

APPROVED FOR PUBLIC RELEASE

TS-TCMS-92001

Rev. Basic

25 February, 1992

*100-840711*

*166320*

*p. 32*

# TCMS OPERATIONS AND MAINTENANCE PHILOSOPHY

(NASA-TM-108756) TCMS OPERATIONS  
AND MAINTENANCE PHILOSOPHY (NASA)  
32 p

N93-26418

Unclass

G3/81 0166320

National Aeronautics and  
Space Administration

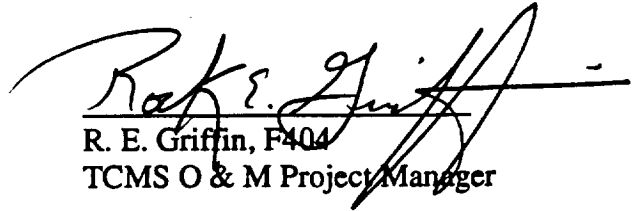
John F Kennedy Space Center

## TCMS OPERATIONS AND MAINTENANCE PHILOSOPHY

Prepared by:



D. P. Buehler, F468  
TCMS Operations & Maintenance

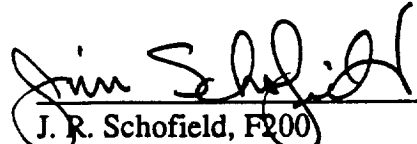


R. E. Griffin, F404  
TCMS O & M Project Manager

Concurrence:



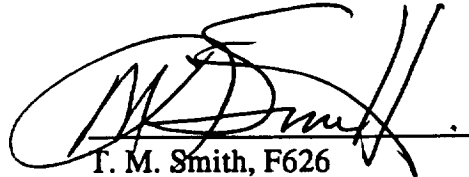
R. M. Gunn, F100  
Director, Product Engineering & Definition



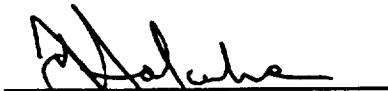
J. R. Schofield, F200  
Director, Payload Projects



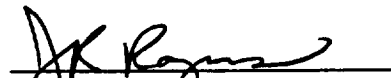
E. G. Spilger, F300  
Director, Space Station Project



T. M. Smith, F626  
Director, SR & QA



J. O. Holcombe, F820  
Director, Production Support

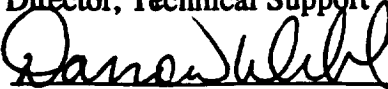


J. R. Rogers, CS-GSD-22  
Chief, Checkout Systems Section

Approved by:



A. P. Tully, F400  
Director, Technical Support



D. L. Webb, CS-EED  
Chief, Systems Eng. & Exp. Div.



B. G. Bruckner, CS-GSD  
Chief, Ground Systems Division



J. H. Straiton, CP-SSO  
Chief, Space Station Support Office

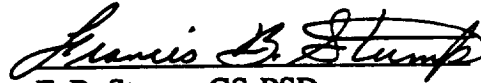
Concurrence:



R. L. Sells, CS-TMO  
Chief, Test Mgmt. & Opns. Office



W. G. Mahoney, CS-PPD  
Chief, Payload Processsing Div.



F. B. Stump, CS-PSD  
Chief, Payload Support Div.

## TABLE OF CONTENTS

<u>Sec/Par</u>	<u>Title</u>	<u>Page</u>
I	INTRODUCTION .....	1-1
1.1	Purpose .....	1-1
1.2	Scope .....	1-1
1.3	Assumptions.....	1-1
1.3.1	Off-Line Support Set .....	1-1
1.3.2	Shifts Worked .....	1-1
1.3.3	User Access to Sets .....	1-2
1.3.4	Learning Curve .....	1-2
1.3.5	Intermediate Level Maintenance Facility (ILMF) .....	1-2
1.4	Roles And Responsibilities .....	1-2
1.4.1	Users .....	1-2
1.4.2	Operations & Maintenance .....	1-3
1.4.3	Sustaining Engineering .....	1-5
1.4.4	Logistics Support .....	1-6
1.4.5	Safety, Reliability and Quality Assurance .....	1-7
1.4.6	Configuration Management.....	1-8
II	OPERATIONS .....	2-1
2.1	User Interface .....	2-1
2.2	Test Set Configuration .....	2-1
2.3	Test Execution .....	2-3
2.4	Test Data Management .....	2-3
2.5	Security .....	2-3
III	ON-LINE MAINTENANCE .....	3-1
3.1	Overview .....	3-1
3.2	Preventive Maintenance .....	3-1
3.3	Corrective Maintenance .....	3-2
3.4	Procedures .....	3-2
3.4.1	Ground Rules and Assumptions .....	3-3
3.4.2	Interfaces .....	3-3
3.4.2.1	Sustaining Engineering .....	3-4
3.4.2.2	System Users .....	3-4
3.5	On-Line Personnel .....	3-4

IV	OFF-LINE MAINTENANCE.....	4-1
4.1	Objectives.....	4-1
4.1.1	On-Site Repair of LRUs .....	4-1
4.1.2	Hot Spares for On-Line Repairs .....	4-1
4.1.3	Subsystem Level Testing/Verification .....	4-1
4.1.4	Verification of Proposed Changes .....	4-1
4.2	Sustaining Engineering Interface .....	4-3
4.2.1	Software Maintenance .....	4-3
4.2.2	Hardware Maintenance .....	4-3
4.2.3	Modifications and Upgrades .....	4-4
4.2.4	O&M Documentation .....	4-4
4.2.5	Off-Line Engineering Support .....	4-4
4.3	Logistics Interfaces .....	4-4
4.3.1	Non TCMS Unique Support .....	4-4
4.3.2	TCMS Unique Support .....	4-4
4.3.2.1	Spare Parts Provisioning .....	4-4
4.3.2.2	Spares Tracking .....	4-5
4.3.2.3	Inventory Stocking and Replenishment .....	4-5
4.3.2.4	Bench Stock .....	4-5
4.3.2.5	Depot Level Repair.....	4-5
4.3.2.6	Calibration Service.....	4-5
V	OPERATOR AND MAINTENANCE PERSONNEL TRAINING	5-1
5.1	Objectives.....	5-1
5.2	Ramp Up Time for Personnel .....	5-1
5.3	Use of Off-Line Support Set .....	5-1
5.4	Rotation of Personnel .....	5-2
VI	SYSTEM DELIVERY .....	6-1
6.1	TCMS (CEC) Activation & Validation .....	6-1
6.2	TCMS Total System Validation .....	6-1
6.3	CAF Set at Johnson Space Center.....	6-1

## LIST OF FIGURES

<u>Figure</u>	<u>Title</u>	<u>Page</u>
2-1	User/Operations Interface.....	2-2
4-1	Repair Flow.....	4-2
6-1	TCMS Activation.....	6-2

## ACRONYM LIST

ATE	AUTOMATIC TEST EQUIPMENT
BIT	BUILT IN TEST
CAF	CENTRAL AVIONICS FACILITY
CCB	CONFIGURATION CONTROL BOARD
CCMS	CHECKOUT, CONTROL AND MONITOR SUBSYSTEM
CEC	CORE ELECTRONICS CONTRACTOR
COTS	COMMERCIAL OFF-THE-SHELF
DBS	DATABASE SUBSYSTEM
DMS	DATA MANAGEMENT SUBSYSTEM
DP	DISPLAY PROCESSOR
ESD	ELECTROSTATIC DISCHARGE
ESR	ENGINEERING SUPPORT REQUESTS
ETA	EXPERIMENT TEST AREA
FDIR	FAULT DETECTION, ISOLATION, AND RECOVERY
GSE	GROUND SUPPORT EQUIPMENT
HDL	HARDWARE DISPOSITION LIST
HPF	HAZARDOUS PROCESSING FACILITY
HSSC	HARRIS SPACE SYSTEMS CORPORATION
IBIT	INITIATED BUILT IN TEST
IDMM	INTERMEDIATE AND DEPOT MAINTENANCE MANUALS
ILMF	INTERMEDIATE LEVEL MAINTENANCE FACILITY
IPR	INTERIM PROBLEM REPORT
JSC	JOHNSON SPACE CENTER
KSC	KENNEDY SPACE CENTER
LCC	LIFE CYCLE COST
LIS	LOGISTICS INFORMATION SYSTEM
LRU	LINE REPLACEABLE UNIT
LSA	LOGISTICS SUPPORT ANALYSIS
MSC	MATERIAL SERVICE CENTER
MTTR	MEAN TIME TO REPAIR
NASA	NATIONAL AERONAUTICS & SPACE ADMINISTRATION
O&M	OPERATIONS AND MAINTENANCE
O & SHA	OPERATION AND SUPPORT HAZARD ANALYSIS
OJT	ON THE JOB TRAINING
OMI	OPERATION AND MAINTENANCE INSTRUCTION
ORT	OPERATIONAL READINESS TEST
PC	PROGRAM CONTROL
PCB	PRINTED CIRCUIT BOARD
PDMS	PAYLOAD DATA MANAGEMENT SYSTEM
PDRD	PROGRAM DEFINITION AND REQUIREMENTS
PGOC	PAYLOAD GROUND OPERATIONS CONTRACT
PICS	PAYLOAD INTEGRATED CONTROL SCHEDULE

PPCU	PARTIAL PAYLOAD CHECKOUT UNIT
PR	PROBLEM REPORT
PRACA	PROBLEM REPORTING AND CORRECTIVE ACTION
PTC	PAYLOAD TEST CONDUCTOR
RCM	RELIABILITY CENTERED MAINTENANCE
RIM	REMOTE INTERFACE MODULE
RTV	RETURN TO VENDOR
SMR	SOURCE, MAINTENANCE AND RECOVERABILITY
SN0	SERIAL NUMBER ZERO
SP	STANDARD PRACTICE
SPF	SOFTWARE PRODUCTION FACILITY
SR&QA	SAFETY, RELIABILITY AND QUALITY ASSURANCE
SRM&QA	SAFETY, RELIABILITY, MAINTAINABILITY AND QUALITY ASSURANCE
SS	SPACE STATION
SSFP	SPACE STATION FREEDOM PROGRAM
SSPF	SPACE STATION PROCESSING FACILITY
TAP	TEST AND ASSEMBLY PROCEDURE
TCID	TEST CONFIGURATION IDENTIFIER
TCMS	TEST CONTROL AND MONITOR SYSTEM
TS	TECHNICAL SUPPORT DIRECTORATE
TSA	TEST STAND AREA



## SECTION I

### INTRODUCTION

#### 1.1 PURPOSE

The purpose of this document is to describe the basic philosophies of operating and maintaining the Test Control and Monitor System (TCMS) equipment. TCMS is a complex and sophisticated checkout system. Operations and maintenance processes developed to support it will be based upon current experience, but will be focused on the specific needs of TCMS in support of Space Station Freedom Program (SSFP) and related activities. This document will act as an overview of the operations and maintenance goals and philosophies.

#### 1.2 SCOPE

This document describes the assumptions, roles and responsibilities, concepts and interfaces for operation, on-line maintenance, off-line support, and Operations and Maintenance (O&M) personnel training on all TCMS equipment located at KSC.

#### 1.3 ASSUMPTIONS

**1.3.1 OFF-LINE SUPPORT SET.** The off-line support set will be located in close proximity to the on-line system and will be available for the following functions:

- a. Troubleshooting of TCMS Line Replaceable Units (LRUs)/anomalies in an off-line mode.
- b. Source of "hot spares" to get on-line systems up and running as quickly as possible.
- c. Verification of repaired LRUs, etc. prior to stocking them as functional assemblies ready for installation in the on-line system.
- d. Pre-configuration of TCMS Sub Systems.
- e. Check out of proposed hardware changes by PGOC Sustaining Engineering prior to installation in the on-line system.
- f. Training of operators and maintenance personnel.

**1.3.2 SHIFTS WORKED.** The TCMS on-line system will be staffed by users on two eight hour shifts, five days per week. Additional processing will be done on third shift and weekends as required. Operations and Maintenance personnel will do all major reconfiguration of the test sets and perform maintenance ,backups and other housekeeping functions on third shift which will be manned by the least number of personnel allowable.

O&M personnel will work three eight hour shifts five days per week and one to two weekend shifts to support weekend processing and for required troubleshooting and

corrective maintenance, preventive maintenance and system administration. O&M and Sustaining Engineering will, to the maximum extent possible, schedule activity so as not to interrupt user processing. Due to the limited operating budget, O&M personnel stationed in the Hazardous Processing Facility (HPF) will be limited to those absolutely necessary to operate the sets. O&M will dispatch additional personnel from the SSPF to the HPF as needed.

**1.3.3 USER ACCESS TO SETS.** The SSPF will contain three TCMS sets which will be available to the user community. Each of these sets (A, B, &C) can be subdivided into half sets (A1, A2, B1, B2, C1 & C2). The Hazardous Processing Facility (HPF) contains another two half sets which will be available to users. In addition, TCMS set serial number zero (SN0) will be used for sustaining engineering and the Software Production Facility (SPF) set will be used for software development. The off-line support set will be used by O&M personnel.

**1.3.4 LEARNING CURVE.** O&M, Sustaining Engineering and the user organizations will hire and train additional personnel prior to TCMS set availability. Preparing personnel to perform their roles in activation, validation and ongoing operations will require extensive training even for experienced personnel. Estimated training periods are: two years for Sustaining Engineering, seven months for Operations & Maintenance, and three months for user personnel. See section five for more detail.

**1.3.5 INTERMEDIATE LEVEL MAINTENANCE FACILITY (ILMF).** Plans are being developed to repair common Core items in the CCMS II ILMF. The off-line Support Facility will be available for fault isolation, verification, and sustaining engineering of TCMS unique items. The Off-Line Support Facility will be used for the intermediate level repair of any TCMS unique LRUs, mission or time critical LRUs, or LRUs where it is more cost effective than repair by an outside source.

## **1.4 ROLES AND RESPONSIBILITIES**

**1.4.1 USERS.** The term "user" refers to Space Station Systems Engineers who direct, perform, and control GSE and flight hardware test and checkout (end item testing) activities from TCMS user room consoles. The Systems Engineering & Experiments Division (CS-EED) and the Payload Processing Division (CS-PPD) will share user responsibilities along with PGOC Payload Projects Directorate. Depending on the type of testing in progress, either CS-EED or CS-PPD will assume user responsibility.

Typical user responsibilities will include the following:

- a. Define individual user functional responsibilities, interface, and seating assignments for each engineering console in the user rooms. Assign user consoles during software development, payload, experiment, or GSE validation, processing and other required tasks.

- b. Prepare and submit for inclusion in the KSC Payload Integrated Control Schedule (PICS) TCMS user schedules required to support payload testing.
- c. Develop applications programs required for payload and experiment testing. (These programs are combined with operations and maintenance applications programs during system build to provide a TCMS test configuration.)
- d. Develop applications and models for use in simulation.
- e. Monitor user consoles during testing.
- f. Control integrated test sequencing.
- g. Troubleshoot user application programs and flight hardware anomalies.
- h. Provide point of contact for Operator and User interface for TCMS test support.
- i. Define/concur with TCMS configuration changes during testing.
- j. Coordinate TCMS related test problems with the TCMS Master Console operator for troubleshooting and resolution.
- k. Coordinate with the TCMS Master Console operator concerning user console assignments or reassignments of TCMS resources.
- l. Perform testing of Space Station hardware.
- m. Recommend system modifications to enhance system performance, operability, and maintainability.

**1.4.2 OPERATIONS AND MAINTENANCE.** Operations and Maintenance (O&M) involves managing and controlling TCMS before, during and after testing of flight hardware as well as using system diagnostics and troubleshooting techniques to diagnose system problems to the LRU level. The term "operator" refers to personnel who manage and control the overall operation of TCMS via an individual master console for each test resource set. This includes preparing TCMS sets for testing; configuring the TCMS hardware and operating software for payload processing; and providing hardware and operational software maintenance. Operator functions will be the responsibility of the Ground Systems Division (CS-GSD) and PGOC Technical Support Directorate.

Typical O&M responsibilities will include the following:

- a. Operation and operational maintenance of TCMS in support of payload processing.
- b. Provide configuration accounting for and serve as custodian of, TCMS hardware, software, and firmware.
- c. Develop and maintain operational configuration baselines to manage the identification, documentation, scheduling, and support requirements for the TCMS.
- d. Configure TCMS hardware and software to support test requirements and schedules.
- e. Define/concur with TCMS configuration and configuration changes during testing.
- f. Define/concur with DMS Kit configuration and configuration changes during testing.
- g. Coordinate with the user any TCMS problems that may affect test schedules.
- h. Prepare and submit for inclusion in the KSC Payload Integrated Control Schedule (PICS) TCMS operator schedules required to support outage, maintenance, and system modifications.
- i. Troubleshoot, document, and resolve problems related to TCMS hardware and system software. Prepare and investigate Interim Problem Reports (IPR) and Problem Reports (PR) associated with TCMS equipment.
- j. Monitor activity of TCMS from each set's master console.
- k. Provide point of contact for Operator/User interface for TCMS test support.
- l. Provide storage and recall capability for operational test data and on-line post test data analysis.
- m. Establish a TCMS Working Group to discuss TCMS change requests before forwarding them to CP-SSO.
- n. Maintain Operation and Maintenance Instructions (OMIs) for TCMS hardware and system software.

- o. Develop TCMS operational and operational maintenance concepts and procedures recognizing functional interfaces, resource allocations, software, hardware and system capabilities, spare parts, test equipment, documentation, support services availability, and requirements.
- p. Recommend system modifications to enhance system performance operability, and maintainability.
- q. Plan, direct and coordinate the organizational and off-line support set activities of TCMS, associated interfaces and related support equipment.
- r. Provide and manage TCMS system security including control of passwords and access privileges.
- s. Perform systems and database housekeeping functions.
- t. Perform operations, maintenance and administration of the SPF and Database Subsystem (DBS).
- u. Plan, direct and coordinate Off-Line Support Facility and ILMF activities of TCMS, associated interfaces and related support equipment.
- v. Coordinate the repair of TCMS hardware in the CCMS ILMF.
- w. Provide systems management and performance management functions.
- x. Provide documentation and tracking of TCMS LRU hardware configuration to support maintenance and sustaining engineering functions. This includes, as a minimum, the LRU bar code, part number, revision, serial number, and reference designator. This information is maintained for the current and past locations of the LRU. This applies to installed hardware and non-installed hardware (spares and items being repaired). This function is expected to reside in the Payloads Data Management System (PDMS) supply support application area.

**1.4.3 SUSTAINING ENGINEERING.** Sustaining Engineering refers to the line organization responsible for providing hardware and software support by performing approved hardware and system software modifications and other sustaining engineering functions, resulting from Change Requests, Engineering Support Requests, Problem Reports, and Software Problem Reports. Sustaining engineering will be the responsibility of CS-GSD and the PGOC Product Engineering and Definition Directorate.

Typical sustaining engineering responsibilities will include the following:

- a. Sustaining engineering of TCMS in support of payload processing.
- b. Assume sustaining engineering functions when transferred from DL/HSSC and DL-DSD. To ensure a smooth transition, CS-GSD/PGOC will work with DL/HSSC prior to actual turnover of these functions.
- c. Investigate, develop, and apply advanced system engineering processes and tools (including computer systems, operating systems, computer aided engineering techniques, language processors, test and validation techniques, and troubleshooting tools and techniques) to enhance the accuracy, operability, reliability, and efficiency of TCMS.
- d. Prototype modified systems software and hardware designs to evaluate the feasibility and applicability to TCMS.
- e. Recommend system modifications to enhance system performance, operability, and maintainability.
- f. Maintain capability of the system to simulate payloads, experiments, and GSE for user software development and validation.
- g. Provide data base design services.
- h. Design and develop test equipment and test tools for verification and maintenance of TCMS, special interfaces and related peripherals; develop software and hardware interfaces for Automatic Test Equipment (ATE).
- i. Develop test and diagnostic software and system and utility programs to facilitate operation and maintenance of TCMS.
- j. Provide assistance as required to O&M personnel in troubleshooting difficult problems.

**1.4.4 LOGISTICS SUPPORT.** The term "Logistics Support" refers to the Payload Support Division (CS-PSD) and the PGOC Production Support Directorate which provides Logistics, Materiel and Procurement support for TCMS.

Typical responsibilities of Logistics Support include the following:

- a. Logistics Support functions, including spare parts provisioning, critical spares tracking and reporting for testing support, stock inventory and replenishment, and modification kitting functions.
- b. Continuously monitor the level of spare LRUs. In consultations with the operator, determine proper levels and reorder quantities based on current

and projected failure rates. Initiate procurements of LRUs to maintain the proper level of verified spares in stock.

- c. Research the continued availability and obsolescence trends of TCMS LRUs/subsystems and piece parts. Identify those items that are about to become obsolete. Consult with Sustaining Engineering as to an appropriate course of action.
- d. Provide and maintain an adequate bench stock in laboratory and other areas as required to support repair, fabrication, and modification activities.
- e. Custodian for all TCMS spare LRUs. These LRUs in electrostatic discharge (ESD) protected packages are stored in close proximity to operational sets. This does not include "hot spare" LRUs or any installed equipment.
- f. Provide materiel support functions, including packaging, handling, delivery, and transportation.
- g. Provide property control and calibration services for TCMS test equipment.
- h. Manage external maintenance contracts and depot support for TCMS equipment that are required by organizational and CCMS ILMF maintenance management. Manage and track all items returned to vendor (RTV) for repair. Provide RTV status and repair actions to the operators.

**1.4.5 SAFETY, RELIABILITY AND QUALITY ASSURANCE.** SR & QA functions will assure the safe and reliable validation and operations and maintenance of TCMS hardware and software.

Typical responsibilities of SR & QA include the following:

- a. Monitor during troubleshooting and problem resolution relative to TCMS hardware and system software.
- b. Provide a Technical Library in the SSPF to house TCMS data packages, engineering drawings, completed problem reports, etc.
- c. Track and audit TCMS software configuration. SR & QA will provide software assurance support for software modifications.
- d. Review and concur with test plans for TCMS hardware and software modifications.

- e. Review and plan Operation and Maintenance Instructions(OMIs) for TCMS hardware and system software.
- f. Develop and maintain Operation and Support Hazard Analysis (O & SHA) for operation of TCMS system.
- g. Provide Safety, Reliability, Maintainability and Quality Assurance (SRM & QA) sustaining engineering.
- h. Quality Assurance (QA) shall document and maintain TCMS anomalies via the Nonconformance Problem Reporting and Corrective Action (PRACA) system (Reference SP 10.001.a91).
- i. Monitor TCMS O&M activities, especially on-line testing.

**1.4.6 CONFIGURATION MANAGEMENT.** Configuration management is used to describe two distinct functions in the TCMS realm. Therefore, for the sake of clarification, the following is provided to distinguish the differences between the control and tracking of TCMS design and test configurations.

**1.4.6.1 Controlling the records of the TCMS implemented design** (consisting of the identification, control, verification and accounting of system components and operating system software after turnover) is the responsibility of the PGOC Program Control (PC) Directorate. PC will identify the TCMS components to be under configuration control and will define these components' baseline configuration. The Payloads Level III/TV CCB will disposition proposed changes to the configuration baseline. Verification of changes to the TCMS will be accomplished by quality reviews to assure that hardware and software designs satisfy approved requirements, and that modifications have been incorporated according to the modification instructions. Refer to PGOC Configuration Management Plan, MDC Y0148.

**1.4.6.2 Test configuration management** consists of the control, tracking, and setup of the TCMS hardware quantities and interfaces to be configured for a particular set of Space Station Flight Element tests. The TCMS O&M organization will be responsible for test configuration management of the TCMS. Test configuration management will be accomplished by the use of specific O&M system software designed for that purpose.

Configuration management of mission unique software, files, and cabling will be the responsibility of the TCMS users and operators. Configuration management of files which are used for system administration or to automate operator functions, such as start up scripts, will be the responsibility of the TCMS operators.



## SECTION II

### OPERATIONS

#### 2.1 USER INTERFACE

Control of payload testing from a Display Processor (DP) will be a function of the Space Station Systems Engineers (user community) under direction of the Payload Test Conductor (PTC). Control of the TCMS equipment to accomplish this testing will be a function of the TCMS Systems Engineers (O&M community) under direction of the TCMS Set Manager. Together, utilizing the proper interfaces, the user community and the O&M community will function as an integrated test team. Figure 2-1 illustrates the user/operator interface.

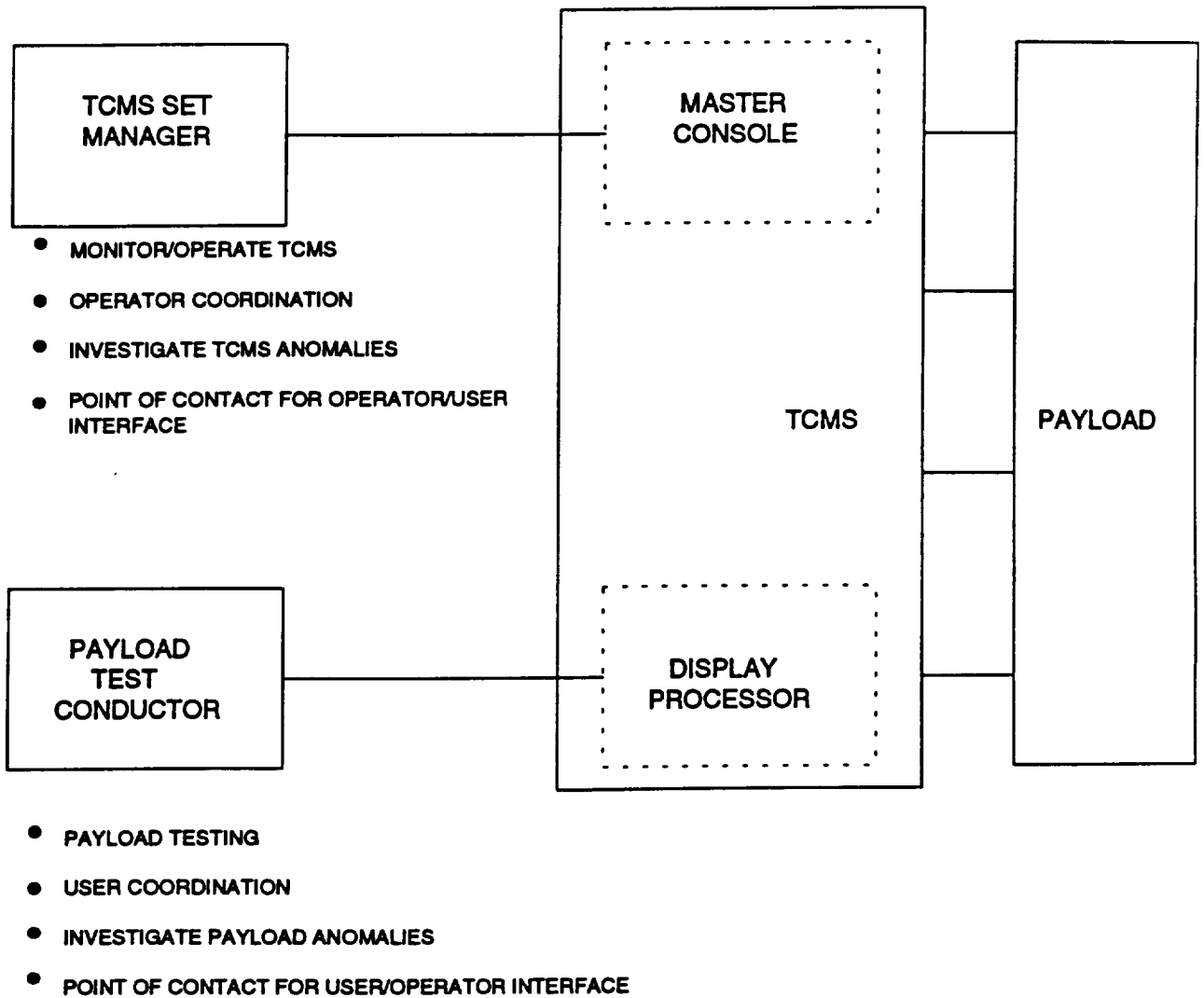
Testing will be accomplished according to work authorization documents (OMI, TAP, IPR, AND PR) which are written by Space Station Systems Engineering and TCMS Systems Engineering. The work authorization documents will define in detail the setup procedures needed for testing activity. These documents will be approved by both the customer and O&M community.

The TCMS operations staff (O&M community) will be responsible for configuring, operating and monitoring TCMS from the Master Console. The Payload Test Conductor will lead test article system level testing and will be responsible for all aspects of the testing including acting as the point of contact for any problems that may arise. These problems will be investigated jointly by the user community and the O&M community until the source of the problem is isolated to either the payload or the TCMS. If the problem is with the TCMS, the TCMS Set Manager will be the point of contact until the problem is resolved.

Space Station Ground Operations Engineering (user community) will be responsible for coordinating the transportation, handling, staging, and scheduling of GSE and flight hardware involved in pre-launch processing. In addition, they will have the option to use TCMS Display Processors (DP) or payload workstations to access external data systems in order to review and update logistics, scheduling, Problem Reporting and Corrective Action (PRACA) information.

#### 2.2 TEST SET CONFIGURATION

The TCMS operations staff will configure the TCMS hardware and software sets for processing. This hardware and software configuration will be defined during the test build process, which creates the Test Configuration Identifier (TCID) for each test, simulation or software development Test Resource Set (TRS).



**FIGURE 2-1**  
**USER/OPERATIONS INTERFACE**

## 2.3 TEST EXECUTION

Test execution and control will be the responsibility of the TCMS user staff and will be controlled as specified in the OMI by the Payload Test Conductor. O&M will be responsible for monitoring test execution, and configuration of TCMS resources to support testing. The TCMS Set Manager will monitor the testing from the Master Console. When an anomaly in the flight hardware is detected, the Space Station Systems Engineer (user community) is responsible for isolating the failed component, repairing or replacing it, and reverifying its functionality using TCMS capabilities.

## 2.4 TEST DATA MANAGEMENT

Test data will be recorded, archived and cataloged for later retrieval. Retrieval of this data can then be initiated by authorized TCMS operators and users from the control room, from a user room, or from a CM office workstation. Any manipulation of this test data and preparation of data reports will be the responsibility of the TCMS user.

In case of catastrophic failure, TCMS Operations and Maintenance will manage the process of impounding records and data. O&M in conjunction with the users will develop an impound procedure.

## 2.5 SECURITY

TCMS System Security Administration will be the responsibility of the TCMS Operations and Maintenance community. Security will be implemented at level 3, according to NHB 2410.9 which will include a combination of physical security, where sensitive components are locked in a secure area, and software security using passwords, logon ID privileges for access controls, and audit trail techniques. Implementation may be reduced to level 2 in some areas. A TCMS Security Plan and Risk Assessment will be drafted by the security working group prior to implementation of TCMS Verification.

## SECTION III

### ON-LINE MAINTENANCE

#### 3.1 OVERVIEW

The TCMS will be designed and supported based on the three-level maintenance concept defined in the Program Definition and Requirements Documents (PDRD) of the Space Station Freedom Program (SSFP). The three levels of maintenance are:

- a. Operational Maintenance - maintenance in direct support of TCMS operations and performed on-line. This includes scheduled and corrective maintenance. Organizational and on-line maintenance are used interchangeably herein. Only this type of maintenance is addressed in this section.
- b. Intermediate Maintenance - maintenance performed off-line in direct support of organizational level maintenance. Refer to Section IV for discussion.
- c. Depot Maintenance - maintenance that is performed off-line in direct support of intermediate level maintenance and requires equipment, facilities, or skills that are not normally available at the intermediate level, such as repairing, modifying, or rebuilding parts or components. Refer to Section IV for discussion.

On-line maintenance refers to operational maintenance only. The goal of on-line maintenance is to provide a preventive maintenance and corrective maintenance (LRU replacement) service in order to keep TCMS at full operational status as much as possible and minimize system downtime.

#### 3.2 PREVENTIVE MAINTENANCE

Preventive maintenance is performed on a scheduled basis. The design of TCMS will be such that routine preventive maintenance will not be intrusive or destructive to system operation, nor will it preclude meeting systems availability requirements. The capability to schedule and document preventive maintenance activity will be provided through the Operations and Maintenance Instructions. The OMI documentation, Work Authorization Documentation (WAD) and scheduling procedure will be compatible with the Payload Data Management System (PDMS).

Preventive maintenance will be planned and accomplished utilizing the Reliability Centered Maintenance (RCM) concept. RCM is a scheduled maintenance strategy that can ensure cost effectiveness by significantly lowering maintenance costs. An inherent component of RCM is the premise that if the failure does not have safety consequences, then scheduled maintenance is desirable only if it is cost effective.

### 3.3 CORRECTIVE MAINTENANCE

The TCMS will be designed with self-test features, using modular architecture, for ease of maintenance. Corrective operational maintenance will primarily be accomplished by removal and replacement of LRUs.

Corrective maintenance will be performed in the most effective manner to repair/replace/restore the failed unit to an operationally ready state. Life Cycle Cost (LCC) and Logistics Support Analysis (LSA) will be considered to identify items, equipment, modules, etc., for repair and determine their repair location, level of repair, and disposition of removed LRUs.

Life Cycle Cost is defined as the total cost of acquiring, operating, and supporting a system over its lifetime. LSA is a systematic and comprehensive analysis performed during the design, development and operational phase of a system. These analyses will be used to identify support criteria, support resources, and establish baseline supportability requirements for incorporation into the design process. LSA will be used along with other criteria where applicable to the KSC environment to establish specific maintenance requirements.

### 3.4 PROCEDURES

The focal point for operational and maintenance procedures will be the Master Console. From here the TCMS Set Manager or Master Console Analyst will have the visibility into the internal operations and health & status of the system using the following available fault detection and isolation tools:

- a. Operational Readiness Test (ORT).
- b. Health and Status Displays.
- c. Fault detection, isolation, and recovery (FDIR) software.
- d. The capability to initiate remote diagnostics in off-line subsystems through the maintenance/service bus.

Once a problem is detected, it must be isolated to a particular subsystem. That subsystem is then removed from on-line support status and replaced with a hot spare from the off-line support set or redundant subsystem. Troubleshooting then proceeds on the failing subsystem. If the faulty LRU is found, it is replaced; if not, the subsystem is moved to the Off-Line Support Facility where troubleshooting continues involving special off-line test equipment (see Off-Line Maintenance, Section 4). Final determination of what

constitutes an LRU, it's level of repair, and where it is repaired will be made by the organization responsible for TCMS Operations and Maintenance.

**3.4.1 GROUND RULES AND ASSUMPTIONS.** The following ground rules and assumptions will apply to organizational level maintenance for TCMS:

- a. Mean time to repair (MTTR) shall not exceed 30 minutes for 90% of repairs with the remaining 10% requiring 90 minutes or less.
- b. Built-in-test (BIT) diagnostics shall identify system faults with a 75% accuracy.
- c. BIT will be provided for both commercial-off-the-shelf (COTS) and custom-built hardware.
- d. Upon replacement of an LRU, an initiated BIT (IBIT) will be performed to verify the unit is operating properly.
- e. Health and status will be continuously monitored by a background process during all system operations.
- f. Self-Test diagnostics shall verify functionality of components and interfaces upon all power-up/reset conditions.
- g. BIT equipment will be capable of locating a problem to a LRU level(including black box and PCBs).
- h. System operators will have been trained in BIT diagnostics.
- i. Maintenance personnel will be on-station during test operations to remove/replace identified failed units. Maintenance personnel will be assigned to support on-line testing or off-line support.
- j. Spares will be located in the Material Service Center (MSC) in the SSPF in order to maintain system operation readiness within the prescribed repair times.
- k. Subsystem ORT, BIT, and system/subsystem diagnostics will be used as a reverification method for subsystems and LRUs which have been repaired.

**3.4.2 INTERFACES.** The TCMS maintenance organization will interface with other organizations in order to facilitate the efficient operation of TCMS. These interfaces are briefly described in the following paragraphs.

3.4.2.1 Sustaining Engineering. In the event of a system software failure during test execution, PGOE Sustaining Engineering personnel may be called upon to assist TCMS O&M system and software engineers in fault diagnosis, isolation and restoration of system software. System hardware design problems which arise will also be the responsibility of PGOE Sustaining Engineering.

3.4.2.2 System Users. When an anomaly is detected during on-line testing, the TCMS systems engineer will work with the flight systems engineer to isolate the failure to either TCMS or flight hardware/GSE/user provided software. If it is a TCMS system problem, the TCMS systems engineer will then isolate the problem to identify the failed hardware or software component, and work with other O&M personnel to restore full capability as quickly as possible. During this process, the TCMS system engineer is responsible for documenting data and troubleshooting steps using PRACA.

### 3.5 ON-LINE PERSONNEL

On-line maintenance will be performed by PGOE personnel. Maintenance personnel will be rotated through the Off-Line Support Set to gain a greater understanding of the TCMS maintenance environment, as well as insight into the nature and causes of system and LRU failures. This arrangement will enhance experience in all aspects of maintenance, foster greater communications among all TCMS maintenance personnel, and reduce the integration which would be required with separate maintenance groups. The result will produce a more rapid and accurate isolation of system problems and afford a depth of expertise and support capability.

Training of on-line maintenance personnel will be performed on the off-line support set.

## SECTION IV

### OFF-LINE MAINTENANCE

#### 4.1 OBJECTIVES

**4.1.1 ON-SITE REPAIR OF LRUs.** The CCMS II ILMF will be used for the on-site repair of all LRUs where it is deemed to be cost effective or necessary to protect schedule and assure TCMS functionality. The off-line Support Set will be used for repair and verification of TCMS unique LRUs. It is not intended that existing repair facilities for Commercial Off The Shelf (COTS) items will be duplicated. Where such repair facilities are available, they will be used as long as it is practical. The decision of what will be repaired on site and what will be returned to the vendor for repair will be decided by CS-GSD/O&M with assistance from CS-PSD/logistics support. CS-PSD will provide information concerning availability of resources (spares), life cycle cost and Logistics Support Analysis (LSA). In making this decision, consideration will be given to support for on-line processing requirements, the payload schedule (time constraints), and availability of resources.

Typical flow of subassemblies in the repair cycle is shown in Figure 4-1.

**4.1.2 HOT SPARES FOR ON-LINE REPAIRS.** Hot spares will be used to the maximum extent possible for replacement of defective TCMS components. This will assure that the replacement part is configured and/or functioning properly and calibrated.

**4.1.3 SUBSYSTEM LEVEL TESTING/VERIFICATION.** Once an LRU has been repaired it must be verified prior to stocking it as a known good unit. This is true whether the LRU was repaired locally or by an outside depot. This should be done by using an off-line set and thereby not impacting on-line system availability and running the risk of corrupting test data. The LRUs may be installed in the off-line support set and operated for a period of time to verify it is functioning properly. Only after this verification phase could the LRU be stocked as a good replacement part.

Another application for the off-line support set occurs when the LRU replaced during on-line troubleshooting contains multiple components. The off-line support set may be used for further fault isolation without impacting the on-line system. For example, an entire display processor is changed out during on-line troubleshooting and the off-line support set is used to isolate the fault to a circuit board. The failing component could then be replaced with a new one and the defective component would then be repaired, returned to the vendor for repair or discarded depending on practicality.

**4.1.4 VERIFICATION OF PROPOSED CHANGES.** Any change to the hardware of the TCMS will need to be verified before it can be installed in the on-line system. This



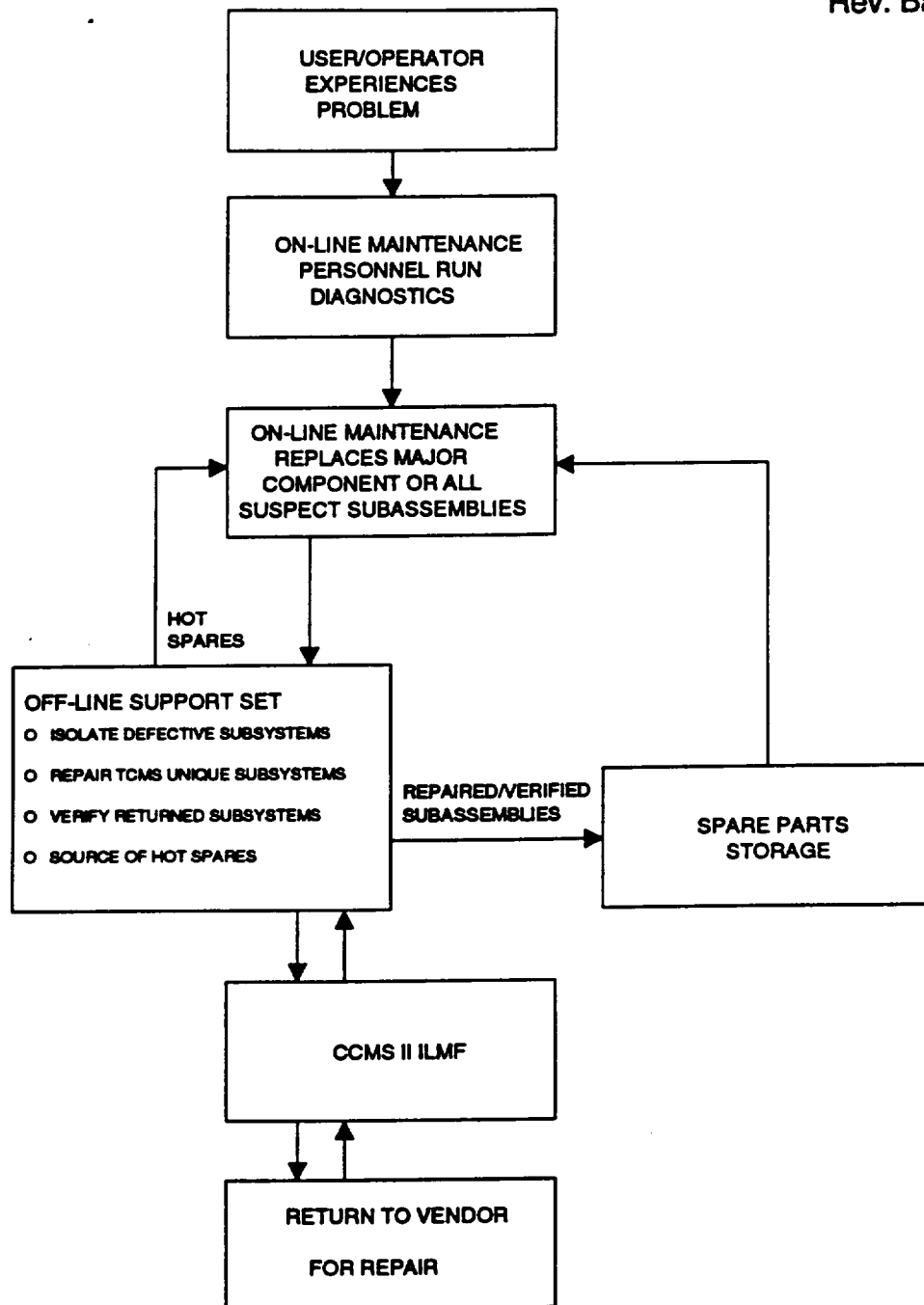


FIGURE 4-1  
REPAIR FLOW

will be accomplished by using the off-line support set. Once the change has been properly verified, it can then be installed in the on-line system without danger of impacting on-line testing.

**4.2 SUSTAINING ENGINEERING INTERFACE.** TCMS sustaining engineering will consist of the engineering activities for system software maintenance, system software validation, hardware and system software modifications and upgrades, system documentation, and other services necessary to provide an accurate definition and simulation of Space Station functions and interfaces, as described below.

- a. Maintain the design so that it fulfills its original intent and is compatible with the intended operational use.
- b. Upgrade operational performance capabilities through product improvement redesigns for safer or more cost effective operations.
- c. Minimize or eliminate critical single point failures and residual hazards.
- d. Incorporate approved changes and associated documentation as they evolve.
- e. Provide technical expertise to NASA and PGOC organizations.

NASA CS-GSD/PGOC-PED will provide sustaining engineering for the TCMS and will ensure that sustaining engineering is performed in accordance with the MDSSC Sustaining Engineering Management Plan, MDC Y1010. NASA CS-GSD/PGOC PED will integrate and implement sustaining engineering policies and procedures.

**4.2.1 SOFTWARE MAINTENANCE.** NASA CS-GSD/PGOC PED software design engineers will provide modifications and upgrades to TCMS system software and will perform validation/verification of commercial software upgrades. The NASA CS-GSD/PGOC PED software design engineers will also provide the sustaining engineering activities for TCMS system software. The TCMS application software will be provided by NASA CS-EED/CS-PPD and PGOC PPD

**4.2.2 HARDWARE MAINTENANCE.** The O&M organization is responsible for organizational and intermediate maintenance levels (off-line support facility) for TCMS. Product Support (NASA CS-PSD/PGOC PS) will be responsible for maintaining TCMS maintenance agreements and arranging for or performing depot level maintenance for TCMS hardware. NASA CS-GSD/PGOC PED will provide technical assistance to Operations and Maintenance at the intermediate and depot maintenance levels. Depot level maintenance will be performed in accordance with the MDSSC Hardware Disposition List (HDL) for the TCMS. The TCMS Integrated Logistics Support Plan, MDC Y1118, describes maintenance levels and responsibilities.

**4.2.3 MODIFICATIONS AND UPGRADES.** Modifications and upgrades for TCMS system software components and design of hardware modifications will be the responsibility of NASA CS-GSD/PGOC PED. TCMS problems or deficiencies will be documented on Problem Reports (PRs) using the NASA Problem Reporting and Corrective Action (PRACA) system. Recommendations for hardware or software modifications, studies, and proposals regarding TCMS problems or deficiencies are documented on Engineering Support Requests (ESRs). ESRs are reviewed, authorized, and funded through the Payloads Level III/IV Configuration Control Board (CCB).

**4.2.4 O&M DOCUMENTATION.** O&M Documentation for the TCMS will consist of procedures, OMIs, specifications, drawings, and Operation and Maintenance (O&M) manuals. Copies will be located with TCMS sets. NASA CS-GSD/PGOC PED will provide the necessary documentation and will be responsible for maintaining the documentation to reflect all modifications and changes to the TCMS hardware and software.

**4.2.5 OFF-LINE ENGINEERING SUPPORT.** NASA CS-GSD/PGOC PED will provide engineering assistance as needed to off-line maintenance organizations for the fault isolation and repair of TCMS unique hardware. NASA CS-GSD/PGOC PED will also provide engineering to NASA CS-GSD/PGOC TS and NASA CS-PSD/PGOC PS for development of Intermediate and Depot Maintenance Manuals (IDMMs).

#### **4.3 LOGISTICS INTERFACES**

**4.3.1 NON-TCMS UNIQUE SUPPORT.** Logistics support among Shuttle Payload Operations Divisions is composed of several different functions under the purview of the Payload Support Division, NASA CS-PSD, and implemented by the MDSSC -KSC Production Support Directorate:

- a. Integrated Logistics Planning Department, F814.
- b. Payload Depot Department, F822.
- c. Operations Support Department, F840.
- d. Logistics Support Department, F860.
- e. Physical Distribution Department, F850.
- f. Procurement Department, F890.

**4.3.2 TCMS UNIQUE SUPPORT.** The following are statements in response to TCMS O&M Philosophy unique requirements. The department with prime responsibility is included for each function.

**4.3.2.1 Spare Parts Provisioning.** Production Support will utilize the TCMS operations and maintenance concepts developed by the O&M organization as a basis for spare part provisioning. Point of contact for maintenance concept development and spares provisioning coordination is the Integrated Logistics Planning Department, F814.

**4.3.2.2 Spares Tracking.** Production Support is responsible for critical spares tracking/reporting for testing support as identified by the O&M organization. This does not include "hot spare" LRUs or any installed equipment. Post issue tracking will be the responsibility of the organization making the demand. Point of contact for inventory management is the Logistic Support Department, F860.

**4.3.2.3 Inventory Stocking and Replenishment.** Inventory stocking, replenishment and modification kitting functions will be accomplished in accordance with applicable Standard Practices (SPs). Point of contact for inventory stocking and replenishment is the Logistics Support Department, F860. The modification kitting function point of contact is the Operations Support Department, F840.

**4.3.2.4 Bench Stock.** Adequate bench stock will be maintained based on requirements data provided by the O&M organization. Point of contact is the Operations Support Department, F840.

**4.3.2.5 Depot Level Repair.** To support CS-GSD O&M responsibilities, an off-line (depot level) repair capability under CS-PSD is made available, as an option, for the repair and manufacturing support of TCMS equipment that for reasons of cost, schedule or capability can not be adequately supported by the O&M organization. Reference the Space Station Logistics Capabilities Manual, (KSC-MN-0012.4.01) for details. Point of contact for support is the Payload Depot Department, F822.

**4.3.2.6 Calibration Service.** Calibration service for TCMS test equipment will be provided. The O&M organization will provide calibration specifications including calibration cycle requirements. Point of contact for all calibration needs is the Payload Depot Department, F822.

## SECTION V

### OPERATOR AND MAINTENANCE PERSONNEL TRAINING

#### 5.0 O&M TRAINING

Adequate training will be crucial to developing a skilled O&M team. As often as practicable, O&M will staff with personnel who already possess basic skills for the jobs they will fill. But, due to the unique design and function of TCMS, all personnel will require specialized training to effectively carry out their responsibilities. This training will be sustained throughout the life of the program. In-house training will be developed to supplement Core training classes provided by HSSC. Outside training classes will be procured for specific topics. Production Support will coordinate and provide all training other than that provided within the O&M department. O&M will provide training requirements and course evaluations to Production Support.

#### 5.1 OBJECTIVES

The training goals for O&M are:

- a. Hire the best people.
- b. Train all personnel to a standard level.
- c. Provide job specific training.
- d. Provide on the job training (OJT).
- e. Provide advanced and refresher training as needed.
- f. Cross train personnel to support critical functions.

#### 5.2 RAMP UP TIME FOR PERSONNEL

Due to the complexities of TCMS and the O&M process, a seven month training period will be required for new O&M personnel. This training period will include lecture, lab and OJT. All personnel who perform O&M functions to a set used for Space Station Processing must be certified (Stand Boarded).

#### 5.3 USE OF OFF-LINE SUPPORT SET

The off-line support set will be the primary laboratory for O&M training. Use of this resource will increase training availability and reduce risk involved with using an on-line set. Since the off-line set will be used for many other functions besides training, O&M will schedule its use for training so as not to conflict with availability for LRU checkout and support of on-line systems.

#### 5.4 ROTATION OF PERSONNEL

O&M personnel will be cross trained and rotated among assignments. This will:

- a. Eliminate single point failures.
- b. Improve everyone's understanding of TCMS and the O&M process.
- c. Provide growth opportunities for personnel.
- d. Allow personnel to move to different shifts.
- e. Provide depth of capability.

## SECTION VI

### SYSTEM DELIVERY

#### 6.1 TCMS (CEC) ACTIVATION & VALIDATION

The O&M Department will actively participate in the planning and execution of TCMS activation and validation. This is important to provide O&M personnel experience on the system and to ensure they can perform O&M during normal operations. O&M will work closely with PGOC PED, NASA and Harris. Activities which will be accomplished for activation are shown in figure 6-2.

#### 6.2 TCMS TOTAL SYSTEM VALIDATION

The O&M Department will actively participate in the planning and execution of validating the total TCMS, including GSE, DMS kits, etc. O&M will use this experience to develop procedures prior to the start of normal operations.

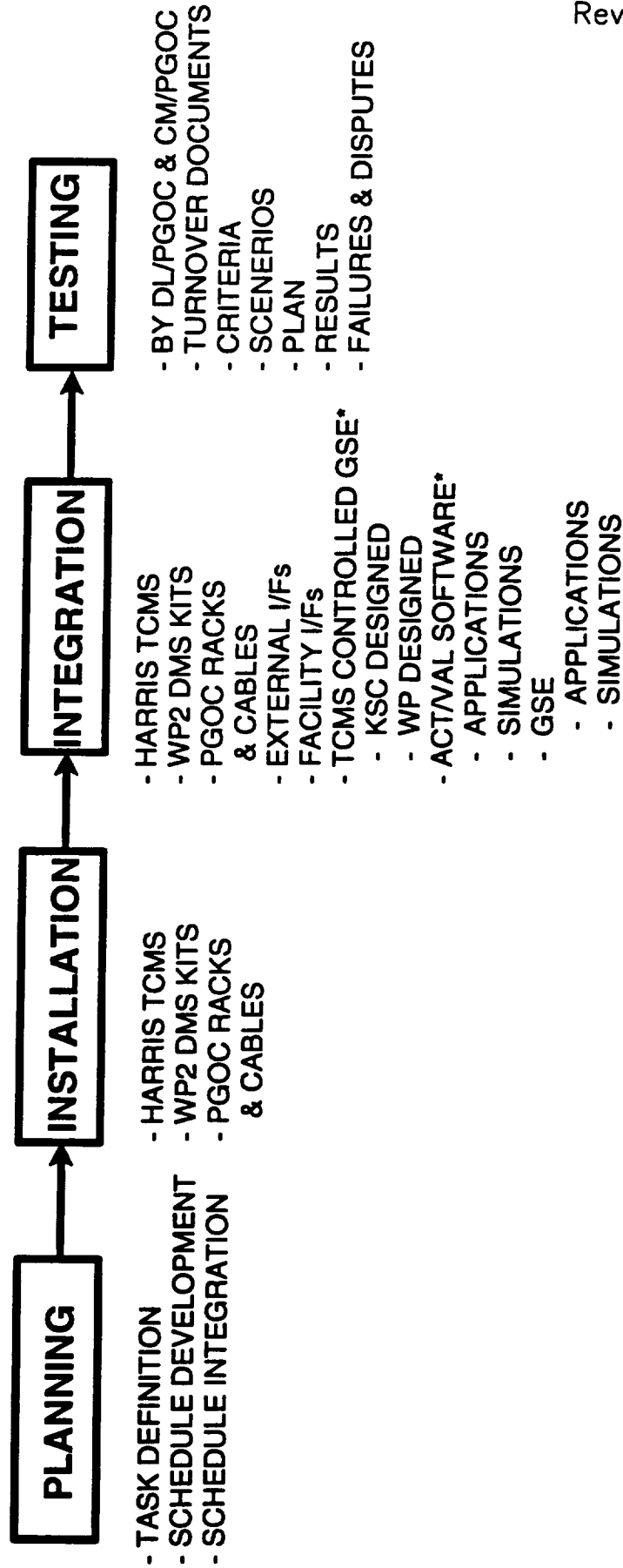
#### 6.3 CAF SET AT JOHNSON SPACE CENTER (JSC)

The O&M Department will perform Operations and Maintenance services at Johnson Space Center if/when a TCMS is installed there. The methods and processes used will be determined after approval of this set.

# TCMS ACTIVATION

(DE/PED LEAD)

(CM/TS SUPPORT)



\* INDICATES ACTIVITIES TO BE COVERED BY OTHER AVWGs AND SUPPORTED BY TCMS AVWG MEMBERS

Figure 6-1