1. INTRODUCTION

It has been agreed that an important contribution to minimising the resource requirements for the development and operation of the FIRST satellite is a common approach to instrument testing and in-flight operations, with the maximum reuse of equipment and software through all phases of the mission. Discussions have been held between the three FIRST instruments and ESA/ESOC with the intention of producing an agreed approach to the development and implementation of the FIRST Ground Segment (FGS), which meets this goal. Based on this concept, described in RD1, the FGSDD (RD2) describes the systems and the interfaces making up the entire FGS and their evolution over time and the FGS-IRD (RD3) gives the requirements on the interfaces between the systems.

Figure 2-A shows the configuration to be used during the Instrument-Level Test (ILT) phase and identifies the different systems that make up the complete test system (called the Electrical ground Support Equipment, or EGSE). The user requirements on each system are documented in separate URDs (RDs4-7 and this document) and an additional set of ICDs (listed in RD8) describe the interfaces between them.

This document is extracted from the original EGSE URD (RD9) and provides the high-level requirements on the parts of the EGSE-ILT system that are common to all the FIRST instruments. It does not address those parts of the EGSE-ILT specific to any one instrument (interfaces to specific test equipment). The IID Parts A and B (AD1 & AD2) (will) describe the interfaces between the spacecraft and the instruments and those between the EGSE and the system-level checkout equipment.

The next section of this document gives an overview of the EGSE-ILT system and describes the subsystems that it contains. Section 3 goes into more detail of the requirements on each subsystem.

1.1 Documents

1.1.1 Applicable Documents

AD1:	Instrument Interface Document Part A	PT-IID-A-04624
AD2:	Instrument Interface Document Part B	
	HIFI	PT-HIFI-02125
	PACS	PT-PACS-02126
	SPIRE	PT-SPIRE-02124
AD3	Packet Structure ICD	SCI-PT-IF-07527

1.1.2 Reference Documents

RD1	FIRST Operation Scenario Document, Issue 0.95	SPIRE-ESA-DOC-000407
RD2	FIRST Ground Segment Design Document (FGSDD) Issue 0 Rev2	FIRST/FSC/DOC/0146
RD3	FGS Interface Requirements Document, Issue 1.0	FIRST/FSC/DOC/0117
RD4	FCSS URD	FIRST/FSC/DOC/0115
RD5	RTA URD	TBW
RD6	OBS Maintenance URD	TBW
RD7	MIB Editor URD	TBW
RD8	FIRST ground Segment List of ICDs, Issue 0; Rev1	FIRST/FSC/DOC/0150

RD9 EGSE Users Requirements Document, Draft 2 FIRST-SPI-DOC-000102

1.2 Acronyms and Glossary

APID	Application ID
CDMS	Command and Data Management System
DDS	Data Distribution System
EGSE	Electrical Ground Support Equipment
ERT	Earth Received Time
FGS	FIRST Ground Segment
FINDAS	FIRST Integrated Network and Data Archive System
FIRST	Far-Infrared and Sub-millimetre Telescope
HIFI	Heterodyne Instrument for FIrst
IA	Interactive Analysis
ICD	Interface Control Document
I/F	Interface
kbps	Kilo-bits per second
MIB	Mission Information Base
MOC	Mission Operations Centre
PACS	Photoconductor Array Camera and Spectrometer
PCS	Power Control System
QLA	Quick-Look Analysis
SPIRE	Spectral and Photometric Imaging Receiver
TEI	Test-Equipment Interface
URD	User Requirements Document

A full list of FGS terms is available at http://astro.estec.esa.nl/FIRST/FINDAS/fscdt.html

2. EGSE-ILT OVERVIEW

2.1 EGSE Systems

Figure 2-A shows the configuration of FCSS and other systems used during the Instrument-Level Tests and the interfaces between them. The provision of the FCSS is the responsibility of ESA with support from the instrument teams for development. Those systems outside the FCSS are provided by the instrument teams.

A more detailed view of the complete EGSE system is given in Annex A which shows the subsystems which comprise the EGSE-ILT.

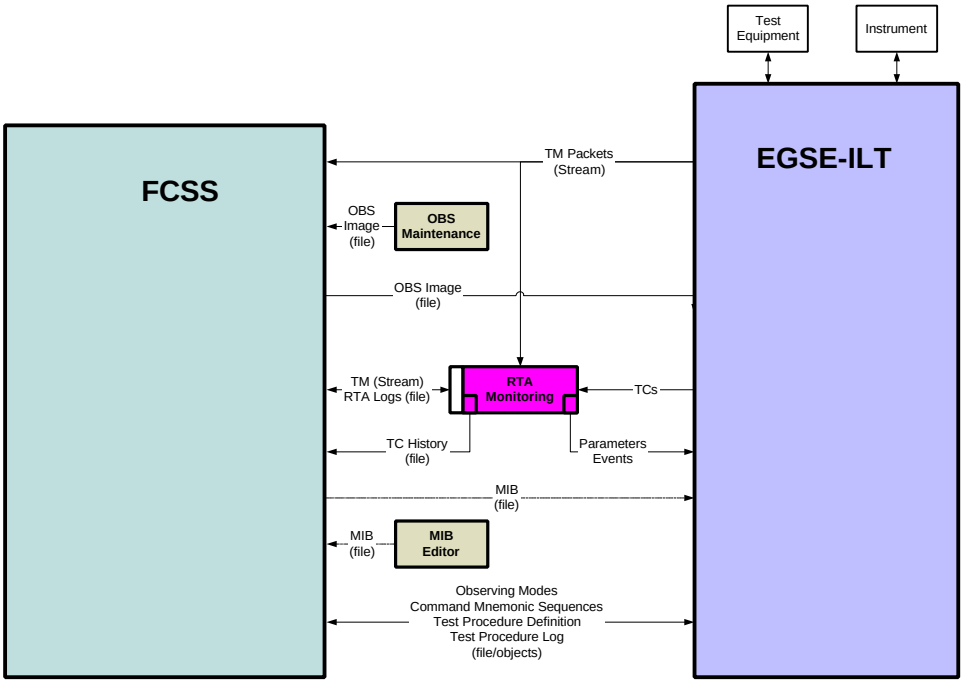


Figure 2-A EGSE Configuration for ILT

2.2 EGSE-ILT Subsystems

2.2.1 CDMS Interface

This component provides the hardware and software interfaces to the instrument under test. It simulates the telecommand and telemetry interfaces of the spacecraft Command and Data Management Subsystem (CDMS), the spacecraft Power Control Subsystem (PCS)) and the thermometry interfaces. It receives commands from and returns telemetry data through the TC/TM interface.

This subsystem will also simulate some of the activities of the operational ground equipment (e.g. absolute time stamping of telemetry packets)

2.3 Test Equipment Interface

This component provides the hardware and software to control and monitor the test equipment required to stimulate the instrument and simulate the operational environment during tests. It is controlled and provides information for monitoring the equipment through the TC/TM Interface. This command and telemetry information will be formatted as TC and TM packets conforming to the same structure as the instrument TC and TM as defined in the PS-ICD (AD3). In this way the test equipment may be treated as subsystems of the satellite as far as the commending and telemetry are concerned.

This subsystem will also simulate some of the activities of the operational ground equipment (e.g. absolute time stamping of telemetry packets)

There may be more than one instance of the Test Equipment interface depending on the types of test equipment to be controlled.

2.4 TC/TM Interface

The TM/TC interface routes TC and TM packets between the subsystems in EGSE-ILT. Telecommand packets addressed to the instrument will be passed directly to it through the CDMS interface, packets addressed to test equipment will be routed to the Test Equipment Interface.

2.5 Test Control

This subsystem provides facilities for:

- generating commands in the form of command mnemonics and parameters (from Command Mnemonic Sequences provided by the FCSS, and from interactive input from the user/operator in the form of mnemonics and parameters in engineering units).
- executing test procedures and controlling operation of the system.
- implementing the real-time autonomy functions provided by the CDMS in flight. This means that it needs to provide facilities to respond to events generated by the RTA component, if necessary by taking appropriate action, including commanding the instrument and/or test equipment.

2.6 SCOS2000

This component of the EGSE provides two of the subsystems required by the EGSE-ILT, as well as the RTA and monitoring functions, which lie outside the scope of this document.

The commanding subsystem translates mnemonics plus parameters into TC packets which can be sent to the instrument or test equipment. It does this based on information stored in the Mission Information Base (MIB), which is imported from the FCSS.

The OBS Management subsystem is responsible for creating the appropriate commands for uplinking instrument on-board memory patches and verifying their correct installation. It uses an on-board image file provided by the OBS maintenance system.

3. EGSE-ILT SUBSYSTEM REQUIREMENTS

This section provides the requirements for each subsystem (or group of subsystems) in the EGSE-ILT system. Each Requirement is assigned a unique number and an indication of the desirability of its implementation.

3.1 Interfaces

This section includes requirements on the CDMS Interface and Test Equipment Interface subsystems.

3.1.1 Functional Requirements

IF-FR-01	Essential	An interface with the instrument shall be provided *This will include a simulation of the CDMS and PCS interfaces*

IF-FR-02	Essential	The number of interfaces to test-equipment shall not be restricted.
IF-FR-03	Essential	The interfaces shall accept TC packets from the TC/TM interface subsystem
IF-FR-04	Essential	The CDMS interface shall pass TC-packets directly to the instrument
IF-FR-05	Essential	Each individual Test-Equipment Interfaces (TEI-i) shall be able to unpack a TC-packet and control the corresponding test-equipment accordingly
IF-FR-06	Essential	Each individual Test-Equipment Interfaces (TEI-i) shall be able to accept data from the corresponding test-equipment and pack the data in a TM-packet
IF-FR-07	Essential	The interfaces shall associate each TM-packet with the ERT.
IF-FR-08	Essential	The interfaces shall be able to handle a TM-data stream from the instrument or test equipment with a maximum data-rate of 400 kbps
IF-FR-09	Essential	The interfaces shall be able to mimic the polling-scenario(s) of the CDMS. *The protocol for data transfer between the interface and the instrument is defined in AD3*
IF-FR-10	Essential	The interfaces shall be able to send TC-packets at a rate of at least 4kbps. *For efficient memory uplink it would be useful to be able to send TC data at a rate 10 times as fast as the nominal uplink rate.*
IF-FR-11	Essential	The CDMS interface shall be able to limit the TC-stream to 2 TC-packets per second. Typical data transfer will take place by transferring one packet at a time in two time slots during each second - see AD3

3.2 TC/TM Interface

TI-FR-01	Essential	The TC/TM interface shall be able to merge TM-packets from the instrument and all TEIs into a single TM-stream. *This stream will be passed to the RTA and FCSS systems*
TI-FR-02	Desirable	It shall be possible to change the final destination of a packet without modifying the packet's address *This will allow reconfiguration of the system without having to recompile test procedures and/or commands*

3.3 Test Control

3.3.1 Test Procedures

A test procedure in the sense of this document is a list of activities, written in a computer and human readable format. It may contain:

- instrument commands
- commands to the test equipment

- commands to the environment control equipment
- time synchronisation command(s)
- wait instructions for absolute and relative time
- wait instructions for input (from user or from TM)
- branches
- loops
- TM read instructions (events and HK)
- use of variables and constants
- comments
- integer and floating point calculations
- read/write statements from/into local files or displays (within the EGSE-ILT System)
- string operations
- execution of sub-procedures or other procedures
- monitoring of conditions (parameter changes, out of limits etc)

The telemetry will contain dedicated HK packets from test environment and test equipment control. These are therefore also accessible for reading from test procedures.

3.3.2 Command Mnemonic Sequences

Command Mnemonic Sequences are generated by the FCSS as a result of the instantiation of an observation. . They contain a relative-time tagged sequence of instrument (and test equipment) mnemonics, which can be converted to TC packets and sent to the instrument and test equipment directly from Test Control during instrument testing. The format of this sequence is still TBD, but it needs to be computer and human readable.

3.3.3 Autonomy Procedure

In order to simulate the autonomy functions of the OBDH within the EGSE, Test Control must be able to run one or more procedures (at the same time) which can monitor TM values (and events) against defined conditions (e.g. changes, out of limits etc) and branch according to the result of this. The nominal case is that no actions (commands etc.) are triggered by these procedures. In case an out-of-limit or unexpected event situation is encountered, predefined actions will be triggered. These actions may consist of:

- issue warning message(s) to Test Control or operator
- stop or abort ongoing test procedures or command timelines
- execute predefined sets of commands
- generate log information
- generate events packets

The format and syntax of autonomy procedures may be similar to test procedures. Note that autonomy procedures may run when no test procedure is executing, since although no science

TM packets are generated when the instrument is idle or standby, HK packets are still generated.

3.3.4 Requirements

3.3.4.1 Commanding

TC-CMD-01	Desirable	It shall be possible to issue any instrument specific command and manually provide all its required parameters at any time. *This could be provided by the commanding function in SCOS2000*
TC-CMD-02	Essential	It shall be possible to issue any command for test equipment and environment control for immediate execution at any time. *If TE commands are defined in the MIB, this may be provided by the commanding function in SCOS2000*
TC-CMD-03	Essential	All manual commanding activities shall be logged, incl. the time at which every command is sent.
TC-CMD-04	Essential	It shall be possible to select and execute test procedures from Test Control and provide all user input eventually needed by these procedures.
TC-CMD-05	Essential	All commands generated by a test procedure shall be logged, incl. the time at which they were sent.
TC-CMD-06	Essential	It shall be possible to generate and edit test procedures from within Test Control.
TC-CMD-07	Essential	It shall be possible to import/export test procedures and associated files (e.g. calibration files) from/to FINDAS. *This will allow the possible association of test procedures with telemetry (using OBSIDs) simulating the function available in routine operations*
TC-CMD-08	Desirable	It shall be possible to store a TBD number (~10<n<~100) of test procedures within Test Control.
TC0CMD-10	Essential	Test Control shall be able to convert Command Mnemonic Sequences into a set of command mnemonics with absolute times. *These shall be issued to the commanding function of SCOS2000. The conversion may be done 'on-the-fly' rather than storing the absolutely timed menmonics.*
TC-CMD-11	Essential	The assignment of absolute times to the commands in a Command Mnemonic Sequence shall take less than a few seconds
TC-CMD-15	Essential	Test Control will allow the storage of a set of a TBD number (~10<n<~100) of Command Mnemonic Sequences. *This is only necessary if the time taken to generate and*

		import the sequences from FINDAS is excessive (greater than a few seconds).
TC-CMD-17	Essential	It shall be possible to add to and maintain an electronic log of the ongoing test activities.
TC-CMD-19	Essential	It shall be possible to abort, stop and resume any test procedure and Command Mnemonic Sequence by manual interaction.
TC-CMD-20	Essential	It shall be possible to synchronise the whole EGSE setup (simulates spacecraft reference time updating).
TC-CMD-21	Essential	The syntax and parameter range of manual commands, commands from test procedures and commands from Command Mnemonic Sequences shall be verified within Test Control before they are sent to the instrument.
TC-CMD-22	Essential	In the case of commands being unverified, a message will be displayed to the Test Control user and current procedures will be stopped or suspended.

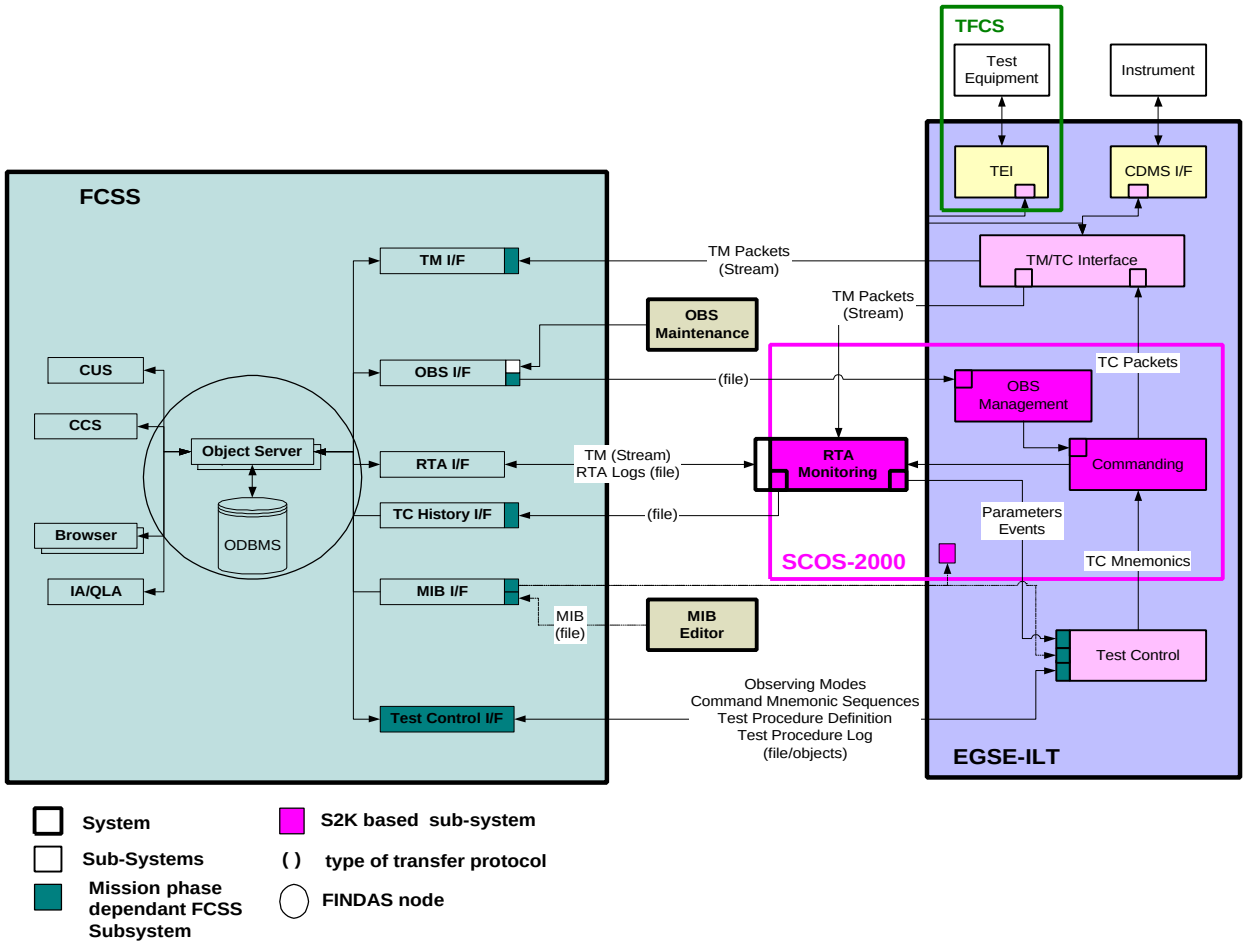
3.3.4.2 Autonomy Proceduress

TC-AUT-01	Essential	It shall be possible to generate and edit autonomy procedures from within the Test Control system.
TC-AUT-02	Essential	It shall be possible to run one or more autonomy procedures in parallel with a test procedure.
TC-AUT-03	Essential	It shall be possible to start, abort, stop and resume any autonomy procedure by manual interaction from Test Control.
TC-AUT-04	Essential	It shall be possible to define conditions under which autonomy procedures are started automatically. *For example a procedure may be started if a TM parameter changes value or goes out of limits.*
TC-AUT-05	Essential	Autonomy procedures shall be able to read TM values (events + HK)
TC-AUT-06	Essential	It shall be possible for autonomy procedures to run also during instrument idle or standby modes.
TC-AUT-07	Essential	It shall be possible for autonomy procedures to generate event packets
TC-AUT-08	Essential	It shall be possible for autonomy procedures to generate log information
TC-AUT-09	Essential	It shall be possible for autonomy procedures to stop or abort ongoing test procedures or command timelines
TC-AUT-10	Essential	Autonomy procedures may generate warning messages to the operator

3.3.4.3 User Interface

TC-UI-01	Essential	All Test Control specific activities shall be carried out via computer keyboard(s) and/or mouse (mice) with displays available in separate windows.
TC-UI-02	Essential	There shall be a separate window from where test procedures, autonomy procedures or command mnemonic schedules can be selected, started, aborted, stopped and resumed.
TC-UI-03	Essential	Manual commanding shall be supported by tools, which allow the sending of one single command: at a specified absolute time; after a specified relative time; or for immediate execution. Commands submitted for execution at or after a specified time shall be removable while not yet executed.
TC-UI-04	Essential	It shall be possible to track the execution of an ongoing test procedure via a display indicating the position within the procedure and showing at least the recent past and near future steps of the procedure. Back and forward scrolling shall be possible.
TC-UI-05	Essential	It shall be possible to track the execution of a command mnemonic sequence via a display indicating the position within the sequence and showing at least the recent past and near future of the command timeline. Back and forward scrolling shall be possible.
TC-UI-06	Essential	The manual command window shall remain accessible at all times.
TC-UI-07	Essential	The message window for the feedback from autonomy procedures and test procedures shall be displayable at all times.
TC-UI-08	Essential	On user request it shall be possible to display the logging information originating from manual commanding or test procedures.
TC-UI-09	Essential	Both, the spacecraft reference time (= simulated test time ≠ local time) at 1 sec resolution and the actual local time shall be displayed to the Test Control user.
TC-UI-10	Essential	There shall be a separate window in which editing of autonomy and test procedures and logs is possible.
TC-UI-11	Essential	There shall be a separate window in which export and import activities from/to Test Control are carried out.

Annex A


TFCS
Test Equipment
Instrument
TEI
CDMS I/F
TM/TC Interface
FCSS
TM I/F
TM Packets (Stream)
OBS Maintenance
TM Packets (Stream)
CUS
OBS I/F
(file)
TC Packets
OBS Management
CCS
Object Server
RTA I/F
TM (Stream)
RTA Logs (file)
RTA Monitoring
Commanding
ODBMS
TC History I/F
(file)
Parameters
Events
Browser
SCOS-2000
TC Mnemonics
IA/QLA
MIB I/F
MIB (file)
MIB Editor
Test Control
Observing Modes
Command Mnemonic Sequences
Test Procedure Definition
Test Procedure Log
(file/objects)
Test Control I/F
EGSE-ILT
System
Sub-Systems
Mission phase dependant FCSS Subsystem
S2K based sub-system
( ) type of transfer protocol
FINDAS node