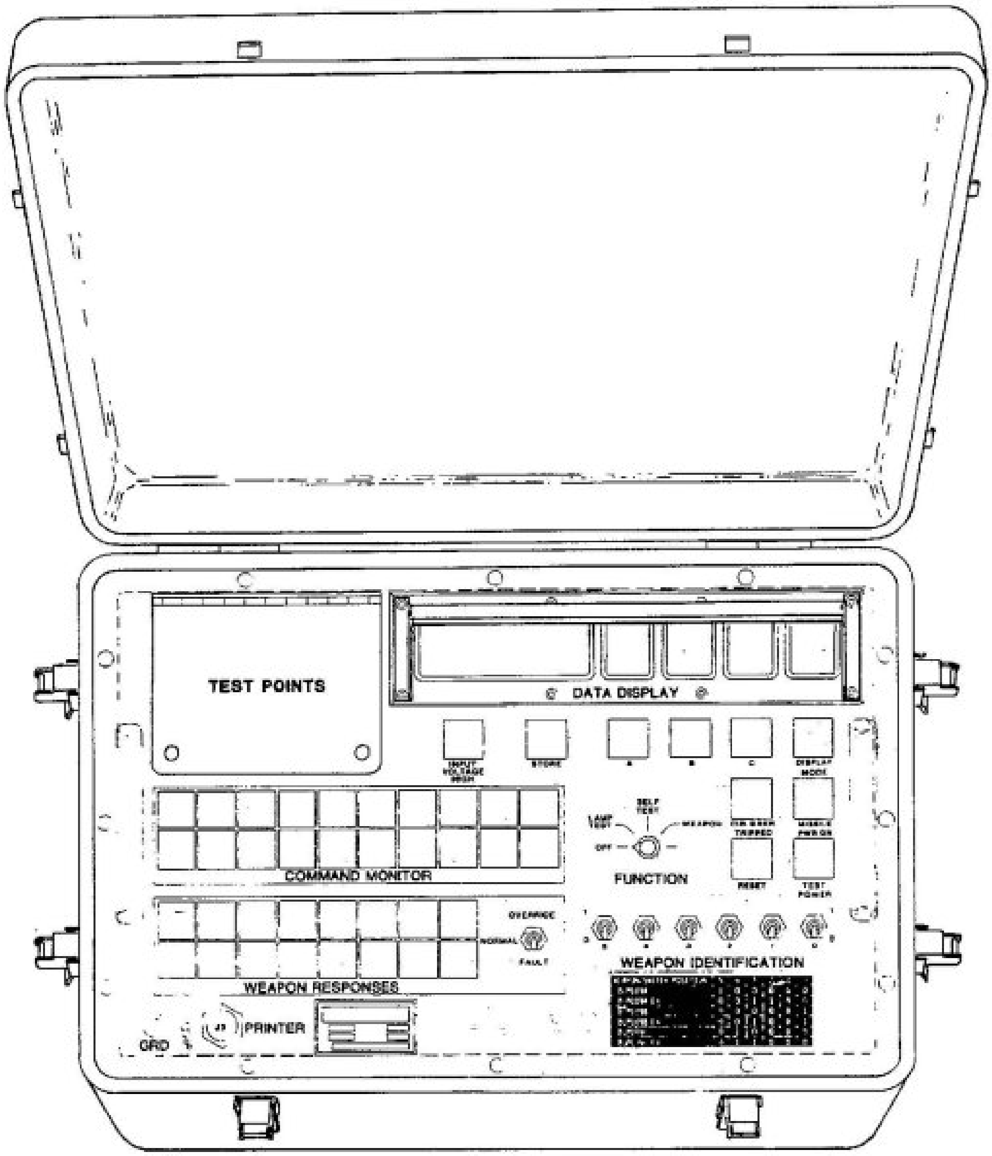
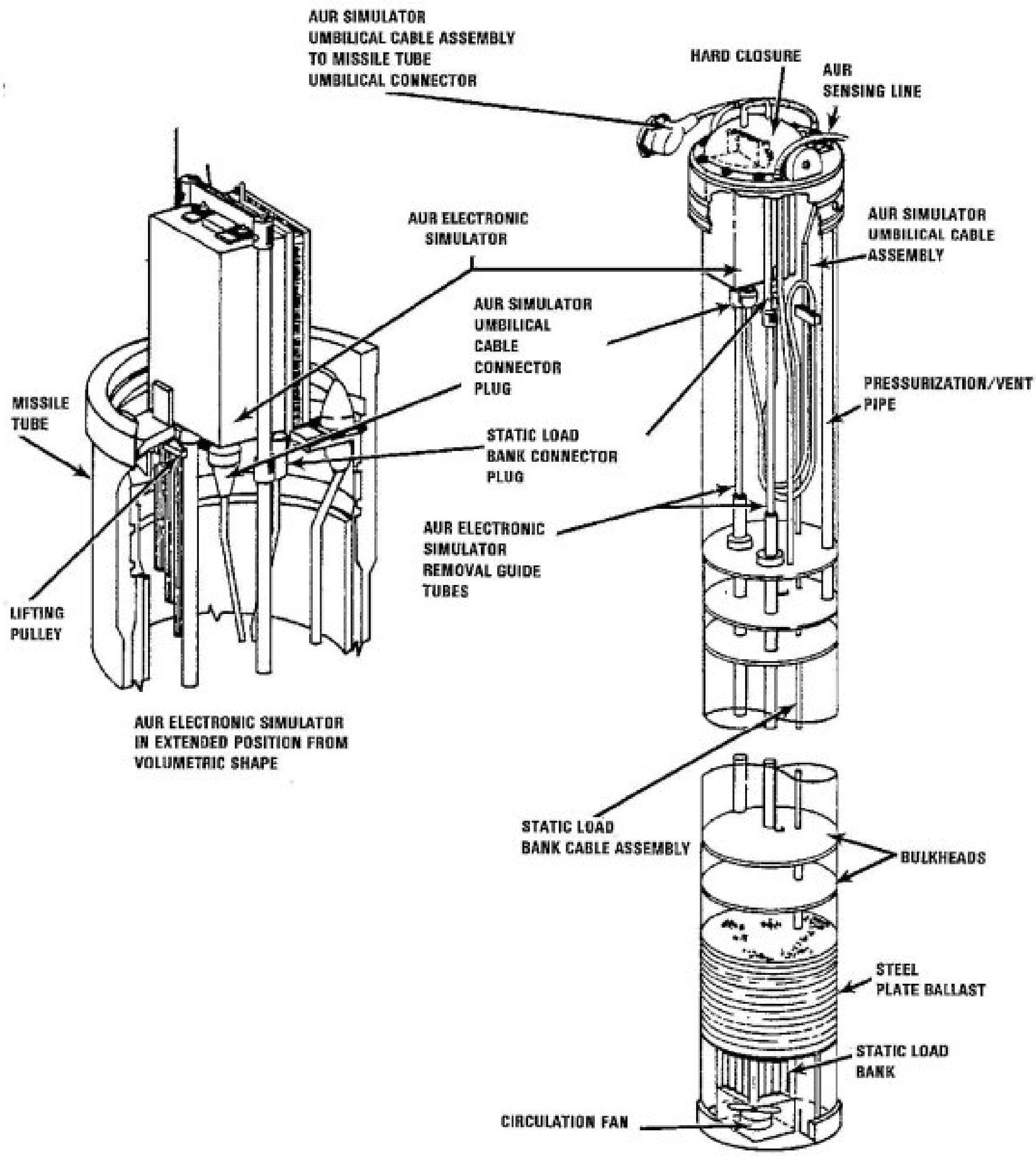


Figure 1-30. AURES/AURS Interface



AURES IN AUR SIMULATOR ARRANGEMENT

Figure 1-31. Missile Tube Ballast Can

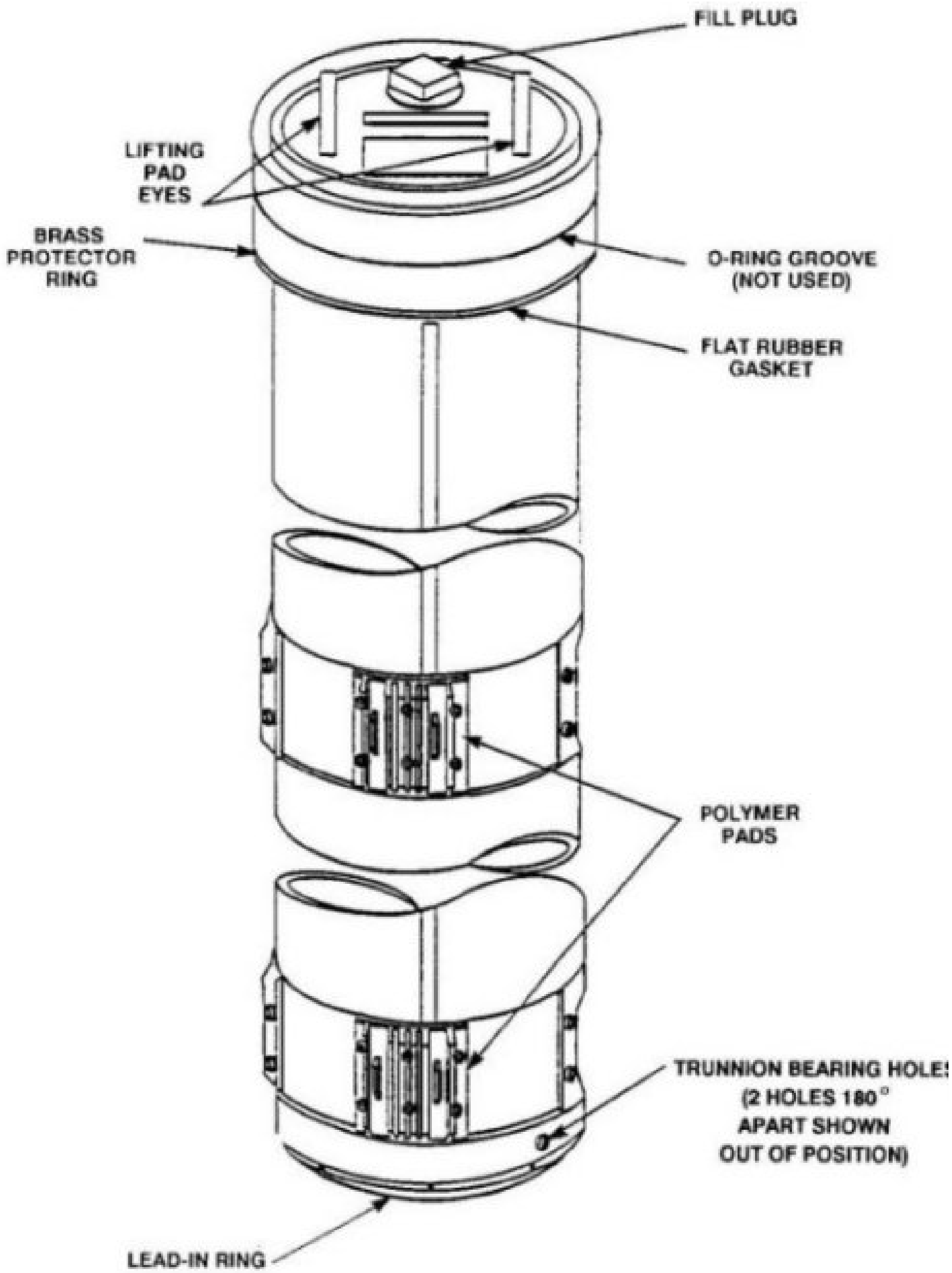


Figure 1-32. Shipping and Storage Skid Mk 30

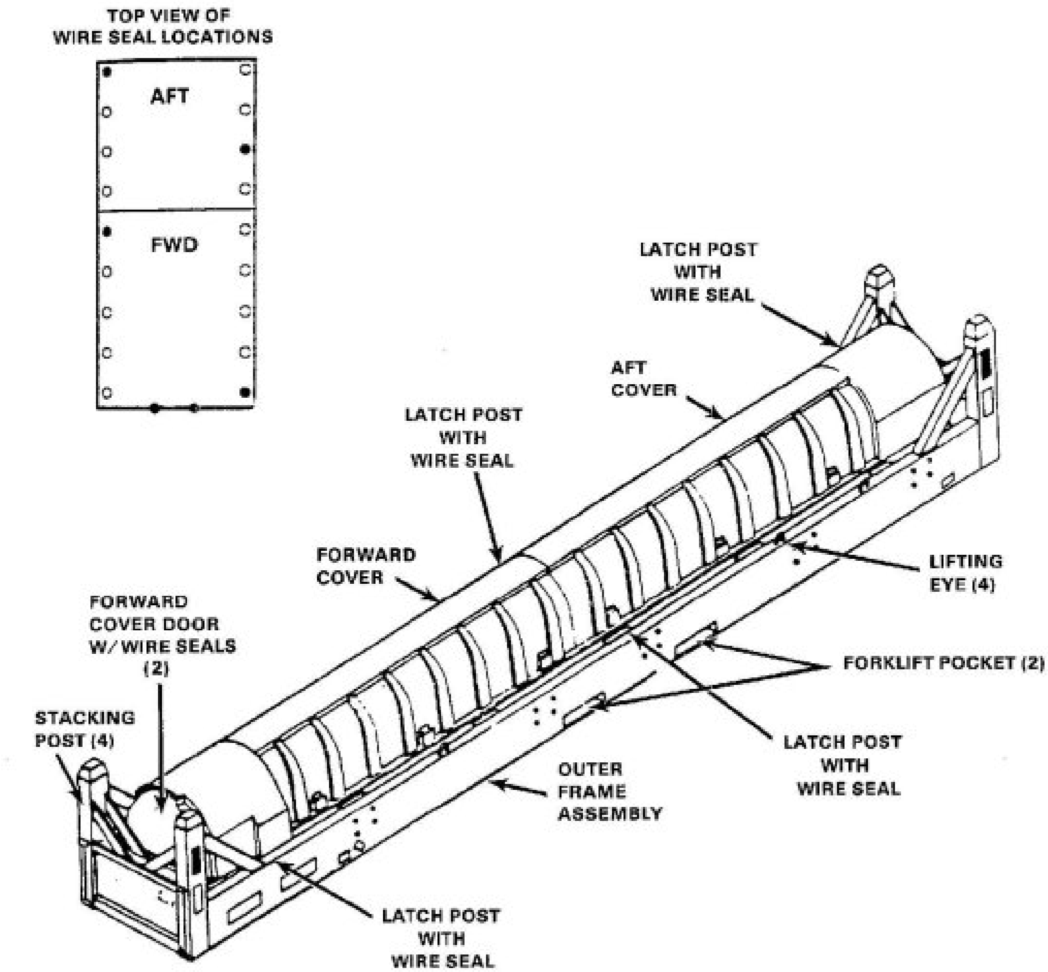


Figure 1-33. AUR Simulator Shipping Skid

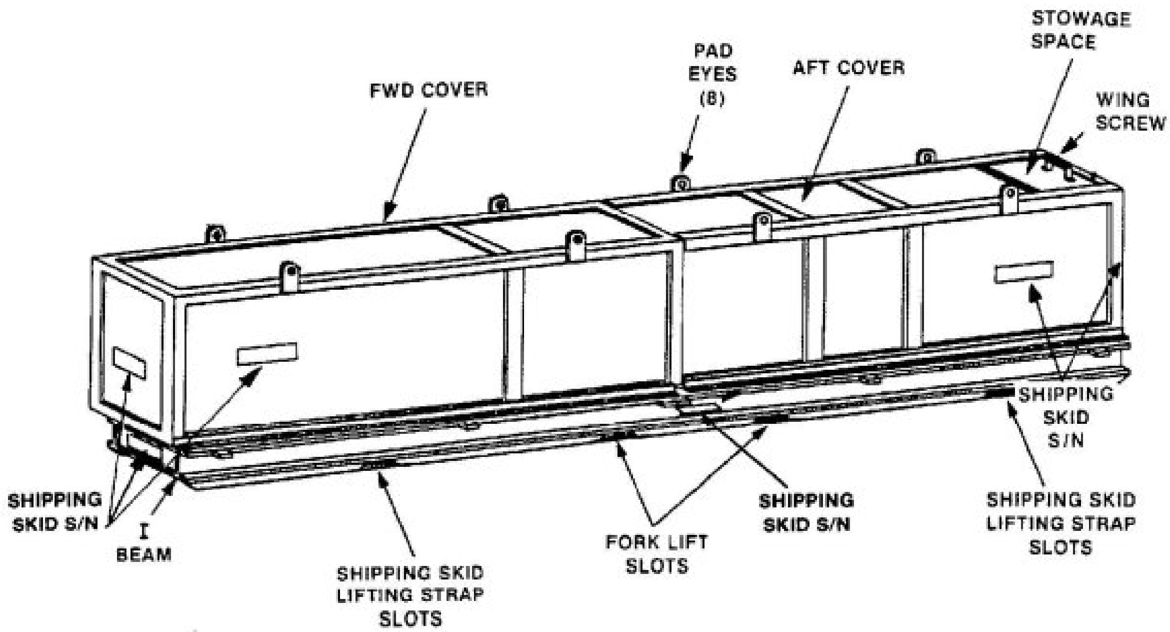


Figure 1-34. Mk 10 Canister

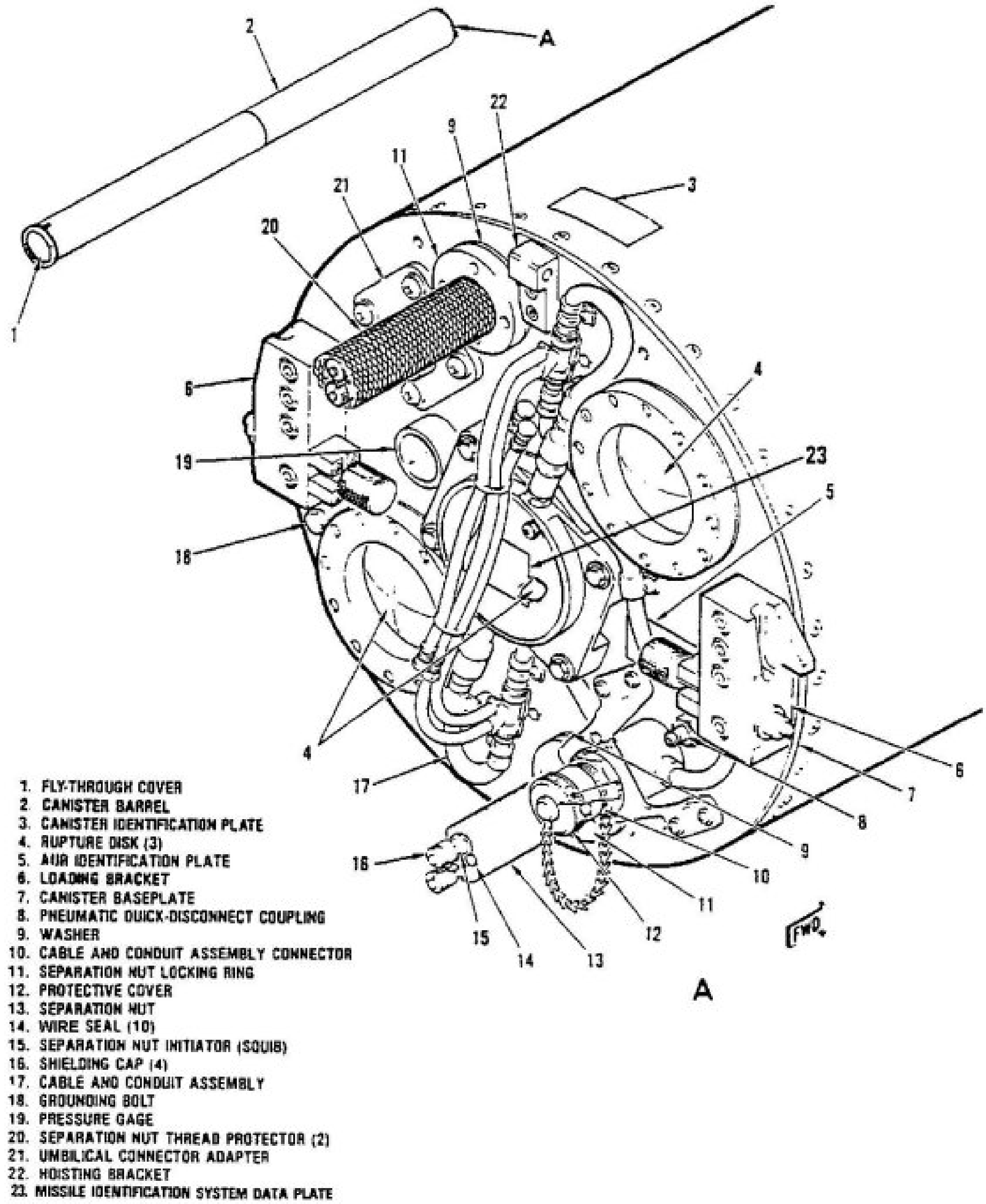
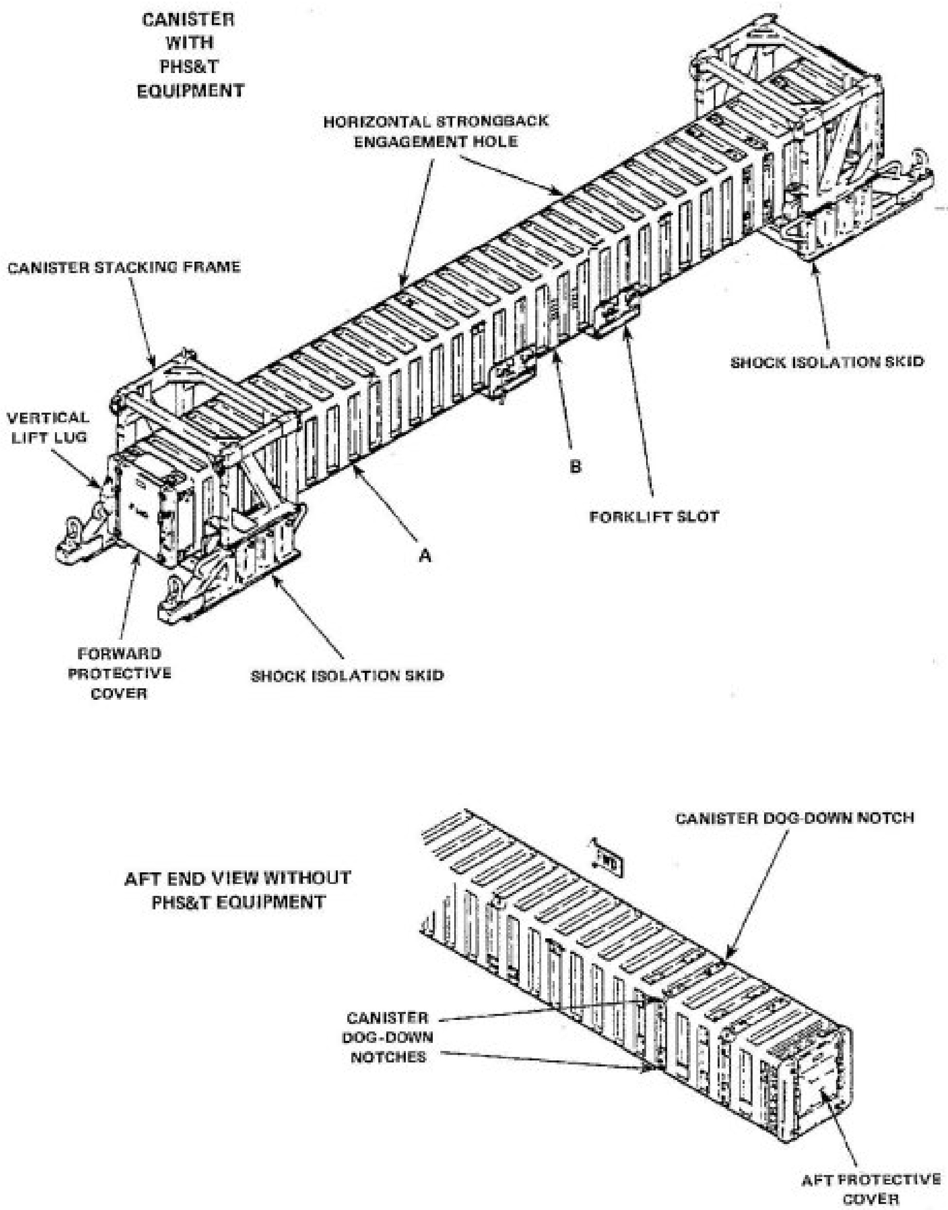
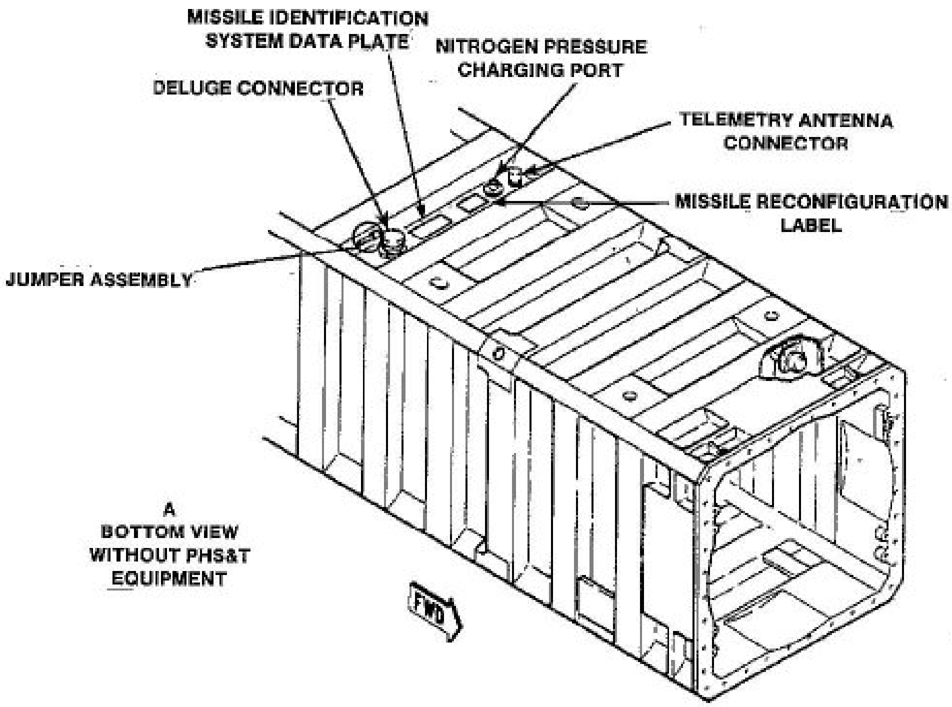
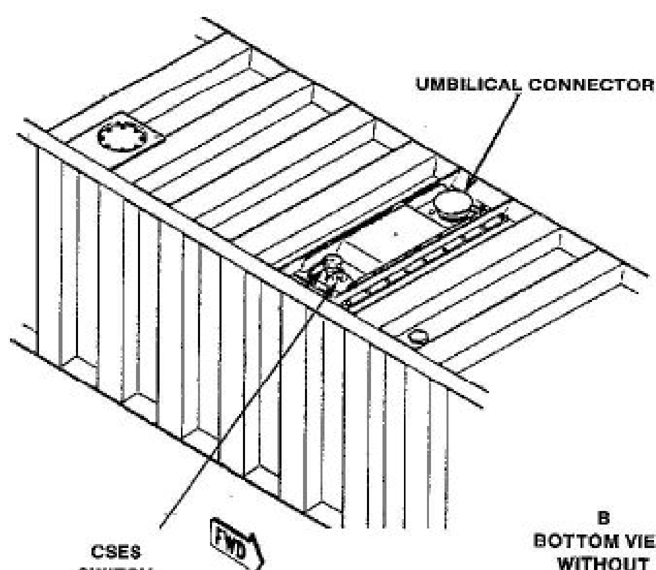


Figure 1-35. Mk 14 Canister (2 Sheets)





A
BOTTOM VIEW
WITHOUT PHS&T
EQUIPMENT



B
BOTTOM VIEW
WITHOUT
PHS&T
EQUIPMENT

Figure 1-36. Shipping and Storage Skid Mk 34

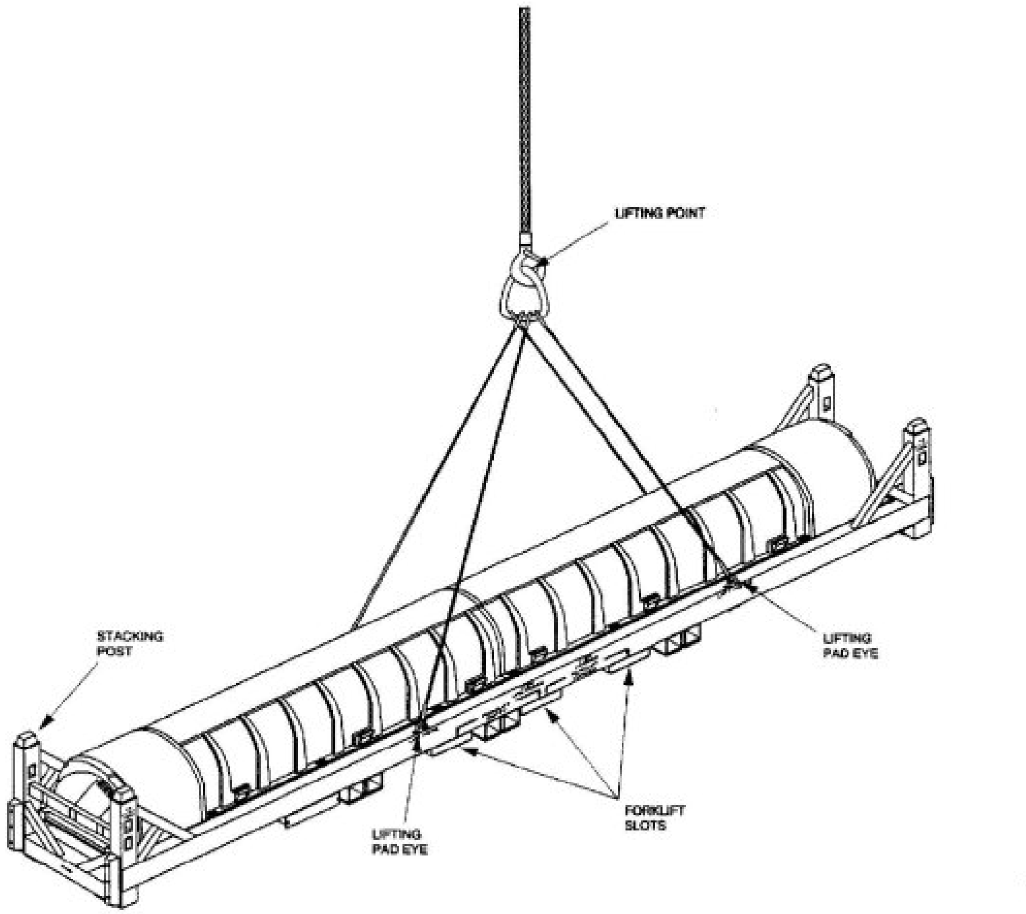


Figure 1-37. CLS Submarine Missile Tube Trainer Assembly

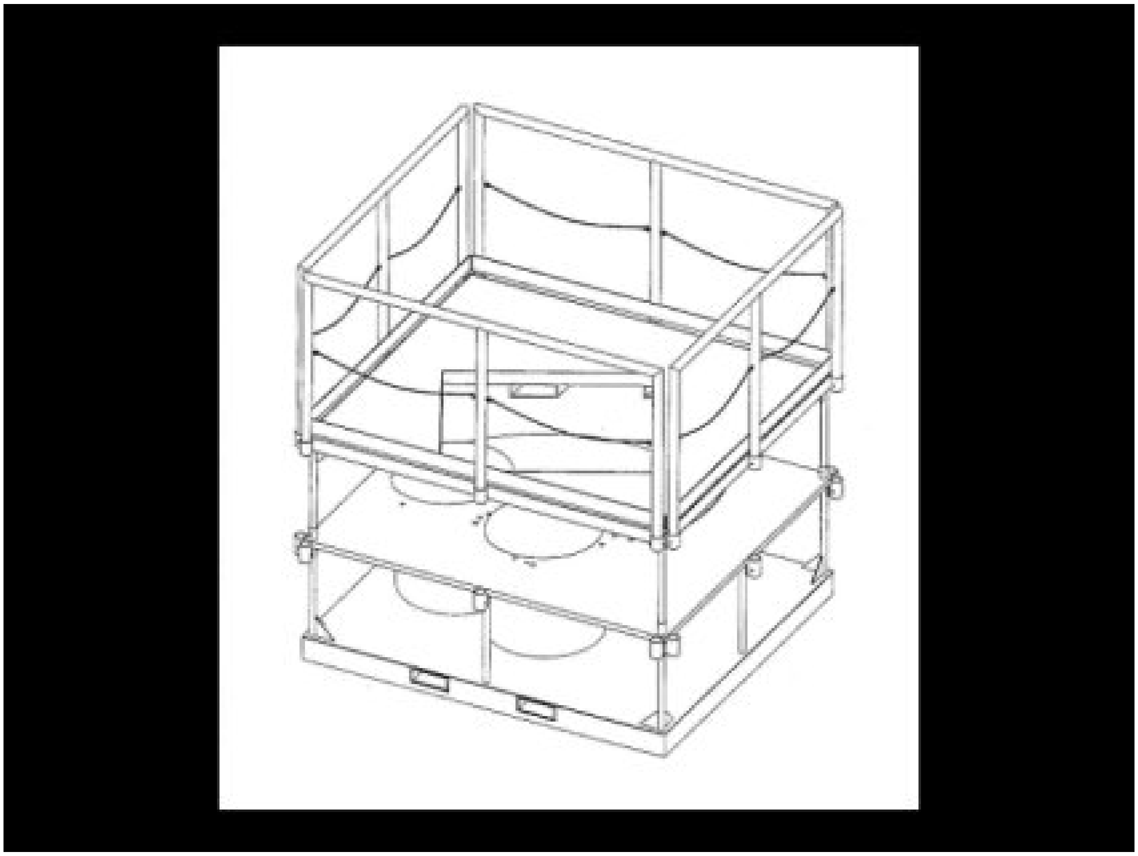


Figure 1-38. SMTT Training Shape

Figure 1-39. CLS Mk 45 Mod 2 Aft Cover

Figure 1-40. CLS Mk 45 Mod 2 Capsule Closure Assembly

Figure 1-41. SSGN (Prototype) Multiple All-Up-Round Canister (MAC)

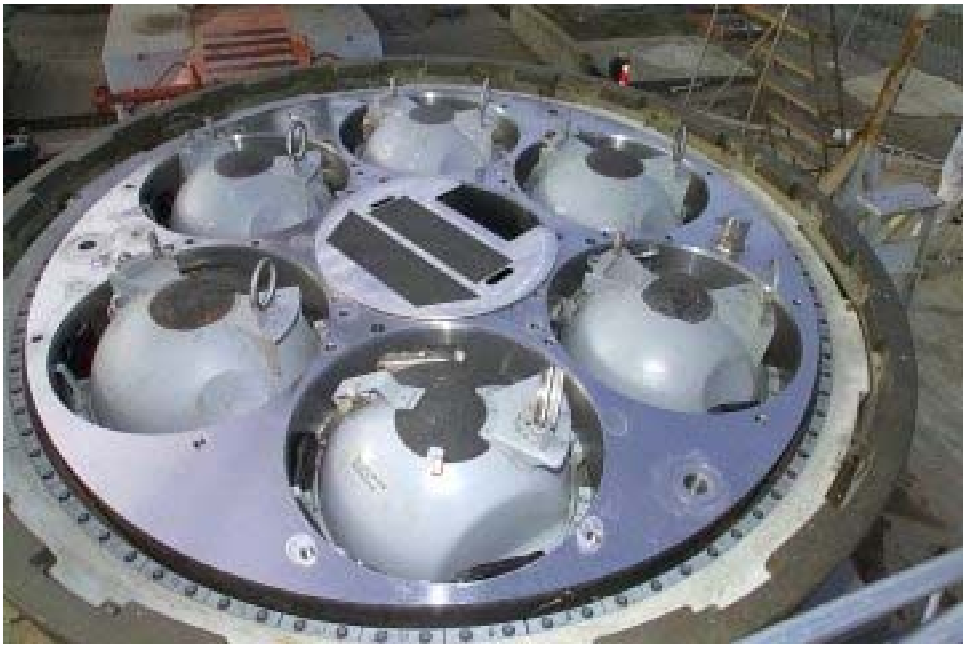
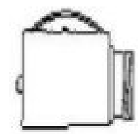
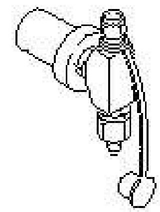
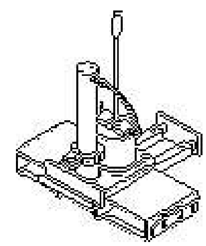
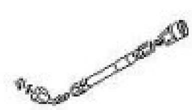
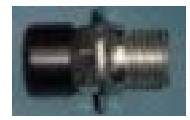
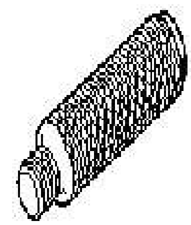
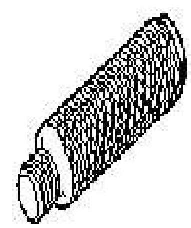
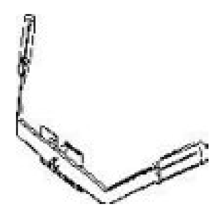
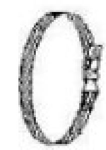
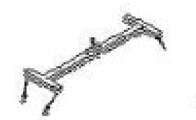
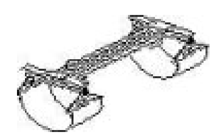
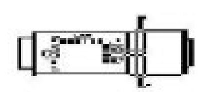
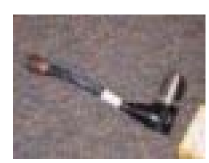
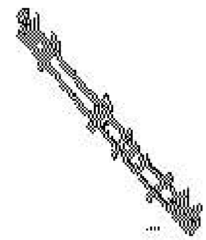
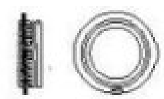
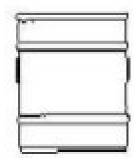


Table 1-1. Support Equipment Description

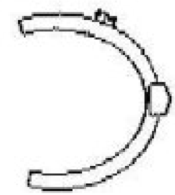
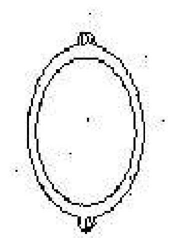
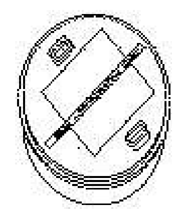
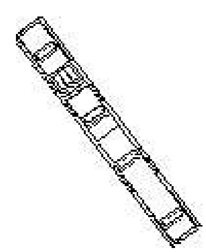
EQUIPMENT	FUNCTION	ILLUSTRATION
Adapter Box Assy P/N JCM-17683	Used with Rocket Motor/Ident Test Set Box Assembly for performing CLS missile electrical checks.	
Adapter, Capsule Pneumatic P/N 7324001-01	Interface between TTL Capsule/TOTEM Capsule pneumatic coupling and pressurization equipment.	
Adapter, Endlift, Container Mk 156 Mod 0 P/N 5166882	Handle CNU-308/E Shipping Container with pallet truck.	
Adapter, Hook Mk 91 Mod 0 P/N 2643315	Use with forklift and sling to handle uncontainerized TTL and Mk 10 weapons.	
Adapter, Hook Mk 176 Mod 0 P/N 6213621	Use with forklift and sling to handle uncontainerized CLS weapons.	
Adapter, Missile Round Pneumatic Test P/N 6242918-1	Perform VLS weapon pressure check and pressure service.	

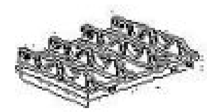
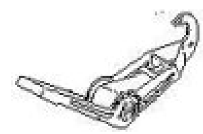
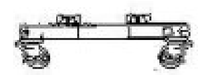
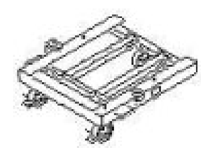
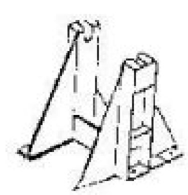
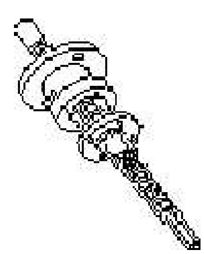
EQUIPMENT	FUNCTION	ILLUSTRATION
Adapter, Support Cradle, Forward Mk 168 Mod 0 P/N 5917395	Supports forward end of CLS weapon when connected to the Mk 26 Uprighting Fixture.	
Adapter, Trunnion Bearing Assembly Mk 174 Mod 0 P/N JCM-17863	Attaches to CLS weapon to act as pivot to permit transitioning between vertical and horizontal during onload/off-load.	
Alignment Guide, Nose Cover Attachment P/N 76Z7894-1	Aligns nose cover/capsule screw holes to attach nose cover to Capsule Mk 1 Mod 0/TOTEM Capsule.	
Alignment Guide, Nose Cover Attachment P/N 76Z7897-3	Aligns nose cover/capsule screw holes to attach nose cover to Capsule Mk 3 Mod 0/TOTEM Capsule.	
Alignment Tool, Guidance Set P/N 6145719	Maintain control of the Cruise Missile Guidance Set during 109A warheading and dewarheading.	
Assembly, Chain and Adjuster P/N MB-1/CGU-4E	Secure weapons and containers in small boats.	

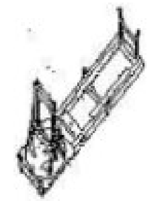
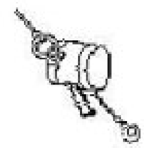
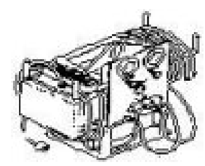
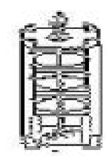
EQUIPMENT	FUNCTION	ILLUSTRATION
Assembly, Protective Sleeve, O-ring P/N 101-5951066/4/5/50/6 (SSN 688) P/N 7066384-71 (SSN 774)	Protect O-rings on CLS weapon.	
Band, CLS, TOMAHAWK, Mk 90 Mod 0 P/N 5167268	Used with Taglines Mk 4 Mod 0 to maintain control of uncontainerized CLS weapons.	
Band, Mk 87 Mod 0 P/N 5166711	Used with Taglines Mk 3 Mod 0 to maintain control of uncontainerized TTL and Mk 10 weapons.	
Beam, Hoisting, AUR Container Mk 46 Mod 0 P/N 5167804	Handle containerized TTL and Mk 10 weapons.	
Beam, Lifting, MK 44, Mod 0 P/N 5167164	Handle uncontainerized TTL and Mk 10 weapons.	
Cable Adapter Umbilical Assy P/N 3193140-028-101	Used with Rocket Motor/Ident Test Set Box Assembly for performing TTL missile electrical checks.	
Cable Adapter Umbilical Assy P/N 3193140-028-102 (Conventional Use Only)	Used with Rocket Motor/Ident Test Set Box Assembly for performing TTL missile electrical checks.	

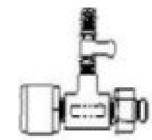
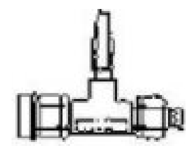
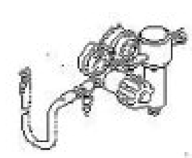
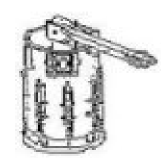
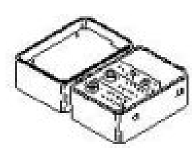
EQUIPMENT	FUNCTION	ILLUSTRATION
Cable Assy P/N 3193140-013-101	Used with Rocket Motor/Ident Test Set Box Assembly for performing missile electrical checks.	
Canister Loader, VLS, Mk 33 Mod 0 P/N 5167196	Encanister/decanister VLS weapons	
Cap, Faraday, Upper Umbilical Connector P/N JCM-14339-001	Provides electrical shielding for the electrical umbilical connector on CLS AUR and CLS Loading and Handling Training Shape.	
Container, Closure Shipping P/N JCM-14843-002	Protects the CLS AUR and CLS Loading and Handling Training Shape Capsule Closure Assembly during transport and handling.	
Cover Assy, Shock Plate P/N 7124611-002	Used to cover the AUR bore holes in the middle and lower shock plates. Provides a flat, non-skid surface without raised handles and will prevent items from falling into the MAC cell.	
Cover Assy, Top Hat P/N 7124611-004	Placed over loaded AURs to protect them from damage after the CLC has been removed, during the AUR close-out procedure, or in the event that an AUR has to be pulled and replaced. Provides a level surface strong enough for a worker to stand on.	
Cover Assy, Top Plate P/N 7124611-003	Used to cover the MAC AUR cells and to provide a flat, non-skid surface without raised handles. It prevents items from falling into the MAC cell.	

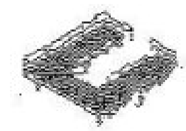
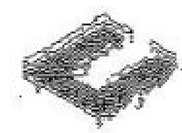
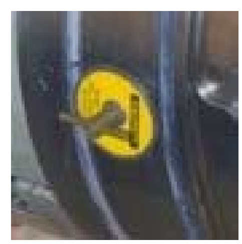
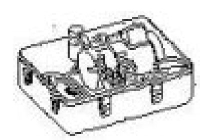
EQUIPMENT	FUNCTION	ILLUSTRATION
Cover, Capsule Loading P/N JCM-17759	Used instead of CPC when loading/offloading CLS AUR and CLS Loading and Handling Training Shape, when working on weapons loaded in missile tube or MAC cell. Protects the Capsule Closure Assembly.	
Cover, Closure Protective (CPC), Mk 19 and Clamp Ring P/N JCM-14865-001	Protects the CLS AUR and CLS Loading and Handling Training Shape Capsule Closure Assembly during transport and handling.	
Cover, Counterbore P/N 101-5580126-171 (SSN 688)	Installed on missile tube aboard SSN-688 class to prevent personnel, tools, water, debris, etc from entering empty missile tube.	
Cover, Counterbore P/N 7066384-73 (SSN 774)	Installed on missile tube aboard SSN-774 class to prevent personnel, tools, water, debris, etc from entering empty missile tube.	
Cover, Counterbore P/N 7124611-001	Inserted into the individual AUR stowage locations, supported on the Datum B of SSGN MAC AUR cell. It permits inspection of the counterbore area prior to loading and prevents items from falling into the AUR cell.	

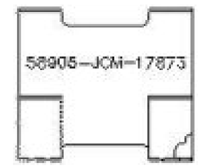
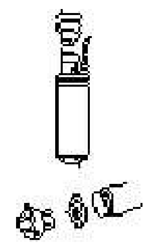
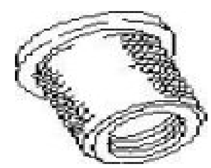
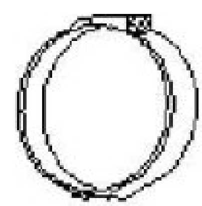
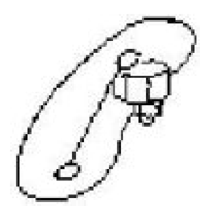
EQUIPMENT	FUNCTION	ILLUSTRATION
Cover, Missile Tube Muzzle Hatch and Magnet Protective P/N 101-5951066-54 (SSN 688) Cover, Missile Tube Muzzle Hatch and Switch Probe Protective P/N 7066384-72 (SSN 774)	Protect muzzle hatch magnets in hatch opening of submarine.	
Cover, Muzzle Face Protective P/N 101-5951066-49	Used to prevent damage to muzzle hatch gasket sealing surface in missile tube.	
Cover, Safety MTEL P/N JCM-14566-001	Installed on MTEL prior to CLS weapon onload/after offload. Protects MTEL, missile tube, and MAC cell (SSGN).	
Cover, VLS Missile Tube, CLS Spent Capsule P/N 6510965	Installed over spent CLS to prevent personnel, tools, debris, etc from entering spent capsule.	
Cradle Mk 33 Mod 0 P/N 6213118	Secure and transport TTL and Mk 10 weapons by truck and small boat.	

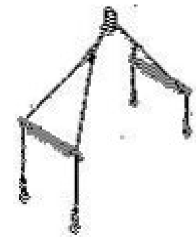
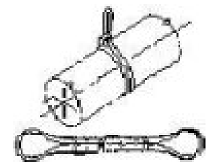
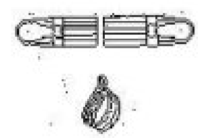
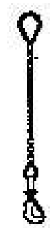
EQUIPMENT	FUNCTION	ILLUSTRATION
Cradle Mk 34 Mod 0 P/N 6213249	Secure and transport CLS weapons by small boat.	
Cradle, Undersea Weapons Transporting Mk 27 Mod 0 P/N 5165994	Transfer weapons on small boats.	
Device, Tie-down P/N CGU-1/B	Secure weapons and containers in small boats.	
Dolly Assembly, Missile Handling Mk 34 Mod 0 P/N 5167224	Transport Mk 30 Shipping and Storage Skid.	
Dolly, VLS Transport Mk 35 Mod 0 P/N 5167396	Transport Mk 14 Canister	
Fixture, CLS Capsule Uprighting Mk 26 Mod 0 P/N 5917401 or Mk 26 Mod 1 P/N 6213396	Transition CLS weapons between vertical and horizontal during onload and off-load.	
Fixture, Missile Positioning MTU-68/E P/N 76Z3550-30	Move the missile about nine inches out of/into the capsule during UGM-109A-1 warheading and dewarheading.	

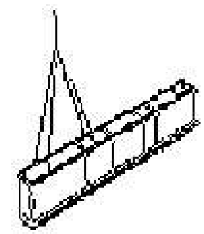
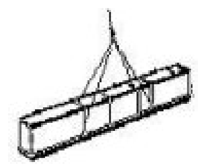
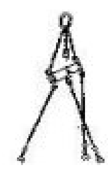
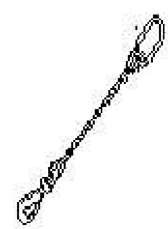
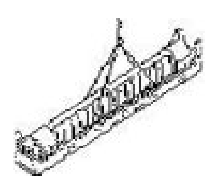
EQUIPMENT	FUNCTION	ILLUSTRATION
Fixture, Tilt Mk 23 Mod 0 P/N 5167473	With Kit A, transition Mk 14 Canister between the horizontal and vertical positions. With Kit B, transition CLS weapon between vertical and horizontal for onload and offload.	
Gauge, Load Button P/N 7339399/No NSN	Verify any TTL capsule load button is not oversized, bent or otherwise distorted so as to cause problems during tube loading aboard a submarine	
Hoist, Chain, Hand, 2-ton, 15-ft Lift P/N LHH-2B-15	Used with Hoisting Sling Mk 157 to change position of lifting adapter or MTEL.	
Hydraulic Power Unit (HPU) Mk 8 Mod 0 P/N JCM-14899-001	With MTEL, provides insertion and extraction force to seat/unseat CLS weapons (except ballast can) into/out of the missile tube/MAC cell.	
Installation Guide Mk 116 Mod 0 P/N JCM-14375-001	Align MTEL to prevent missile tube damage during MTEL installation and removal.	
Kit, Pressure Servicing Mk 182 Mod 0 P/N 5759440	Pressurize TTL and Mk 10 weapons	
Kit, Pressure Servicing, CLS Forward Mk 184 Mod 0 P/N 6199900 Consists of:	Pressurize CLS AUR and CLS Loading and Handling Training Shape forward section.	

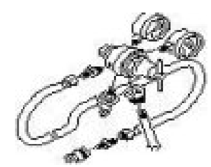
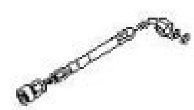
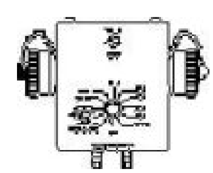
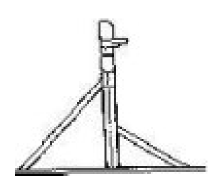
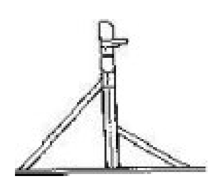
EQUIPMENT	FUNCTION	ILLUSTRATION
Closure Pressure Hose Pneumatic Adapter P/N 6146684		
CPC Pneumatic Adapter P/N 6199896		
Pressurizing Gear Tester T3159 P/N 5545882		
CLS Pressurizing Hose Assembly, FWD P/N 6146623		
Lifting Adapter Assembly Mk 169 Mod 0 P/N JCM-14699-001	Attaches to CLS weapon (except ballast can) to upright, lift or lower CLS weapon during submarine onload/off-load.	
Missile Tube Extension/Loader (MTEL) Mk 23 Mod 1 P/N JCM-14455-002	Aligns, and with HPU, inserts/extracts CLS weapon (except ballast can) into/out of missile tube/MAC cell.	
Multi-Test Box Mk 71 Mod 0 P/N 6574418	Verify electrical continuity and isolation of specific wires in the pyro harness.	

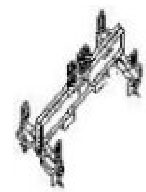
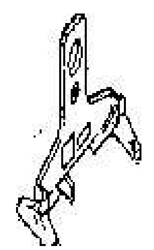
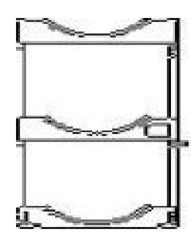
EQUIPMENT	FUNCTION	ILLUSTRATION
Pin, Trunnion P/N 5768606	Alternate to Mk 174 Trunnion Bearing Adapter to transition the All-Up-Round Simulator and CLS Ballast Can between vertical and horizontal during onload/off-load.	
Platform, Loading P/N 5580126	Used on SSN 688 Class submarines for access to missile tubes.	
Platform, Loading P/N 7066384-A1	Used on SSN 774 Class submarines for access to missile tubes.	
Platform, MTEL Work P/N 7126403-002	Allows access to the area above the MTEL during SSGN handling operations.	
Plug Assembly, Moisture and Dust JCM-17838/4730-01-346-3387	Seals pressure/vent port on CLS AUR, AUR Simulator and CLS Loading and Handling Trainer.	
Pressure Vacuum Distributor H3353 P/N 5758382	Purge and backfill warhead cavity and missile during 109A warheading and dewarheading.	

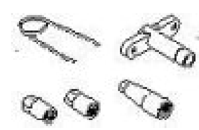
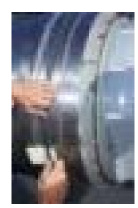
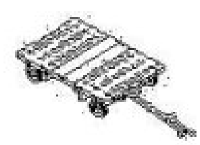
EQUIPMENT	FUNCTION	ILLUSTRATION
Protective Shield, Umbilical Cable P/N JCM-17873	Installed on the CLS AUR and CLS Loading and Handling Training Shape umbilical cable during off-load to prevent damage from contact with the missile tube while extracting the weapon from the tube. Not required with new design umbilical cable with angled cable flange penetrator overmold.	
Pump, Submersible, 440 Volt with Foot Valve Assembly	Remove ballast from CLS ballast can.	
Retainer, Separation Nut Lockring Wrench P/N 76L5319-1	Prevent Mk 10 separation nut lockring wrench from backing out of lockring and rounding holes.	
Security Band Assembly P/N 5979383	Attaches over nose cover of UGM-109A-1 to prevent unauthorized/inadvertent tube load aboard the submarine.	
Security Cover 4FZ P/N 76A2994-1	Replaces electrical connector protective cover on UGM-109A-1 aboard submarine to allow connection of 4FZ security system.	

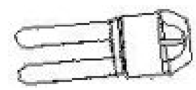
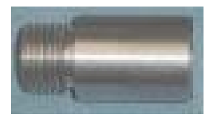
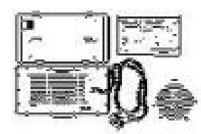
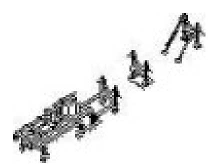
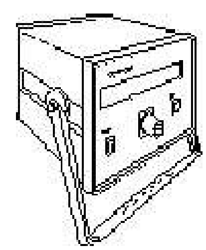
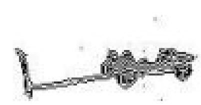
EQUIPMENT	FUNCTION	ILLUSTRATION
Sling, Hoisting, Container HLU-265/E P/N 76Z3525-16 or Mk 152 Mod 0 P/N 5167256	Handle CNU-308/E Shipping Container.	
Sling, Lifting Mk 95 Mod 0 P/N 2642629	Handle uncontainerized TTL and Mk 10 weapons.	
Sling, Lifting Mk 114 Mod 0 P/N 2643810	Handle uncontainerized TTL and Mk 10 weapons in areas where clearance does not allow use of Mk 95 Sling.	
Sling, Lifting Mk 162 Mod 0 P/N 1001-6212682	Connect lifting apparatus and lifting device. Shall not be used to handle CLS AUR and AURS.	
Sling, Lifting Assembly P/N 5580126-271 (SSN 688) P/N 7066384-A14 (SSN 774)	Handle CLS loading platform.	
Sling, Lifting Assembly P/N 6510856 (SSN 688) P/N 7066384-A13 (SSN 774)	Used to lift ballast can.	

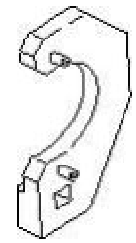
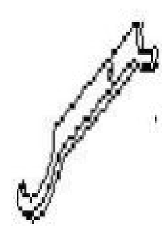
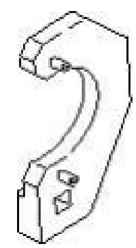
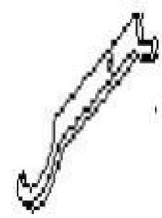
EQUIPMENT	FUNCTION	ILLUSTRATION
Sling, Lifting, AUR, Mk 154 Mod 0 P/N 5167321	Handle uncontainerized CLS weapons.	
Sling, Lifting, AUR Simulator Shipping Skid Cover P/N 5951067	Remove/install AUR Simulator Shipping Skid covers.	
Sling, Lifting, AUR Simulator Shipping Skid P/N 6510902	Handle AUR Simulator Shipping Skid	
Sling, Lifting and Tilting (Lifting Adapter/MTEL) Mk 157 Mod 1 P/N JCM-14748-002	Transition the Lifting Adapter and MTEL between vertical and horizontal.	
Sling, Pendant Mk 165 Mod 0 P/N 6213009 or Mk 165 Mod 1 P/N 6213750	Interface between lifting device and load.	
Sling, Weapon, Handling Mk 153 Mod 0 P/N 5167582	Handle Mk 30 AUR Shipping and Storage Skid or Mk 34 AUR Simulator Shipping and Storage Skid	

EQUIPMENT	FUNCTION	ILLUSTRATION
Socket, Special, 3/8-inch P/N JCM-16654	Remove/install Moisture and Dust Plug Assembly.	
Special Hose Assembly P/N 6309846 Consists of:	Perform Mk 14 Canister nitrogen line leak check.	
Regulator Hose Assembly P/N 6309846-1		
Digital Pressure Gage Hose Assembly P/N 6309846-2/ Setra Model 360		
Pneumatic Test Adapter P/N 6309846-3		
Rocket Motor/Ident Test Set, Box Assy 6557811	Used when performing missile electrical checks.	
Stand, Deployment P/N 6510854	Used to support sections of SSN 688 Class loading platform.	
Stand, Deployment P/N 7066384-A3	Used to support sections of SSN 774 Class loading platform.	

EQUIPMENT	FUNCTION	ILLUSTRATION
Straps, Tie-down, Special Purpose P/N CBU	Secure weapons and containers in small boats.	
Strongback, Horizontal, VLS Mk 3 Mod 0 P/N 5598249-9	Handle Mk 14 Mod 1 Canister	
Strongback, Horizontal, VLS Mk 3 Mod 1 P/N 72511117-9	Handle Mk 14 Mod 1 or Mod 2 Canister	
Strongback, Vertical, VLS Mk 4 Mod 0 P/N 5497606	Onload/off-load Mk 14 Canister	
Support System Mk 8 Mod 0 P/N 6213373	Support TTL and Mk 10 weapons in storage.	
Tagline, Mk 3 Mod 0 P/N 5166715 or Mk 4 Mod 0 P/N 5166702	With Mk 87/Mk 90 Band, maintain control of uncontainerized weapons during handling. Maintain control of containers during handling.	

EQUIPMENT	FUNCTION	ILLUSTRATION
Tester, Igniter, Amptec Model 630AN/630BN/641N	Used for testing the igniters in solid fuel rocket engines, detonation circuits in warheads, explosive separation bolts or any other squib actuated devices.	
Threadsaver, Trunnion Bearing P/N JCM-17679	Used in place of trunnion bearing assemblies to preserve threads in trunnion bearing holes.	
Tool Kit, Nose Diaphragm P/N 76Z0667-1	Remove/install nose diaphragm during UGM-109A-1 warheading and dewarheading.	
Tool Kit, Special Weapons P/N 76Z6333-8	Set of four tools to: align missile/capsule; detach/attach holdback nuts; protect holdback assembly; and remove/install booster lanyard nut during UGM-109A-1 warheading and dewarheading.	
Tool, Lip Seal P/N JCM-17678	Used to install lip seals.	
Trailer, Munitions Aero 51 B/C/D P/N 67A314F100	Transport containerized and uncontainerized weapons.	

EQUIPMENT	FUNCTION	ILLUSTRATION
Truck, Handlift Mk 45 Mod 2 P/N 5167104	Handle CNU-308/E Shipping Container	
Truck, Pallet, Low Lift	Handle CNU-308/E Shipping Container	
Trunnion P/N JCM-14514-001	Used when lowering the CLS AUR into the Mk 23 Tilt Fixture. Can also be used for uprighting the All-Up-Round Simulator and Ballast Can.	
Umbilical Breakout Box (UBOB) Mk 674 Mod 1 P/N 7379010	Perform VLS weapon electrical tests.	
Universal Restraint Stand Mk 121 Mod 0 P/N 6146521	Warhead 109A. May be used for maintenance on TTL, Mk 10 and VLS weapons	
Vertical Launch System (VLS) Canister Code Plug Test Set Mk 673 Mod 0 P/N 6375451	Determine VLS canister code plug configuration.	
Weapons Skid Aero 21C P/N 64A114H1-4 or Munitions Transporter MHU-191-M P/N 1500AS100-1	With Mk 130 Mod 0 Extension Handle, Aero 64A/64B Soft Belt Adapters and front and rear Aero 58A/58B Skid Adapters installed, transport uncontainerized TTL and Mk 10 weapons.	

EQUIPMENT	FUNCTION	ILLUSTRATION
Wrench, Canister Separation Nut Lockring P/N 76Z4738-1	Loosen and tighten separation nut lockring during Mk 10 encanisterization and decanisterization.	
Wrench, Spanner P/N JCM-17635	Tighten CLS AUR and CLS Loading and Handling Training Shape umbilical cable connector P130B	
Wrench, Canister Separation Nut Lockring P/N 76Z4738-1	Loosen and tighten separation nut lockring during Mk 10 encanisterization and decanisterization.	
Wrench, Spanner P/N JCM-17635	Tighten CLS AUR and CLS Loading and Handling Training Shape umbilical cable connector P130B	

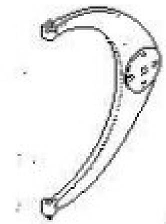
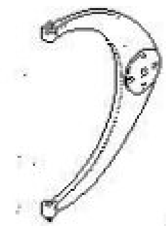
EQUIPMENT	FUNCTION	ILLUSTRATION
Wrench, Spanner P/N 76M0235-1	Remove/install positive retention nose cone during 109A warheading and dewarheading.	
Wrench, Spanner, Nose Coupler KMU-467/E P/N 76Z3553-8	Remove/install positive retention nose cone during 109A warheading and dewarheading.	

Table 1-2. Shipboard Equipment Used for TOMAHAWK Support

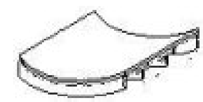
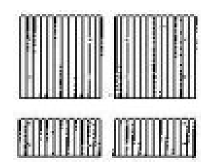
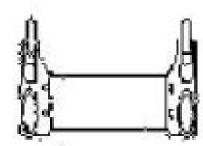
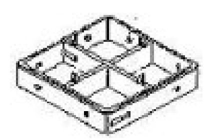
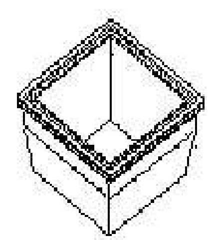
EQUIPMENT	FUNCTION	ILLUSTRATION
Adapter, Dolly P/N SK5711-735	Adapt tender stowage rack dollies to support TTL weapons.	
Chocks, Portable (Stowage Rack) P/N SK5111-738	Adapt stowage rack for TTL stowage on board AS- 39 Class submarine tenders.	
Decking, Small Boat (LCM Mk 6)	Provide a platform to secure weapons in LCM Mk 6. Consists of four deck sections secured together with iron bolts and angle irons.	
Dolly, Stowage Rack	Stow TTL weapons on AS-39 Class Submarine Tenders. A telescoping tug bar is used with the dolly. All dollies are modified with the Adapter, Dolly, P/N SK5711-735.	
Plenum Cell Cover Assembly	Seals the bottom of a launcher cell to permit launch gases to be vented through the uptake into the atmosphere	
Sill Assembly	Seal the Mk 14 Canister in the launch cell to divert launch gases to the atmosphere via the plenum cell.	

Table 1-3. Reference Documentation

DOCUMENT NUMBER	TITLE
	Record Book All-Up-Round (AUR) Volumetric Shape
	Record Book Missile Tube Ballast Can (MTBC)
0348-LP-078-1000	Technical Manual for Magazine Sprinkler System
0924-LP-066-6010/-6020	Electrically Suspended Gyro Navigator (ESGN) AN/WSN-3A(V)2
0967-LP-529-6010	Dual Miniature Inertial Navigation System (DMINS) AN/WSN-1(V)2
0978-LP-040-0910	Weapon Delivery Systems Equipments Manual for SSN 688 Class Submarines
ASME/ANSI B30.5-1989	Safety Standards for Mobile and Locomotive Cranes
ASME/ANSI B30.8-1988	Safety Standards for Floating Cranes and Floating Devices
CINCLANTFLTINST 8010.4	Atlantic Fleet Conventional Ordnance Management Manual
CINCPACFLTINST 8010.12	Pacific Fleet Ammunition Requisitioning and Reporting Guide
CMP PUB 4440/2	Record Book for TOMAHAWK Test Missile (TOTEM)
CMP PUB PMA 280-1203	User's Logistics Support Summary (ULSS) for the TOMAHAWK Cruise Missile UGM-109-1 and TOMAHAWK Cruise Missile UGM-109-2
CMP PUB PMA 280-1207	Integrated Logistics Support Plan (ILSP) for Sea Launched Cruise Missile (SLCM) TOMAHAWK All-Up-Round
CMP PUB ULSS 4105-D	Advanced TOMAHAWK Weapon Control System AN/SWG-4(V) Launch Control Group Replacement (TL4 Configuration)
CMP PUB ULSS PMA 280-1205	VLS Mk 14 Canisters with TOMAHAWK Cruise Missiles at Intermediate Maintenance Activities and Limited Maintenance Activities
CMPINST 5102.1	Explosive Mishap Reporting Procedures
Code of Federal Regulations Title 46	Shipping

DOCUMENT NUMBER	TITLE
Code of Federal Regulations Title 49	Transportation
DOD Regulation 4500.32-R	Defense Transportation System, Policies and Procedures
DOD-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
ILSP-167 P/D	Integrated Logistics Support Plan (ILSP) for Vertical Launching System Mk 41
JCS PUB 6 VOL II Part 4	Joint Reporting Structure (JRS) Volume II, Joint Reports, Part 4, Nuclear Weapons (NUREP)
MD 4790.100/.200	Shore Activity Maintenance Data Collection System
MD 55658	Checkout Procedures and Inspection Requirements for Vertical Launching System Umbilical Breakout Box Mk 674 Mod 0
MD 56068	User’s Manual for VLS Canister Code Plug Test Set Mk 673 Mod 0
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-1320-235	Truckloading Encapsulated TOTEM, TOTEM Capsule and Expended Capsule
MIL-STD-1320-246	Truckloading CLS Ballast Cans Chocked
MIL-STD-1320-264	Truckloading VLS Canisters Mk 13, 14 & 15 and All Mods and Mixed Loads "Empty and w/o PHS&T"
MIL-STD-1949	Military Standard Inspection Magnetic Particle
MIL-STD-2000	Standard Requirements for Soldered Electrical and Electronic Assemblies
MIL-STD-410	Nondestructive Testing Personnel Qualification and Certification
MIL-STD-6866	Military Standard Inspection Liquid Penetrant
NAVAIR 19-15BC-13	Operations and I-Level Maintenance Instructions with Illustrated Parts Breakdown, Weapons Skid Aero 21C; Part Number 64A114H-4
NAVSEA Dwg. 6213981	Truckload Guided Missile U/RGM-109 (TOMAHAWK) in Shipping and Storage Container CNU- 308/E

DOCUMENT NUMBER	TITLE
NAVSEA Dwg. 6213982	Truckload Guided Missile UGM-109-2 (TOMAHAWK-CLS) in Shipping and Storage Skid Mk 30 Mods 0, 1 and 2
NAVSEA Dwg. 6213983	Truckload Guided Missile RGM-109 (TOMAHAWK) in VLS Canister Mk 14 Mods 0 and 1
NAVSEA Dwg. 6213987	Truckload, Guided Missile RGM-109 (TOMAHAWK) in VLS Canister MK 14 Mods 0 and 1 and Guided Missile U/RGM-109 (TOMAHAWK) in Container CNU-308/E
NAVSEA Dwg. 6214071	ISO Container Load, Shipping and Storage Skid Mk 30 Mods (TOMAHAWK) in 40 Ft Full Height Open Top ISO Container
NAVSEA OD 44979	Firing Craft Operating Procedures and Checklists
NAVSEA OD 46574	Weapon and Combat Systems Quality Assurance Requirements for Shore Stations and Engineering Agents
NAVSEA OD 48845	Metrology Requirements List
NAVSEA OD 48854	Field Calibration Activity Metrology Requirements List
NAVSEA OP 2239	Explosive Driver’s Handbook
NAVSEA OP 3206	Handling and Stowage of Naval Ordnance Aboard Ammunition Ships
NAVSEA OP 3221	Loading and Stowage of Military Explosives Aboard Breakbulk Merchant Ships
NAVSEA OP 3347	United States Navy Ordnance Safety Precautions
NAVSEA OP 3565	Radio Frequency Hazards to Ordnance, Personnel and Fuel
NAVSEA OP 4	Ammunition Afloat
NAVSEA OP 5, Vol I	Ammunition and Explosives Ashore Regulations for Handling, Storing, Production Renovation and Shipping
NAVSEA OR 99 Series	Intermediate and Depot Maintenance Instructions for (Specified Handling and Support Equipment)
NAVSEAINST 5511.28	Guided Missiles: Security Classification Guide
NAVSEAINST 8020.9	Non-Nuclear Ordnance and Explosive Handling Qualification and Certification Program
NAVSEAINST 8020.13	Emergency Response Procedures for Transportation Accidents

DOCUMENT NUMBER	TITLE
NAVSEAINST 8023.2	US Navy Explosive Safety Policies, Requirements and Procedures (Department of Navy Explosive Safety Policy Manual)
NAVSEAINST 4855.7	Reporting of Unsatisfactory Material
NAVSUP PUB 409	MILSTRIP/MILSTRAP Desk Guide
NAVSUP PUB 437	Military Standard Requisitioning and Issue Procedures (MILSTRIP)
NAVSUP PUB 4500	Consolidated Hazardous Items List (CHIL)
NAVSUP PUB 485	Afloat Supply Procedures
NAVSUP PUB 505	Preparing Hazardous Materials for Air Shipment
NAVSUPINST 4400.189	Reporting of Non-Conforming and Quality Deficient Material Obtained Through the Supply Systems
NAVSUPINST 4423.14	Navy Uniform Source, Maintenance and Recoverability Codes
NAVSUPINST 4440.120	Disposition of Used or Damaged Material
NAVSUPINST 4600.70	Military Traffic Management Regulations
NSPCCINST P8010.12	Supply Management of Ammunition
NTP-A-20-7703	Navy Training Plan (NTP) UGM-109 TOMAHAWK Cruise Missile Submarine Torpedo Tube Launch (TTL) and SSN 688 Class Vertical Launch System (VLS) Capsule Launching System (CLS)
OD 44979	Firing Craft Operating Procedures and Checklists for Weapon Loading and Handling Systems SSN 774 Class
OPNAVINST 4790.4	Ships' Maintenance and Material Management (3M) Manual
OPNAVINST 5102.1	Mishap Investigation and Reporting
OPNAVINST 5510.1	Department of Navy Information and Personnel Security Program Regulation
OPNAVINST 5530.13	Physical Security Instructions for Sensitive Conventional Arms, Ammunition and Explosives (A A&E)
OPNAVINST C8126.1/DOD C-5210.41M	Nuclear Weapons Security Manual
OPNAVINST S5513.2	Cruise Missile Classification Guide

DOCUMENT NUMBER	TITLE
PEO(CU) INST 4601.1	Physical Security Measures for Sea Launched Cruise Missiles During Transportation
PEO(CU) INST 8023.1	TOMAHAWK Conventional All-Up-Round Qualification and Certification
PEO(CU) INST 8800.1	TOMAHAWK Missile Nomenclature
PEO(CU) letter 5513 Ser PEO(CU)/142 12 May 1990	Security Classification Guidance
PEO(CU) P1540/1	Capsule Launching System (CLS) Missile Tube Loading and Handling Trainer Assembly Setup/Breakdown and Maintenance Procedures
PEO(W) PUB 4440	Record Book for TOMAHAWK Cruise Missile
PEO(W) INST 4440.2	TOMAHAWK Cruise Missile Record Book (PEO(W) PUB 4440)
S4140-AA-ASY-010	Capsule Launching System (CLS) Submarine Missile Tube Trainer Assembly Setup/Breakdown and Maintenance Procedures
S9086-T8-STM-010/CH593	Naval Ships' Technical Manual, Chapter 593, Pollution Control
S9086-XG-STM-000/CH-613	Navy Ships' Technical Manual - Chapter 613, Wire, Fiber Rope and Rigging
S9086-XG-STM-010	Naval Ships' Technical Manual, Chapter 700, Shipboard Ammunition Handling and Stowage
S976-AC-MMA-010	Instructions for Missile Tube Ballast Can: Description, Installation, Maintenance and Repair
S9CG0-B2-CSM-000/ CG 59-CG 64	Combat System Technical Operator Manual (CG 59 thru CG 64)
S9CG0-BU-CSM-000/ CG 52-CG 55	Combat System Technical Operator Manual (CG 52 thru CG 55)
S9CG0-BY-CSM-000/ CG 56-CG 58	Combat System Technical Operator Manual (CG 56 thru CG 58)
S9DDG-BT-CSM-000	Combat System Technical Operator Manual for DDG-51 Class
S9SSN-W4-SSM-Series	Ship Systems Manual for SSN 688 Class
SECNAVINST 4855.5	Product Quality Deficiency Report Program

DOCUMENT NUMBER	TITLE
SECNAVINST 5000.2	Implementation of Defense Acquisition Management Policies, Procedures, Documentation, and Reports
SG420-AP-MMM-010	NAVSEA Periodic Testing Arrangements for Ordnance Handling Equipment
SG420-BQ-MMA-010	Lift System Strikedown CG 47 Class Ship
SG420-BU-MMA-050	NAVSEA SSN 688 Class Weapon Delivery System Equipment Manual, Volume 5 - Vertical Launch System
SG420-C9-MME-010	Operation and Maintenance Instruction with Parts List Intermediate and Depot Maintenance Levels Virginia Class Vertical Launch System (VLS) Loading Platform
SG420-CC-MME-010	Vertical Launch System Loading Platform
SG420-DG-IEM-090	Introduction to Vertical Launch System Mechanical Equipment
SG420-DG-IEM-100	Vertical Launch System Mechanical Equipment
SG420-DG-IEM-120	Missile Tube Control and Indication Equipment
SG420-DG-IEM-130	Weapons Launch Console
SW020-AC-SAF-010/-020/-030	Transportation and Storage Data for Ammunition, Explosives and Related Hazardous Materials
SW020-AG-SAF-010	Navy Transportation Safety Handbook for Ammunition, Explosives and Related Hazardous Materials
SW260-DE-MMO-000	TOMAHAWK Weapon System Mk 36 and Mk 37 (Block III)
SW261-PB-MMO-000	TOMAHAWK Weapon System Mk 37 (Block III)
SW279-AC-OMP-010	All-Up Round Electronic Simulator (AURES) Mk 101 AURES User Manual
SW279-AC-OMP-020	All-Up Round Electronic Simulator (AURES) Mk 101 Mod 4 AURES User Manual
SW279-AD-URM-010	Users Manual For All-Up Round Electronic Simulator (AURES) Mk 112
SW281-DO-MMM-010 thru 050	VLS Systems Manual
SW282-B4-GTP-010	CCS Mk 1 Mod 0 General Information Manual
SW282-B4-MMO-010 thru 050/(C) CCS Mk 1	CCS Mk 1 Mod 0/2 - Description, Operation and Maintenance SSN 688 Class
SW394-AF-MMO-010 thru 050	Vertical Launch System Mk 41

DOCUMENT NUMBER	TITLE
SW394-AG-MMA-010	Description, Operation, Installation and Maintenance Instructions for AUR Simulator
SW394-EE-PRO-010	Vertical Launching System (VLS) Canister Dockside Handling Procedures
SW395-AA-IFM-010/ SWIM 010 - 060	Submarine Torpedo Tubes and Weapons Handling Systems Interface Manual
SW820-AA-WHM-010/ UGM-109-1	TOMAHAWK Cruise Missile UGM-109-1 Intermediate Level Activity Handling and Stowage
SW820-AD-WHS-010/ UGM-109-2	TOMAHAWK Cruise Missile UGM-109-2 Intermediate Level Activity Handling, Loading and Stowage
SW820-AD-WHS-030/ UGM/RGM-109	TOMAHAWK Vertical Launch All-Up-Rounds, Handling and Stowage Aboard AS-39 Class
SW820-AF-OMP-010/TOMAHAWK EQUIP	TOMAHAWK Support and Test Equipment Description, Maintenance and Repair Parts Breakdown (RPB)
SW820-AF-OMP-020/VLS/SSN SUPP EQUIP	TOMAHAWK Support and Test Equipment Description, Maintenance and Repair Parts Breakdown (RPB) (Vertical Launch System/Submarine Launch (VLS/SSN) Support Equipment)
SW820-AP-MMI-010	TOMAHAWK Cruise Missile System Description
SW820-AP-MMI-020	TOMAHAWK Cruise Missile General Handling Procedures
SW820-AP-MMI-030	TOMAHAWK Cruise Missile Maintenance Procedures
SW820-AP-MMI-040	TOMAHAWK Cruise Missile UGM-109A-1 Warhead Installation/Removal and Air Vehicle Maintenance
SW850-D9-PRO-010/ REM MSL RECOVERY	TOMAHAWK Cruise Missile Recovery Procedures: Recovery Exercise Module (REM) Configurations
SW850-EA-MMM-010/ TOTEM	TOMAHAWK Test Vehicles Description, Operation, Maintenance and Repair Parts Breakdown (RPB) TOMAHAWK Test Missile (TOTEM) UTM-109-1
SW850-EA-MMM-020/ CTS	TOMAHAWK Test Vehicles Description, Operation, Maintenance and Repair Parts Breakdown (RPB) TOMAHAWK Crew Training Shape (CTS) UTM-109-1A
SW850-EA-MMM-050/EMPLOYMENT	TOMAHAWK Test Vehicles Employment Procedures

DOCUMENT NUMBER	TITLE
SW850-EA-MMM-060	TOMAHAWK Test Vehicles; COTS TOTEM Description, Operation, Maintenance and Repair Parts Breakdown (RPB)
SW850-EB-MMM-010/TOMFISH	TOMAHAWK Inert Fitment Shape (TOMFISH) Description, Certification, Verification, Operation, Maintenance and Repair Parts Breakdown (RPB) (Submarine and Tender/Shorebase)
SW850-FA-MMM-010/WIT MK 35	TOMAHAWK Warhead Installation Trainer Mk 35 Mod 0 Description, Operation and Maintenance with Repair Parts List (RPL) and Quality Assurance Test and Inspection Procedures (QATIP) (Shorebase)
SWOP 0-1	Numerical Index to Joint Nuclear Weapons Publications
SWOP 0-1B	Numerical Index to Joint Nuclear Weapons Publications - Navy Supplement
SWOP 4-1	Glossary of Nuclear Weapons Material
SWOP 5-8	Unsatisfactory/Information Report
SWOP 20-5	Plutonium Contamination Standards
SWOP 20-7	Nuclear Safety Criteria
SWOP 20-11	Firefighting with Nuclear Warheads
SWOP 45-51	Transport of Nuclear Weapons Material
SWOP 45-56	Instructions for Logistical Movement of Nuclear Weapons. Includes SAFEPOT Maintenance with IPB and Command Disablement Procedures
SWOP 50-2	Procedures for the Use and Control of Logistics Codes for Permissive Action Linked (PAL) Equipped Weapons
SWOP 100-4	Custody, Accountability and Control of Nuclear Weapons and Nuclear Material
SWOP DE-2	Operator Maintenance Instruction with IPB for Disablement Equipment
SWOP H-1	Navy Nuclear Weapons Handling Equipment Certification Policies and Maintenance Instructions
SWOP W80.82-0	Weapon Summary, TOMAHAWK Land-Attack Missile UGM- 109A
SWOP W80.82-1	Depot Level Warhead Assembly, Test, Maintenance and Storage Procedures (Shorebase) Ship and Sub

DOCUMENT NUMBER	TITLE
SWOP W80.82-9	Operator and Organizational Maintenance, TOMAHAWK Land-Attack Missile UGM-109A
TO300-AM-ORD-10 (NAVSEA OD 465743)	Weapons and Combat Systems Quality Assurance Requirement for Shore Stations and Engineering Agents
TW120-AA-PRO-010	Nuclear Weapons Radiological Controls Program
TW510-AA-PRO-020/TMIS	Torpedo Management Information System Submarine Organizational Level Maintenance Activity Reporting Instructions for Submarine Fired Weapons/Vehicles
TW510-AA-PRO-030/ TMIS	Torpedo Management Information System Intermediate Level Maintenance Activity Reporting Instructions for Submarine Fired Weapons/Vehicles
TWA390-BA-GSE-010	Attack Submarine Vertical Launch System Peculiar Support Equipment Item Management Plan
ULSS PMA 280-1206	TOMAHAWK Cruise Missiles for Transhipment Activities.

Table 1-4. Abbreviations and Acronyms

ABBREVIATION/ACRONYM	DEFINITION
AA&E	Arms, Ammunition and Explosives
ACC	Attack Control Console
ACN	Advance Change Notice
ACR	Anticircular Run
ADM	Air Data Module
AE	Ammunition Ship
AEL	Allowance Equipage List
AFA	Analog Filter Assembly
AFIRT	Aft Flange Installation and Removal Tool
AGR	Anti-Jam Global Positioning System Receiver
ANSI	American National Standards Institute
AOE	Fast Combat Support Ship
APL	Allowance Parts List
APML	Assistant Program Manager, Logistics
AS	Submarine Tender
ASDS	Advanced Seal Delivery System
ASME	American Society of Mechanical Engineers
ATR	Ammunition Transaction Report
AUR	All-Up-Round
AURBb	All-Up-Round Ballast, Grade B
AURES	All-Up-Round Electronic Simulator
AURS	All-Up-Round Simulator
AURVS	All-Up-Round Volumetric Shape
AVCC	Alternator Voltage Control Converter
BDI	Battle Damage Information
BDII	Battle Damage Indication Imagery
BIT	Built-in-Test
BPU	Battery Power Unit
BR	Bend Radius

ABBREVIATION/ACRONYM	DEFINITION
BSTR	Booster
BUS	Bus Voltage
CAGE	Commercial and Government Entity
CAIMS	Conventional Ammunition Integrated Management System
CAL	Calibration
CATMIS	Canister Asset Tracking Management Information System
CC/A	Combat Control Acoustics Set
CCA	Capsule Closure Assembly; Circuit Card Assembly
CCC	Central Computer Complex
CCLS	Composite Capsule Launching System
CCN	Certification Control Number
CCS	Combat Control System; Central Control Station
CCW	Counter-Clockwise
CD	Command Disable
CDS	Command Disable System
CG	Center of Gravity; Guided Missile Cruiser
CHIL	Consolidated Hazardous Items List
CHT	Collection, Holding and Transfer
CII	Configuration Item Identifier
CINCLANTFLTINST	Commander-in-Chief, Atlantic Fleet Instructions
CINCPACFLTINST	Commander-in-Chief, Pacific Fleet Instructions
CL	Checklist
CLC	Capsule Loading Cover
CLF	Combat Logistics Force
CLS	Capsule Launching System
CMA	Cruise Missile Airframe
CMFR	Cruise Missile Feedback Report
CMGS	Cruise Missile Guidance Set
CMP	Cruise Missile Project
CMP PUB	Cruise Missiles and Joint Unmanned Aerial Vehicles Publication

ABBREVIATION/ACRONYM	DEFINITION
CMPINST	Cruise Missiles and Joint Unmanned Aerial Vehicles Instruction
CMTS	Combined Missile Test Set
CNTT	Chief, Naval Technical Training
COE	Certificate of Equivalency
COSAL	Coordinated Shipboard Allowance List
COSBAL	Coordinated Shorebase Allowance List
COTS TOTEM	Commercial Off The Shelf TOMAHAWK Test Missile
CPC	Closure Protective Cover
CPSL	Capsule
CRF	Container Repair Facility
CRPA	Controllable Radiation Pattern Antenna
CRS	Corrosion Resistant Steel
CSAS	Configuration Status Accounting System
CSES	Canister Safe Enable Switch; Combat System Electronic Space
CTS	Crew Training Shape
CW	Clockwise
DAMA	Demand Assigned Multiple Access
DCASPRO	Defense Contract Administration Services Procurement Office
DCM	DC-DC Converter Module
DCP	DSMAC Control Processor
DDG	Guided Missile Destroyer
DDS	Dry Dock Shelter
DECAN	Decanisterization
DECAP	Decapsulate
DIU	DSMAC Illuminator Unit
DIUE	DSMAC Illuminator Unit Electronics
DIUR	DSMAC Illuminator Unit Reflector
DLS	Digital Linear Switch
DMINS	Dual Miniature Inertial Navigation System

ABBREVIATION/ACRONYM	DEFINITION
DMS	Digital Missile Simulator
DOD	Department of Defense
DODIC	Department of Defense Information Code
DOE	Department of Energy
DOT	Department of Transportation
DPG	Digital Pressure Gauge
DRAI	Dead Reckoning Analyzer Indicator
DSMAC	Digital Scene Matching Area Correlation
DSN	Defense Switching Network
DSP	DSMAC Signal Processor
DTD	Data Transfer Device; Dated
DTG	Data Terminal Group
E-CMFR	Electronic Cruise Missile Field Report
EAB	Emergency Air Breathing
EBW	Exploding Bridgewire (Squib)
ECP	Engineering Change Proposal
EED	Electroexplosive Device
EID	End Item Description
EMI	Electromagnetic Interference
EMS	Environmental Monitoring Sensor
ENCAN	Encanisterization
ENCAP	Encapsulate
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
EQUIP	Equipment
ESD	Electrostatic Device; Electrostatic Discharge
ESDS	Electrostatic Discharge Sensitive
ESGN	Electrically Suspended Gyro Navigator
ESM	Electronic Support Measures
ESQD	Explosive Safety Quantity Distance
ESSD	Electrostatic Sensitive Devices

ABBREVIATION/ACRONYM	DEFINITION
EXT	Extend; Extraction
FBM	Fleet Ballistic Missile
FCA	Fleet Calibration Activity
FCS	Fire Control System
FEDLOG	Federal Logistics Data
FFIRT	Forward Flange Installation and Removal Tool
FIC	Firing Interlocks Closed
FM	Frequency Modulation
FP	Flash Point
FTCTU	Fleet Training Center Training Unit
GEU	Guidance Electronics Unit
GFE	Government Furnished Equipment
GN_2	Gaseous Nitrogen
GPS	Global Positioning System
GPSS	Global Positioning System Subsystem
GS	Guidance System
GSM	Guidance Set Mockup
H&S	Health and Status
He	Helium
HEPA	High Efficiency Particulate Air
HERO	Hazards of Electromagnetic Radiation to Ordnance
Hg	Mercury
HPU	Hydraulic Power Unit
HRA	Hydraulic Ram Assembly
HTML	HyperText Markup Language
HYD	Hydraulic
IAW	In Accordance With
I/O	Initial Outfitting; Input/Output
IC	Interlocks Closed
ID	Inside Diameter; Identification
IFF	Identification Friend or Foe

ABBREVIATION/ACRONYM	DEFINITION
ILSP	Integrated Logistics Support Plan
IMA	Intermediate Maintenance Activity
IMMM	In-Flight Mission Modification Messages
IMU	Inertial Measuring Unit
InHg	Inches of Mercury
INS	Insertion; Inertial Navigation Set
INST	Installation; Instruction
INSTL	Installation
IP	Inspection Point
IPB	Illustrated Parts Breakdown
IRTU	Insulation Resistance Test Unit
ISEA	In-Service Engineering Agent
ITL	Intent to Launch
IW/ER	Insensitive Warhead/Extended Range
JRS	Joint Reporting Structure
JTA	Joint Test Assembly
KB	Kilobyte
KW	Kilowatt
LA	Land Attack
LCG	Launch Control Group
LCM	Landing Craft, Mechanized
LCU	Landing Craft, Utility; Launch Control Unit
LFS	Launch Capable Flight Software
LLCE	Limited Life Component Exchange
Lo-temp	Low temperature
LOG	Logistics
LOGAIR	Logistics Airlift
LP	Low Pressure
LSEQ	Launch Sequencer
LTP	Launch Test Payload
MAC	Military Airlift Command, Multiple All-Up-Round Canister

ABBREVIATION/ACRONYM	DEFINITION
MCE	Maximum Credible Event
MCIO	Mission Control Input/Output
MCM	Mission Control Module
MCP	Mission Control Processor
MDD	Maintenance Due Date
MDS	Missile Designator Series
MEASURE	Metrology Automated System for Uniform Recall and Reporting
METRL	Metrology Requirements List
MIC	Missile Interface Console
MIL-SPEC	Military Specification
MIL-STD	Military Standard
MILSTAMP	Military Standard Transportation and Movement Procedures
MILSTRIP	Military Standard Requisitioning and Issue Procedures
MIP	Maintenance Index Page
MIS	Missile Identification System
Mk	Mark
Mod	Model; Modification
MON	Monitor
MRA	Missile Radar Altimeter
MRC	Maintenance Requirements Card
MRSS	Midbody Range Safety Subsystem
MS	Military Specification
MSA	Mine Safety Apparatus
MSD	Material Support Date
MSDDC	Military Surface Deployment & Distribution Command
MSDS	Material Safety Data Sheet
MSEM	Maintenance Standard Electronic Module
MSL	Missile
MTB	Multi-test Box

ABBREVIATION/ACRONYM	DEFINITION
MTBC	Missile Tube Ballast Can
MTCP	Missile Tube Control Panel
MTEL	Missile Tube Extension Loader
MV	Millivolts
NALC	Naval Ammunition Logistics Code
NAS	Naval Air Station
NAVICP-M	Navy Inventory Control Point Mechanicsburg
NAVMAG	Naval Magazine
NAVMAT	Navy Material Command
NAVMATINST	Naval Material Command Instruction
NAVSEA	Naval Sea Systems Command
NAVSEAINST	Naval Sea Systems Command Instruction
NAVSUP	Naval Supply Systems Command
NAVSUP PUB	Naval Supply Systems Command Publication
NAVSUPINST	Naval Supply Systems Command Instruction
NAVSURFWARCENDET	Naval Surface Warfare Center Detachment
NC	Normally Closed
NCC	Navigation Control Console
NESIP	Naval Explosive Safety Improvement Plan
NL TOTEM	Encapsulated No-Launch No-Wet TOMAHAWK Test Missile
No.	Number
NOTTS	Naval Ordnance Transportation Tracking System
NP	Navigation Processor
NSDSA	Naval Sea Data Support Activity
NSN	National Stock Number
NSSF	Naval Submarine Support Facility
NSTM	Naval Ship's Technical Manual
NSWC	Naval Surface Warfare Center
NSWCDET	Naval Surface Warfare Center Detachment
NSWCDIVPH	Naval Surface Warfare Center Division, Port Hueneme

ABBREVIATION/ACRONYM	DEFINITION
NTIK	Non-Tactical Instrumentation Kit
NTP	Navy Training Plan
NTSP	Navy Training System Plan
NUREP	Nuclear Weapons Report
NUWC	Naval Undersea Warfare Center
NUWCDIV	Naval Undersea Warfare Center Division
NUWCDIVNPT	Naval Undersea Warfare Center Division, Newport
NWAD	Naval Weapons Assessment Division
NWS	Naval Weapons Station
OD	Ordnance Data; Outside Diameter
OFP	Operational Flight Program
OLSS	Operational Logistics Support Summary
OP	Operating Procedure; Ordnance Publication
OPNAV	Office of Chief of Naval Operations
OPNAVINST	Chief, Naval Operations Instruction
OR	Ordnance Requirement
ORDALT	Ordnance Alteration
OSHA	Occupational Safety and Health Administration
OTH	Over the Horizon
OTL	Operational Test Launch
OTLP	Operational Test Launch Payload
PAL/CD	Permissive Action Link/Command Disable
P/N	Part Number
PCM	Pulse Code Modulation
PEO(CU)INST	Program Executive Officer, Cruise Missiles and Joint Unmanned Aerial Vehicles Instruction
PEO(U&W)	Program Executive Officer for Unmanned Aviation and Strike Weapons
PEO(W)	Program Executive Office for Strike Weapons and Unmanned Aviation
PEO(W)INST	Program Executive Office for Strike Weapons and Unmanned Aviation Instruction

ABBREVIATION/ACRONYM	DEFINITION
PFU	Power Filter Unit
PG	Procedural Guide
PGA	Pneumatic Gauge Assembly
PHS&T	Packaging, Handling, Storage and Transportation
PIP	Push-In-Pull
P/L	Position Launch
PLA	Plain Language Address
PMS	Planned Maintenance System
PPCA	Pyro and Power Control Assembly
PPM	Parts Per Million
PROM	Programmable Read Only Memory
PSA	Power Switching Amplifier
psid	Pound(s) Per Square Inch Differential
psig	Pound(s) Per Square Inch Gauge
PTMCR	Preliminary Technical Manual Change Request
PUB	Publication
P/V	Pressure/Vent
PV	Pressure Velocity
PVC	Pressurization/Vent Control
PVD	Pressure Vacuum Distributor
PVTV	Pressure Vent Test Vehicle
PVTV	Pressure Vent Test Vehicle TOMAHAWK Test Missile
PWD	Programmed Warhead Demolition
Q-D	Quantity-Distance
QA	Quality Assurance
QAST	Quality Assurance Service Test
QATIP	Quality Assurance Test and Inspection Procedure
QDR	Quality Deficiency Report
QUICKTRANS	Contractor-Operated Logistics Airlift
RA	Radar Altimeter
RASS	Random Access Storage Set

ABBREVIATION/ACRONYM	DEFINITION
RDX	Cyclonite
REM	Recovery Exercise Module
REPROG	Reprogram
RF	Radio Frequency
RFI	Ready-For-Issue
RGAP	Rate Gyro/Accelerometer Package
RJA	Relay Junction Assembly
RLEP	Remote Launch Enable Panel
RM	Rocket Motor
RMUC	Reference Measuring Unit and Computer
RNS	Radio Navigation Set
ROID	Report of Item Discrepancy
RPB	Repair Parts Breakdown
RPL	Repair Parts List
RPU	Receiver Processor Unit
RSC	Range Safety Command
RSEU	Range Safety Electronics Unit
RSS	Range Safety System
S&TE	Support and Test Equipment
S/N	Serial Number
SAFEPOT	Small Arms Fire Enclosure for the Protection of Ordnance in Transit
SAMDS	Shore Activity Maintenance Data System
SATCOM	Satellite Communications
SATNAV	Satellite Navigation
SB	Shore Base
SCG	Storage Compatibility Group
SCS	Submarine Combat System
SDL	Satellite Data Link
SEC	Second
SHIPALT	Ship Alteration

ABBREVIATION/ACRONYM	DEFINITION
SIB	Ship Information Book
SIP	Standard Inspection Procedure
SLCM	Sea Launched Cruise Missile
SMDC	Shielded Mild Detonating Cord
SMR	Source, Maintenance and Recoverability
SMTT	Submarine Missile Tube Trainer
SOF	Special Operations Forces
SPAWAR	Space and Naval Warfare Systems
SPU	Secondary Power Unit
SRA	Specialized Repair Activity
SSGN	Submarine, Guided-Missile, Nuclear Propulsion
SSN	Submarine, Nuclear Propulsion (Fast Attack)
STA	Station
START	Strategic Arms Reduction Treaty
SUBASE	Submarine Base
SUBROC	Submarine Rocket
SWF	Strategic Weapons Facilities
SWFTR	Submarine Weapon Field Trouble Report
SWL	Safe Working Load
SWOP	Special Weapons Ordnance Publication
T&E	Test and Evaluation
TACTOM	Tactical TOMAHAWK
TAE	Ammunition Ship (Military SEALIFT)
TALMIP	TOMAHAWK AUR Logistics and Maintenance Technical Information Products
TCG	Track Control Group
TCM	TOMAHAWK Cruise Missile
TEMP	Temperature
TERCOM	Terrain Contour Matching
TFBR	Technical Feedback Report
TGT	Target

ABBREVIATION/ACRONYM	DEFINITION
TLAM	Land-Attack TOMAHAWK Missile
TMDER	Technical Manual Deficiency/Evaluation Report
TMIS	Torpedo Management Information System
TMPS	Theater Mission Planning System
TNT	Trinitrotoluene
TOA	Time of Arrival
tol	Tolerance
TOMFISH	TOMAHAWK Fitment Shape
TOMIS	TOMAHAWK Management Information System
TOT	Time-On-Target
TOTEM	TOMAHAWK Test Missile
TR	Trainer (i.e., Warhead Installation Trainer TR1001)
TRB	Record Book for TOMAHAWK Cruise Missile, PEO(W) PUB 4440
TRNR	Trainer
TRS	Technical Repair Standard
TRT	Tensioner Rigging Tool
TSN	TOMAHAWK Strike Network
TTL	Torpedo Tube Launched
TVC	Thrust Vector Control
TWCS	TOMAHAWK Weapon Control System
TWS	TOMAHAWK Weapons System; Tactical Weapons Simulator
TYCOM	Type Commander
UBOB	Umbilical Breakout Box
UIC	Unit Identification Code
ULSS	User's Logistics Support Summary
UOC	Usable on Code
UR/IR	Unsatisfactory/Information Report
URL	Uniform Resource Locator
UWARS	Universal Restraint Stands

ABBREVIATION/ACRONYM	DEFINITION
VDA	Variable Dive Attack Maneuver
VDC	Volts DC
VLA	Vertical Launch Anti-Submarine Rocket
VLC	Vertical Launch Console; Vertical Launch Center
VLS	Vertical Launching System
VLT	Vertical Launch TOMAHAWK
VLV	Valve
VSA	Vertical Support Assembly
W/H	Warhead
WARHD	Warhead
WB	Work Boat
WCC	Weapon Control Console
WDC	Weapon Data Converter
WH INST TRNR	TOMAHAWK Warhead Installation Trainer
WIT	Warhead Installation Trainer
WIU	Warhead Interface Unit
WLC	Weapon Launch Console
WMP	Weapon Monitor Panel
WPNSTA	Weapons Station
WSA	Warhead Support Assembly

Table 1-5. Summary of Reports

WEAPON SYSTEM	REPORT	MEDIA	GOVERNING DIRECTIVE	PURPOSE OF REPORT
UGM-109-1 UGM-109-2 RGM-109-2 RGM-109-4	ELECTRONIC CRUISE MISSILE FIELD REPORT (E-CMFR)	Web-based E-CMFR Form located in TOMAHAWK Management Information System (TOMIS) database		An electronic reporting system that replaces the former CMFR system. For use by Intermediate Maintenance Activities to report damaged, faulty, or failed equipment, ineffective documentation, routine requests for technical assistance, corrective maintenance and/or results of PMS accomplishment for RGM-/UGM-109C/D/E AURs and related equipment.
UGM-109A-1	NUCLEAR WEAPONS UNSATISFACTORY/ INFORMATION REPORT (UR/IR)	NAVSEA Form 8110/4	SWOP 5-8	Report damaged, faulty or failed equipment or ineffective documentation for 109A and related equipment.
UGM-109-1 UGM-109-2 RGM-109-2 RGM-109-4	PMS TECHNICAL FEEDBACK REPORT (TFBR)	NAVSEA Form 4790/7B	OPNAVINST 4790.4	Report PMS documentation deficiencies.
UGM-109-1 UGM-109-2 RGM-109-2 RGM-109-4	CONVENTIONAL AMMUNITION INTEGRATED MANAGEMENT SYSTEM (CAIMS)	Ammunition Transaction Report	CINCLANTFLTINST 8010.4/ CINCPACFLTINST 8010.12/ NSPCCINST P8010.12	Report transfer/change in condition of items identified in PEO(CU) INST 8800.1.

WEAPON SYSTEM	REPORT	MEDIA	GOVERNING DIRECTIVE	PURPOSE OF REPORT
UGM-109-1 UGM-109-2 RGM-109-2 RGM-109-4	PRODUCT QUALITY DEFICIENCY REPORT (QDR)	Standard Form 368	NAVSEAINST 4855.7	Report receipt of defective AURs or material.
UGM-109-1 UGM-109-2 RGM-109-2 RGM-109-4	REPORT OF ITEM DIS-CREPANCY (ROID)	Standard Form 364	NAVMATINST 4355.7	Report shipping and packaging discrepancies
UGM-109-1 UGM-109-2	SUBMARINE WEAPON FIELD TROUBLE REPORT (SWFTR)	SWFTR Form		For use by Organizational Level Activities under the cognizance of the Submarine Type Commanders (TYCOMs) to report damaged, faulty, or failed equipment, ineffective documentation, routine requests for technical assistance, corrective maintenance and/or results of PMS accomplishment for UGM-109C/D/E AURs and related equipment.
UGM-109-1 UGM-109-2 RGM-109-2 RGM-109-4	TECHNICAL MANUAL DEFICIENCY/ EVALUATION REPORT (TMDER)	NAVSEA Form 4160/1	NAVSEAINST 4160.3	Report errors, omissions or discrepancies or recommend changes to basic manuals.
UGM-109-1 UGM-109-2 RGM-109-2 RGM-109-4	HAZARDOUS INCIDENT REPORT	Message	OPNAVINST 5102.1 for Navy/ CMPINST 5102.1 for contractor	Report accident or incident with material loss or damage to any variant creating hazard/potential hazard.

WEAPON SYSTEM	REPORT	MEDIA	GOVERNING DIRECTIVE	PURPOSE OF REPORT
RGM-109-4	CANISTER SHORE ACTIVITY MAINTENANCE DATA SUMMARY	OPNAVINST Form 4790/5(2A)	NAVSEAINST 4790.6	Report Mk 14 Canister preventive and unscheduled maintenance and defects
RGM-109-4	CANISTER/ MISSILE CONFIGURATION SUMMARY SHORE ACTIVITY MAINTENANCE DATA SUMMARY	NAVSEA Form 4790/5(2B)	NAVSEAINST 4790.6	Report Mk 14 Canister configuration changes to include encan/decan

Table 1-6. Common Descriptive Data

ITEM	DESCRIPTION
Engine:	
Designation	F107-WR-400(a) or F107-WR-402(b)
Type	Turbofan
Thrust.	600 lb
Rocket Motor Assembly:(a)	
Designation	Mk 106 Mod 0
Type	Single-chamber, fixed nozzle
Propellant	Arcadene 228G solid grain (304 lb)
Control	Jet tab thrust vector
Safe-Arm Igniter Assy	Electromechanical, dual initiator
Rocket Motor Assembly:(b)	
Designation	Mk 111 Mod 0
Type	Single-chamber, omnidirectional nozzle
Propellant	UTP-25201C solid grain (349 lb)
Control	Nozzle thrust vector
Safe-Arm Igniter Assy	Electromechanical, dual initiator
Electrical System:	
Shroud Converter:	
Type	AC/DC
Input	115/200V, 400Hz, 3 phase, Y
Output	27.5-28.5 Vdc
Guidance Set Battery:	
Type	Thermal
Output	23-33 Vdc
Airframe Battery:	
Type	Thermal, dual output
Output 1/Output 2	25-32 Vdc/26-44 Vdc
Engine Generator/Regulator:	
Type	Dual output

ITEM	DESCRIPTION
Output	28+/−1 Vdc (regulated)
Output 2	24-40 Vdc (semi-regulated)
REM Batteries (2):(c)	
Type	Silver oxide-zinc, remotely activated
Output	25-32 Vdc
RSS Battery:(d)	
Type	Thermal
Output	23-33 Vdc
Fuel:	Propellant, high density synthetic hydrocarbon, JP-10, MIL-P-87107C
Pneumatic System:	
Airframe Supply Bottle:	
Pressure	6000 psi (helium)
Volume	39 cu in
TVC Supply Bottle:(e)	
Pressure	6000 psi (nitrogen)
Volume(g)	23 cu in
Volume(h)	60 cu in
REM Flotation Supply Botles(2):(c)	
Pressure	6000 psi (nitrogen)
Volume	60 cu in each
Hydraulic System:(f)	
Hydraulic Reservoir/Accumulator	3550 psi
Pressurization/Vent System:	
Transducer:(g)	
Type	Dual differential, pressure sensing
Range	0.5 - 12.5 psid
Pressure Relief Valve:(g)	
Type	Poppet, spring-loaded
Cracking Pressure	12-16 psid

ITEM	DESCRIPTION
Reseat Pressure	10.8 psid (min)
Pressure Relief Valve:(h)	
Type	Poppet, spring-loaded
Cracking Pressure	3.4-17.0 psid
Reseat Pressure	3.0 psid
CLS Electrical System:(h)	
Type	Vdc
Input	24-30 Vdc and 4.5-5.5 Vdc
Output	24-30 Vdc
Engine:(i)	
Designation	Model F415-WR-400
Type	Turbofan
Thrust	650 lb
Rocket Motor Assembly:(i)	
Designation	Mk 135 Mod 0
Type	Single-chamber, fixed nozzle
Propellant	Arcadene 360B HTPB, high performance, aluminized composite propellant (322 lb)
Control	Jet tab thrust vector
Safe Arm Igniter Assy	Mk 38
Airframe Battery:(i)	
Type	Lithium thermal, dual output
Output 1/Output 2	28-34 Vdc/40-65 Vdc
Alternator:(i)	
Type	Engine shaft mounted, three phase permanent magnet generator
Output	4.3 KVA (max)

ITEM	DESCRIPTION
Voltage	140-250 Volts

NOTES:

(a) - Applicable to UGM/JUGM-109A.

(b) - Applicable to UGM/JUGM-109C/D only.

(c) - Applicable to JRGM/JUGM-109A/C-M only.

(d) - Applicable to JUGM-109C/D-S/W only.

(e) - Applicable to variants with Mk 106 Mod 0 Rocket Motor only.

(f) - Applicable to variants with Mk 111 Mod 0 Rocket Motor only.

(g) - Applicable to UGM/JUGM-109-1 only.

(h) - Applicable to UGM/JUGM-109-2 only.

(i) - Applicable to JUGM/UGM-109E-1/2 only.

Table 1-7. Variant Unique Descriptive Data

ITEM	109A	109C	109D	109E
Guidance:	Land Attack AN/DWS-15 (V)I Block III	Land Attack AN/DWS-15 (V)I Block III w/ DSMAC or DSMAC IIA and GPSS	Land -Attack AN/DWS-15 (V)I Block III w/ DSMAC or DSMAC IIA and GPSS	Land Attack Guidance Electronics Unit w/DSMAC,GPSS, and TERCOM
Warhead:				
Type/Weight	W80 Mod 0 Non-Conventional	WDU-25/B Conventional high explosive (Picratol/H-6) 992 lb (378 lb explosive)	BLU-97/B Conventional high explosive (Cyclotol 70/30) 287grams each	WDU-36/B Conventional High Explosive Warhead (PBXN-107 Type II) 690 lb (265 lb explosive)
Warhead:				
Type/Weight		WDU-36/B Conventional high explosive (PBXN-107 Type II) 690 lb (265 lb explosive)		
Fuel Capacity:				
TACTICAL;	1121 lb (a)	350 lb (a) 546 lb (b)	527 lb (a) 568 lb (b)	1100 lb
REM	1121 lb (a)	354 lb (a) 558 lb (b)		
RSS		350 lb (a) 468 lb (b)	474 lb (a) 474 lb (b)	
Warhead Arming Devices:				
Dual Air Valve:		FZU-43/B Pyrotechnic actuated dual initiator		FZU-43/B Pyrotechnic actuated dual initiator

ITEM	109A	109C	109D	109E
Fuze Booster Assembly				
Type		FMU-138/B Electropneumatic armed,impact detonated		BBU-47/B Electropneumatic armed, programmable detonated
Type		FMU-148/B Electropneumatic armed, programmable detonated		

NOTES:

(a) - Variant with Mk 106 Mod 0 Rocket Motor

(b) - Variant with Mk 111 Mod 0 Rocket Motor

Table 1-8. Container Weights and Dimensions

ITEM	WEIGHT (empty) (pounds)	LENGTH (inches)	WIDTH (inches)	HEIGHT (inches)
CNU-308/E SHIPPING CONTAINER	1709	265.00	34.00	35.00
MK 30 SHIPPING AND STORAGE SKID	2650	312.63	40.00	44.00
AUR SIMULATOR SHIPPING SKID	2700	321.19	39.12	49.88
MK 14 VLS CANISTER (w/PHS&T)	3241	280	40.34	43.45
	(kilograms)	(centimeters)	(centimeters)	(centimeters)
CNU-308/E SHIPPING CONTAINER	775	673	86	89
MK 30 SHIPPING AND STORAGE SKID	1202	794	102	112
AUR SIMULATOR SHIPPING SKID	1225	816	99	127
MK 14 VLS CANISTER (w/PHS&T)	1470	711	102	110

Table 1-9. Weights of TTL Variants and Related Material

ITEM	HANDLING WEIGHT* (LBS)	
	Pounds	Kilograms
	lbs	kg
TACTICAL AUR		
UGM-109A-1	4273	1938
UGM-109C-1	4548	2063
UGM-109D-1	4391	1992
UGM-109E-1	4510	2046
EXERCISE AUR		
JUGM-109A-1	4245	1926
JUGM-109A-1(QAST)	**	**
JUGM-109C-1	4483	2033
JUGM-109D-1	4367	1981
TRAINING/CERTIFICATION VARIANTS		
TOMAHAWK TEST MISSILE (TOTEM) UTM-109-1	3550	1610
ENCAPSULATED NL TOTEM	3550	1610
COMMERCIAL OFF THE SHELF (COTS) TOTEM	4050	1837
PRESSURE VENT TEST VEHICLE (PVTV) TOTEM	4550	2063.9
CREW TRAINING SHAPE (CTS) UTM-109-1A	3576	1622
WARHEAD INSTALLATION TRAINER (WIT) MK 35/0 w/WARHEAD	4137	1877
TOMAHAWK FITMENT SHAPE (TOMFISH) MK 1/0	4250	1928
VEHICLES AND CAPSULES		
TOTEM TEST VEHICLE TM-109-1C	2600	1179
CAPSULE MK 1/0	938	425
CAPSULE MK 3/0	1005	456
TOTEM CAPSULE	950	431

ITEM	HANDLING WEIGHT* (LBS)	
	Pounds	Kilograms
	lbs	kg
WIT MK 35/0 CAPSULE w/nose and slot covers	864	392
WIT MK 35/0 CAPSULE w/o nose and slot covers	832	377
WIT MK 35/0 TRAINER w/WARHEAD	3273	1485
TTL NOSE COVER (aluminum/lightweight/Block IV)	27/14/27	12.2/6.4/12.2
TTL FWD SLOT COVER (metal/Kevlar/Universal)	4/3/2	1.8/1.4/0.9
TTL AFT SLOT COVER (metal/Kevlar/Universal)	1/1/2	0.5/0.5/0.9
SHIPPING CONTAINER CNU-308/E (empty)	1709	775

NOTES:

* AUR handling weights calculated using heaviest components plus a small safety factor.

** Weight will vary depending on test requirements. Refer to Test and Evaluation Plan for data.

Table 1-10. Centers of Gravity for TTL Variants

ITEM	*APPROXIMATE FWD MEASUREMENT (IN) FROM CAPSULE CG
TACTICAL AUR	
UGM-109A-1 w/ W80 Warhead	10.0
UGM-109A-1 w/o W80 Warhead	2.5
UGM-109C-1	12.0
UGM-109D-1	11.5
UGM-109E-1	10.6
EXERCISE AUR	
JUGM-109A-1 w/ NTIK or REM & Inert Warhead	10.0
JUGM-109A-1w/QAST	**
JUGM-109C-1-M	11.5
JUGM-109C-1-S/W	10.5
JUGM-109D-1-S/W	11.5
TRAINING/CERTIFICATION VARIANTS AND CAPSULES	
TOMAHAWK TEST MISSILE (TOTEM) UTM-109-1	7.5
ENCAPSULATED NL TOTEM	7.5
COMMERCIAL OFF THE SHELF (COTS) TOTEM	7.5
ENCAPSULATED PVTV TOTEM	20
CREW TRAINING SHAPE (CTS) UTM-109-1A	6.0
WARHEAD INSTALLATION TRAINER (WIT) MK 35/0 w/W80	9.5
WARHEAD INSTALLATION TRAINER (WIT) MK 35/0 w/o W80	3.5
TOMAHAWK FITMENT SHAPE (TOMFISH) MK 1/0	0.0
CAPSULE MK 1/0, empty w/nose and slot covers	0.0
CAPSULE MK 1/0, empty w/o nose and slot covers	-5.0
CAPSULE MK 3/0, empty w/nose and slot covers	0.0
CAPSULE MK 3/0, empty w/o nose and slot covers	-2.39

ITEM	*APPROXIMATE FWD MEASUREMENT (IN) FROM CAPSULE CG
TOTEM CAPSULE, empty w/ nose and slot covers	0.0
TOTEM CAPSULE, empty w/o nose and slot covers	-3.5
WIT CAPSULE, empty w/nose and slot covers	7.0
WIT CAPSULE, empty w/o nose and slot covers	2.5

*Measure from center of capsule CG stripe.

AUR CG calculation is for AUR configured with Mk 111 Rocket Motor, aluminum nose cover and slot covers installed. Add up to 1.0 inch to measurement for variants with Mk 106 Mod 0 Rocket Motor. Subtract 0.5 inch from measurement with lightweight nose cover installed.

AUR/WIT/CTS CGs at station 142.1.

TOTEM, NL TOTEM and COTS TOTEM Capsule CGs at station 144.0.

PVTV TOTEM Capsule CG at station 155.0.

** QAST CG will vary depending on test requirements. Refer to Test and Evaluation Plan for data.

Table 1-11. Weights of CLS Variants and Related Material

	MAX. HANDLING WEIGHT (POUNDS)*		MAX. HANDLING WEIGHT (KILOGRAMS)*	
ITEM	CLS Mk 45 Mod 1	CLS Mk 45 Mod 2	CLS Mk 45 Mod 1	CLS Mk 45 Mod 2
TACTICAL VARIANTS:				
UGM-109C-2	5905	5905	2679	2679
UGM-109D-2	5749	5749	2608	2608
UGM-109E-2	5900	5900	2676	2676
EXERCISE VARIANTS:				
JUGM-109C-2	5816	TBF	2638	TBF
JUGM-109D-2	5696	TBF	2584	TBF
JUGM-109E-2-S/W	5625	TBF	2552	TBF
JUGM-109E-2-W	5612	TBF	2546	TBF
CAPSULE:				
Capsule Launching System Mk 45 (w. CPC)	2132	2290	967	1039
Capsule Launching System Mk 45 (Spent)**	2218	2376	1006	1078
	MAX. HANDLING WEIGHT (POUNDS)*		MAX. HANDLING WEIGHT (KILOGRAMS)*	
TRAINING/INERT VARIANTS:				
AUR VOLUMETRIC SHAPE	6800		3084	
AUR SIMULATOR	6870		3116	
AURES Mk 101	70		32	
AURES Mk 112	70		32	
Missile Tube Ballast Can (w/o additional ballast)	6800		3084	
AURBb	5680 ± 300		2576 ± 136	

	MAX. HANDLING WEIGHT (POUNDS)*	MAX. HANDLING WEIGHT (KILOGRAMS)*
CLS Loading and Handling Trainer Assembly (Mod 1)	6390	2899
CLS Loading and Handling Trainer Assembly (Mod 2)	TBF	TBF
SHIPPING SKID:		
Shipping and Storage Skid Mk 30 Mod 2 w/covers	2650	1202
AUR Simulator Shipping Skid w/covers	2700	1225
MISCELLANEOUS:		
SABOT	26	12
Closure Protective Cover (CPC) Mk 19	84	38
Capsule Loading Cover (CLC)	17	8
Clamp Ring	30	14
Forward Capsule Support Adapter Mk 168	50	23
CLS Uprighting Fixture Mk 26	130	59
Lifting Adapter Mk 169	500	227
Lifting Adapter Extension	300	136
Missile Tube Extension Loader (MTEL) Mk 23	2000	907
MTEL Adapter	480	218
Container, Shipping/Storage, MTEL Adapter, Lifting Adapter Extension (Loaded)	2120	962
Container, Shipping/Storage, Work Platform (Loaded)	750	340
MTEL Shipping Pallet	1100	499
Installation Guide Mk 116	185	84
Hydraulic Power Unit (HPU) Mk 8	290	132
Tilt Fixture, Mk 23	3000	1361

	MAX. HANDLING WEIGHT (POUNDS)*	MAX. HANDLING WEIGHT (KILOGRAMS)*
SSN 688 Class Loading Platform:		
Forward Section	5800	2631
Starboard Section	3800	1724
Port Section	3800	1724
All Three Sections-Stacked	13400	6078
SSN 774 Class Loading Platform:		
Forward Section	6100	2767
Starboard Section	3900	1769
Port Section	3900	1769
All Three Sections-Stacked	13900	6305
* AUR handling weights calculated using heaviest components plus a small safety factor. ** Includes approximately 86-gallons (325 liters) of water.		

Table 1-12. Centers of Gravity for CLS Variants

ITEM	CENTER OF GRAVITY (INCHES)
	CLS MK 45 1/2
TACTICAL AUR	
UGM-109C-2	126 ± 6
UGM-109D-2	127 ± 6
UGM-109E-2	127 ± 6
EXERCISE AUR	
JUGM-109C-2-M	133
JUGM-109C-2-S/W	132
JUGM-109D-2-S/W	132
JUGM-109E-2-S/W	143
CAPSULE LAUNCHER	
SPENT CLS *	163 ± 6
OTHER	CENTER OF GRAVITY (INCHES)
AUR SIMULATOR SHIP SKID (LOADED)	141
AUR SIMULATOR SHIP SKID (EMPTY)	160
AUR SIMULATOR VOLUMETRIC SHAPE w/ AURES	153
AUR SIMULATOR VOLUMETRIC SHAPE w/o AURES	155
AURBb	122.51 ± 1.00
MISSILE TUBE BALLAST CAN	132
CLS LOADING AND HANDLING TRAINING SHAPE	127

AUR variant, AUR Volumetric Shape, AURBb, AUR Simulator and CLS Loading and Handling Trainer CGs are measured from 'datum B' (lower edge of upper flange).

Missile Tube Ballast Can CG is measured from brass protector ring (flat gasket mounting surface).

AUR Simulator Shipping Skid: Trunnion end.

*CG will vary for empty/spent capsule depending on amount of residual water remaining in capsule after draining.

Table 1-13. Weights of RGM-109-2 Mk 10 Variants and Related Material

	HANDLING WEIGHT*	
ITEM	Pounds	Kilograms
TACTICAL AUR		
RGM-109C-2	3973	1802
RGM-109D-2	3823	1734
RGM-109E	3837.5	1741
EXERCISE AUR		
JRGM-109C-2	3973	1802
JRGM-109D-2	3823	1734
JRGM-109E-2	3938	1786
TRAINING/CERTIFICATION VARIANTS		
CANISTER TRAINER MK 17	3662	1661
CANISTER		
CANISTER MK 10	495	225

NOTE:

* AUR handling weights calculated using heaviest components plus a small safety factor.

Table 1-14. Centers of Gravity for RGM-109-2 Variants

ITEM	*APPROXIMATE FWD MEASUREMENT (IN) FROM CANISTER CG
TACTICAL AUR	
RGM-109C-2	11.5
RGM-109D-2	11.5
RGM-109E-2	14.8
EXERCISE AUR	
JRGM-109C-2-M	11.5
JRGM-109C-2-S/W	10.0
JRGM-109D-2-S/W	11.5
TRAINERS AND CANISTERS	
CANISTER TRAINER MK 17 MOD 0	0.0
CANISTER MK 10 (Empty)	2.0

* Measure from center of canister CG stripe.

AUR CG calculation is for AUR configured with Mk 111 Rocket Motor. Add up to 0.5 inch to measurement for variants with Mk 106 Mod 0 Rocket Motor.

AUR CG at station 138.0.

Mk 17 Trainer Canister CG at station 130.0.

Table 1-15. Weights of VLS Variants

ITEM	* HANDLING WEIGHT	
	Pounds	Kilograms
AUR		
JRGM/RGM-109C-4	7290	3307
JRGM/RGM-109D-4	7133	3236
RGM-109E-2	7154	3245
TRAINER		
CANISTER TRAINER MK 14	6528	2961

NOTE:

* Handling weights calculated using heaviest components plus a small safety factor.

CHAPTER 2 SECURITY AND SAFETY

2.1 SCOPE.

This chapter discusses TOMAHAWK Weapon System (TWS) security and safety requirements, regulations and general policies relating thereto.

2.2 SECURITY.

TOMAHAWK mission criticality, high cost and political sensitivity require an adequate level of security be maintained regarding security safeguards and physical protective measures used for commercial/government transport. OPNAVINST 5530.13, PEO(CU)INST 4601.1 and NAVSEA SW020-AG-SAF-010 contain specific security requirements for transport of TOMAHAWK Cruise Missiles (TCM) variants over public highways. Storage and transport of TCM variants on military installations will be IAW NAVSEA OP 5, NAVSEA OP 4461 and amplifying local directives.

2.2.1 Security Classification. All TCMs carry a minimum security classification of CONFIDENTIAL. OPNAVINST S5513.28 contains specific information on the security classification of TCM variants and their components.

2.2.2 Maintaining Unwarheaded 109A Certification. Prior to, during, and subsequent to warhead installation, the 109A variant receives no missile systems testing at the intermediate level. To ensure that the variant retains its certification, the following requirements apply to the 109A without warhead installed:

a. The 109A without warhead shall be safeguarded in accordance with the provisions of OPNAVINST 5530.13 and OPNAVINST C8126.1/DOD C-5210.41-M and shall be protected at the same level of security provided Category II Arms, Ammunition and Explosives (AA&E).

b. Formal entry and access control shall be maintained in accordance with OPNAVINST 5530.13 after the tamper resistant tape seals are broken on the shipping container.

c. Upon breaking the tamper resistant tape seals on the shipping container, the 109A shall be provided two-person control which is defined in Special Weapons Ordnance Publication (SWOP) 4-1 as 'The close surveillance and control of materials at all times by a minimum of two authorized persons, each capable of detecting incorrect or unauthorized procedures with respect to the task to be performed, and each familiar with established security requirements'.

2.2.3 Warheaded 109A. Warheaded 109A TCMs are secured, handled, maintained and transported in accordance with applicable SWOPs.

2.2.4 Transportation Security. All shipping containers containing TCM variants are secured by wire seals. Shipping containers containing 109A variants without warhead are shipped from the manufacturer to the military first destination with tamper resistant tape seals, as well as wire seals, applied to the container. Additionally, the manufacturer places tamper resistant tape seals on the 109A variant prior to shipment. Tamper resistant tape seals are serially numbered with the back of the seal coated with a bar pattern release agent that will show the bars if the seal was removed and re-affixed or has been subjected to tampering. Serial numbers or seal identifying data are recorded in the Record Book for TOMAHAWK Cruise Missile, PEO(W) PUB 4440, that accompanies each TCM variant. Seal locations are illustrated in the record book as well as in applicable volumes of this document addressing removal/installation of seals during handling and maintenance processes.

2.2.4.1 Receipt. During receipt inspections, tamper resistant tape and wire seals are inspected for integrity. Additionally, seal serial numbers/identifying data are compared with the information contained in the record book. If seals are missing, broken, or show evidence of tampering, compromise of the variant is suspected and Program Executive Officer for Unmanned Aviation and Strike Weapons [PEO(U&W)] (PMA-280714) as well as the applicable In-Service Engineering Agent are notified.

2.2.4.2 Transfer. Navy activities apply wire seals to shipping containers when transferring TCMs out of Navy custody. Additionally, activities apply tamper resistant tape seals to a 109A variant without warhead and its shipping container prior to shipment to the depot or to another intermediate maintenance activity. Seal serial numbers/identifying data are recorded in the record book.

2.3 SAFETY.

Operations associated with the TOMAHAWK Weapons System (TWS) present a number of safety considerations at all levels. The TCM contains a number of hazardous components. Handling evolutions involve moving heavy weights using dollies or hoists where ’free-wheeling’ or pendulum effects can occur. Operations may have to be performed under adverse conditions where weather or sea state can impact safety. During TCM or related equipment maintenance processes, personnel may be exposed to various hazardous materials which may require the use of protective equipment or employing special procedures. To maximize safety, only qualified ordnance certified personnel as specified in NAVSEA OP 4 and OP 5 and NAVSEAINSTs 8020.9 and 8023.2 shall be used to perform TWS evolutions. Additionally, procedural volumes of this document contain the general safety summary, Table 2-1 "General Safety Summary"⇒, as well as generic and specific warnings and cautions to identify potential hazards to personnel or equipment. These warnings and/or cautions appear prior to the step or series of steps in which potential hazards exist.

2.3.1 Explosives Safety Quantity Distance (ESQD) Arc Restrictions. At some activities, other than designated ammunition handling facilities (i.e., WPNSTA), handling of explosives is substantially restricted because nonexplosive ordnance activities (i.e., inhabited buildings) are in close proximity to ordnance handling operations. To safely accommodate handling of more than one TOMAHAWK All-UP-Round (AUR) at these ESQD restricted activities, special handling procedures have been developed and approved for the conventional TOMAHAWK AUR.

2.3.1.1 The concept for these special handling procedures is based on maintaining a Maximum Credible Event (MCE) of one TOMAHAWK AUR regardless of the number of AURs involved. The acknowledged ESQD arc to inhabited buildings for one conventional TOMAHAWK AUR is 600 feet. The conventional TOMAHAWK AUR ESQD area is 600 feet.

2.3.1.2 A maximum of two conventional TOMAHAWK AURs in their launch configuration, either in or out of their shipping containers, must be maintained in a nose-to-tail configuration with respect to each other either horizontally or vertically. Other stacking restrictions regarding numbers in stacks on or off transport vehicles still apply. This nose-to-tail configuration is to be maintained on the bed of a truck driven onto a pier, in small boats or on the pier itself. Additionally, a maximum of two other conventional TOMAHAWK AURs in their launch configuration (off-loaded from combatant) may be placed in a nose to-tail configuration in specially positioned chocks or shipping containers on the pier. All four missiles must be in a nose-to-tail configuration in groups of two, and each group of two must be positioned no closer than 10 feet side-to-side or 5 feet nose-to-tail (Figure 2-1 "Explosive Safety Quantity Distance (ESQD) Arc Restrictions (Typical)"⇒).

2.3.1.3 The use of these procedures will prevent sympathetic detonation and maintain an MCE of one conventional TOMAHAWK AUR. If ESQD restrictions are less than 600 feet to inhabited buildings, these procedures will not provide relief, and the requirements of NAVSEA OP 4 or OP 5 prevail. Conversely, where ESQD arcs to inhabited buildings are well beyond 600-ft arc, the ordnance handling activity may utilize the procedure to reduce, thus enhance the effect of the available ESQD arc. These procedures are not applicable in magazines, bunkers, workshops or inside ships.

2.3.2 TCM Hazardous Components. TCM hazardous components range from the nonexplosive, combustible JP-10 fuel used by the TCM to cruise to the target, comparatively low-explosive electro-explosive devices (EED) used to separate the TCM from its launching device, to the highly destructive, high explosive warhead. Also included in the general category of explosives are the solid propellant rocket motor and the Capsule Launching System gas generator. TCM hazardous component locations are illustrated in Figure 2-2 "TOMAHAWK Cruise Missile Hazardous Component Locations (2 Sheets)"⇒. All TOMAHAWK AURs are assigned to Storage Compatibility Group “J” and to a DOT Hazard Class IAW SW020–AC-SAF-010/020/030. Table 2-2 "Storage and Hazard Data"⇒ summarizes storage and hazard data for all AURs. Table 2-3 "Pyrotechnic and Hazardous Materials Data"⇒ provides AUR pyrotechnic and hazard data associated with composite material breakdown/combustion and postlaunch waste water in spent CLS capsules.

2.3.3 Permits. As all TCMs contain some hazardous materials in their shipping configurations, current Department of Transportation (DOT) Exemptions and Certifications of Equivalency (COE) are required to authorize the movement of these items. Copies of the applicable permits must accompany the shipment, and any special instructions contained in the permit must be observed. The permits have the force and effect of federal law, and failure to have a permit or to comply fully with its provisions may result in fine and/or imprisonment. The fact that a shipment is made by or for the government in no way relieves the shipper from full compliance with permit requirements. Five permits have been issued by federal agencies that effect shipment of TCMs.

2.3.4 Hazards Associated With Composite Material Breakdown/Combustion. CLS AURs may be encapsulated in a steel or a composite material CLS. If a CLS made of composite material is subjected to fire, additional precautions must be taken as outlined below and summarized in Table 2-3 "Pyrotechnic and Hazardous Materials Data"⇒.

2.3.4.1 Composite materials composed of carbon/graphite fibers present several hazards when subjected to fire, explosion, etc. Carbon/graphite fibers can be released into the atmosphere if their epoxy binder burns. When subjected to temperatures of approximately 752°F (400°C) the epoxy binder will ignite or decompose, possibly releasing fiber material. Once free, the fibers can be transported up to several miles by air currents. The fiber material is highly conductive and fibers can potentially damage electric/electronic equipment. Mechanical agitation, especially an explosion, can also fragment the composite causing fibers to become airborne.

2.3.4.2 Fires should be extinguished with CO_2, dry chemicals (AFFF), or water. Special firefighting equipment such as Scott airpacks/MSAs/positive pressure self-contained breathing apparatuses will be required. Hazardous combustion by-products may consist of carbon monoxide, carbon dioxide, acrolein, phenols, amines, aldehydes, aromatic amines, hydrofluoric acid and fluoroboric acid.

2.3.4.3 Personnel should wear protective clothing, such as:

a. Disposable coveralls and shoe covers

b. Gloves, preferably with leather palms

c. Safety glasses with side shields for cleanup personnel

d. Full face respirators for cleanup personnel

e. Positive-pressure self-contained breathing apparatus for firefighting personnel.

2.3.4.4 Waste materials should be collected with a vacuum cleaner equipped with High Efficiency Particulate Air (HEPA) filter elements. Waste materials should be packaged in polyethylene plastic bags. If sheeting or bags are not available, fibers shall be contained using an acrylic floor wax (i.e., Wax, Floor, Water Emulsion, P-W-155C). Affected areas shall be decontaminated by washing down and/or vacuuming. Local solid waste disposal authorities shall be consulted for approved burial sites/techniques for composites or composite contaminated materials. Local cognizant industrial hygienist or medical department representative shall be consulted for detailed health hazard control guidance, based upon extent of exposure.

2.3.5 CLS Post-Launch Waste Water. CLS post-launch waste water has a lead (Pb) concentration consistently averaging between 5 to 10 milligrams per liter (mg/l) (particle setting may cause concentrations to range from 1 to 5 mg/l at the top and 10 to 30 mg/l at the bottom of the capsule) and cyanide concentration consistently between 20 to 25 mg/l. Because Environmental Protection Agency regulations identify lead concentrations equal to or greater than 5 mg/l and cyanide in any amount as hazardous, CLS post-launch waste water is considered hazardous waste (HW). The internal volume of an expended CLS contains approximately 700 gallons of HW. Tube flushing will produce approximately 300 additional gallons of HW. Therefore, approximately 1,040 gallons of HW are generated during off-load of one expended CLS.

Figure 2-1. Explosive Safety Quantity Distance (ESQD) Arc Restrictions (Typical)

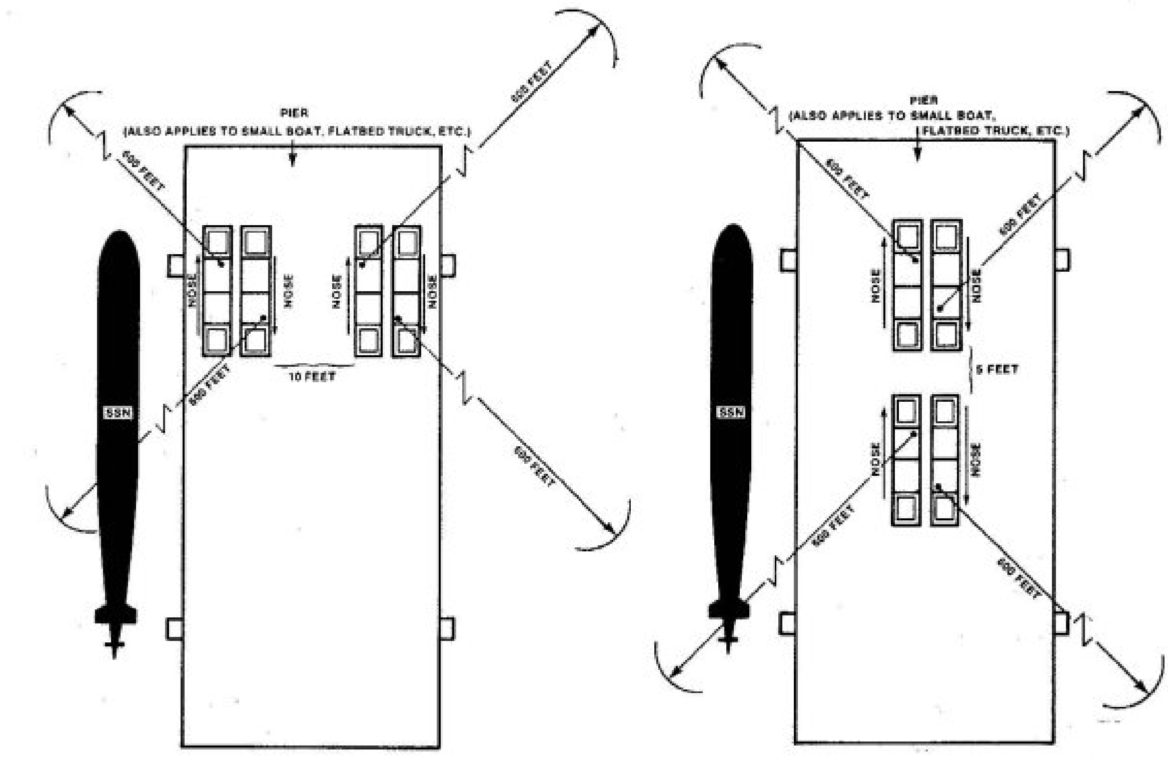
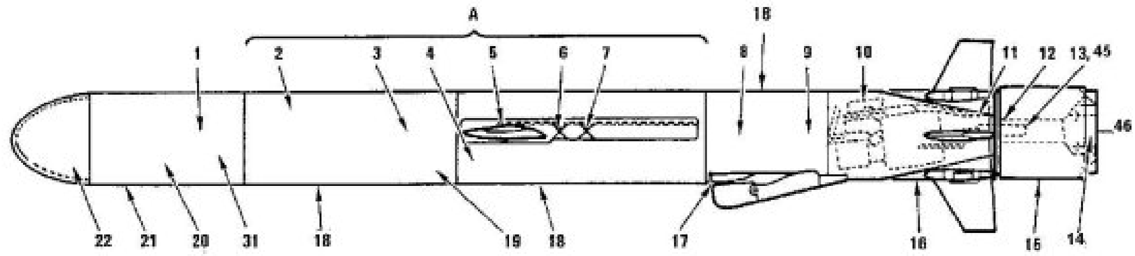
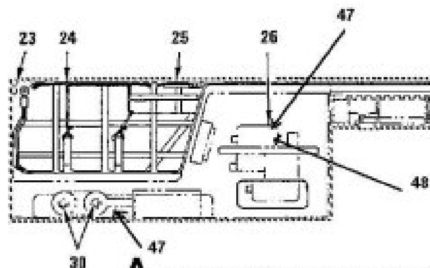
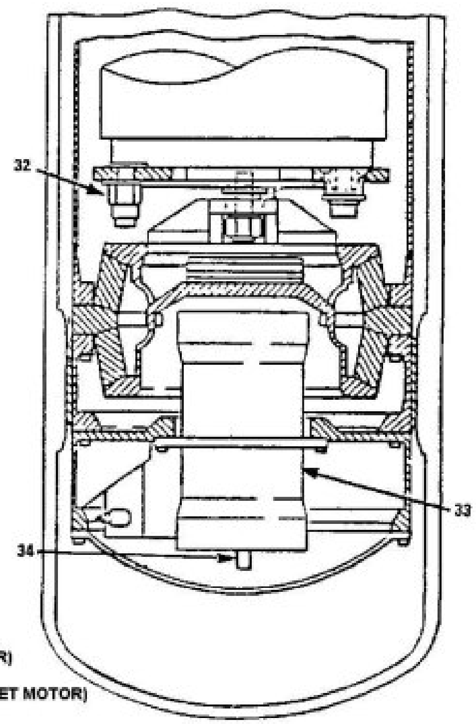


Figure 2-2. TOMAHAWK Cruise Missile Hazardous Component Locations (2 Sheets)

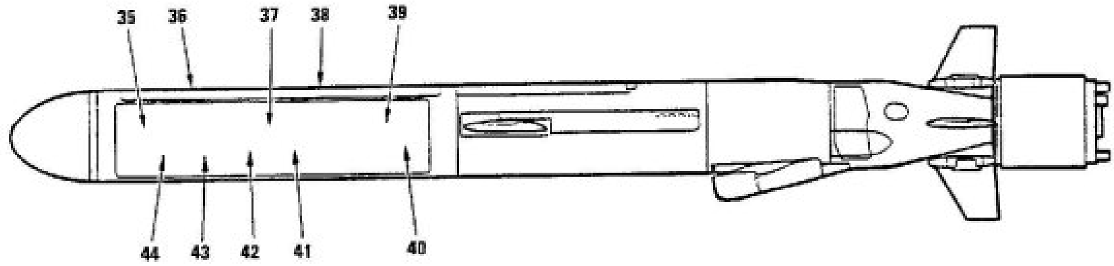




A RECOVERY EXERCISE MODULE (REM)



1. N/A
2. WDU-25/B WARHEAD OR WDU-36/B WARHEAD (109C)
3. WARHEAD FUZE-BOOSTER ASSEMBLY (109C)
4. CMA THERMAL BATTERY
5. WING SLOT PLUG THRUSTERS (2)
6. CMA He 3-WAY VALVE (WING EXTEND/He VENT CONTROL)
7. CMA He 3-WAY VALVE (SLOT DOOR CLOSE/He VENT CONTROL)
8. CMA He 3-WAY VALVE (ENGINE INLET DEPLOYS/SLOT DOOR OPEN CONTROL)
9. CMA He 3-WAY VALVE (He SUPPLY/FIN DEPLOY CONTROL)
10. ENGINE START CARTRIDGE
11. CABLE CUTTER
12. ROCKET MOTOR SEPARATION ASSEMBLY
13. SAFE-ARM/IGNITER SUPPLY (MK 106 ROCKET MOTOR)
14. TVC GN_2 SUPPLY VALVE (MK 106 ROCKET MOTOR)
15. ROCKET MOTOR
16. SHROUD SEPARATION ASSEMBLY
17. ENGINE INLET COVER THRUSTER
18. FUEL SECTIONS (109A/C)
19. DUAL AIR VALVE (109C)
20. W80 WARHEAD (109A)
21. DSMAC WINDOW COVER THRUSTERS (109C/D)
22. GUIDANCE SET THERMAL BATTERY (109A/C/D)
23. PARACHUTE COMPARTMENT COVER (2) (REM)
24. MAIN PARACHUTE REEFING CUTTERS (2) (REM)
25. DRAG PARACHUTE REEFING CUTTERS (2) (REM)
26. BATTERY (2) (REM)
27. PARACHUTE RISER COMPARTMENT COVER THRUSTER (REM)
28. MAIN PARACHUTE GROUND DISCONNECT CARTRIDGE (REM)
29. RISER (SWING ARM) RELEASE CARTRIDGES (2) (REM)
30. FLOTATION SYSTEM GN_2SUPPLY VALVES (2) (REM)
31. RSS THERMAL BATTERY (J-109C)
32. SEPARATION NUT INITIATOR (4)
33. CLS GAS GENERATOR
34. EBW, INITIATOR
45. ARMING-FIRING DEVICE AND IGNITER ASSEMBLY (MK 111 ROCKET MOTOR)
46. GAS GENERATOR AND HYDRAULIC RESERVOIR/ACCUMULATOR (MK 111 ROCKET MOTOR)
47. SPECIAL INSTRUMENT LITHIUM ACTIVE BATTERY
48. RECOVERY BEACON LITHIUM ACTIVE BATTERY (6008 REM)



35. RSS THERMAL BATTERY (JUGM-109D)
36. SHIELDED MILD DETONATOR CORD AND TRANSFER TIPS (JUGM/UGM-109D)
37. SUBMUNITION PACK SEPARATOR ASSEMBLY (JUGM/UGM-109D)
38. INITIATOR MANIFOLD (JUGM/UGM-109D)
39. RSS THERMAL BATTERY (JUGM-109D)
40. FUEL MODULE (2) (JUGM/UGM-109D)
41. BLU-97/B SUBMUNITION (JUGM/UGM-109D)
42. BLU-97(T-1)/B SUBMUNITIONS (JUGM-109D)
43. SUBMUNITION PACK EJECTOR ASSEMBLY (JUGM/UGM-109D)
44. PAYLOAD COVER JETTISON SYSTEM (JUGM/UGM-109D)

Table 2-1. General Safety Summary

GENERAL

Operators and maintenance personnel shall strictly observe all safety precautions applicable to their work or duty station. Personnel are to immediately report any unsafe conditions or any equipment that is considered unsafe.

Carelessness is one of the major causes of injury to personnel. Personnel shall be thoroughly and frequently instructed in the general safety precautions associated with the system. Should situations arise which are not covered in the safety precautions presented in this or other applicable documents, the commanding officer, or other authorities, may issue orders as deemed necessary.

For handling or maintenance of ordnance, personnel performing operations shall be qualified and ordnance certified IAW NAVSEA OP 4 and OP 5, NAVSEAINST 8020.9 and 8023.2 and other applicable documents. Familiarity with safety standards ASME/ANSI B30.5-1989 and B30.8-1988 will help ensure safe crane operations.

The following are general safety precautions not related to any specific procedures and therefore do not appear elsewhere in this publication. These are precautions that personnel must understand and apply during many phases of operations and maintenance.

LIVE CIRCUITS

Personnel must observe all safety precautions while working on and around electrical equipment. Do not replace components or make adjustments with the high voltage supply turned on. Under certain conditions, dangerous potentials may exist when the power control is in the OFF position. To avoid casualties, always remove power and discharge and ground a circuit prior to touching it.

SERVICING OR ADJUSTING EQUIPMENT

Under no circumstances should the servicing or adjusting of equipment be attempted alone. The immediate presence of someone capable of rendering aid is required.

RESUSCITATION

Personnel working with or near high voltages shall be thoroughly instructed in the latest methods of cardiopulmonary resuscitation (CPR). Should someone be injured by electricity and stop breathing, begin resuscitation at once: a delay could result in the death of a victim.

VENTILATION

Ensure there is adequate ventilation to vent flammable and harmful vapors. Keep away from heat, sparks, and open flame. Avoid prolonged breathing of vapors or repeated contact with the skin. Failure to comply may result in injury to personnel.

RESPIRATORS

Personnel shall wear approved respirators when working with toxic cleaning agents, adhesives, and other toxic materials.

FIRST AID

An injury, no matter how slight, shall never remain unattended. First aid or medical attention shall be given immediately.

HAZARDS ASSOCIATED WITH COMPOSITE MATERIAL COMBUSTION/BREAKDOWN

Composite materials composed of carbon/graphite fibers present several hazards when subjected to fire, explosion, etc. The epoxy binder will ignite or decompose at high temperatures, possibly releasing fiber materials. Mechanical breakdown (i.e., explosion) will also liberate and fragment fibers. Such fibers can be spread via air currents for considerable distances. Fiber material is highly conductive and can potentially damage electric/electronic equipment. Combustion by-products may consist of carbon monoxide, carbon dioxide, acrolein, phenols, amines, aldehydes, aromatic amines, hydrofluoric acid, and fluoroboric acid.

COMMUNICATIONS

During a weapon loading/handling evolution, communications must be established and maintained among all parties (e.g., handling/loading supervisor, security, crane/hoist operators, handling personnel, damage control party) throughout the evolution. Should communications become lost to any party engaged in an evolution, stop the operation and secure the weapon until communications are reestablished.

HAZARDOUS MATERIALS AND SITUATIONS

Procedures involving hazardous materials or situations where there is potential for personnel injury or damage to equipment are preceded by WARNING or CAUTION as appropriate. For each hazardous material used, a Material Safety Data Sheet (MSDS) shall be posted and reviewed to determine specific hazards involved, protective equipment requirements, and appropriate handling and emergency procedures to be utilized.

NUCLEAR SAFETY PRECAUTIONS

All personnel performing technical operations on a TOMAHAWK Cruise Missile "A" variant containing the W80 Warhead must be familiar with the Nuclear Safety Rules for Operations provided in applicable Type Commander directives and SWOP 20-7.

FUEL PRECAUTIONS

TOMAHAWK Cruise Missiles are fueled with JP-10, a nonexplosive, combustible liquid. The flashpoint for JP-10 is 130 degrees F and auto-ignition may occur at 474 degrees F.

Firefighting involving JP-10 is the same as for any other hydrocarbon fuel. Carbon dioxide, dry chemical and water spray are the methods used to combat fire.

The probability of fuel leaking from the missile is highly unlikely since the capsule/canister also serves as a fuel tight barrier. In the event leakage should occur, the affected areas should be wrapped in Buna-N rubber sheeting and/or ordnance tape to provide a fuel tight seal.

Do not use organic cartridge respirators or oxygen breathing apparatus to combat fuel associated casualties, including cleanup of spills or combustion by-products. A minimum of two personnel shall be present during operations involving fuel spills. No smoking, matches, or open flames are permitted in the area of a fuel spill.

EXPLOSIVE HAZARDS

The TOMAHAWK Cruise Missile contains a number of explosive components. They range from comparatively low-explosive electroexplosive devices (EED) to the highly destructive, high explosive warhead. Also included in the general category of explosives is the solid propellant rocket motor. General safety precautions regarding handling and storage of explosives shall be observed at all times. Personnel shall be familiar with the operating procedures and precautions necessary to prevent the spurious initiation of EEDs. Areas containing explosives shall be clearly posted with the appropriate warning signs. See NAVSEA OP 4 and OP 5.

POST LAUNCH WASTE WATER DISPOSAL

Removal of post launch waste water from expended capsules involves handling material which is not authorized for direct dumping into coastal or inland waters. In many locations, disposal of post launch waste water into shore sewage systems is prohibited. Contact the local public works department and advise them of detailed disposal considerations to obtain guidance for waste water disposal.

SAFETY HARNESSES

Personnel performing over-the-side operations or working in or around open hatches/missile tubes shall wear safety harnesses with safety lines secured.

LITHIUM BATTERIES

REM-equipped TOMAHAWK missiles contain two lithium active battery packs, one used to power the recovery beacon and one used to power a special instrumentation electronics package. Lithium active batteries can become hazardous if the case is ruptured or the leads are shorted together causing the battery to discharge at a high rate. Either situation can cause a violent chemical reaction, the venting of potentially hazardous gasses including sulfur dioxide (SO_2), hydrochloric acid (HCl), sulfuric acid (H_2SO_4), and sulfurous acid (H_2SO_3), and possible explosion. This violent reaction can also be caused by water entering the battery through a rupture in the case. Extreme care shall be used when disconnecting the active lithium batteries to prevent the leads from shorting. Cease all operations and notify Explosive Ordnance Disposal (EOD) if a ruptured or crushed lithium battery is observed. Do not spray water into the REM compartment during missile washdown or decontamination operations.

Table 2-2. Storage and Hazard Data

Q-D CLASS 1.1

DOT HAZARD MARKING "ROCKET AMMUNITION W/EXPLOSIVE PROJECTILE"

UN ID No.: UN0397

- RGM/UGM-109C w/WDU-25/B/WDU-36/B Warhead, Rocket Motor Mk 106 Mod 0/Mk 111 Mod 0 and Liquid Sustainer Engine (Land Attack-Conventional)
- JRGM/JUGM-109C-W w/WDU-25/B/WDU-36/B Warhead, RSS, Rocket Motor Mk 106 Mod 0/Mk 111 Mod 0 and Liquid Sustainer Engine (Land Attack-Conventional-Exercise)
- RGM/UGM-109D w/BLU-97/B Payload Module (Kit-001/-002), Rocket Motor Mk 106 Mod 0/Mk 111 Mod 0 and Liquid Sustainer Engine (Land Attack-Conventional-Submunition)
- JRGM/UGM-109D-W w/BLU-97/B Payload Module (Kit-003/-004), RSS, Rocket Motor Mk 111 Mod 0 and Liquid Sustainer Engine (Land Attack-Conventional-Submunitions-Exercise)
- RGM/UGM-109E w/WDU-36/B Warhead, Rocket Motor Mk 135 Mod 0 and Liquid Sustainer Engine (Land Attack-Conventional)

Q-D CLASS 1.3

DOT HAZARD MARKING "ROCKET MOTOR, CLASS B EXPLOSIVE"

UN ID No.: all UN0396

- UGM-109A with W80 Warhead, Rocket Motor Mk 106 Mod 0 and Liquid Sustainer Engine (Land Attack)
- UGM-109A w/o W80 Warhead, Rocket Motor Mk 106 Mod 0 and Liquid Sustainer Engine (Land Attack)
- JUGM-109A-M/S w/ or w/o Inert W80 Warhead, REM or RSS, Rocket Motor Mk 106 Mod 0 and Liquid Sustainer Engine (Land Attack-Exercise)
- JRGM/JUGM-109C-M/S w/Inert Warhead, REM or RSS, Rocket Motor Mk 106 Mod 0/Mk 111 Mod 0 and Liquid Sustainer Engine (Land Attack-Conventional-Exercise)
- JRGM/JUGM-109D w/Inert Submunitions or Functional Indicator BLU-97/B Payload (Kit 003), RSS, Rocket Motor Mk 106 Mod 0/Mk 111 Mod 0 and Liquid Sustainer Engine (Land Attack-Conventional-Submunitions-Exercise)
- JRGM/JUGM-109E w/Inert Warhead, REM or RSS, Rocket Motor Mk 135 Mod 0 and Liquid Sustainer Engine (Land Attack-Conventional-Exercise)

Table 2-3. Pyrotechnic and Hazardous Materials Data

ITEM	HAZARD
ROCKET MOTOR	Mk 106/0 = 304 lb propellant; Mk 111/0 = 349 lb propellant; Mk 135/0 = 322 lb propellant
CONVENTIONAL WARHEAD	WDU-25/B = 378 lb explosive WDU-36/B = 265 lb explosive
PAYLOAD MODULE	BLU-97/B = 106 lb explosive
FUEL JP-10	Flashpoint (FP) = 130 degrees F Auto-Ignition Temperature = 474 degrees F
CLS SEPARATION NUT INITIATORS (4)	Zirconium Potassium Perchlorate/Titanium Hydride/Potassium Perchlorate Mixture = 295 milligrams
CLS GAS GENERATOR	Class B Pyrotechnic Propellant Grain Material = 7 lb
CLS IGNITER	Boron/Potassium Nitrate Binder Mixture = 100 grams
CLS GAS GENERATOR EBW INITIATOR	Boron Phosphate Nitrate/Superfine RDX Mixture = 240 milligrams
GN_2 BOTTLES	6000 psi for Mk 106/0 Rocket Motor thrust vector control; 5000 psi for REM flotation system
He BOTTLES	6000 psi for air frame wing slots, wings, and inlet deployment jet tab control
HYDRAULIC RESERVOIR/ACCUMULATOR	3500 psi for Mk 111/0 Rocket Motor thrust vector control
BLEED AIR VALVE	Zirconium/potassium perchlorate (65 mg) and Titanium hydride/potassium perchlorate (220 mg)
FUEL SYSTEM ISOLATION VALVE	Zirconium/potassium perchlorate (65 mg) and Titanium hydride/potassium perchlorate (220 mg)
BOOSTER IGNITER	$BKNO_3$ Pellets, 107.5 gm
BOOSTER SEPARATION RING	(FLSC)/CH6 (5.76 gm) and Loaded Charge Case HNS (.17 gm)
SHROUD EXPLOSIVE BOLT	ZPP (16 mg), Lead azide (14 mg) and RDX (200 mg)
CABLE CUTTER	Zirconium/potassium perchlorate (65 mg) and Titanium hydride/potassium perchlorate (220 mg)
INLET COVER THRUSTER	Zirconium/potassium perchlorate (65 mg) and Titanium hydride/potassium perchlorate (220 mg)

ITEM	HAZARD
ENGINE START CARTRIDGE AND IGNITERS	Ammonium nitrate based propellant (298 gm), Igniter mix IB-43, and Boron/potassium nitrate (17.5 gm)
WING PLUG THRUSTERS	Zirconium/potassium perchlorate (65 mg) and Titanium hydride/potassium perchlorate (220 mg)
WING DEPLOYMENT PNEUMATIC VALVES	Zirconium/potassium perchlorate (65 mg) and Titanium hydride/potassium perchlorate (220 mg)
FIN CABLE CUTTER	Hercules Hi Temp (Boron, Calcium Chlorate, Tellurium Dioxide, Viton B) (285 gm)
FIN DEPLOYMENT SYSTEM PYROTECHNIC LINEAR ACTUATORS (UGM-109E)	1.3C Main Charge Talley TAL 11.0g, 1526 HTB Enhanced Thiokol 2D 140 mg Pellet, Equivalent to MIL-P-46994A 11B Pellet
CMA BATTERY	Iron sulfide, lithium fluoride, potassium chloride, lithium bromide, magnesium oxide, Iron powder (MH 100 and NH 100), Cab-O-Sil, potassium perchlorate

NOTE: Refer to SW020-AC-SAF-010/-020/-030 for Net Explosive Weights

COMPOSITE CLS HAZARD INFORMATION

Composite materials in the Composite CLS are reinforced with carbon/graphite fibers to provide stiffness, high strength-to-weight ratio, and ease of fabrication. Carbon/graphite fibers can be released into the atmosphere if their epoxy binder burns. (approximately 752 degrees F (400 degrees C) will cause epoxy binder to ignite or decompose.) Once free, the small lightweight fibers can be transported up to several miles by air currents. Because of their high electrical conductivity, they can damage unprotected electrical/electronic equipment. Similarly, mechanical agitation, especially an explosion, can fragment the composite and cause fibers to become airborne.

EXTINGUISHING AGENTS: Carbon dioxide; dry chemical (AFFF); water.

SPECIAL FIREFIGHTING EQUIPMENT: Scott air packs; mine safety apparatus (MSA); or positive pressure self-contained breathing apparatus.

HAZARDOUS PRODUCTS OF COMBUSTION: carbon monoxide, carbon dioxide; acrolein; phenols; amines; aldehydes; aromatic amines; and hydrofluoric and fluoroboric acids.

PERSONNEL PROTECTIVE EQUIPMENT:

a. All personnel - Disposable coveralls and shoe covers; gloves (leather palm preferred)

b. Firefighters - Positive pressure self-contained breathing apparatus

c. Clean-up personnel - Full face respirator; safety glasses w/side shield.

ITEM	HAZARD
CLEAN-UP MATERIALS: Polyethylene sheeting and tape (for containing debris); vacuum cleaner equipped w/High Efficiency Particulate Air (HEPA) filter elements; polyethylene bags; water emulsion floor wax (P-W-155C (NSN 7930-00-141-5888)).	
HAZARDOUS WASTE DISPOSAL: Local solid waste disposal authorities shall be consulted for approved burial sites/techniques for composites or composite-contaminated materials. In addition, the local cognizant industrial hygienist or medical department representative should be consulted for detail health hazard control, guidance, based upon extent of exposure.	
POST-LAUNCH WASTE WATER IN SPENT CLS CAPSULES: Removal of post-launch water from expended CLS capsules involves handling material which may be harmful to personnel and which is not authorized for direct dumping into coastal or inland waters.	

CHAPTER 3 FUNCTIONAL DESCRIPTION
SECTION I. CHAPTER ORGANIZATION

3.1 SCOPE.

This chapter discusses functional descriptions of TOMAHAWK Cruise Missile (TCM) components and systems as well as interfaces between the TCM and its launch platform. Section II discusses the TCM electrical power system and type commands and requests for status issued to the TCM by the launch platform systems and TCM responses to those commands and requests for status which are, in general, common among all TCMs irrespective of launch platform. Section III discusses unique interfaces between torpedo tube launch TCMs and the submarine. Section IV discusses unique interfaces between Capsule Launching System (CLS) TCMs and the submarine. Section V discusses unique interfaces between Vertical Launching System (VLS) TCMs and the surface ship.

SECTION II. GENERAL

3.2 ELECTRICAL POWER SYSTEM.

The TCM electrical power system consists of a dc monitor/reset power bus, regulated bus, semi-regulated bus, and a Cruise Missile Airframe (CMA) bus, a Mission Control Module (MCM) bus, a pyro bus and an arm battery activate bus.

3.2.1 Prelaunch Electrical Power. The launch platform's electrical power distribution system converts 3-phase 400 Hz delta power to 3-phase wye power to provide operating power for the missile; provide single phase wye power for Recovery Exercise Module (REM) heater power; and dc power for commands to and responses from the TCM. The routing of power in the missile is described in the following paragraphs.

3.2.1.1 Converter/Operate Power. Ship wye power is routed to the TCM ac-dc converter. The dc output of the converter is connected to the missile REGULATED bus via the POWER BUS control relay. For land-attack TCMs, power is fed to the DSMAC set, GPSS (109C and 109D only) and the CMGS from the REGULATED bus. For all TCMs, power is also fed through the normally closed contacts of the BUS ISOLATE relay to power the CMA and MCM buses. The CMA bus supplies power to the airframe electrical equipment. The MCM bus powers the decoder/relay drivers inside the MCM.

3.2.1.2 Cruise Missile (CM) Identification Power. The dc CM identification power is applied to the TCM when the launch operator selects the missile designated for launch. Power is routed back to confirm the identity of the TCM selected and permit it to be prepared for launch or to advise the launch operator that there is a mismatch between the TCM selected and the actual TCM in the launching device. In the latter instance, further processing is automatically precluded.

3.2.1.3 REM Heater Power. When the launch operator selects a REM-equipped TCM and the identity of the TCM has been confirmed, power is applied to the REM battery heaters. The heaters warm the battery electrolyte in preparation for REM battery activation.

3.2.1.4 Monitor/Reset Power. A dc monitor/reset voltage is applied to the DC MONITOR/RESET POWER bus. The DC MONITOR/RESET POWER bus powers the submarine launch TCM dual differential pressure transducer, the WARHEAD DEADFACE relay (109A) and the rocket motor safe-arm monitoring circuits. The bus also supplies power to energize the POWER BUS CONTROL relay and connects the ac-dc converter output to the missile REGULATED bus. It supplies power to energize the FIRST MOTION relay via the first motion loop to generate the MISSILE ENABLED mark that is sent prior to missile launch.

3.2.1.5 DC Monitor/Reset Power Return. The DC MONITOR/RESET POWER RETURN provides the return leg back for dc monitor/reset power.

3.2.1.6 Chassis/Static Ground. A copper ground path is provided to assure that the launch platform and missile are at the same ground potential.

3.2.2 Launch/Boost Electrical Power. Launch/boost electrical power is supplied by two remotely activated thermal batteries. One battery, located in the missile midbody, is the CMA battery. The second battery is the BPU located in the CMGS (109C/D). A REM-equipped TCM also has two electrically activated REM batteries. The CMA and CMGS batteries supply short duration power (about 30 seconds) to power the TCM until the engine-driven generator/regulator can take over. The REM batteries power REM subsystems and, once activated, last about 15 hours. Activation of batteries is described in the following paragraphs.

3.2.2.1 CMA Battery Activation. When the launch operator sets the switch to FIRE (Intent to Launch (ITL), DC power is routed to the coil of the ARM BATTERY ACTIVATE BUS relay. The relay energizes and applies CMA bus power to the ARM BATTERY ACTIVATE bus. Upon CMGS command, the CMA BATTERY ACTIVATE relay energizes and fires the battery pyros to activate the battery. Output 1 powers the MCM and CMA buses. Output 2 powers the SEMI-REGULATED bus, which in turn, supplies power to the fin servoactuators.

3.2.2.2 CMGS Battery Activation. The CMA battery output is sensed by the MCM. When the specified voltage is attained, a CMA BATTERY GO signal is sent to the CMGS. Upon CMGS command, the CMGS BATTERY ACTIVATE relay energizes and applies power to fire the CMGS battery pyros. Battery output is applied to the CMGS subsystems and the REGULATED bus.

3.2.2.3 REM Battery Activation. To allow time to activate the REM batteries and perform the REM BIT, about 29 seconds are added between ITL and CMA battery activation. REM battery activation begins when the REM ACTIVATE command is issued by the CMGS after receipt of ITL. BATTERY ACTIVATE power is provided by the ARM BATTERY ACTIVATE bus. Upon receipt of REM ACTIVATE, the REM performs a pre-battery activate BIT. If REM BIT fails, the REM will not issue the REM ENABLE command and, as a result, the MISSILE ENABLED signal will not be sent. If BIT passes, the REM batteries activate and post-battery activate BIT is begun.

3.2.2.4 Bus Isolation. Battery power is supplied only to those circuits essential to the launch/boost phase. For a land-attack TCM, power-up of the BPU is sensed by the CMGS RMUC. The RMUC, in turn, sends a discrete coded word to the MCM. From the MCM, power is applied to the coil of the BUS ISOLATE relay. The relay energizes to isolate the REGULATED bus from the MCM and CMA buses. The BUS ISOLATE relay remains energized until the engine-driven generator/regulator comes on line during the transition to cruise flight.

3.2.2.5 First Motion. Upon first motion, the electrical connection between the TCM and the launch platform is disconnected and deenergizes the FIRST MOTION relay. The opening of relay contacts is sensed by the CMGS, which starts the safe eject test. The ARM ENABLE relay energizes and the normally open contacts of the ARM ENABLE relay close, applying power to the normally-open contacts of the SAFE/ARM relay. The CMGS confirms safe eject velocity and distance, then commands the MCM to energize the SAFE/ARM relay. This action routes electrical power from the CMA battery to energize the PYRO bus. The SAFE EJECT relay energizes, completing the circuits that hold the SAFE EJECT relay and the ARM ENABLE relay energized. The PYRO bus supplies the power to activate the CMA pyros. The PYRO bus remains energized until the completion of transition to cruise flight.

3.2.3 Cruise Electrical Power. After the sustainer engine has started and comes up to speed, a dual-output generator/regulator assumes the airframe and CMGS electrical loads. Output 1 is dedicated to the CMGS and airframe equipment. Output 2 serves the fin servoactuator system. Load transients occurring on Output 2 have no influence on Output 1.

3.2.4 RSS Thermal Battery Activation. In the event that an RSS-equipped TCM loses cruise electrical power, the RSS thermal battery is activated to provide electrical power to close the throttle and initiate fin flip, thus aborting the mission.

3.3 DIGITAL DATA LINK.

Communications between the TCM and the launching platform is performed via the digital data lines. The lines consist of four pairs of twisted wires (1 true and 1 complement per pair). Also provided are a shield carry-through and a digital I/O power supply return. The lines are connected when the launch operator selects the designated missile and disconnected prior to launch. The digital data link utilizes serial 17 bit (16 data and 1 odd parity) data words. The least significant bit is sent first and the parity bit is sent last. The first word is always the same in every data block, and is used to initialize the CMGS/launch platform system interface software. The second word is always a control word to request status or identify the data block and the number of data words within the data block. The last word in the data block is a checksum (2's complement addition) of the control word and all following data words. Information transferred over the digital data link includes the operational flight program, platform alignment data, missile status/command sequences and mission data (land-attack TCM). The digital data lines used for communication are:

a. DATA ENABLE - Lines used to send the DATA ENABLE command, a discrete signal, to permit the RMUC to accept and transmit data.

b. CLOCK - Lines used to send timing signals to synchronize commands and data.

c. DATA UPLINK - Lines used to transmit digital data sent to the RMUC.

d. DATA DOWNLINK - Lines used to transmit digital data from the RMUC.

e. SHIELD CARRY THROUGH - Line used to provide shield continuity on wires carrying digital data. The shield is floated at the launch platform and grounded in the missile.

f. DIGITAL I/O POWER SUPPLY RETURN - Line used to provide a common ground reference for digital input/output power to the I/O channel power supply and the CMGS.

3.4 DIGITAL COMMANDS/DATA BLOCKS SENT TO A LAND-ATTACK TCM.

Digital commands and data blocks sent to a land-attack TCM over the digital data link discussed in paragraph 3.3⇒ are described in the following paragraphs. Commands unique to a CLS TCM are discussed in Section IV.

3.4.1 Bootstrap Load (Program). A BOOTSTRAP LOAD program permits the loading of programs into the RMUC. When REPROGRAM discrete is received by the RMUC, it activates the Programmable Read Only Memory (PROM) and reestablishes the serial data link. The program is loaded into computer memory and data transmission begins.

3.4.2 Request Status. The REQUEST STATUS block is sent once every second to request a go/no-go summary of missile BIT results. It is also used to request the present operating mode of the CMGS (e.g., warmup, coarse level, navigate (Table 3-1 "Land-Attack TCM CMGS Alignment Modes"⇒).

3.4.3 Alignment Data. The ALIGNMENT DATA block is sent once every second to send reference data to align the CMGS inertial platform relative to the launch platform inertial reference system. Alignment data blocks continue to be sent until the missile is commanded to terminate alignment.

3.4.4 Mission Data. The MISSION DATA block includes target characteristics, waypoints, guidance parameters, terrain correlation maps and DSMAC scenes (109C and 109D only). It also identifies the type missile and the type mission to be flown. Each group is sent by a unique data block that is repeatedly sent until all data for that group are transferred to the CMGS.

3.4.5 Battery Activate. Receipt of the ITL command causes the CMGS to initiate the battery activate sequence. For a tactical TCM, the CMA battery activates first, followed by the CMGS battery. For a REM-equipped TCM, the REM batteries activate first, followed by the CMA and CMGS batteries.

3.4.6 Launch Sequence Command. The LAUNCH SEQUENCE COMMAND block is used to reinitialize the RMUC, terminate CMGS alignment, zero mission data, shut down the CMGS, and declassify the CMGS memory. When the REINITIALIZE command is sent, the CMGS recycles to Mode 0, begins normal operation to transfer mission data and begins a new alignment. (For an explanation of alignment modes, see Table 3-1 "Land-Attack TCM CMGS Alignment Modes"⇒.) When the TERMINATE ALIGNMENT command is sent, the RMUC continues to accept alignment data and switches to the NAVIGATION mode. At this time, the CMGS becomes an independent navigator. The ZERO MISSION DATA command causes the program to zero all memory locations dedicated to mission data. The SHUT DOWN CMGS command causes the CMGS to perform a controlled shutdown that includes a gyro despin to preclude gyro damage. The DECLASSIFY CMGS MEMORY command is used to declassify the CMGS memory following an abort.

3.5 DIGITAL DATA RESPONSES FROM A LAND-ATTACK TCM.

Two types of digital data responses are sent by the missile. The first, GOOD DATA word, is sent after receipt of each data block that passes the parity and checksum tests. The second, MISSILE STATUS word, is sent in response to a status request.

3.5.1 Good Data Word. As the CMGS accepts data, each word is checked for odd parity. The data words are read, stored in a data table, and added to form a checksum that is checked against the checksum word at the end of the data list. If the word parities are good and checksums agree, a GOOD DATA word is sent (except in response to a missile status request).

3.5.2 Missile Status Word. The MISSILE STATUS word, sent once every second in response to a status request, shows the results of pre-launch BIT via a combination of software commanded and hardware continuous tests conducted by the CMGS prior to MISSILE ENABLED. It also shows the present mode of the CMGS. The CMGS software will decode any BIT failure and transmit the information to the launch platform as a zero bit in the appropriate bit position of the MISSILE STATUS word.

3.6 DISCRETE COMMANDS SENT TO A TCM.

The following paragraphs discuss discrete commands issued to the TCM by the launch platform. Discrete commands unique to CLS are discussed in Section IV.

3.6.1 Booster Safe Command. The BOOSTER SAFE command is a dc signal that sets the rocket motor in the SAFE position.

3.6.1.1 Mk 106 Rocket Motor. For the Mk 106 Rocket Motor, the BOOSTER SAFE command interrupts the armed holding circuit. The command allows the safe-arm mechanism to spring-return to SAFE, thus positioning a physical barrier between the igniter initiators and propellant igniter. The signal is applied continuously until the BOOSTER ARM command is received.

3.6.1.2 Mk 111 Rocket Motor. For the Mk 111 Rocket Motor, the safe-arm indicator plate is held in the SAFE position by spring tension. In the safe position, the safe-arm indicator plate will not complete the electrical circuit to the bridgewires and ARM monitor which are necessary for rocket motor ignition. It also prevents the proper alignment of the barrier slots with the poppet slots and consequently prevents a vent path for the initiator output to reach the igniter and subsequent rocket motor ignition. The Mk 111 Rocket Motor will remain in SAFE position until such time as the BOOSTER ARM command is received. The Mk 111 Rocket Motor arming-firing device cannot be manually safed.

3.6.2 Booster Arm Command. The BOOSTER ARM command is a dc signal that places the rocket motor in the ARMED position.

3.6.2.1 Mk 106 Rocket Motor. For the Mk 106 Rocket Motor, the BOOSTER ARM command removes the physical barrier between the igniter initiators and propellant igniter to arm the rocket motor.

3.6.2.2 Mk 111 Rocket Motor. For the Mk 111 Rocket Motor, the BOOSTER ARM command is sent to the solenoid rotor of the arming-firing device. The energized rotor causes the safe-arm indicator plate to rotate, which in turn moves the sweep contacts on the switch plate assembly to complete the electrical circuit to the pyros and aligns the barrier slots to allow initiator output to reach the igniter explosive thereby arming the rocket motor.

3.6.3 Warhead Safe Control/Command (109A only). The WARHEAD SAFE control/command is a dc signal that sets the warhead to the safe condition.

3.6.4 Warhead Prearm Control/Command (109A only). The WARHEAD PREARM control/command is a unique signal placing the warhead in the prearmed condition.

3.6.5 Reprogram Command (Land-Attack only). The REPROGRAM command is a dc signal that allows the CMGS to be reprogrammed. It zeros the RMUC memory except for calibration coefficients. To prevent gyro damage, this command is never issued without first performing a controlled shutdown of the CMGS.

3.6.6 Fire Command or Intent to Launch. The FIRE or ITL command is a dc signal that energizes the ARM BATTERY ACTIVATE BUS relay. The CMA battery activates first, followed by the CMGS battery about one second later. For a REM-equipped missile, the REM batteries activate first, followed by the CMA and CMGS batteries.

3.6.7 REM Abort Command. The REM ABORT command is a dc signal that disconnects the REM batteries which results in a turnoff of all REM-battery-powered equipment.

3.7 DISCRETE SIGNALS SENT FROM A TCM.

The following paragraphs discuss the discrete signals transmitted from a TCM to the launch platform. Discrete signals unique to CLS are discussed in Section IV.

3.7.1 Weapon Identification. Electrical identification of the TCM is derived from CM identification power. Decode circuit defects open on the identification lines not applicable to the identified TCM. Weapon identification also allows the launch platform to configure for REM and applies ac power to the REM battery heaters.

3.7.2 Simulator Present. SIMULATOR PRESENT is a continuity to DC MONITOR/RESET POWER that indicates that a simulator is connected instead of an actual TCM.

3.7.3 Booster Safe Monitor. The BOOSTER SAFE monitor is a continuity to DC MONITOR/RESET POWER that indicates the rocket motor igniter is safed.

3.7.4 Booster Armed Monitor. The BOOSTER ARMED monitor is a continuity to DC MONITOR/RESET POWER that indicates the rocket motor igniter is armed.

3.7.5 Warhead Safe Monitor (109A only). The WARHEAD SAFE monitor is a continuity to DC MONITOR/RESET POWER RETURN that indicates the warhead has been safed.

3.7.6 Warhead Prearmed Monitor (109A only). The WARHEAD PREARMED monitor is a continuity to DC MONITOR/RESET POWER RETURN that indicates the warhead has been prearmed.

3.7.7 Missile Bus Monitor. The MISSILE BUS monitor is a dc signal that monitors the dc output of the ac-dc converter. Upon loss of voltage, prior to MISSILE ENABLED, the launch platform automatically safes the warhead (109A only) and rocket motor igniter.

3.7.8 Missile Enabled. MISSILE ENABLED is a continuity to DC MONITOR/RESET POWER that indicates the missile batteries have been successfully activated, BIT has passed and the MISSILE STATUS word is good. The signal is combined in software with other conditions to complete the closing of firing interlocks. For a REM/RSS-equipped missile, the MISSILE ENABLED signal is routed through the REM/RSS. Before the MISSILE ENABLED signal can be sent, the REM/RSS must first pass all REM/RSS BIT's and issue a REM/RSS ENABLED to complete the circuit.

3.7.9 Differential Pressure (TTL only). Because encapsulated TTL TCMs are subjected to pressure differences when in a flooded torpedo tube prior to launch, two dc signals (A and B) are provided by the missile dual differential pressure transducer to indicate differential pressure between the shroud compartment and ambient outside pressure. The redundant signals, which are derived from DC MONITOR/RESET POWER, are used to monitor the missile pressure and provide a PRESSURE IN BAND signal.

SECTION III. TORPEDO TUBE LAUNCH

3.8 GENERAL.

This section discusses launch platform and TCM physical and functional interfaces aboard the submarine. These interfaces include missile/capsule and torpedo tube physical interfaces as well as the submarine systems utilized to:

a. Maintain pressure in TCMs during preparation for launch.

b. Secure and prevent unauthorized launch of the UGM-109A-1.

c. Compute TCM attack solutions.

3.9 MISSILE/CAPSULE AND TORPEDO TUBE PHYSICAL INTERFACES.

The missile/capsule and torpedo tube physical interfaces consist of the mechanical, electrical and pneumatic interfaces described in the following paragraphs.

3.9.1 Mechanical Interfaces. The mechanical interfaces consist of the following restraining devices:

a. Loading button on the capsule barrel closure to load/unload the missile/capsule from the torpedo tube.

b. Two guide studs on the capsule barrel to align the capsule in the torpedo tube. The forward guide stud also engages the tube stop bolt.

c. Two shear holdback assemblies to restrain the missile in the capsule until ejection.

d. Two spring-loaded latches at the aft end of the capsule to restrain the capsule in torpedo tube (UGM-109A/C/D-1).

e. Capsule retention fixture installed on the capsule to restrain the capsule in the torpedo tube. The retention fixture also houses a clamp that is removed and installed on the capsule barrel closure in order to secure the eletrical umbilical cable (UGM-109E-1).

3.9.2 Electrical and Pneumatic Interfaces. The electrical and pneumatic interfaces consist of the electrical and pneumatic umbilical discussed below. The routing of the umbilicals is shown in Figure 3-1 "TTL Electrical and Pneumatic Umbilical Routing (2 Sheets)"⇒.

3.9.2.1 Electrical Umbilical. The electrical umbilical connects between the breech door and the missile to transfer power/commands and status signals between the missile and submarine combat system.

3.9.2.2 Pneumatic Umbilical. The pneumatic umbilical connects between the breech door and the capsule to connect the PVC system to pressurize the missile and supply pneumatic pressure to close the capsule flow slots in preparation for capsule ejection, when authorized.

3.10 PRESSURIZATION/VENT CONTROL SYSTEM.

The PVC system features independent four-tube controls to regulate internal TCM pressure to withstand sea ambient pressure during pre-launch operations. With the electrical and pneumatic umbilicals connected to the TCM and the PVC system activated, dual-differential transducers in the TCM (one operator selected and one alternate) compare internal free volume pressure with outside ambient pressure and output signals to PVC system equipment. The signals energize/deenergize manifold pressure/vent block solenoids which permit pressurization or venting to occur in order to maintain TCM internal pressure within prescribed limits. When pressure is not within prescribed limits, the system inhibits launch until the TCM is pressurized/vented and the PRESSURE IN BAND indication is restored. Should the selected transducer fail, the system automatically vents the TCM and likewise inhibits launch until the operator selects the alternate transducer and the PRESSURE IN BAND indication is restored. Should the automatic PVC system fail, the PVC system can be operated manually utilizing the TCM pressure relief valve as the backup to prevent TCM overpressurization. Just prior to launch, the fire control system sends an IMPULSE FIRE mark to terminate pressure/vent commands to prevent pressure cycling and a possible out-of-band condition at launch.

3.11 SECURITY SYSTEM.

Security of the UGM-109A-1 is maintained by connecting the missile to the submarine 4FZ Security Alarm System using a special security plate. The security plate is a kidney-shaped plate that replaces the electrical connector access protective cover and covers the pull switch lanyard attachment, the electrical umbilical connection and the upper holdback assembly on the aft end of the capsule. It is held in place by two captive thumbscrews that are lockwired together to provide visual evidence of any tampering. A pneumatic coupling is installed in the plate to provide a connection to the 4FZ Security Alarm System. The security plate is provided separately and is installed after weapon shipping aboard the submarine and replaced by the electrical connector access protective cover prior to weapon unshipping.

3.12 NAVIGATION SYSTEM.

Navigation and ownship parameter data are used in computing attack control solutions. Data include latitude, longitude, velocity, heading, pitch, roll and depth computations. Except for navigation equipment digital data, input data are supplied as either synchro or event data and are converted to digital data for use by the submarine computer equipment.

3.12.1 Navigation Equipment Alignment. Computer equipment, through closed-loop control, maintains true vertical alignment of navigation equipment stable platforms by collecting velocity data from the velocity meters and using these data to provide torquing pulses to the gimbal-mounted torquing motors.

3.12.2 Velocity and Position Computation. True position of the submarine is continuously updated by computer equipment, using primarily navigation equipment data and secondarily, Dead Reckoning Analyzer Indicator (DRAI) data. The electromagnetic underwater log (EM Log), which measures ownship speed through the water, is used in conjunction with the computers to provide damping to the navigation equipment. It also provides ownship speed to the DRAI.

3.12.3 Reset Computations. Latitude and longitude information is periodically computed by the computer equipment from navigation satellite receiver data. These data are used to reset navigation equipment position at the direction of the system operator.

3.12.4 Status and Performance Monitoring. The computer equipment reacts to navigation operator directions concerning mode of operation and requests for data to be displayed on the

Navigation Control Console (NCC). Navigation software continuously monitors the equipment to provide the navigation operator with equipment failure or misalignment indications.

SECTION IV. CAPSULE LAUNCHING SYSTEM

3.13 GENERAL.

This section discusses CLS unique electrical interrelationships between the submarine fire control system and CLS. Additionally, this section discusses launch platform and TCM physical and functional interfaces aboard the submarine. These interfaces include missile/capsule and missile tube physical interfaces as well as the submarine systems utilized to:

a. Maintain pressure in TCMs during stowage and preparation for launch.

b. Operate missile tubes.

c. Compute TCM attack solutions.

3.14 CLS UNIQUE ELECTRICAL INTERRELATIONSHIPS.

In addition to common electrical interrelationships between the submarine combat system and the TCM discussed in Section II, the CLS has unique requirements for pre-launch electrical power in order to receive commands and provide responses to those commands. Unique power requirements, commands and responses for CLS TCMs are discussed in the following paragraphs.

3.14.1 CLS Unique Prelaunch Electrical Power Requirements. CLS unique pre-launch electrical power requirements are:

a. CLS Regulator Power - Supplies power to the CLS regulator which in turn provides power to CLS components.

b. CLS Converter Power - Supplies power to the CLS Firing Unit Converter.

c. CLS Monitor Power - Supplies power to monitor discrete events from CLS prelaunch and launch sensors.

d. CLS Power Return - Provides the return path for CLS Regulator Power, CLS Converter Power and CLS Monitor Power.

e. Liquid Detector Power - Supplies power to the CLS liquid detector.

f. Coded Charge Signal Excitation - Initiates dc power to allow the Coded Charge Signal to charge the CLS firing capacitor.

g. Coded Launch Signal Excitation - Initiates dc power to allow the Coded Launch Signal to discharge the firing capacitor to fire the CLS gas generator.

3.14.2 CLS Unique Commands. The Coded Charge Signal and Coded Launch Signal are unique digital commands and the Capsule Arm Command is a unique discrete command sent by the submarine fire control system to the CLS:

a. Coded Charge Signal - A coded signal sent to charge the firing capacitor.

b. Coded Launch Signal - A coded signal sent 700 milliseconds after the Coded Charge Signal to discharge the firing capacitor which, after separation nut release, fires the gas generator to launch the TCM.

c. Capsule Arm Command - A command which causes capsule firing circuits to be placed in the armed position.

3.14.3 CLS Unique Discrete Responses. The following are discrete signals sent by the CLS:

a. Capsule Safe Monitor - A continuity of CLS Monitor Power indicating that the CLS firing circuits are in the SAFE position.
b. Capsule Armed Monitor - A continuity of CLS Monitor Power indicating that the CLS firing circuits are in the ARMED position.
c. Liquid in Capsule - A signal indicating the presence of liquid in the capsule.
d. Capsule Dry - A continuity of CLS Monitor Power indicating the absence of liquid in the capsule
e. Fire Pulse Detected - A continuity of CLS Monitor Power indicating that the CLS firing capacitor has discharged.

3.15 MISSILE/CAPSULE AND MISSILE TUBE PHYSICAL INTERFACES.

The missile/capsule and missile tube interfaces consist of mechanical and electrical interfaces which are described in the following paragraphs.

3.15.1 Mechanical Interfaces. The mechanical interfaces consist of the following restraining devices and connections:

a. The lateral support group on the interior of the CLS provides positioning and lateral shock and vibration mitigation for the missile.
b. Six launch seals on the CLS prevent high pressure gases from the ejected missile from contacting the missile surfaces forward of missile station 180.6.
c. Two holddown studs on the aft end of the missile position and secure the missile to the vertical support assembly inside the CLS.
d. Eight retention segments on the top of the capsule mate with the upper missile tube flange to restrain the CLS in the missile tube.
e. Lateral support pads on the CLS bear against shock lands bolted to the missile tube to position and provide lateral shock support for the CLS in the missile tube.
f. An umbilical cable bracket is attached to the CLS exterior to provide protection for the umbilical on the outside of the CLS.
g. A differential pressure transducer sensing line connects the CLS to the ship’s differential pressure transducer via connections on the CLS and missile tube.

3.15.2 Electrical Interfaces. All electrical interfaces are routed through the electrical umbilical cable. The routing of the electrical umbilical is shown in Figure 3-2 "CLS Electrical Umbilical Routing"⇒.

3.16 PRESSURIZATION/VENT (P/V) SYSTEM.

The P/V system features automatic independent missile tube controls to replenish internal AUR pressure during stowage in the missile tube; and to pressurize/vent the space below the capsule closure assembly within a specified range of positive pressure over the underhatch volume pressure prior to TCM launch. A differential pressure transducer in the missile tube monitors pressure above the capsule closure assembly and sends a continuous signal to the Vertical Launch Console (VLC). When the underhatch volume pressure is not within prescribed limits, the signal causes a pressurization/vent control valve to activate to permit pressurizing/venting of the

AUR to occur in order to maintain pressure within band. When underhatch volume pressure is not equal to sea ambient pressure or AUR pressure is not within prescribed limits, the system inhibits launch until required pressurization/venting has occurred and the PRESSURE IN BAND indication is restored. Immediately prior to TCM launch, the P/V control valve is closed to terminate pressurization/venting and to prevent reflood water or missile launch by-products from entering the ship.

3.17 MISSILE TUBE CONTROL SYSTEM.

The Missile Tube Control System monitors the status of the missile tubes and supports launch. The system provides all the interfaces between the ship systems and the submarine fire control system. Monitoring and control occur in the Vertical Launch Center (VLC). A brief functional description of the components of the missile tube control system is presented in the following paragraphs.

3.17.1 Missile Tube Control Panel. Missile Tube Control Panels (MTCP), located in the VLC, provide two normal modes of system operation: MONITOR and OPERATE. When switches are in the MONITOR position, command functions are disabled but monitoring functions and displays are operating. When a switch is locked in the OPERATE position, monitoring and display functions are operating and command functions are enabled for the common functions and for the selected tube. The MTCP also has a special SIMULATE mode of operation to support maintenance and trouble-shooting.

3.17.2 Differential Pressure Transducers. Two differential transducers, one adjacent to each missile tube, sense the differential pressure between the underhatch area and the CLS. A pressure switch senses TCM pressure. When underhatch differential pressure or AUR pressure is outside the specified pressure range, the differential pressure transducer activates the pressure/vent system to increase/vent pressure as required.

3.17.3 Environmental Monitoring Sensor. An Environmental Monitoring Sensor is located in the underhatch area of each missile tube to sense underhatch pressure, temperature, and the presence of fluid. Detection of one of these conditions outside the specified range results in an alarm signal being sent to the MTCP.

3.17.4 Dew Point Monitor. The Dew Point Monitor, consisting of a sensor in the 700 psig piping and electronics equipment, monitors the moisture level of the air being supplied to the TCM by the pressurization/vent system.

3.17.5 Hatch and Valve Position Sensors. Hatch and valve position sensors are magnetic proximity switches that sense the position of missile tube hatches and flood and drain system outboard valves. The sensors provide a constant status of hatches and valves and will signal an alarm when conditions are not consistent with operations.

3.18 NAVIGATION SYSTEM.

Navigation and ownship parameter data are used in computing attack control solutions. Data include latitude, longitude, velocity, heading, pitch, roll and depth computations. Except for navigation equipment digital data, input data are supplied as either synchro or event data and are converted to digital data for use by the submarine computer equipment.

3.18.1 Navigation Equipment Alignment. Computer equipment, through closed-loop control, maintains true vertical alignment of navigation equipment stable platforms by collecting velocity data from the velocity meters and using these data to provide torquing pulses to the gimbal-mounted torquing motors.

3.18.2 Velocity and Position Computation. True position of the submarine is continuously updated by computer equipment, using primarily navigation equipment data and secondarily, Dead Reckoning Analyzer Indicator (DRAI) data. The electromagnetic underwater log (EM Log), which measures ownship speed through the water, is used in conjunction with the computers to provide damping to the navigation equipment. It also provides ownship speed to the DRAI.

3.18.3 Reset Computations. Latitude and longitude information is periodically computed by the computer equipment from navigation satellite receiver data. These data are used to reset navigation equipment position at the direction of the system operator.

3.18.4 Status and Performance Monitoring. The computer equipment reacts to navigation operator directions concerning mode of operation and requests for data to be displayed on the Navigation Control Console (NCC). Navigation software continuously monitors the equipment to provide the navigation operator with equipment failure or misalignment indications.

SECTION V. VERTICAL LAUNCHING SYSTEM

3.19 GENERAL.

This section discusses launch platform and TCM physical and functional interfaces aboard the ship. These interfaces include missile/canister and launch cell physical interfaces as well as ship systems utilized to:

a. Compute TCM attack solutions.

b. Provide a means of detecting and controlling hazardous conditions in launch cells.

3.20 MISSILE/CANISTER AND LAUNCH CELL PHYSICAL INTERFACES.

The missile/canister and launch cell/module physical interfaces consist of the mechanical, electrical and pneumatic interfaces described in the following paragraphs.

3.20.1 Mechanical Interfaces. The mechanical interfaces consist of the following:

a. Pyrotechnically activated separation bolts to restrain the missile in the canister until launch.

b. Thermal lined, corrugated shell structure for loading in the launch cell.

c. 16 lateral supports inside the Mk 14 Canister to provide shock isolation for the TCM in the Mk 10 Canister.

d. Deluge connector to connect the ship's deluge system to provide distribution of water on the missile warhead in the event of an emergency.

e. Latches to secure the Mk 14 Canister in the cell.

f. Mk 14 Canister and sill assembly interface to direct rocket motor exhaust gas into the module plenum.

3.20.2 Electrical Interfaces. The electrical interfaces consist of the following:

a. Telemetry monitoring connector to transmit data from a telemetry missile prior to launch.

b. Umbilical connector connects to the MK 14 Canister Cable Assembly which, in turn, connects the code plug, FWD closure breakwire, temperature sensor, AFT closure breakwire, All-Up-Round (AUR) cable and conduit assembly and AUR umbilical connector adapter to transmit commands from the fire control system and receive responses from the canister and TCM.

c. Antenna connector to transmit data from telemetry monitoring equipment to the missile.

d. Canister Safe Enable Switch (CSES) (Mk 14 Canister) to monitor weapon status (safe or enable).

3.20.3 Pneumatic Interface. The nitrogen supply valve provides a means to pressurize the Mk 10 by way of a nitrogen line inside the Mk 14 Canister.

3.21 NAVIGATION SYSTEM.

The navigational systems provide data on ownship's time, position, heading, velocity, pitch angular rate, and roll angular rate. The data is used for track data management and engagement planning.

3.21.1 Inertial Navigation Set (INS). Most ships have two INSs aboard. One is in the forward Gyro Room, the other in the aft Gyro Room. The INSs are designated FWD and AFT. They serve as the primary navigation data source. Each set provides ownship heading, position, speed, roll, pitch, and time. These data are provided to the TOMAHAWK Weapons Combat System (TWCS) by the Launch Data Processing Control Center via an interface with the Digital Linear Switch (DLS).

3.21.2 Digital Linear Switch (DLS). The DLS determines if the input to the TWCS is from the FWD or AFT INS unit. During a casualty to one, when one unit may be inoperable, an operator can switch the DLS to the operating unit.

3.21.3 Data Terminal Group (DTG). The DTG (also called Input/Output Control Console [IOCC]) provides an interface with the INS. Data is manually loaded by keyboard and automatically though a paper tape reader. The control panel furnishes DTG control and indicators. Output is displayed on a panel for operator evaluations. The printer and paper tape provide two means of producing hard copies of output data. Reset and control data may be transmitted to either INS as selected by the DLS.

3.21.4 Radio Navigation Set (RNS). The RNS receives Satellite Navigation (SATNAV) data for updating INS. Reset data is transmitted to either INS as selected at the DLS that also interfaces with the DTG.

3.21.5 Global Positioning System (GPS). The GPS is a satellite navigation system which provides continuous worldwide information. The information is used to calculate 3-dimensional speed and precise time of data. GPS also provides a parallel digital interface for information exchange with the INS.

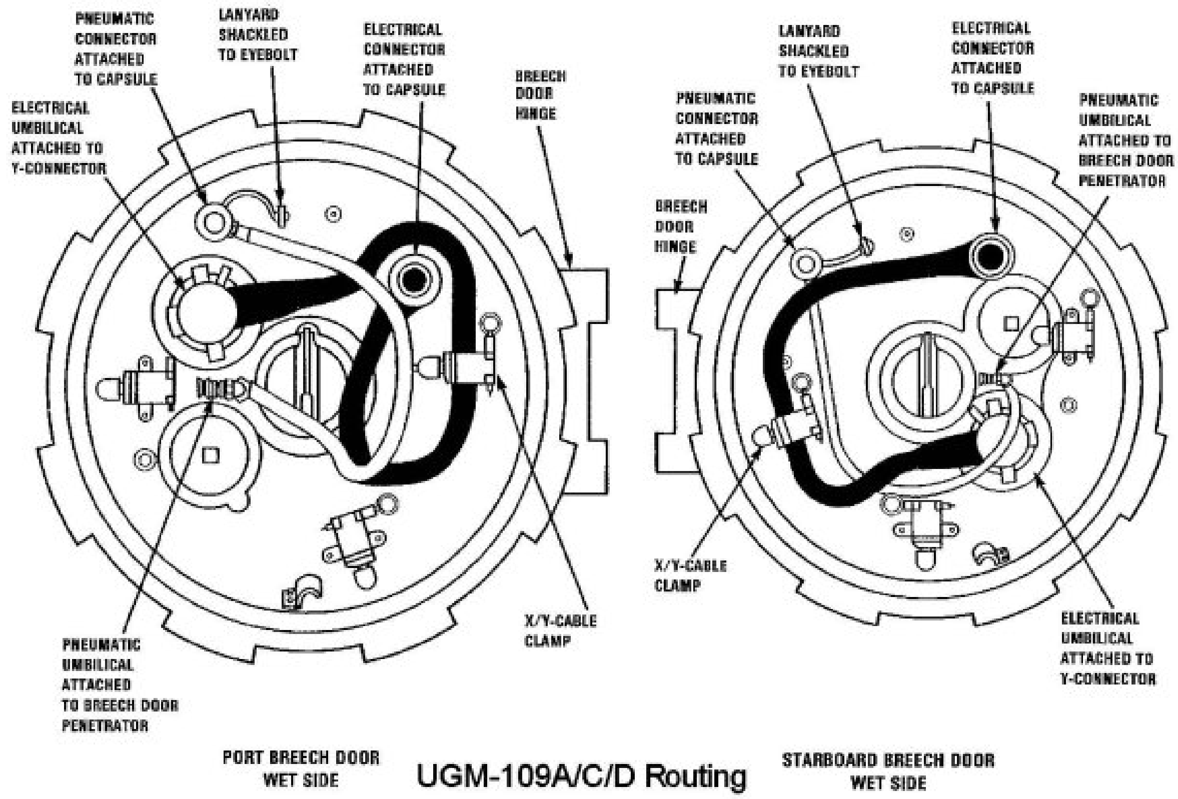
3.22 VLS DAMAGE CONTROL SYSTEM.

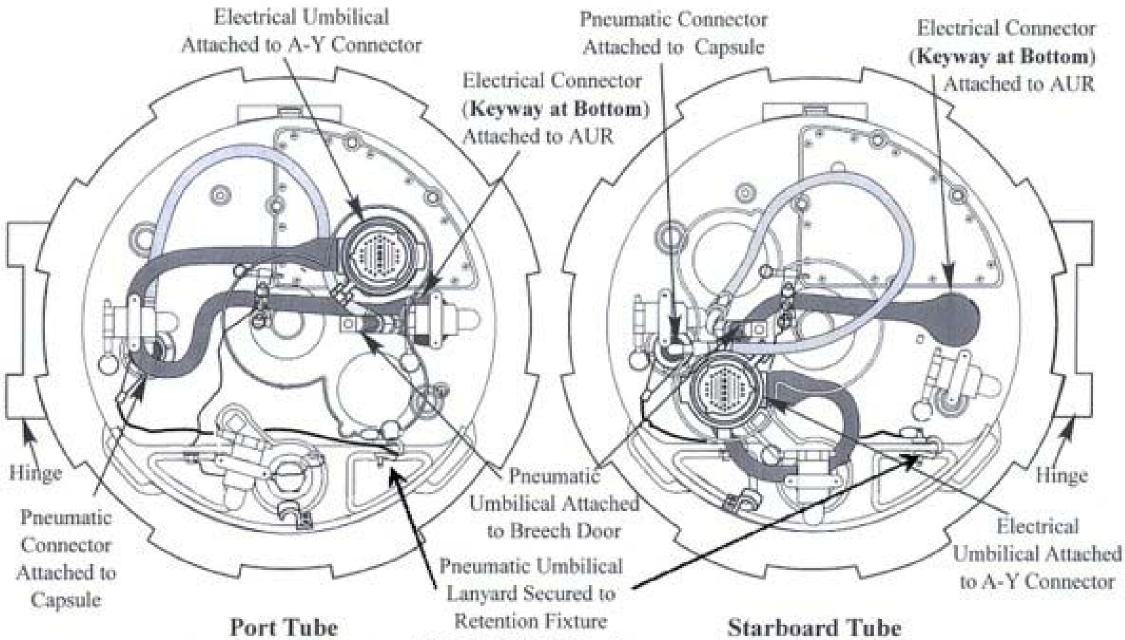
The VLS Damage Control System provides for detection and control of hazardous conditions within launch cells and modules. Elements of the damage control system include the damage control monitoring system which utilizes sensors located inside and outside launch cells to monitor conditions; deluge system which distributes water over a missile warhead when activated in an emergency; and the magazine sprinkler system that provides remote fire fighting capability in missile modules. Conditions monitored include the status of the anti-icing system, deluge system operating, module high-water level condition (one-half inch or deeper), a continuous launch sequencer (LSEQ) power-off condition, and, when implemented, missile fuel leak. In the event a sensor reports a hazardous condition, the Local Status Panel, located at the entrance to magazines, displays the hazard and advises the Central Control Station of the hazardous condition. The LSEQ, which continually monitors cell conditions, generates the hazard message to the launch control unit, which after analysis of the hazard, directs the VLS to act to eliminate or reduce the hazard.

3.23 EXHAUST GAS MANAGEMENT SYSTEM.

The exhaust gas management system (Figure 3-3 "VLS Exhaust Gas Control"⇒) directs the gas from the rocket motor to the external atmosphere. Exhaust gas from the rocket motor expands downward from the bottom of the canister into the module plenum where is vented through the uptake and open uptake hatch. Sealing of the system is particularly critical to ensure that all exhaust gas is vented to the atmosphere, and not into the ship. The Mk 14 Canister and the sill assembly installed at the time of loading provide this effective seal against improper venting of gases.

Figure 3-1. TTL Electrical and Pneumatic Umbilical Routing (2 Sheets)





UGM-109E Routing

Figure 3-2. CLS Electrical Umbilical Routing

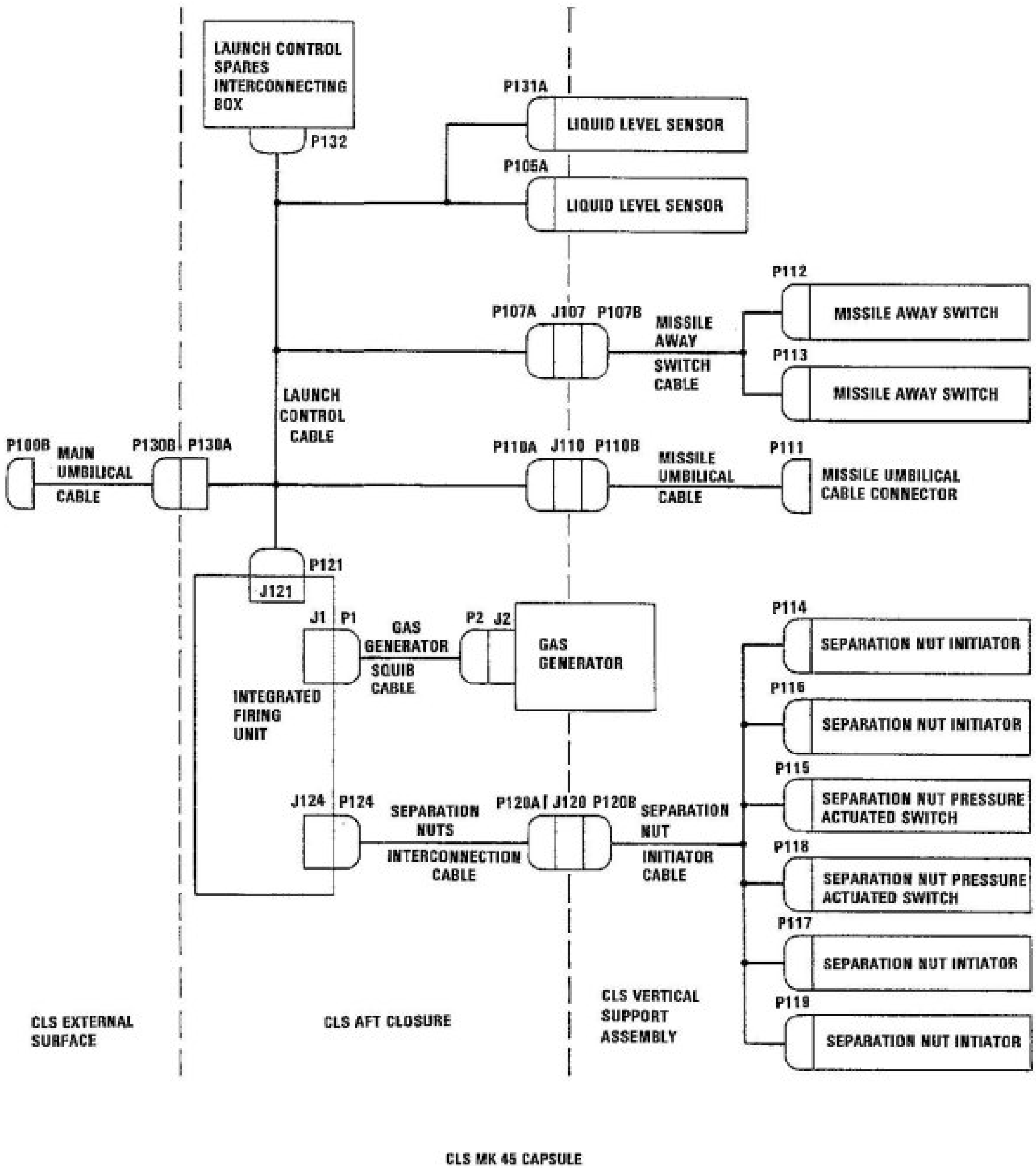


Figure 3-3. VLS Exhaust Gas Control

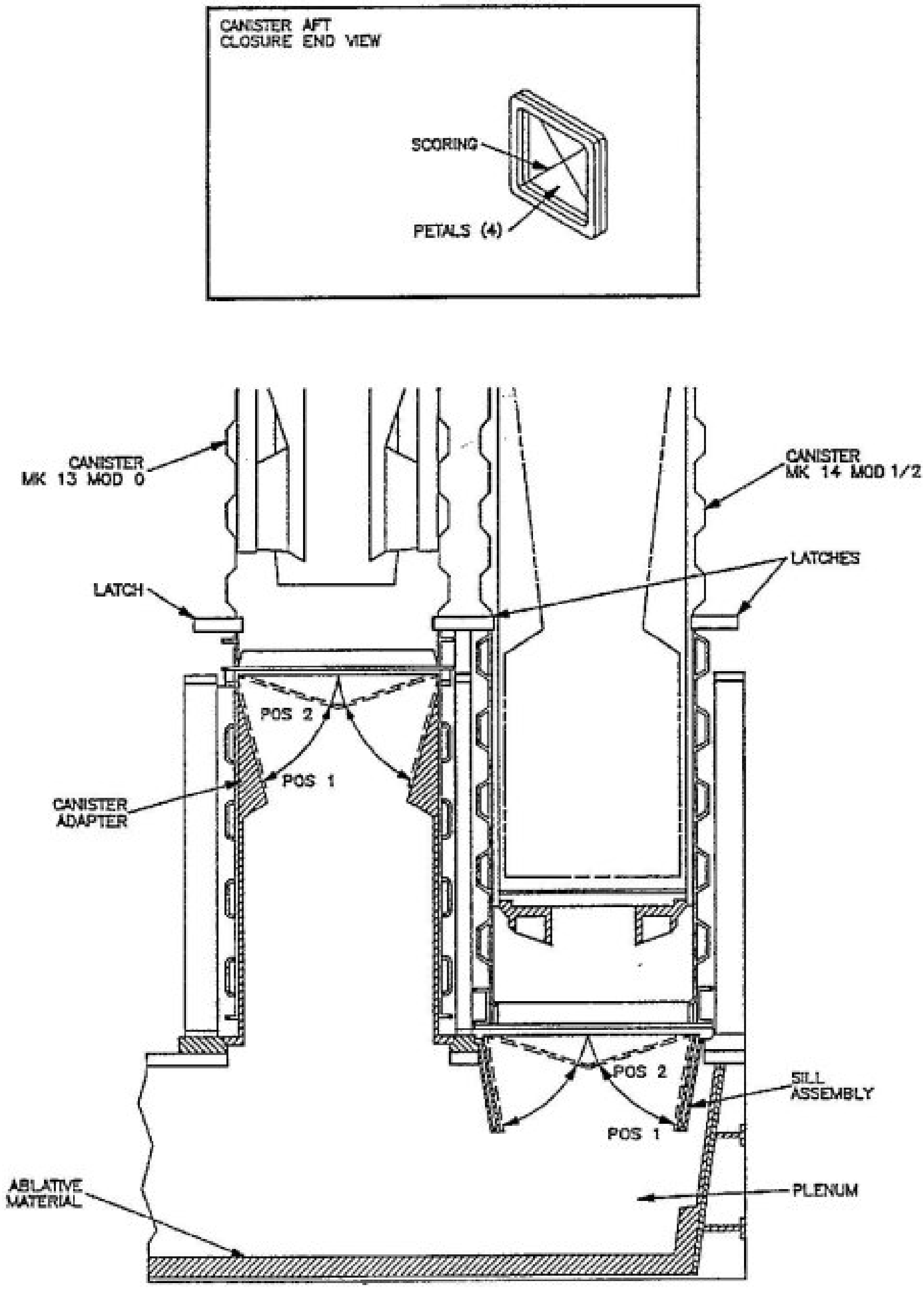


Table 3-1. Land-Attack TCM CMGS Alignment Modes

MODE	COMMENT
0, Warmup	Mode 0 performs the first set of BITs and sequences the CMGS inertial platform into gyro control. Operations include warmup, loading of operational flight program, initialization, BIT, gyro caging and gyro spinup. BIT results are contained in the MISSILE STATUS word. If all BITs are passed and gyros have spun up, the mode number advances to Mode 1.
1, Standby	Mode 1 tests availability to present position and checks to see if inertial platform is under gyro control. Program will advance to Mode 2 when present position is available and platform is determined to be under gyro control.
2, Course Level	During Mode 2, the inertial platform is torqued to level by computer program torquing commands. Mode is complete when the computed tilt angle and mode time tests are passed.
3, Spare	Not used.
4, Align Axis#1	Mode 4 performs the first fine alignment phase and is completed when a series of mode time, computed tilt angle, gyro bias change and azimuth angle change tests are satisfied. If sufficient maneuvering occurs in this mode to estimate the platform azimuth angle, Modes 5 and 6 are bypassed and Mode 7 will be entered at alignment completion.
5, Slue	During Mode 5, the platform is slued 90° from its previous orientation by torquing the vertical gyro.
6, Align Axis #2	Mode 6 performs the second fine alignment phase and duplicates the Mode 4 alignment. Upon passing of mode completion tests, the alignment process advances to Mode 7.
7, Alignment Complete	Mode 7 is used only to indicate that alignment complete tests have been passed. The computer program continues to perform the Mode 6 alignment until the CMGS is commanded to terminate alignment. When this occurs, the computer program advances to Mode 8.
8, Navigate	Mode 8 signals that the CMGS has terminated alignment, and it has become an independent navigator.

CHAPTER 4 OPERATIONS
SECTION I.

4.1 SCOPE.

This chapter discusses TWS operations aboard the various types of launch platforms. These discussions include: brief descriptions of the launch platforms and on board equipment used to load, store and launch weapons; typical weapon onload scenarios; and typical launch operations. Section II discusses TTL launch platforms, procedures and operations. Section III discusses CLS launch platforms, procedures and operations. Section IV discusses VLS launch platforms, procedures and operations.

SECTION II. TORPEDO TUBE LAUNCH

4.2 LAUNCH PLATFORMS.

The TTL TWS is employed aboard SSN 688, SSN 774, and SSN 21 Class submarines. TCM launch operations are performed utilizing equipment located in the Attack Center, Combat Systems Electronic Space (CSES) and Torpedo Room. General locations of the complexes are shown in Figure 4-1 "General Locations of SSN Complexes"⇒. The following paragraphs describe the major TWS-related TTL systems aboard the submarine. A simplified interface block diagram of submarine TWS-related equipment is shown in Figure 4-2 "SSN/TWS-related Equipment TTL Interfaces"⇒.

4.2.1 Submarine Combat System. Submarine Combat Systems (SCS) include the Combat Control System (CCS) and the AN/BSY-1 Combat Control/Acoustic Set (CC/A). SSN 688 Class submarines may employ either the CCS or CC/A. Each SCS, supported by the ownship navigation system, CSES, Over-the-Horizon (OTH) targeting and the appropriate software programs, provides the necessary power, discretes and data to power up weapons, transmit orders, process and display data, initialize and align the missile guidance set, and initiate weapons launch. Also included are control and monitoring circuits as well as various firing interlocks.

4.2.2 Combat Systems Electronic Space (CSES). The CSES equipment is shared by both the SCS and the navigation system. Computer software programs, which include the operational flight program, preplanned land-attack mission/targeting data generated at a shore-based Theater Mission Planning System (TMPS) installation and provided to the submarine prior to deployment, platform alignment data and sequential control commands, are stored on disks in the CSES. The data are loaded into computer memory and sent to the missile on command. Missile responses and status are evaluated by the CSES to provide data for displays on TCM status, Built-In-Test (BIT), checksums and launch countdown.

4.2.3 Navigation Equipment. TOMAHAWK capable submarines are equipped with either the Electrically Suspended Gyro Navigator (ESGN) AN/WSN-3A(V)2 or the Dual Miniature Inertial Navigation System (DMINS) AN/WSN-1(V)2. Each system consists of two Inertial Measuring Units (IMUs) and one dual-channel Navigation Control Console (NCC). Velocity and attitude data are generated in raw form by the IMUs and transmitted to the CSES via the NCC. The raw data are processed by the CSES computers to obtain velocity, attitude and position data and then transmitted to various ship user subsystems.

4.2.4 Weapon Launch and Pressurization/Vent Equipment. The SSN 688 Class submarine weapon launch equipment consists of a weapon launch console (WLC) flanked by two banks of canted torpedo tubes; two tubes port and two tubes starboard. Also included are four PVC manifolds (one for each torpedo tube) to control the air which pressurizes the TCM prior to launch. Pressurization and torpedo tube pre-launch operations are controlled from the WLC. Figure 4-3 "SSN TTL Pressurization/Vent Control System"⇒ depicts the PVC system.

4.2.5 Weapon Shipping/Unshipping Equipment. Both the SSN 688 and SSN 774 Class submarines use a shipping line to ship and unship weapons. On SSN 688 Class submarines, the major components are a portable topside deck skid, intermediate shipping rails and a shipping tray located in the torpedo room. The weapons, restrained by a shipping harness, are lowered or raised along the shipping line, aft end down, using a chain drive. Figure 4-5 "TTL Weapon Shipping, Handling and Stowage Equipment (SSN 688 Class)"⇒ depicts SSN 688 Class submarine shipping, handling and stowage equipment. On SSN 774 Class submarines, the major components are a portable topside deck skid, intermediate and shipping trunk mounted shipping rollers, and a shipping cradle located in the torpedo room. The weapons, restrained by a shipping nose piece and shipping cables, are lowered or raised along the shipping line, forward-end down, using a pier-side crane connected to the shipping cables.

4.2.6 Weapon Handling and Stowage Equipment. Two-level stowage racks are provided aft of the torpedo tubes for stowage of weapons. On the SSN 688 Class, the weapons are supported by dollies on athwartship tracks and are restrained by lashing straps. On the SSN 774 Class, the weapons are supported in cradles which in turn are supported at each end by an end truss track and restrained by lashing bands. Transfer of weapons to the torpedo tube, or to any other stowage position or working space, is accomplished via athwartship transfer mechanisms, vertical hoist(s), pivot mechanisms/trays and loading rammers.

4.3 WEAPON ONLOAD.

The supporting submarine tender or shore base removes the weapon from its shipping container and places the weapon on the topside skid (SSN 688 Class). Subsequent actions to lower the weapon to the torpedo room are depicted in Figure 4-5 "TTL Weapon Shipping, Handling and Stowage Equipment (SSN 688 Class)"⇒ for SSN 688 Class submarines. Weapon onload is performed in accordance with applicable volumes and parts of NAVSEA OD 44979.

4.4 OPERATIONAL CONSTRAINTS/RESTRICTIONS.

Tactical employment of a TCM may impose constraints on the operating parameters of the submarine and restrictions on the submarine's tactical flexibility. The following paragraphs identify the different constraints and methods of alerting the ship's commanding officer to an operational constraint or restriction.

4.4.1 Launch Constraints. The launch constraints imposed on the operational parameters of the submarine during employment of tactical and exercise variants are described in the applicable tactical employment manuals.

4.4.2 Weapon Mix. Weapon mix will depend on the particular conditions that exist at the time the decision is made to load torpedo tubes. The SCS is capable of processing a combination of TOMAHAWK variants, Mk 48 Torpedoes and other defensive systems. Prime consideration for specific weapon mix is the time required to prepare and launch a TCM, to include the time required to recycle the torpedo tube and, when authorized, to eject the capsule.

4.4.3 Alert Messages and Interlocks. Various alert messages and firing interlocks are used to warn operators or inhibit launch when conditions exist that could impact missile performance, endanger the submarine or result in the launch of a dud missile. Firing interlocks may be either software or hardware interlocks. Prior to permitting activation of the FIRE switch, the submarine fire control system must receive an indication that the following interlocks are closed:

a. WPN IDENT - Indicates that the designated weapon is loaded in torpedo tube

b. INPUTS MATCHED - Indicates that all mission data have been transferred to the missile and the CMGS has responded with appropriate MISSILE STATUS and GOOD DATA words

c. WITHIN LIMITS - Indicates that speed and depth of the submarine are within limits

d. TUBE READY - Indicates that the torpedo tube outer door is open

e. BOOSTER ARMED - Indicates that the rocket motor igniter is armed

f. WARHEAD PREARMED - Indicates that the UGM-109A-1 warhead is in prearmed condition.

g. PRESSURE IN BAND - Indicates that missile pressure is between 3.8 - 7.2 psid.

Upon activation of the FIRE switch and indication of MISSILE ENABLED (i.e., batteries activated, BIT passed, MISSILE STATUS word good), the fire control system performs a firing interlock check and closes final interlocks prior to permitting the impulse fire relay to energize and eject the TCM from the torpedo tube.

4.5 LAND-ATTACK TCM OPERATIONAL SEQUENCE.

This paragraph describes typical actions and responses required to launch a land-attack TCM. Primary coverage is given to a normal launch. Abnormal launch conditions and abort procedures are discussed by highlighting only those events that differ from a normal launch. Typical launch operations are shown in Figure 4-6 "UGM-109-1 Land-Attack TCM Operational Sequence (7 Sheets)"⇒. The figure illustrates the orders given by the ship's commanding officer, typical actions taken by equipment operators and typical equipment operations, status displays and machine decisions. The operational sequence is described in the following paragraphs. Operating procedures and checklists, as well as actions to be taken under abnormal conditions, are contained in appropriate volumes and parts of NAVSEA OD 44979.

4.5.1 Weapon Preparation and Tube Loading. Preparation starts with the authorization to launch a land-attack TCM. A torpedo tube is made ready for loading. For a UGM-109A, the 4FZ Security Alarm System is disconnected and the capsule security band unlocked and removed. The weapon serial number is reverified. The missile is then depressurized and moved to the loadline where the slot covers are removed.

4.5.1.1 The loading pole is attached between the rammer and capsule loading button. Upon order to load tube, the loadline rollers are raised and ramming is commenced. The capsule nose cover and lashing straps are removed as they clear the forward loadline rollers. Ramming is continued until the capsule forward guide stud contacts the tube stop bolt. The stop bolt is then rotated to the LOCK position. On a UGM-109A/C/D-1, the capsule latch pins are pulled to allow the capsule latches to extend and engage the slots in the aft land of the torpedo tube. On a UGM-109E-1, the retention fixture is installed in the torpedo tube and secured to the capsule. The loading pole is removed. Two shipping nuts are then removed from the missile holdback assemblies.

4.5.1.2 After verifying STOP BOLT LOCKED indication, covers are removed and the electrical umbilical is connected between the breech door Y-connector and the missile and secured to the inside of breech door. The pneumatic umbilical is connected between the breech door penetrator and the capsule and secured to the eyebolt on the inside of the breech door. The breech door is shut and locked.

4.5.2 Weapon Power-Up and Make Ready. Weapon power-up and make ready is initiated by the weapon control console (WCC) operator in the attack center. The WCC operator activates switches to select Land-Attack TOMAHAWK mode, Land-Attack TOMAHAWK Preset Submode and the designated torpedo tube to be used for launch. These selections permit the WCC operator to monitor the selected tube and any alerts concerning launch. The weapon launch control (WLC) operator in the torpedo room positions the designated tube weapon loaded switch to the assigned missile variant. This action initiates alignment of torpedo room equipment to the selected weapon and allows verification in the attack center, through displays on equipment indicators, that the appropriate weapon is loaded in the tube. If such verification can not be obtained, the launch is recycled or aborted.

4.5.2.1 When ordered, FIRING ORDER and MAKE READY ORDERED are input by the attack control console (ACC) operator which permit other operator actions and equipment responses to commence in preparation for launch. The mission disk pack is removed from secure storage and mounted on the random access storage set (RASS). The disk pack serial number is entered and the RASS is initialized.

4.5.2.2 The WLC operator positions the designated tube weapon supply switch to POWER ON. WEAPON READY indicators appear on the WCC, ACC and WLC to reflect that the weapon is ready to receive commands. A tube status check is again performed to verify readiness. If WEAPON READY indicators are not obtained, the launch is recycled or aborted.

4.5.2.3 Positioning the weapon supply switch to POWER ON applies DC MONITOR/RESET POWER to the PVC system and a PRESSURIZE indicator appears on the WLC. Upon receipt of this indicator, the ship 700-psi air isolation valve of the designated tube pressure/vent manifold is opened to supply air to the missile. When missile pressure stabilizes between 3.8 and 7.2 psid, a PRESSURE IN BAND indicator appears on the WLC and the PRESSURIZE indicator goes out. PRESSURE IN BAND, PRESSURIZE and VENT indicators may cycle on and off during the preparation for launch due to changes in missile pressure.

4.5.3 Mission Assignment. With RASS initialized, the CMGS is ready to accept mission data when BALLISTICS SET and CMGS PROGRAMMED are indicated to the WCC operator (CMGS flight program has been transferred to the missile and the missile has responded with a valid Missile Status Word.). The WCC operator changes the submode until Land-Attack TOMAHAWK Evaluation is indicated on the WCC. THEATER, MPS, MISSION and VERIFY codes are received from the appropriate authority and entered on the WCC. Mission data are then indicated on the WCC. Mission data are also transferred to the central computer resident memory. The WCC operator enters the target number and the pre-established waypoints to that target are displayed on the WCC. The WCC operator reviews the mission data and approximate flight path to the target and makes route alterations by introducing or deleting waypoints. The WCC operator then assigns the mission to a designated torpedo tube and a verification that the mission is assigned to the correct tube is performed. Once a mission has been assigned, no further modifications can be made without resetting the mission and then reentering the mission number and verification code. After assigning the mission, the WCC operator normally selects the Land-Attack TOMAHAWK Preset submode for the remainder of the launch in order to monitor torpedo tube and missile status and any alerts concerning launch.

4.5.3.1 CMGS alignment begins automatically upon completion of a successful upload of the Operational Flight Program (OFP). The mission data are loaded into the CMGS and a course level is performed, followed by the alignment of axis#1. The inertial platform is then slued 90° and alignment of axis #2 is performed. The two-position alignment technique eliminates the need to perform submarine maneuvers at latitudes below 75°. If the submarine is maneuvering and the CMGS can estimate platform azimuth angle during alignment of axis#1, the slue and alignment of axis #2 will be bypassed. Launches at latitudes above 75°, however, will require submarine maneuvers to meet the alignment timeline. Upon completion of alignment, the CMGS will provide an ALIGNMENT COMPLETE message to the WCC operator.

4.5.3.2 If CMGS computer BIT is not passed, or valid communications can not be established or becomes lost with the CMGS computer, an alert message is provided to the WCC operator. To establish or restore communications, a controlled shutdown of the CMGS is performed and missile electrical power recycled. The normal start-up sequence is then repeated and program load reattempted. When program load is accomplished, the reprogram command is sent to the CMGS.

4.5.4 Tube Ready. The final steps to launch the missile are making the torpedo tube ready and arming the weapon. Upon receipt of indications that alignment and mission transfer are complete and that inputs match, the ACC operator gives the order to flood the designated torpedo tube. Responding to the order, the WLC operator floods the tube, and when so ordered, equalizes tube pressure with ambient sea pressure. Indicators advise operators that the tube is flooded and equalized. When ordered, the ACC operator orders OPEN DOOR for the designated tube. Responding to the order, the WLC operator opens the muzzle door. Indicators advise ACC and WLC operators that the muzzle door is open. When ordered, the WLC operator turns the launch mode switch to EJECT. The ACC operator selects the firing tube and a NEXT indicator appears.

4.5.5 Rocket Motor Arming. When ordered, the booster armed and warhead arm supply key-lock (UGM- 109A only) switches are activated by the ACC operator for the designated tube. BOOSTER ARMED indicators on the ACC and WLC advise operators of successful arming of the rocket motor. If indicators do not reflect that the rocket motor is armed, the launch is recycled or aborted.

4.5.6 Warhead Prearming (UGM-109A only). When ordered, the warhead arm switch on the ACC is activated for the designated tube. After approximately 24 to 40 seconds, WARHEAD ARMED indicators on the ACC and WLC will advise operators that the warhead has been successfully prearmed.

4.5.7 Weapon Firing. With INTERLOCKS CLOSED indicated and firing status ready, the order is given to the ACC operator to position the STANDBY/FIRE switch to STANDBY. Upon order, the switch is then positioned to FIRE and held until the FIRE indicator is present. Subsequent actions occur automatically. The missile batteries activate and missile essential busses are isolated. The CMGS performs a status check using battery power and, if successful, sends a MISSILE ENABLED signal. With the closing of final interlocks, the impulse fire relay energizes, the stop bolt rolls, the electrical umbilical deadfaces, and the tube fires. Upon firing, TUBE FIRED indicators on the ACC and WLC advise operators that the tube has been successfully fired. If indicators reflect that the tube was not successfully fired, the launch is aborted in accordance with NAVSEA OD 44979.

4.6 POST-LAUNCH OPERATIONS.

The post-launch operational sequence begins after the missile has been launched from the torpedo tube. Operations consist of those evolutions to either eject the capsule or return the capsule to the stowage racks. The operations also include resetting the tube if required, and securing the torpedo tube. A typical post-launch sequence is briefly described in the following paragraphs. Post-launch operations are preformed in accordance with NAVSEA OD 44979.

4.6.1 Tube Reset. If the WLC indicator continues to show TUBE FIRED at the completion of missile launch, the WLC operator takes action to reset the tube and close the outer door.

4.6.2 Capsule Ejection. (UGM-109A/C/D-1) When ordered to eject capsule, the WLC operator positions the missile interrupter switch to MANUAL and the tube stop to LOCK. The WLC operator then activates the switch to route ship 700-psi air to the capsule. Upon application of air pressure, the capsule sleeve moves forward, unlocking the capsule latches. Continued movement of the capsule sleeve retracts the capsule latches and closes the flow slots. With the closing of the flow slots, the weapon supply switch on the WLC is turned to OFF.

(UGM-109E-1) When ordered to eject capsule, the WLC operator shall unload the capsule from the torpedo tube in accordance with NAVSEA OD 44979. The capsule nose cover shall be re-installed. The AUR will then be loaded back into the torpedo tube.

4.6.2.1 When ordered, the ACC operator orders OPEN DOOR. Responding to the order, the WLC operator opens the muzzle door. WLC and ACC indicators advise the operators that the tube is ready to eject the capsule. On order, the tube is fired and the capsule ejected. If indicators show that the tube did not fire, operators refer to NAVSEA OD 44979 for further guidance.

4.6.2.2 Upon receipt of indicators that the tube successfully fired, the WLC operator closes the muzzle door, turns the weapon loaded switch to OFF, secures the ship 700-psi air isolation valve to the pressure/vent manifold, and drains the tube. After the tube is drained, the breech door is opened. The umbilicals and inside of the breech door are rinsed with fresh water to remove salt water residue, and then dried. The umbilicals are then disconnected and removed, and the tube is secured using procedures contained in NAVSEA OD 44979.

4.6.3 Capsule Return to Stowage. Upon order to stow capsule, the WLC operator turns the weapon supply and weapon loaded switches to OFF, secures the ship 700-psi air isolation valve to the pressure/vent manifold and drains the tube. The breech door is then opened and the umbilicals, the inside of the breech door and the aft face of the capsule are rinsed with fresh water to remove salt water residue, and dried. The umbilicals are then disconnected and removed. The capsule latches are manually retracted by pressing and holding their spring-loaded plungers; then lifting the latches and securing them with the pins provided. The capsule is removed from the tube using procedures contained in NAVSEA OD 44979 rinsed with fresh water, dried, covers installed and the capsule is then moved and secured to a stowage position.

4.7 LAND-ATTACK TCM CASUALTY MODE.

There is no casualty mode for land-attack TCM variants.

SECTION III. CAPSULE LAUNCHING SYSTEM

4.8 LAUNCH PLATFORM.

The TWS provides selected SSN-688 Class, SSN-774 Class and SSGN-726 Class submarines with the capability to carry, target, and launch TCMs against enemy land targets. TCM launch operations are performed aboard the submarine utilizing equipment located in the Attack Center, Combat Systems Electronic Space (CSES) and Vertical Launch Center. General locations of the complexes are shown in Figure 4-8 "General Locations of SSN 688 Class Submarine Complexes"⇒. The following paragraphs describe the major TWS-related CLS systems aboard the submarine. A simplified interface block diagram of TWS-related equipment aboard the submarine is shown in figure 4-9 "SSN 688 Class Submarine TWS-related Equipment Interfaces (2 Sheets)"⇒.

4.8.1 Submarine Combat System (SCS). The SCS include the Combat Control System (CCS) and the AN/BSY-1 Combat Control/Acoustic Set (CC/A). SSN 688 Class submarines may employ either the CCS or CC/A. Each SCS, supported by the ownship navigation system, CSES, Over-the-Horizon targeting (OTH-T) and the appropriate software programs, provides the necessary power, discretes and data to power up weapons, transmit orders, process and display data, initialize and align the missile guidance set, and initiate weapons launch. Also included are control and monitoring circuits as well as various firing interlocks.

4.8.2 Combat Systems Electronic Space (CSES). The CSES equipment is shared by both the SCS and the navigation system. Computer software programs, which include the operational flight program, preplanned land-attack mission/targeting data generated at a shore-based Theater Mission Planning System (TMPS) installation and provided to the submarine prior to deployment, platform alignment data and sequential control commands, are stored on disks in the CSES. The data are loaded into computer memory and sent to the missile on command. Missile responses and status are evaluated by the CSES to provide data for displays on TCM status, Built-In-Test (BIT), checksums and launch countdown.

4.8.3 Navigation System. SSN/VLS capable submarines are equipped with the Electrically Suspended Gyro Navigator (ESGN) AN/WSN-3A(V)2. The system consists of two Inertial Measuring Units (IMUs) and one dual-channel Navigation Control Console (NCC). Velocity and attitude data are generated in raw form by the IMUs and transmitted to the CSES via the NCC. The raw data are processed by the CSES computers to obtain velocity, attitude and position data and then transmitted to the various ship user subsystems.

4.8.4 Weapon Launch System. The weapon launch system consists of the missile tube assembly and the various ship systems which operate the missile tube assembly during stowage and launch operations. The following paragraphs describe the components of the weapon launch system.

4.8.4.1 Missile Tube Assembly. The missile tube assembly (Figure 4-10 "SSN 688 Class Submarine Missile Tube Assembly"⇒) houses and physically protects the weapon in the missile tube. The assembly consists of the missile tube, hatch and linkage gear, and interfaces to operate the assembly. Ship system interfaces include connections for the flood and drain and pressurization/vent systems. AUR interfaces provide shock mitigation and alignment of the AUR as well as a means to pressurize the AUR in the missile tube. Missile tubes are topped by hatches that are individually operated by outboard hydraulic rotary actuators and are locked by an over-center toggle linkage mechanism with locking further enhanced by a device to assure that hatches do not inadvertently open when adjacent tubes are subjected to launch pressure.

4.8.4.2 Hydraulic System. The hydraulic system (Figure 4-11 "SSN 688 Class Submarine Hydraulic System"⇒) provides power to actuate flood and drain system valves and missile tube hatches.

4.8.4.3 Pressurization/Vent System. The pressurization/vent system (Figure 4-12 "SSN 688 Class Submarine Pressurization/Vent System"⇒) replenishes the AUR internal atmosphere during stowage and pressurizes or vents the AUR to maintain internal pressure within a specified range of positive pressure over the underhatch volume pressure prior to launch using 700 psig ship service air.

4.8.4.4 Flood and Drain System. The flood and drain system (Figure 4-13 "SSN 688 Class Submarine Flood and Drain System"⇒) floods and equalizes the missile tube underhatch volume to sea pressure so that the hatch can be opened, drains the underhatch volume to remove water and allows this volume to be maintained at submarine internal ambient pressure.

4.8.4.5 Missile Tube Control System. The missile tube control system (Figure 4-14 "SSN 688 Class Submarine Missile Tube Control System"⇒) contains the controls, indicators, and interlock circuitry necessary to ready the missile tubes for launch and to monitor missile tube operation. The system also provides all of the interfaces between the ship systems and the SCS.

4.9 ONLOAD AND OFFLOAD.

The following paragraphs provide general information regarding preparation for, and onload and offload of weapons, as well as offload of a spent CLS. Various volumes of NAVSEA OD 44979 contain specific procedures to be used by SSN personnel. Technical manual SW820-AD-WHS-010/UGM-109-2 contains specific procedures for submarine tender and shore based personnel supporting SSNs. For SSGN Class procedures refer to NAVSEA OD 64501 and SW820-AD-WHS-040/UGM-109-2.

4.9.1 Onload. Submarine onload begins when the submarine arrives at a designated shore base activity or supporting submarine tender to receive a complement of weapons. Wind and sea motion, which affect the submarine's position and movement, are factors in determining the feasibility of loading operations. To prevent damage to the missile, ship, or equipment, it is recommended that weapons not be onloaded or offloaded if roll exceeds 3 degrees or pitch exceeds 1/2 degree, and winds exceed 30 knots. The submarine tender/shore base loading supervisor and the submarine's commanding officer will determine if conditions are satisfactory prior to commencing onload. Prior to onload, the security system is neutralized for each missile tube to be loaded; flood and drain system and pressure/vent system operability are verified at the VLC; and SCS operability is verified through operator conducted system diagnostics. During loading, responsibility for all operations is shared between the submarine's commanding officer and the submarine tender/shore base loading supervisor. All actions involving ship system preparation are the responsibility of the submarine's commanding officer. His permission is required prior to commencing loading operations. His designated representative is responsible for weapon handling operations and ensures that a weapon transfer inspection is conducted. Upon completion of submarine preparation, responsibility for loading transfers to the submarine tender/shore base loading supervisor. The submarine crew conducts the final hookup and closeout of the missile tube upon disconnect and removal of the loading equipment from the submarine. The following paragraphs provide a general overview of procedures used during loading operations. For purposes of illustration, loading of a generic weapon into one missile tube is discussed. There are some minor differences in loading procedures among AURs, AUR Simulator Volumetric Shapes and ballast cans which are not discussed. For multiple loadings, the procedures are the same except that multiple actions may be occurring simultaneously to prepare missile tubes and weapons. Additionally, loading equipment is moved from missile tube to missile tube until the full complement of weapons is aboard the submarine. Similarly, post-loadout is accomplished on a tube by tube basis until full closeout is accomplished. Onload terminates when the submarine has received its scheduled complement, final hookup has been accomplished, all loading equipment has been removed, missile tube hatches are closed and secured, and ship system equipment has been activated.

4.9.1.1 Prepare Missile Tube and Ship Systems. After supporting submarine tender/shore base personnel have erected the loading platform (Figure 4-15 "Loading Platform Installed"⇒). submarine personnel prepare the missile tube and ship systems for onload. The missile tube hatch is opened and gagged (Figure 4-16 "SSN 688 Class Submarine Missile Tube Equipment"⇒). and the missile tube is visually inspected to ensure it is free of potential contaminants. Contaminants, if present, will damage the lip seal on an AUR or o-ring on an AUR Volumetric Shape/Simulator during loading. The muzzle face protective cover and the missile tube muzzle hatch and magnet protective cover are installed (Figure 4-16 "SSN 688 Class Submarine Missile Tube Equipment"⇒). For the AUR Volumetric Shape/Simulator onload, the mylar O-ring protective sleeve assembly is also installed. Special procedures like direct tube to tube transfer of AURs on the same submarine or between different submarines may utilize lip seal protective covers (fabricated from split garden hose or equivalent) or a lip seal protective sleeve (fabricated from various sheet materials). The counterbore cover is installed to prevent personnel, tools, water and debris from entering the empty missile tube. The Environmental Monitoring Sensor (EMS) pressure and temperature ambients are checked, and a leak test performed. SCS circuits are checked using the All-Up-Round Electronic Simulator (AURES). The accuracy of the differential pressure transducer is verified and the pressurize/vent (P/V) plug is removed and stowed. The counterbore cover is removed.

4.9.1.2 Install Loading Equipment. After the missile tube and ship systems have been prepared for loading, submarine tender/shore base personnel install the loading equipment aboard the submarine. This includes the Installation Guide Assembly Mk 116, Hydraulic Power Unit (HPU) Mk 8, Missile Tube Extension Loader (MTEL) Mk 23 and the MTEL Safety Cover. The installation guide is installed on the missile tube inner shoulder to assist in centering the MTEL over the missile tube. The MTEL is lowered over the missile tube, maneuvered to align its guide holes with the missile tube pins, and bolted to the muzzle face. The installation guide is then removed. The MTEL safety cover is installed over the MTEL mouth to prevent objects from falling into the open missile tube. The HPU is positioned on the loading platform and connected to the electrical source aboard the submarine. Hoses are connected between the HPU and the MTEL. A check is made to insure the centering guides and the insertion pin stop-plates are in the correct position on the MTEL

4.9.1.3 Prepare Weapon. As the missile tube and ship systems are being prepared for loading and loading equipment is being installed, submarine tender/shore base personnel prepare the weapon for loading. After opening the Shipping and Storage Skid Mk 30, two trunnions or trunnion bearing assemblies are installed in the weapon to allow vertical uprighting with either the Tilt Fixture, Mk 23 Mod 0 with Kit B, or a Shipping and Storage Skid Mk 30 that has been rigged for uprighting. The weapon is removed from the skid and placed in the uprighting equipment being used where, if not previously performed, a pressure check and inspection, to include rocket motor safe/armed and weapon configuration tests, are performed. Interface support and elastomer loading guard pads as well as the upper flange grooves are greased to facilitate loading the weapon into the missile tube. The forward section of the weapon is depressurized and the Closure Protective Cover (CPC) is replaced with the Capsule Loading Cover (CLC). The annular space vent plug is removed and stowed. Two lip seals are then greased and carefully installed into the upper flange grooves. The lifting adapter is then attached to upright the weapon to the vertical position.

4.9.1.4 Load Weapon in Missile Tube. The weapon is uprighted about the trunnions or trunnion bearing assemblies and lifted off the Mk 23 fixture (Figure 4-34 "Tilt Fixture Mk 23 Mod 0 with Kit B"⇒) or uprighting skid (Figure 4-17 "CLS Weapon Onload"⇒). The trunnions or trunnion bearing assemblies are removed and the weapon is lifted over the MTEL and aligned for insertion into the missile tube. The MTEL safety cover is removed. The weapon is lowered into the MTEL until the bellyband and the moisture and dust plug can be sequentially removed. The MTEL centering guides are released to allow the flange to pass, permitting the weapon to be lowered until the lifting adapter is above the bellmouth. The lifting adapter arm is then pinned in the vertical position and the weapon is further lowered until the lifting adapter insertion pins rest on the MTEL stop plates (Figure 4-18 "CLS Weapon Seating in Missile Tube"⇒). Seating the weapon in the missile tube is accomplished hydraulically using the HPU. The lifting adapter arm is disconnected from the crane and the MTEL hydraulic cylinders are connected to the lifting adapter insertion pins. The hydraulic cylinders are extended using the HPU until the weapon seats in the missile tube.

4.9.1.5 Remove Loading Equipment. After the AUR has been fully seated in the missile tube, the MTEL hydraulic cylinders are disconnected from the lifting adapter insertion pins. The insertion pins are inserted into the lifting adapter and the MTEL hydraulic cylinders are then fully retracted. The HPU is disconnected from the MTEL and the MTEL unbolted from the muzzle face and removed from the deck. The lifting adapter is unbolted and removed from the weapon which signifies completion of the loading sequence and final hookup and testing becomes the responsibility of submarine personnel.

4.9.1.6 Post-Loadout. Post-loadout involves connecting the weapon to the ship systems through missile tube interfaces (Figure 4-19 "Secure CLS Weapon in Missile Tube"⇒). The umbilical cable connector is connected to the missile tube umbilical connector. Eight retention segments are installed to restrain the CLS in the missile tube at launch. Umbilical cable brackets are connected to the retention segments to restrain the umbilical. The SCS, missile tube, and weapon are then tested to ensure operability. The annular space vent is plugged and the P/V sensing line connected to the pressure transducer in the missile tube. A leak test at the missile tube hatch opening is conducted and the underhatch area cleaned. The CLC is removed and the capsule closure is inspected to ensure no damage occurred during loading. The missile tube hatch and fairing are then closed and the loading platform removed.

4.9.1.7 SSGN Onload Overview. The following paragraphs provide a brief description of the unique aspects of onloading the Tomahawk onboard a SSGN-726 Class submarine.

4.9.1.8 AUR Onload Sequence. An onload sequence begins with staging and preparing the work platform (Figure 4-4 "MTEL Work Platforms"⇒) onto the MTEL, attaching the MTEL adapter (Figure 4-7 "MTEL With MTEL Adapter Installed"⇒) onto the MTEL, and attaching the lifting adapter extension (Figure 4-21 "Lifting Adapter and Extension"⇒) onto the lifting adapter. The MTEL work platform, the MTEL adapter and the lifting adapter extension are support equipment unique to SSGN.

4.9.1.9 Organizational-Level Preparations. The submarine crew opens the missile tube hatch providing access to the Multiple All-Up-Round Canister (MAC) (Figure 4-33 "Multiple All-Up-Round Canister (Fully Loaded)"⇒) and its individual AUR cells, and tags out the hydraulic system. The appropriate AUR cells are inspected for dirt, debris or foreign material that will damage lip seals during loading, and the area is cleaned as required.

4.9.1.10 Installing Loading Equipment. The HPU is transferred and secured to the SSGN work area. There are two different MTEL Adapters and each must be used in the appropriate AUR cells. The 7124601-003 Adapter is used with MAC cells A, C, E, and G. The 7124601-004 Adapter is used with MAC cells B, D and F (Figure 4-35 "Multiple All-Up-Round Canister MTEL Orientation"⇒). The prepared MTEL/MTEL Adapter is lowered onto the AUR cell and oriented with the large and small alignment pins temporarily placed in the MAC top plate. The MTEL/MTEL Adapter is secured to the MAC with four bolts. The hydraulic hoses from the HPU are connected to the manifold on the MTEL.

4.9.1.11 Uprighting and Inserting. Procedures to upright the AUR are similar to the SSN Class with the exception of installing the lifting adapter extension. Inserting the AUR is essentially the same as for the SSN Class as well, with the MTEL adapter providing an interface between the existing MTEL design and the MAC top plate. The additional height of the MTEL adapter requires the lifting adapter be attached to the AUR with an extension of equal height.

The MTEL adapter is outfitted with a guide ring. The guide ring can be rotated to the open or shut position to engage or disengage the guide shoes. The guide shoes perform the same function as the MTEL centering guides, which is to assist in keeping the AUR in the center of the cell during loading and offloading operations.

4.9.1.12 Removing Loading Equipment. The MTEL/Adapter is unbolted from the MAC top plate and removed. The lifting adapter/extension is unbolted from the capsule upper flange and removed. The HPU is disconnected from the electrical power source and removed.

4.9.1.13 Organizational-Level Closeout Operations. Topside personnel connect the pressure/vent sensing line and install the eight retention segments to secure the AUR in the AUR cell. Topside personnel mate the AUR upper umbilical cable connector to the MAC umbilical cable stowage receptacle. Inside the MAC, the crew connects the AUR ground strap, moves the P1130 connector to the stowage position of the aft cover, and mates the MAC umbilical cable to the J1130 connector (Figure 4-36 "AUR Aft Cover Viewed in MAC"⇒). Each AUR requires one MAC umbilical to be connected to the J1130 connector. A bubble test is performed on the installed AUR to check for leaks at the MAC top plate.

4.9.2 Offload. Submarine offload begins when the submarine arrives at a designated shore base activity or supporting submarine tender to discharge a complement of weapons or spent CLSs. Wind and sea motion, which affect the submarine's position and movement, are factors in determining the feasibility of offload operations. To prevent damage to the missile, ship, or equipment, it is recommended that weapons not be offloaded if roll exceeds 3 degrees or pitch exceeds 1/2 degree, and winds exceed 30 knots. The submarine tender/shore base loading supervisor and the submarine's commanding officer will determine if conditions are satisfactory prior to commencing offload. Prior to offload, ship systems are neutralized for each missile tube to be offloaded. During offload, responsibility for all operations is shared between the submarine's commanding officer and the submarine tender/shore base loading supervisor. All actions involving ship system and weapon preparation are the responsibility of the submarine's commanding officer. His permission is required prior to commencing offload operations. His designated representative is responsible for weapon handling operations and ensures that a weapon transfer inspection is conducted. Upon completion of submarine and weapon preparation, responsibility for offload transfers to the submarine tender/shore base. The following paragraphs provide a general overview of procedures used during offload operations. For purposes of illustration, offload of a generic weapon from one missile tube is discussed. There are some minor differences in offload procedures among AURs, AUR Simulator Volumetric Shapes, ballast cans and spent CLSs which are not discussed. For multiple offloads, the procedures are the same except that multiple actions may be occurring simultaneously to prepare missile tubes and weapons. Additionally, loading equipment is moved from missile tube to missile tube until the full complement of weapons is offloaded from the submarine. Similarly, post-offload procedures are accomplished on a tube by tube basis until full closeout is accomplished. Offload terminates when all weapons scheduled for offload have been removed from the submarine and all loading equipment has been removed

4.9.2.1 Prepare Missile Tube and Ship Systems. Initially, the SCS must be disengaged from those missile tubes containing weapons to be offloaded. After the SCS has been disengaged from those missile tubes to be offloaded and the loading platform (Figure 4-15 "Loading Platform Installed"⇒) installed by supporting submarine tender/shore base personnel, the first missile tube hatch is opened and gagged (Figure 4-16 "SSN 688 Class Submarine Missile Tube Equipment"⇒). The muzzle face protective cover, the missile tube muzzle hatch and magnetic protective cover and the EMS protective cover are installed to protect submarine personnel and equipment while preparing AUR weapons for removal.

4.9.2.2 Prepare Spent CLS for Offload. In addition to those above tasks to be performed to prepare for weapon offload, reflood water and residue must be removed from a spent CLS prior removing it from the missile tube. Submarine tender/shore base personnel pump approximately half of the reflood water in the spent CLS into a holding tank using a submersible pump. The submarine crew then performs a P/V piping blow-down to ensure reflood water is removed. The upper tube and muzzle hatch areas are then flushed with fresh water and all residual reflood water is pumped from the spent CLS. Remaining residue and by-products are cleared from above the CLS in order to attach the lifting adapter. Additionally, egress of the TCM from the CLS causes the diaphragm to rupture leaving residue which must be removed to permit attachment of the CLC and to secure the umbilical cable to the cover.

4.9.2.3 Prepare Weapon for Offload. Once the missile tube has been prepared, the submarine crew prepares the weapon for offload. The CLC is installed. The umbilical cable connector is disconnected, the connector protective cap installed, and the connector is secured to the CLC. Umbilical cable clamps, retention segments and the annular space vent plug are then removed. A protective shield is installed on the umbilical to prevent contact with the missile tube and damage to the umbilical.

4.9.2.4 Install Offload Equipment. Submarine tender/shore base personnel connect the lifting adapter to the weapon. The MTEL is positioned, and secured over the missile tube. The HPU is positioned on the loading platform and connected to the electrical source aboard the submarine and to the MTEL cylinders. The lifting adapter insertion pins are installed and the MTEL hydraulic cylinders are connected to the insertion pins.

4.9.2.5 Remove Weapon from Missile Tube. With the MTEL cylinders attached to the lifting adapter insertion pins, the HPU is energized causing the hydraulic cylinders to retract thereby extracting the weapon from its seated position in the missile tube. The weapon is positioned on the stop plates and the hydraulic cylinders are detached from the insertion pins. A crane hook is attached to the lifting adapter arm to withdraw the weapon. As the weapon is raised, the insertion pins are retracted, the moisture and dust plug is installed, and the bellyband and tag lines are attached. The weapon is fully extracted from the missile tube, lifted clear of the submarine and transferred to the tender or dockside where trunnions or trunnion bearing assemblies are installed. The weapon is positioned on the Tilt Fixture, Mk 23 Mod 0 with Kit B, or on a MK 30 skid rigged with a Mk 26 Uprighting Fixture.

4.9.2.6 Remove Offload Equipment. After the weapon has been removed from the missile tube, the offload equipment is removed from the submarine or moved to another missile tube. The MTEL centering guides are disengaged, the HPU/MTEL connection is severed and the hydraulic cylinders are stowed on the MTEL. After detaching the MTEL from the missile tube, the MTEL is removed.

4.9.2.7 Secure Missile Tube and Ship Systems after Weapon Offload. After the offloading equipment has been removed from the missile tube, the submarine crew secures the missile tube and ship systems. The crew installs the missile tube counterbore cover, the P/V port plug, and the missile tube umbilical security cap. The missile tube muzzle hatch protective cover, muzzle face protective cover, fairing, cofferdam, and counterbore cover are removed. The missile tube hatch is ungagged and the hatch is closed. Flood and drain, pressurization/vent and security systems are then energized to return the submarine to normal operations. The loading platform is removed.

4.9.2.8 Post-Launch P/V Refurbishment after Spent CLS Offload. After the offload equipment has been removed from the missile tube, the submarine crew conducts post-launch P/V refurbishment. The P/V valve is disassembled, cleaned, and reinstalled. Differential transducer lines are cleaned and the transducer is checked and tested. P/V piping is flushed, dried and tested for serviceability. Upon completion of the refurbishment, the P/V plug is reinstalled.

4.9.2.9 Post-Launch Missile Tube Refurbishment after Spent CLS Offload. Launching a TCM and exposure to sea water during the launch may cause minor damage to the missile tube necessitating post-launch missile tube refurbishment. The submarine crew removes the missile tube counterbore cover, inspects the interior of the missile tube and performs, or arranges for, missile tube maintenance depending on the complexity of repairs required.

4.9.2.10 SSGN Offload Overview. The following paragraphs describe unique aspects of offloading the Tomahawk from a SSGN-726 Class submarine. Primary elements unique to offloading from the SSGN platform are the location of the umbilical for disconnection by submarine personnel, and the requirements for the MTEL work platform, MTEL adapter, and lifting adapter extension.

As discussed in the SSGN onload overview, there are two MTEL adapters each of which must be used in the appropriate AUR cells. The 7124601-003 Adapter is used with MAC cells A, C, E and G. The 7124601-004 Adapter is used with MAC cells B, D and F.

Similar to the MTEL centering guides, the guide ring of the MTEL adapter is rotated to the shut position to engage the guide shoes and assist in keeping the AUR in the center of the cell during offload.

4.10 OPERATIONAL CONSTRAINTS/RESTRICTIONS.

Tactical employment of the TCM imposes a number of constraints on the operating parameters of the submarine. The constraints imposed during tactical launch operations of the TOMAHAWK Cruise Missile are provided in applicable tactical publications. Employment also places restrictions on the submarine’s tactical flexibility which are described in Operating Guidelines, tactical employment manuals and operation manuals.

4.10.1 Weapon Mix. Weapon mix will depend on the particular conditions that exist at the time the decision is made to prepare weapons for launch. The SCS is capable of processing a combination of land-attack TCM variants for single or salvo launch from vertical missile tubes, as well as a combination of land-attack TCM variants, Mk 48 Torpedoes and other defensive systems for launch from torpedo tubes. Prime consideration for selecting a specific weapon for launch should be the time required to prepare and launch a single TCM or, in the case of salvo fire, the time required to prepare and launch multiple TCMs.

4.10.2 Alert Messages and Interlocks. Various alert messages and firing interlocks are used to warn operators or inhibit launch when conditions exist that could impact missile performance, endanger the submarine or result in the launch of a dud missile. Firing interlocks may be either software or hardware interlocks. Prior to permitting activation of the FIRE switch, the fire control system must receive an indication that the following interlocks are closed:

a. OPERATIONAL FLIGHT PROGRAM TRANSFERRED - Indicates that the flight program has been successfully transferred to the missile.
b. MISSILE ALIGNED - Indicates that the CMGS inertial platform relative to the submarine's inertial reference system has been aligned.
c. MISSION DATA TRANSFERRED - Indicates that all data relative to the mission have been transferred to the missile.
d. WITHIN LIMITS - Indicates that speed and depth of the submarine are within limits.
e. INPUTS MATCHED - Indicates that the CMGS has responded with good MISSILE STATUS, missile presetting is complete and launch constraints are satisfied,
f. TUBE IN ACTIVE FIRING SEQUENCE - Indicates that the proper tube has been selected and sequenced, all controls have been positioned and all indicators are go.
g. TUBE READY - Indicates that the underhatch volume has been flooded and the pressurization/vent control valve is closed.
h. CAPSULE/BOOSTER PREARMED - Indicated that the capsule and rocket motor are in the prearmed position.

Upon activation of the FIRE switch and indication of MISSILE ENABLED (i.e., , hatch open, booster armed, capsule armed, batteries activated, BIT passed, MISSILE STATUS word good), the fire control system closes firing interlocks prior to permitting the coded charge and launch signals to be sent to the CLS.

4.11 LAND-ATTACK TCM OPERATIONAL SEQUENCE.

This paragraph describes typical actions and responses required to launch a land-attack TCM. Primary coverage is given to normal launch of a single weapon. For salvo launch, the operational steps for a single launch are sequentially accomplished for each weapon selected for launch. Abnormal launch conditions and abort procedures are discussed by highlighting only those events that differ from a normal launch. Typical launch operations are shown in Figure 4-20 "UGM-109-2 Land-Attack TCM Operational Sequence (10 Sheets)"⇒. The figure illustrates the orders given by the ship's commanding officer, typical actions taken by equipment operators and typical equipment operations, status displays and machine decisions. The operational sequence is described in the following paragraphs. For a full discussion of operating procedures and checklists, as well as actions to be taken under abnormal conditions, refer to the appropriate volumes and parts of NAVSEA OD 44979.

4.11.1 Weapon Preparation. Preparation for launch commences with the authorization from the commanding officer. He will issue the necessary make ready command for a single or salvo launch. Based on that command, the MAKE READY command is issued and the appropriate land-attack weapon for the mission is selected. To verify the correct missile has been selected and to permit weapon power-up, the Weapon Supply Switch is placed in the IDENT position. Should a weapon conflict result from CM IDENT POWER application, an ID ERROR will be displayed and all relays to the weapon will remain closed.

4.11.2 Weapon Power-Up and Make Ready. When the correct designator is reflected, the Missile Power keyswitch is placed in the ENABLE position and the Weapon Supply Switch is moved from IDENT to ON. This permits MONITOR/RESET POWER and CAPSULE POWER to flow to the missile and CLS respectively so the SCS can transmit commands, receive responses, and open relay circuitry for missile OPERATE POWER. Additionally, activation of the switches permits the flow of REM BATTERY HEATER POWER to exercise weapons. Weapon responses are monitored to ensure that BOOSTER SAFE and CAPSULE SAFE indicators show that the weapon is in a safe status. If a BOOSTER ARMED or CAPSULE ARMED indication exists, or there is no condition status indicated, the launch is aborted.

4.11.3 Mission Assignment. The appropriate mission disk pack is removed from secure storage and mounted on the random access storage set (RASS). The disk pack serial number is entered and the RASS initialized. With RASS initialized, the Cruise Missile Guidance Set (CMGS) is ready to accept mission data when BALLISTICS SET and CMGS PROGRAMMED are indicated to the Weapon Control Console (WCC) operator (CMGS flight program has been transferred to the missile and the missile has responded with a valid Missile Status Word.). The WCC operator changes the submode until Land-Attack TOMAHAWK Evaluation is indicated on the WCC. THEATER, MPS, MISSION and VERIFY codes are received from the appropriate authority and entered on the WCC. Mission data are then indicated on the WCC. Mission data are also transferred to the central computer resident memory. The WCC operator enters the target number and the pre-established waypoints to that target are displayed on the WCC. The WCC operator reviews the mission data and approximate flight path to the target and makes route alterations by introducing or deleting waypoints. The WCC operator then assigns the mission to the designated missile tube and a verification that the mission is assigned to the correct tube is performed. Once a mission has been assigned, no further modifications can be made without resetting the mission and then reentering the mission number and verification code. After assigning the mission, the WCC operator normally selects the Land-Attack TOMAHAWK Preset submode for the remainder of the launch in order to monitor tube and missile status and any alerts concerning launch.

4.11.3.1 CMGS alignment begins automatically upon completion of a successful upload of the Operational Flight Program (OFP). A two-position alignment technique eliminates the need to perform submarine maneuvers at latitudes below 75°. Launches at latitudes above 75°, however, will require submarine maneuvers to meet the alignment timeline. Upon completion of alignment, the CMGS will provide an ALIGNMENT COMPLETE message to the WCC operator.

4.11.3.2 If CMGS computer built-in test (BIT) is not passed, or valid communication can not be established or becomes lost with the CMGS computer, an alert message is provided to the WCC operator. To establish or restore communications, a controlled shutdown of the CMGS is performed and missile electrical power recycled. The normal start-up sequence is then repeated and program load reattempted. When program load is accomplished, the reprogram command is sent to the CMGS.

4.11.4 Rocket Motor/Capsule Prearm. When proper authorization is given, the BOOSTER ARM and CAPSULE ARM switches are activated to prearm the rocket motor and capsule respectively.

4.11.5 Tube Ready. When the WCC display indicates INPUTS MATCHED YES, and when proper authorization is given, the READY TO FLOOD pushbutton at the Vertical Launch Console

(VLC) is depressed and the FLOOD/DRAIN valve opened. The Hatch Control Switch must be in REMOTE. FLOOD/DRAIN VALVE OPEN and EQUALIZE indicators illuminate, and the PRESSURE IN BAND indicator remains illuminated. Consoles are continuously monitored to ensure that all systems are operational. Any anomaly will be displayed on the WCC as a systems alert or mode message which must be resolved prior to proceeding with the launch.

4.11.6 Weapon Firing. When the STANDBY ENABLE is displayed, the STANDBY switch is activated. A STANDBY indicator illuminates at the VLC which directs the closing of the P/V valve and unlatching of the missile tube hatch. The command is then given to activate the FIRE switch. Activation of the FIRE switch activates the HATCH OPEN RELAY which automatically routes all subsequent commands directly to the weapon. The FIRE command opens the missile tube hatch, arms the rocket motor and CLS, and sends the ITL signal to the missile. It also sends the coded charge and launch signals to the CLS after the missile batteries are activated and MISSILE ENABLED and FIC signals have been sent to the VLC.

4.11.6.1 Once the FIRE command has been sent, operators no longer have the ability to intervene in the launch with the exception of sending an ABORT command. An abort can be accomplished any time until the MISSILE ENABLED signal is sent to the SCS. Once batteries have been activated and the ABORT command issued, the missile is dudded and cannot be recycled for firing.

4.11.6.2 Upon receipt of the coded launch signal, the gas generator ignites, initiating missile launch. FIRE PULSE DETECTED signal is received from the CLS and all functions to the missile are terminated. At first motion, a MISSILE AWAY signal is received from the CLS and all commands are terminated.

4.11.7 Multiple Launch/Salvo Fire. Upon receipt of the multiple launch/salvo fire order from the commanding officer, and subsequent to selection of the missile tube firing order, commands and orders are inputted into each weapon sequentially until FIRE is ordered. During multiple launch/salvo fire, activation of the FIRE switch initiates the salvo fire. Interlocks for all weapons programmed for launch must be closed prior to launching the first missile. Once the FIRE switch is activated, firing is automatic and only the loss of HATCH OPEN, CAPSULE ARMED, or MISSILE ENABLE will inhibit launch automatically. The salvo firing sequence may be manually interrupted by pushing the STANDBY or FIRE button a second time. Manual interruption will not abort or stop a weapon in process of being fired after ITL has been issued to a missile in the firing sequence. The salvo may be restarted by manually pressing the FIRE button again.

4.12 POST-LAUNCH OPERATIONS.

After first motion and transmittal of the MISSILE AWAY signal, the missile clears the missile tube and missile launched is indicated. The order is given to close the missile tube and secure the system after ensuring a HANGFIRE alert is not indicated. The Hatch Control Switch is moved from REMOTE to CLOSE, and the Weapon Supply Switch turned OFF. The Missile Tube Power Switch is moved to MONITOR and Missile Power turned OFF. Post-launch operations are performed in accordance with NAVSEA OD 44979.

4.13 LAND-ATTACK TCM CASUALTY MODE.

There is no casualty mode for land-attack TCM variants.

4.14 BLOCK IV TACTOM OPERATIONAL SEQUENCE.

The following paragraphs describe typical actions and responses during a Block IV TACTOM launch.

4.14.1 Prelaunch Sequence. The Block IV TACTOM Missile prelaunch sequence includes checks of missile hardware and software; loading of missile flight capable software, mission data, and strike data; and alignment of the inertial measurement unit. The prelaunch sequence starts when the application of power is initiated and completes when the missile is ready for launch.

The missile prelaunch sequence initiates with the application of power from the launch platform. The missile's first operation, upon power application is to run Built-In-Tests of the air data module, inertial measurement unit, mission control processor, and navigation processor.

Once the initial Built-In-Tests are completed, the platform's SCS interrogates the missile for its ID number, tail number, OFS cyclic redundancy check status, and OFS version ID. The SCS also requests version IDs from other missile software components such as the DSMAC flight software and GPS flight software. After these checks are passed, the SCS loads the Missile Launch Capable Flight Software (LFS). Once the LFS is loaded, the Missile Response Status Word reported to the SCS will show the missile to be launch capable.

After the software loads are completed, the Anti-Jam GPS Receiver, Digital Scene Matching Area Correlator, and Satellite Data Link Transceiver are powered up and Built-In-Tests are performed. Next, the Thrust Vector Control and Fin Control System Built-In-Tests are performed.

Initialization of the Inertial Measurement Unit begins with the transmittal of the missile initialization message from the FCS, which contains data from the platform's inertial navigation system. This allows the navigation processor to transition from Mode 1 (Ready to Align) to Mode 2 (Aligning).

Alignment data from the platform is combined with up to 220 KB of mission data and loaded into the missile. The Mission Data also includes strike data and communications parameters. Mission data loads are verified by checksum tests after download completion. The loading of mission data continues with the over-water data (planned by the launch platform), GPS almanac data, and GPS keys.

The FCS continues to monitor the navigation processor status until Mode 3 (aligned) is reported. At that point, the FCS issues the Booster Arm and the Intent to Launch (ITL) commands. Once the ITL is issued, responsibility for aborting the launch passes from the FCS to the missile. Next, the FCS issues a Terminate Alignment to the missile, which causes the Mission Control Processor (MCP) to command the navigation processor into "Navigate" mode. The MCP then initiates the rocket motor, thrust vector control, and fin control system. The cruise missile airframe battery is also enabled.

Before the MCP issues the Enable Missile command, it performs several initial status checks, including a status update from the navigation processor and verification of proper GPS load data.

4.14.2 Launch Sequence. The Block IV TACTOM Missile launch sequence from application of Intent-To-Launch (ITL) to wing deployment includes discrete signals from missile, removal of launcher power, digital interface deadfacing, gas generator ignition, first motion, booster ignition, deployment of fins and wings, rocket motor jettison, and engine start-up.

The missile launch sequence begins upon transmission of Firing Command (ITL) by the launch platform to the missile. The ITL and subsequent sequence results in missile battery activation, transition from platform power to internal missile power, execution of missile Built-In-Test, and the subsequent return of Missile Enable to the launch platform. After receipt of Missile Enable, the launch platform's SCS removes launcher power to the missile and the Mission Control Processor (MCP) issues a Mk-82 deadface command to prevent spurious digital commands.

Following the deadface command, the SCS issues a gas generator ignition command. When the missile senses first motion a launcher position and velocity test is initiated. When launcher position and velocity is detected the missile disables the booster and waits for a deceleration indication and when the deceleration occurs the booster is ignited and the missile enables ACR monitor, TVC control, and initiates booster guidance/autopilot. Missile enable is then turned off. When water broach is detected the wing slot plugs are ejected. Shroud separation occurs, fins are deployed, and boost roll control is initiated. Regardless of the launch platform, the missile then jettisons the inlet cover and deploys the wings. When the rocket motor thrust decays the missile jettisons the rocket motor and starts the cruise engine and follows the cruise route to the designated target.

4.14.3 Submarine Weapon System Interfaces. During the pre-launch phase, the Block IV TACTOM AUR interfaces directly to the SCS and the Mk 45 Capsule Launching System (CLS). The Mk 45 Capsule provides for all mechanical and environmental interfaces to the AUR (including the longitudinal shock isolation, lateral support, mounting to Mk 45 canister aft structure restraint/gas generation system, umbilical cable connection, temperature control, humidity control, and storage). Each SCS provides the Mk 82 digital data link for all command and response message traffic to/from the AUR. Each SCS also provides power, discrete, and analog signals to the AUR via the capsule wiring harness that connects to the side of the Mk 45 capsule. All commands, power application, data loads and status requests to the missile are applied by submarine class SCS.

Once in flight, the Block IV TACTOM missile is capable of receiving various directions (flex command, re-targeting, BDI request, H&S requests) via the use of In-Flight Mission Modification Messages (IMMM) transmitted by the Strike Controller via the TOMAHAWK Strike Network (TSN). It is also capable of acquiring and receiving GPS information directly from the GPS satellite constellation.

4.14.4 TOMAHAWK Strike Network In-Flight Communications. The TOMAHAWK Strike Network (TSN) is used to link communications between a Block IV TACTOM with a strike controller or missile controller during flight. The missile sends health and status (H&S) messages and receives commands from the controller to modify mission outcome or communication parameters. Messages are transmitted via UHF Satellite Communications on 5 KHz and 25 KHz UHF Demand Assigned Multiple Access (DAMA) channels.

Message Types:

From Block IV TACTOM Missile:

- H&S: Sent to controller to report missile location, current mission outcome, and status of selected missile subsystems. H&S messages may be prescheduled, triggered by events, or in response to a request by the controller.
- Battle Damage Information: This is an H&S message that also contains an estimate of navigation error at the target. BDI messages are sent during the terminal portion of the mission.
- Battle Damage Indication Imagery: This is an H&S message that includes a compressed single frame of imagery collected with the DSMAC sensor. Collection of images is controlled by mission data.

From Strike/Missile Controller (In-Flight Mission Modification):

- Preplanned Outcome: These messages can be used to select one of up to 16 preplanned mission outcomes. The missile will transition to the chosen outcome at a preplanned point in the route. This type of message can also be sent to modify communications parameters or request missile status.
- Aimpoint Update: This message is used to command the missile to directly transition to a new target location, specified by GPS location. The message also provides commands for flyout altitude to the target, dive angle, and warhead fuze delay. This type of message can also be sent to modify communications parameters or request missile status.
- Retarget: This message also provides a new aim point to the missile, but also includes a segment of mission data to guide the missile to the target. The message also specifies where in the preplanned mission the missile shall divert to the new mission data. This type of message can also be sent to modify communications parameters or request missile status.

4.14.5 GPS To Missile Interface. The Block IV TACTOM missile uses the Global Positioning System (GPS) for navigation aiding throughout its flight. GPS signals are received by the Anti-jam GPS Receiver (AGR) via the AGR Antenna. These components provide the missile with improved resistance to GPS jamming as compared to Block III.

As in Block III, the Block IV TACTOM missile receives GPS crypto keys and almanac data from the launch platform during missile preparation. GPS crypto keys are transferred in a matter that memory locations are zeroed after the key information is transferred.

Initial GPS satellite acquisition occurs shortly after launch. The missile tries to acquire all satellites that are in view to its antenna, up to a total of eight. The missile will select to receive data from the best set of four satellites based upon the accuracy of the navigation solution. Satellites are tracked first using C/A (Coarse Tracking) code, and then using P/Y (Precision Tracking) code. First Fix is achieved when P/Y measurements are achieved from the best set of four satellites. During normal GPS track, the AGR will keep track of up to eight satellites to enable faster reacquisition.

The AGR with its Controllable Radiation Pattern Antenna (CRPA) allows it to vary its pattern to avoid jamming sources.

SECTION IV. VERTICAL LAUNCHING SYSTEM

4.15 LAUNCH PLATFORMS.

The VLS TWS is employed using the VLS Mk 41 aboard CG 47 Class ships, CG 52 and up (VLS Mk 41 Mod 0), DD 963 Class ships (VLS Mk 41 Mod 1) and DDG 51 Class ships (VLS Mk 41 Mod 2). The VLS Mk 41 is a multi-purpose launching system capable of launching TCMs as well as STANDARD Missiles and the Vertical Launch Anti-Submarine Rockets (VLA). The VLS Mk 41 Mod 0 configuration (Figure 4-22 "Vertical Launching System Mk 41 Mod 0"⇒) consists of two Mk 211 Mod 0 or Mod 1 Launch Control Units (LCU), two Mk 158 Mod 0 Launchers having 61 cells each, one fore and one aft, two status panels, one fore and one aft, and a Remote Launch Enable Panel (RLEP). The VLS Mk 41 Mod 1 configuration (Figure 4-23 "Vertical Launching System Mk 41 Mod 1"⇒) consists of two Mk 211 Mod 0 or Mod 1 LCUs, one Mk 158 Mod 0 Launcher having 61 cells forward, one status panel forward, and an RLEP. The VLS Mk 41 Mod 2 configuration (Figure 4-24 "Vertical Launching System Mk 41 Mod 2"⇒) consists of two Mk 211 Mod 1 LCUs, one Mk 159 Mod 0 Launcher having 29 cells forward, one Mk 158 Mod 0 Launcher having 61 cells aft, two status panels, one fore and one aft and an RLEP. Launch control is provided by the TOMAHAWK Weapon Control System.

4.15.1 Launch Control Unit. LCUs (Figure 4-25 "Launch Control Unit (LCU)"⇒), designated LCU 1 and LCU 2, maintain control of the launcher sequencer (LSEQ) in the launchers, which, in turn, monitor launcher conditions and provide the interface to permit weapon launch. Each LCU consists of a data processing set which receives orders from the weapon control system, selects the weapon to engage the target, and issues pre-launch and launch commands to the launcher; a signal data recorder-reproducer set which contains the tapes that control the launch control computer program and record operational history and digital data pertinent to fault isolation and data analysis; and a data terminal group which allows manual access to the VLS program and provides hard copy of data received from the data processing set.

4.15.2 Launchers. Each launcher (Figure 4-26 "Vertical Launching System Launcher"⇒) consists of 8-cell modules, six each for the Mk 158 Mod 0 Launcher and two each for the Mk 159 Mod 0 Launcher, an 8-cell system module, and a 5-cell strike down module.

4.15.2.1 8-Cell Module. Each 8-cell module consists of the following:

a. An upright structure to provide vertical storage space for eight missile canisters.

b. A deck to protect the canisters during stowage with a hatch assembly that opens to permit missile launch.

c. A plenum and uptake assembly to capture and vent exhaust gases to the atmosphere.

d. Electronic equipment to monitor stored missile canisters and module components and to assist in launching missiles.

4.15.2.2 8-Cell System Module. The 8-cell system module is like the 8-cell module except that equipment is added to serve the entire launcher. The 8-cell system module receives and distributes power and control signals from outside the launcher to all modules and collects control and damage control signals from all modules and sends them outside the launcher.

4.15.2.3 5-Cell Strikedown Module. The 5-cell strikedown module replaces three cells with a crane on an elevator, both hydraulically operated. The crane is used for maintenance, loading STANDARD Missile-2 BLK II and VLA canisters, removing empty canisters and reconfiguring cells. The crane is stowed inside the module when not in use.

4.15.3 Remote Launch Enable Panel (RLEP). The RLEP (Figure 4-27 "Remote Launch Enable Panel (RLEP)"⇒), located in the Combat Information Center (CIC), interfaces directly with the status panel and is used to control Remote Launch Enable and Remote Magazine Power Enable signals when the status panel permits remote operation.

4.15.4 Status Panel. The status panel (Figure 4-28 "Status Panel"⇒) receives and displays module status and launcher hazard signals from sensors within the launcher, forwards such signals to the Central Control Station (CCS), and receives enable signals from the RLEP to enable launcher enable power and launch enable functions within the launcher when the CONTROL key-switch is set to REMOTE.

4.15.5 TOMAHAWK Weapon Control System (TWCS). The TWCS is a general purpose computer system that receives track and target data from weapon and sensor systems from own and other ships. Targets are selected by operators for engagement by the VLS. Missile select commands, target related data, and launch commands are transmitted to the VLS for launch control. The VLS provides the TWCS with missile inventory and equipment availability status. The TWCS is comprised of two functional groups: Track Control Group and Launch Control Group.

4.15.5.1 Track Control Group (TCG). The TCG performs targeting and track data processing, threat evaluation and weapon assignments using an Operator Interactive Display Terminal and TCG Preprocessor Control Center, Data Processor Control Center and Data Storage Control Center equipment.

4.15.5.2 Launch Control Group (LCG). The LCG receives engagement plans and launch orders from the TCG to prepare, control, evaluate and launch TCMs using Operator Interactive Display Terminals and LCG Data Processor Control Center and Data Storage Control Center equipment. The LCG also provides direct interface with LCU data processors.

4.16 ONLOAD, OFFLOAD AND CROSSDECK WEAPONS.

This paragraph provides general information regarding preparation for, and onload and offload of weapons as well as offload of a spent canister. Technical manual SW394-EE-PRO-010 contains the procedures for shore base personnel to prepare the weapon for onload and to perform weapon onload or offload. Technical manual SW394-AF-MMO-050 provides a detailed discussion of on board procedures for: preparing launchers and cells for onload and offload; securing weapons in launch cells; preparing weapons/canisters for offload; and activating launchers upon completion of operations.

4.16.1 Onload. Ship onload begins when the ship arrives at a designated shore activity to receive a complement of weapons. Wind and sea motion, which affect the ship's position and movement, are factors in determining the feasibility of loading operations. The shore base loading supervisor and the ship's commanding officer will determine if conditions are satisfactory prior to commencing onload. Prior to onload, launchers are neutralized and placed in the strikedown mode at the status panel. During onload, responsibility for operations is shared between the ship's commanding officer and the shore base loading supervisor. All actions involving ship system preparation are the responsibility of the ship's commanding officer. His permission is required prior to commencing loading operations. His designated representative is responsible for weapon handling operations and ensures that a weapon transfer inspection is conducted. Upon completion of ship preparation, responsibility for loading transfers to the shore base loading supervisor. The ship's crew conducts the final hookup and closeout of the launcher upon disconnect and removal of the loading equipment. The following paragraphs provide a general overview of procedures used during loading operations. For purposes of illustration, loading of a generic weapon into one launcher is discussed. For multiple loadings, the procedures are the same except that multiple actions may be occurring simultaneously to prepare launch cells and weapons. Additionally, loading equipment is moved from missile to missile until the full complement of weapons is aboard the ship. Similarly, post-loadout is accomplished on a cell by cell basis until full closeout is accomplished. Onload terminates when the ship has received its scheduled complement, final hookup has been accomplished, all loading equipment has been removed, cell hatches are closed and secured, and ship system equipment has been activated.

4.16.1.1 Prepare Launcher. Launcher preparations include preparing below-deck and above-deck areas for loading. The launcher entry procedure takes the launcher offline, puts the launcher in strikedown, ensures power is available to strikedown controls, and, if required, performs launcher blowout to ensure residual launch gases are not present in the plenum area. In addition, the launcher crew performs the prior-to-use inspection of torque tools to be used to undog and dog the dogdown latches. The above-deck preparations include positioning required handling equipment and ensuring the area is free of unnecessary equipment.

4.16.1.2 Prepare Cell. Cell preparation may include the requirement to transfer weapons between cells prior to commencing onload of new weapons. This may be necessitated by the need for certain missiles to be located in certain cells for accessibility to telemetry connections or the Critical Function Interrupt Switch. Transfer of missiles between cells may involve removal and/or installation of sill assemblies, canister adapters and plenum cell covers. Exact requirements for tasks to be performed are dictated by the types of missiles to be transferred between cells.

4.16.1.3 Prepare Weapon. As the launchers and cells are being prepared for onload, shore base personnel prepare the weapon for loading. If using a Mk 3 Horizontal Strongback, the strongback is installed and secured to the canister. A crane hook is attached to the strongback lifting shackle, and the canister is raised to remove the packaging, handling, storage, and transport (PHS&T) equipment (Figure 4-29 "Mk 14 VLS Canister PHS&T Equipment"⇒) from the canister. If a forklift is used, the fork tines are inserted into the canister forklift channels, the canister is raised and all PHS&T equipment except the forklift channels are removed. FWD and AFT protective covers are removed. The canister is then moved to, and secured on, the Tilt Fixture, Mk 23 Mod 0 with Kit A (Figure 4-30 "Secure Canister to Mk 23 Tilt Fixture"⇒) in the horizontal position. The strongback or forklift and forklift channels are removed.

4.16.1.4 Load Weapon. The Mk 4 Vertical Strongback is installed on the FWD canister lifting lugs. Pins securing the canister in the horizontal position are removed and the canister is raised to the vertical position (Figure 4-31 "Upright Mk 14 VLS Canister to Vertical Position"⇒). Pins securing the canister to the tilt fixture are removed and the canister is raised and positioned over the launch cell. The canister is oriented so that the umbilical connector will be on the walkway side of the canister when installed in the launch cell. The canister is slowly lowered into the launch cell until the bottom of the canister contacts the sill assembly. The strongback is removed from the canister and lowered to the pier. The canister is secured in the cell and connected to the electronic circuitry of the VLS and the deluge system.

4.16.1.5 Post-Loadout. Post-loadout is the reactivation of the launcher. This process brings the launcher back on line and able to launch missiles. It includes returning power to the launch sequencer and taking the launcher out of strikedown mode at the status panel.

4.16.2 Offload. Ship offload begins when the ship arrives at a designated shore base activity to discharge a complement of weapons or expended canisters. Wind and sea motion, which affect the ship's position and movement, are factors in determining the feasibility of offloading operations. The shore base loading supervisor and the ship's commanding officer will determine if conditions are satisfactory prior to commencing offload. Prior to offload, launchers are neutralized and placed in the strikedown mode at the status panel. During offload, responsibility for operations is shared between the ship's commanding officer and the shore base loading supervisor. All actions involving ship system and weapon preparation are the responsibility of the ship's commanding officer. His permission is required prior to commencing offloading operations. His designated representative is responsible for weapon handling operations and ensures that a weapon transfer inspection is conducted. Upon completion of ship and weapon preparation, responsibility for offload transfers to the shore base loading supervisor. The following paragraphs provide a general overview of procedures used during offload operations. For purposes of illustration, offloading of a generic weapon from one launch cell is discussed. For multiple offloads, the procedures are the same except that multiple actions may be occurring simultaneously to prepare launch cells and weapons. Additionally, loading equipment is moved from missile to missile until the full complement of weapons is offloaded from the ship. Similarly, post-offload procedures are accomplished on a cell by cell basis until full closeout is accomplished. Offload terminates when all weapons scheduled for offload have been removed from the ship.

4.16.2.1 Prepare Launcher. Launcher preparations include preparing below-deck and above-deck areas for offload. The launcher entry procedure takes the launcher offline, puts the launcher in strikedown, ensures power is available to strikedown controls, and, if required, performs launcher blowout to ensure residual launch gases are not present in the plenum area. In addition, the launcher crew performs the prior-to-use inspection of torque tools to be used to undog and dog the dogdown latches. The above-deck preparations include positioning required handling equipment and ensuring the area is free of unnecessary equipment.

4.16.2.2 Prepare Crane. If the offload involves expended Mk 14 Canisters, the shipboard strikedown crane may be utilized for offload. Preparation of the crane includes bringing the crane up to the 01 level and preparing it for operation.

4.16.2.3 Remove Weapon. The weapon is disconnected from all VLS electrical circuitry and the deluge system. Additionally, all devices securing the canister in the cell are removed. The

Mk 4 Vertical Strongback is installed on the FWD canister lifting lugs. The canister is slowly extracted from the launch cell and swung outboard to the pier. The canister is oriented so that the canister bottom faces the Tilt Fixture, Mk 23 Mod 0 with Kit A, FWD rest. The canister is lowered to and locked on the tilt fixture. The canister is lowered to the horizontal position and the Mk 4 Strongback is removed. The Mk 3 Horizontal Strongback or forklift channels/forklift are installed, the canister is removed from the tilt fixture and PHS&T equipment is installed.

4.16.3 Crossdeck Weapons. Crossdecking of weapons is performed similar to onload and offload except weapons may be transferred from one launcher to another aboard the same ship or between different ships without lowering the weapon to the pier into the Mk 23 Tilt Fixture. Crossdecking is accomplished using the Mk 4 Vertical Strongback and crane hook arrangement to extract, transfer and insert weapons between launch cells.

4.17 OPERATIONAL CONSTRAINTS/RESTRICTIONS.

Tactical employment of the TCM imposes a number of constraints on the operating parameters of the ship. The constraints imposed during tactical launch operations of the TOMAHAWK Cruise Missile are provided in applicable tactical publications. Employment also places restrictions on the ship's tactical flexibility which are described in Operating Guidelines, tactical employment manuals and operation manuals.

4.17.1 Weapon Mix. Weapon mix will depend on the particular conditions that exist at the time the decision is made to prepare weapons for launch. The TWCS is capable of processing a combination of TOMAHAWK Cruise Missile variants. Other weapons control systems are used to launch STANDARD missiles and VLA. Prime consideration for selecting a specific weapon for launch should be the time required to prepare and launch a single TCM. Additionally, the VLS will neither select a TCM in a module with a launch in progress nor suspend a launch in progress in order to support a TCM launch.

4.17.2 Weapon Availability. Various factors are used by the VLS to verify that a particular TCM is available for selection. These factors summarize missile, cell and module status conditions. A particular missile is available for selection if no availability factor applies. If any factor does apply, the missile may still be available if the factor can be overridden. Table 4-1 "Missile Availability Factors"⇒ identifies availability factors and the capability for override.

4.18 LAND-ATTACK TCM OPERATIONAL SEQUENCE.

This paragraph describes typical actions and responses required to launch a land-attack TCM. Primary coverage is given to normal launch of a single weapon. For multiple launch, the operational steps for a single launch are sequentially accomplished for each weapon selected for launch. Abnormal launch conditions and abort procedures are discussed by highlighting only those events that differ from a normal launch. Typical launch operations are shown in Figure 4-32 "RGM-109-4 Land-Attack TCM Operational Sequence (15 Sheets)"⇒. The figure illustrates the orders given by the ship's commanding officer, typical actions taken by equipment operators and typical equipment operations, status displays and machine decisions. The operational sequence is described in the following paragraphs. For a full discussion of operating procedures, as well as actions to be taken under abnormal conditions, refer to SW261-DE-MMO-030.

4.18.1 Prelaunch Reprogramming. Before Intent to Launch is signalled, the TWCS can identify and reprogram land-attack Block III TCMs. During the reprogramming process, TWCS issues a READY ALERT request to the VLS, issues a non-launch select order, and applies power to the missile in the selected cell. The TWCS downloads mission information and updates DSMAC and GPSS Flight Software. When download is complete, the missile is deselected, power is removed and the TWCS orders the VLS to STANDBY.

4.18.2 Missile Selection. Missile selection is controlled by the MISSILE SELECT ORDER issued by the TWCS. The TWCS may select a specific missile by launcher, module and cell (WCS MISSILE SELECTOR ORDER) or the TWCS may designate a type missile and allow the VLS to select the specific TCM to be launched (VLS MISSILE SELECT ORDER). Upon receipt of the VLS MISSILE SELECT ORDER, the VLS selects the cell to be used for launch based on the following:

a. The cell selected must have the least number of launches of those TCMs available.

b. The TCM must be in a module or half-module which contains the most available TCMs with no TCM launch that has progressed beyond rocket motor arming.

c. If all modules or half-modules have the same number of TCMs available that satisfy a and b above, the module or half-module with the lowest designation number is selected. If the same number module in both forward and aft launchers can meet the criteria, the forward magazine is selected.

4.18.3 Cell Selection. When the MISSILE SELECT ORDER is received by the launch control unit (LCU), the LCU determines if the ordered TCM is available, confirms missile identification, and sends cell identification, position and alignment data to the TWCS. The LCU also sends a cell select message to the launch sequencer (LSEQ) and starts a 650-ms timer.

4.18.4 Cell/Missile Preparation. Upon receipt of the cell select order, the LSEQ begins to prepare the cell and the missile for launch. The LSEQ performs a status check to verify missile selection as well as warhead and rocket motor safed. If missile selection is not verified or warhead and/or rocket motor safe indications are not received, the LSEQ takes no further action until the LCU completes evaluation of the failure. With missile selection and warhead and rocket motor safed verified, the LSEQ applies OPERATE POWER, and, if applicable, REM HEATER POWER to the missile and starts a 400-ms timer. At the end of 400-ms delay, the LSEQ sends a select response message to the LCU confirming the type missile and warhead selected. The LSEQ continuously monitors missile functions and sends a failure message to the LCU if monitor functions change to an improper condition.

4.18.5 Select Response Evaluation. If the LCU receives the select response message prior to the end of the 650-ms delay, the LCU starts an 80 second clock and updates the missile availability file. This delay is used to ensure that the TWCS remains in communication with the LCU throughout the launch sequence. The 80 second delay is reset each time a valid message pertaining to the selected missile is received from the TWCS. If 80 seconds pass without receiving a message, the LCU sends an equipment failure status message and commences the cell safing procedure.

4.18.6 Mission Assignment. The appropriate mission disk pack is removed from secure storage and mounted on the random access storage set (RASS). The disk pack serial number is entered and the RASS initialized. With RASS initialized, the TWCS is ready to transmit missile and alignment data messages to the missile via the LCU. THEATER, MPS, MISSION and VERIFY codes are received from the appropriate authority and entered. Mission data are then indicated and transferred to the central computer resident memory. The operator enters the target number and the pre-established waypoints to that target are displayed. The operator reviews the mission data and approximate flight path to the target and makes route alterations by introducing or deleting waypoints. The operator then assigns the mission to the designated cell and a verification that the mission is assigned to the correct cell is performed. Once a mission has been assigned, no further modifications can be made without resetting the mission and then reentering the mission number and verification code.

4.18.6.1 CMGS alignment begins automatically upon completion of a successful upload of the Operational Flight Program (OFP). Alignment data are repeatedly sent about each second during the prelaunch stage. A two-position alignment technique eliminates the need to perform maneuvers at latitudes below 75°. Launches at latitudes above 75°, however, require maneuvers to meet the alignment timeline. Upon completion of alignment, the CMGS provides an ALIGNMENT COMPLETE message.

4.18.6.2 If CMGS computer built-in test (BIT) is not passed, or valid communications can not be established or becomes lost with the CMGS computer, an alert message is provided. To establish or restore communications, a controlled shutdown of the CMGS is performed and missile electrical power recycled. The normal start-up sequence is then repeated and program load reattempted. When program load is accomplished, the reprogram command is sent to the CMGS.

4.18.7 Rocket Motor Arm. When all data has been loaded into the CMGS, the TWCS orders BOOSTER ARM via the LCU to the LSEQ. When this order is received by the LCU, the LCU dedicates the half-module containing the selected missile to a TOMAHAWK launch and activates the circuits necessary for launch. The LSEQ removes REM power, if applied, and prepares the cell for firing. The cell and uptake hatches are opened and the plenum drain closed. The rocket motor is then armed.

4.18.8 Missile Activation. After receiving the missile/module ready status message from the LCU, the TWCS issues a MISSILE FIRE ORDER to the LCU. Upon receipt of this order, the LCU issues a BATTERY ACTIVATE command to the TCM which causes the CMGS to terminate alignment and activates missile batteries. When the batteries are fully operational, the TCM sends a MISSILE ENABLE signal to the LSEQ. The LSEQ removes power to the TCM and reports the missile enabled. The LCU sends a launch status message to the TWCS to report MISSILE ENABLED. If the launch sequence is stopped after battery activation, the missile is dudded and cannot be recycled for firing.

4.18.9 Rocket Motor Ignition and Missile Release. After receiving MISSILE ENABLED, the TWCS send a BOOSTER IGNITION order to the LCU. Upon receipt of this order, the LCU checks the status of current launches and waits until launch rate and priority requirements are met before issuing the IGNITION command to the LSEQ. The LSEQ applies booster ignition voltages to the TCM causing the rocket motor to ignite. After rocket motor ignition and receipt of the CLOSURE RUPTURE signal indicating the aft closure plate has been blown open, the LSEQ applies power to detonate the explosive restraining bolts allowing release of the TCM. When the canister forward closure is broken, the breakwire opens to send a MISSILE AWAY signal to the LSEQ which, in turn, notifies the LCU of missile away.

4.18.10 Cell Safing. The cell safing sequence may begin at any time when an unsafe condition is monitored, a launch sequence is terminated (ABORT command issued), interrupted (SAFE command issued by the TWCS), or when a MISSILE AWAY signal is not sent (missile misfire or restrained fire). During this sequence, the SAFE MISSILE command is sent, relays open to disconnect power and data lines to the cell. In the case of a restrained fire, the deluge system is activated. If missile batteries were activated prior to an unsuccessful firing attempt, missile inventory is updated to reflect the unavailability of that TCM for launch. If batteries were not activated, the TCM is placed in a 30-minute cool down period prior to being made available for future launch.

4.19 POST-LAUNCH.

When the LSEQ receives the MISSILE AWAY signal, the LSEQ disconnects prelaunch cell power and signals from the cell and cancels the missile/cell selection. After a delay to allow the missile and exhaust gases to clear the launcher, cell and uptake hatches are closed.. The LCU evaluates the launch and updates missile inventory and cell firing count to reflect the change in status brought about by the launch.

4.20 LAND-ATTACK TCM CASUALTY MODE.

There is no casualty mode for land-attack TCM variants.

Figure 4-1. General Locations of SSN Complexes

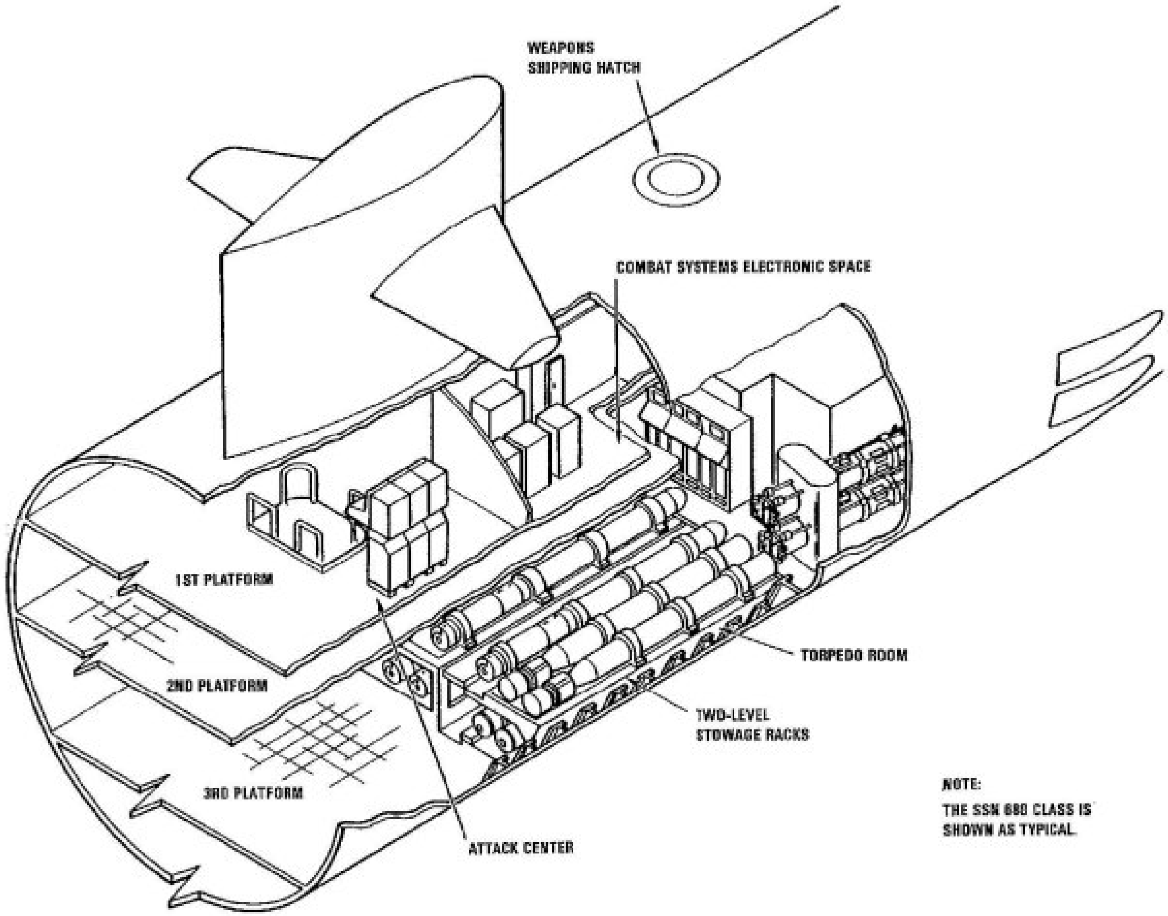


Figure 4-2. SSN/TWS-related Equipment TTL Interfaces

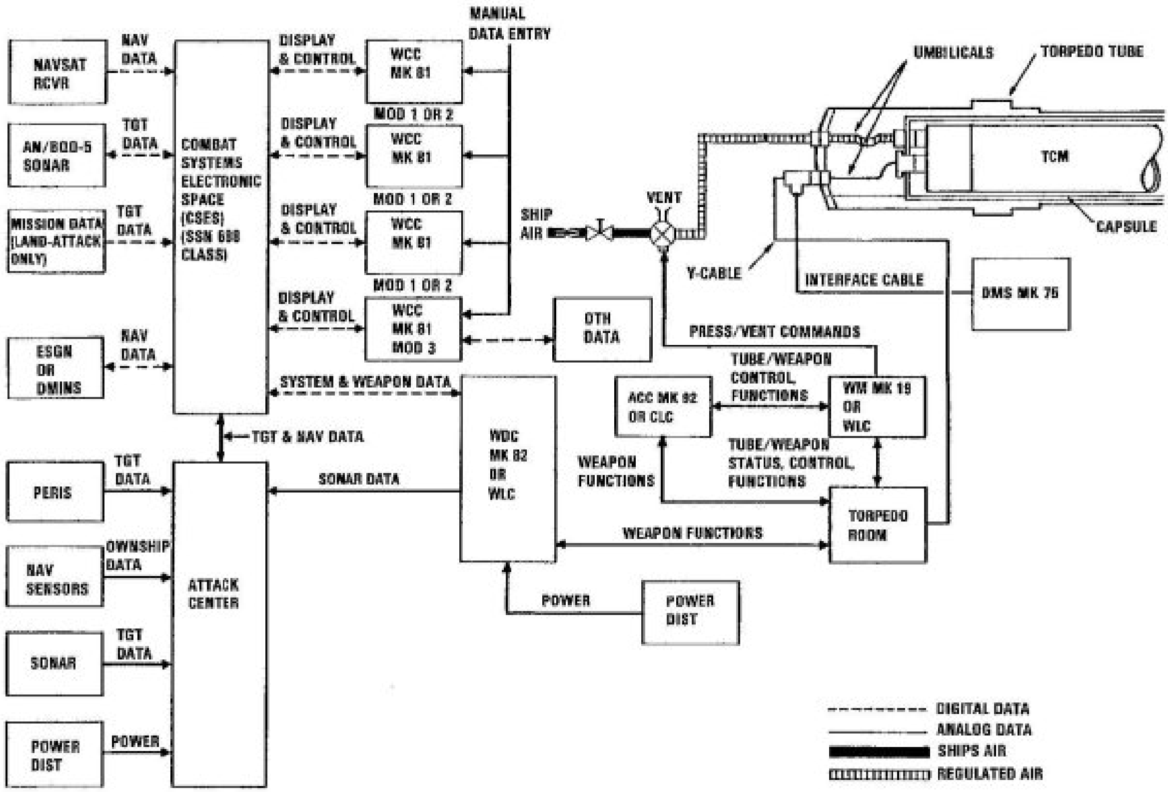


Figure 4-3. SSN TTL Pressurization/Vent Control System

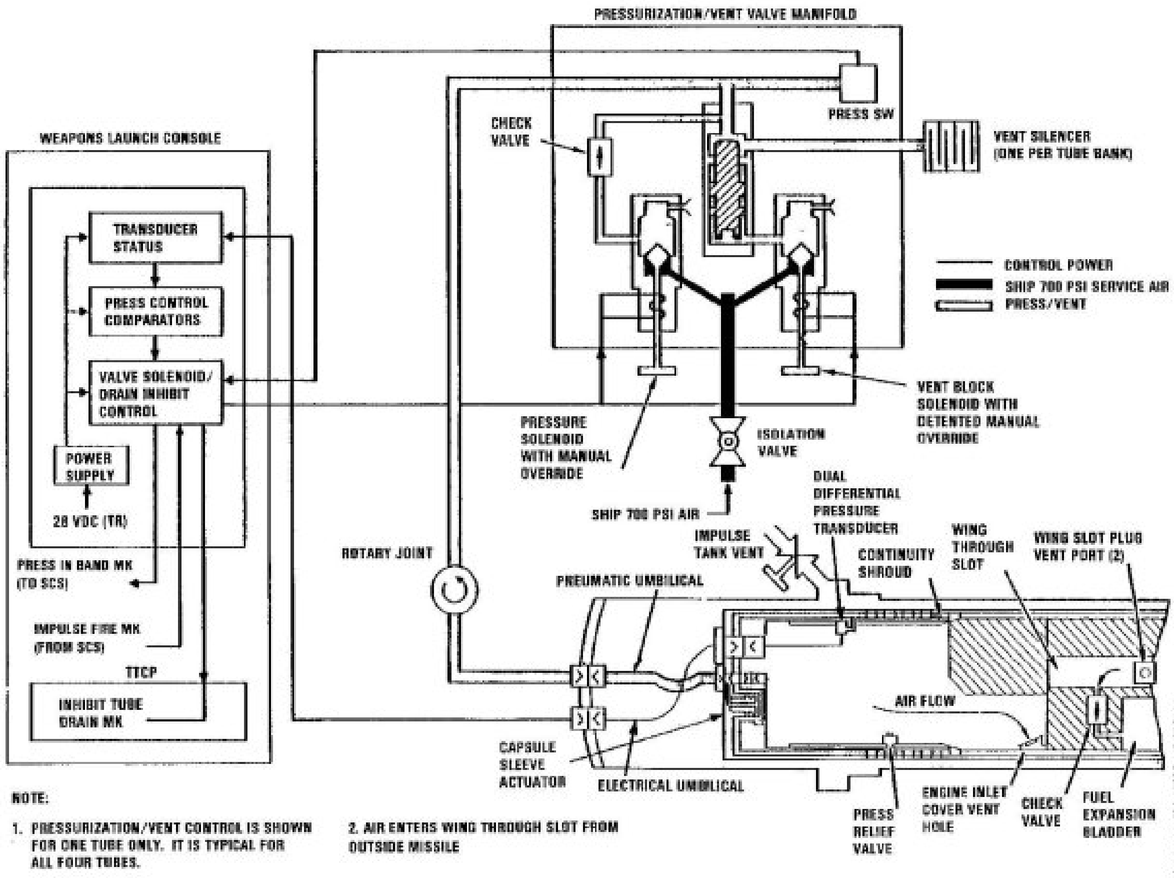


Figure 4-4. MTEL Work Platforms

Figure 4-5. TTL Weapon Shipping, Handling and Stowage Equipment (SSN 688 Class)

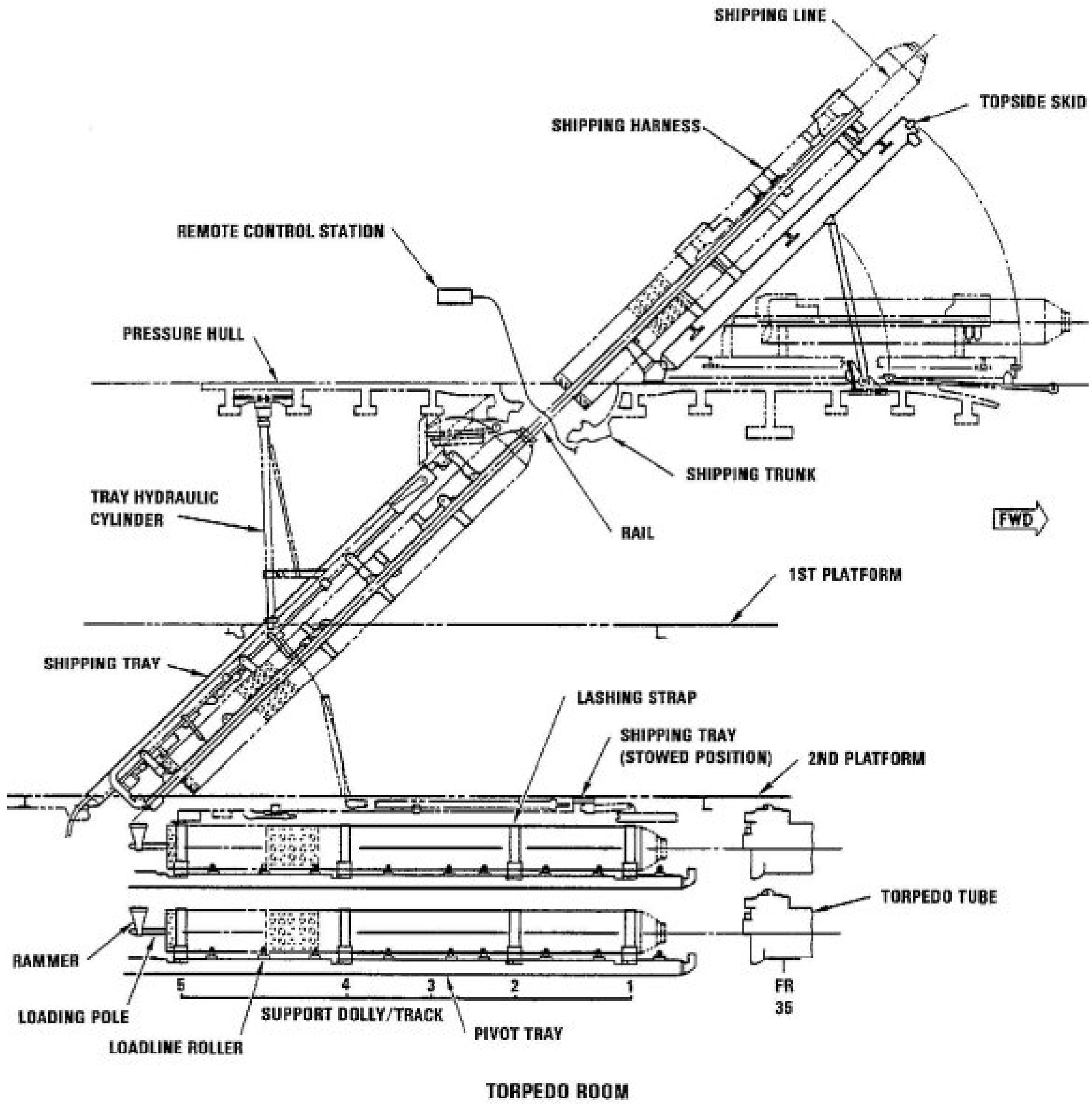
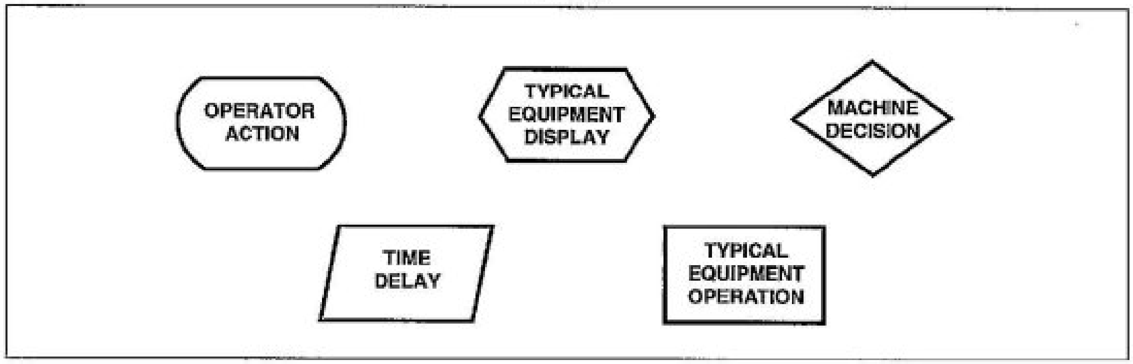


Figure 4-6. UGM-109-1 Land-Attack TCM Operational Sequence (7 Sheets)

LEGEND



INITIAL CONDITIONS

1. SUBMARINE COMBAT SYSTEM (CCS OR CC/A) POWERED UP
2. PVC SYSTEM OFF.

NOTES

1. RECYCLE AND ABORT LAUNCH ARE PERFORMED IN ACCORDANCE WITH NAVSEA OD 44979.

2. EVENTS WITH AN ASTERISK DENOTE REM OPERATIONS. FOR LAUNCHES WITHOUT REM, THE EVENT IS DELETED.

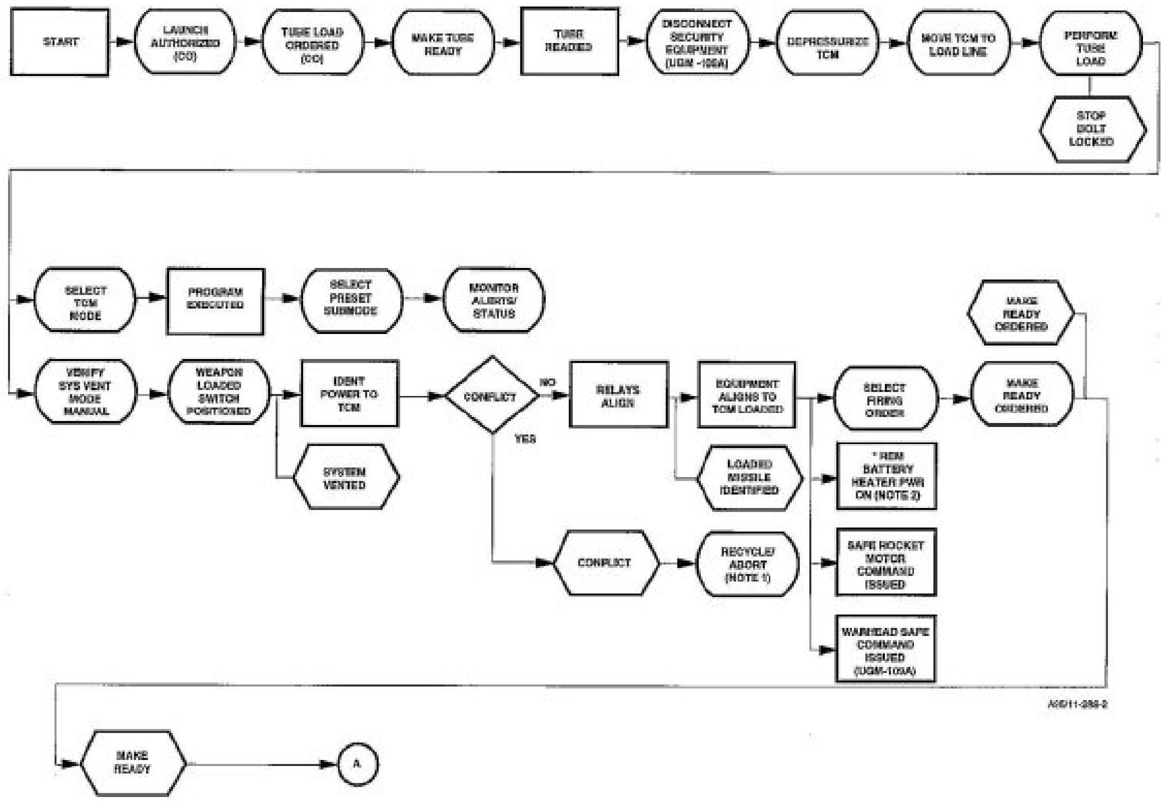
3. UGM -109A ONLY – THE MISSILE POWER MONITOR RELAY APPLIES WARHEAD SAFE COMMAND WHEN DEENERGIZED AND TUBE IS SELECTED. THE WARHEAD SAFE COMMAND IS REMOVED WHEN THE MISSILE AC-DC CONVERTER ACTIVATES AND THE MISSILE POWER MONITOR RELAY ENERGIZES. IF MISSILE VOLTAGE DROPS TO A SPECIFIED LEVEL DUE TO MISSILE POWER FAILURE, THE MISSILE POWER MONITOR RELAY WILL DEENERGIZE AND AUTO SAFE THE SELECTED TUBE.

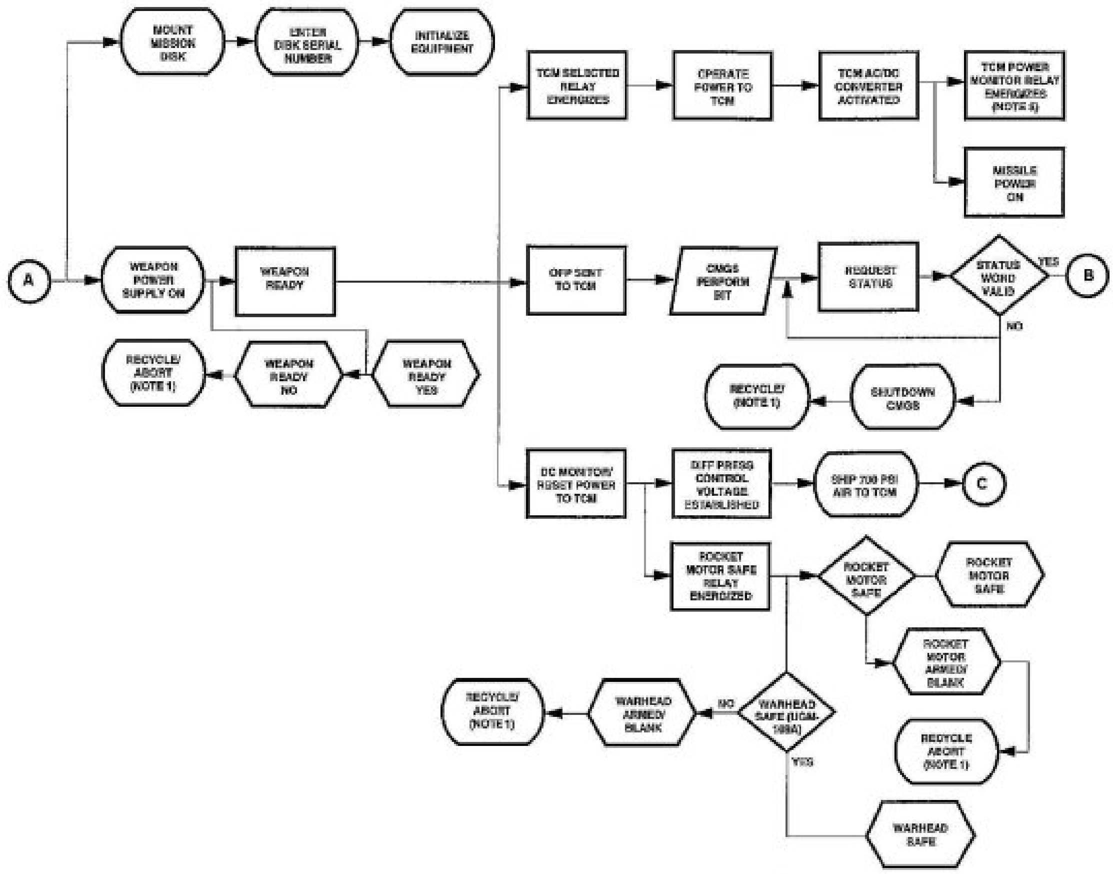
4. UGM -109A ONLY – RECYCLE THE WARHEAD SAFE–ARM SWITCH TO SAFE. IF SAFE INDICATION EXISTS, PLACE SAFE–ARM SWITCH TO ARM AND PROCEED WITH LAUNCH. IF NO INDICATION PERSISTS, INITIATE SECURE TUBE PROCEDURES AND ABORT LAUNCH.

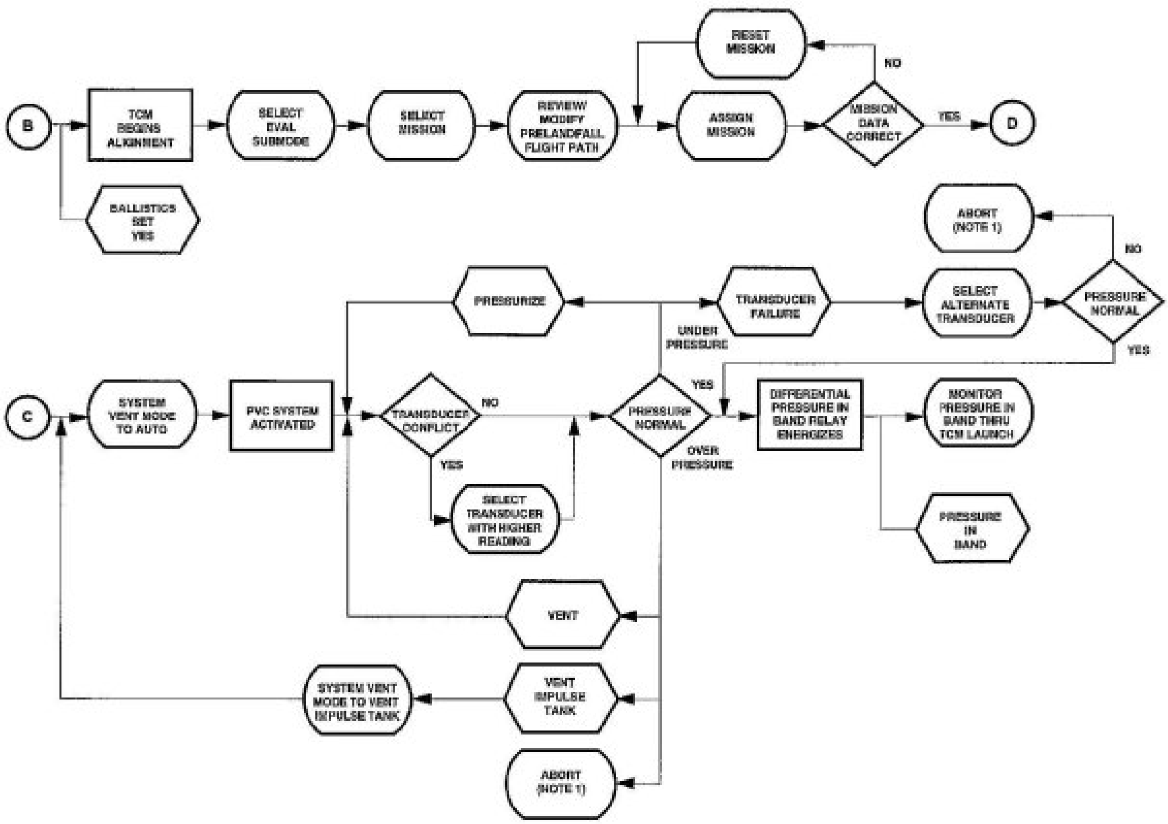
5. UGM -109A ONLY – IN THE EVENT OF TUBE RECTIFIER FAILURE, POWER IS AVAILABLE THROUGH TORPEDO ROOM SWITCHING TO SAFE THE WARHEAD AND/OR ROCKET MOTOR (BOOSTER) FROM THE ALTERNATE TORPEDO TUBE RECTIFIER, I.E. RECTIFIER 1 CAN SUPPLY TUBE 1 OR TUBE 3 CIRCUITS AND RECTIFIER 3 CAN SUPPLY TUBE 3 OR TUBE 1 CIRCUITS. IDENTICAL CIRCUITRY SWITCHING IS AVAILABLE FOR THE PORT RECTIFIERS.

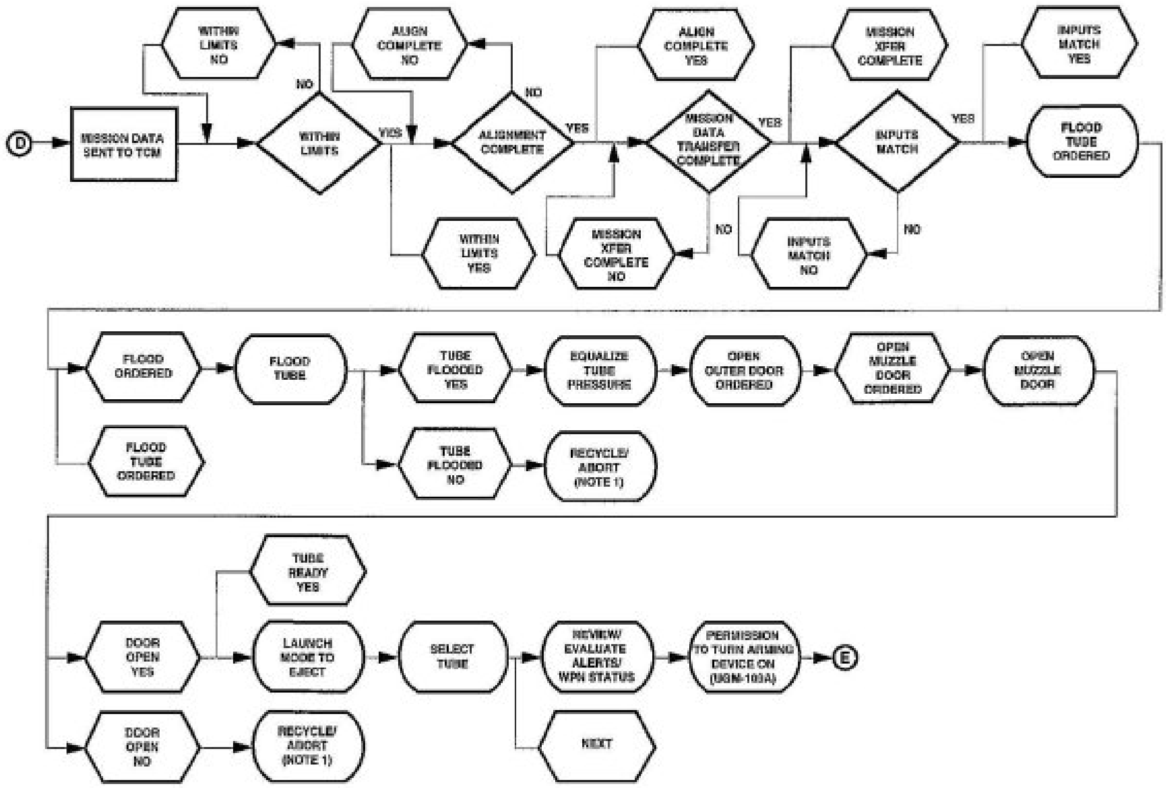
6. ONCE ITL HAS BEEN SENT, OPERATORS NO LONGER HAVE THE ABILITY TO INTERVENE IN LAUNCH, WITH THE EXCEPTION OF SENDING AN ABORT COMMAND. AN ABORT CAN BE ACCOMPLISHED ANY TIME UP UNTIL THE MISSILE ENABLED SIGNAL IS SENT. THIS OCCURS APPROXMATELY 7 SECONDS AFTER ITL FOR TACTICAL AND RSS VARIANTS AND 36 SECONDS FOR REM VARIANTS. ONCE BATTERIES HAVE BEEN ACTIVATED, THE MISSILE IS IRREVOCABLY DUDDED AND CANNOT BE RECYCLED FOR FIRING.

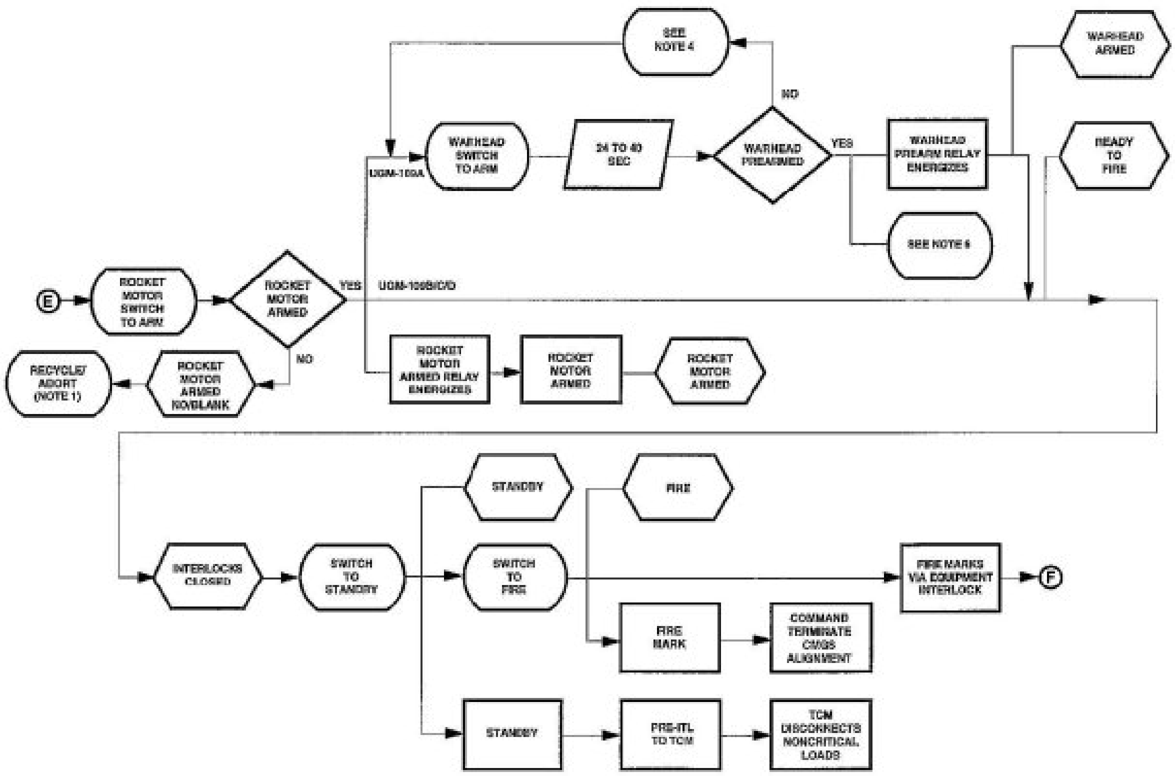
7. THE CAPSULE CAN BE EITHER IMPULSE EJECTED OR RETURNED TO TORPEDO ROOM RACKS AFTER MISSILE IS LAUNCHED.


START
LAUNCH AUTHORIZED (CO)
TUBE LOAD ORDERED (CO)
MAKE TUBE READY
TUBE READIED
DISCONNECT SECURITY EQUIPMENT (UGM -109A)
DEPRESSURIZE TCM
MOVE TCM TO LOAD LINE
PERFORM TUBE LOAD
STOP BOLT LOCKED
SELECT TCM MODE
PROGRAM EXECUTED
SELECT PRESET SUBMODE
MONITOR ALERTS/ STATUS
VERIFY SYS VENT MODE MANUAL
WEAPON LOADED SWITCH POSITIONED
SYSTEM VENTED
IDENT POWER TO TCM
CONFLICT
NO
YES
RELAYS ALIGN
EQUIPMENT ALIGNS TO TCM LOADED
LOADED MISSILE IDENTIFIED
CONFLICT
RECYCLE/ ABORT (NOTE 1)
SELECT FIRING ORDER
MAKE READY ORDERED
MAKE READY ORDERED
* REM BATTERY HEATER PWR ON (NOTE 2)
SAFE ROCKET MOTOR COMMAND ISSUED
WARHEAD SAFE COMMAND ISSUED (UGM-109A)
MAKE READY
A


A
MOUNT MISSION DISK
ENTER DISK SERIAL NUMBER
INITIALIZE EQUIPMENT
WEAPON POWER SUPPLY ON
WEAPON READY
RECYCLE/ ABORT (NOTE 1)
WEAPON READY NO
WEAPON READY YES
TCM SELECTED RELAY ENERGIZES
OPERATE POWER TO TCM
TCM AC/DC CONVERTER ACTIVATED
TCM POWER MONITOR RELAY ENERGIZES
MISSILE POWER ON
OFP SENT TO TCM
CMGS PERFORM BIT
REQUEST STATUS
STATUS WORD VALID
YES
B
NO
RECYCLE/ (NOTE 1)
SHUTDOWN CMGS
DC MONITOR/ RESET POWER TO TCM
DIFF PRESS CONTROL VOLTAGE ESTABLISHED
SHIP 700 PSI AIR TO TCM
C
ROCKET MOTOR SAFE RELAY ENERGIZED
ROCKET MOTOR SAFE
ROCKET MOTOR SAFE
ROCKET MOTOR ARMED/ BLANK
RECYCLE ABORT (NOTE 1)
RECYCLE/ ABORT (NOTE 1)
WARHEAD ARMED/ BLANK
NO
WARHEAD SAFE (UGM-109A)
YES
WARHEAD SAFE


B
TCM BEGINS ALIGNMENT
BALLISTICS SET YES
SELECT EVAL SUBMODE
SELECT MISSION
REVIEW MODIFY PRELANDFALL FLIGHT PATH
RESET MISSION
ASSIGN MISSION
MISSION DATA CORRECT
NO
YES
D
ABORT (NOTE 1)
NO
PRESSURIZE
TRANSDUCER FAILURE
SELECT ALTERNATE TRANSDUCER
PRESSURE NORMAL
YES
UNDER PRESSURE
C
SYSTEM VENT MODE TO AUTO
PVC SYSTEM ACTIVATED
TRANSDUCER CONFLICT
NO
YES
PRESSURE NORMAL
YES
OVER PRESSURE
DIFFERENTIAL PRESSURE IN BAND RELAY ENERGIZES
MONITOR PRESSURE IN BAND THRU TCM LAUNCH
SELECT TRANSDUCER WITH HIGHER READING
PRESSURE IN BAND
VENT
SYSTEM VENT MODE TO VENT IMPULSE TANK
VENT IMPULSE TANK
ABORT (NOTE 1)


D
MISSION DATA SENT TO TCM
WITHIN LIMITS NO
NO
WITHIN LIMITS
YES
WITHIN LIMITS YES
ALIGN COMPLETE NO
NO
ALIGNMENT COMPLETE
YES
ALIGN COMPLETE YES
MISSION DATA TRANSFER COMPLETE
YES
NO
MISSION XFER COMPLETE NO
MISSION XFER COMPLETE
INPUTS MATCH
YES
NO
INPUTS MATCH NO
INPUTS MATCH YES
FLOOD TUBE ORDERED
FLOOD ORDERED
FLOOD TUBE ORDERED
FLOOD TUBE
TUBE FLOODED YES
TUBE FLOODED NO
EQUALIZE TUBE PRESSURE
RECYCLE/ ABORT (NOTE 1)
OPEN OUTER DOOR ORDERED
OPEN MUZZLE DOOR ORDERED
OPEN MUZZLE DOOR
TUBE READY YES
DOOR OPEN YES
LAUNCH MODE TO EJECT
SELECT TUBE
REVIEW/ EVALUATE ALERTS/ WPN STATUS
PERMISSION TO TURN ARMING DEVICE ON (UGM-109A)
E
NEXT
DOOR OPEN NO
RECYCLE/ ABORT (NOTE 1)


E
ROCKET MOTOR SWITCH TO ARM
ROCKET MOTOR ARMED
YES
UGM-109B/C/D
NO
ROCKET MOTOR ARMED NO/BLANK
RECYCLE/ ABORT (NOTE 1)
UGM-109A
WARHEAD SWITCH TO ARM
24 TO 40 SEC
WARHEAD PREARMED
NO
SEE NOTE 4
YES
WARHEAD PREARM RELAY ENERGIZES
SEE NOTE 6
WARHEAD ARMED
READY TO FIRE
ROCKET MOTOR ARMED RELAY ENERGIZES
ROCKET MOTOR ARMED
ROCKET MOTOR ARMED
INTERLOCKS CLOSED
SWITCH TO STANDBY
STANDBY
SWITCH TO FIRE
FIRE
FIRE MARK
COMMAND TERMINATE CMGS ALIGNMENT
FIRE MARKS VIA EQUIPMENT INTERLOCK
F
STANDBY
PRE-ITL TO TCM
TCM DISCONNECTS NONCRITICAL LOADS

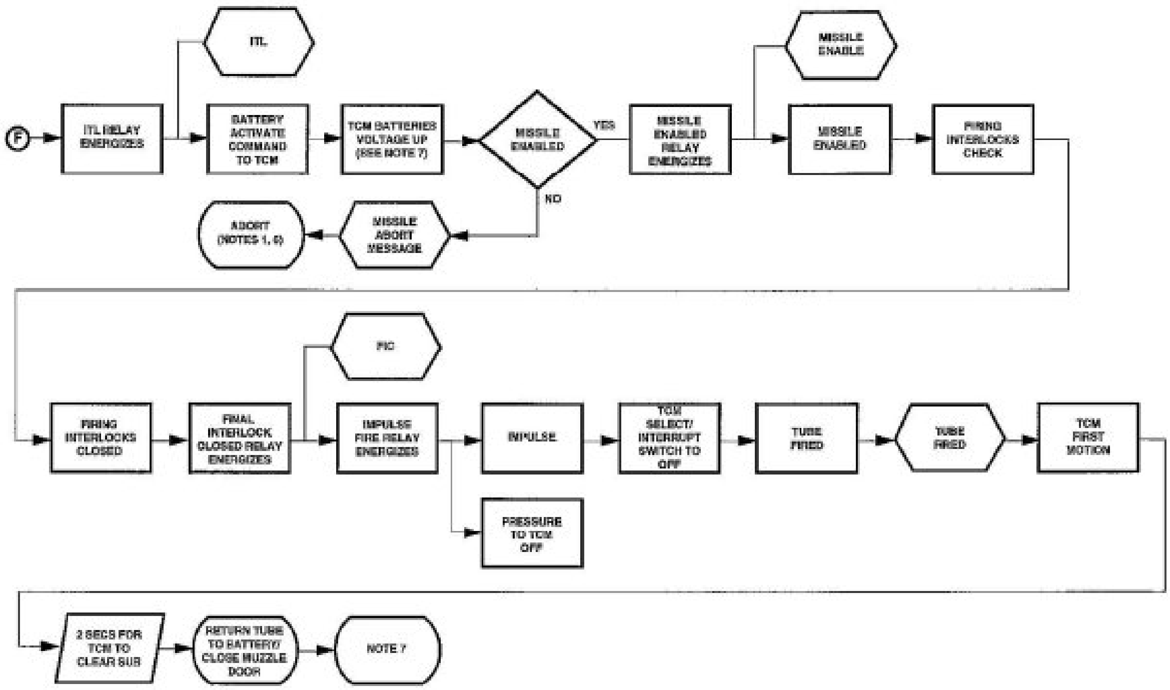

F
ITL RELAY ENERGIZES
ITL
BATTERY ACTIVATE COMMAND TO TCM
TCM BATTERIES VOLTAGE UP (SEE NOTE 7)
MISSILE ENABLED
YES
NO
MISSILE ENABLED RELAY ENERGIZES
MISSILE ENABLE
MISSILE ENABLED
FIRING INTERLOCKS CHECK
MISSILE ABORT MESSAGE
ABORT (NOTES 1, 6)
FIRING INTERLOCKS CLOSED
FINAL INTERLOCK CLOSED RELAY ENERGIZES
FIC
IMPULSE FIRE RELAY ENERGIZES
IMPULSE
PRESSURE TO TCM OFF
TCM SELECT/ INTERRUPT SWITCH TO OFF
TUBE FIRED
TUBE FIRED
TCM FIRST MOTION
2 SECS FOR TCM TO CLEAR SUB
RETURN TUBE TO BATTERY/ CLOSE MUZZLE DOOR
NOTE 7

Figure 4-7. MTEL With MTEL Adapter Installed

Figure 4-8. General Locations of SSN 688 Class Submarine Complexes

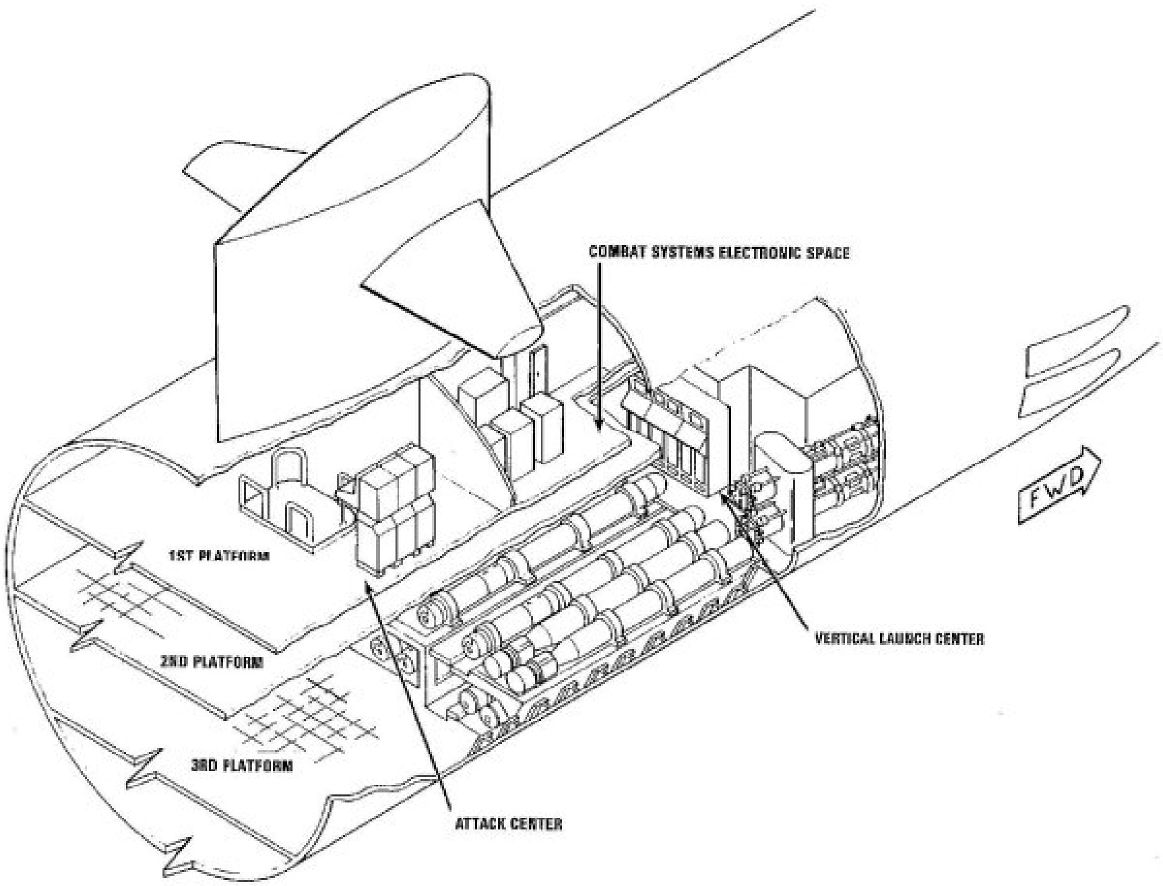
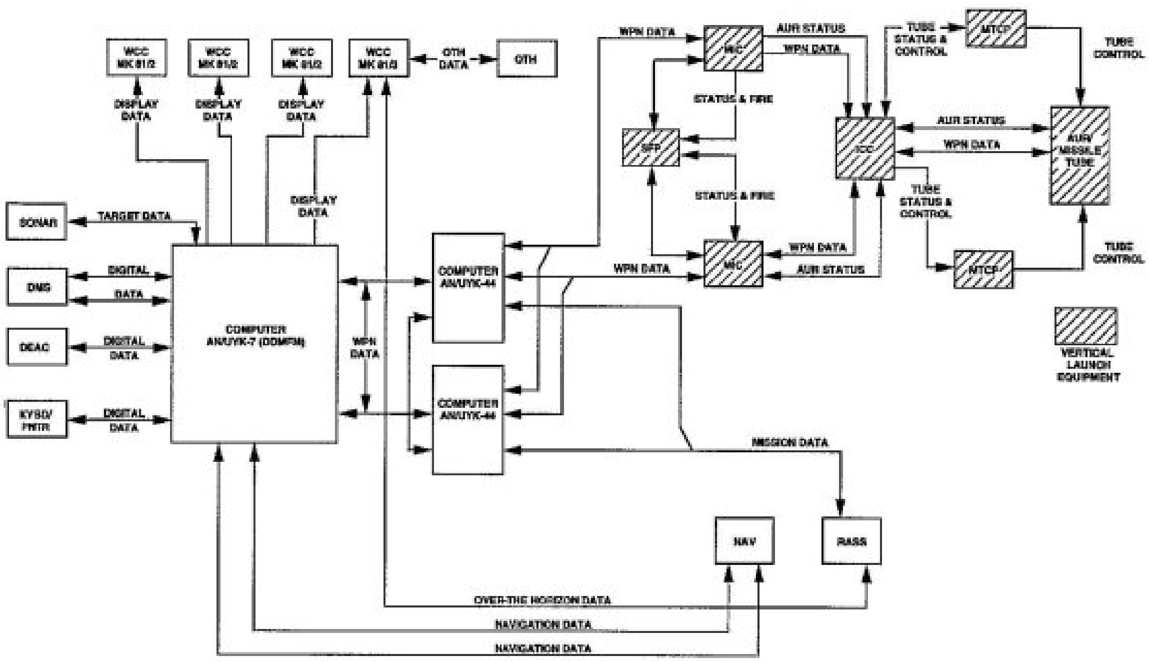
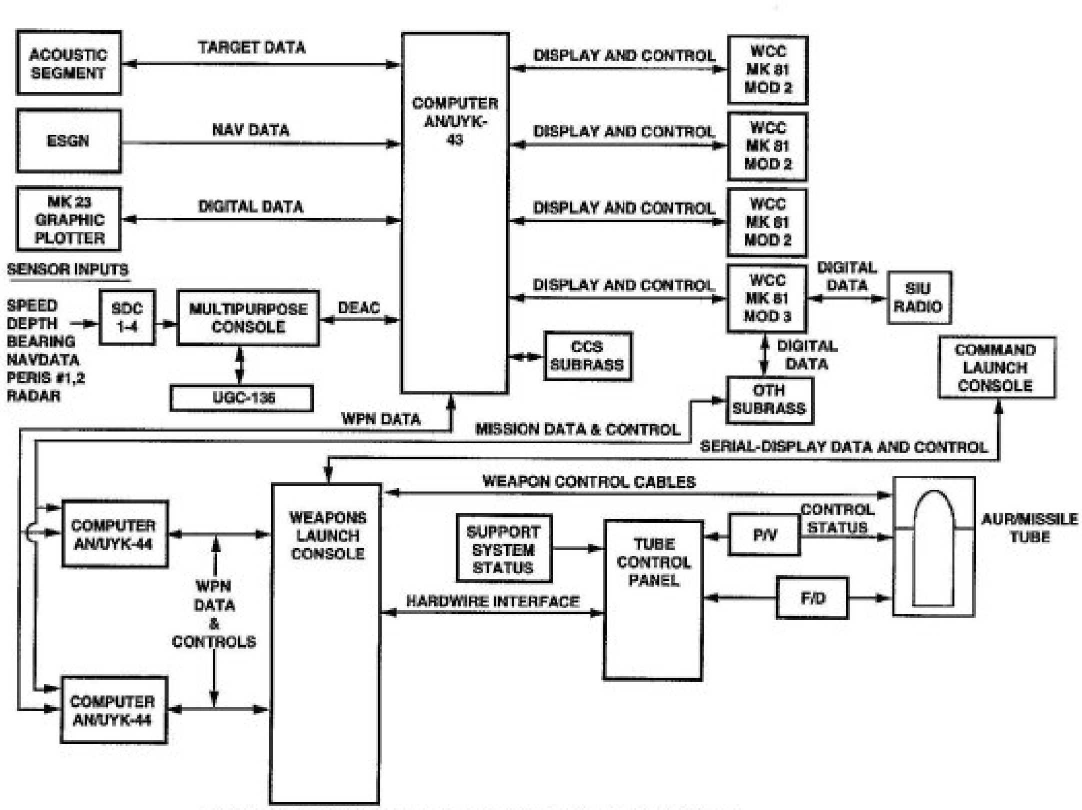


Figure 4-9. SSN 688 Class Submarine TWS-related Equipment Interfaces (2 Sheets)



COMBAT CONTROL SYSTEM MK 1



COMBAT CONTROL/ACOUSTIC AN/BSY-1

Figure 4-10. SSN 688 Class Submarine Missile Tube Assembly

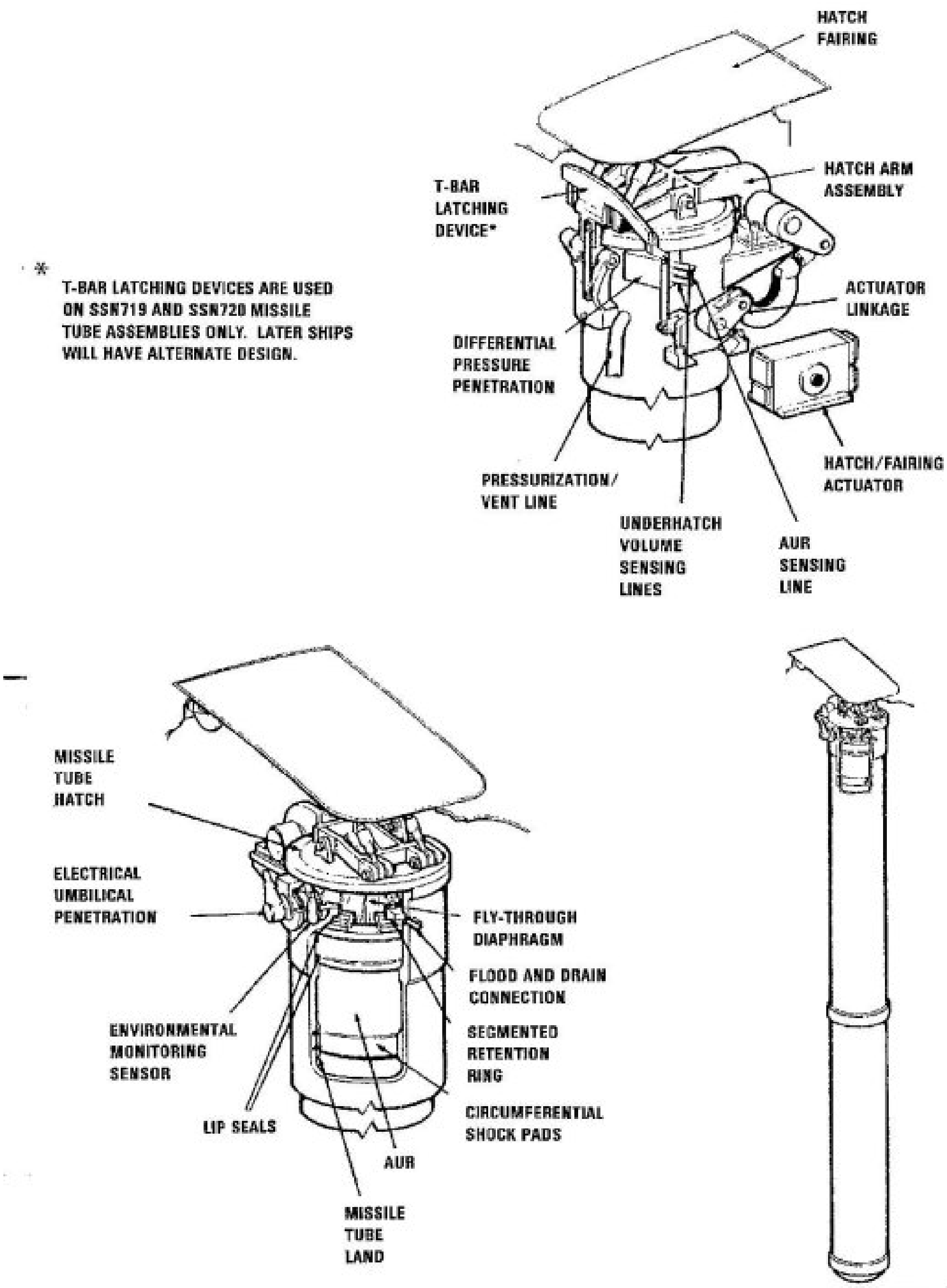
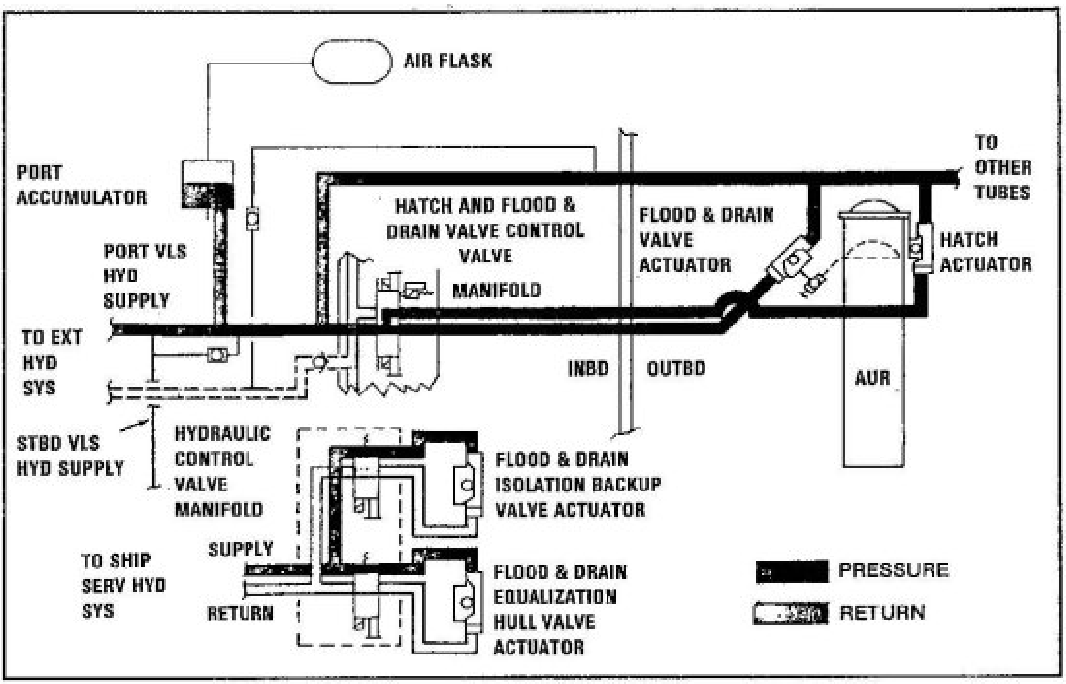


Figure 4-11. SSN 688 Class Submarine Hydraulic System



READY TO LAUNCH HATCH OPEN

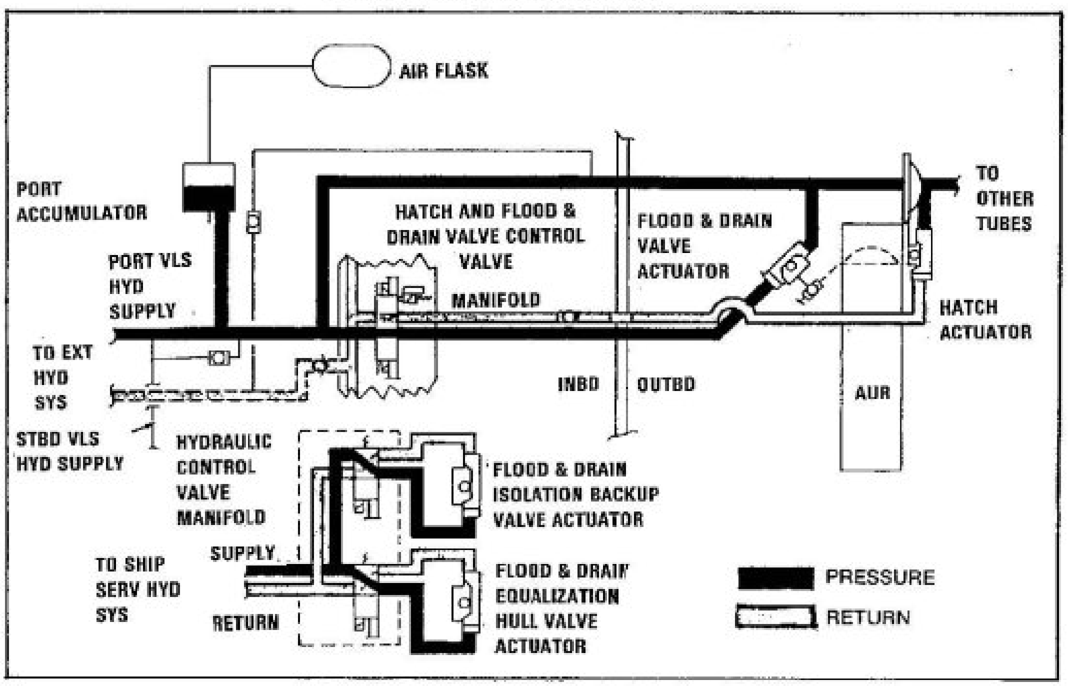


Figure 4-12. SSN 688 Class Submarine Pressurization/Vent System

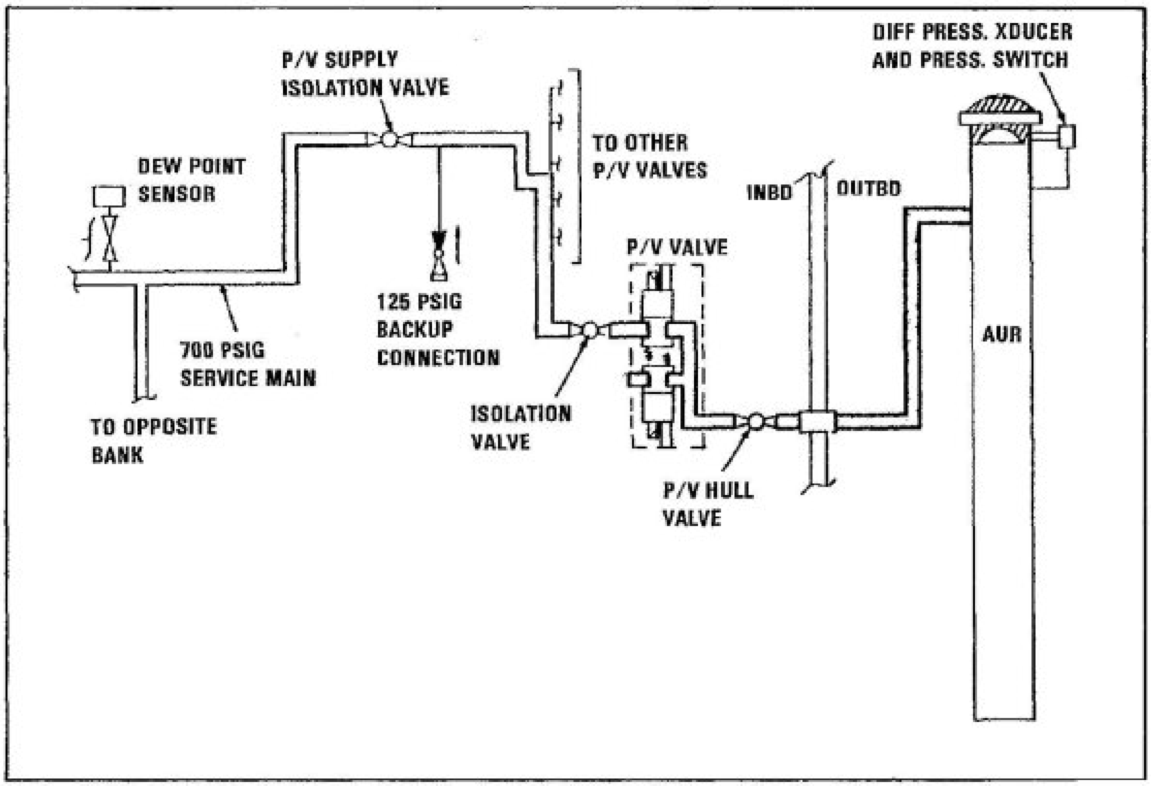


Figure 4-13. SSN 688 Class Submarine Flood and Drain System

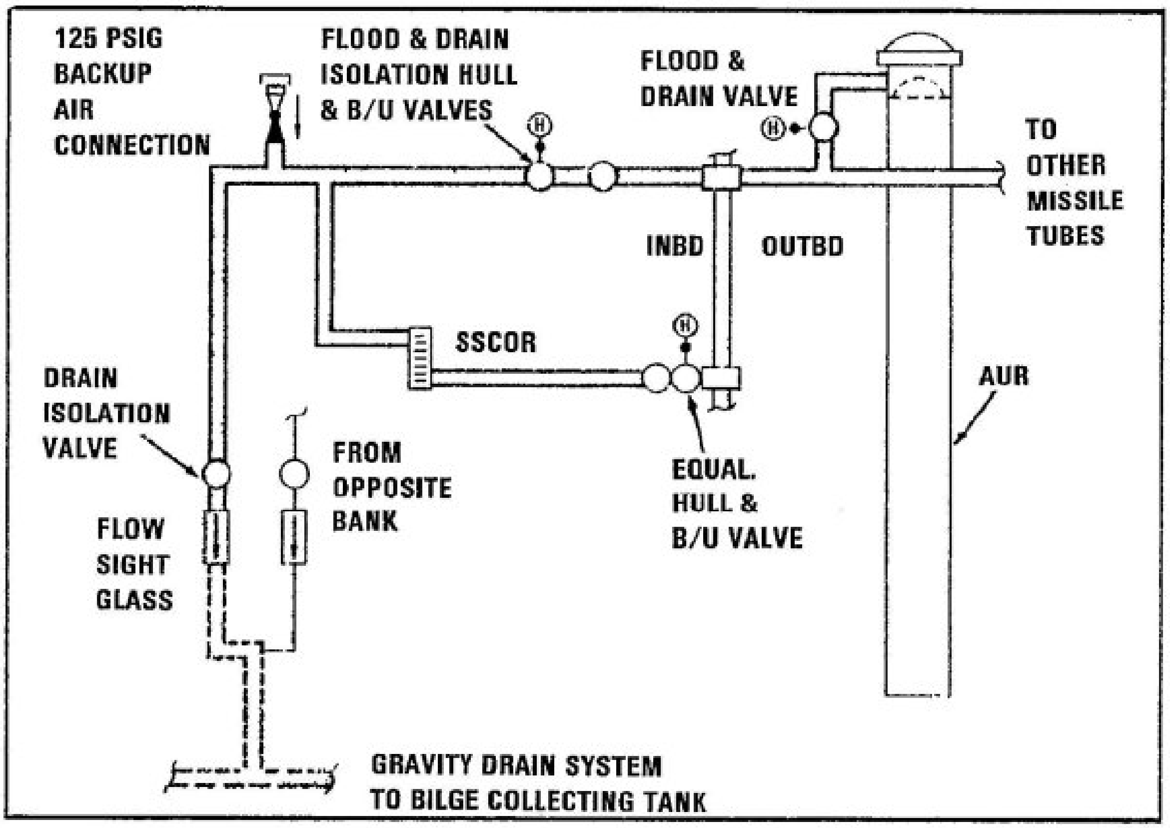


Figure 4-14. SSN 688 Class Submarine Missile Tube Control System

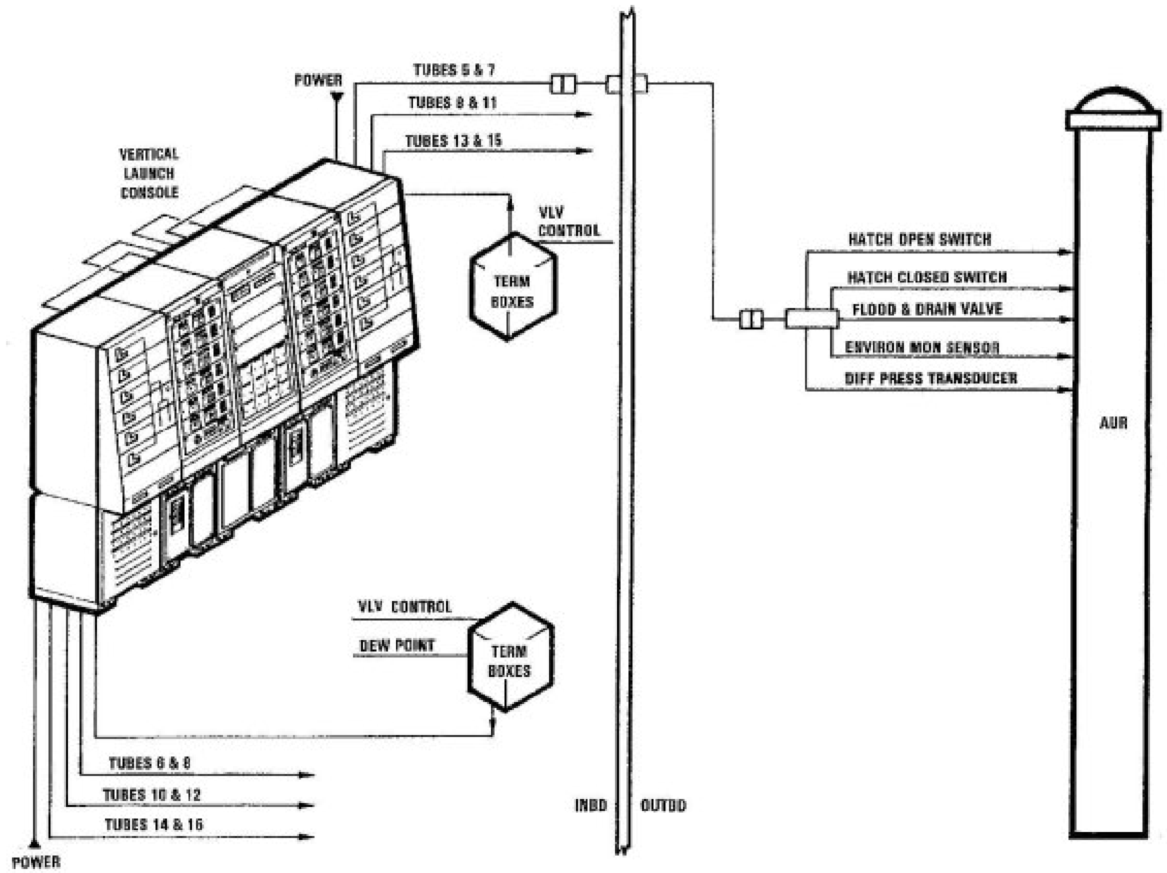
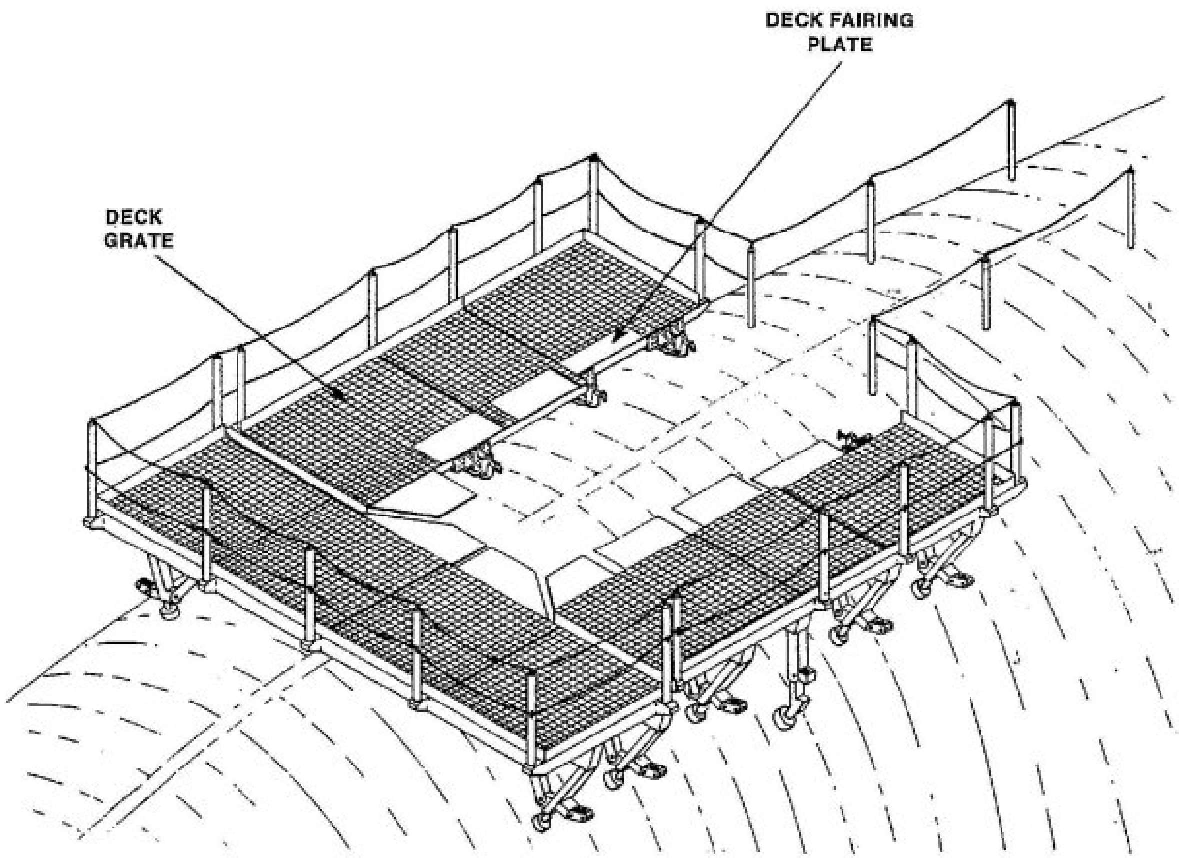


Figure 4-15. Loading Platform Installed



NOTE: GRAB RAILS NOT SHOWN FOR CLARITY

Figure 4-16. SSN 688 Class Submarine Missile Tube Equipment

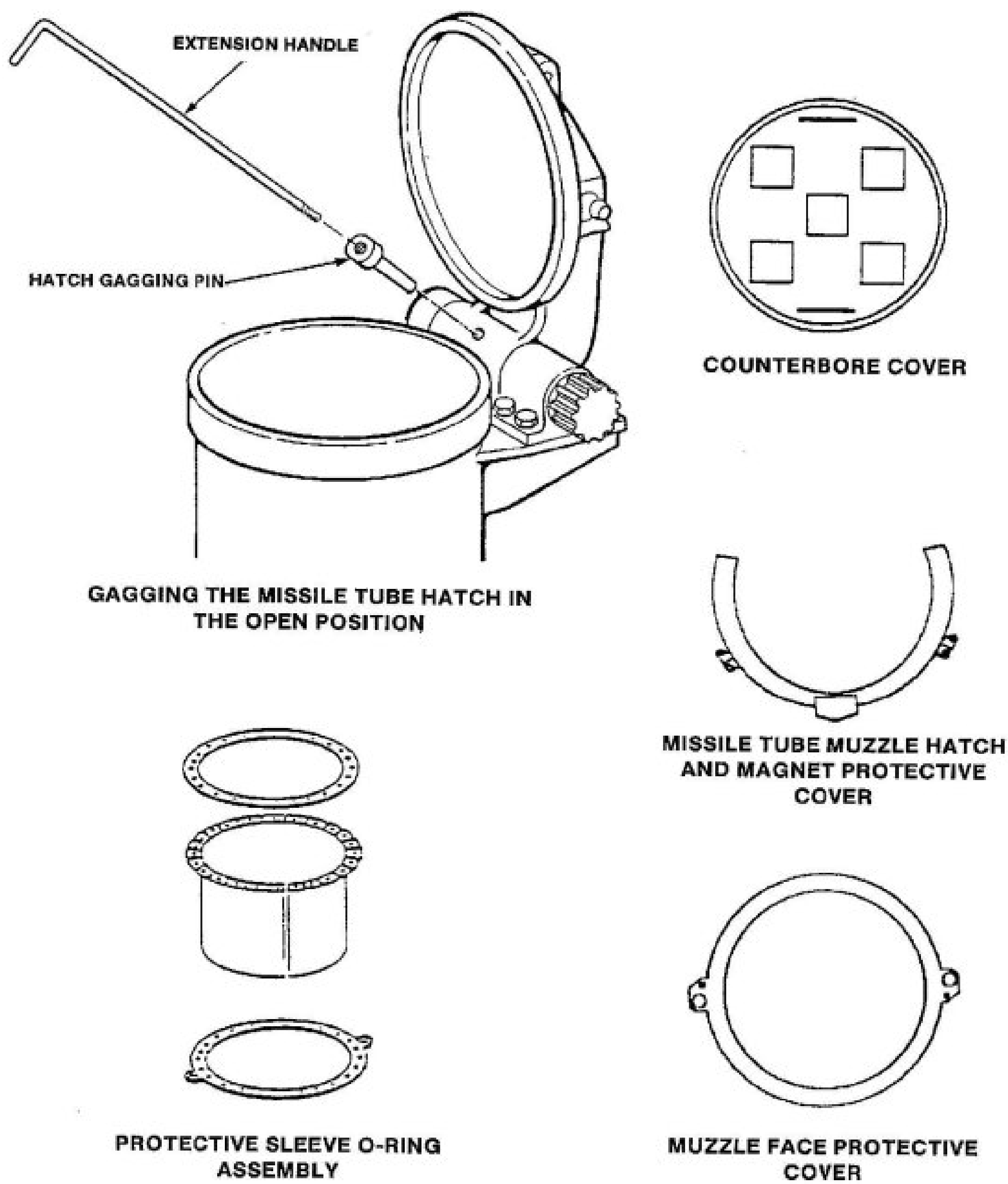


Figure 4-17. CLS Weapon Onload

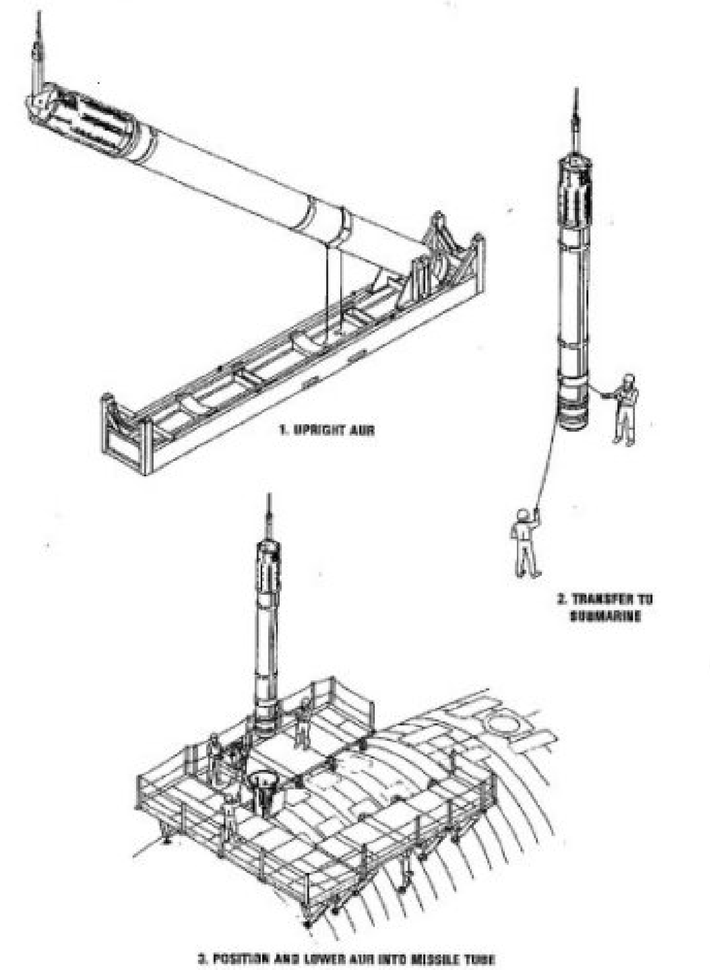


Figure 4-18. CLS Weapon Seating in Missile Tube

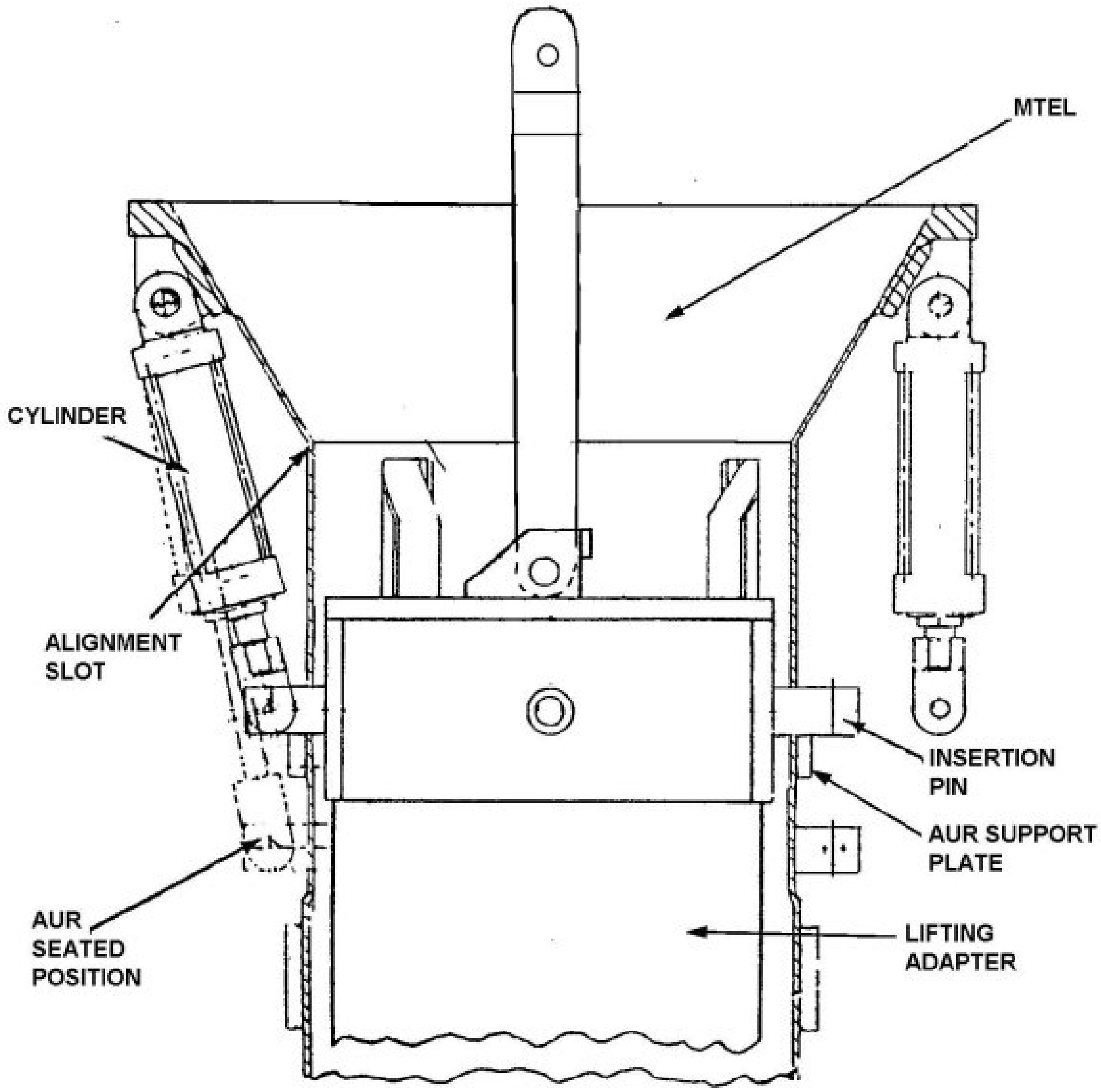


Figure 4-19. Secure CLS Weapon in Missile Tube

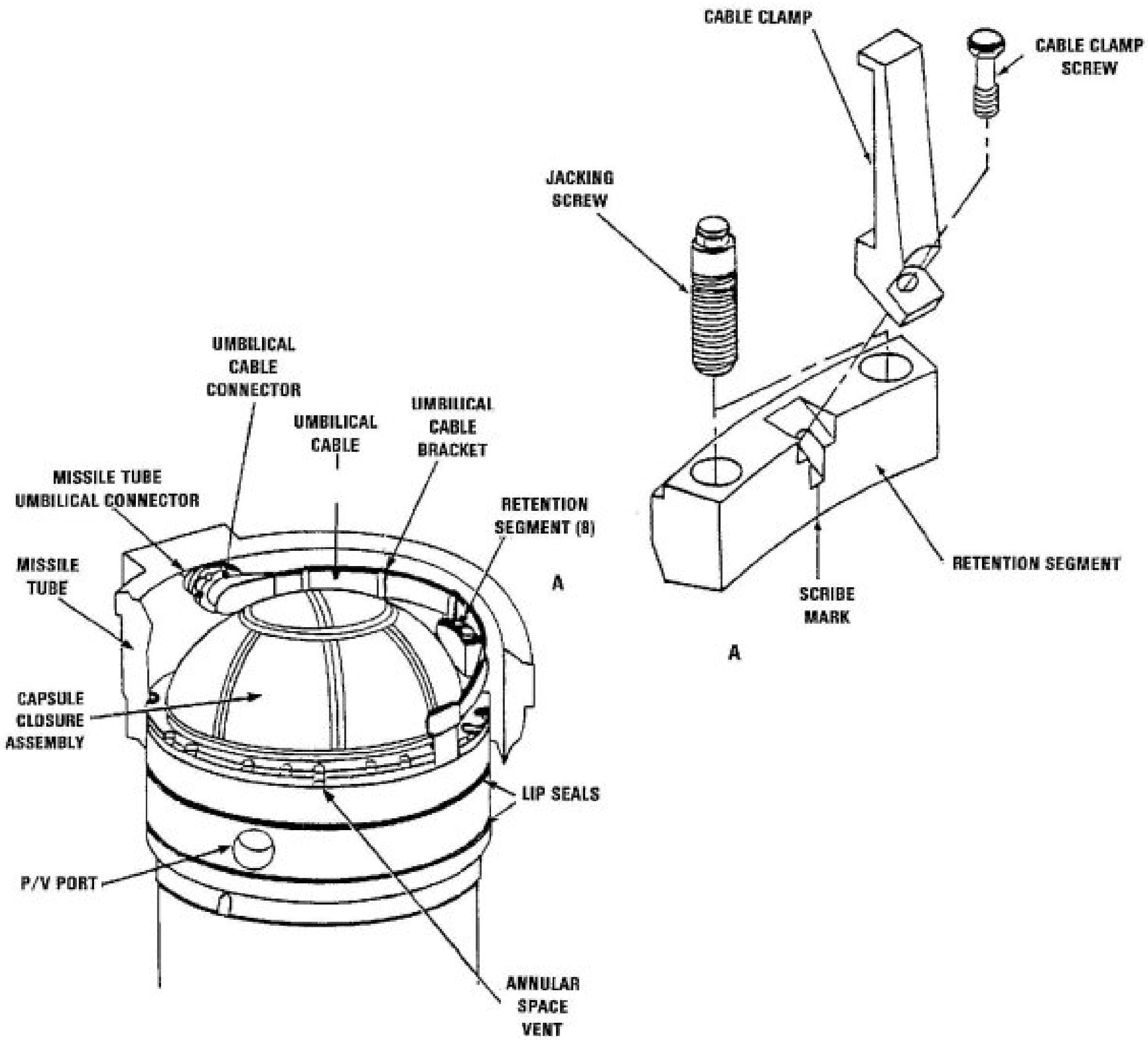
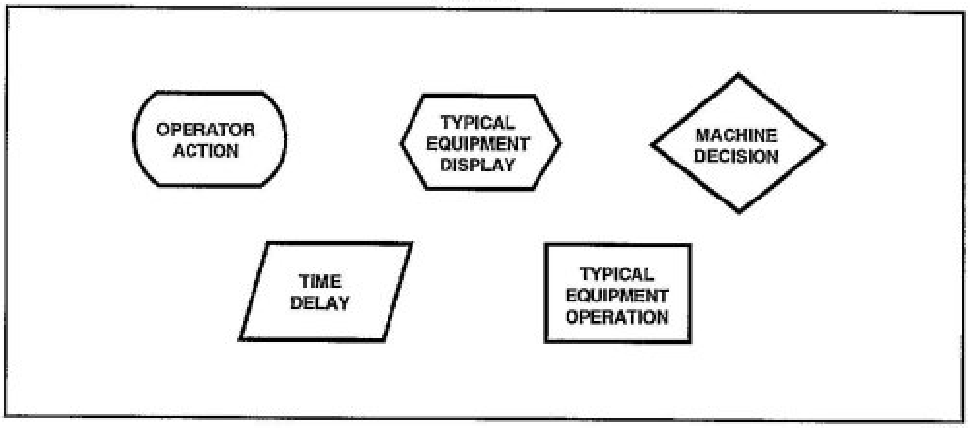


Figure 4-20. UGM-109-2 Land-Attack TCM Operational Sequence (10 Sheets)

LEGEND



INITIAL CONDITIONS

1. COMBAT CONTROL SYSTEM POWERED UP.
2. VLS SHIP SYSTEMS OPERATIONAL.
3. SHIP MOTION WITHIN LIMITS.
4. SUBMARINE IN LAUNCH ENVELOPE.

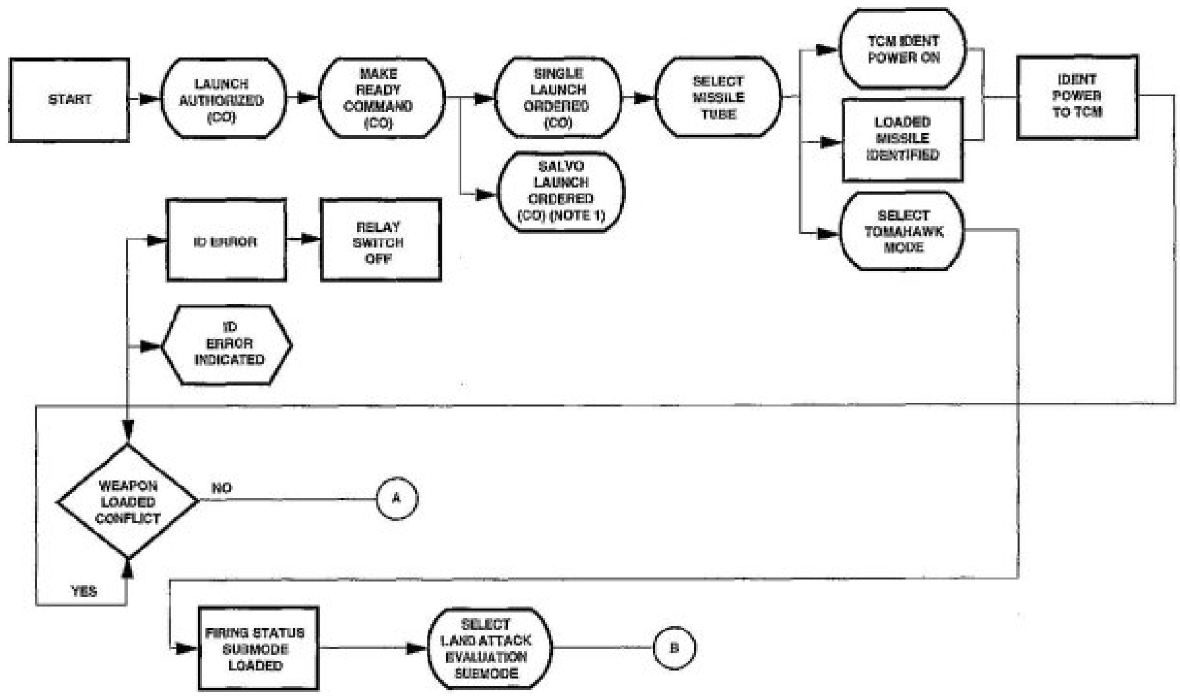
NOTES

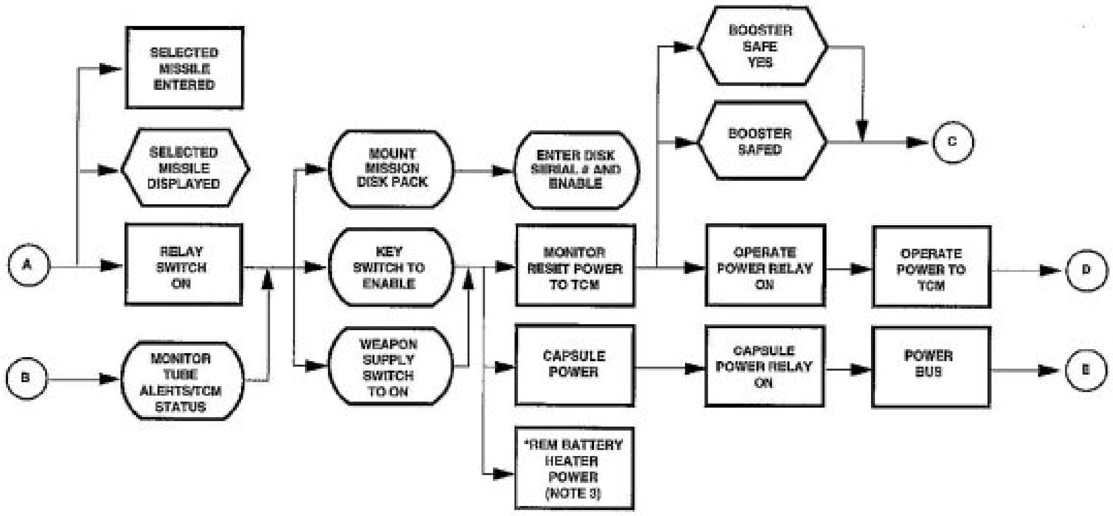
1. FOR SALVO LAUNCH, EVENTS DEPICTED FOR SINGLE LAUNCH WILL BE ACCOMPLISHED FOR EACH MISSILE TUBE AND ALL-UP-ROUND SELECTED FOR LAUNCH SEQUENTIALLY.

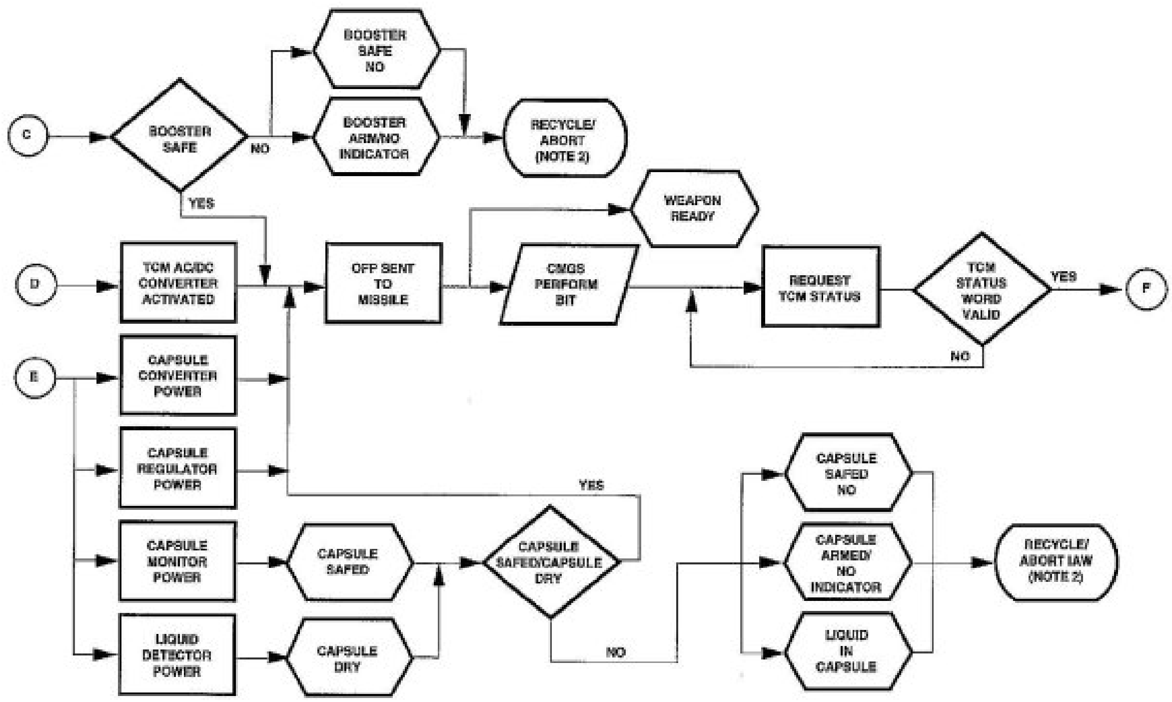
2. RECYCLE AND ABORT LAUNCH ARE PERFORMED IN ACCORDANCE WITH NAVSEA OD 44979.

3. EVENTS WITH AN ASTERISK DENOTE REM OPERATIONS. FOR LAUNCHES WITHOUT REM, THE EVENT IS DELETED.

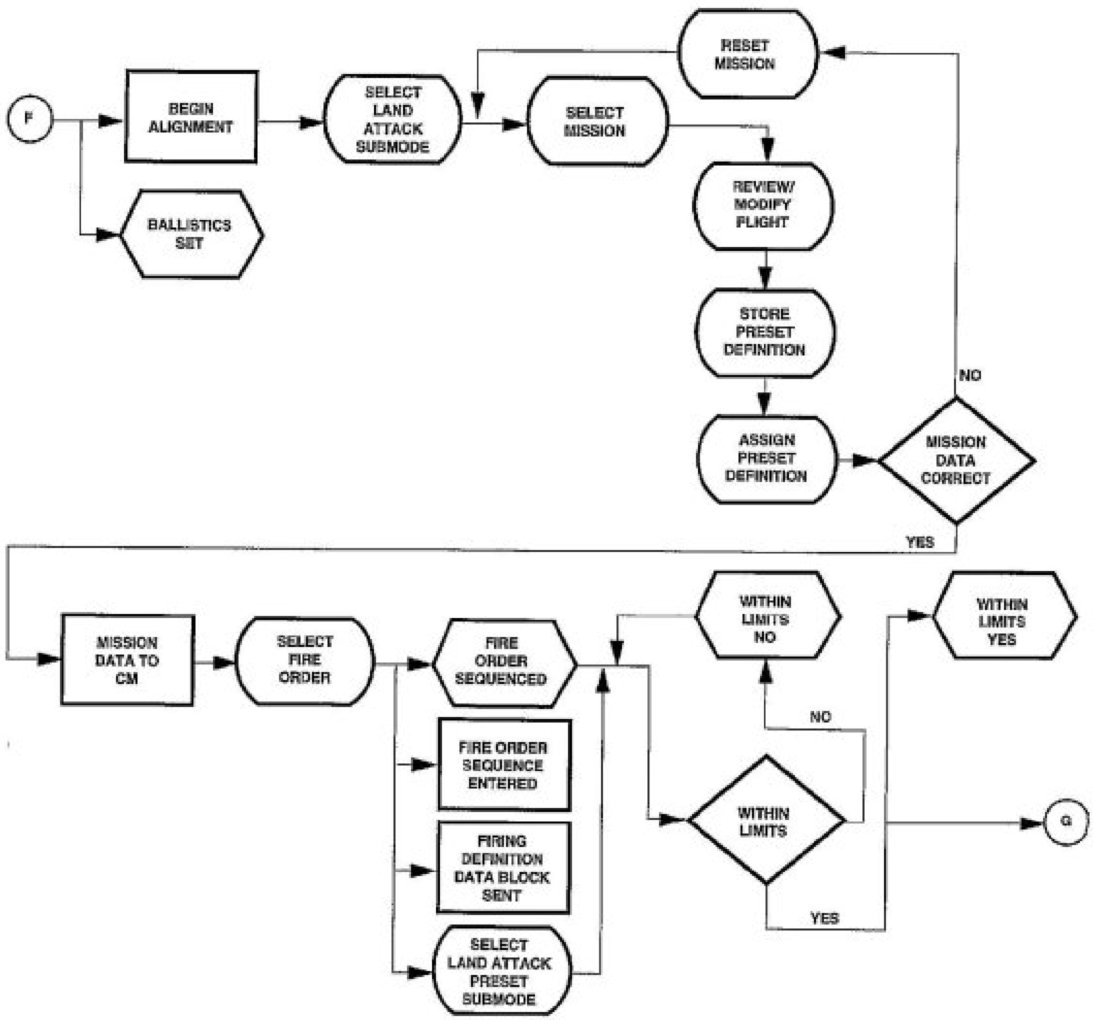
4. ONCE ITL HAS BEEN SENT, OPERATORS NO LONGER HAVE THE ABILITY TO INTERVENE IN LAUNCH, WITH THE EXCEPTION OF SENDING AN ABORT COMMAND. AN ABORT CAN BE ACCOMPLISHED ANY TIME UP UNTIL THE MISSILE ENABLED SIGNAL IS SENT. THIS OCCURS APPROXIMATELY 7 SECONDS AFTER ITL FOR TACTICAL AND RSS VARIANTS AND 36 SECONDS FOR REM VARIANTS. ONCE BATTERIES HAVE BEEN ACTIVATED, THE MISSILE IS IRREVOCABLY DUDDED AND CANNOT BE RECYCLED FOR FIRING.

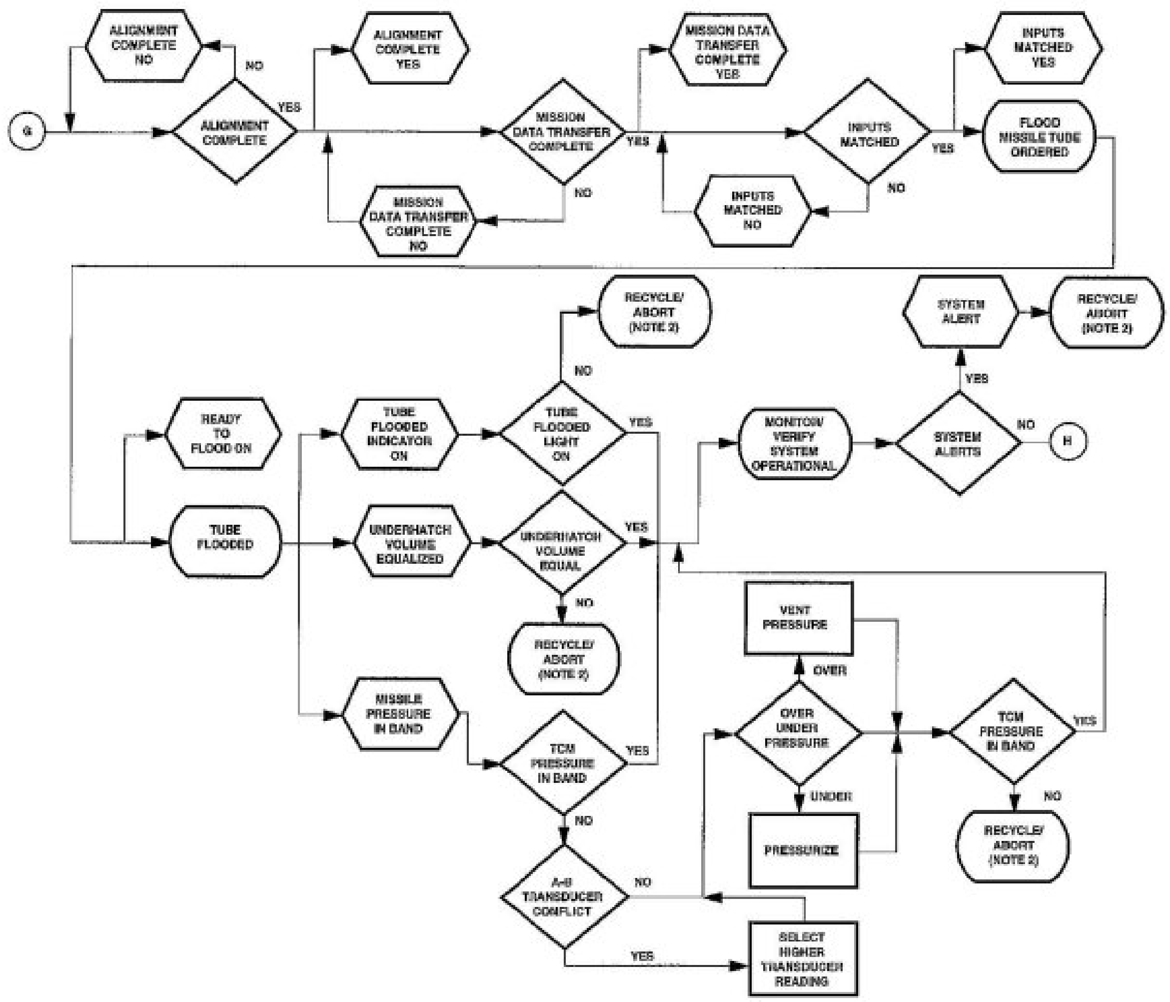

START
LAUNCH AUTHORIZED (CO)
MAKE READY COMMAND (CO)
SINGLE LAUNCH ORDERED (CO)
SALVO LAUNCH ORDERED (CO) (NOTE 1)
SELECT MISSILE TUBE
TCM IDENT POWER ON
LOADED MISSILE IDENTIFIED
SELECT TOMAHAWK MODE
IDENT POWER TO TCM
ID ERROR
RELAY SWITCH OFF
ID ERROR INDICATED
WEAPON LOADED CONFLICT
NO
A
YES
FIRING STATUS SUBMODE LOADED
SELECT LAND ATTACK EVALUATION SUBMODE
B

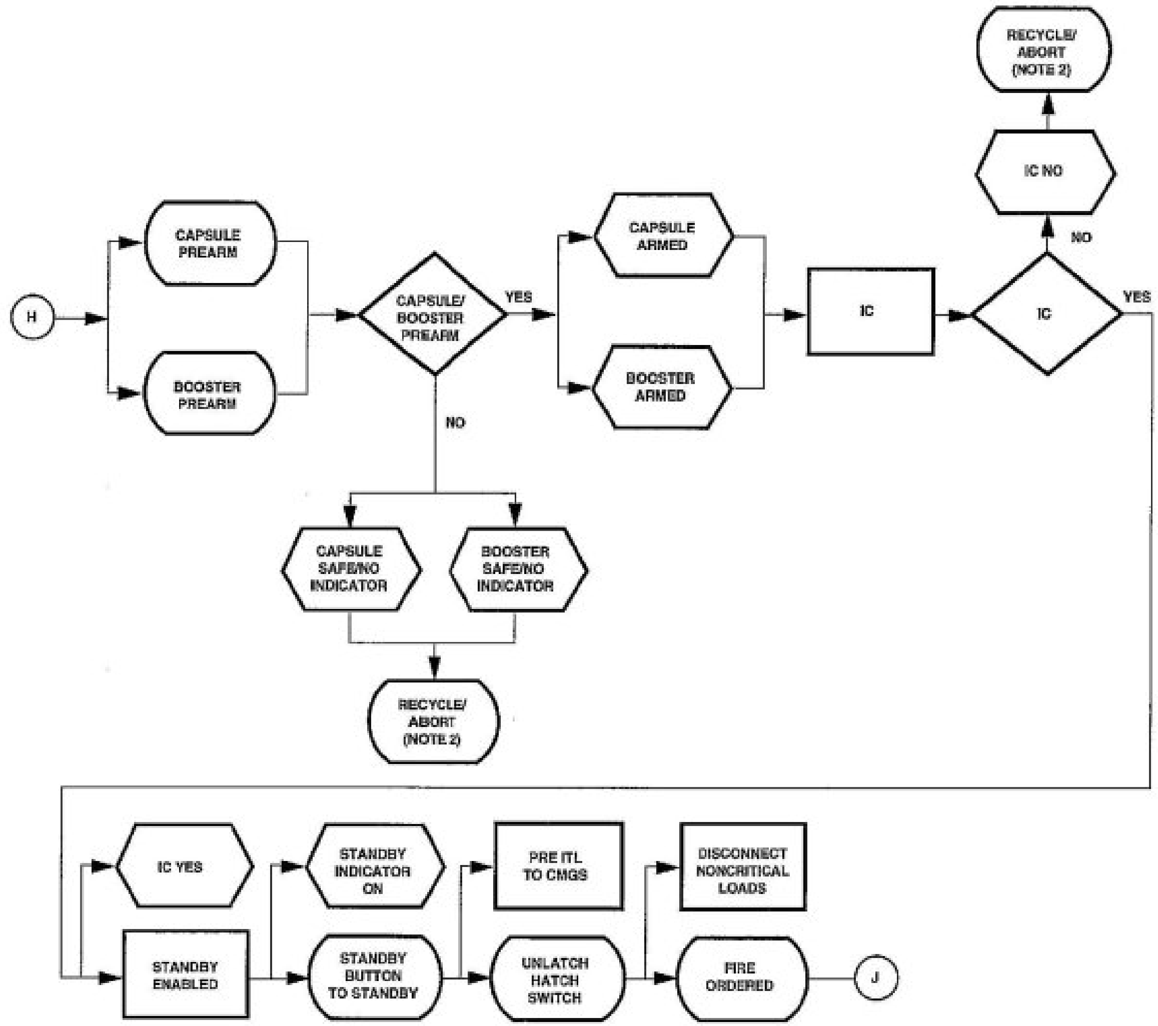

SELECTED
MISSILE
ENTERED
SELECTED
MISSILE
DISPLAYED
RELAY
SWITCH
ON
A
B
MONITOR
TUBE
ALERTS/TCM
STATUS
MOUNT
MISSION
DISK PACK
KEY
SWITCH TO
ENABLE
WEAPON
SUPPLY
SWITCH
TO ON
ENTER DISK
SERIAL # AND
ENABLE
MONITOR
RESET POWER
TO TCM
CAPSULE
POWER
*REM BATTERY
HEATER
POWER
(NOTE 3)
BOOSTER
SAFE
YES
BOOSTER
SAFED
C
OPERATE
POWER RELAY
ON
OPERATE
POWER TO
TCM
D
CAPSULE
POWER RELAY
ON
POWER
BUS
E

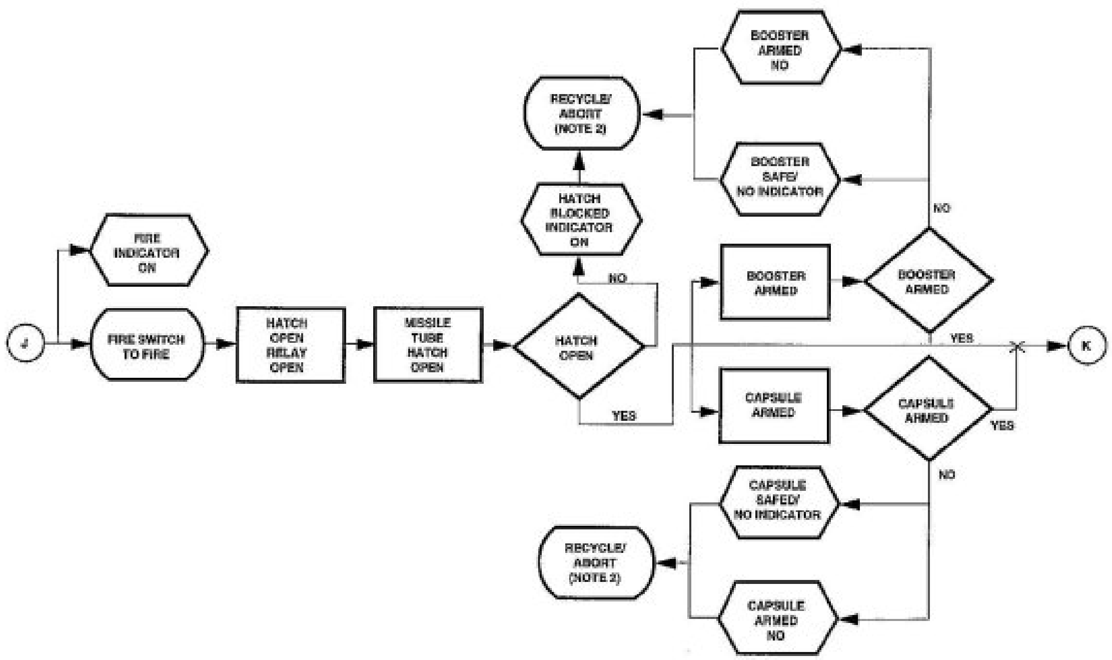


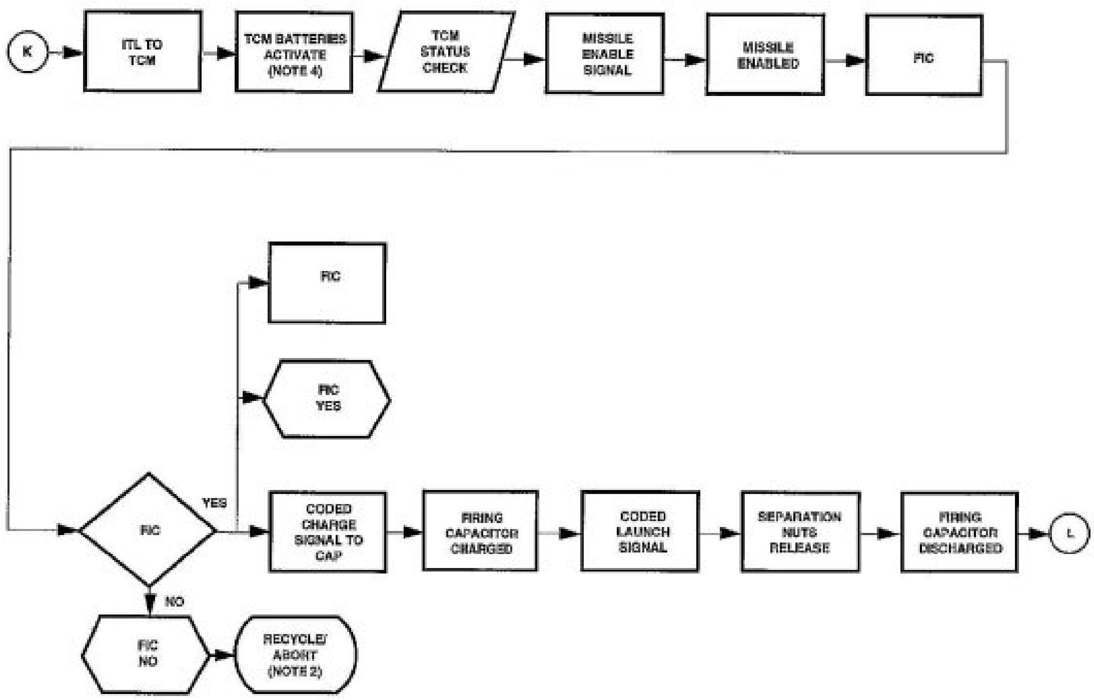
C
BOOSTER SAFE
NO
YES
BOOSTER SAFE NO
BOOSTER ARM/NO INDICATOR
RECYCLE/ ABORT (NOTE 2)
WEAPON READY
D
TCM AC/DC CONVERTER ACTIVATED
OFF SENT TO MISSILE
CMGS PERFORM BIT
REQUEST TCM STATUS
TCM STATUS WORD VALID
YES
NO
F
E
CAPSULE CONVERTER POWER
CAPSULE REGULATOR POWER
CAPSULE MONITOR POWER
LIQUID DETECTOR POWER
CAPSULE SAFED
CAPSULE DRY
CAPSULE SAFED/CAPSULE DRY
YES
NO
CAPSULE SAFED NO
CAPSULE ARMED/ NO INDICATOR
LIQUID IN CAPSULE
RECYCLE/ ABORT IAW (NOTE 2)


F
BEGIN ALIGNMENT
BALLISTICS SET
SELECT LAND ATTACK SUBMODE
SELECT MISSION
RESET MISSION
REVIEW/ MODIFY FLIGHT
STORE PRESET DEFINITION
ASSIGN PRESET DEFINITION
MISSION DATA CORRECT
NO
YES
MISSION DATA TO CM
SELECT FIRE ORDER
FIRE ORDER SEQUENCED
FIRE ORDER SEQUENCE ENTERED
FIRING DEFINITION DATA BLOCK SENT
SELECT LAND ATTACK PRESET SUBMODE
WITHIN LIMITS NO
WITHIN LIMITS
NO
YES
WITHIN LIMITS YES
G


G
ALIGNMENT COMPLETE NO
NO
YES
ALIGNMENT COMPLETE
ALIGNMENT COMPLETE YES
MISSION DATA TRANSFER COMPLETE
MISSION DATA TRANSFER COMPLETE NO
NO
YES
MISSION DATA TRANSFER COMPLETE YES
INPUTS MATCHED
INPUTS MATCHED NO
NO
YES
INPUTS MATCHED YES
FLOOD MISSILE TUBE ORDERED
READY TO FLOOD ON
TUBE FLOODED
TUBE FLOODED INDICATOR ON
TUBE FLOODED LIGHT ON
RECYCLE/ ABORT (NOTE 2)
UNDERHATCH VOLUME EQUALIZED
UNDERHATCH VOLUME EQUAL
MISSILE PRESSURE IN BAND
TCM PRESSURE IN BAND
A-B TRANSDUCER CONFLICT
SELECT HIGHER TRANSDUCER READING
MONITOR/ VERIFY SYSTEM OPERATIONAL
SYSTEM ALERTS
SYSTEM ALERT
H
VENT PRESSURE
OVER
OVER UNDER PRESSURE
UNDER
PRESSURIZE


RECYCLE/
ABORT
(NOTE 2)
IC NO
NO
CAPSULE
PREARM
BOOSTER
PREARM
H
CAPSULE/
BOOSTER
PREARM
YES
CAPSULE
ARMED
BOOSTER
ARMED
IC
IC
YES
NO
CAPSULE
SAFE/NO
INDICATOR
BOOSTER
SAFE/NO
INDICATOR
RECYCLE/
ABORT
(NOTE 2)
IC YES
STANDBY
ENABLED
STANDBY
INDICATOR
ON
STANDBY
BUTTON
TO STANDBY
PRE ITL
TO CMGS
UNLATCH
HATCH
SWITCH
DISCONNECT
NONCRITICAL
LOADS
FIRE
ORDERED
J


J
FIRE INDICATOR ON
FIRE SWITCH TO FIRE
HATCH OPEN RELAY OPEN
MISSILE TUBE HATCH OPEN
HATCH OPEN
NO
HATCH BLOCKED INDICATOR ON
RECYCLE/ ABORT (NOTE 2)
YES
BOOSTER ARMED NO
BOOSTER SAFE/ NO INDICATOR
BOOSTER ARMED
BOOSTER ARMED
NO
YES
K
CAPSULE ARMED
CAPSULE ARMED
YES
NO
CAPSULE SAFED/ NO INDICATOR
RECYCLE/ ABORT (NOTE 2)
CAPSULE ARMED NO


K
ITL TO TCM
TCM BATTERIES ACTIVATE (NOTE 4)
TCM STATUS CHECK
MISSILE ENABLE SIGNAL
MISSILE ENABLED
FIC
FIC
FIC YES
FIC
YES
NO
CODED CHARGE SIGNAL TO CAP
FIRING CAPACITOR CHARGED
CODED LAUNCH SIGNAL
SEPARATION NUTS RELEASE
FIRING CAPACITOR DISCHARGED
L
FIC NO
RECYCLE/ ABORT (NOTE 2)

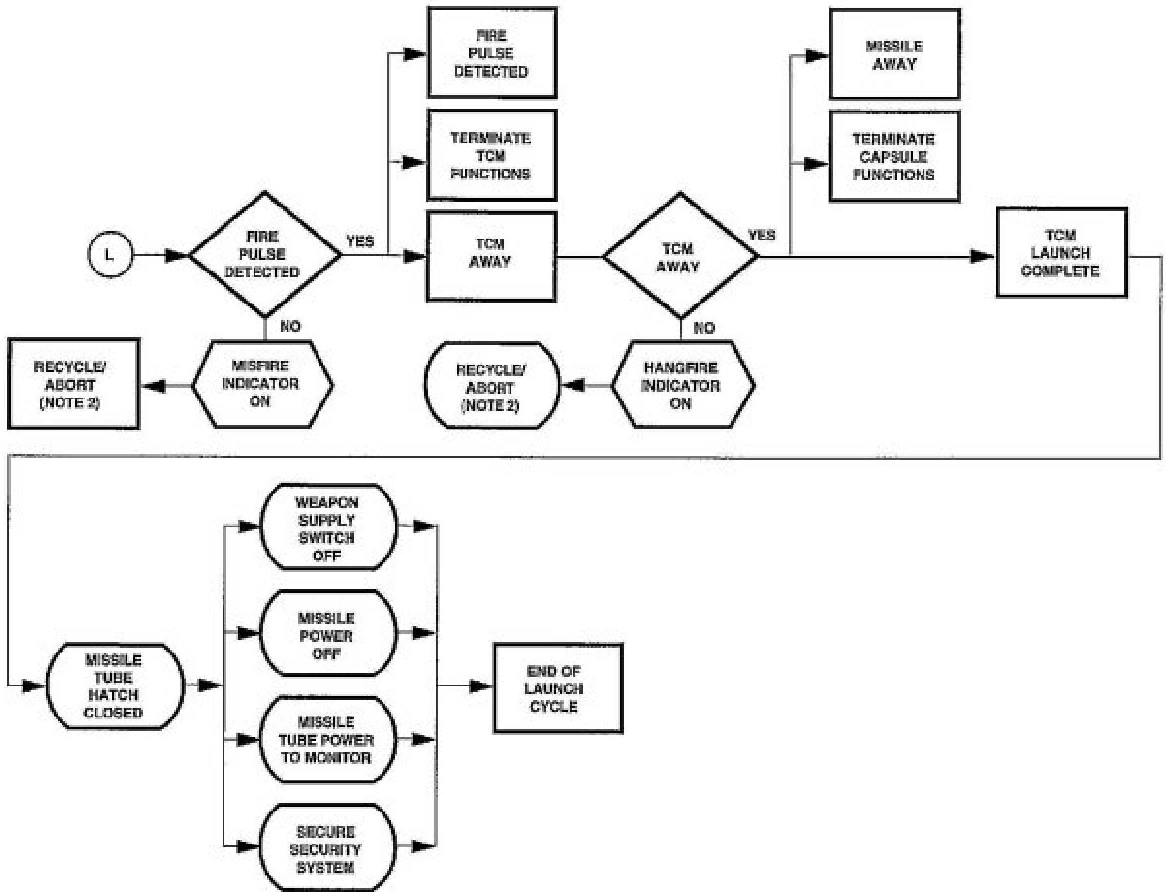

L
FIRE PULSE DETECTED
YES
NO
MISFIRE INDICATOR ON
RECYCLE/ ABORT (NOTE 2)
FIRE PULSE DETECTED
TERMINATE TCM FUNCTIONS
TCM AWAY
TCM AWAY
YES
NO
HANGFIRE INDICATOR ON
RECYCLE/ ABORT (NOTE 2)
MISSILE AWAY
TERMINATE CAPSULE FUNCTIONS
TCM LAUNCH COMPLETE
MISSILE TUBE HATCH CLOSED
WEAPON SUPPLY SWITCH OFF
MISSILE POWER OFF
MISSILE TUBE POWER TO MONITOR
SECURE SECURITY SYSTEM
END OF LAUNCH CYCLE

Figure 4-21. Lifting Adapter and Extension

Figure 4-22. Vertical Launching System Mk 41 Mod 0

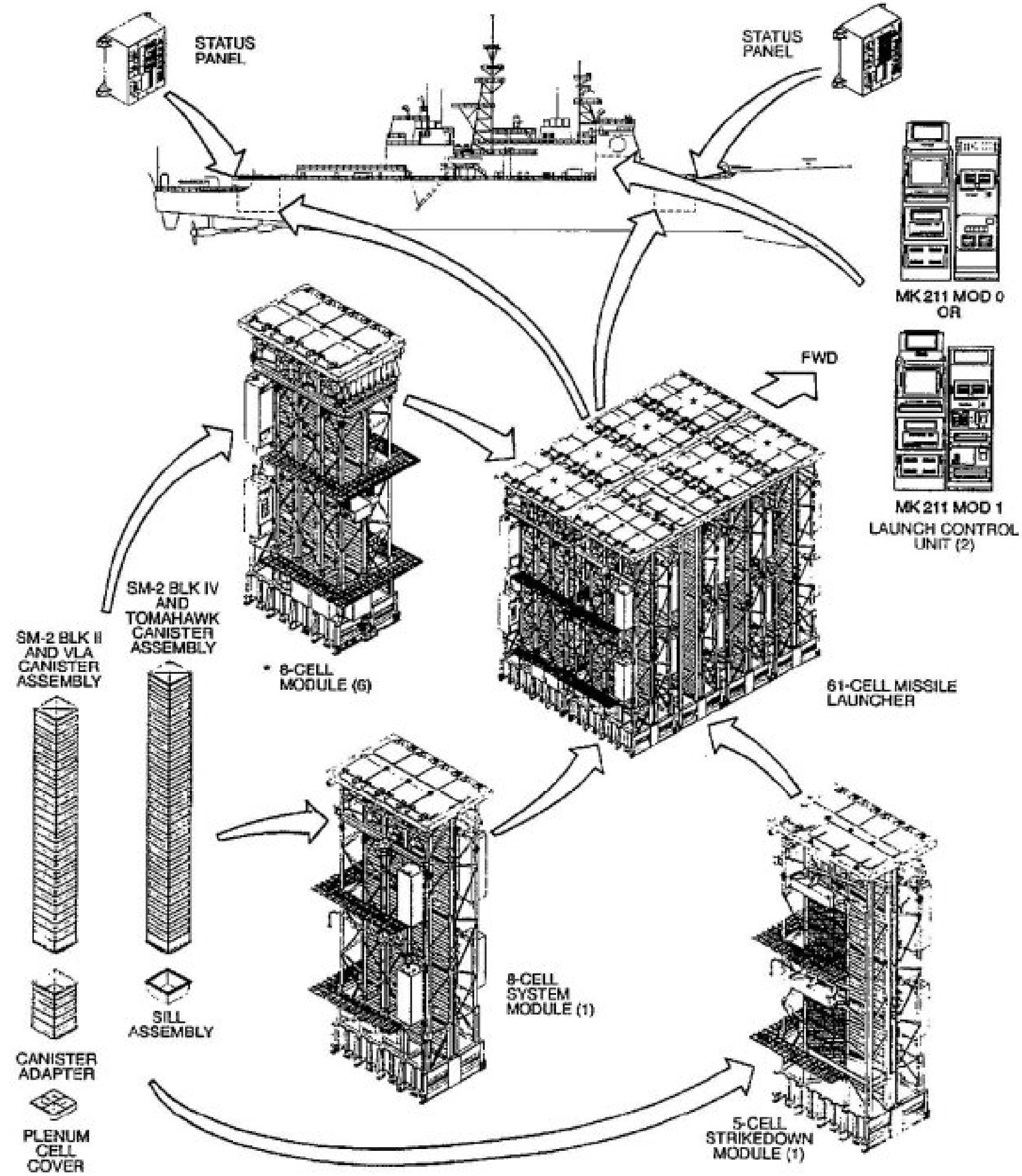


Figure 4-23. Vertical Launching System Mk 41 Mod 1

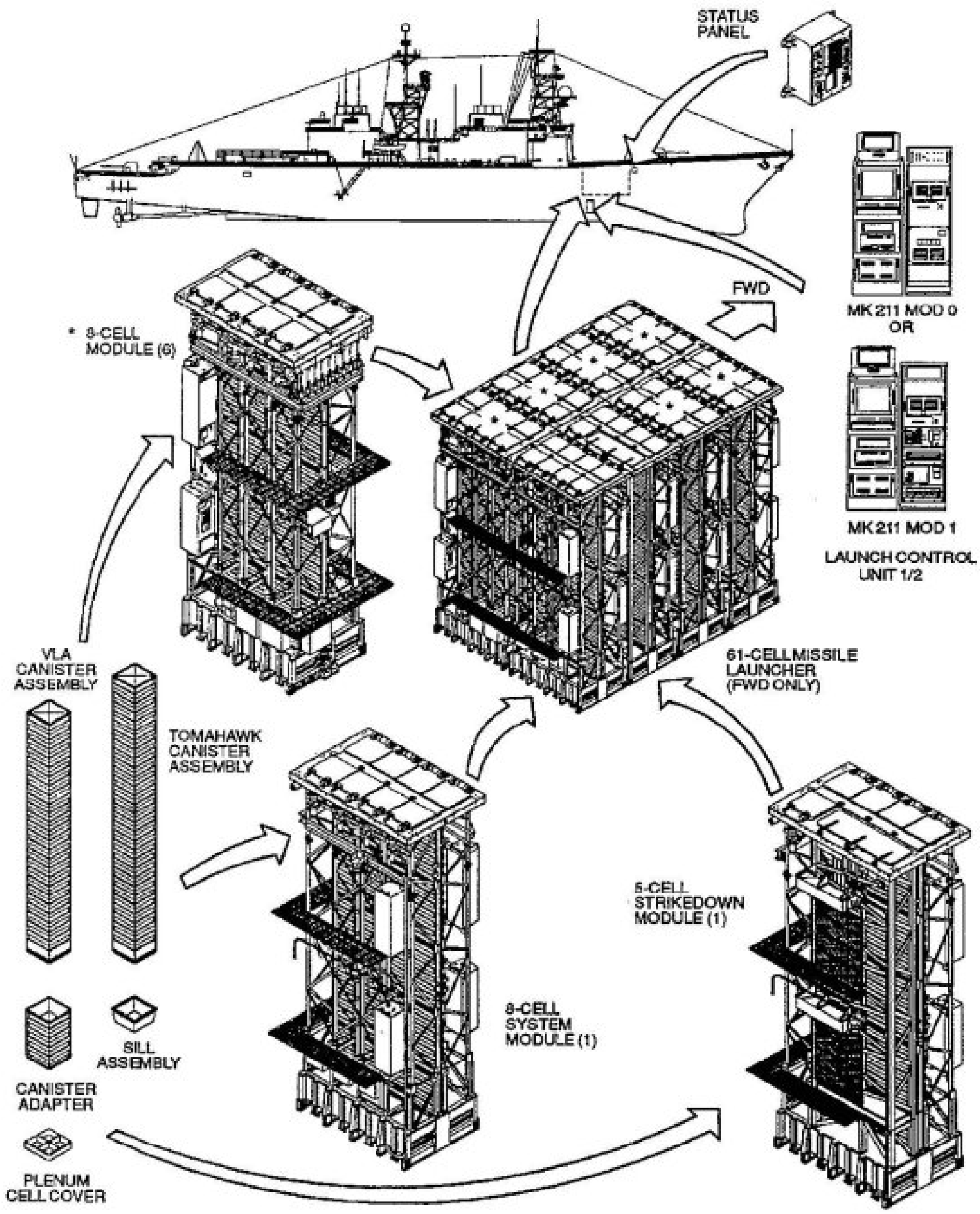


Figure 4-24. Vertical Launching System Mk 41 Mod 2

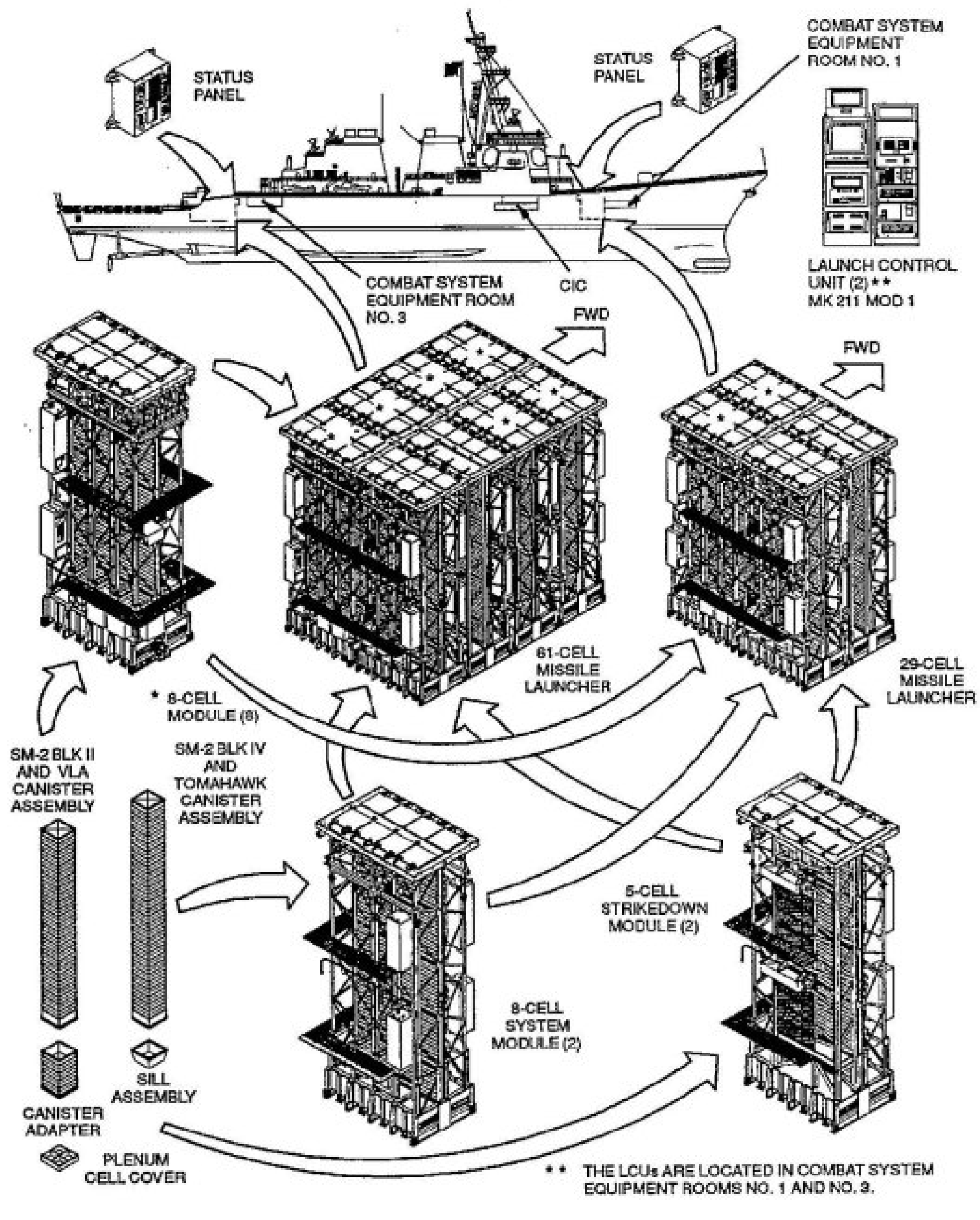


Figure 4-25. Launch Control Unit (LCU)

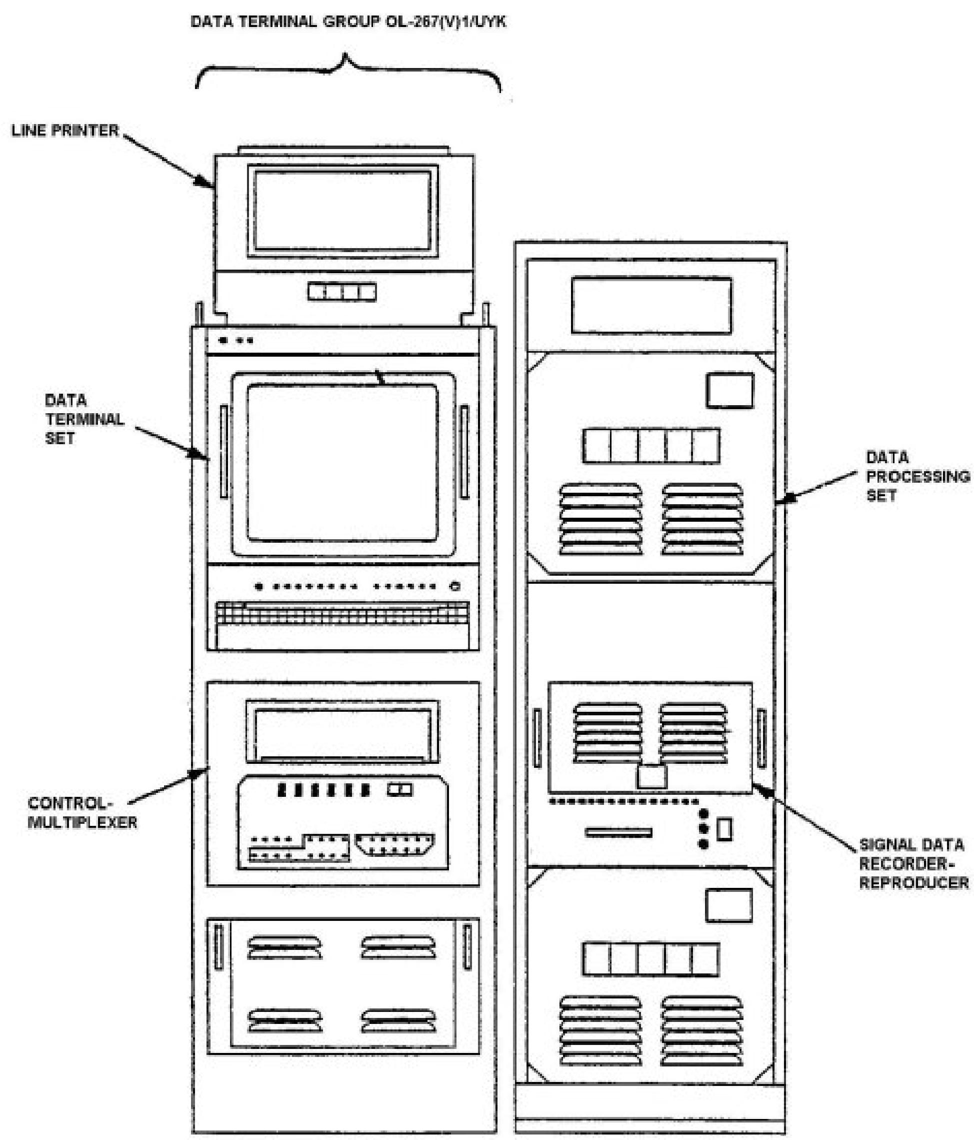


Figure 4-26. Vertical Launching System Launcher

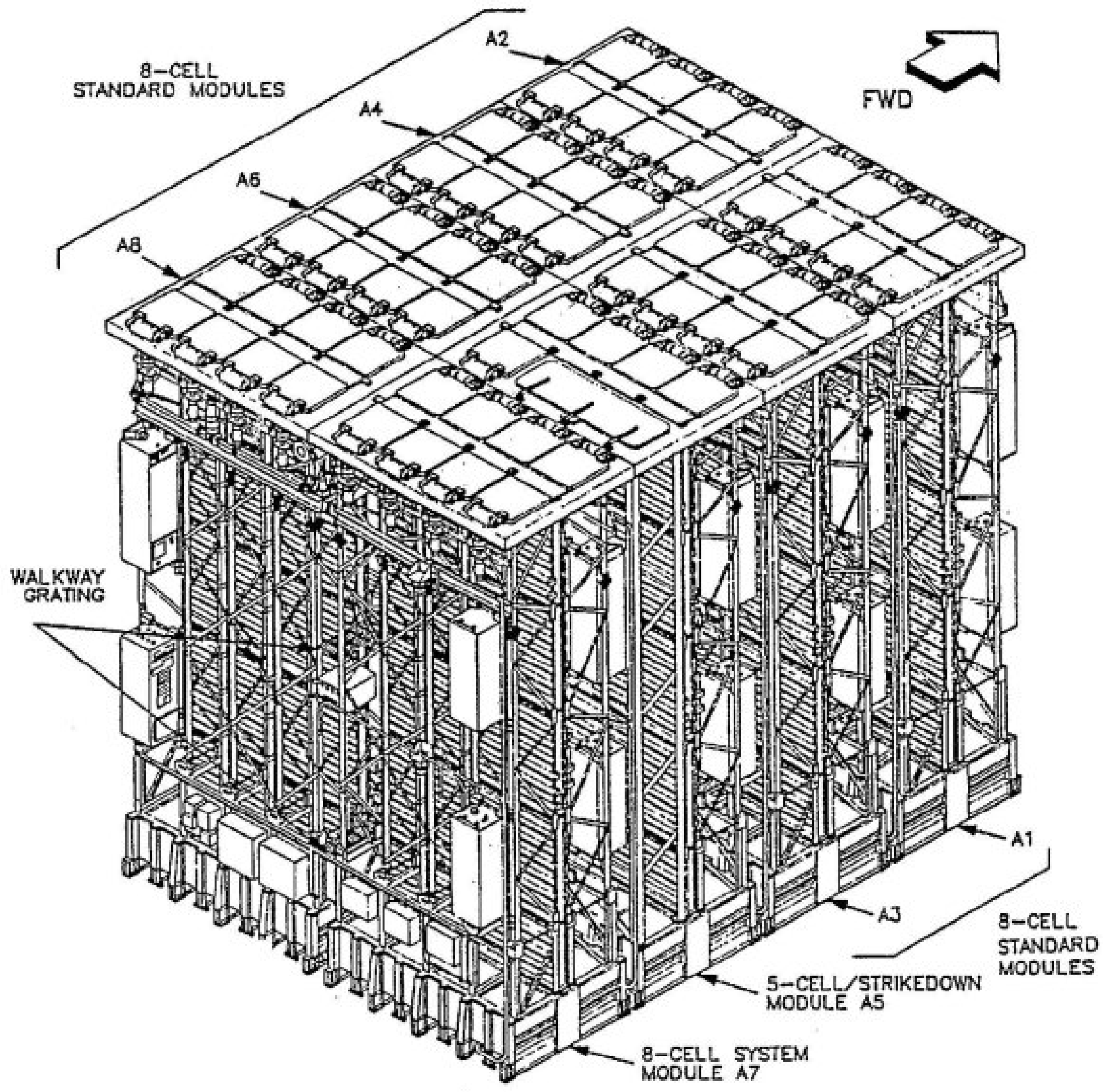


Figure 4-27. Remote Launch Enable Panel (RLEP)

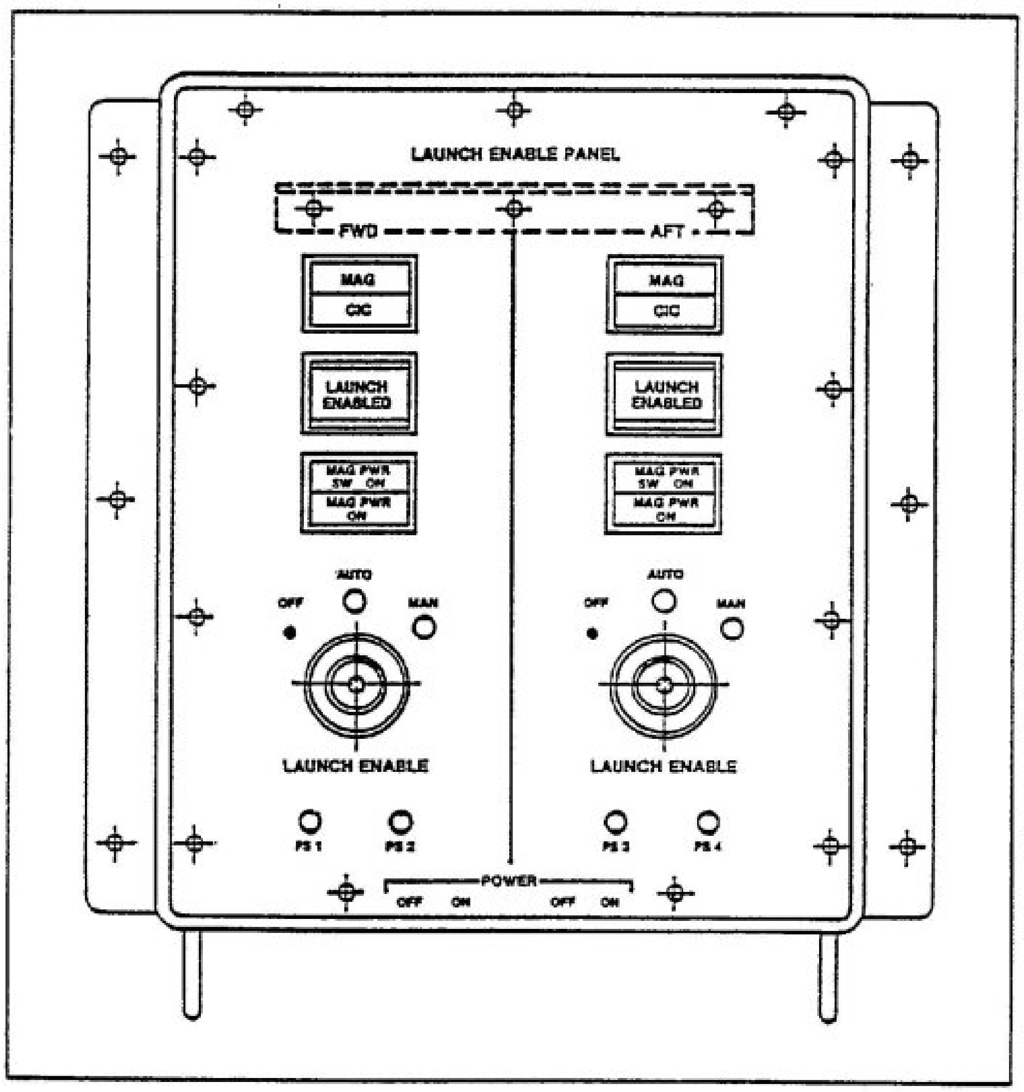


Figure 4-28. Status Panel

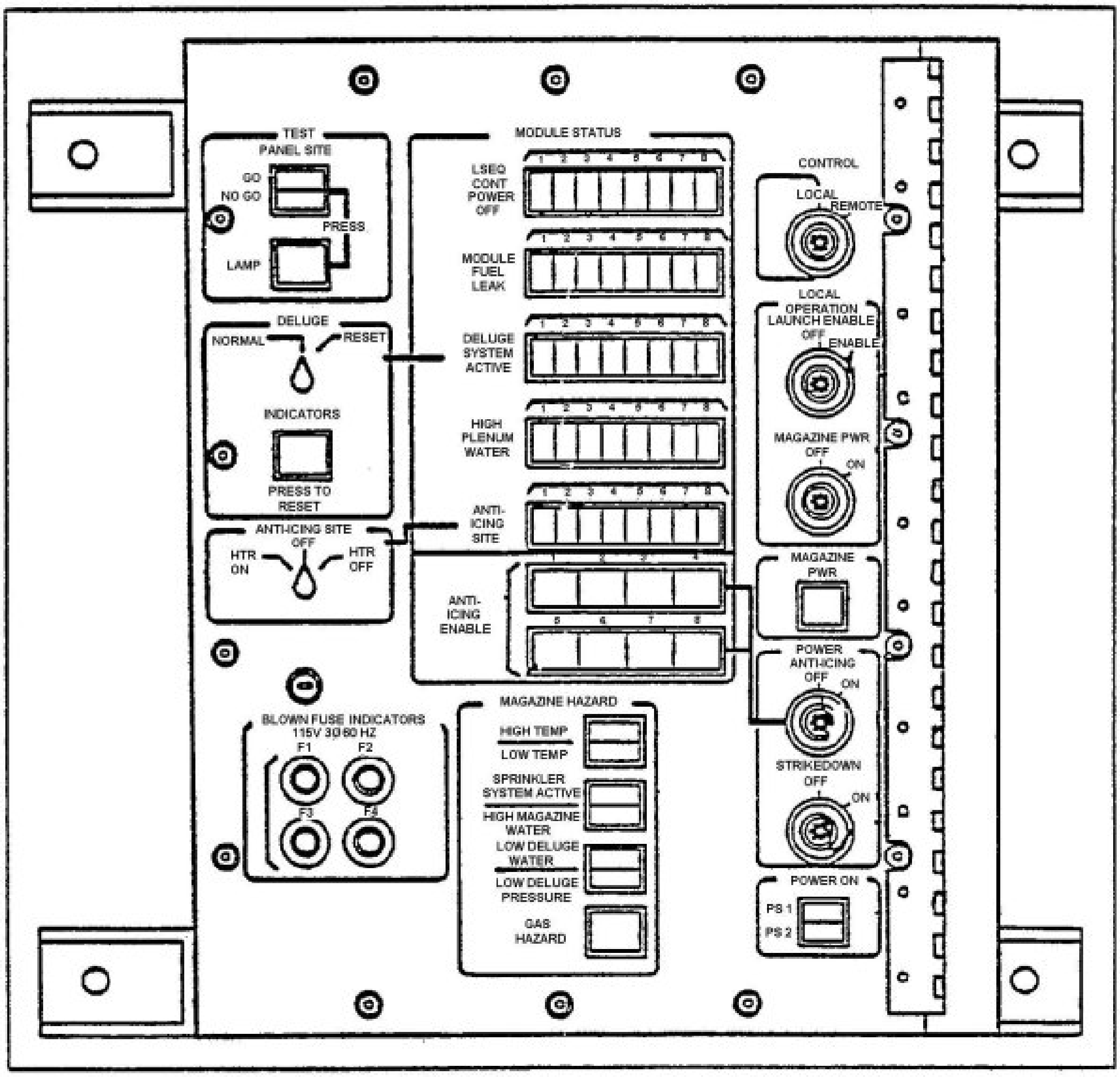


Figure 4-29. Mk 14 VLS Canister PHS&T Equipment

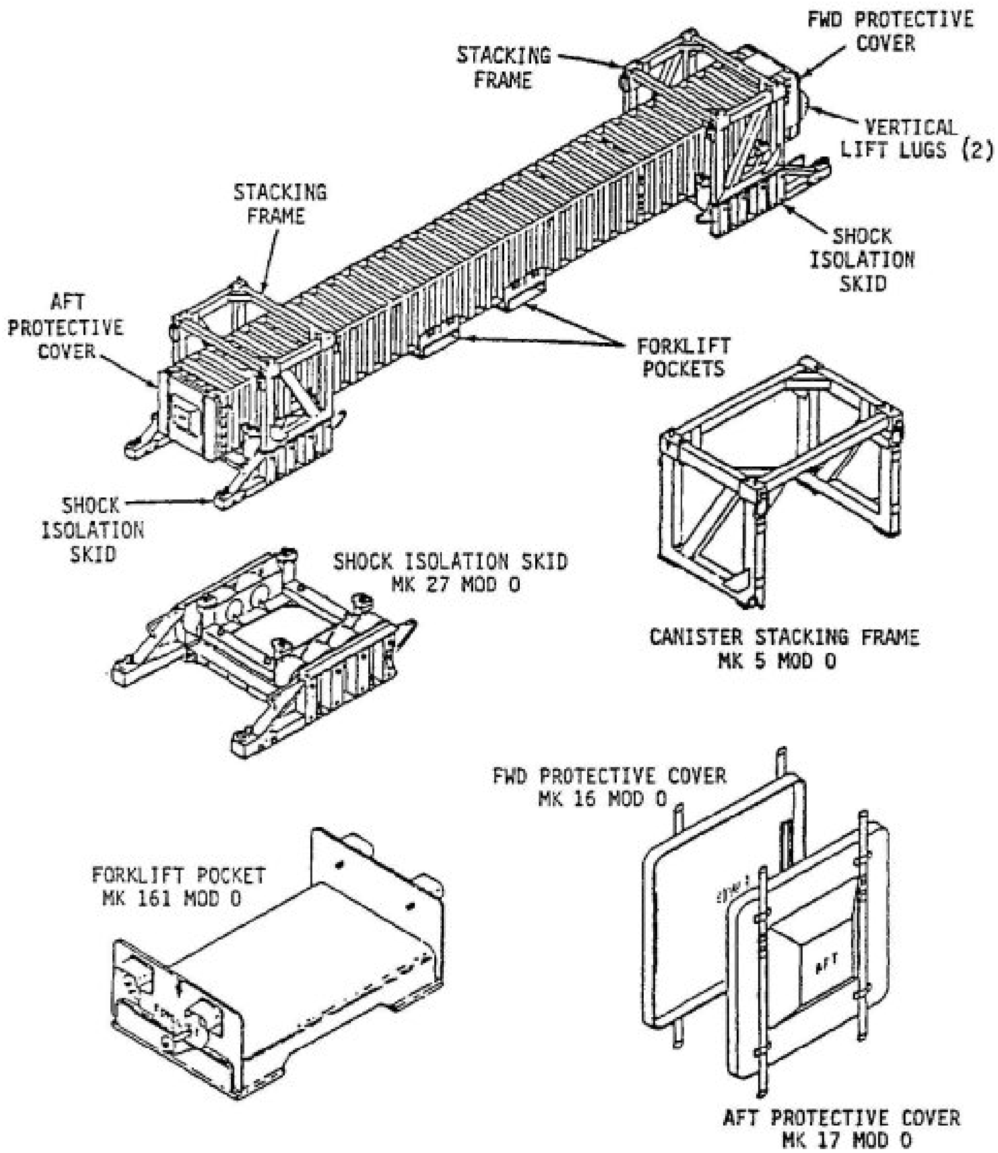


Figure 4-30. Secure Canister to Mk 23 Tilt Fixture

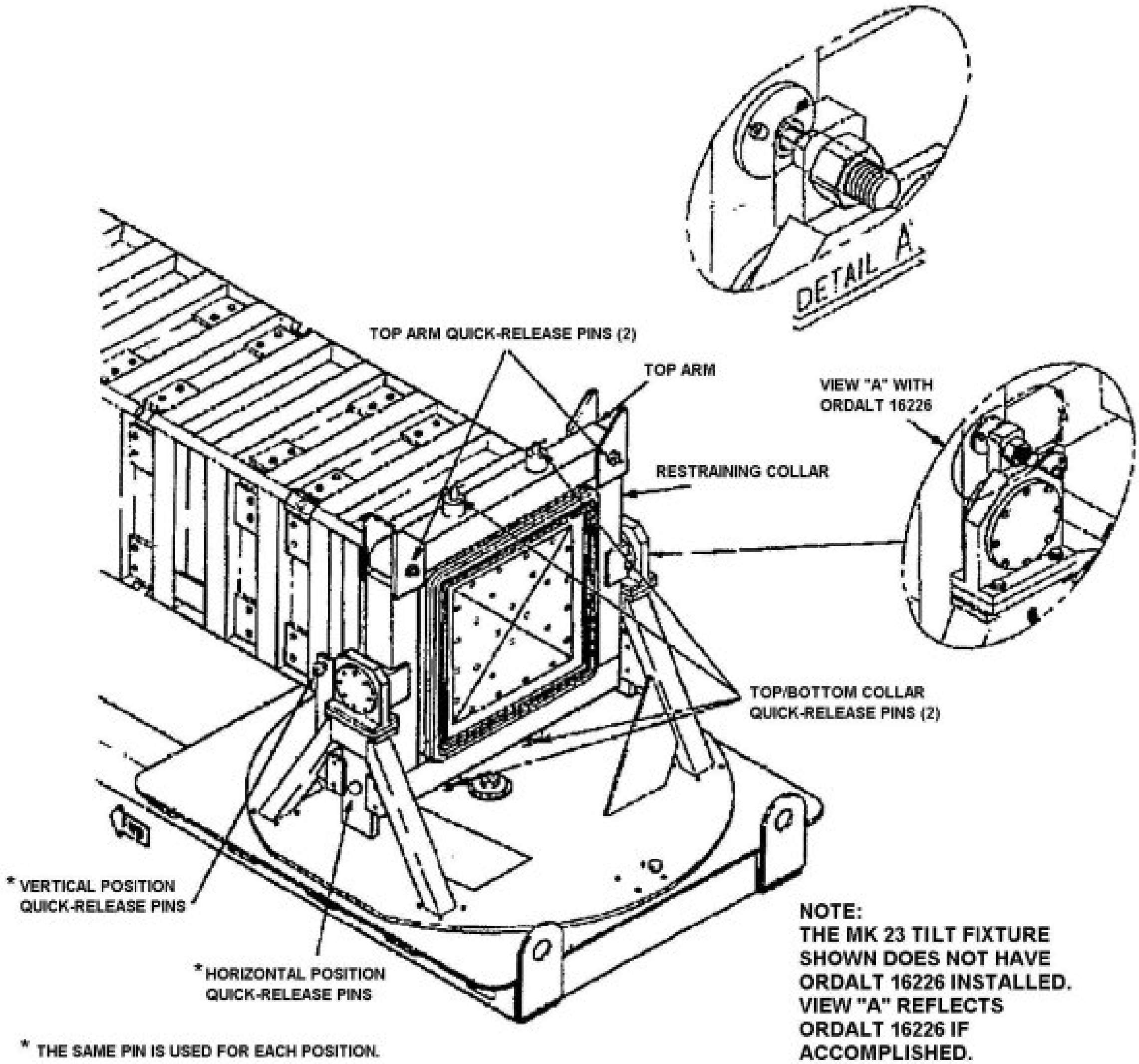


Figure 4-31. Upright Mk 14 VLS Canister to Vertical Position

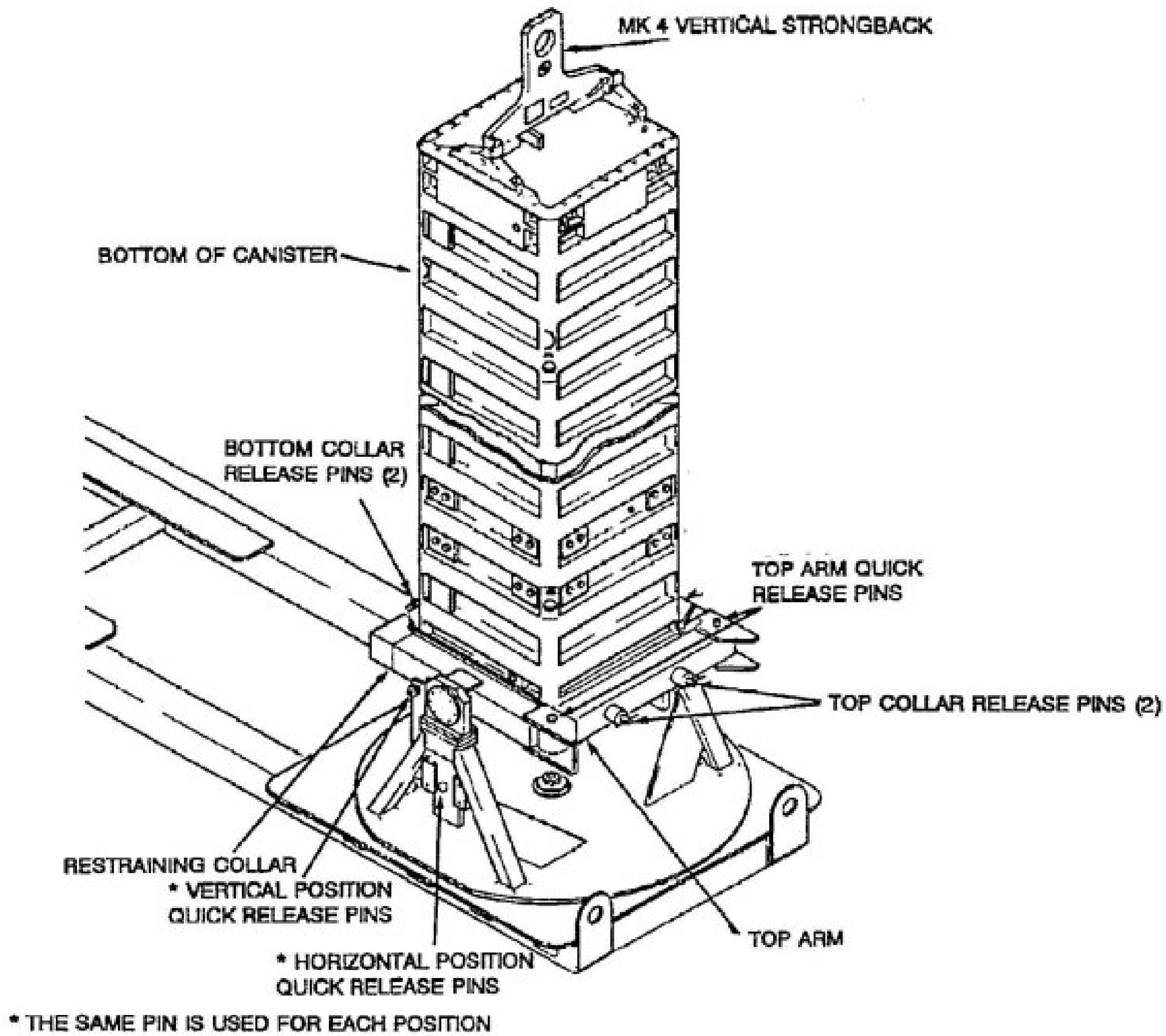
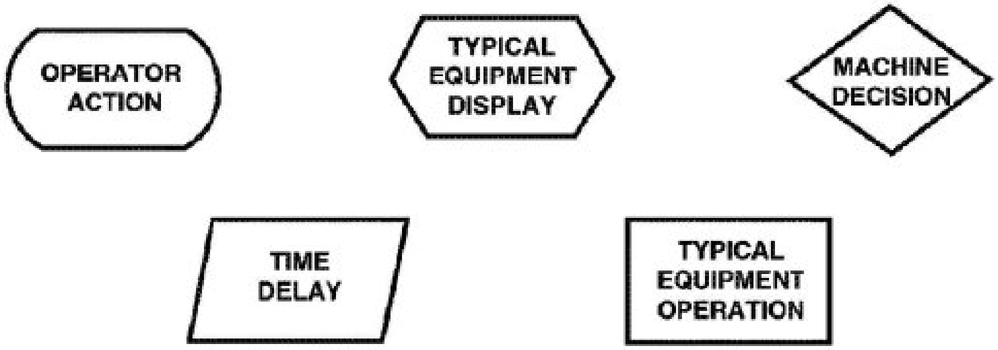


Figure 4-32. RGM-109-4 Land-Attack TCM Operational Sequence (15 Sheets)

LEGEND

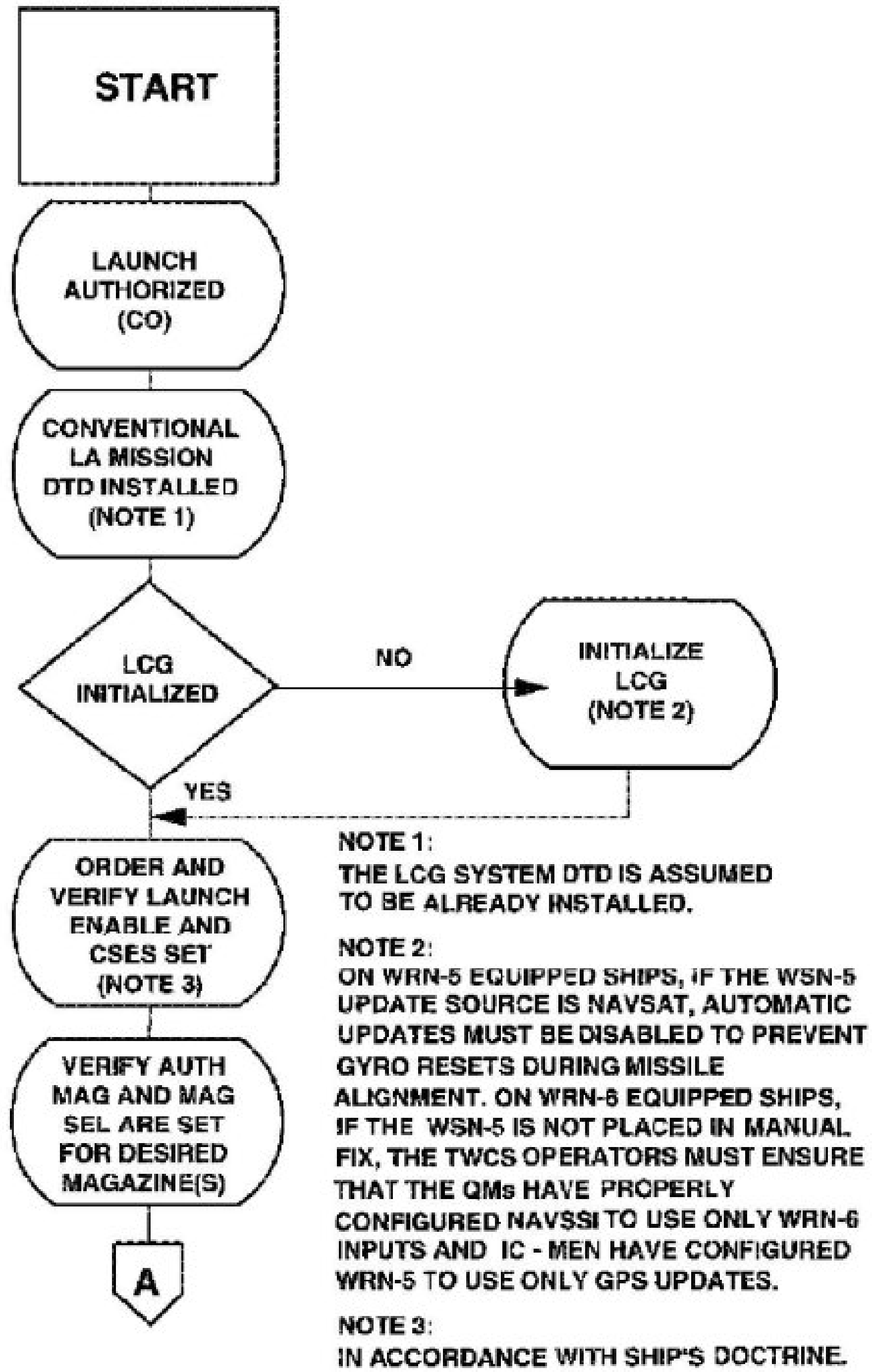


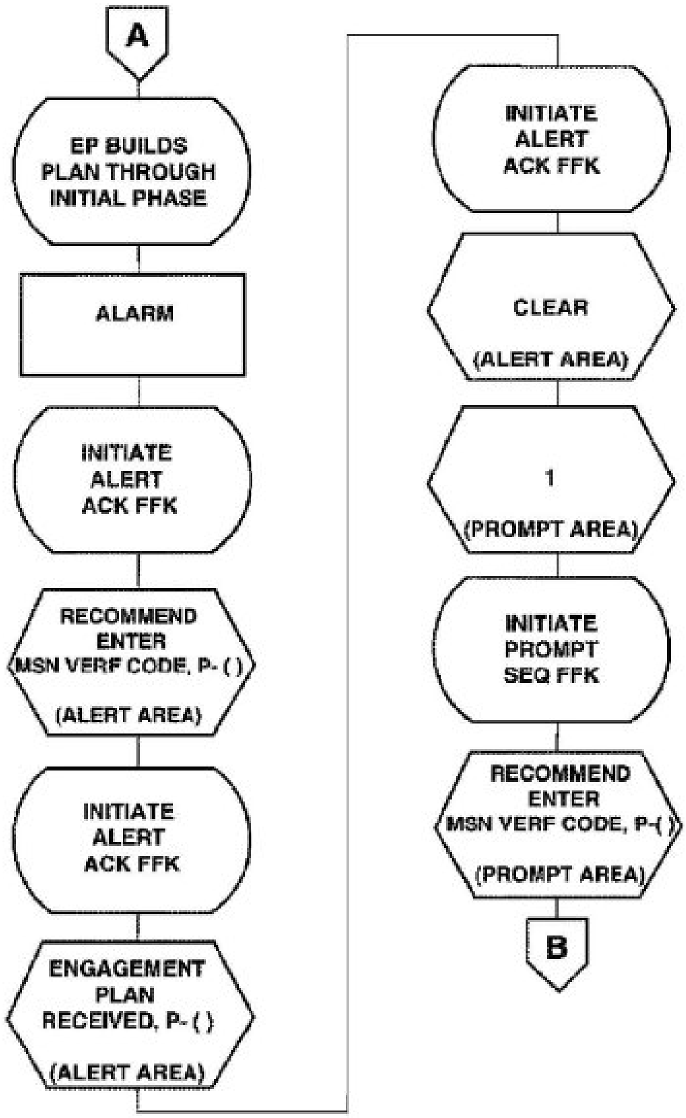
INITIAL CONDITIONS

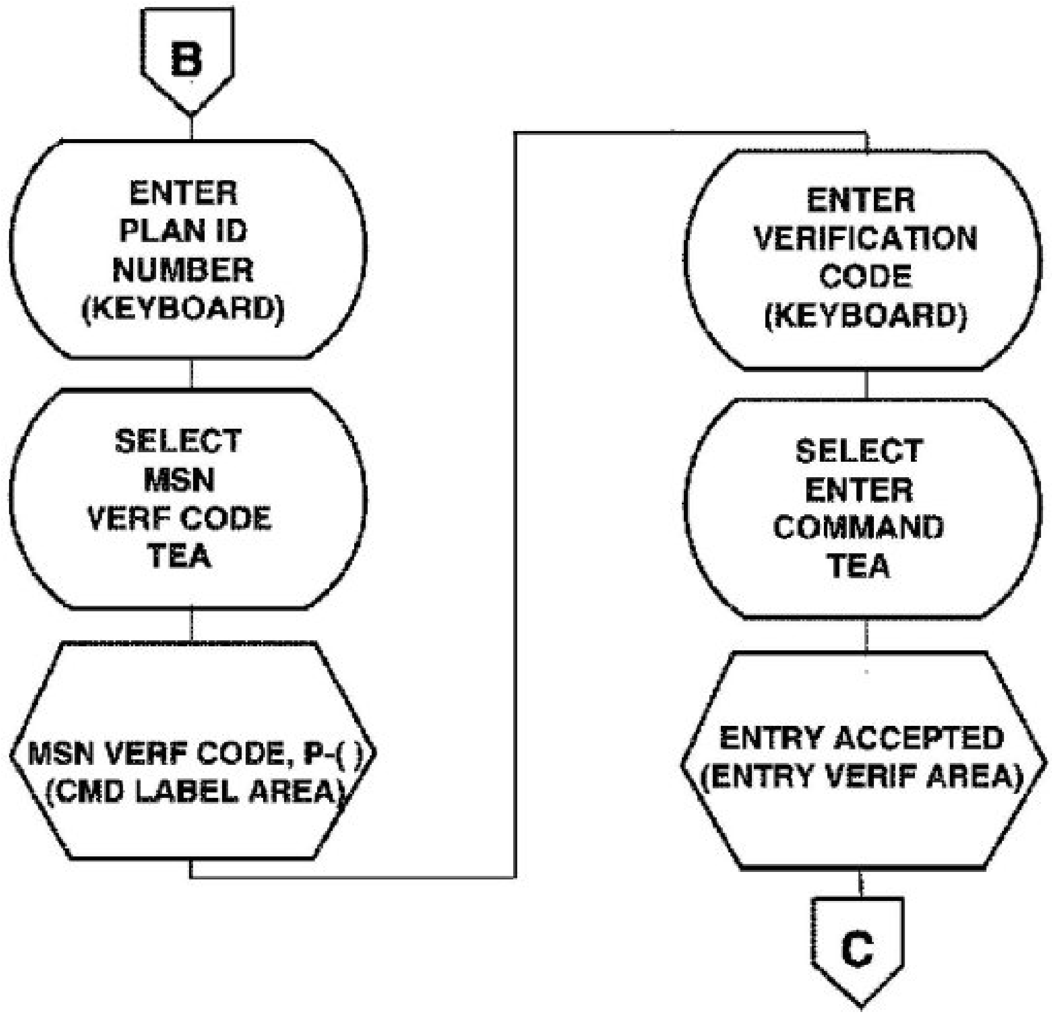
1. WEAPONS CONTROL SYSTEMS POWER UP
2. VERTICAL LAUNCH SYSTEM (VLS MK 41) POWER UP

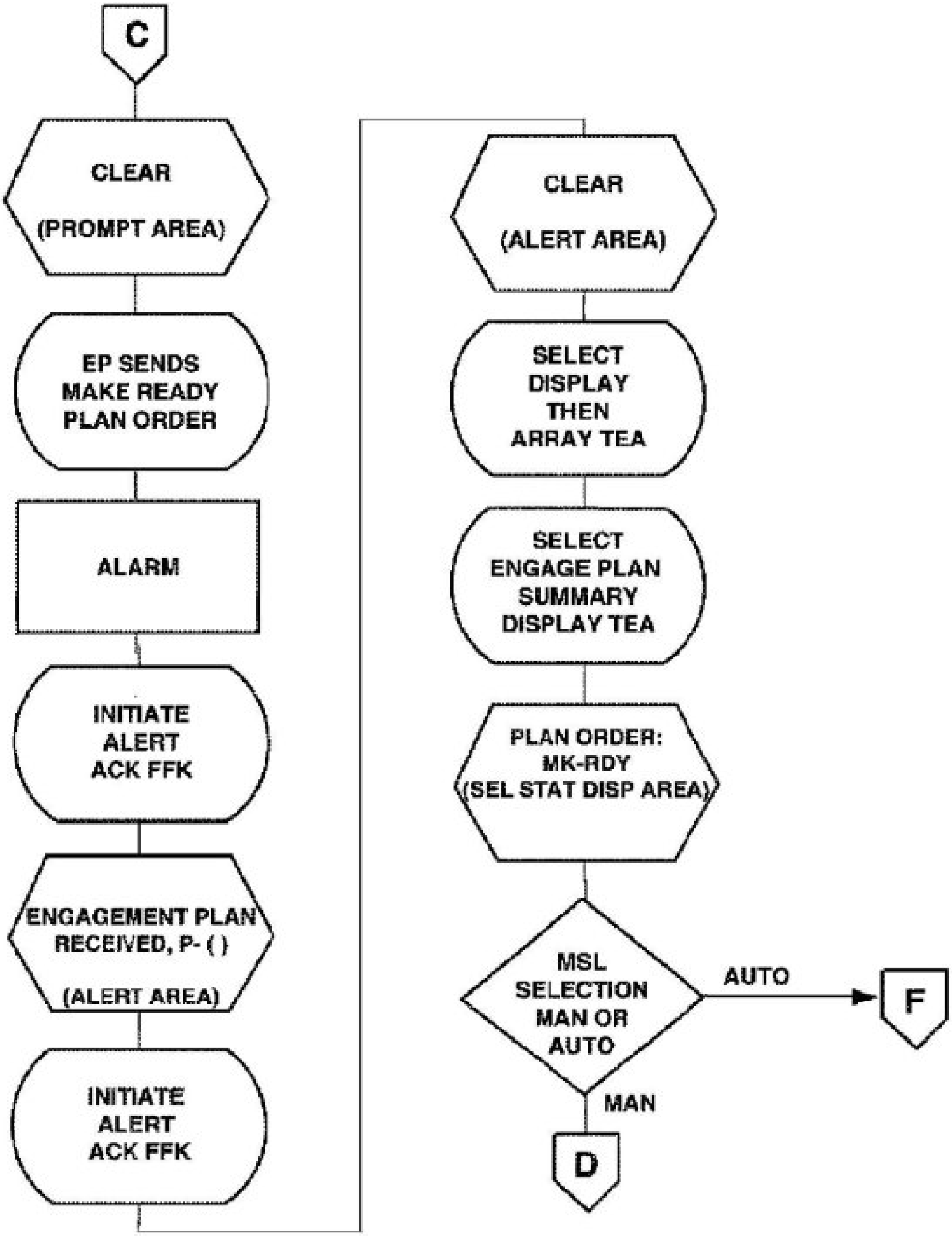
NOTES

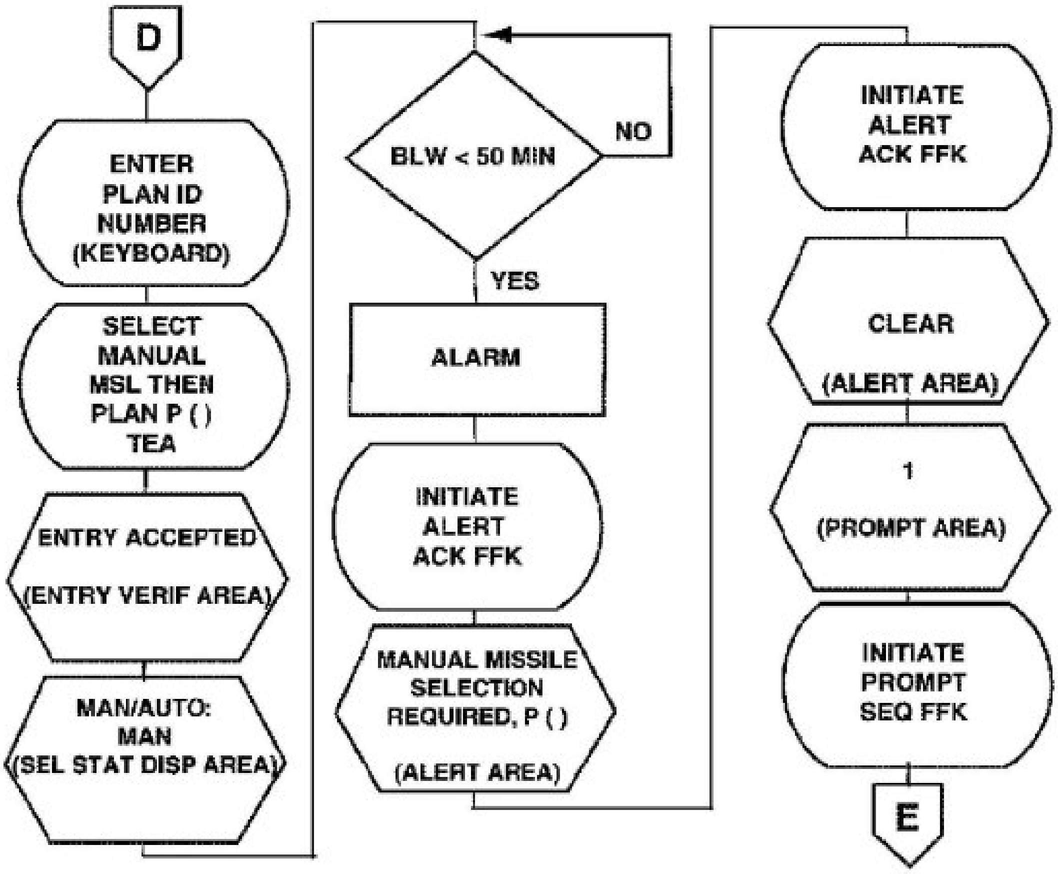
1. FOR SALVO LAUNCH, EVENTS DEPICTED FOR SINGLE LAUNCH WILL BE ACCOMPLISHED FOR EACH MISSILE AND AUR SELECTED FOR LAUNCH SEQUENTIALLY
2. ABORT LAUNCH OPERATIONS ARE PERFORMED IAW NAVSEA OP 3594 VOL 9A
3. DESELECT MISSILES ARE ACCOMPLISHED IAW NAVSEA OP 3594 VOL 9A
4. INOP OF A MISSILE IS MANUALLY ACCOMPLISHED IAW NAVSEA OP 3594 VOL 9A
5. THE SYSTEM PROVIDES SOFTWARE PROGRAMS WHICH AUTOMATICALLY SENDS A CANTCO MESSAGE UNDER CERTAIN CONDITIONS. IF AN ENGAGEMENT PLAN IS UNACHIEVABLE OR UNDESIRABLE, THE LC MAY MANUALLY OUTPUT A CANTCO ORDER TO THE EP.

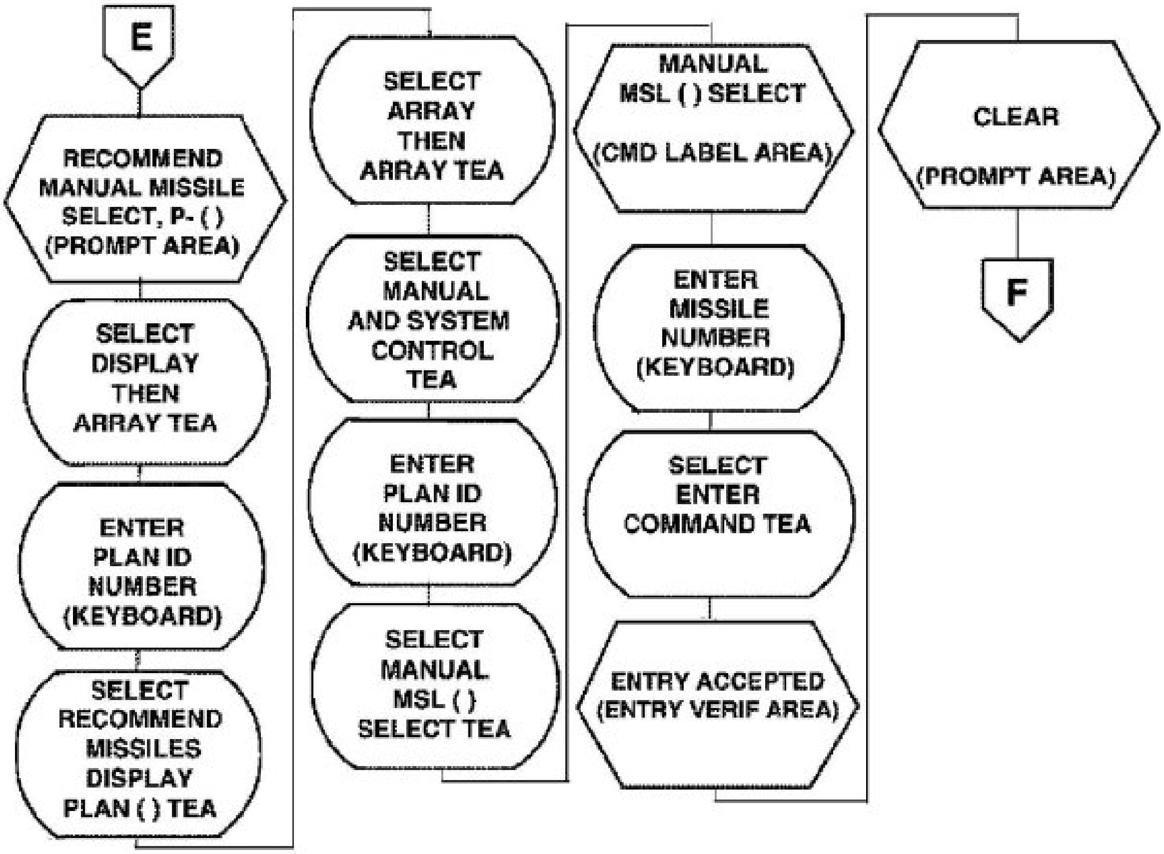

START
LAUNCH AUTHORIZED (CO)
CONVENTIONAL LA MISSION DTD INSTALLED (NOTE 1)
LCG INITIALIZED
NO
INITIALIZE LCG (NOTE 2)
YES
ORDER AND VERIFY LAUNCH ENABLE AND CSES SET (NOTE 3)
VERIFY AUTH MAG AND MAG SEL ARE SET FOR DESIRED MAGAZINE(S)
A
NOTE 1:
THE LCG SYSTEM DTD IS ASSUMED TO BE ALREADY INSTALLED.
NOTE 2:
ON WRN-5 EQUIPPED SHIPS, IF THE WSN-5 UPDATE SOURCE IS NAVSAT, AUTOMATIC UPDATES MUST BE DISABLED TO PREVENT GYRO RESETS DURING MISSILE ALIGNMENT. ON WRN-6 EQUIPPED SHIPS, IF THE WSN-5 IS NOT PLACED IN MANUAL FIX, THE TWCS OPERATORS MUST ENSURE THAT THE QMs HAVE PROPERLY CONFIGURED NAVSSI TO USE ONLY WRN-6 INPUTS AND IC - MEN HAVE CONFIGURED WRN-5 TO USE ONLY GPS UPDATES.
NOTE 3:
IN ACCORDANCE WITH SHIP'S DOCTRINE.

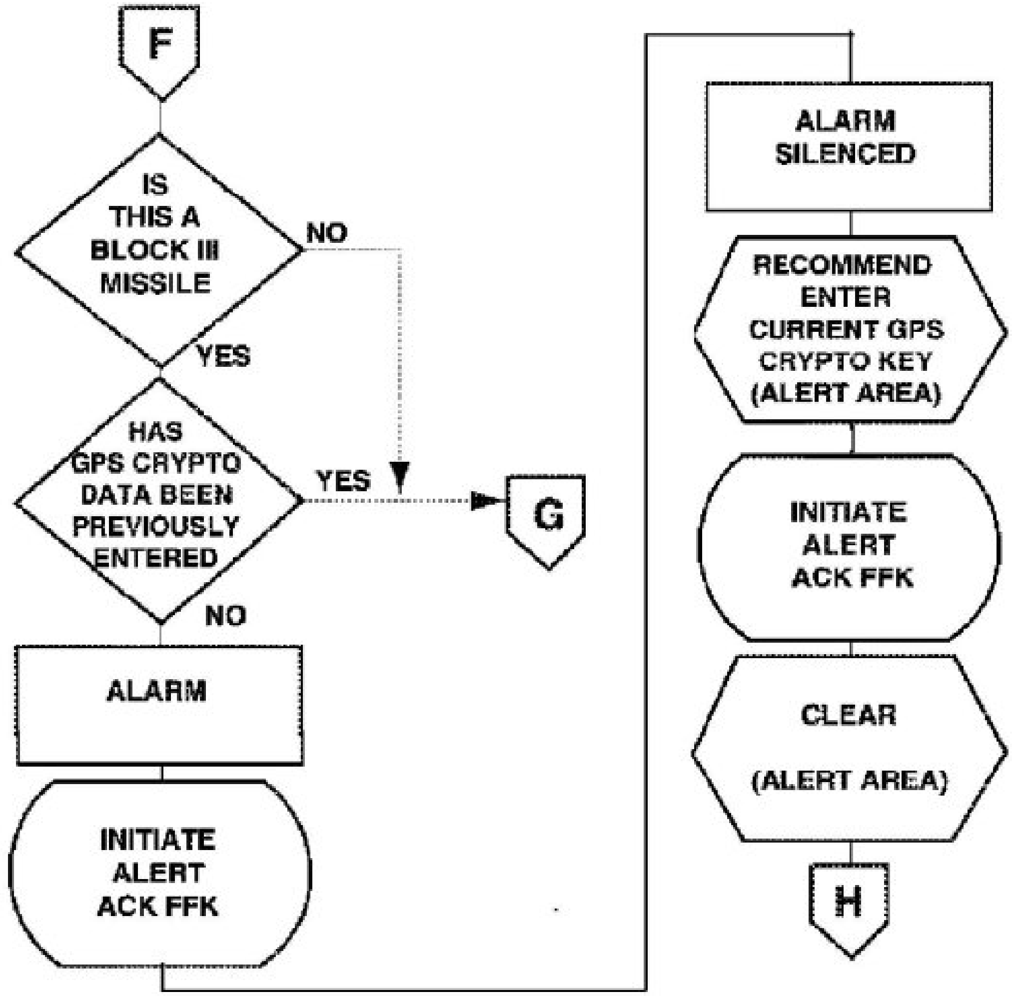

A
EP BUILDS PLAN THROUGH INITIAL PHASE
ALARM
INITIATE ALERT ACK FFK
RECOMMEND ENTER MSN VERF CODE, P- ( )
(ALERT AREA)
INITIATE ALERT ACK FFK
ENGAGEMENT PLAN RECEIVED, P- ( )
(ALERT AREA)
INITIATE ALERT ACK FFK
CLEAR
(ALERT AREA)
1
(PROMPT AREA)
INITIATE PROMPT SEQ FFK
RECOMMEND ENTER MSN VERF CODE, P-( )
(PROMPT AREA)
B

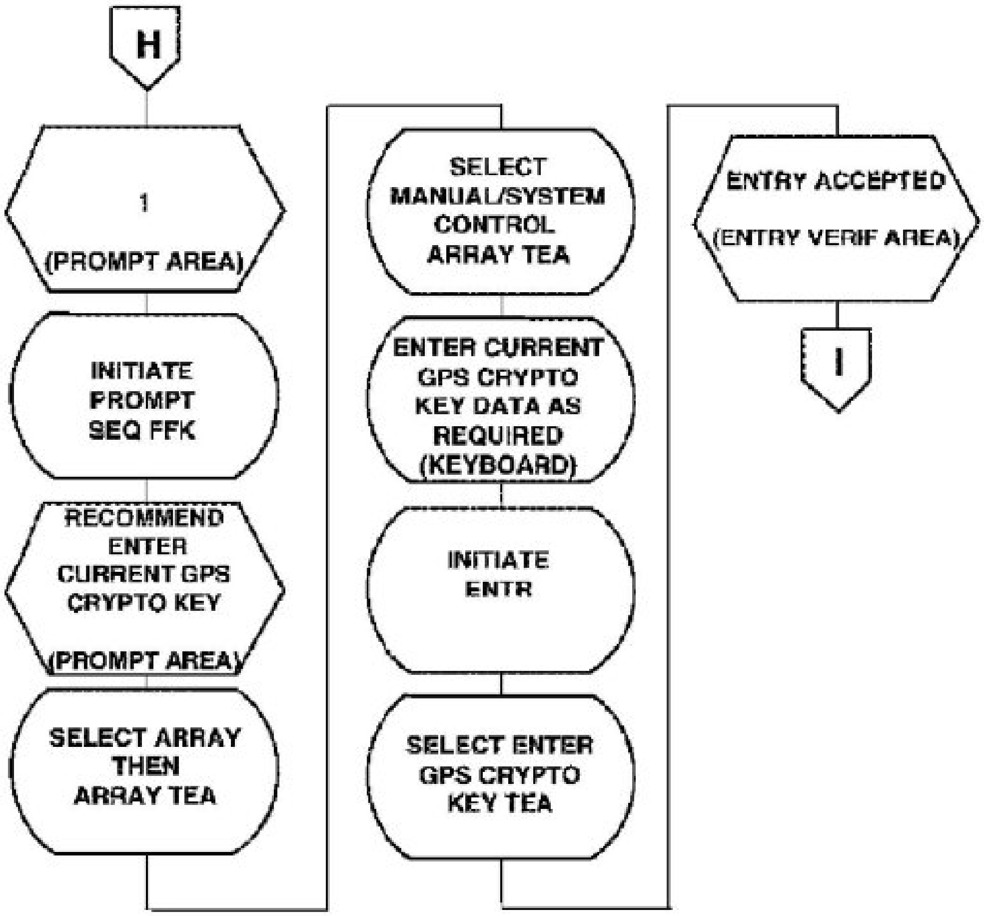

B
ENTER
PLAN ID
NUMBER
(KEYBOARD)
SELECT
MSN
VERF CODE
TEA
MSN VERF CODE, P-( )
(CMD LABEL AREA)
ENTER
VERIFICATION
CODE
(KEYBOARD)
SELECT
ENTER
COMMAND
TEA
ENTRY ACCEPTED
(ENTRY VERIF AREA)
C

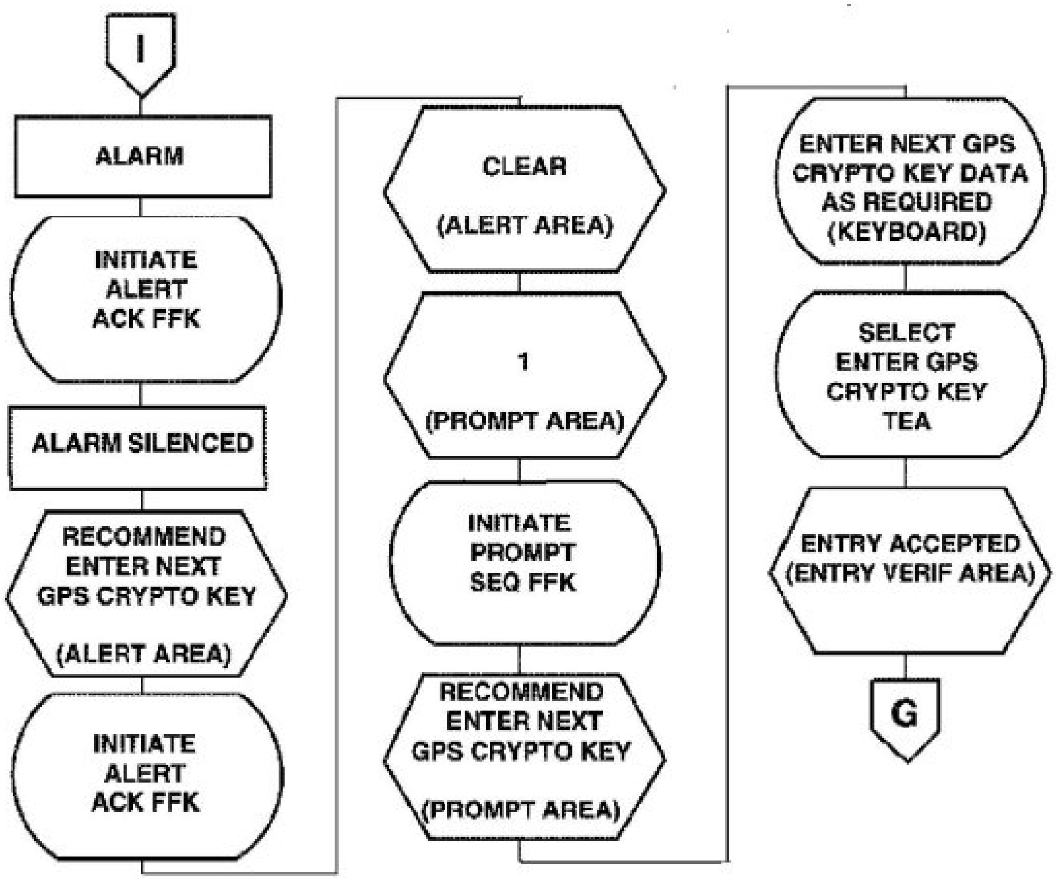

C
CLEAR
(PROMPT AREA)
EP SENDS
MAKE READY
PLAN ORDER
ALARM
INITIATE
ALERT
ACK FFK
ENGAGEMENT PLAN
RECEIVED, P- ( )
(ALERT AREA)
INITIATE
ALERT
ACK FFK
CLEAR
(ALERT AREA)
SELECT
DISPLAY
THEN
ARRAY TEA
SELECT
ENGAGE PLAN
SUMMARY
DISPLAY TEA
PLAN ORDER:
MK-RDY
(SEL STAT DISP AREA)
MSL
SELECTION
MAN OR
AUTO
AUTO
F
MAN
D

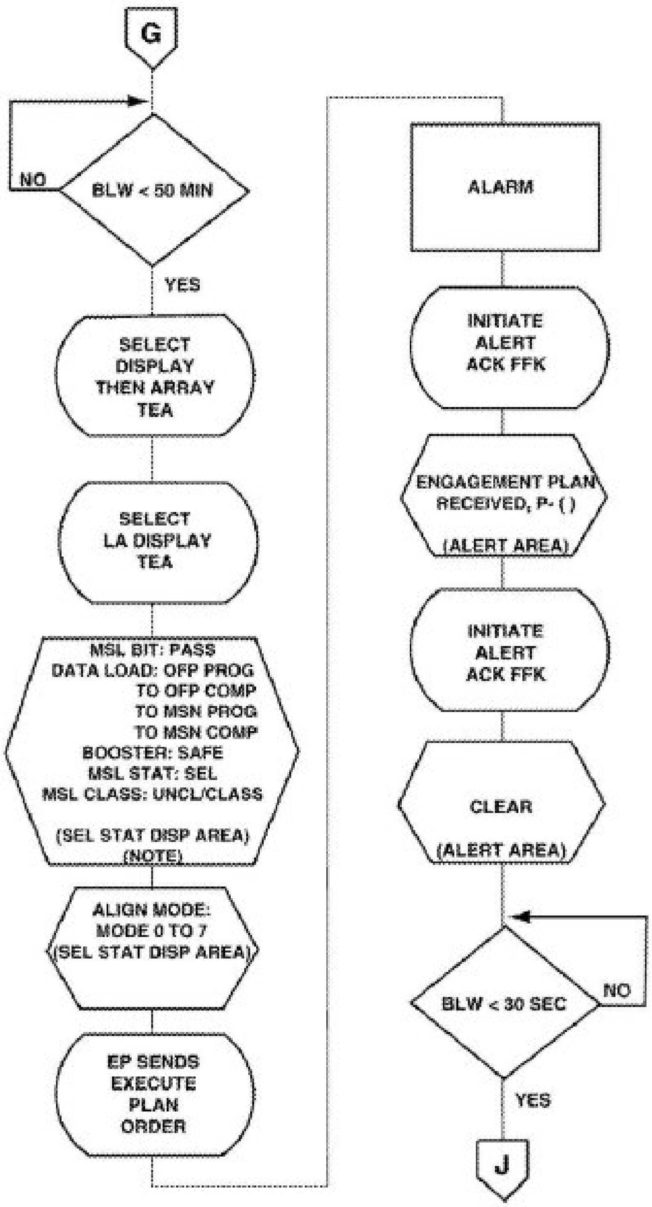

D
ENTER PLAN ID NUMBER (KEYBOARD)
SELECT MANUAL MSL THEN PLAN P ( ) TEA
ENTRY ACCEPTED
(ENTRY VERIF AREA)
MAN/AUTO: MAN
(SEL STAT DISP AREA)
BLW < 50 MIN
NO
YES
ALARM
INITIATE ALERT ACK FFK
MANUAL MISSILE SELECTION REQUIRED, P ( )
(ALERT AREA)
INITIATE ALERT ACK FFK
CLEAR
(ALERT AREA)
1
(PROMPT AREA)
INITIATE PROMPT SEQ FFK
E


E
RECOMMEND MANUAL MISSILE SELECT, P- ( ) (PROMPT AREA)
SELECT DISPLAY THEN ARRAY TEA
ENTER PLAN ID NUMBER (KEYBOARD)
SELECT RECOMMEND MISSILES DISPLAY PLAN ( ) TEA
SELECT ARRAY THEN ARRAY TEA
SELECT MANUAL AND SYSTEM CONTROL TEA
ENTER PLAN ID NUMBER (KEYBOARD)
SELECT MANUAL MSL ( ) SELECT TEA
MANUAL MSL ( ) SELECT (CMD LABEL AREA)
ENTER MISSILE NUMBER (KEYBOARD)
SELECT ENTER COMMAND TEA
ENTRY ACCEPTED (ENTRY VERIF AREA)
CLEAR (PROMPT AREA)
F


F
IS THIS A BLOCK III MISSILE
NO
YES
HAS GPS CRYPTO DATA BEEN PREVIOUSLY ENTERED
YES
G
NO
ALARM
INITIATE ALERT ACK FFK
ALARM SILENCED
RECOMMEND ENTER CURRENT GPS CRYPTO KEY (ALERT AREA)
INITIATE ALERT ACK FFK
CLEAR
(ALERT AREA)
H


H
1
(PROMPT AREA)
INITIATE PROMPT SEQ FFK
RECOMMEND ENTER CURRENT GPS CRYPTO KEY
(PROMPT AREA)
SELECT ARRAY THEN ARRAY TEA
SELECT MANUAL/SYSTEM CONTROL ARRAY TEA
ENTER CURRENT GPS CRYPTO KEY DATA AS REQUIRED (KEYBOARD)
INITIATE ENTR
SELECT ENTER GPS CRYPTO KEY TEA
ENTRY ACCEPTED
(ENTRY VERIF AREA)
I


I
ALARM
INITIATE
ALERT
ACK FFK
ALARM SILENCED
RECOMMEND
ENTER NEXT
GPS CRYPTO KEY
(ALERT AREA)
INITIATE
ALERT
ACK FFK
CLEAR
(ALERT AREA)
1
(PROMPT AREA)
INITIATE
PROMPT
SEQ FFK
RECOMMEND
ENTER NEXT
GPS CRYPTO KEY
(PROMPT AREA)
ENTER NEXT GPS
CRYPTO KEY DATA
AS REQUIRED
(KEYBOARD)
SELECT
ENTER GPS
CRYPTO KEY
TEA
ENTRY ACCEPTED
(ENTRY VERIF AREA)
G



NOTE:
IF THE MISSION DTD CONTAINS A MORE CURRENT DFS/GFS VERSION, THE ALERTS:

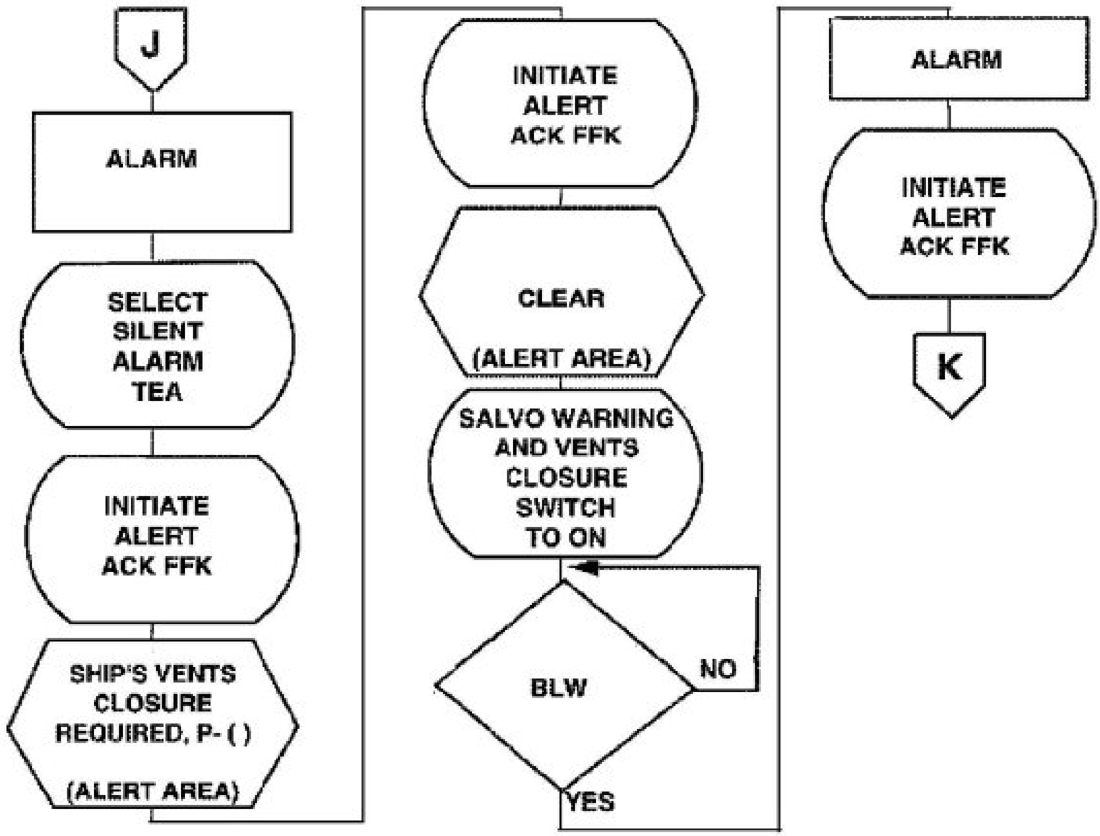
DFS LOAD REQUIRED, MSL- ( )

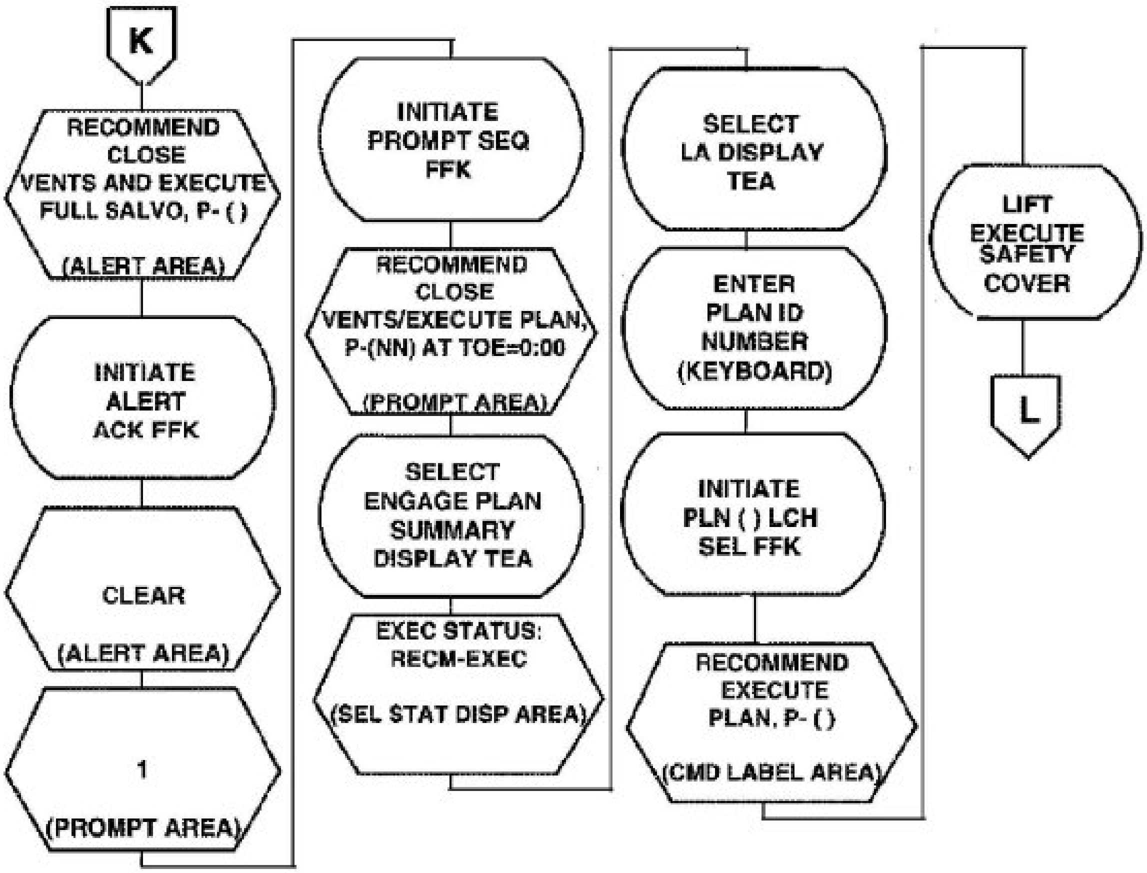
AND/OR

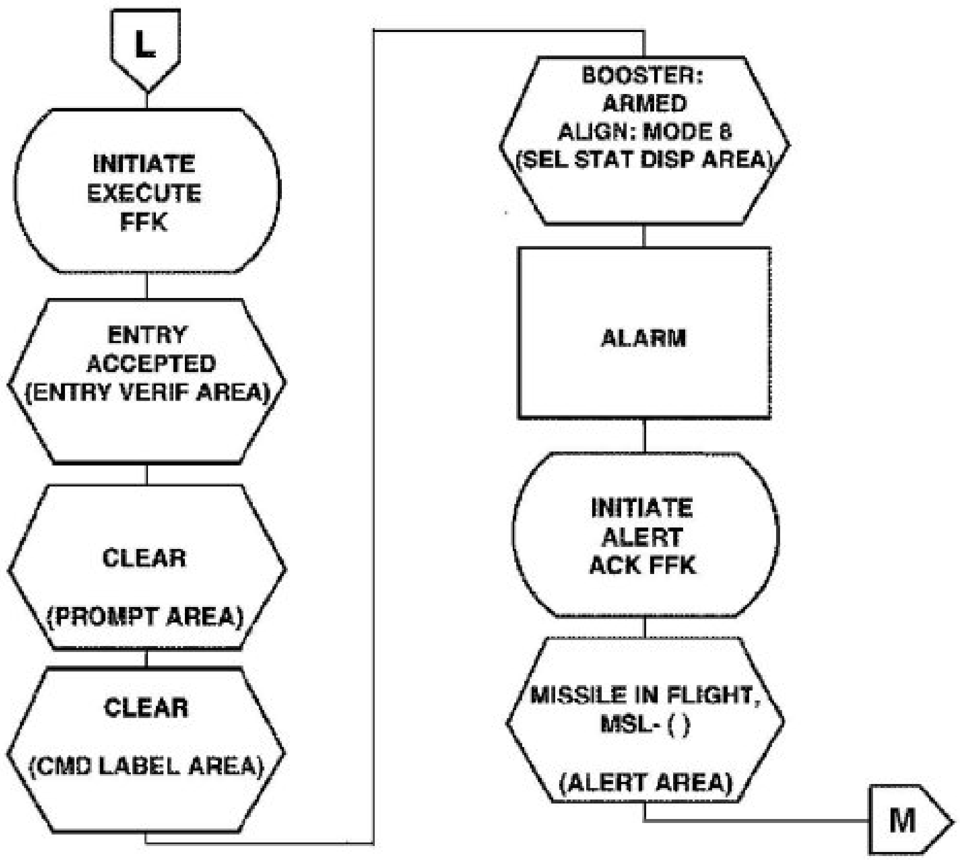
GFS LOAD REQUIRED, MSL- ( )

WILL BE OBTAINED. DATA LOAD WILL ALSO INDICATE

DFS/GFS PROG TO DFS/GFS COMP.


J
ALARM
SELECT
SILENT
ALARM
TEA
INITIATE
ALERT
ACK FFK
SHIP'S VENTS
CLOSURE
REQUIRED, P- ( )
(ALERT AREA)
INITIATE
ALERT
ACK FFK
CLEAR
(ALERT AREA)
SALVO WARNING
AND VENTS
CLOSURE
SWITCH
TO ON
BLW
NO
YES
ALARM
INITIATE
ALERT
ACK FFK
K


K
RECOMMEND CLOSE VENTS AND EXECUTE FULL SALVO, P- ( )
(ALERT AREA)
INITIATE ALERT ACK FFK
CLEAR
(ALERT AREA)
1
(PROMPT AREA)
INITIATE PROMPT SEQ FFK
RECOMMEND CLOSE VENTS/EXECUTE PLAN, P-(NN) AT TOE=0:00
(PROMPT AREA)
SELECT ENGAGE PLAN SUMMARY DISPLAY TEA
EXEC STATUS: RECM-EXEC
(SEL STAT DISP AREA)
SELECT LA DISPLAY TEA
ENTER PLAN ID NUMBER (KEYBOARD)
INITIATE PLN ( ) LCH SEL FFK
RECOMMEND EXECUTE PLAN, P- ( )
(CMD LABEL AREA)
LIFT EXECUTE SAFETY COVER
L


L
INITIATE
EXECUTE
FFK
ENTRY
ACCEPTED
(ENTRY VERIF AREA)
CLEAR
(PROMPT AREA)
CLEAR
(CMD LABEL AREA)
BOOSTER:
ARMED
ALIGN: MODE 8
(SEL STAT DISP AREA)
ALARM
INITIATE
ALERT
ACK FFK
MISSILE IN FLIGHT,
MSL- ( )
(ALERT AREA)
M

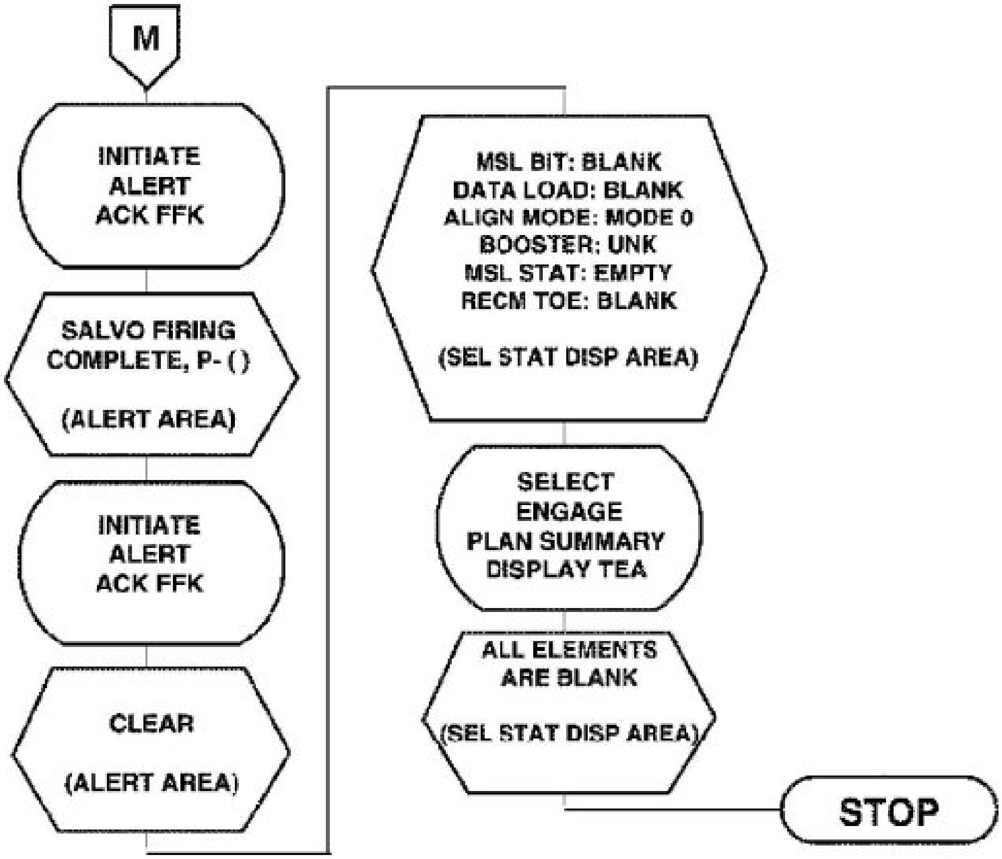

M
INITIATE ALERT ACK FFK
SALVO FIRING COMPLETE, P- ( )
(ALERT AREA)
INITIATE ALERT ACK FFK
CLEAR
(ALERT AREA)
MSL BIT: BLANK
DATA LOAD: BLANK
ALIGN MODE: MODE 0
BOOSTER: UNK
MSL STAT: EMPTY
RECM TOE: BLANK
(SEL STAT DISP AREA)
SELECT ENGAGE PLAN SUMMARY DISPLAY TEA
ALL ELEMENTS ARE BLANK
(SEL STAT DISP AREA)
STOP

Figure 4-33. Multiple All-Up-Round Canister (Fully Loaded)

Figure 4-34. Tilt Fixture Mk 23 Mod 0 with Kit B

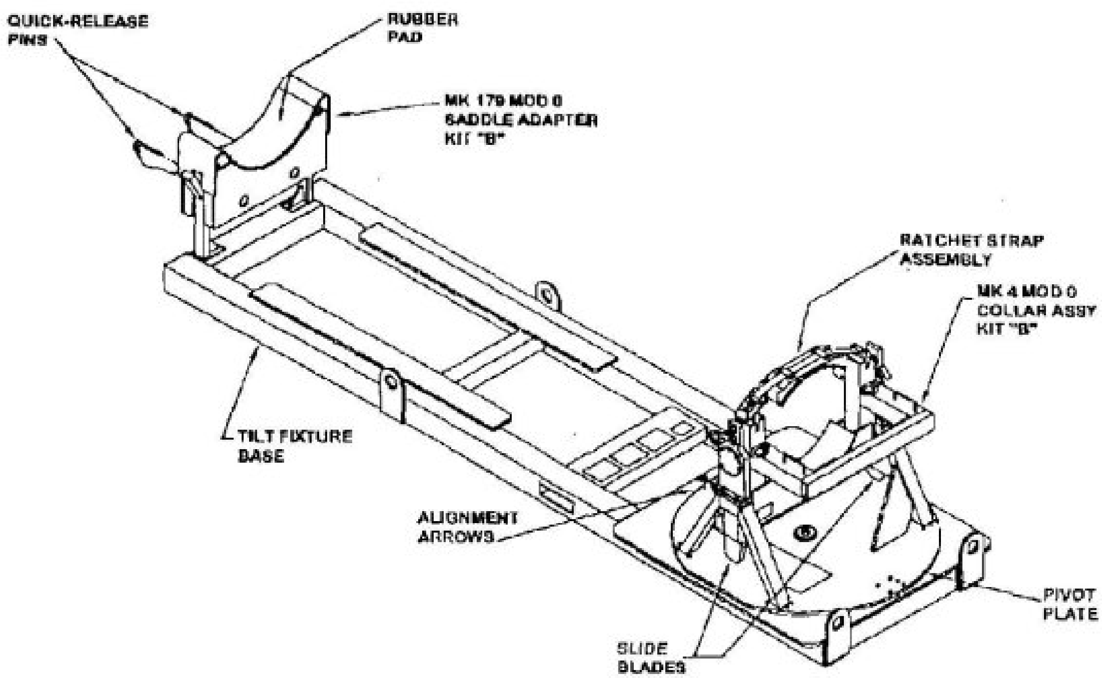


Figure 4-35. Multiple All-Up-Round Canister MTEL Orientation

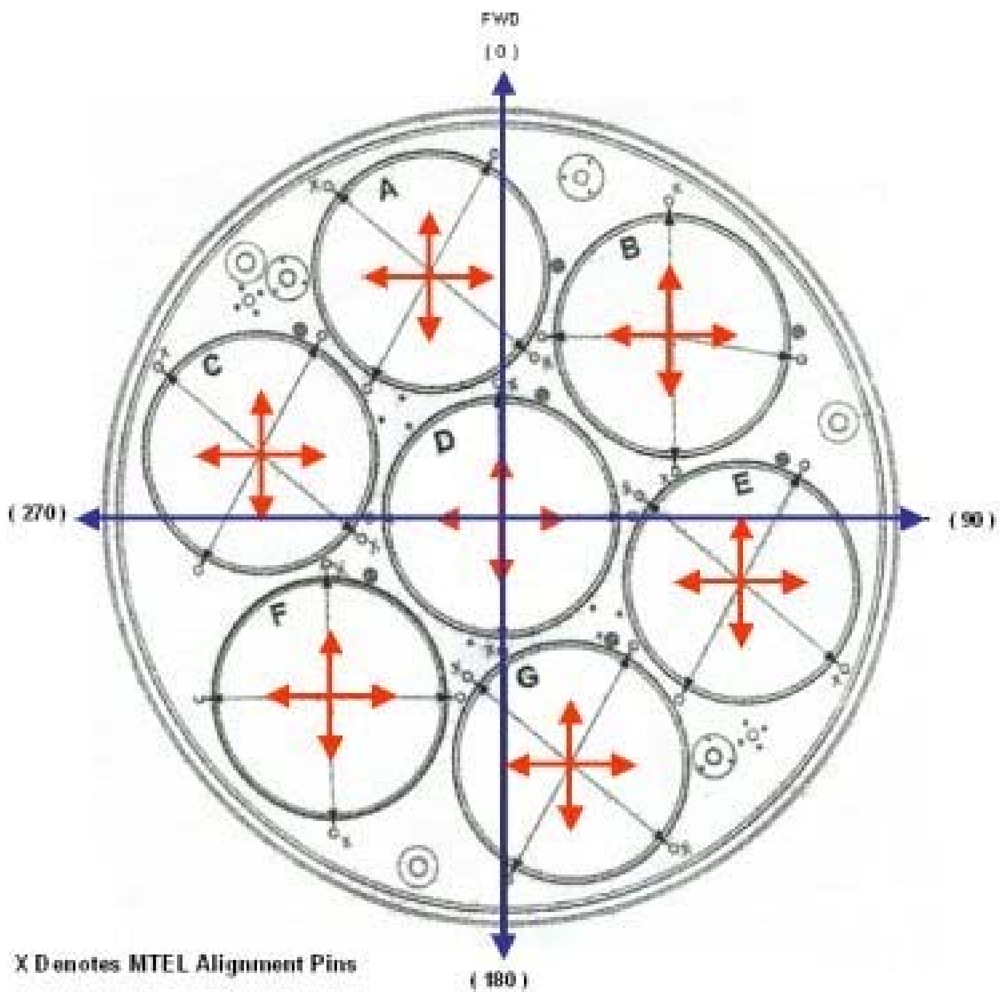


Figure 4-36. AUR Aft Cover Viewed in MAC

Table 4-1. Missile Availability Factors

AVAILABILITY FACTOR	OVERRIDE
Failure in cell	Yes
Number of firings from cell exceeds eight (w/o ORDALT 16235)	Yes
Number of firing counts from cell is/will be 10.75 or greater (w/ ORDALT 16235)	Yes
Missile in cooldown	Yes
Missile fuel leak	Yes
Module hazard/fault	Yes
Module BITE faults	Yes
Launch-sequence detected fault	Yes
Launcher unauthorized by TWCS	No
Canister or plenum cover not present/not dogged down	No
Module declared unavailable	No
Restrained missile firing within module	No
MCP BITE is on but should not be	No
Module set to an offline status	No
No missile in cell	No
Cell and missile already selected for a launching	No
Fault previously reported in half module containing the missile	No
Fault previously reported in missile	No
Launch sequence failure previously reported	No
Launch operations not enabled in VLS	No
Cell-select relay (K1) not energized	No