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A DESCRIPTION OF THE SHIP COMBAT SYSTEM SIMULATION

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COMBAT SYSTEMS DEPARTMENT

1 SEPTEMBER 1984

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FOREWORD

This paper will describe a combat system integration and designed analysis tool called the Ship Combat System Simulation (SCSS). This work was funded under the Combat System Architecture (CSA) Project. The SCSS was designed as an analysis tool to study sensor, command and control, and weapon system integration for shipboard combat systems. The simulation represents the combat system components as nodes in a network. The nodes are connected by links. Data flows between the nodes through the links.

The SCSS has been jointly developed by NWC, NOSC, NSWC, and CACI, Inc. SCSS is supported by naval and industrial laboratories throughout the country. The users of the simulation belong to the SCSS Users' Group, which meets periodically. Members of the Users' Group develop equipment nodes and exchange ideas. The Users' Group maintains SCSS configuration management allowing for Simscript II.5 code written by any one user to be used by all other users. NSWC has been tasked to handle part of the configuration management of the model. This task involves answering inquiries about the model from potential users. This document will be distributed as part of that task.

Approved by:

Paul R. Wessel

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INTRODUCTION

In recent years the U.S. Navy has found itself faced with a severe, multi-threat environment. Probably the most important component of this threat is the cruise missile which may be launched from a variety of platforms. In response to this threat the Navy has developed several new sensor and weapon systems. As these new systems are introduced into the fleet, it has become clear that there is a pressing need to integrate them together in such a way that information from multiple sensors can be organized and properly used almost instantaneously. This integration problem has led to the development of a new analysis tool, the Ship Combat System Simulation. Previous simulations of shipboard systems have stressed sensor and weapon problems, usually modeling command and control as a time delay. This weapon-sensor approach to combat system simulation gave models a structure which proved to be insufficiently flexible to handle the systems integration problem. SCSS has been developed with a structure which will overcome many of these problems.

The objective of the SCSS project is to develop a combat system simulation which may be used to analyze: (1) the total system impact of proposed design changes in weapons and sensors and (2) the effectiveness of various methods of weapon system integration. The ship's combat system is treated as an information-flow network so that individual components may be studied in the context of information received, information processed (and delayed), and information used. Misinformation, as well as correct information, is allowed to enter and flow through the network. Figure 1 presents a typical SCSS network (link/node) diagram. The nodes shown represent elements of a ship combat system such as a fire control radar or a weapons launcher. The nodes as linked together make up the combat system.

Probably as important as the model's constructs (such as nodes, links, messages, networks, etc.) are the model's structural forms. The secondary objective has also been to create a structure which could be changed as new design concepts are introduced. A completely modular structure has been developed which includes a parallel modular structure documentation package. The documentation is maintained on the computer with the model and is updated right along with the code.

Finally, it has also been the objective of this project to provide a model which will be useful to all Navy laboratories. The model has been a joint development project of the Naval Ocean Systems Center (NOSC), the Naval Weapons Center (NWC), and the Naval Surface Weapons Center (NSWC) under funding from the Naval Sea Systems Command. The Naval Ships Weapons Systems Engineering Station (NSWSES) has been peripherally involved.

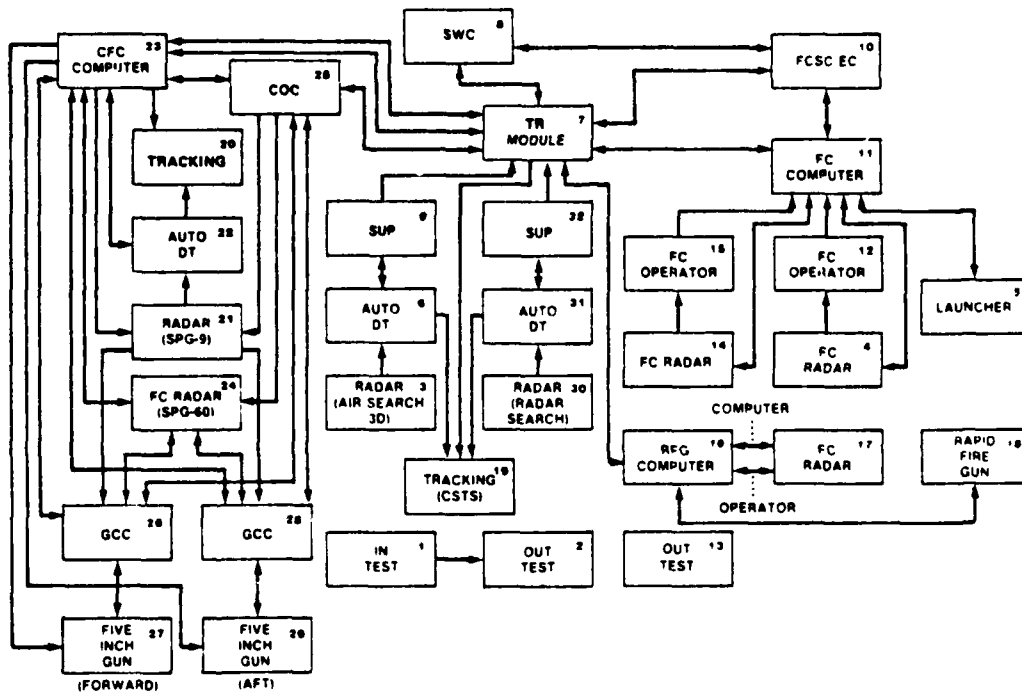


FIGURE 1. LINK NODE DIAGRAM

THE SHIP COMBAT SYSTEM SIMULATION (SCSS)
NODE/MESSAGE/DATA RELATIONSHIPS

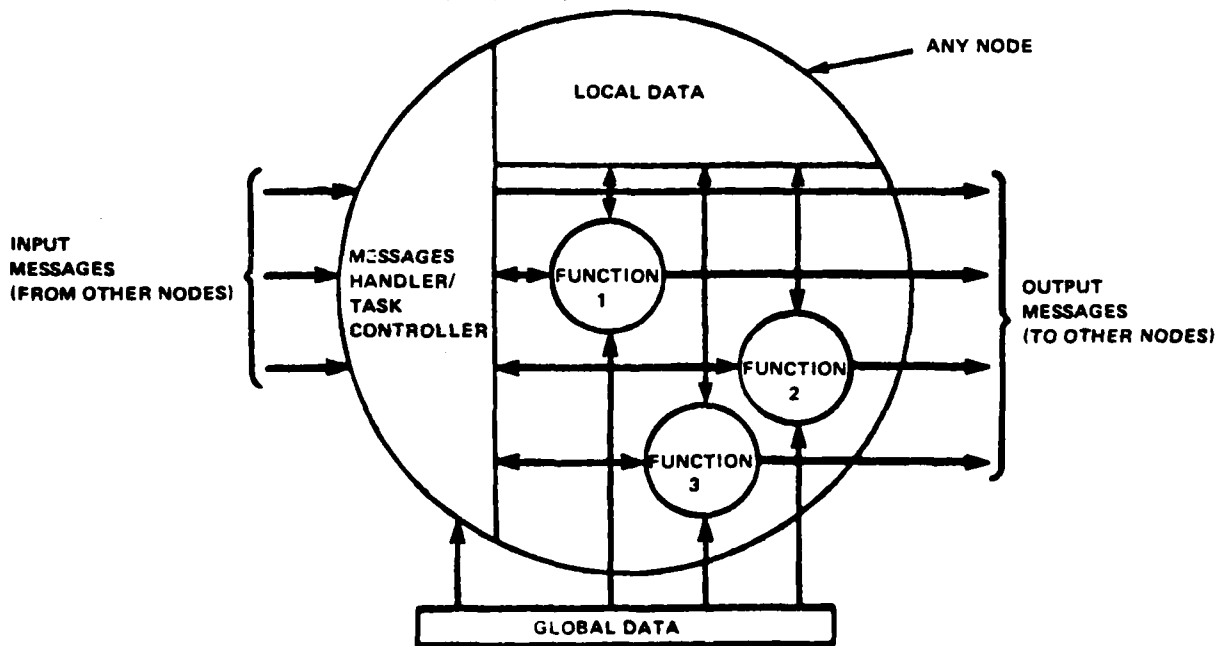


FIGURE 2. NODE DESCRIPTION

SIMULATION DESCRIPTION

The Shipboard Combat System Simulation (SCSS) is written in a process orientation of Simscript II.5. The simulation has two distinct yet overlapping world views. First, there is the external world in which all the observable objects (processes) operate. Each of these observable objects can involve many processes which communicate with each other. The shipboard combat system represents the internal view of the observable object. In the external world interprocess communication is accomplished by appropriate calls to a BOOKKEEPER routine; whereas, the shipboard combat system processes communicate via the node-link message constructs shown in Figure 1.

The ship combat system is represented in SCSS as a network of information processors. Each node in the network represents a decision or action unit in the system. Figure 2 presents the node description. Incoming messages from other nodes arrive at the node's message handler. This portion of the node decodes the message, extracts the data from the message, and routes the message and data to the appropriate function. The selected function uses the incoming data together with the node's data (local data) and the combat system data available to the node (global data) to make a decision or take some action. The decision and/or action and the corresponding data is formulated into a message and sent out over links to the nodes in the combat system. The link serves as an information transfer path. Some links represent computer transfer paths. Others represent voice phones, etc.

Associated with each node is a process description of the simulated combat system element. Examples of such processes range from the radars which interface with the external world (see below) to the launcher, the air detector/tracker, the ship weapons coordinator, etc.

Figure 3 presents the Fire Control Computer, Fire Control Radar, and Launcher nodes with their process description. Each process performs a function shown in the node description in Figure 2. For example, the fire control radar performs the functions: slewing to a bearing, acquiring a threat, preparing itself to operate, scanning to locate the threat, and tracking the threat. The model is intentionally very modular so that as requirements change, new systems (nodes or combinations of nodes) may be quickly integrated into it.

Most node-processes are message driven. An arriving message (presumably sent by some other node) causes some action to be taken by the node. The response of a node to a message falls in one of the following categories:

1. The message is ignored and discarded.
2. The message is enqueued (possibly according to some priority scheme) for later processing.
3. The message is so important that it interrupts the node-process (regardless of what it is currently doing) so as to process this new message immediately.

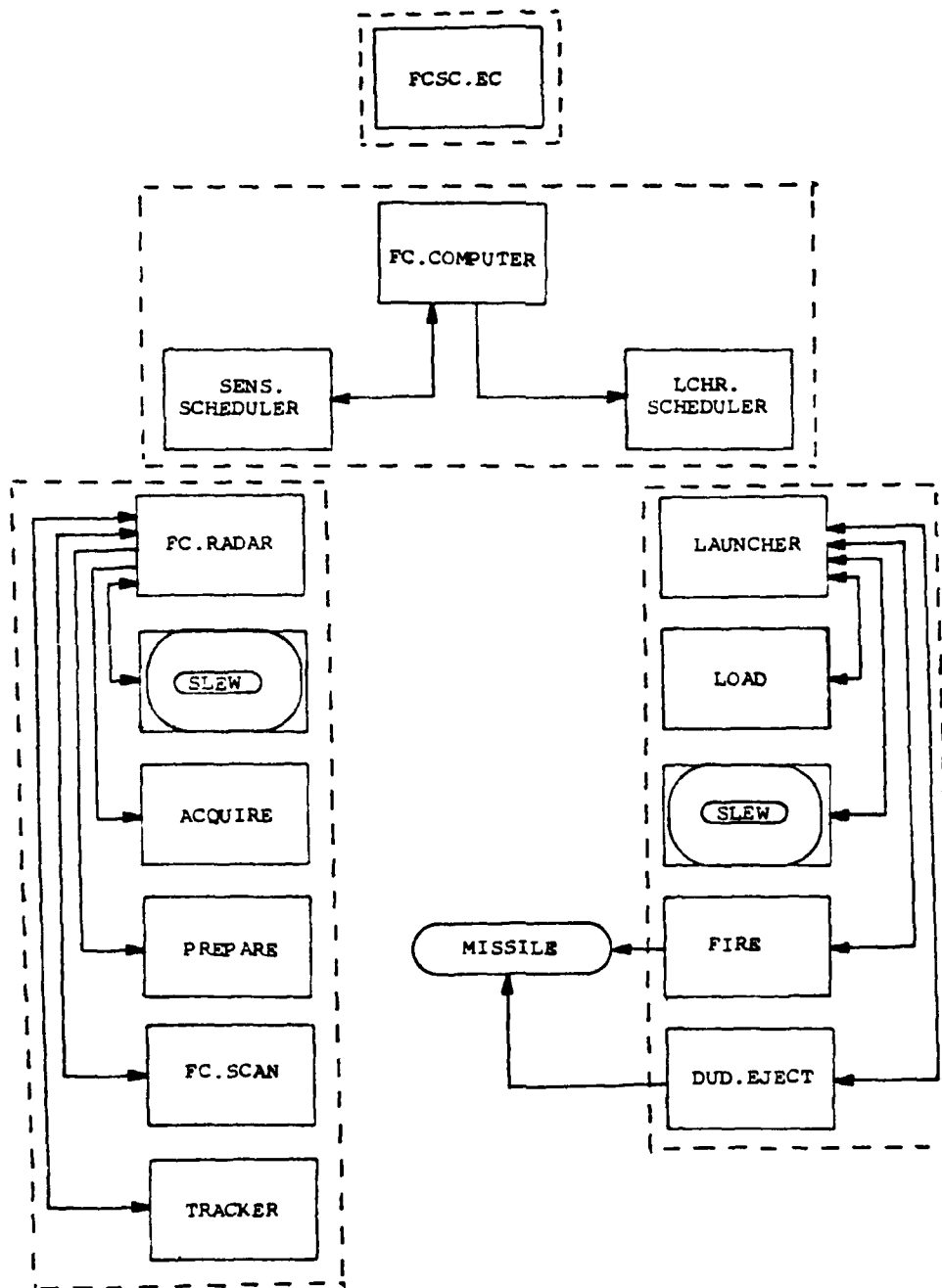


FIGURE 3. NODE FUNCTIONS

4. Sometimes messages can be processed concurrently. For example, a launcher can respond to a "warm-up missile" command while "slewing to a bearing."

Figure 4 illustrates the messages that flow between the indicated nodes for the functions assigning a threat track to a specific weapon system and for launching a weapon at that threat. For both of these functions the circled numbers indicate the flow of the labeled messages through the corresponding links.

The names of the combat system components simulated by these nodes are also shown in the figure. The THREAT RESPONSE MODULE/TRACK STORES nodes is a top level model of the NTDS computer systems. It should be noted that these nodes are generic in nature and can be configured as specific components through input data.

The interface between the ship combat system and the external world is mainly by radar. Since objects are moving continuously (incoming threats, friendly aircraft, launched missiles, etc.), it is necessary to keep track of where everything is. This is represented by an instantaneous "snapshot" approach. For a rotating antenna, one snapshot is produced per revolution. Then appropriate adjustments are made to the computations so that objects in the external world will "appear" at the correct time in the correct place on a radar screen (plan-position-indicator; PPI). The characteristics of the radar are taken into consideration, resulting in elimination of "blips" which represent objects that are out of radar range, hidden by another object, etc.

Certain node-processes look at the information presented on the PPI and initiate messages based on the situation. Other node processes work somewhat autonomously, updating their own files, etc.

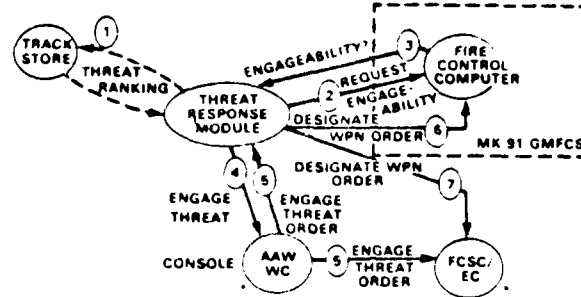
EXTERNAL WORLD

The environment in which the ship is embedded includes missiles and threats (cruise missiles) in addition to the ship. The ship is on a sea characterized by sea state. The sea state affects reflectivity and sea roll. This ship has the capability of changing headings and speeds. The missiles fly through a three-dimensional environment. The missiles and threats fly pursuit navigation when command guided or pursuing a heading and fly linearized proportional navigation in homing on a target. All target detections are based on a curved earth; however, all homing assumes flat earth for simplicity.

All external processes must belong to the common EXT.ENVIRONMENT.SET to be observable. All interactions between external processes are managed by a BOOKKEEPER routine. All external processes have a PROGRAMMED.TRAJECTORY subprocess to handle preprogrammed thrust changes and altitude changes. Also, they have a common NAVIGATION subprocess which performs the trajectory maneuvers through the three-dimensional space. In addition, missiles and threats have a common SEEKER subprocess which allows them to detect, lock-up on, and guide to a target.

SCSS NODE AND LINK DIAGRAM

FUNCTION:
DESIGNATION OF
THREAT TRACK



FUNCTION:
FROM THREAT
DESIGNATION TO FIRE

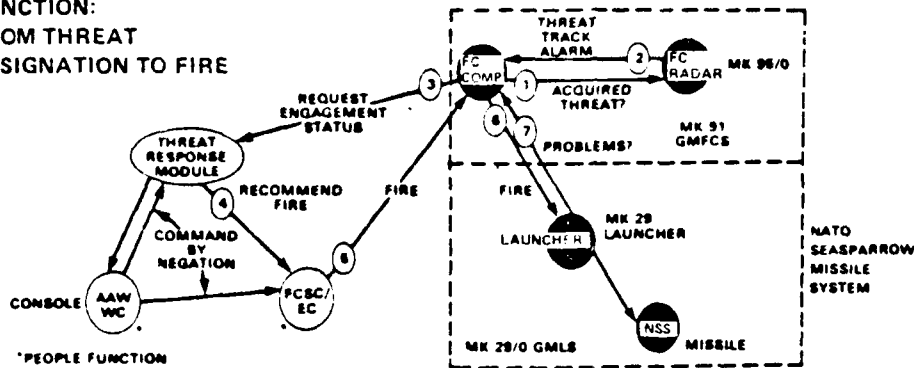


FIGURE 4. MESSAGE/DATA FLOW

- CONSTRUCT A COMMAND, CONTROL, COMMUNICATIONS DIAGRAM
- CONSTRUCT A SEQUENCE AND TIMING DIAGRAM
- CONSTRUCT AN INITIAL CONDITION TABLE FOR THE EXTERNAL ENVIRONMENT
- CONSTRUCT A LINK NODE DIAGRAM
- COLLECT DATA FOR SPECIFIC PROBLEM
- INPUT COLLECTED DATA
- RUN THE MODEL
- ANALYZE THE RESULTS

FIGURE 5. PROCEDURE FOR USING SCSS

MODEL CAPABILITY

Initially the simulation was intended for a single ship combat system analysis. The most current version is a multiple ship model which may be used to simulate NTDS type ships faced with a cruise missile attack. The modules completed to date are the following:

1. Search radar and associated IFF equipment
2. Air detector/tracker (human)
3. Automatic detector/tracker
4. Track supervisor
5. NTDS-like computer (tracking module and threat response module)
6. Ship Weapons Coordinator (SWC)
7. Fire Control Systems Coordinator (FCSC)
8. Fire control computer
9. Fire control radar
10. Launcher
11. Fire control radar operator
12. Missiles
13. Threats (cruise missiles)
14. Gun fire control computer
15. Rapid fire gun
16. Gun fire control computer
17. Control officer console
18. Gun control console
19. Track while scan radar (SPQ-9)
20. Five inch 54 gun
21. Jamming
22. External Communications

23. Vertical Launch System

The above modules may be put together in many different combinations to simulate widely differing combat systems.

APPLICATION

A procedure for using SCSS for an antiair warfare (AAW) system is illustrated in Figure 5. The procedure for using SCSS implies an intimate knowledge of (1) the specific AAW problem and (2) the platform's AAW combat system components. This knowledge leads to the construction of the command, control, and communications (C³) diagram for the AAW system. The C³ diagram is then mapped into the SCSS link/node as diagram shown in Figure 6. Upon examination of Figure 5 it will be evident how events are driven by messages flowing between the nodes.

SUMMARY

The simulation is controlled by a Users' Group. Any organization which has Navy connection (such as a contract), Navy or private industry, can obtain the simulation by becoming a member of this Users' Group. Additional information regarding the simulation or Users' Group membership can be obtained by contacting:

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Naval Surface Weapons Center
Silver Spring, MD 20910

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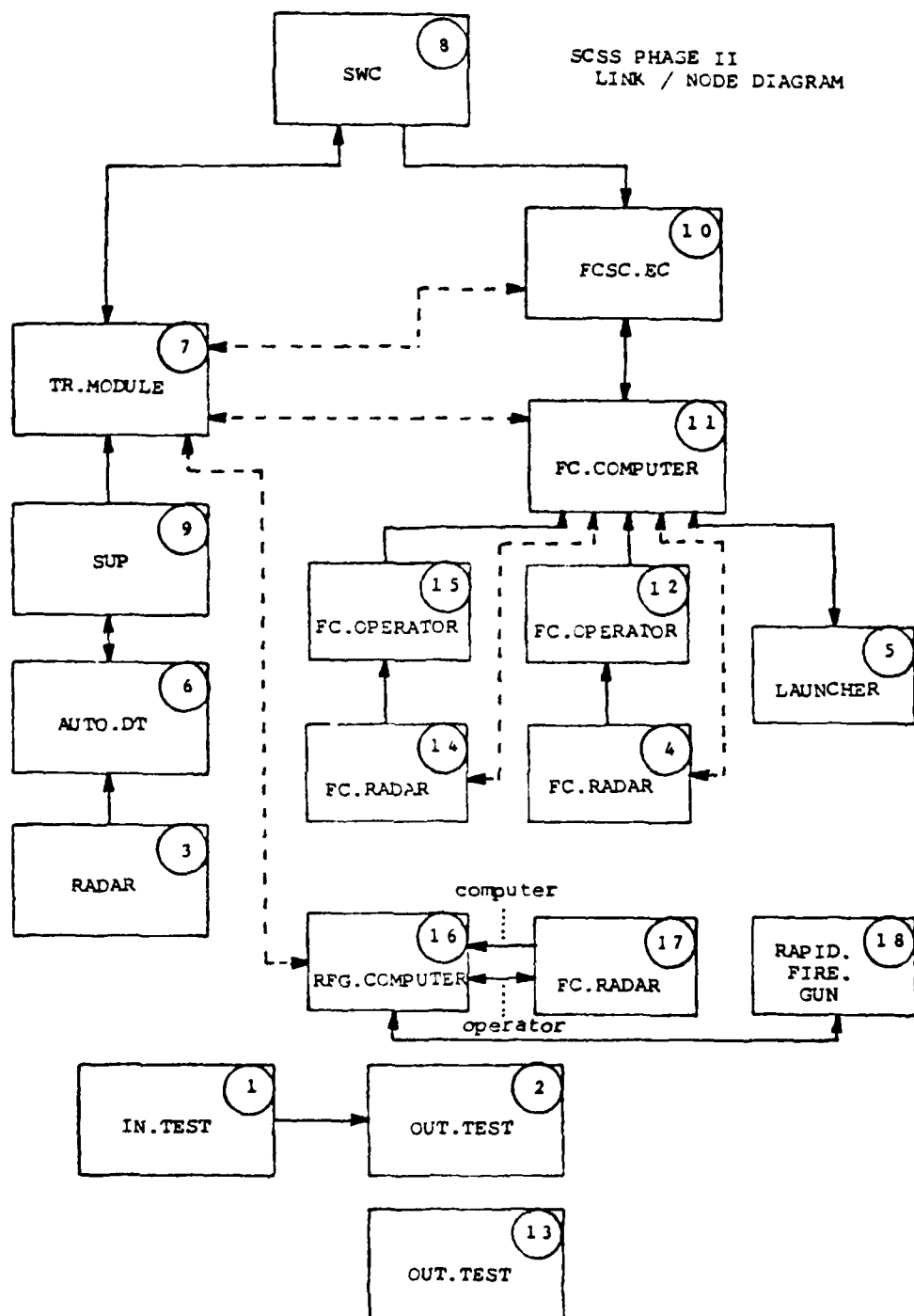


FIGURE 6. LINK NODE DIAGRAM

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