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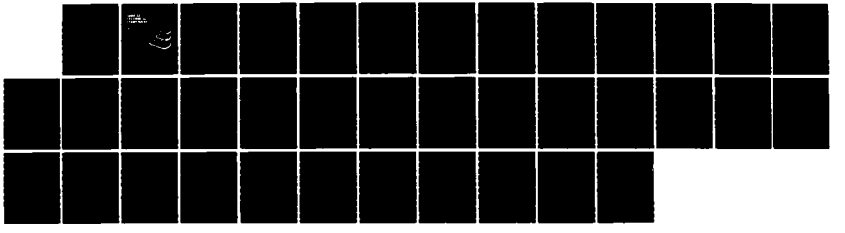

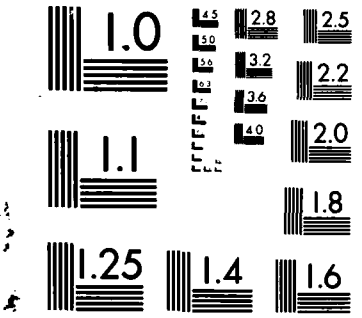

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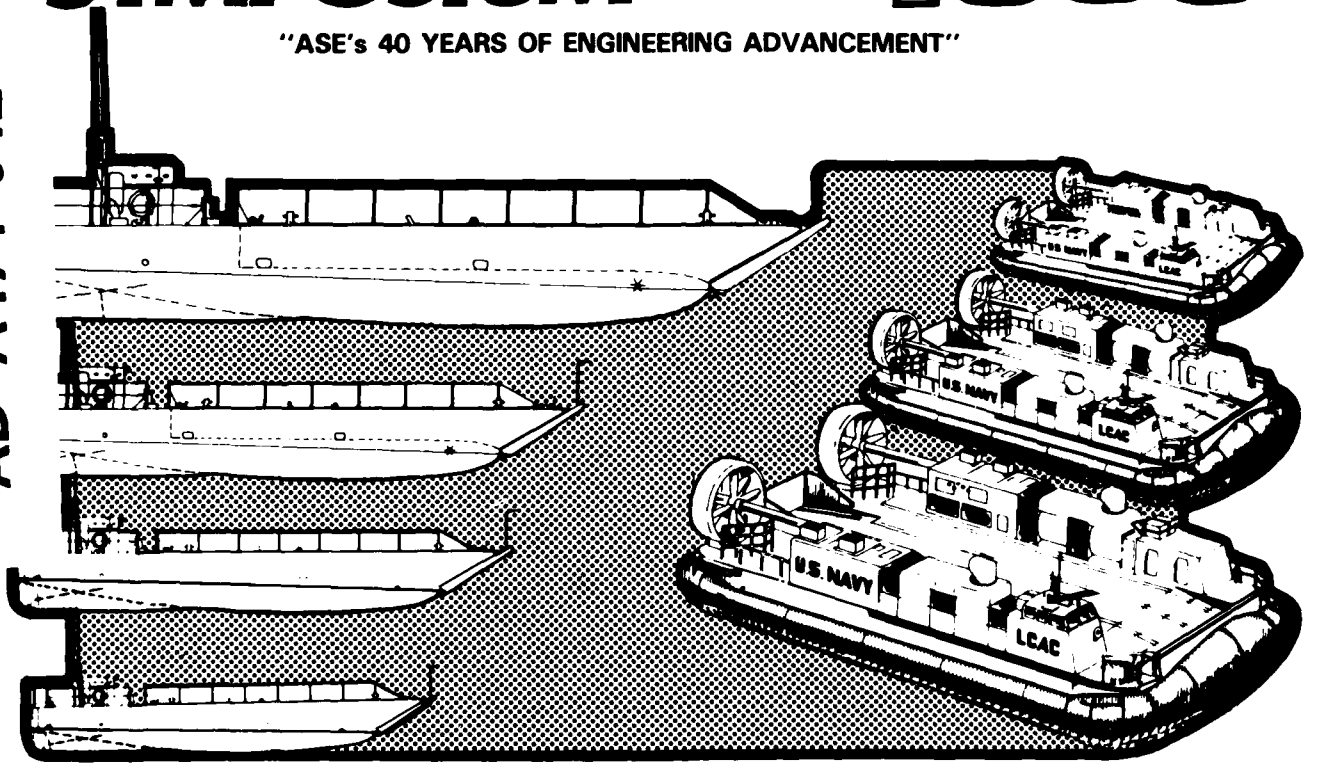

COMBAT SYSTEM TESTING, TRAINING & PERFORMANCE MONITORING

by: D. Tressler

ASSOCIATION OF SCIENTISTS AND ENGINEERS OF THE NAVAL SEA SYSTEMS COMMAND • DEPARTMENT OF THE NAVY • WASHINGTON, D.C. 20362

COMBAT SYSTEM
TESTING, TRAINING AND PERFORMANCE MONITORING

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COMBAT SYSTEM TESTING, TRAINING AND PERFORMANCE MONITORING

ABSTRACT

Combat system and system designs encompassing Testing, Training and Performance Monitoring (TT&PM) attributes are being implemented now, while the CG 47 Class AEGIS Combat Training System/Operational Readiness Test System (ACTS/ORTS) and the DDG 993 Class Combat Simulation Test System (CSTS) are already installed. To date, individual system and combat system design and implementation efforts have proceeded independently, satisfying the specific requirements of each combat system/system sponsor. This is resulting in an improvement in fleet combat system readiness support, but may eventually lead to logistical problems, an inability to conduct battle group TT&PM exercises, and - where system level developements predominate - an inability to conduct combat system level TT&PM functions.

This paper discusses present (CSTS) systems, standardization of combat system TT&PM requirements and implementation of these requirements for future TT&PM capable systems.

The approach defined in this paper is divided into three sections. These sections, while separate in concept, can be progressing concurrently.

Section I - defines the concept and capabilities of the AN/SSQ-91 CSTS presently in the fleet in DDG 993 Class ships, describes similar systems under contract for LHD 1 and MCM 1 ship construction programs, and discusses shorebased applications of CSTS.

Section II - defines the engineering analysis process that will be utilized to define and establish the long range TT&PM technical capabilities and requirements.

Section III - discusses an approach for backfitting TT&PM requirements into the Active Fleet and specifying TT&PM requirements in system/ship procurement programs.

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ACRONYMS

AAW	Anti-Aircraft Warfare
ACDS	Advanced Combat Direction System
ACTS	AEGIS Combat Training System
AFP	Approval for Full Production
AIMS	Aircraft Identification Message System
APL	Allowance Parts List
CCSS	Command and Control Shore Station
CSISEA	Combat System In-Service Engineering Agent
CSTOM	Combat System Technical Operations Manual
CST&A	Combat System Test and Analysis
CSTS	Combat Simulation Test System
CS TT&PM	Combat System Testing, Training and Performance Monitoring
ECM	Electronic Countermeasures
ECN	Engineering Change Notice
ECP	Engineering Change Proposal
F/P/C	Functions, Parameters, and Characteristics
GATS	Gunfire Assessment and Training System
GFCS	Gun Fire Control System
ISEA	In-Service Engineering Agent
ISORTAS	Individual Ship Operational Readiness for Training and Assessment System
LOE	Level of Effort
LTU	Link Terminal Unit
MFCS	Missile Fire Control System
MNS	Mine Neutralization System
MRC	Maintenance Requirement Card
MSORTAS	Multi-Ship Operational Readiness Training and Assessment System
NOSC	Naval Ocean Systems Center
NSWSES	Naval Ship Weapon Systems Engineering Station
NTEC	Naval Training and Education Center
OCSOT	Overall Combat System Operability Test
OEM	Original Equipment Manufacturer
OLSS	Onboard Logistic Support Summary

ACRONYMS (Cont'd)

ORTS	Operational Readiness Test System
ORDALT	Ordnance Alteration
PARMs	Participating Managers
PINS	Precise Integrated Navigation System
PINSCP	Precise Integrated Navigation System Computer Program
PMS	Planned Maintenance Subsystem
POA&M	Plan of Action and Milestones
RCS	Radio Communication System
RESS	Radar Electronic System Simulator
ROC	Required Operational Capabilities
ROH	Regular Overhaul
SAS	Surveillance and AIMS System
SCN	Ship Construction, Navy
SESEF	Shipboard Electronic Systems Evaluation Facilities
SHAPM	Ship Acquisition Participating Manager
SHIPALT	Ship Alteration
SLMs	Ship Logistics Manager
SOM	System Operator's Manual
SORTTS	Shipboard Operational Radar Test and Training System
STEPS	Ship Test and Evaluation Program Standards
SUPSHIP	Supervisor of Shipbuilding
T&C	Test and Certification
TAO	Tactical Action Officer
TCC	Test Control Console
TLR	Top Level Requirements
TLS	Top Level Specifications
TM	Technical Manual
TOR	Tentative Operational Requirements
TSTP	Total Ship Test Program
TT&PM	Testing, Training and Performance Monitoring
UFCS	Underwater Fire Control System

SECTION I
COMBAT SIMULATION TEST SYSTEMS

1.1 BACKGROUND

The first non-AEGIS attempt at implementing a shipboard Combat System Testing, Training and Performance Monitoring (CS TT&PM) capability was the Combat Simulation Test System (CSTS), designated AN/SSQ-91(XN-1), installed in the four DDG 993 Class ships during FY82. The original DDG 993 CSTS deployment concept was to have only the equipment racks and cables built into each of the four ships, with one portable CSTS system available on each coast for shipboard use as required. Enthusiastic fleet acceptance of CSTS provided the impetus to procure a total of four CSTS and permanently install one system in each ship. The enhanced capability to conduct shipboard combat system testing and training prompted other new construction ship classes, e.g. LHD 1, MCM 1, to incorporate the requirement for CSTS.

1.2 CONCEPT

The CSTS concept is to maintain combat system readiness by using onboard simulators/stimulators in a distributed processing system to exercise a ship's combat system. By injecting computer generated information into selected elements of the combat system, the CSTS provides realistic presentations of combat mission scenarios.

1.3 DDG 993 CLASS CSTS

The first CSTS was developed by NAVSEA to provide a shipboard combat system testing and training capability for DDG 993 Class ships. CSTS evolved from earlier in-plant testing systems developed to support combat system equipment testing. The current configuration of DDG 993 CSTS consists of a distributed-data processing system which uses hardware interconnected by a common data bus (see Figure 1.1). CSTS hardware includes data processors and sensor signal simulators.

DDG 993 CSTS uses the design of several Command and Control Shore Station (CCSS) simulators and many of their computer programs. CSTS distributes the functions which were performed by the central CCSS computer and considerable peripheral equipment directly to the shipboard equipment. Using the ship's installed equipment, the CSTS is designed to enable the training of combat system operators at the consoles which are already familiar to them. The CSTS provides data to the operator positions by simulating a live environment. The system is designed to allow shipboard testing and training concurrent with the normal full capability mode, without modification to the ship's equipment or computer programs.

The CSTS is a dual-purpose system used for team training of the ship's combat system operators and for operability testing of the ship's combat system equipment. The ship systems which are presently operating in conjunction with the CSTS include the radio communication system (RCS), surveillance and AIMS system (SAS), gun fire control system (GFCS), missile fire control system (MFCS), underwater fire control system (UFCS), and the ship's log and gyro system. The combat system display consoles receive simulated two-dimensional and three-dimensional radar video inputs, and simulated IFF data from the Video Signal Simulator (SM-441). These simulated video inputs can be changed by the test director from the Test Control Console (TCC) or by his assistant working at the adjacent Link 4A/Link 11 console. Data can also be generated for use by the MFCS MK 74 and GFCS MK 86 tracking systems to provide simulated targets that are coordinated with the search radar targets. Table 1.1 identifies the range and type of target parameters available to the test director.

1.4 LHD 1 CSTS

The CSTS, currently in development for LHD 1, will utilize a design similar to that of the DDG 993 Class CSTS (see Figure 1.2). Tentative enhancements/changes incorporated into the LHD 1 CSTS system include:

a. Improved high speed serial data bus operation developed as a feature in support of speed and future growth.
b. Embedded node processors in all simulators and stimulators versus stand-alone processors.

c. Radar stimulation function for front end injection of scenario data into the following sensors:
   - AN/SPS-49 2-D Long Range Search Radar
   - AN/SPS-52 3-D Search Radar
   - AN/SPS-67 Surface Search Radar
   - AN/UPX-29 IFF System

d. Replacement of existing Link 11 simulator (AN/USQ-76 Modem/Link Terminal Unit (LTU) and stand alone node processor) with three card set simulator for Modem/LTU and embedded node processor.

e. Extension of Ownship Simulation and Environmental functions to include:
   - Live roll, pitch and heading
   - Fully simulated roll, pitch and heading
   - Chaff
   - Coherent Electronic Countermeasures (ECM)
   - Noncoherent ECM
   - Sea Clutter
   - Rain and clouds
   - Landmass

1.5 LHD 2,3,4 CSTS

In addition to the LHD 1 capabilities listed in paragraph 1.4, the CSTS currently proposed for LHD 2,3,4 will add radar stimulation to both the AN/SPN-35 radar and the AN/SPN-43 radar and, with the substitution of the AN/SPS-48 radar for the AN/SPS-52 radar, provide stimulation for the AN/SPS-48 radar (see Figure 1.3).

1.6 MCM 1 CLASS CSTS

The major purpose of the MCM 1 CSTS is to provide interactive combat system operator/team training with the three primary elements of the combat system: (1) Precise Integrated Navigation System (PINS); (2) AN/SQQ-30 Mine Detecting/Classifying Set; and (3) the Mine Neutralization System (MNS) (see Figure 1.4).

The system will be designed to satisfy the following operational requirements:

a. Provide for combat system proficiency training to be conducted at the operator, subteam, and tactical decision-maker levels.
b. Provide for combat system operability testing to verify combat system control and display elements.
c. Provide for combat system performance monitoring to operationally assess the combat system elements and personnel.

The CSTS will meet the above requirements by providing the following shipboard pabilities:

a. Realistic simulation with training scenarios in Detection/Classification, Mine Neutralization, Route Survey, and Minesweeping mission areas.

b. Interactive response to combat system control and display elements as well as console operator inputs.

c. Dynamic stimulation of control and display elements of the combat system.

d. Selectable equipment operating modes to accommodate training at both the operational and tactical levels and testing at all levels.

e. System-level operability reporting for post-evaluation.

f. Selectable test scenario parameters within the performance criteria of the combat system elements.

g. On-line data extraction/data formatting of selectable performance characteristics.

h. Off-line data reduction/data formatting of selectable performance characteristics.

1.7 SHORE-BASE APPLICATIONS

A derivative of the AN/SSQ-91 is under consideration for installation at the Shipboard Electronic Systems Evaluation Facilities (SESEFs) and at various Supervisor of Shipbuilding (SUPSHIP) locations to facilitiate testing of shipboard Link 4A and Link 11 systems (see Figure 1.5.).

SECTION II
COMBAT SYSTEM TT&PM
DESIGN REQUIREMENTS DEVELOPMENT

2.1 BACKGROUND

Establishment of CNO requirements for shipboard combat system TT&PM capabilities has resulted in the initiation of a multitude of hardware and computer program development efforts for equipment, systems and combat systems. Many of these development efforts are proceeding independently, satisfying the requirements and constraints of each individual program. Without adequate coordination and integration with combat system elements, these individual efforts will not culminate in shipboard combat system and battle force level TT&PM capabilities.

2.2 INTRODUCTION

This section describes the engineering approach that will be followed to develop top-down combat system TT&PM design requirements (see Figure 2.1). This section describes the organization, responsibilities, and actions required to establish an analytical basis for such requirements. While the approach capitalizes on the lessons learned and experiences gained in prior efforts, it makes no attempt to reiterate the same material. It should also be noted that the resultant design requirements will not be "TT&PM System requirements", but standard combat system design requirements for TT&PM. The implementation of these requirements may result in a TT&PM system, but will more likely result in modifications to the combat system elements to provide a combat system TT&PM capability.

2.3 OPERATIONAL REQUIREMENTS

OPNAV is imposing TT&PM operational requirements on all new ship classes in the Required Operational Characteristics (ROCs). These requirements are typified by those contained in the LHD 1 ROC:

"Capability shall be provided to facilitate shipboard element, subteam, and team operational training."

"Capabilities shall be provided to facilitate various levels of equipment, subsystems, and combat system testing and readiness assessment."

In addition, OPNAV has promulgated three separate Tentative Operational Requirements (TORs) addressing shipboard combat system and battle group TT&PM requirements. These TORs are listed below:

1. TOR for Individual Ship Operational Readiness for Training and Assessment System (ISORTAS)
2. TOR for Multi-Ship Operational Readiness Training and Assessment System (MSORTAS)
3. TOR for Gunfire Assessment and Training System (GATS).

While the above operational requirements tend to focus on training issues, NAVSEA has promulgated Ship Test & Evaluation Program Standards (STEPS) #1 that defines combat system level testing requirements and responsibilities. This standard states that:

"Combat system level testing shall be engineered to assess overall combat system readiness to perform in accordance with the ship's Required Operational Capabilities (ROC), Top Level Requirements (TLR), Top Level Specifications (TLS) and combat system documents approved for use by NAVSEA. Test procedures shall be developed at the highest practicable level to assess overall combat system material and operational readiness. Combat system level test requirements, development, maintenance and use shall be coordinated with all levels and stages of testing to ensure complete test coverage and minimum test redundancy."

2.4 ENGINEERING APPROACH

The DDG 993 Class, which encompasses a high degree of combat system complexity, has been designated as the model for the CS TT&PM engineering analysis. The combat system configuration will be fully documented. In accordance with MIL-P-24534, a Level 1 combat system interface block diagram will be prepared (see Figure 2.2) and all data that is passed between systems will be tabulated. Figure 2.3 is the DDG 993 Combat System Interface Block Diagram. Each interface path will be numbered for identification. All data that crosses each numbered interface will be tabulated, identified as Level 1,2,3

or 4 data and grouped functionally by the ship's warfare requirements specified in the ROC. Table 2.1 shows a portion of the tabulated data, grouped under the "Anti-Aircraft Warfare (AAW) engagement" function. All analog and digital parameters will be included.

The Table 2.1 data for the entire combat system will be consolidated into a single document which lists the ship's combat system functions, parameters and characteristics (F/P/C) by warfare area. The Level 1 F/P/C listing will serve as the basis for all TT&PM analysis. Responsibility has been assigned to separate Navy activities, cognizant experts in the fields of testing, training and performance monitoring, to analyze the Level 1 F/P/C data. This analysis shall determine:

- o Testing - Which F/P/C data must be evaluated in order to assess multi-ship, combat system and system material readiness? At which of these levels and how is the data most readily measured?

- o Training - Where is F/P/C data incorporated in individual training courses? What data is necessary to include in proficiency training scenarios? What data must be evaluated in order to assess multi-ship, combat system and system personnel readiness?

- o Performance Monitoring - What routine information is required by the various levels of command? How does this information correlate with the F/P/C listing? How often must the F/P/C data be observed to satisfy the information requirements?

The analysis of the Level 1 F/P/C Requirements List will substantially reduce the number of F/P/C elements in the list that should be considered for application of TT&PM. The analysis will identify and delete those Level 1 functions, parameters, and characteristics that are readily observable, or those that should be considered under other programs, such as normal Planned Maintenance Subsystem (PMS) test procedures or shorebased training curricula. Thus, the engineering analysis process reduces the original Combat System F/P/C list to a CS Level 1 F/P/C Requirements List, and further reduces it to a list of CS Level 1 TT&PM functions, parameters and characteristics which must serve as the basis for subsequent TT&PM design analysis.

TT&PM design analysis will concentrate on translating the CS Level I TT&PM functions, parameters and characteristics into actual system performance requirements, such as "numbers of simulated targets," "scenario control," "system architecture," etc. Figure 2.4 is an example of how the F/P/C data would be translated into "numbers of simulated targets."

SECTION III
COMBAT SYSTEM TT&PM
CAPABILITY IMPLEMENTATION

3.1 INTRODUCTION

This section addresses the near-term procurement of existing testing and training systems for high-priority active fleet platforms, invoking of standardized TT&PM Top Level Requirements (TLR) into new construction ship specifications, integration of the TT&PM standards/specifications (described in Section II) into prime equipment/system development/procurement specifications and the overall implementation of CS TT&PM capability into the fleet.

3.2 APPROACH

The immediate requirement is to provide shipboard Combat System testing and training capability for existing fleet units. CNO msg of Aug 85 addresses procuring CSTS-type systems (wrap-around, operational program independent) for additional ship classes, i.e. CGN 36/38, DD 963, CVN 68, LHA 1, LCC 19. The initial configuration for these ships would be based on the generic CSTS architecture illustrated in Figure 3.1. After incorporation of the CS TT&PM Standard and Specifications, discussed in Section II, it is assumed that the architecture would resemble the generic CSTS/embedded systems architecture illustrated in Figure 3.2.

3.3 NEAR-TERM IMPLEMENTATION

Near-term implementation of CS TT&PM capability would consist of integrating existing testing and training systems, e.g. AN/SSQ-91 CSTS, AN/USQ-93 RESS, for non-Battle Group core ships. Figure 3.3 illustrates the proposed configuration for DDG 993 class, which integrates the New Threat Upgrade (NTU) shipboard training system with the existing CSTS. This configuration would also be applicable to other medium-range missile ship classes, i.e., CGN 36/38. This same concept also applies to DD 963 Class ships (see Figure 3.4).

For Battle Group core ships, the TT&PM system architecture would replicate that of the LHD Class CSTS. The ship classes proposed to be in this group consist of CVN 68, LHA 1 and LCC 19.

3.4 LONG-TERM IMPLEMENTATION

The method of implementing the TT&PM requirements resulting from the engineering effort described in Section II will be determined by their nature and magnitude. If the TT&PM requirements can be satisfied through modifications to the elements of the combat system, then the NAVSEA element managers will plan, develop and procure the alterations. Coordination between the element managers will be provided to ensure that TT&PM requirements are being satisfied and integrated.

However, if the TT&PM requirements cannot be satisfied by system modifications, and new hardware or computer programs are necessary (e.g., a new TCC or a high speed data bus), then new responsibilities for managing their development and acquisition must be assigned.

TABLES

Table 1.1 - DDG 993 Class CSTS Target Parameters

DATA ITEM	RANGE/UNITS
Simulated Track Number	1 - 900
Bearing of Target (1)	0 -359 degree (1 degree increments)
Range of Target (1)	0 - 1000 miles (.1 mile increments)
Relative X Location of Target (1)	-1000 to +1000 (.1 mile increments)
Relative Y Location of Target (1)	-1000 to +1000 (.1 mile increments)
Latitude of Target (Degrees)	-90 to +90 (1 degree increments)
Latitude of Target (Minutes)	0 to +59.9 (.1 minute increments)
Longitude of Target (Degrees)	-180 to +180 (1 degree increments)
Longitude of Target (Minutes)	0 to 59.9 (.1 minute increments)
Altitude/Depth of Target	-800 to 100,000 (1 foot increments)
Dive/Climb Angle	0 to 90 degrees (1 degree increments)
Heading Rate Change	-360 to +360 (1 degree per second)
Target Heading	0 to 359 (1 degree increments)
Speed Change Rate	0 to Target Final Speed (1 knot per second)
Target Speed	0 to 2047 (1 knot increments)

SENSOR	MAXIMUM NUMBER OF SIMULATED TARGETS (6)	MAXIMUM SIMULATED RANGE
2D/3D Radar(s)	64 (1)	Air - 512 Miles (2)
AN/SPQ-9	4 (3)	20 Miles (4)
AN/SPG-60	1	Air - 75,000 Yards
AN/SPG-51D	2	Air - 100,000 Yards
		Surface - 40,000 Yards
AN/SQS-53A	8	(5)

NOTES:

(1) Maximum of 6 Targets at same Azimuth.
(2) Function of Radar Horizon. Program Limitation = 512 Miles
(3) Maximum of 4 Targets at same Azimuth.
(4) Function of Target Elevation - must be within vertical beam width of AN/SPQ-9 to be eligible for display (low flyers).
(5) Function of Simulated Oceanographic Data and Sonar Mode.
(6) Combined number of simultaneous targets shall not exceed 64.

Table 2.1 - AAW Engagement F/P/C (Partial)

NUMBER	SIGNAL	SYMBOL	SOURCE	VIA	DESTINATION	LEVEL
482-WD	ASCM ALERT (ASCM)	(DIGITAL)	WDS	DDS No. 2	CDS	
482-WD	COAST STATUS	(DIGITAL)	WDS	DDS No. 2	CDS	
482-WD	PASSIVE ANGLE TRACK (PAT)	(DIGITAL)	WDS	DDS No. 2	CDS	
482-WD	MULTIPLE TARGETS (MULTI TGT)	(DIGITAL)	WDS	DDS No. 2	CDS	
482-WD	RANGE VALID (RNG VAL)	(DIGITAL)	WDS	DDS No. 2	CDS	
482-WD	OFA RESPONSE	(DIGITAL)	WDS	DDS No. 2	CDS	
482-WD	CANNOT COMPLY (CANTOO)	(DIGITAL)	WDS	DDS No. 2	CDS	
482-WD	TARGET ENGAGABLE (TGT ENG)	(DIGITAL)	WDS	DDS No. 2	CDS	
482-WD	TARGET SCHEDULE (SCHD)	(DIGITAL)	WDS	DDS No. 2	CDS	
482-WD	TARGET SCHEDULE (SCHBL)	(DIGITAL)	WDS	DDS No. 2	CDS	

FIGURES

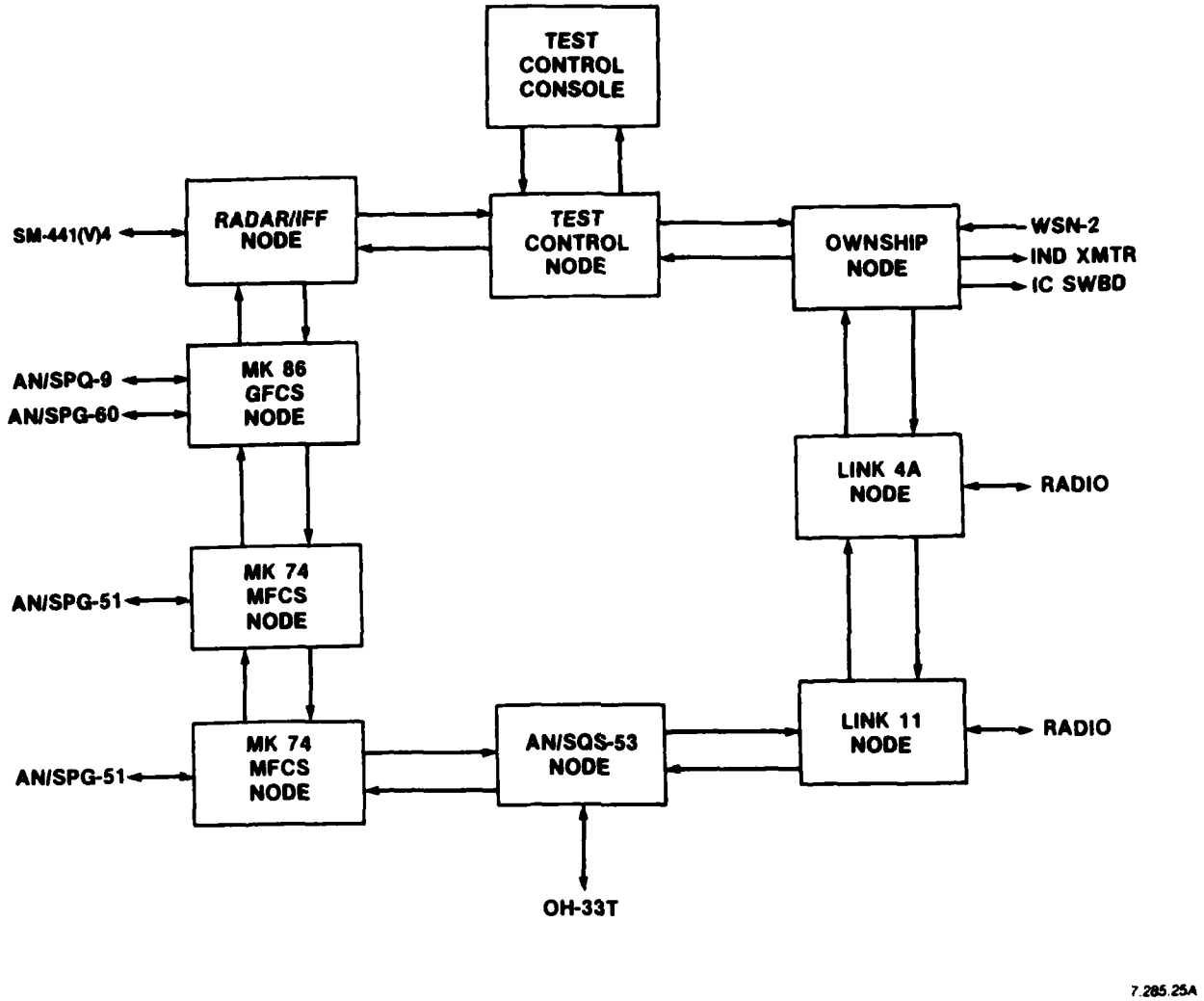


Figure 1.1 - DDG 993 Class AN/SSQ-91(XN-1) CSTS
Simplified Block Diagram

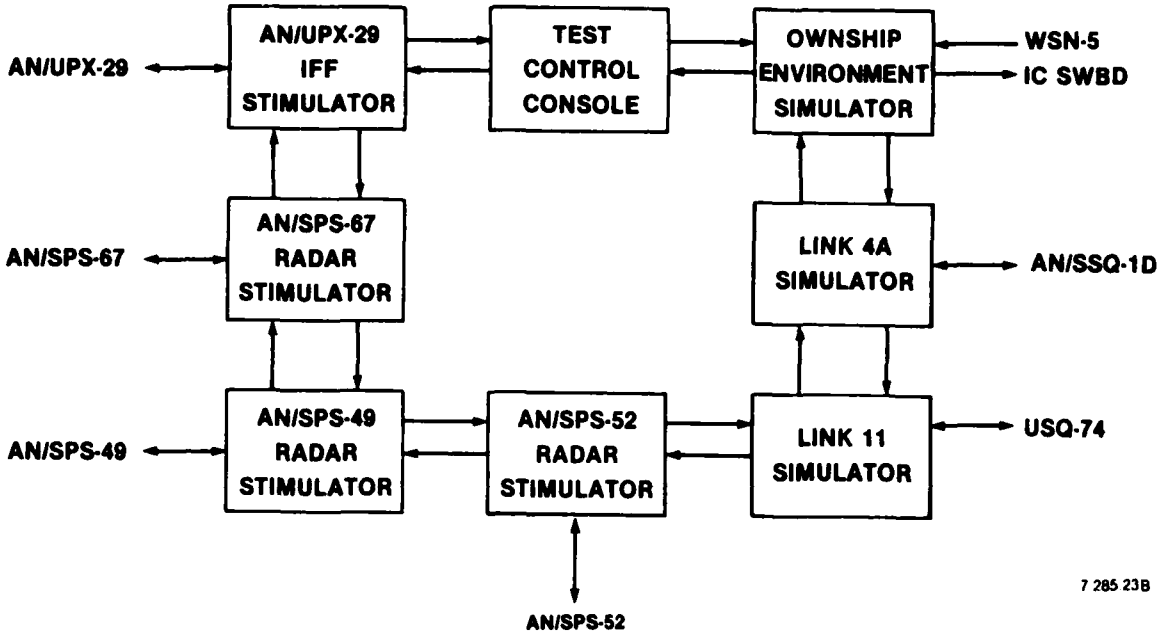


Figure 1.2 - LHD 1 AN/SSQ-91(V) CSTS
Simplified Block Diagram

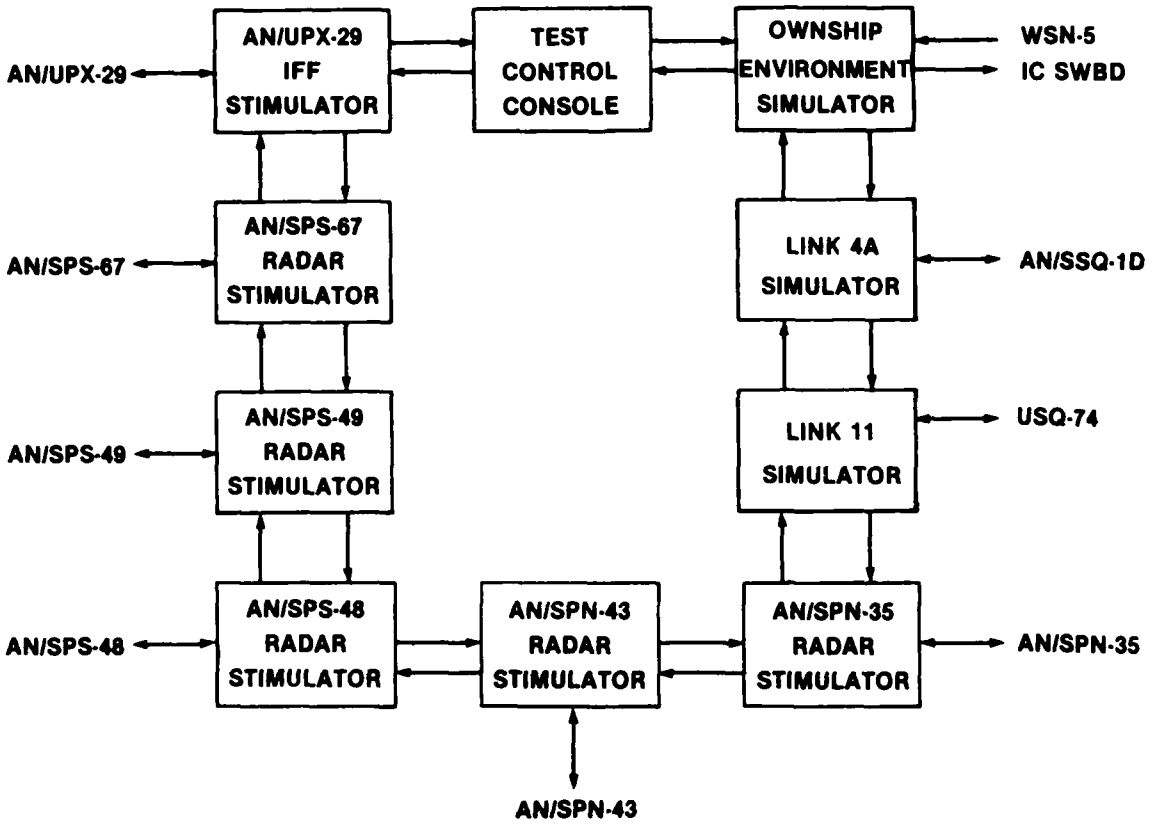


Figure 1.3 - LHD 2,3,4 AN/SSQ-91(V) CSTS
Simplified Block Diagram

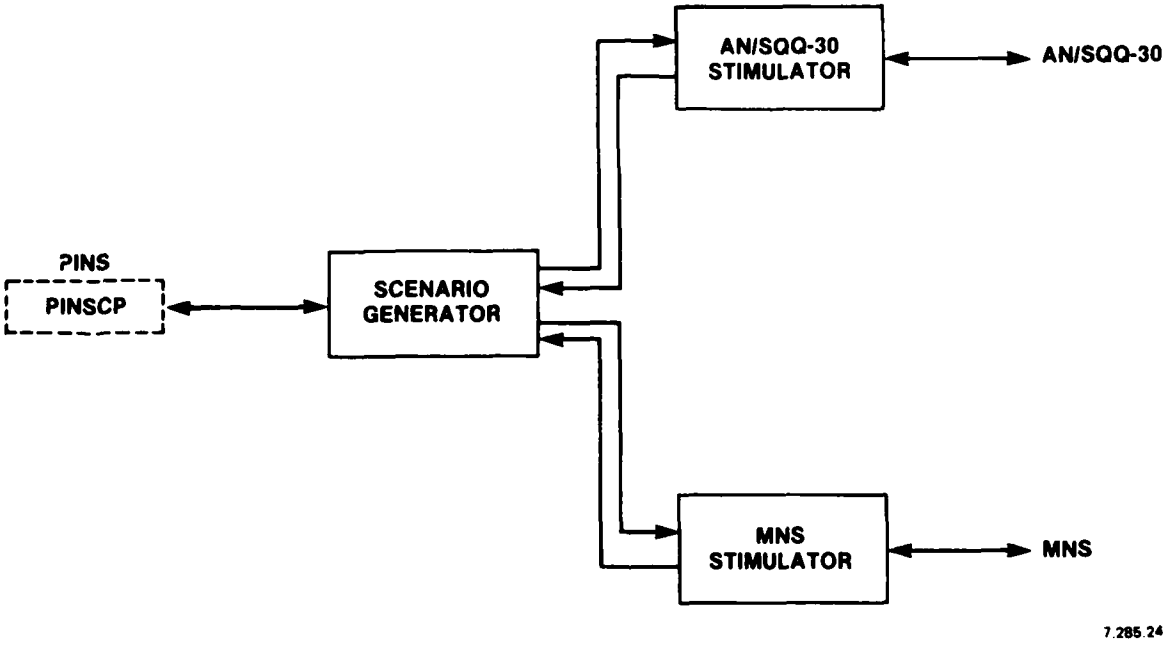


Figure 1.4 - MCM 1 Class AN/SSQ-94 CSTS
Simplified Block Diagram

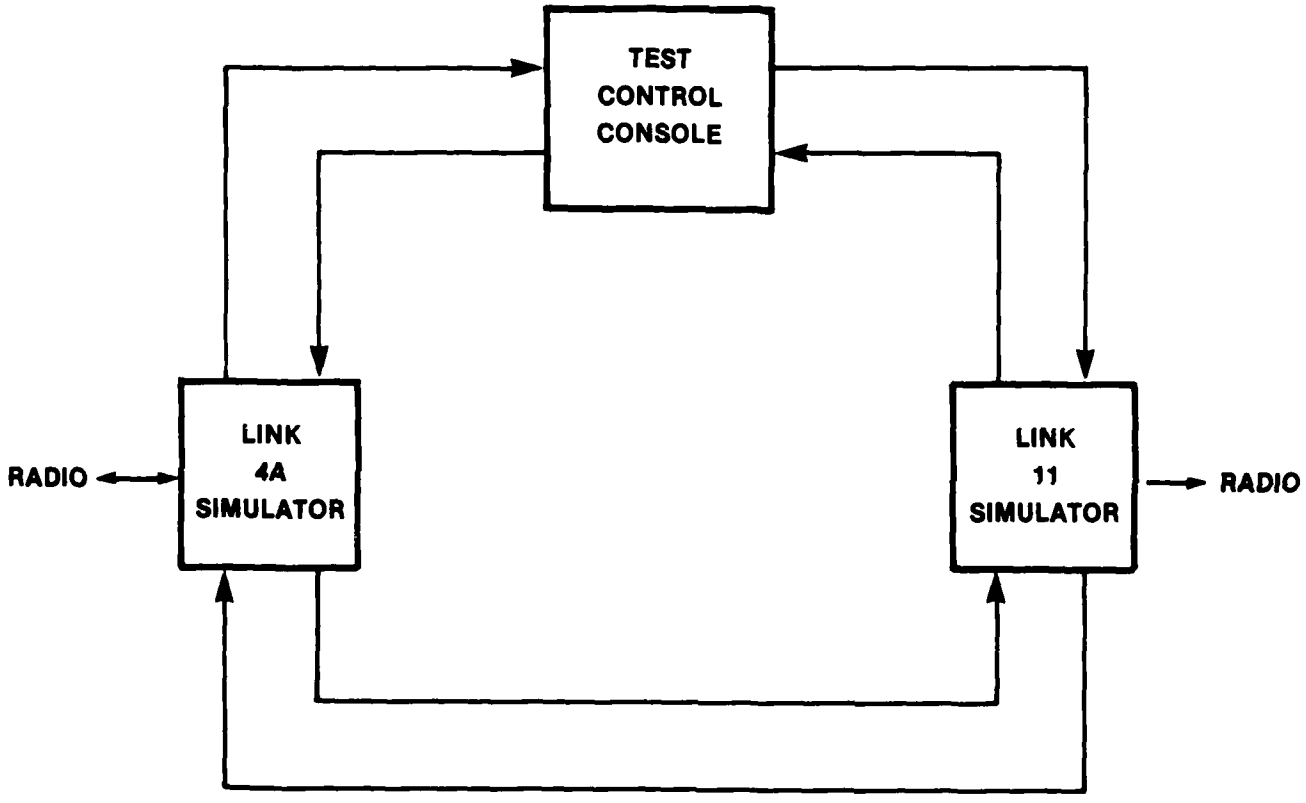


Figure 1.5 - Shore-Based Link 4A/Link 11 CSTS
Simplified Block Diagram

COMBAT SYSTEM TT&PM
DESIGN REQUIREMENTS DEVELOPMENT PROCESS

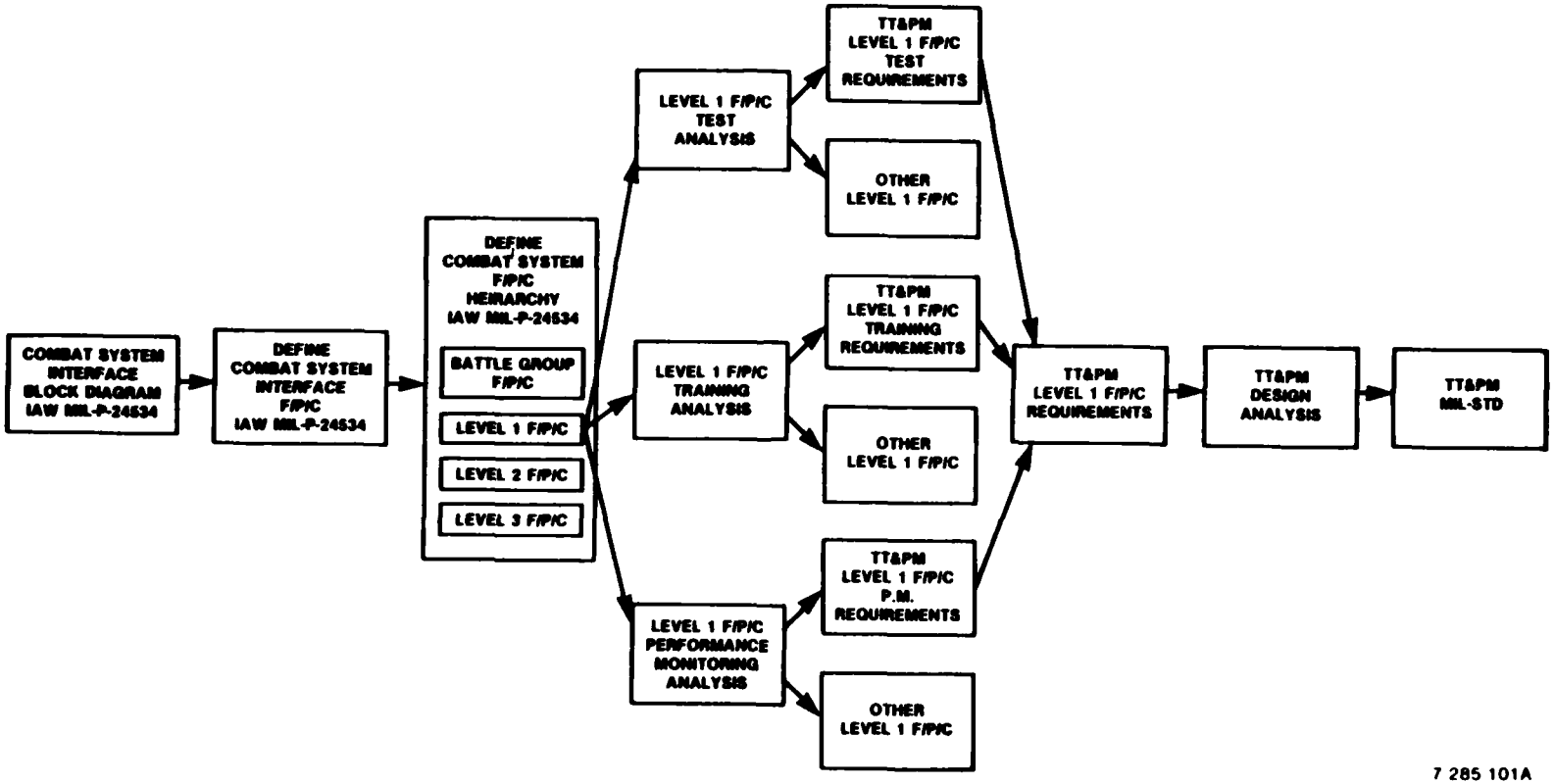


Figure 2.1-Engineering Approach

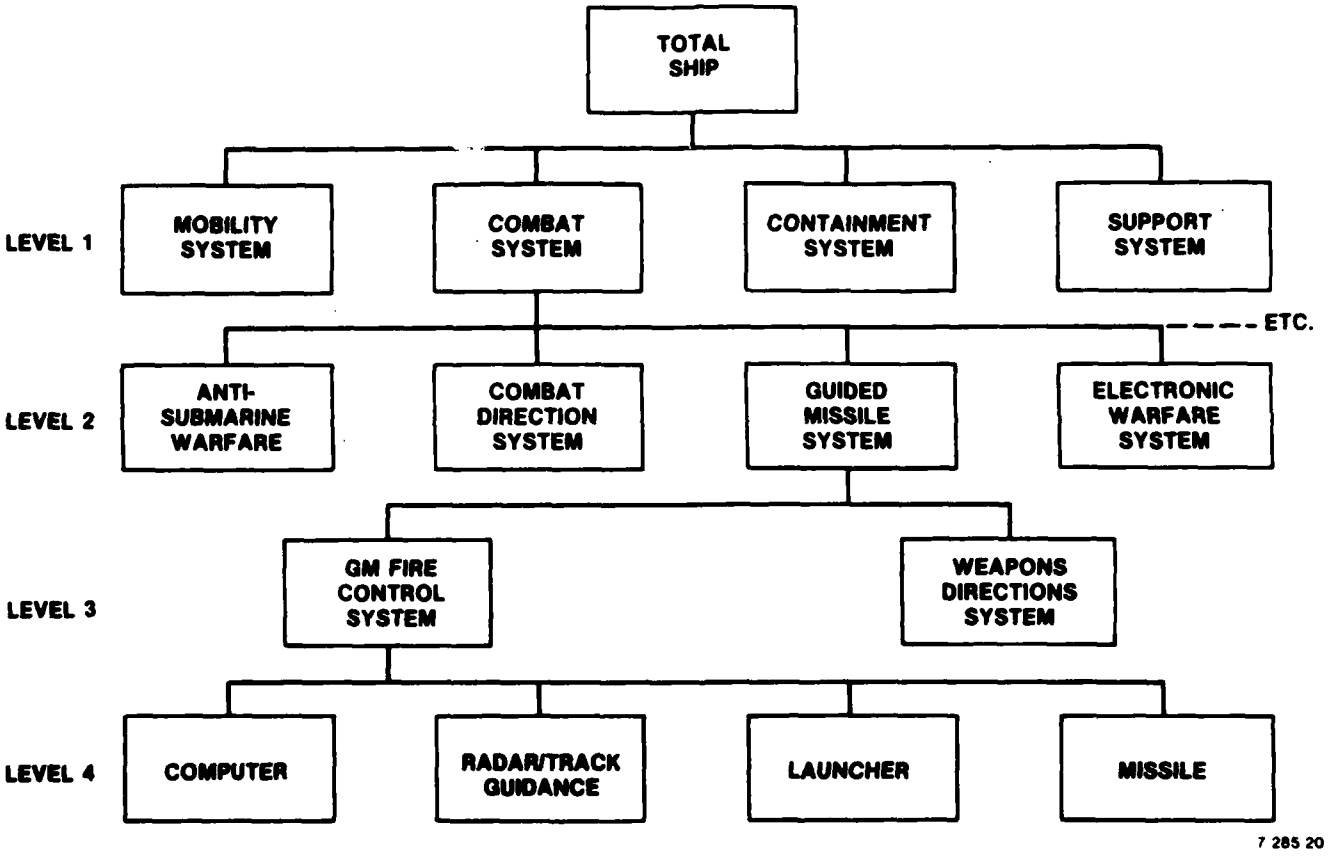


Figure 2.2 - Typical Major Ship's Systems

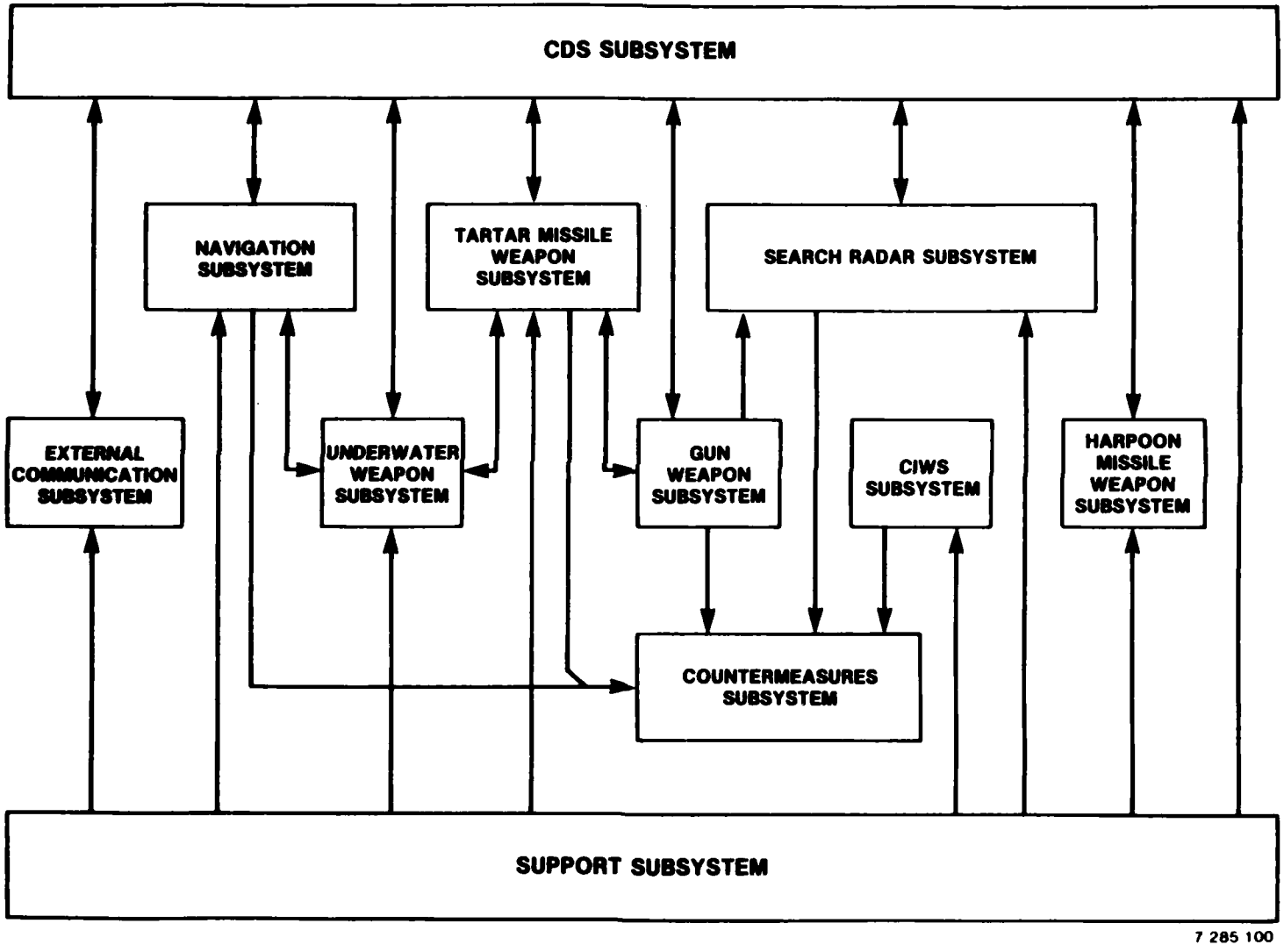


Figure 2.3-DDG 993 Class Combat System Interface Block Diagram

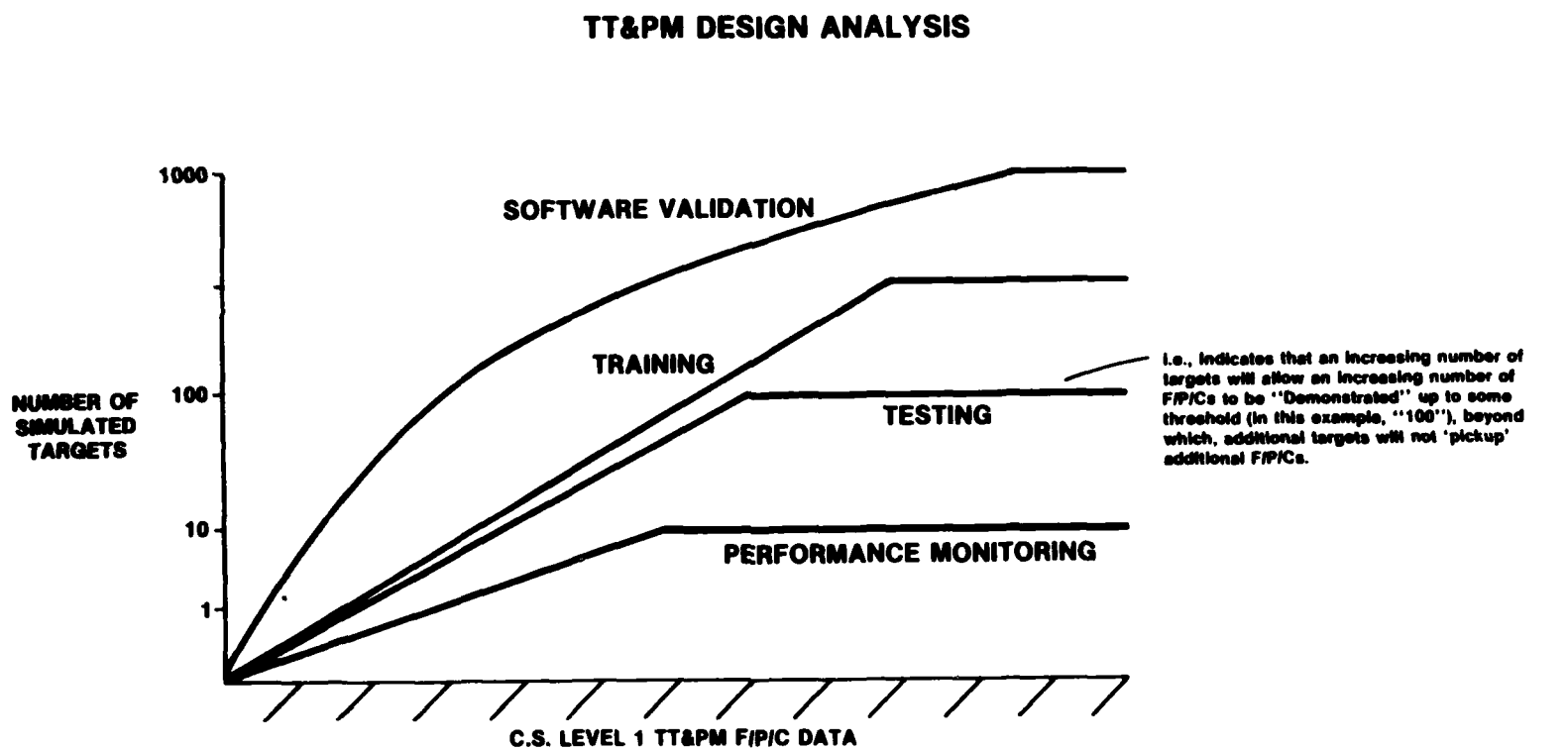


Figure 2.4-TT&PM Design Analysis Example

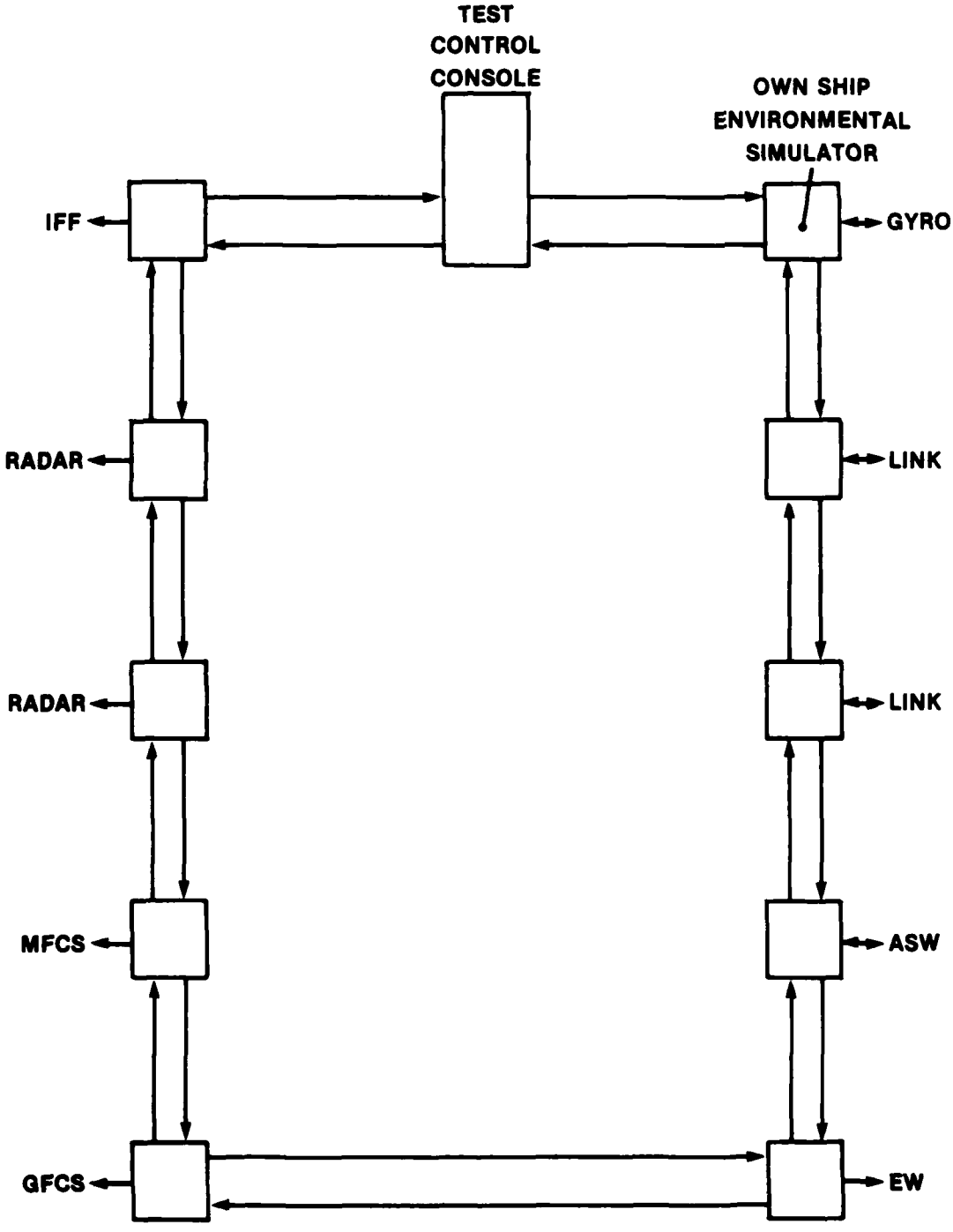


Figure 3.1 - Generic CSTS Configuration

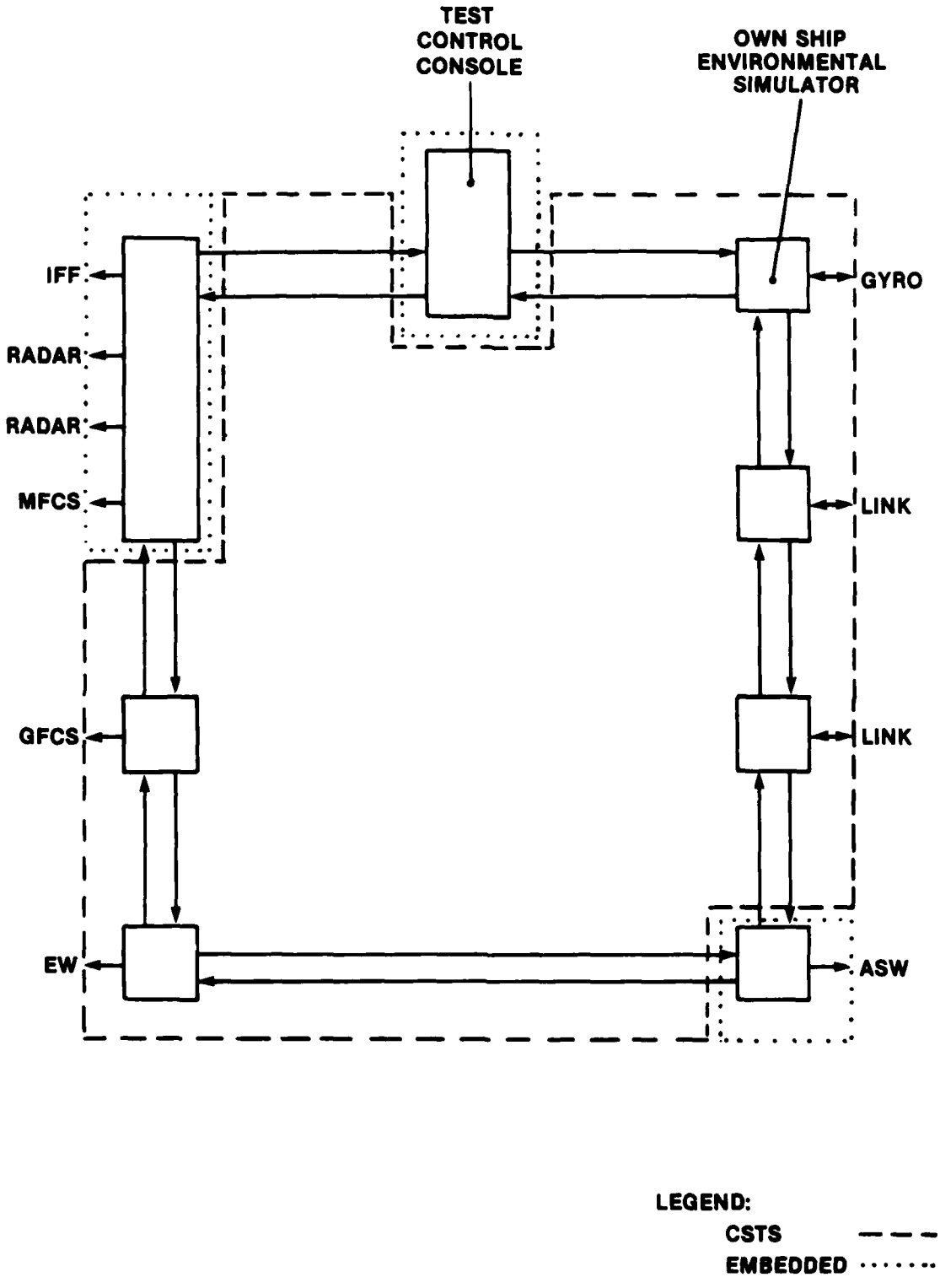


Figure 3.2 - Generic CSTS/Embedded Systems Configuration

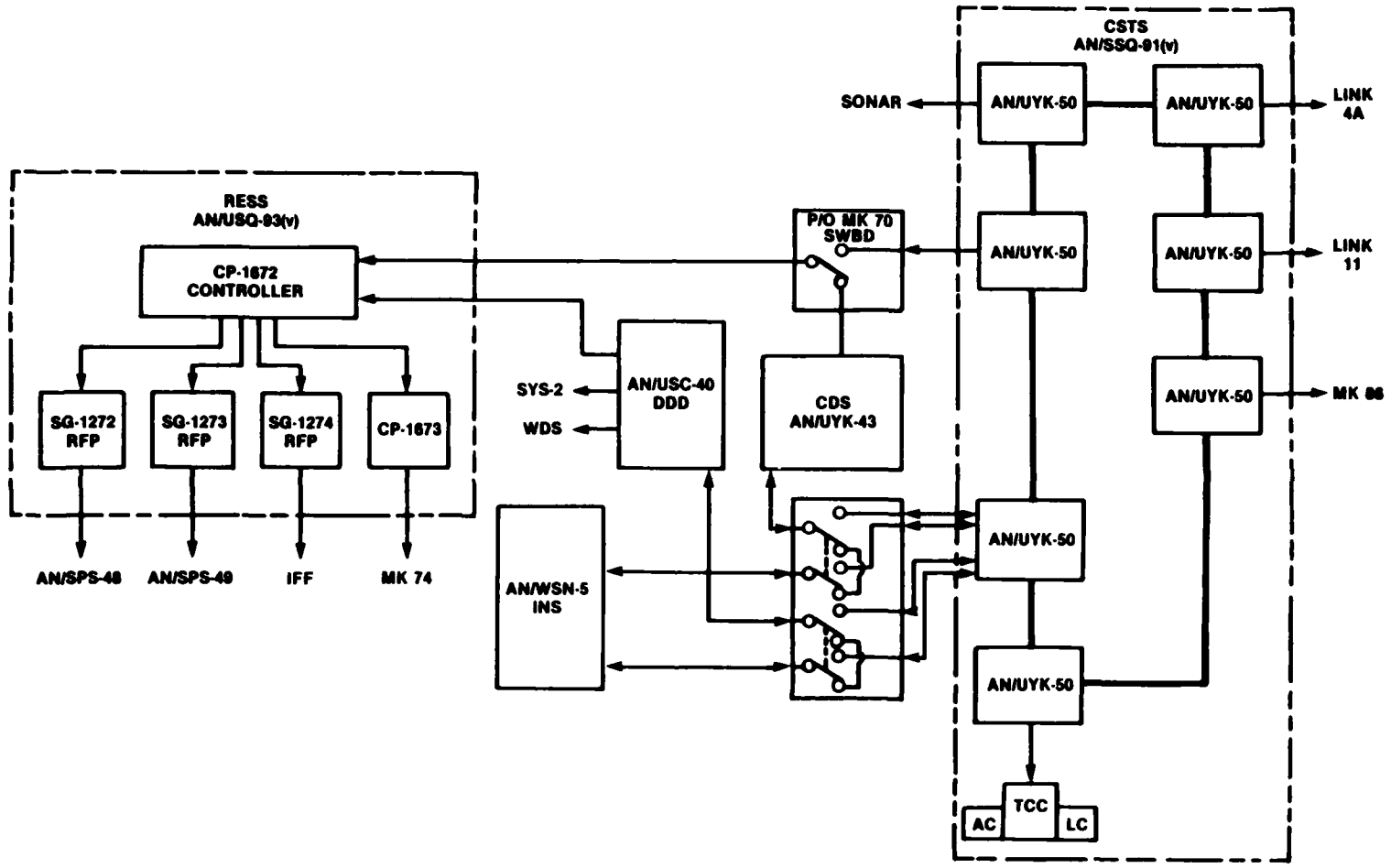


Figure 3.3-DDG 993 Class Upgrade AN/SSQ-91(V)3 CSTS (Proposed) Configuration

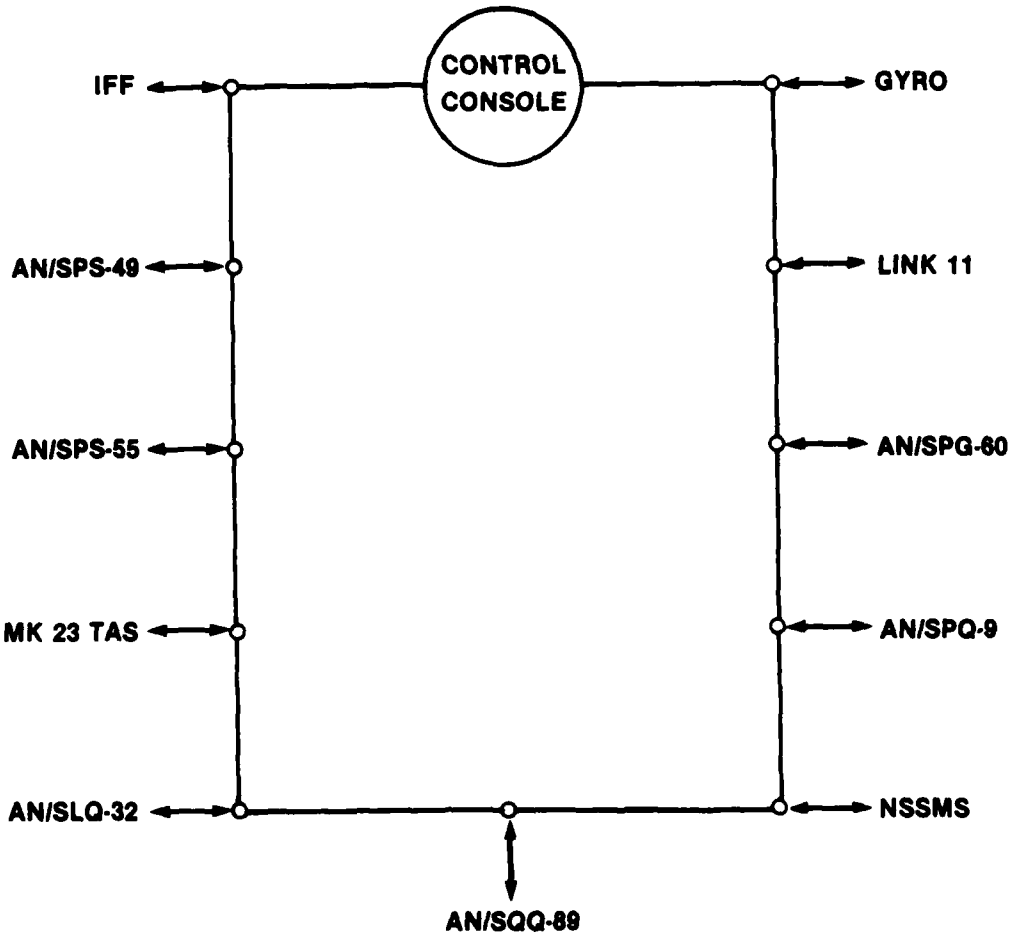
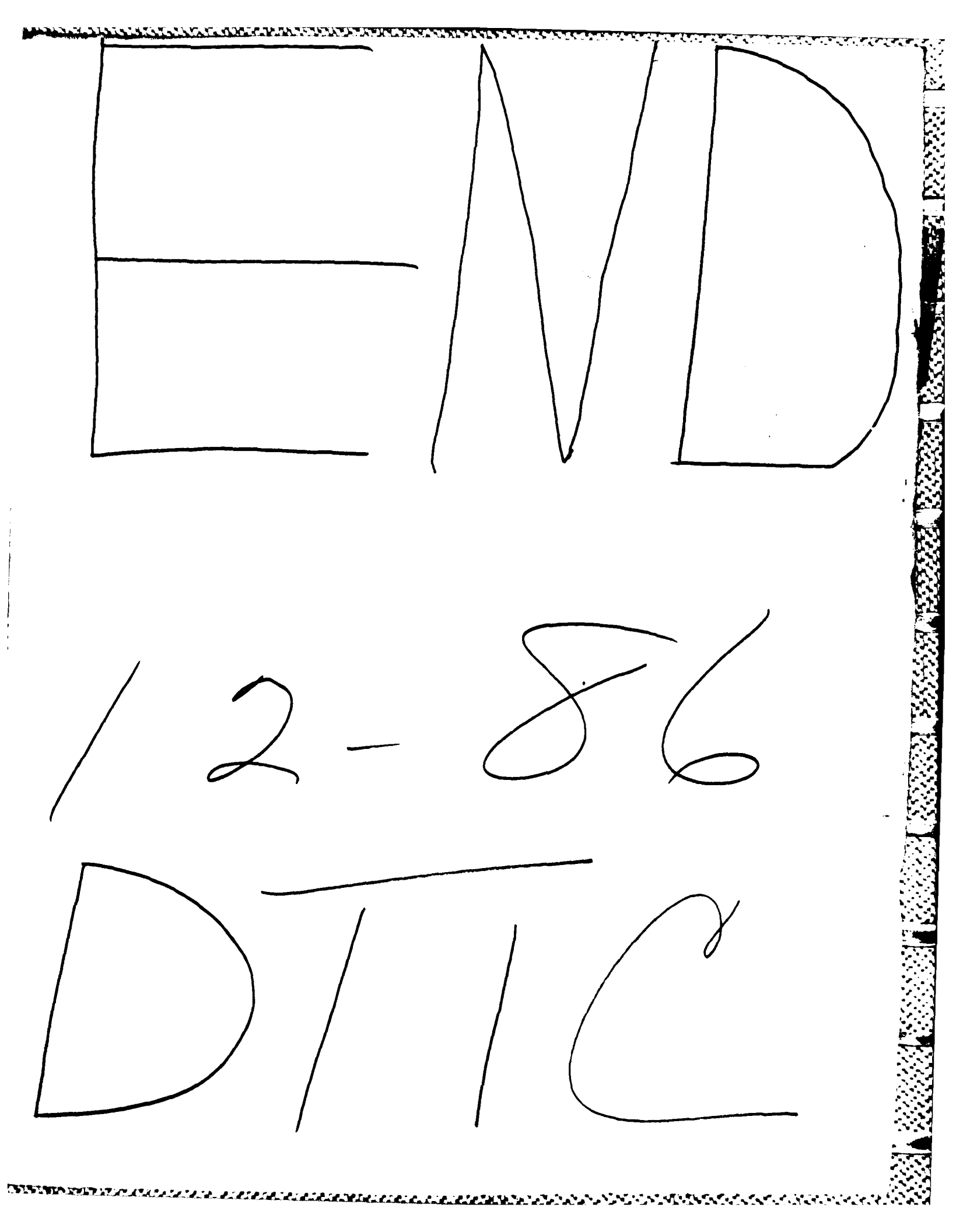


Figure 3.4 - Proposed DD 963 Class
TT&PM Simplified Block Diagram


END
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