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Minutes of Meeting

Herschel

Date:	21.01.2003		
Doc.-No.:	HP-2-ASED-MN-0265		
Meeting place:	Ottobrunn	Chairman:	S. Idler
Date/Time:	21.01.2003 / 9:00	Secretary	C. Schlosser
Agenda dated:	18.12.2002	Close of Meeting:	

Subject: Instrument AIT Meeting

Participants: see list on next page	Additional Distribution:

Page: 1 of Page(s)

☐ Brief-Minutes (except following sheets) ☐ Summary of Results of Sheets 2 till

Common instrument AIT aspects have been discussed and some open points were identified.

Next common instrument AIT meeting is in CW 21/03.

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Reference	Results	Remarks
	Agenda see ASED presentation in annex 1 Introduction Satellite level instrument AIT approach is given and will be updated in test plan, HP-2-ASED-PL-0021 (EQM) and HP-2-ASED-PL-0031(PFM) These are top-level documents, forming the baseline for Instrument AIT procedures. Integration WU test after integration: PACS: no FPU simulator necessary, test data ~~will~~ from BOLC and DECMEC. PLM EGSE is the same on EQM as on PFM. First tests on PFM will be done on PLM level	

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Reference	Results	Remarks
	using the PLM EGSE. First EMC test on PFM (CE, CV) will be done on PLM level. ASED to send the EQM and PFM AIT flow to instruments. A HIFI LOU simulator would be prefered.. HIFI internal discussion is ongoing. An FPU simulator is not necessary if the WU have the capability to work without the FPU, simulating "normal" data traffic (only for AVM tests) FPU integration PACS requires to use the HYDRAJET for mech. integration (Alb.) No mechanical machining is allowed in CR 100. There should not be a special sequence for FPU integration necessary. This has to be checked w.r.t. SPIRE footprint	AI #1 ASED 31.1.03

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Reference	Results	Remarks
	PACS presentation demonstrates FPU integration on hand of the FPU STM integration on instrument level. (see annex 2) HIFI presentation demonstrates FPU integration using drawings. (see annex 3) PACS do provide first draft of FPU integration procedure. HIFI FPU integration approach seems to be valuable. Details will be discussed tomorrow. Build standard HIFI EQM build standard has been presented. Potential I/F to HIFI heaters will be discussed tomorrow. Supply by Cryo struc has to be discussed. Envelope of WW in the one on EQM on FM.	AI #2 PACS #3 deleted

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Reference	Results	Remarks
	PACS EQM build standard has been presented. Not all PACS units are representative in form (only S/C and function). PACS to deliver drawings of these units The cryo harness is nearly identical on PFM and EQM. Therefore termination of not used I/F has to be provided at the instrument units. The only difference could be the length of the harness. EGSE / Testing ESTEC presentation (annex 4) of LST's approach 3 ways of instrument EGSE considered: • I-EGSE off • I-EGSE in listening mode (from CCS) • I-EGSE interactive via CCS I-EGSE will be in listening mode and real time mode during IST, depending on test phase / test objective	AI #4 PACS

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Reference	Results	Remarks
	Next steps: Herschel IST specification to be prepared by ASPI Overall EGSE presentation by Alcatel (annex 5): WIFI needs a stimuli during EMC testing. This should be under remote control from CCS. WIFI to define details New IF between I-EGSE and CCS (RC, ACK RC) do be defined as on IF to the ICUE. Instrument EGSE presentation by Otto Bauer (annex 6) Total test duration during IST ~ 4 d/instrument. Complete I-EGSE systems will be provided (1 real time, 1 for analysis) for all instruments together. Overall EGSE concept has to be updated by ASPI. Requested industry support will be discussed during EGSE working group meeting on 5.2.03	AI #5 WIFI

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Reference	Results	Remarks
	CCS / I-EGSE VF check shall be done in advance. Presentation of I-EGSE on PLM and Satellite level by ESA (annex 7) Problems: - If a test stops for any reason, it has to be repeated completely EQM: - IMT (Integrated Module Test) is a functional performance test of the instruments Concept: Test sequence is running on CCS. Observation information is in the MCS. Handshake between CCS and MCS during IST is not totally clear to all parties. This will be part of the EGSE working group meeting. PACS proposals to modify the CAM + AUM ILT program presented (annex 8)	

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Reference	Results	Remarks
	Cryogenic qualification with and w/o cold vibration with cam. TPM MTM. Due to parallel activities gain of 33 day feasible. To be discussed with ESA during next I/t meeting (?). Test (constraints) Tilting analysis performed for FM (see HP-2-ASED-TN-0068) No problems have been detected for PACS. SPIRE spectrometer mode inside CSV is not possible with the present configuration. It is under investigation to perform this test outside the chamber. Due to position of the LO interfaces, HIFI tests inside the CSV would only be possible in the very beginning of the TVITB test. Therefore, extension of the LO inside the ~~CSV~~ is under investigation. Test durations for instrument tests during TVITB test are needed to support this investigation.	AI # 6 HIFI (PACS, ~~SPIRE~~)

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Reference	Results	Remarks
	HIFI require purging of the FPU and LOU. Further inputs from HIFI are needed (see HP-ASPI-MN-2241)	AI #7 HIFI
	Standing wave tests are currently only foreseen between LOU and FPU. There are no specific requirements from HIFI on the thermal stability. System aspects, already expressed several times, contradicts standing wave test between telescope and FPU.	
	Differences between CQM/AVM and FM testing has to be clarified. (specific test constraints, duration etc.)	AI #8 HIFI #9 PACS ~~#10 SPIRE~~ ~~(Sorry asked that Bruno)~~
	Electrical integration check: No verification of the FPU I/F before connection with the WU possible. Test of WU/FPU I/F on HIFI possible using a FPU simulator with T-adapters. It has to be checked, whether there is a risk in case of wrong connection between WU and FPU. At a minimum the harness data base have to be verified.	

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Reference	Results	Remarks
	PACS will make a suggestion how to verify this I/F. EMC test approach TBCs in E&M EMC are coming from a CR/ECR, which is currently in the pipeline. NIFI states that there is a risk, that no I/C level EMC test can be performed on E&M. CE/CS will be performed on PFM I/C level. (not correct in handout) TB/TV Test approach Major concerns w.r.t. instrument testing are the liquid content (< 25°) and the tilting constraints inside the chamber. At the moment no sun simulation is foreseen. Future instrument I/F meeting approach:	

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Reference	Results	Remarks
	Even if it is difficult to arrange a meeting with all instruments, it shall be maintained to have this kind of meeting on a regular basis. Instrument specific AIT aspects can as well be discussed in the instrument VF meeting. Next instrument AIT meeting shall take place in CW 21/03. (21.05.2003 - tbc.)	

Meeting: HP-2-ASED-MN-0265
Title: Instrument AIT Meeting
Date: 21.01.2003

Action Item List

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No.:	Description:	Due Date	Originator Comp./Pers.	Actionee Comp./Pers.	Source	Completion
1	Update EQM/PFM AIT flows to be distributed	28.2.03	ALC, Houfet	Th. Bayer		
2	PACS to provide 1st draft of integration procedure	28.2.03	D. Schieler	O. Bauer		
3	deleted	—				
4	PACS to provide drawing of AVM units	28.02.03	D. Schieler	O. Bauer		
5	HIFI to define instrument shimming for EMC tests	28.02.03	S. Idler	K. Wafelbakker		
6	Instrument to define test durations during TB/TV	28.02.03	S. Idler	K. Wafelbakker		
7	HIFI to define purging requirements in details	31.01.03	D. Schieler S. Idler	O. Bauer K. Wafelbakker		
8	HIFI to specify differences between EQM and FM testing	28.2.03	S. Idler	K. Wafelbakker		
	PACS	28.2.03	D. Schieler	O. Bauer		
	SPIRE	28.2.03				

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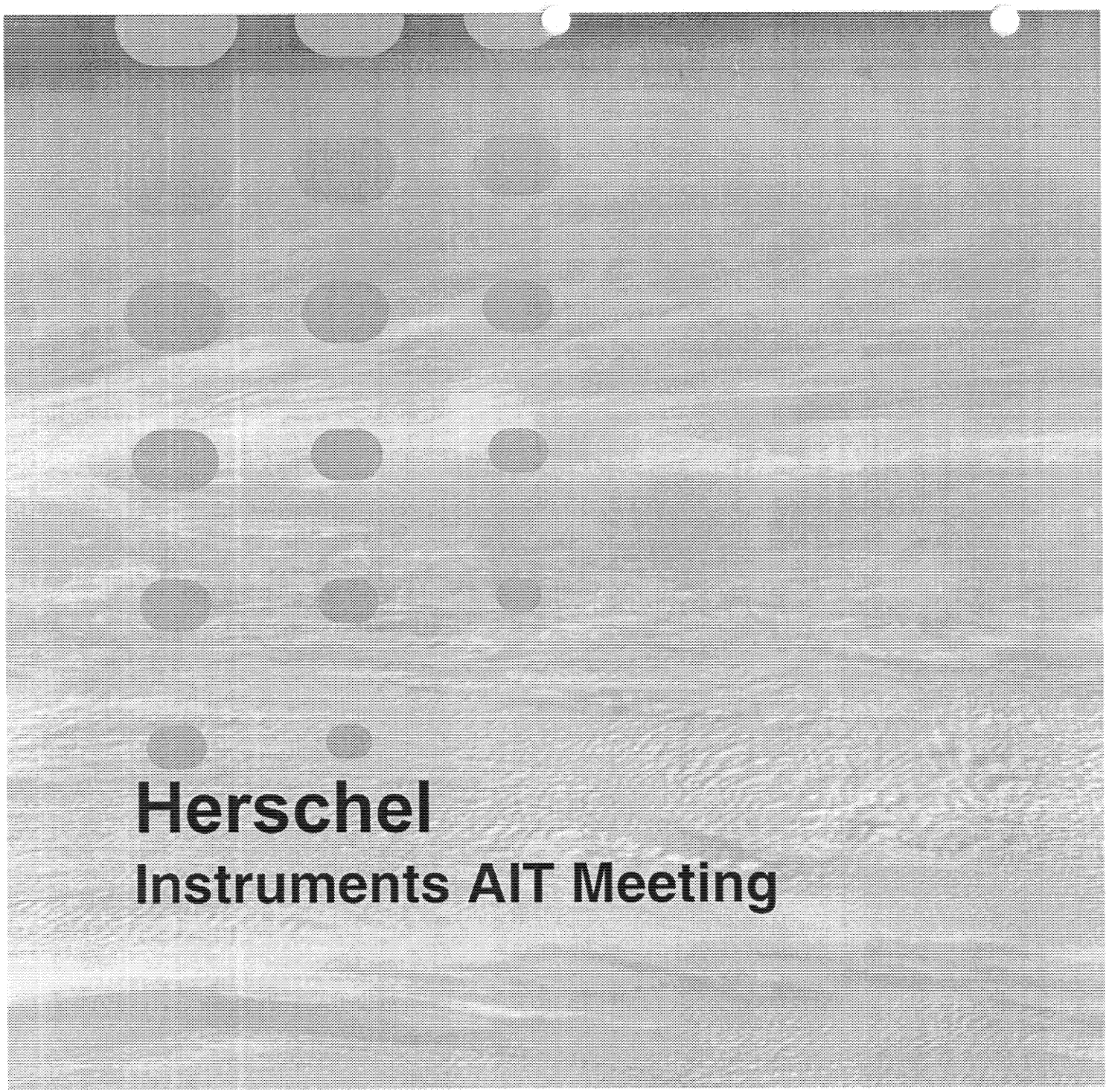
Reference	Participants	Results	Remarks
	C. Schlosser ASED R. Katterloher MPE O. H. Poller MPE N. D. Whyborn SRON Th. Bayer ASED M. Kalle ASED B. Melton ESTEC W. Luinge SRON M. von Berg MPE J. Schubert MPE H. J. wildeman SRON G. Lund ALCATEL J. IDLER ASED W. Rühe ASED	D. Schieb ASED N. Wiedanig ESTEC A. Naber SRON K. Wafelbakker SRON O. PIERSANTI ESTEC G. DOUBROVIK Alcatel D. MONTET ALCATEL	



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Instruments AIT Meeting

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Siegmund Idler
21.01.2003

ANNEX 1

Instruments AIT Meeting - Introduction

Agenda (as per HP-ASED-FX-0836-02 & e-mail from Denis Montet) (1)

- Introduction
- Integration
  - Integration sequence
  - FPU's integration constraints
  - MGSE interfaces
- Test configuration
  - Presentation of Alcatel with respect to interfaces between CCS and instrument EGSE
  - Presentation of Otto Bauer with respect to activities of the EGSE working group,
  - Build standard of deliverable items
- Test constraints
  - Tilting
  - Purging
  - Standing wave test limitations
  - CQM/AVM test limitations

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Instruments AIT Meeting - Introduction

Agenda (as per HP-ASED-FX-0836-02 & e-mail from Denis Montet) (2)

- EQM/FM testing
  - Electrical integration check
  - EMC/ESD
  - TB/TV
  - Presentation of ESTEC with respect to IST approach
- AOB
- Agreement on future meetings
- Close-out of minutes

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Instruments AIT Meeting - Introduction

Scope and objectives of HP-2-ASED-PL-0021/0031

- Container for all information related to satellite level instrument AIT activities
- Tool for co-ordination of satellite level instrument AIT activities
- Basis for establishment of test procedures
- All instrument related aspects in one document
- Tailoring to instrument related aspects
- Regular updates
- Instrument suppliers are asked to regularly comment the documents and to provide all new AIT relevant data to be included therein

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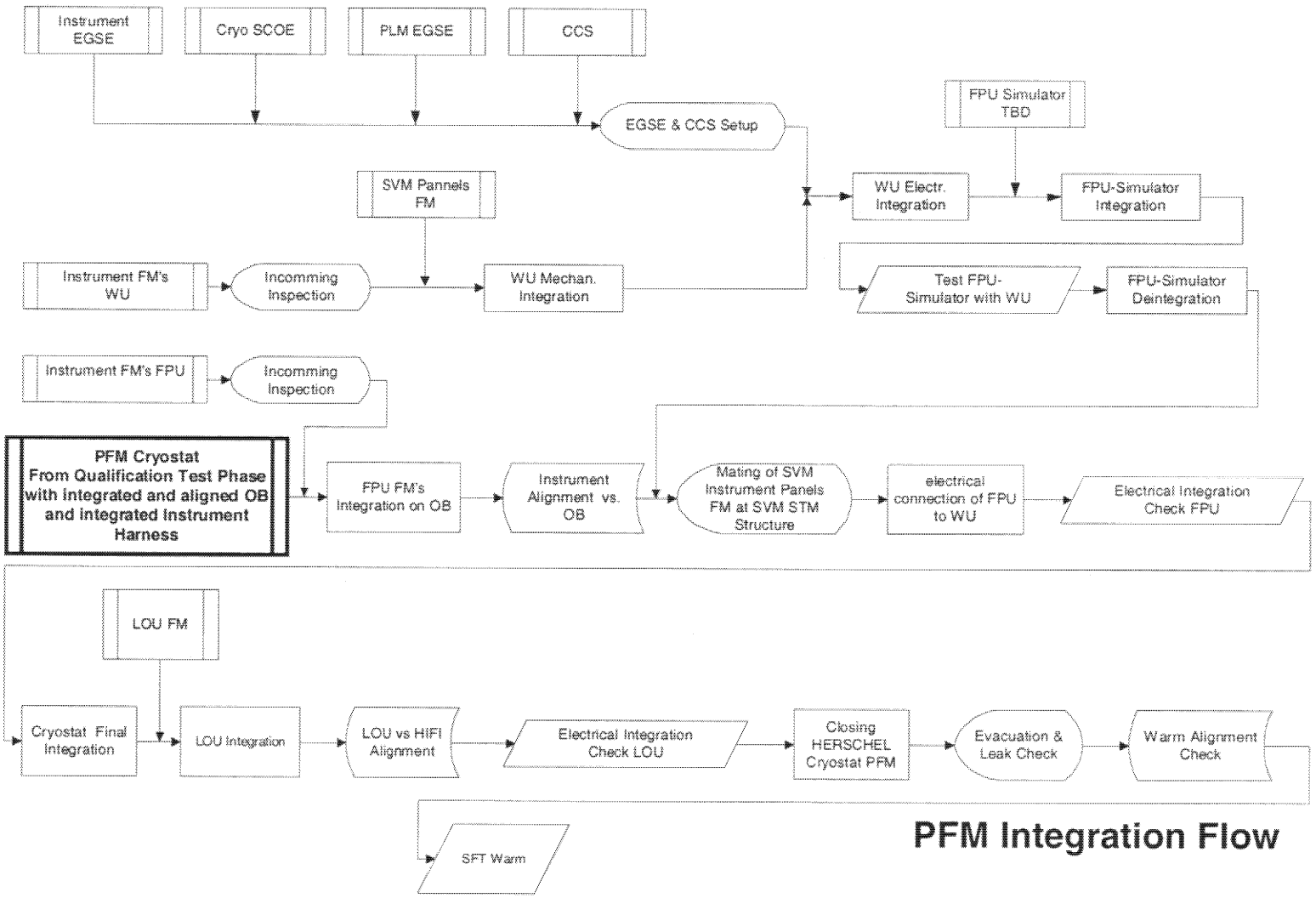
Instruments AIT Meeting - Integration



PFM Integration Flow

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Instruments AIT Meeting - Integration

FPU's integration constraints

- PLM integrated on rotary table
- PLM with x-axis in vertical position
- Facility constraints:
  - Crane velocity 1-5 m/min
  - Lowering speed 0.2-4 m/min (3 mm/sec)
  - For further reduction of lowering rate a HYDRASET is available

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Instruments AIT Meeting - Integration

FPU's integration requirements

- No mechanical machining or adaptation of OBA after integration (clean room class 100)
- Access to all MGSE interfaces with integration tools at fully integrated OBA mandatory
- Access to all thermal, mechanical and electrical FPU interfaces at fully integrated OBA mandatory
  - Access to all thermal links
  - Access to all mounting feet
  - Access to all connectors for mating/de-mating
  - Red tag items (protections needed for integration) must be removable
- The use of instrument hoisting devices (MGSE) shall not impose a sequence for the FPU integration
- Special integration tools, if needed, to be provided by instruments

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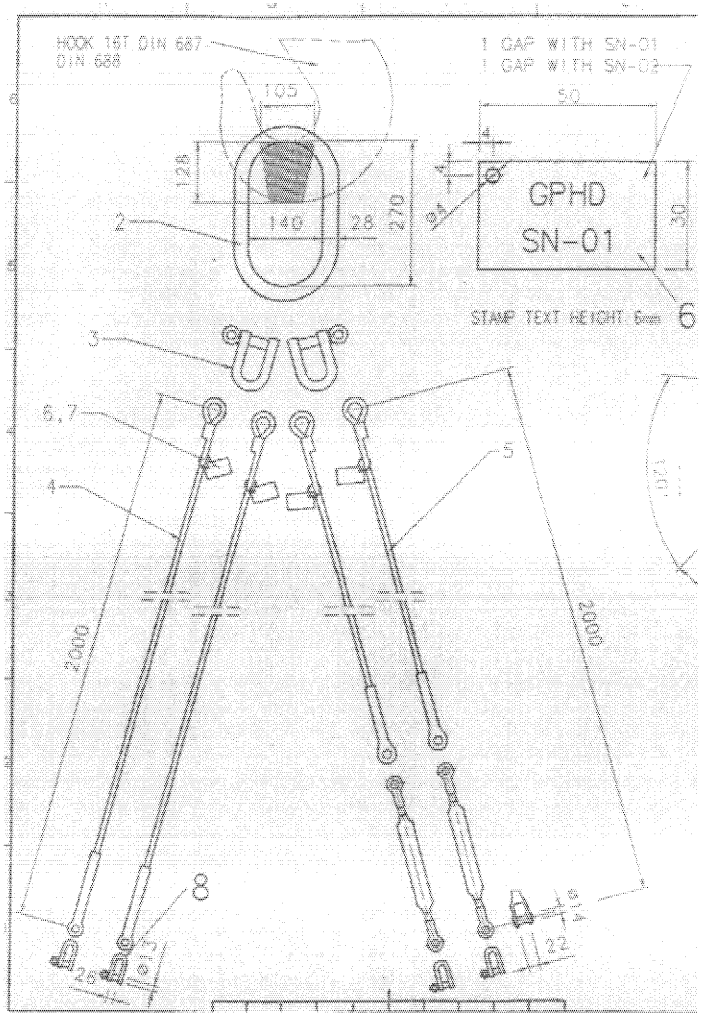
Instruments AIT Meeting - Integration

MGSE interfaces

- IID-A, section 10.11.2.4: The instruments shall deliver ... the MGSE necessary to transport, handle and integrate instrument hardware ...
- Lifting device from Astrium GmbH:
  - Lifting of FPU's with General Purpose Hoisting Device (GPHD)
  - The GPHD will be used for flight hardware items up to a total weight of 500 kg in clean room class 100 conditions
  - The GPHD consists of 4 leg slings (2 m long), 2 slings equipped with turn buckles (adjustment range 100 mm, with end stops)
  - There will be no direct physical interface to flight hardware



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Instruments AIT Meeting - Integration

Items to be clarified

- FPU thermal interfaces (accessibility at fully integrated OBA)
- FPU integration procedure from PACS and SPIRE
- HIFI FPU MGSE/hoisting device
- HIFI LOU integration/alignment procedure and MGSE/hoisting device

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Instruments AIT Meeting - Test Configuration

EGSE interfaces

- See presentation of Alcatel and Otto Bauer

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Instruments AIT Meeting - Test Configuration

Build standard of deliverable items

- The following information is available at ASED:
  - HIFI: HP-HIFI-CR-0066, dated 30.09.2002, update requested by HP-ASPI-MN-2241, AI 05
  - PACS: HP-2-ASED-PL-0021, § 5.1.2, to be updated as per e-mail from Reinhard Katterloher to Dietmar Schink, dated 17/01/03
  - SPIRE: HP-2-ASED-PL-0021, § 5.1.3, will be updated by SPIRE (see annex to e-mail from Bruce Swinyard to Siegmund Idler, dated 11/12/02)
- The following information is required:
  - Detailed information of built standard of FPU CQM's and AVM's
  - Identification in what they differ from PFM's in form, fit and function
  - Electrical interface description (differences with respect to PFM, if any)

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Instruments AIT Meeting - Test Constraints

Herschel Tilting Analysis (HP-2-ASED-TN-0068, issue 1)

Scope of analysis

- Analysis of impact of all relevant tilting requirements and constraints on the Herschel PFM during the ground test activities:
  - at H-EPLM level and
  - at spacecraft level
- Recommendations how to perform tilting operations efficiently during the testing to fulfil the thermal interface requirements
- A tilting analysis for the PLM EQM ground testing will be included in a later issue

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Instruments AIT Meeting - Test Constraints

Herschel Tilting Analysis (HP-2-ASED-TN-0068, issue 1)
Requirements and constraints

- Instrument tilting requirements for PACS and SPIRE during
  - Cooler recycling (duration 2h)
  - A subset of instrument tests (test duration 2h)
- Tilting constraints from cryostat geometry for the following components:
  - Passive Phase Separator (PPS)
  - Gaseous He outlet
  - Rupture Disc (RD124)
  - He II Tank (HTT) internal Level-0 strap extensions
  - Filling Port
  - Cryo cover cooling GSE
- Tilting constraints in integration and test facilities and during transport

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Instruments AIT Meeting - Test Constraints

Herschel Tilting Analysis (HP-2-ASED-TN-0068, issue 1)
Analysed test set-ups and StM/PFM tests

- He-Subsystem test set-up during ground tests
  - Test set-up in ambient environment
  - TB/TV test set-up
- Instrument Short Functional and Specific Performance Tests (SFT, SPT)
- Integrated Module Tests (IMT)
- Integrated System Tests (IST)
- TB/TV tests
- System Validation Tests (SVT)

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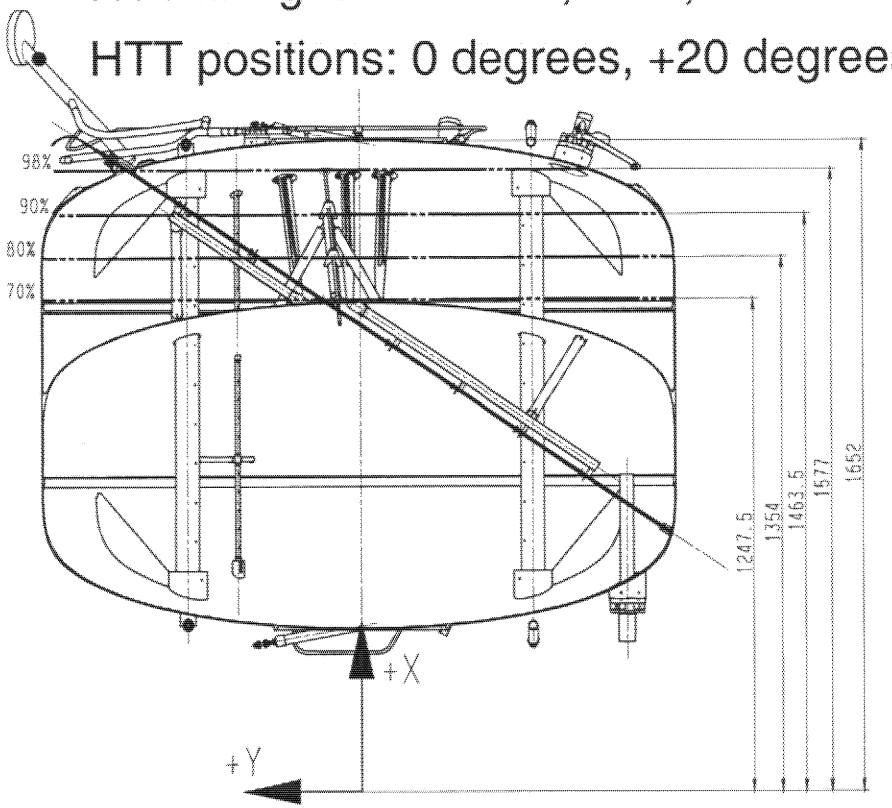
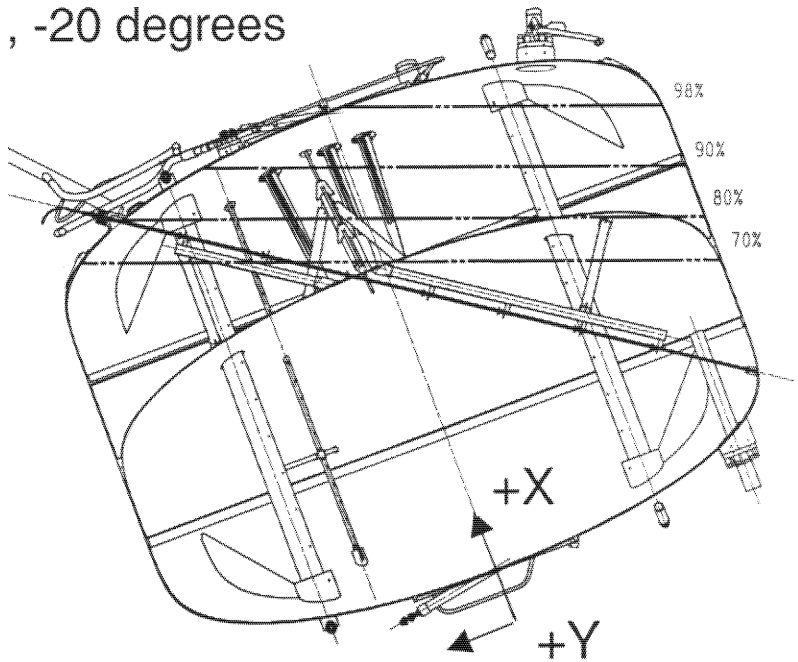
Instruments AIT Meeting - Test Constraints

Herschel Tilting Analysis (HP-2-ASED-TN-0068, issue 1)
Analysed He II Tank (HTT) filling levels and positions

- HTT filling levels: 98%, 90%, 80% and 70%
- HTT positions: 0 degrees, +20 degrees , -20 degrees





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Instruments AIT Meeting - Test Constraints

Herschel Tilting Analysis (HP-2-ASED-TN-0068, issue 1)
Conclusions as regards instrument tests

- Tilting requirements for PACS and SPIRE cooler recycling in the same direction as needed to bring the He to the respective level-0 interfaces.
- All PACS and SPIRE tests including PACS/SPIRE parallel mode testing can be performed.
- Inside the LSS, PACS and SPIRE tests can be performed down to a He II filling level of about 84%, respectively 79%.
- SPIRE spectrometer test inside the LSS is with the existing LSS motion systems not feasible. Analysis to be performed whether orbit representative and stable conditions could be achieved outside the TV/TB test.
- The ability to perform the HIFI tests is only given during the very beginning of the TB/TV test. The foreseen level-0 interface extensions shall ensure that the HIFI tests can be performed without limitations.
- Transport of PLM and satellite to be performed in horizontal position and with reduced liquid He level < 50%.

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Instruments AIT Meeting - Test Constraints

Purging

- HIFI require purging of FPU and LOU (HIFI-CR-0062 and -0064)
- No purging requirements for PACS and SPIRE
- Required inputs from HIFI (see also HP-ASPI-MN-2241):
  - Clarification of / agreement on inlet/outlet interfaces
  - Max. allowed time without purging
  - Required flow rate and purity of purge gas
  - Driving requirements for purging (e. g. cleanliness, moisture)

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Instruments AIT Meeting - Test Constraints

Standing wave test limitations (HIFI)

- Test of standing waves between LOU and FPU by measuring of LO to mixer coupling as function of LO frequency
  - No requirement on cryo cover concerning background simulation
  - Thermal/mechanical test constraints to be specified (e. g. temperature stability)
- Test of standing waves within or near the beam path from telescope to FPU not planned
  - Representative test would need telescope, i. e. must be performed on spacecraft level with open cover in LSS
  - Dedicated mechanism needed to close cover
  - Risk: cover closure failure

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Instruments AIT Meeting - Test Constraints

CQM/AVM test limitations

- Differences between CQM/AVM and PFM models with regard to test constraints and test sequences to be clarified.

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Instruments AIT Meeting - EQM/PFM Testing

Electrical integration check (FPU to Warm Units interface) (1)

- Electrical interface checks shall be performed before connecting the harness to the corresponding unit or instrument
- S/C AIT approach:
  - Flight harness continuity check (Warm Units and FPU's not connected)
  - Warm Units grounding, shielding and isolation verification via cryo harness (Warm Units connected and off, FPU's not connected)
  - Warm Units output signals verification via cryo harness (Warm Units connected and powered, FPU's not connected)
  - Measurement versus FPU's currently not planned (safety reasons)
  - Warm Units output signals verification via cryo harness using T-adapter (Warm Units and FPU's connected and powered)

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Electrical integration check (FPU to warm units interface) (2)

- Measurement performed using Integration Data Acquisition System (IDAS)
  - Computer supported measurement equipment
  - Automatic testing and test evaluation
  - Measurement capability for resistance, voltage, currents, pulses, timing and frequencies
  - Successful used for e. g. XMM and METOP
- Verification based on EICD (HP-2-ASED-IC-0001)
  - Derived from IID-B's
  - Also used for harness manufacturing
- Points to be clarified
  - EICD data base verification (e. g. by comparison with data base used for test harness manufacturing/verification)
  - Signals to be checked

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EMC test approach (1)

	Configuration:
EQM Integrated Module	• ISO modified QM Cryostat • Optical Bench Assembly • CQM FPUs/Outer CVV electronic (LOU) and CVV instrumentation • CVV inner cryo harness, el. representative • CVV outer cryo-harness, representative • CVV cover closed • Avionics Modules: Warm units integrated in a SVM dummy and interconnected with representative harness. • No telescope, no sunshield/sunshade
PFM Integrated Module	• Full flight configuration except: - CVV cover closed - No Telescope - No sunshield/sunshade
PFM Herschel S/C	• Full flight configuration except: - CVV cover closed

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EMC test approach (2)

	Facility
EQM Integrated Module	• Cleanroom 100000
PFM Integrated Module	• Cleanroom 100000
PFM Herschel S/C	• Cleanroom 100000 / anechoic chamber (for RE)

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EMC test approach (3)

	EMC Tests
EQM Integrated Module	• CE/CS on warm units • CS on cryoharness bundles (tbc) (see below) • CS on cryoharness simulating RS (tbc) (see below) • ESD • RS (tbc) (see below)
PFM Integrated Module	• CE/CS on warm units • No RE/RS
PFM Herschel S/C	• No CE/CS • RE/RS (to cover compatibility to launcher)

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EMC test approach (4)

Test Descriptions

1. CS Common Mode Current on Cryo Harness Bundles ([RD1], §. 6.3.1.1)
Test method: Sine wave injection CM plus CE - CM current emissions (to define the injection level).
Test 1: CE - CM current emission measurement (frequency domain) on selected cable bundles.
Test 2: Sine wave injection on selected cables bundles. Injection level: 6 dB higher than the emissions measured on the bundle.

- Frequency range: 10 kHz – 50 MHz
- The required frequency range shall be covered by manually testing at certain spot frequencies

2. CS simulating RS on the Cryo Harness (ref. [RD1], § 6.3.1.1)
Test method: Sine wave injection CM on cryo harness bundles.

- Frequency range: 14 kHz – TBD MHz
- Injection level: 2 mA_{rms}
- Measurement accuracy is expected to decrease above 50 MHz

3. RS on HPLM EQM in cold conditions (ref. [RD1], § 6.3.1.2)
Test method: RS E-field injection

- Frequency range: 14 kHz – 18 GHz
- Above 30 MHz, test with horizontal and vertical antenna polarization.
- Injection level: 2 V/m, 1 m distance, 30 % amplitude modulation by 1 kHz square wave, 18 V/m or 10 V/m in RF notches
- Calibration of the E-field levels will be performed in the EMC facility.

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EMC test approach (5)

4. RS on HPLM EQM in cold conditions (ref. [RD1], § 6.3.1.2)
Test method: RS AC H-field injection

- Frequency range: 30 Hz - 50 kHz
- Injection Level: 140 dB_{pT} sine wave, distance tbd.
- Calibration of the H-field level will be performed in the EMC facility.
- The required frequency range shall be covered by manually testing at certain spot frequencies.

5. RS on HPLM EQM in cold conditions ([RD1], § 6.3.1.2)
Test method: RS DC H-field injection

- Injection Level: 160 dB_{pT}, distance tbd.
- Calibration of the H-field level will be performed in the EMC facility.

The general arrangements necessary for the RS tests are shown in Fig 1 below.

References:

[RD1]: HP EMC Control Plan, HP-1-ASPI-PL-0038, issue 3, 27.05.02
[RD2]: HP EMC Specification, HP-1-ASPI-SP-0037, issue 3, 14.06.02

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EMC test approach (6)

- E/H field sources which radiate into CVV
  - Low frequencies (< 10 kHz): fields from sources located outside CVV (as e. g. from solar array) decrease with $1/r^3$ (near field), dominant sources are FPU's $\Rightarrow$ instrument auto-compatibility test sufficient.
  - Medium frequencies (10 kHz to 100 MHz): noise propagation via parasitic currents in the cryo harness dominates $\Rightarrow$ RS test: common mode noise on cryo harness by radiation onto CVV (ISO approach). RS test is performed using standard external antennas with CVV cover being closed and providing the appropriate thermal background to verify the instrument EMI compatibility.
  - High frequencies (> 100 MHz): dominant sources are HIFI LOU (X-band TTC-RF is off during HIFI operation), top opening is not considered as a critical noise coupling mechanism $\Rightarrow$ HIFI auto-compatibility test is considered to be sufficient, plus RS test as for medium frequencies.

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EMC test approach (7)

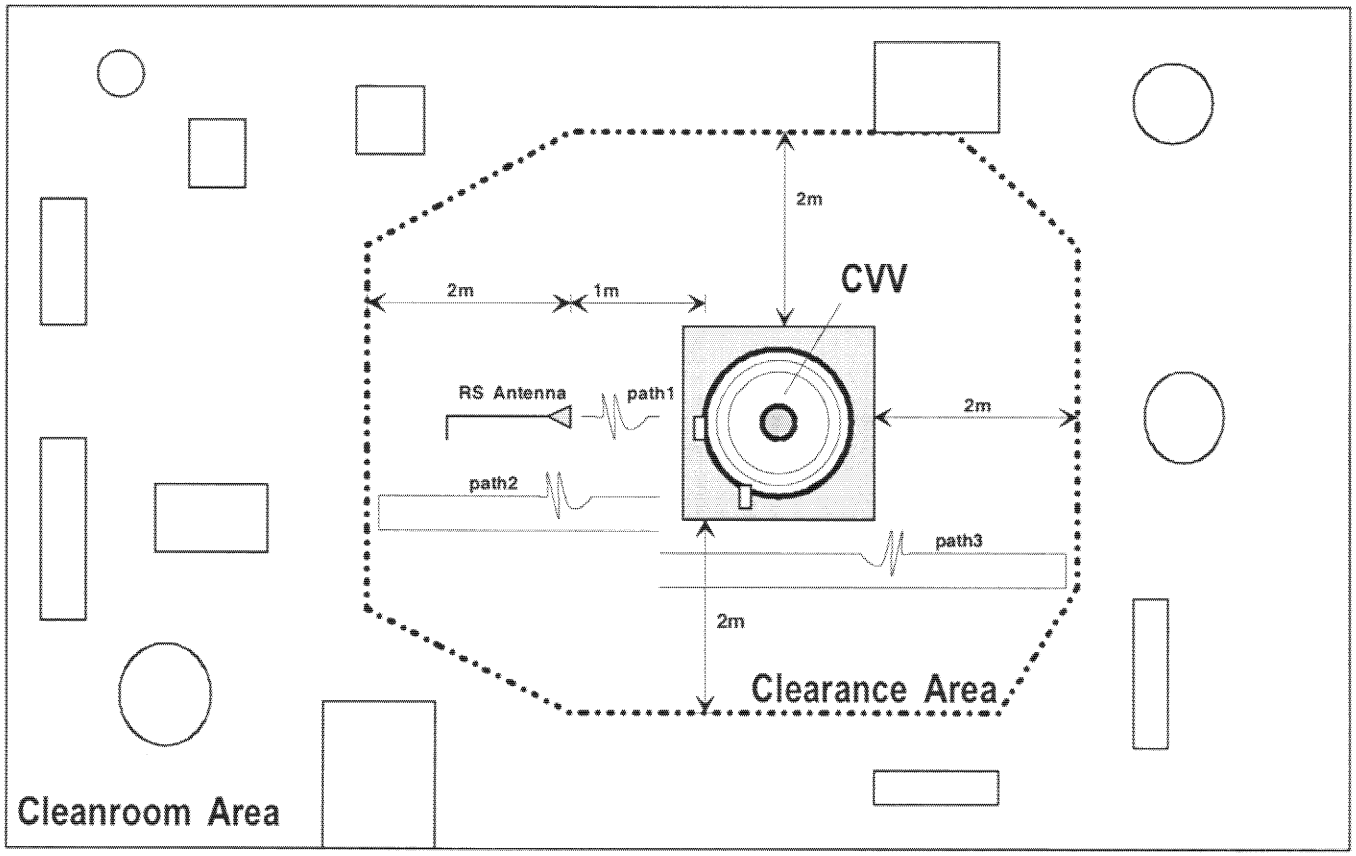

Fig1.: General Arrangement of the HPLM Inside the Integration Facility during RS tests

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Instruments AIT Meeting - EQM/PFM Testing

TB/TV test approach (1)

- Thermal balance
  - Confirmation of adequacy of thermal analysis and temperature prediction models
  - Verification of external vent line performance (delta p, nozzle)
- Thermal vacuum
  - Verification of proper function and performance of payload with all sensors operational
  - Verification of performance of active and passive thermal control
  - Complete system level qualification/acceptance test
- Major constraints
  - Test time limited by Helium II level
  - Tilting

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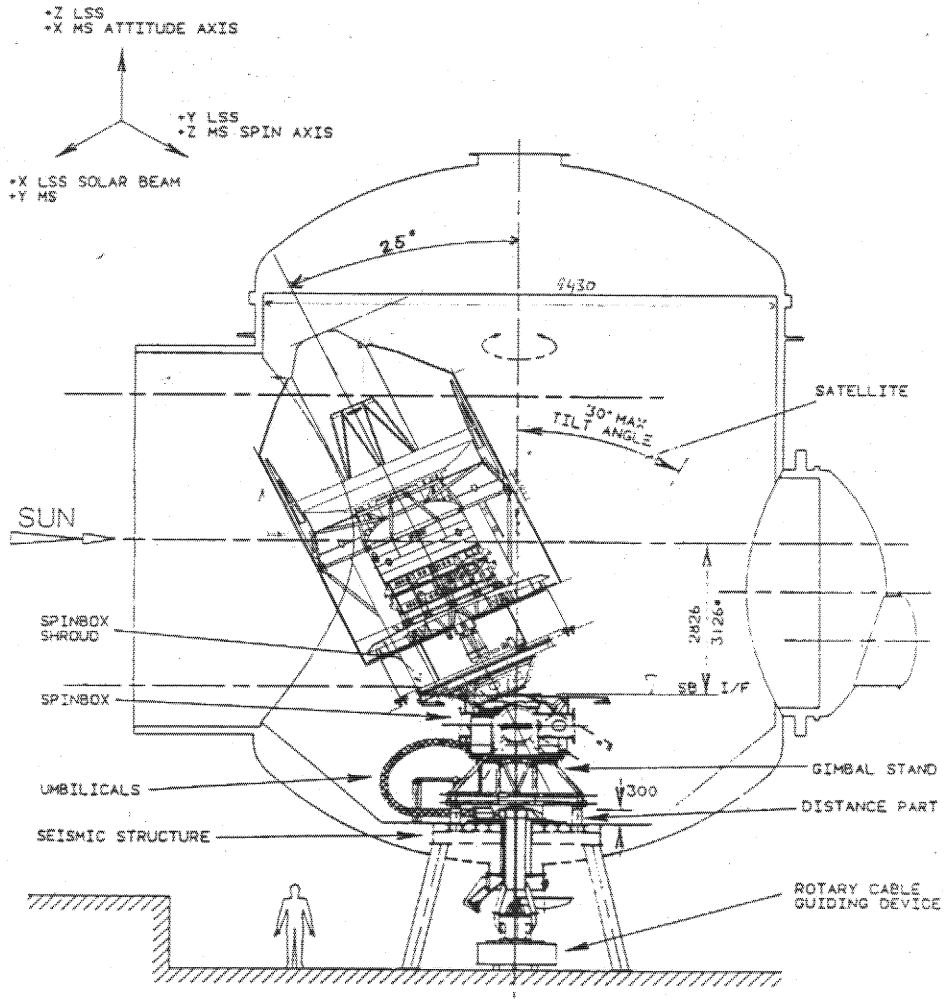
TB/TV test approach (2)

- Detailed inputs needed from instruments
  - Test requirements, test flow, sequences, breakpoints
  - Test constraints (temperature requirements, temperature stability requirements)
  - Test time



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Instruments AIT Meeting - EQM/PFM Testing

IST approach

- See presentation of ESTEC

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HERSCHEL Instrument AIT Meeting Ottobrunn

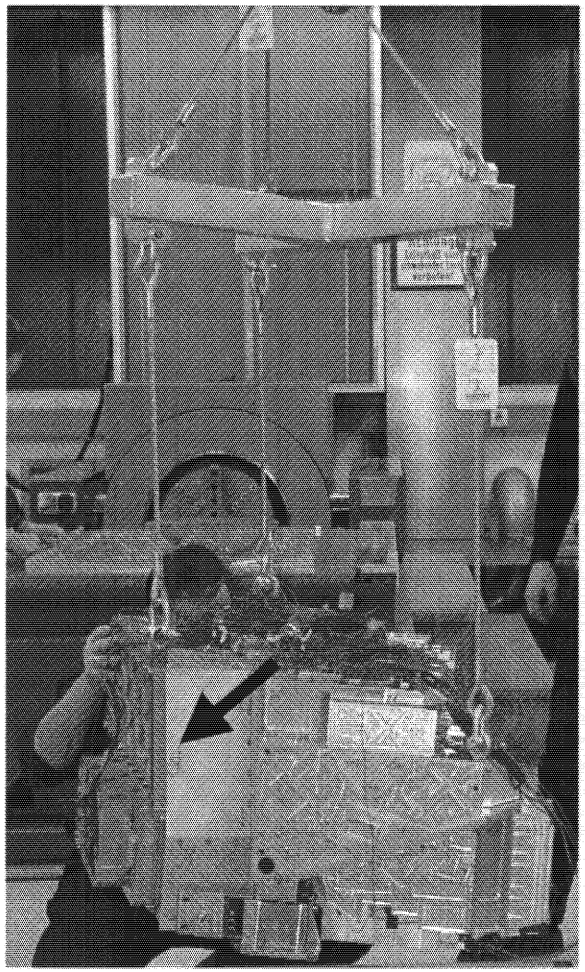
FPU Integration Sequence

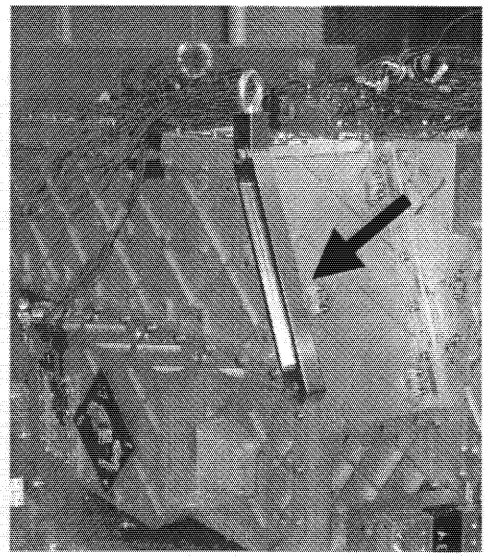
Josef Schubert
MPE

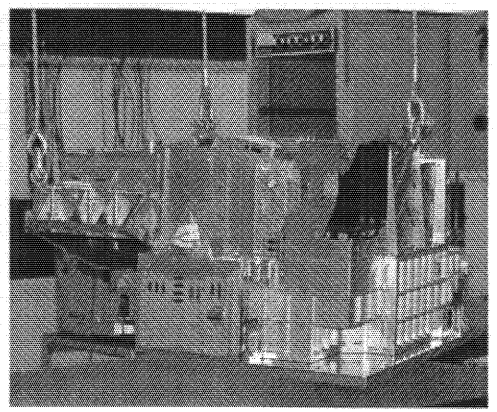
ANNEX 2

FPU Hoisting Tools

- PACS Hosting Tool with elongated eyelet at the spectrometer side (red tagged item)
- For a slow let down of the PACS FPU a fine drive for the crane is needed

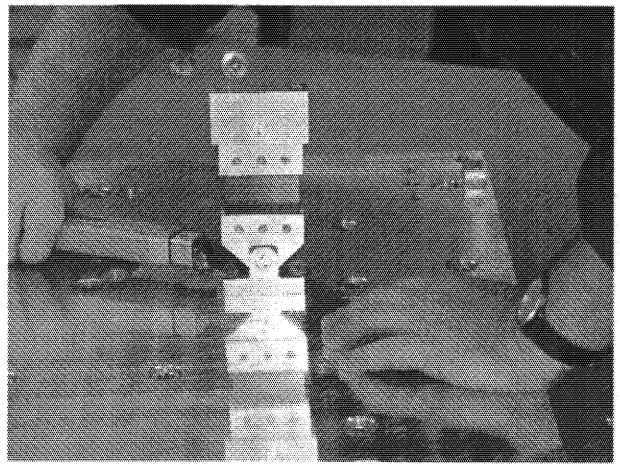






FPU Integration Sequence on Optical Bench

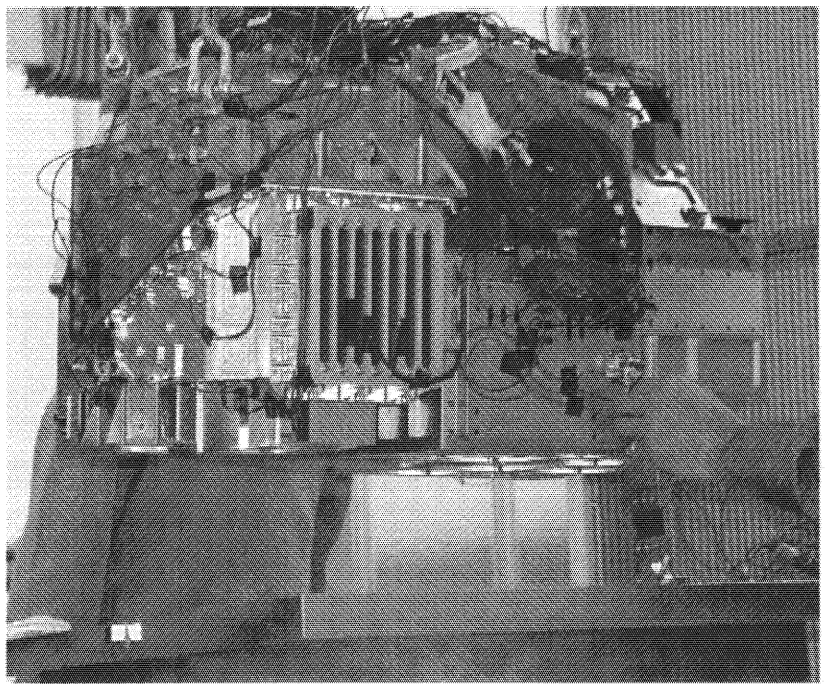
- Prior to the PACS FPU integration, the PACS FPU-one axis suspension feet needs to be mounted on the optical bench
- Two dowel pins (SST, diameter 12mm, H7) and shimming plates to be placed into the pin holes of the optical bench
- Tightening torque for all M8 mounting screws is 23Nm (@ RT)



Lessons learned during STM-FPU integration (I)

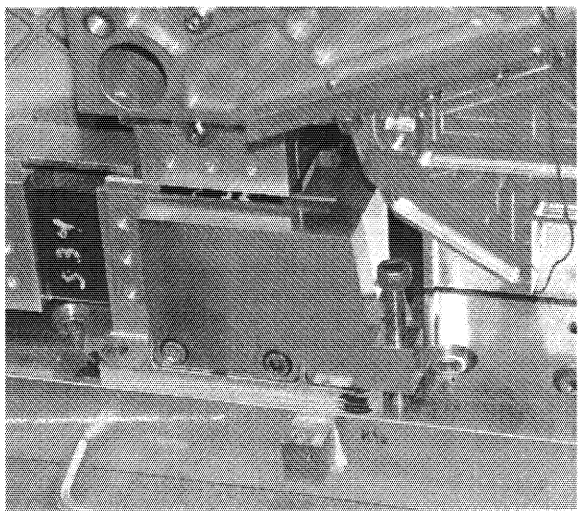
- Hoisting device needs to have an adjustable tightrope length (threaded rod). Balancing of PACS-FPU can not be done with counter weights on the hosting device.
- Mount guiding tool for FPU integration via crane under discussion. This would insure, that the one axis suspension feed cannot be damaged during lowering of the FPU

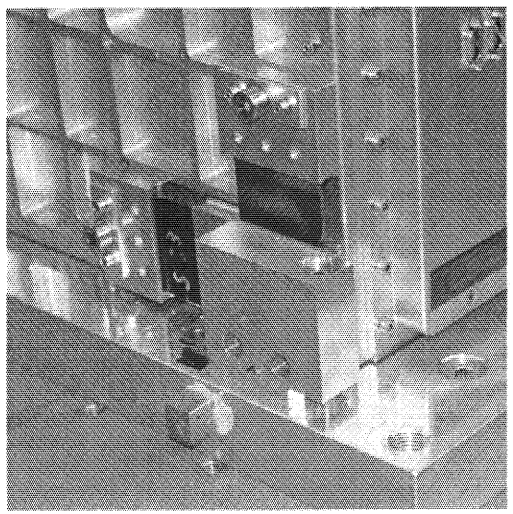
  -> two additional threads within the optical bench needed.

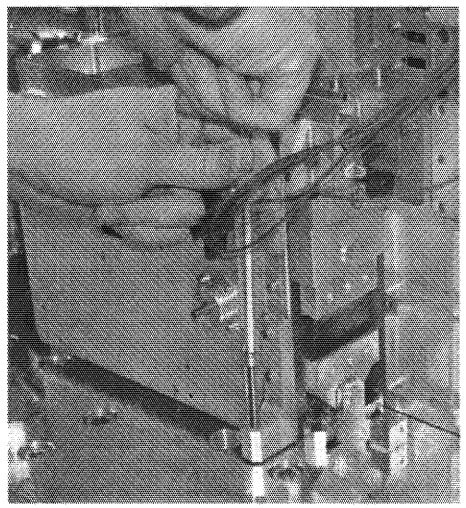


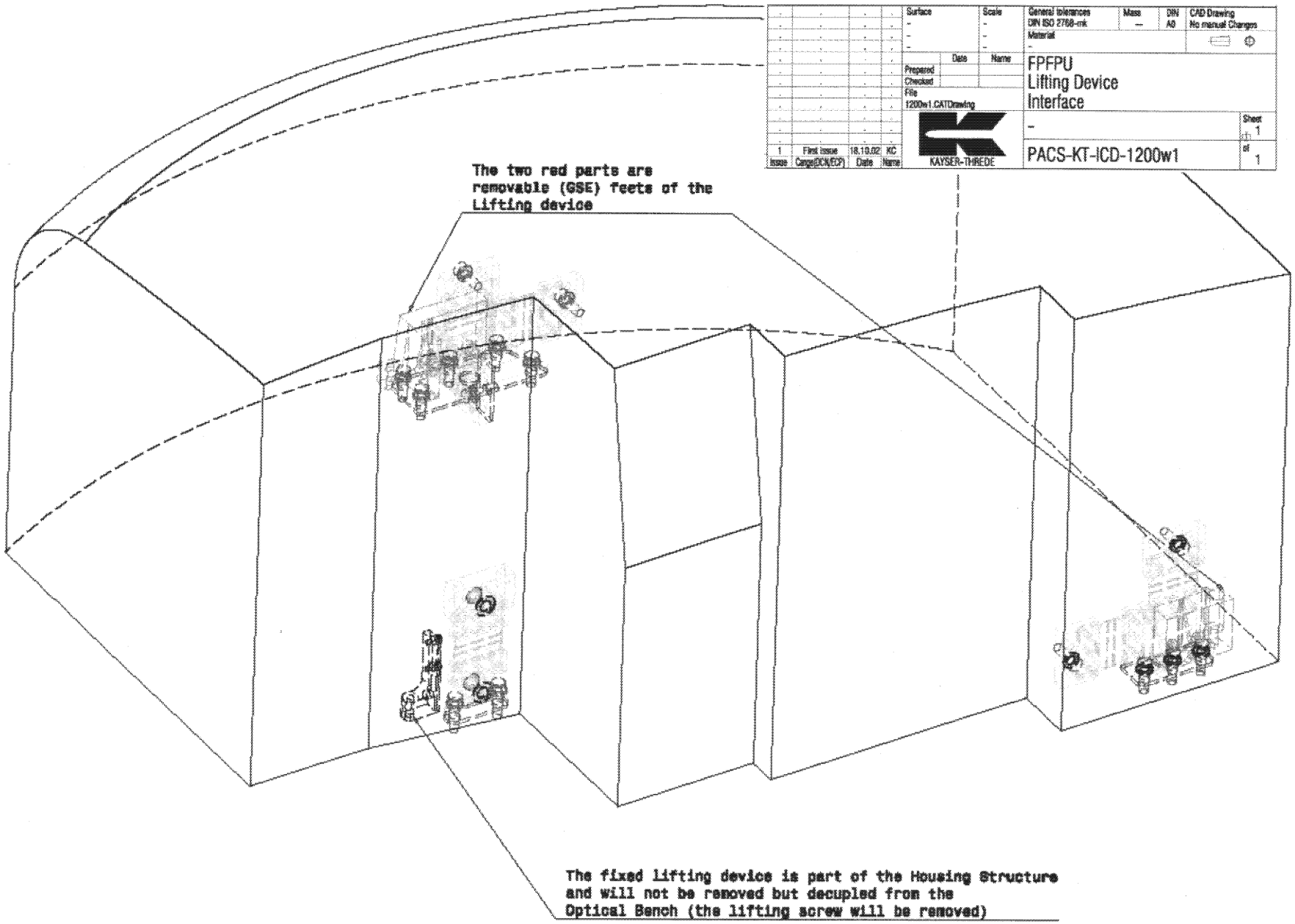
Lessons learned during STM-FPU integration (II)

- Elongated pin hole in the two axis suspension feet is not necessary; tolerances are within the elastic range of the CFRP plates
- Now shimming plates (nominal 3mm) below the PACS feet might be critical; only 1 mm distance left between PACS and optical bench
- Lifting tool was successfully tested (for emergency only)



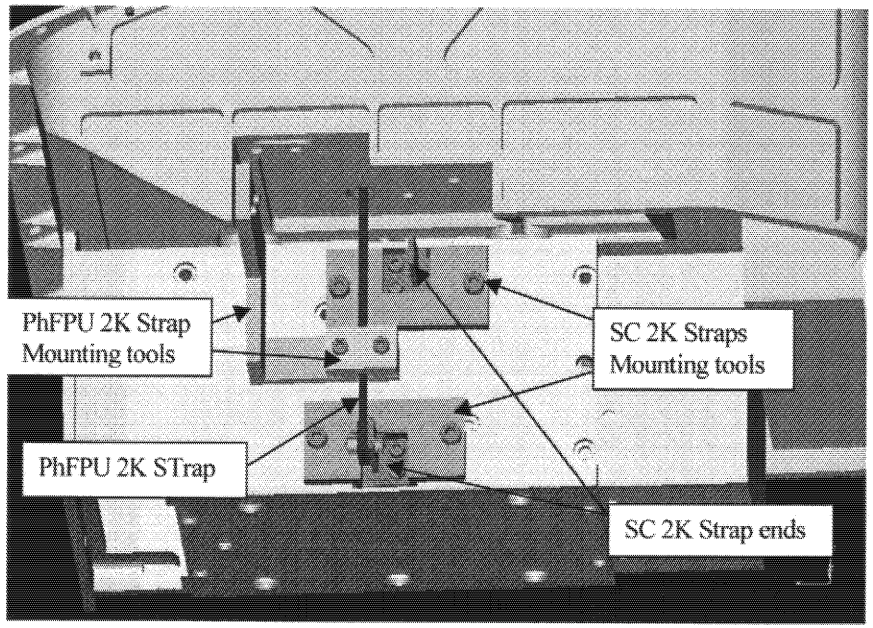




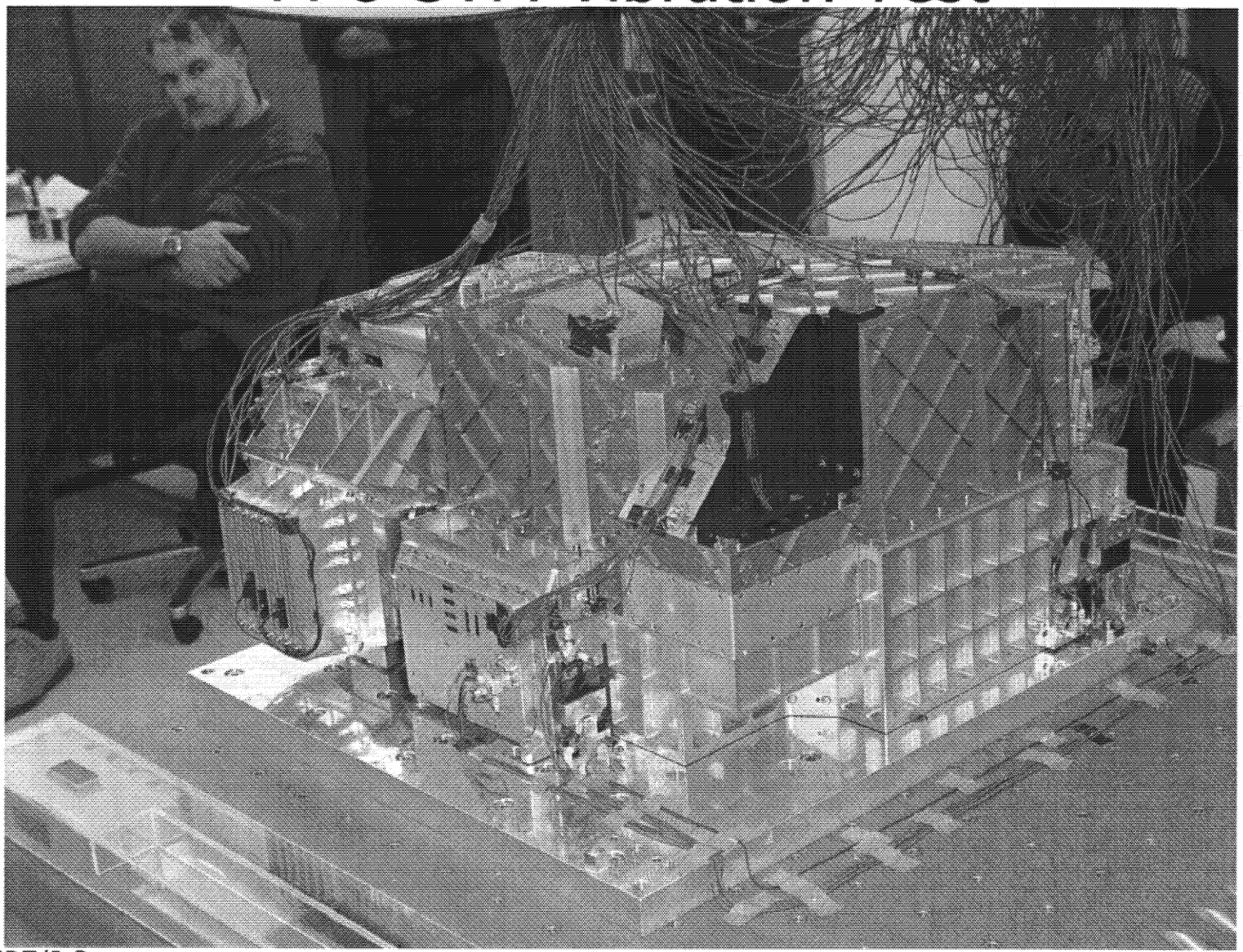

Surface
Scale
General tolerances
DIN ISO 2768-mK
Mass
DIN
A0
CAD Drawing
No manual Changes
Material
Date
Name
Prepared
Checked
File
1200w1.CAT/Drawing
FPFPU
Lifting Device
Interface
Sheet
1
1
First issue
18.10.02
KC
Issue
Change(DCN/ECP)
Date
Name
KAYSER-THREDE
PACS-KT-ICD-1200w1
1
The two red parts are removable (GSE) feets of the Lifting device
The fixed lifting device is part of the Housing Structure and will not be removed but decupled from the Optical Bench (the lifting screw will be removed)

FPU Integration Constrains

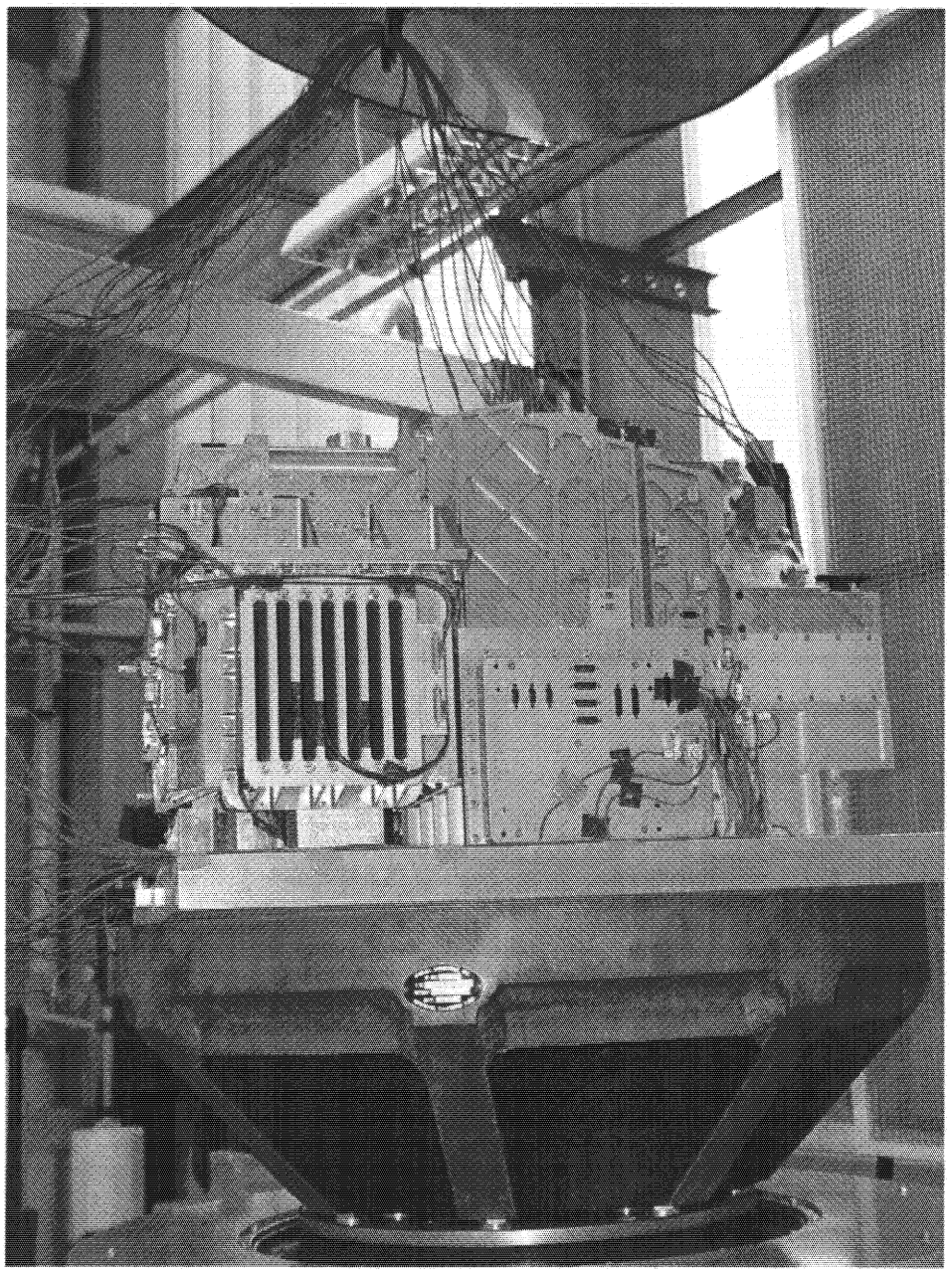
- In the case the short circuit connectors are removed from the FPU connector panels, test personal needs to be grounded during handling
- Cooling traps to the 2K cooler I/F are fragile. PACS/CEA will provide a integration tool.



FPU STM Vibration Test



FPU STM Vibration Test



FPU STM Vibration Test

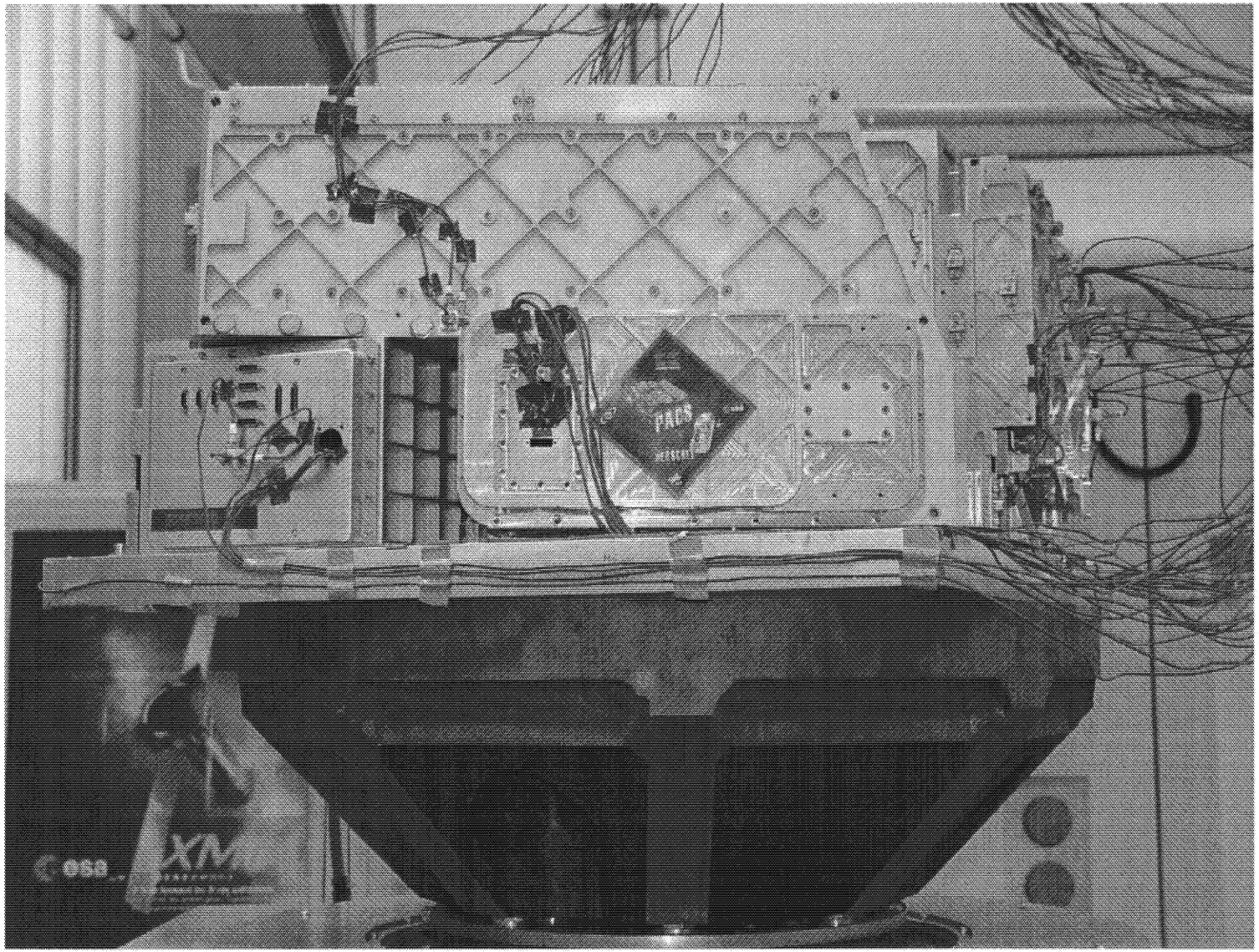
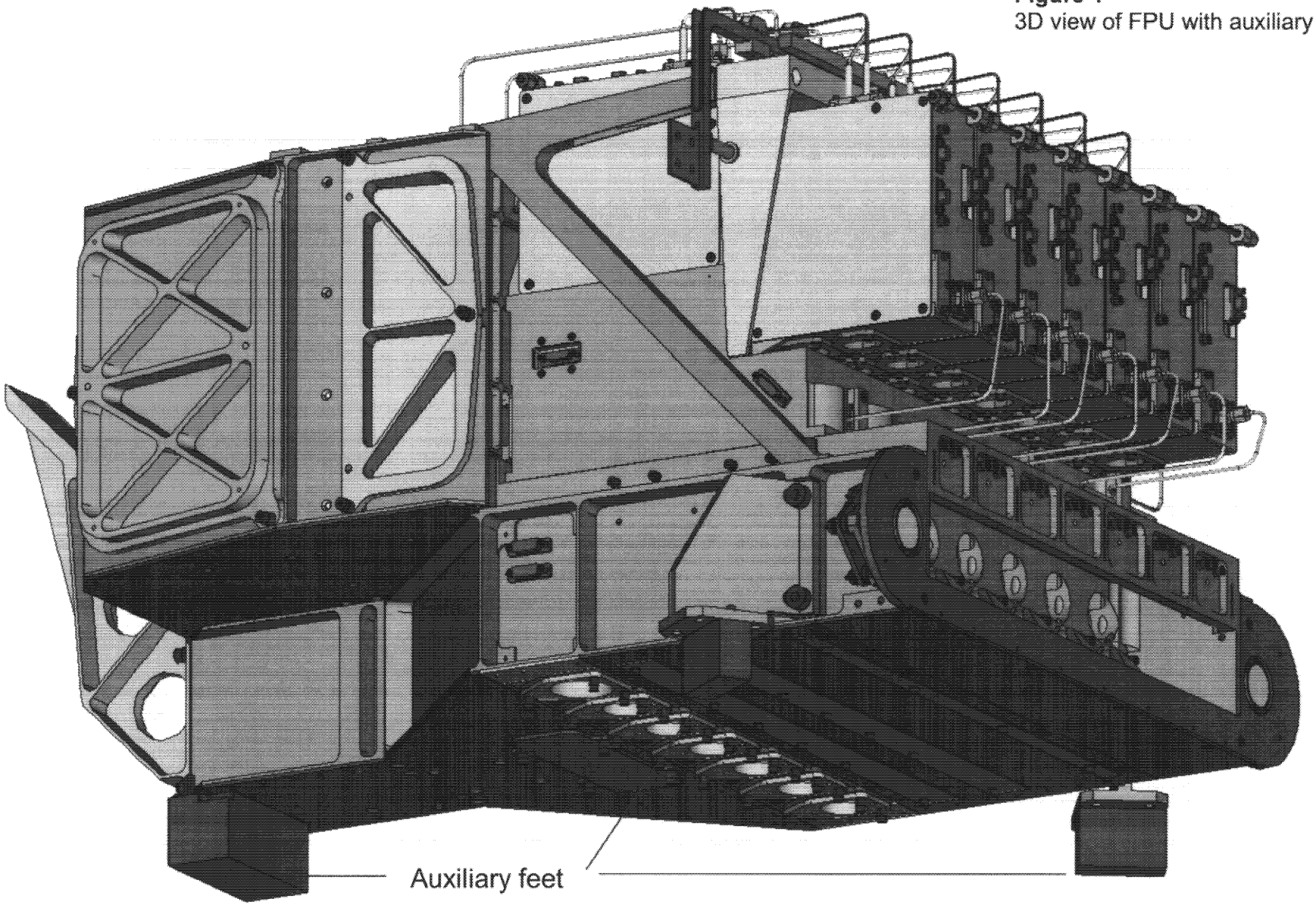
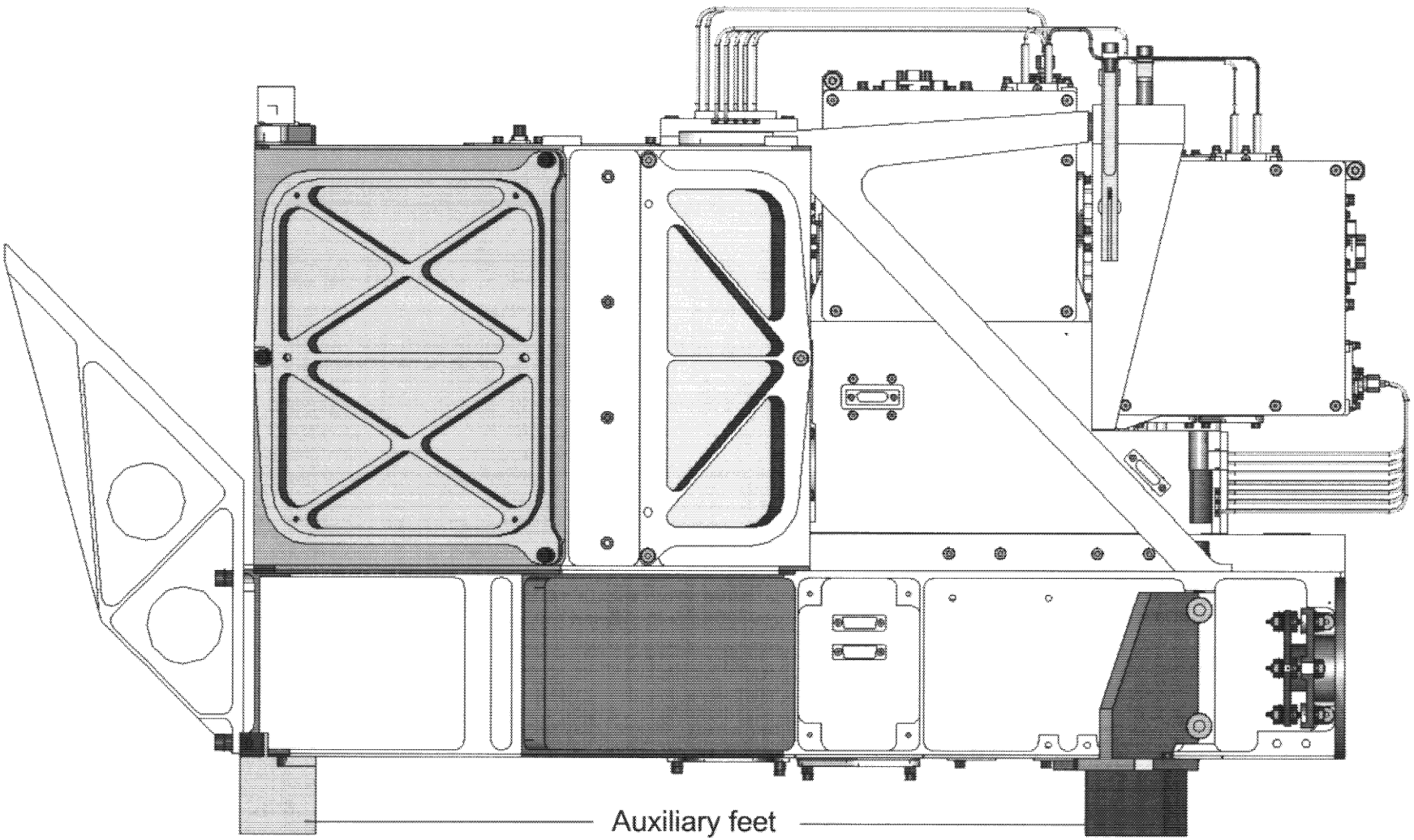


Figure 1
3D view of FPU with auxiliary feet installed



ANNEX 3

Figure 2
Side view of FPU with auxiliary feet installed



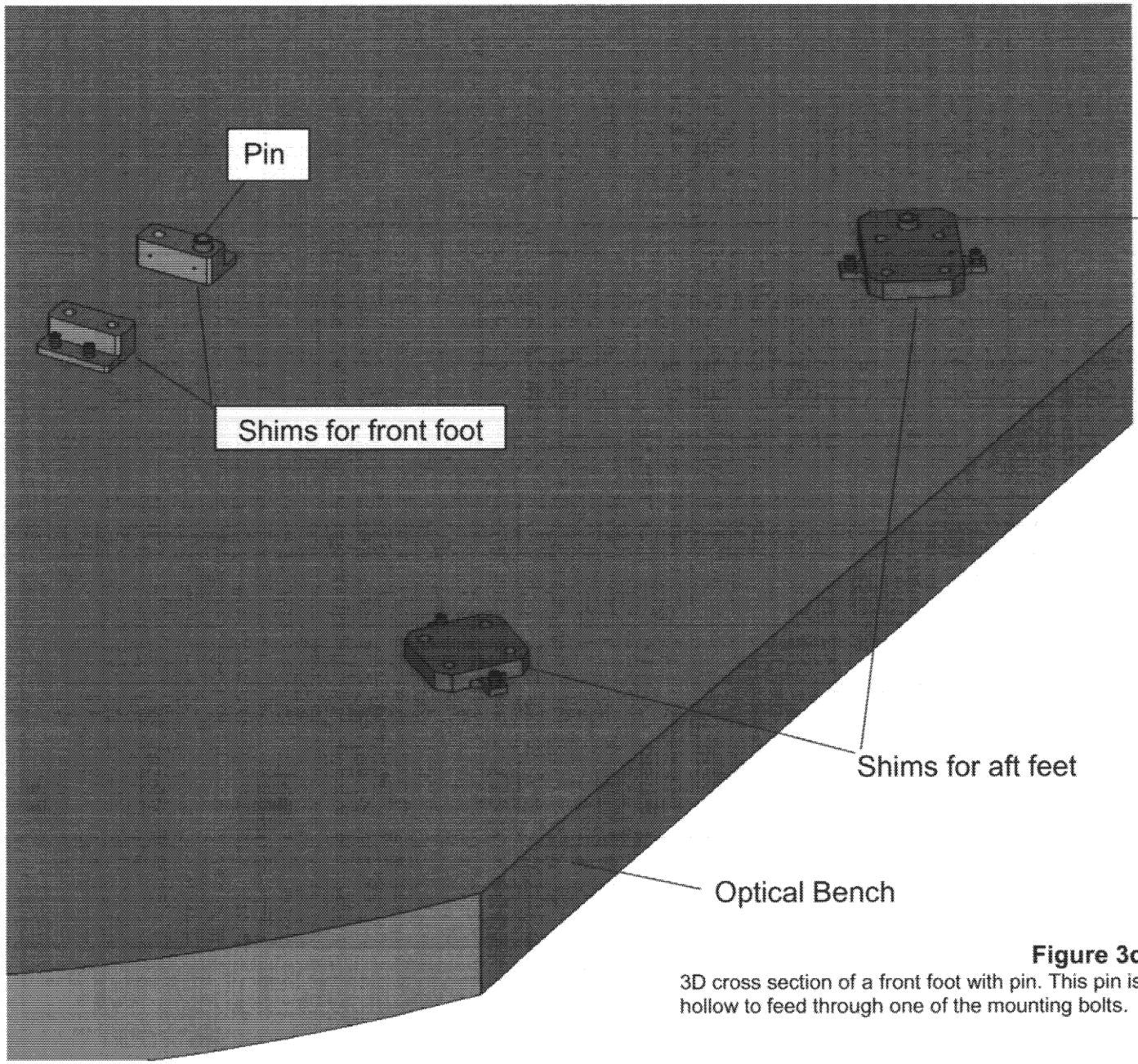
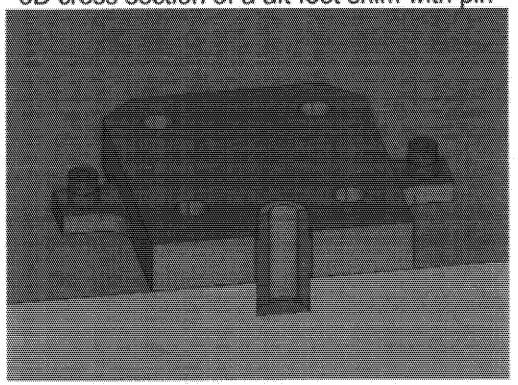


Figure 3a
Shims on optical bench

Figure 3b
3D cross section of a aft foot shim with pin



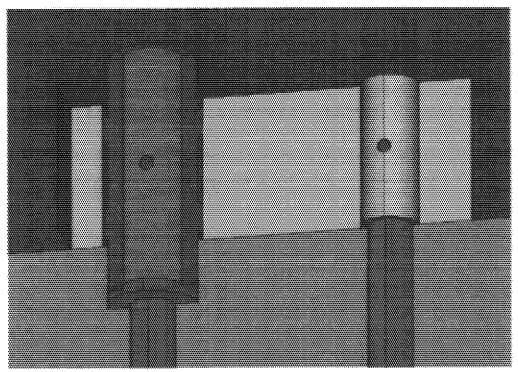


Figure 3c
3D cross section of a front foot with pin. This pin is hollow to feed through one of the mounting bolts.

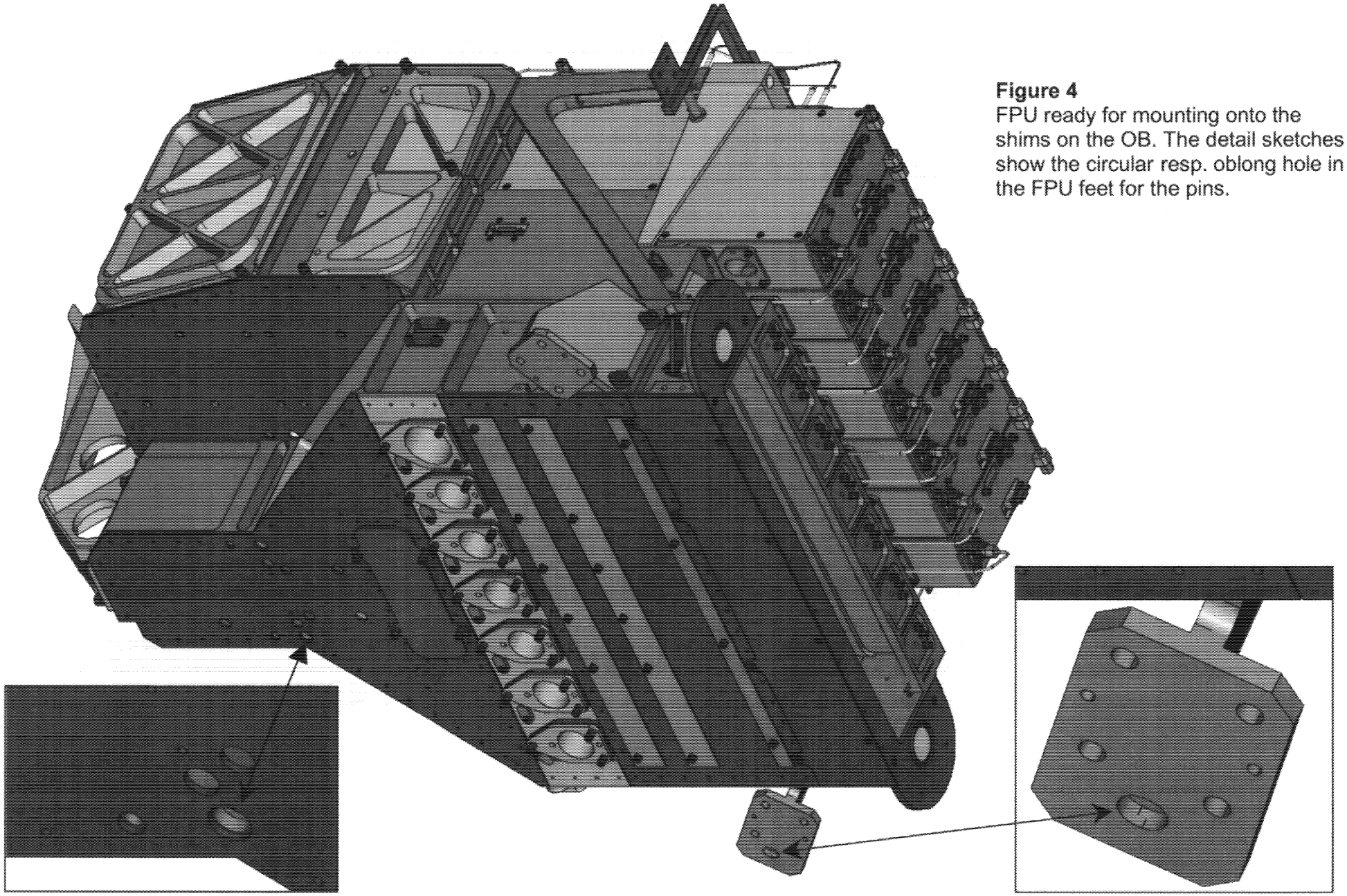


Figure 4
FPU ready for mounting onto the shims on the OB. The detail sketches show the circular resp. oblong hole in the FPU feet for the pins.

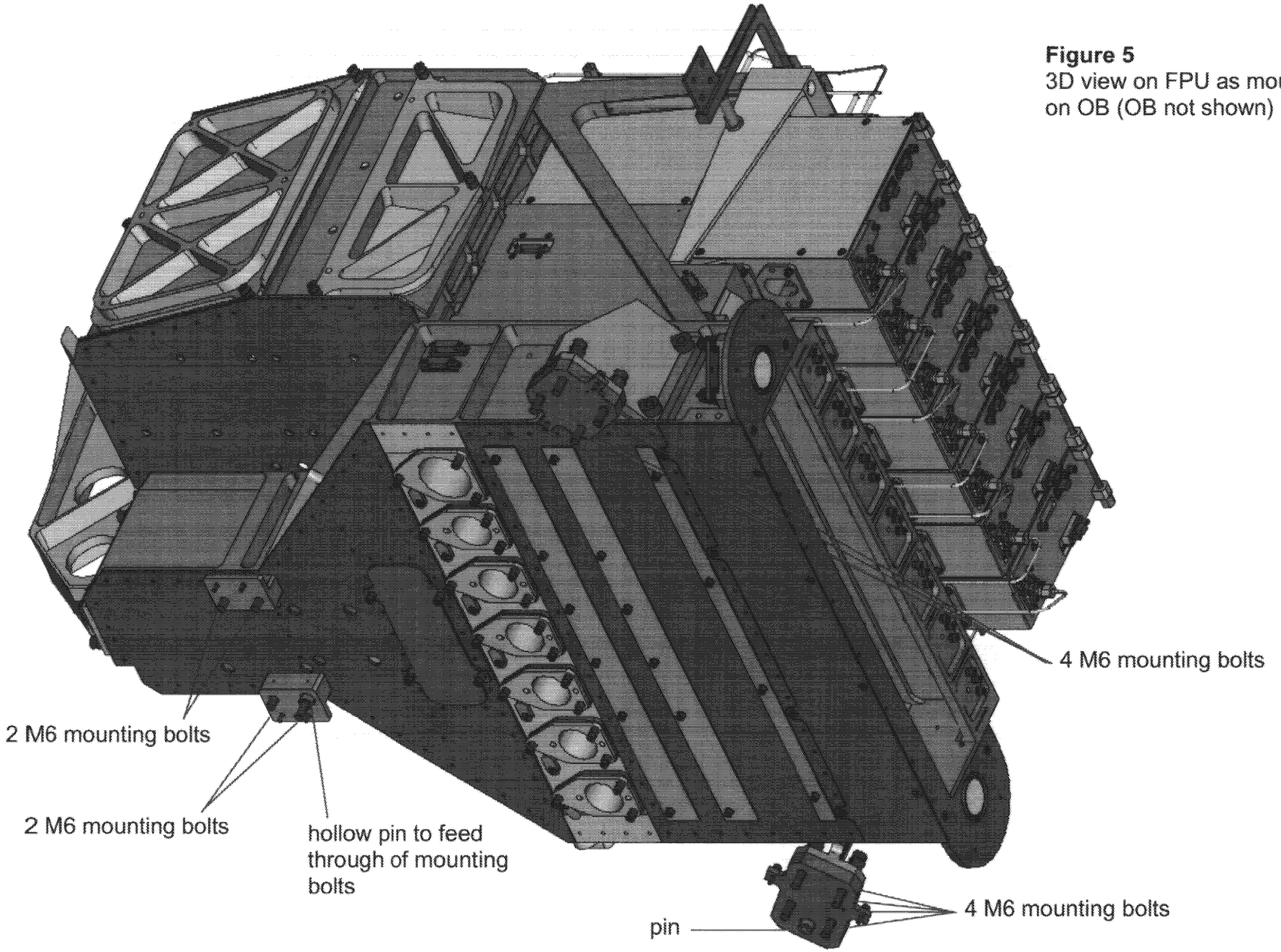


Figure 5
3D view on FPU as mounted on OB (OB not shown)

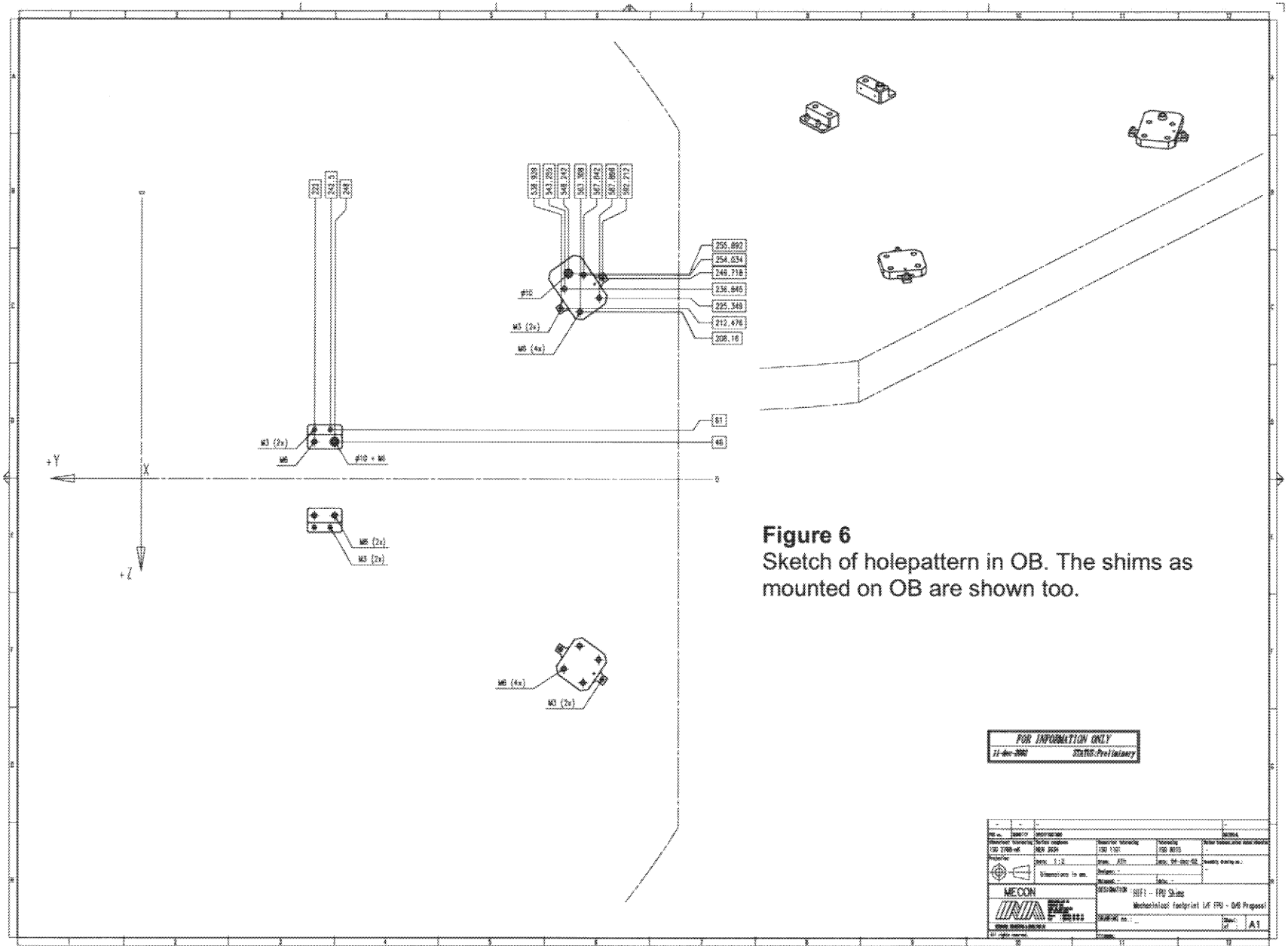
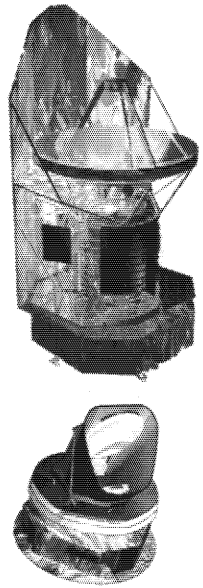


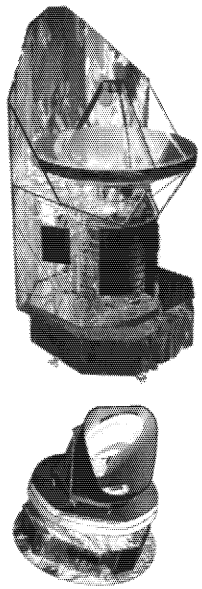
Figure 6
Sketch of holepattern in OB. The shims as mounted on OB are shown too.

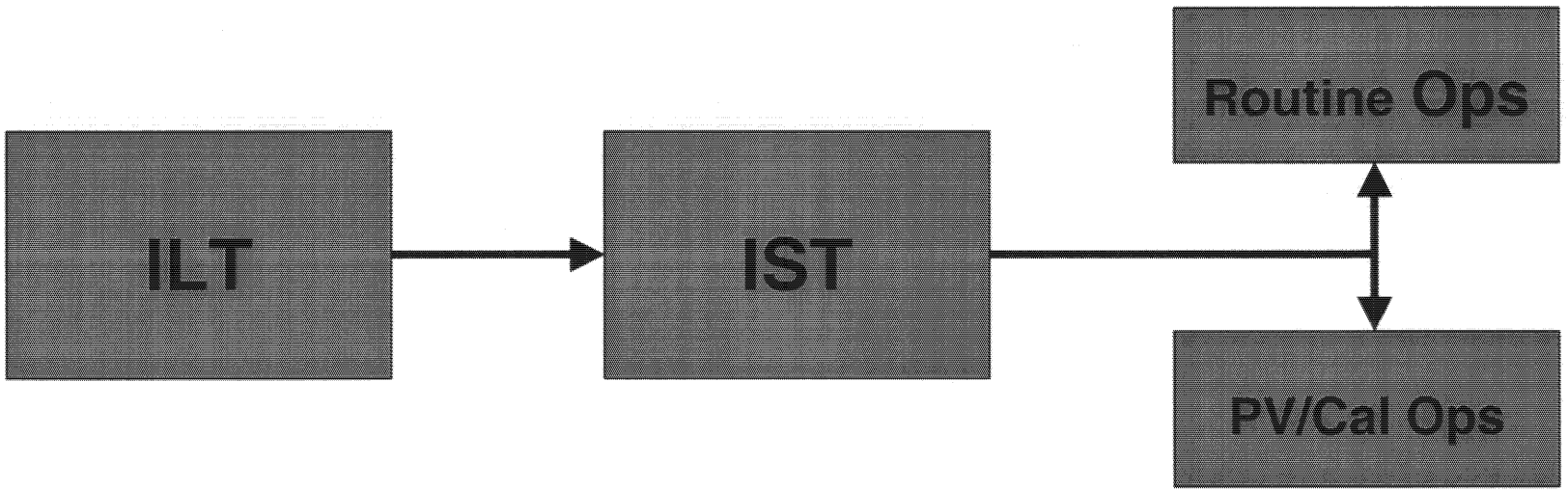


Approach to ISTs

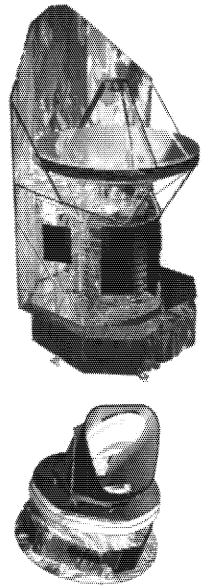
21 January 2003

HP-2-AED-TN-0268
annex 4



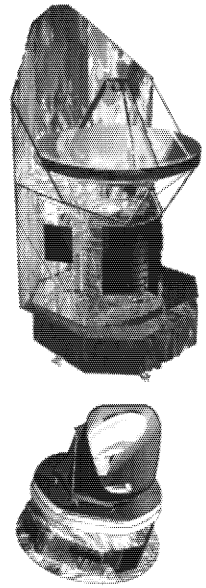


Smooth Transition Requirement



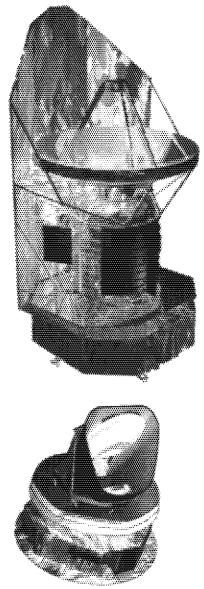
ILTs

- Performed individually at instrument level before delivery
- To include functional, performance and reference tests of instruments
- Make use of HCSS and EGSE-ILT based on SCOS 2000
- During ILT, EGSE-ILT interfaces the HCSS to get the "Observation Plan" and ObsID requested for the test.



ISTs

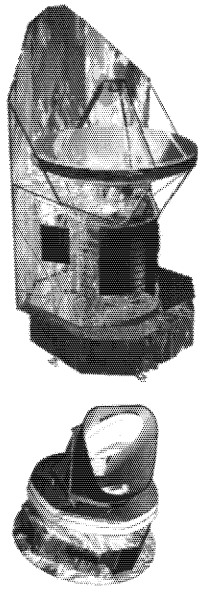
- To verify correct operation of the full integrated spacecraft in a series of representative mission scenarios including failure cases
- To be performed on the AVM (Herschel and Planck), STM/CQM (Planck only) and PFM (Herschel an Planck)
- ISTs to combine procedures developed and debugged at SVM, PLM and Instrument level
- IST to include some Instruments performance tests (Herschel PFM)



Operations(1)

From: Reference Mission Scenario (Herschel)

- Commanding of the satellite (spacecraft and instruments) is carried out exclusively by the Mission Operations Centre (MOC) located at ESOC.
- For Herschel an Operational Day (OD = 24 hours) has been defined as basic planning unit for the operational phase.
- Each OD can be divided into: DTCP (I.e visibility period of about 3 hours) and autonomy period (remaining 21 hours)
- HSC to submit to MOC an Observation Plan covering about 3 weeks
- From the Observation Plan, MOC to derive a detailed Schedule of activities and the related MTL for each OD.

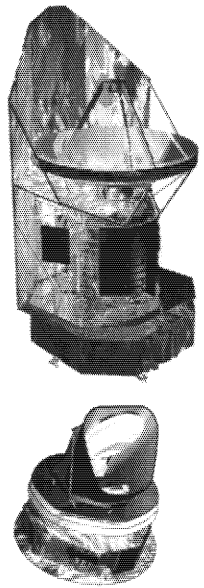


Operations(2)

From: Reference Mission Scenario (Herschel)

Some activities during DTCP

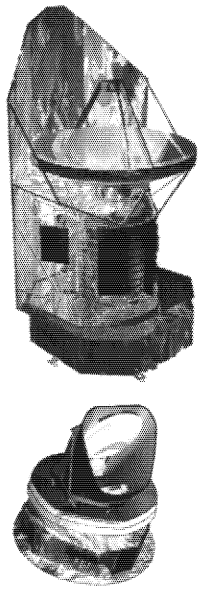
.....	
P + 2 min	**Request downlink of events, recorded HK and recorded Science in this order of priority.**
.....	
P + 10 min	Evaluate recorded HK and events data, start downlink of science data
.....	
P + 1 hour	Update on-board schedule (top-up, normally for 24 h)
.....	



Operations (3)

During the Operation (routine) phase:

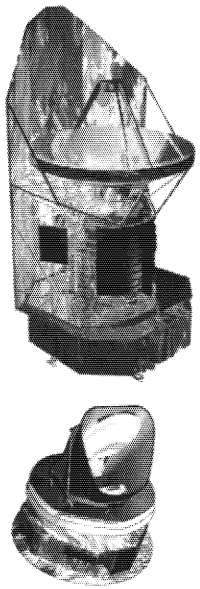
- The HSC shall provide in advance the Observation Plan
- There is no real time involvement of the HSC
- The MOC can transfer science data to the HSC after several hours
- All commanding and recovery actions shall be controlled by the MOC



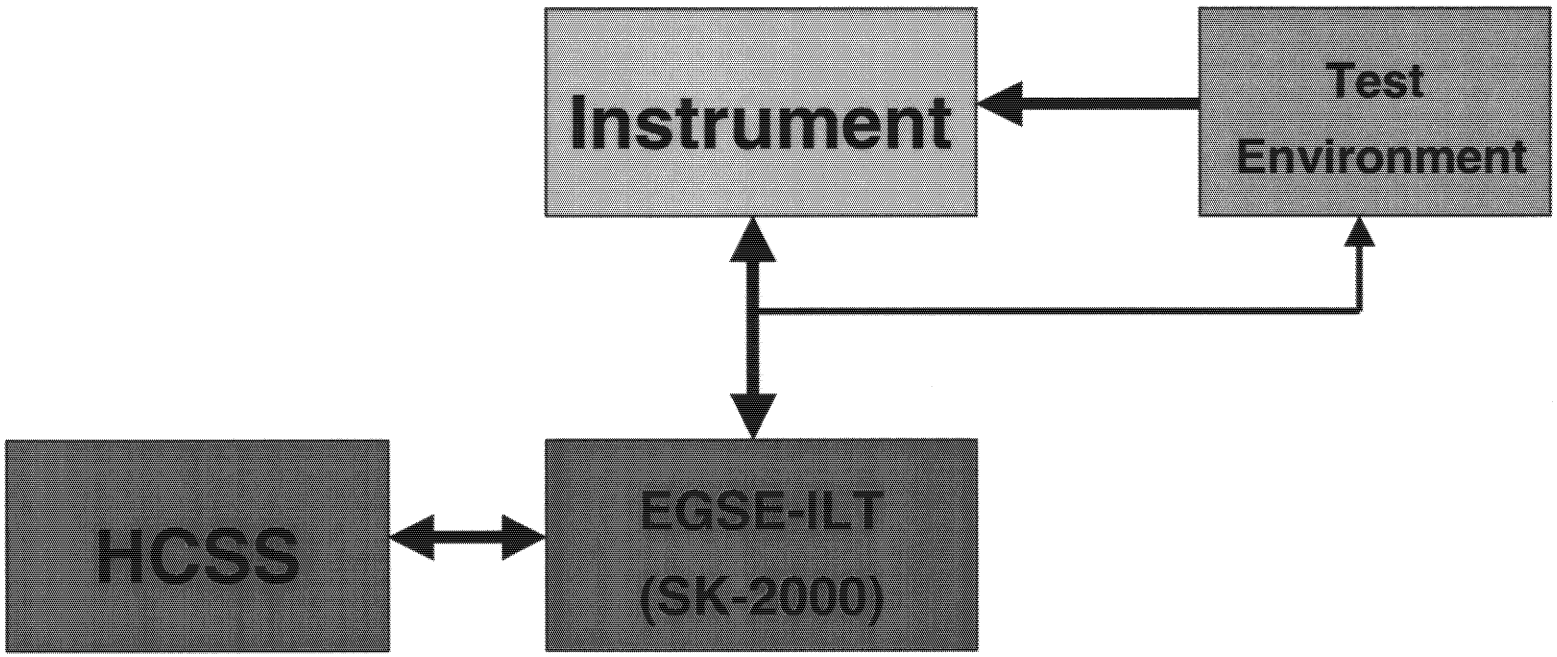
Operations (4)

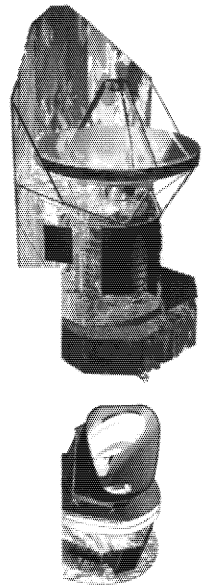
During the Calibration/PV phase (may be in T.O.):

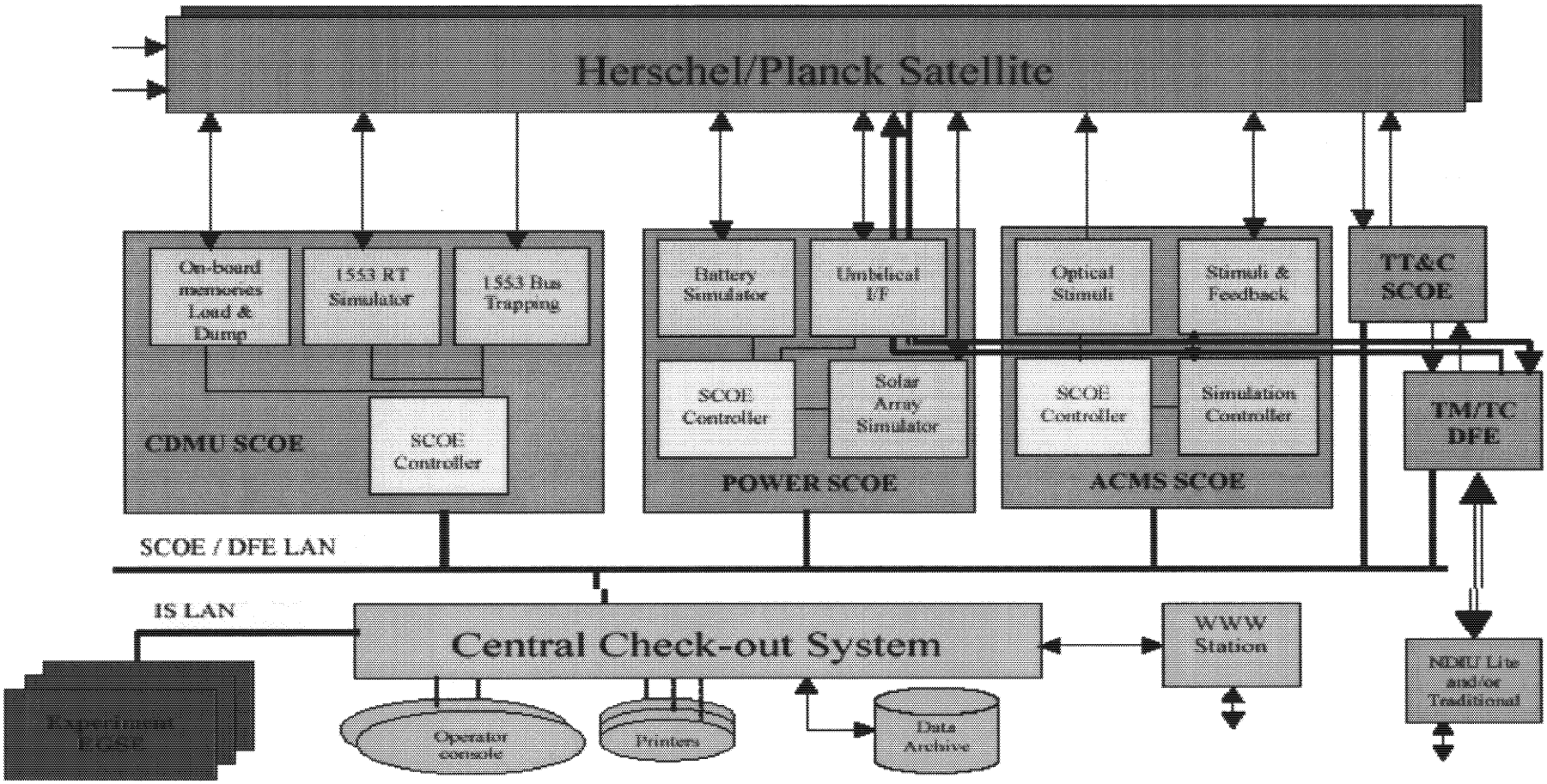
- **An ICC is installed in the MOC**
- **10 hrs visibility per day looks possible**
- **Real time interaction ICC/MOC might be requested (unclear)**



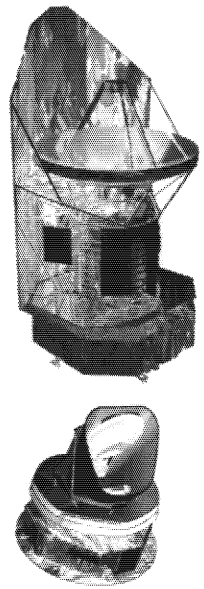
Set-up for ILT (Herschel)





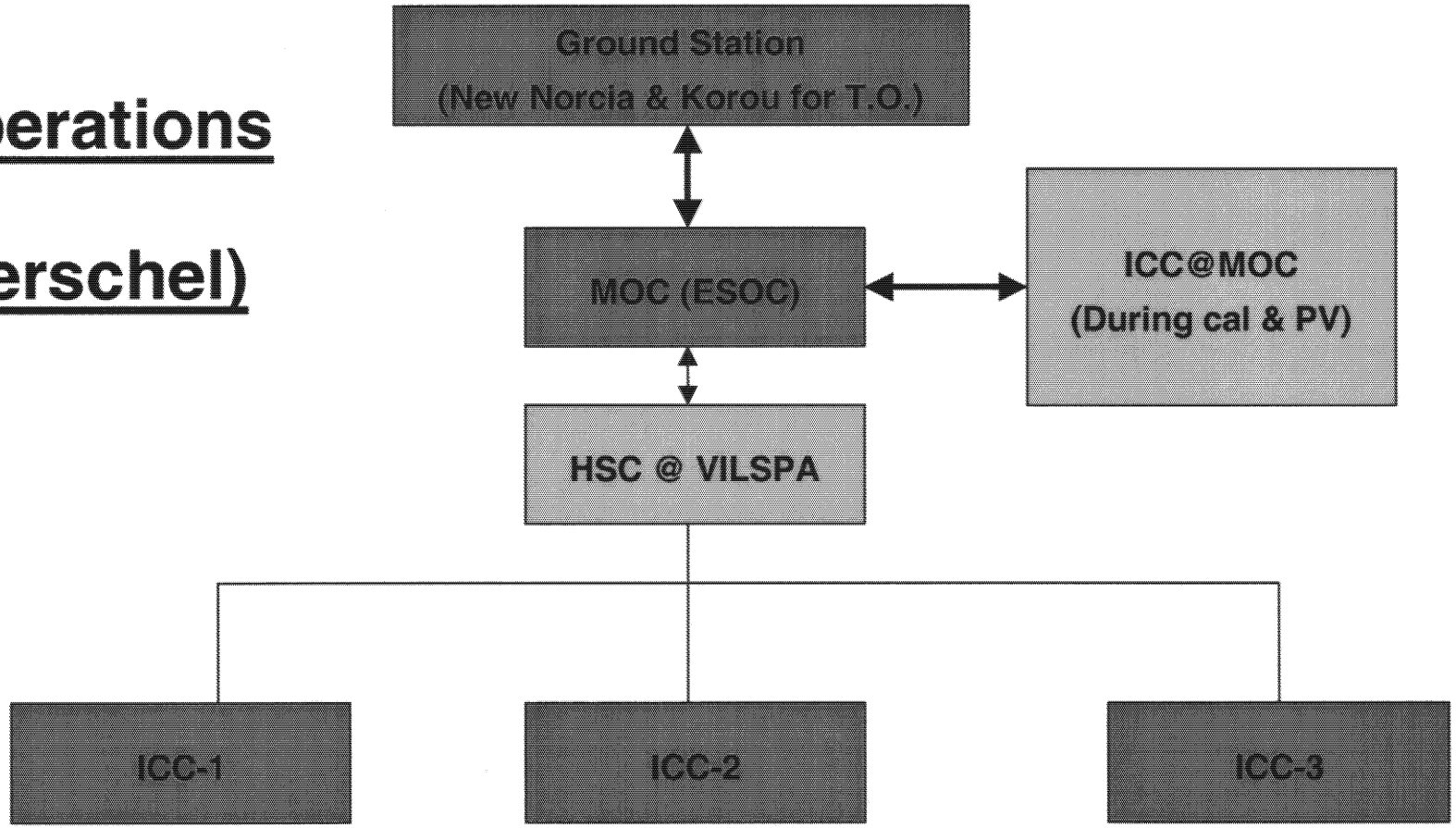


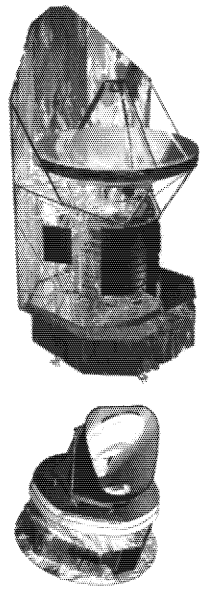
Set-up for ISTs



Operations

(Herschel)



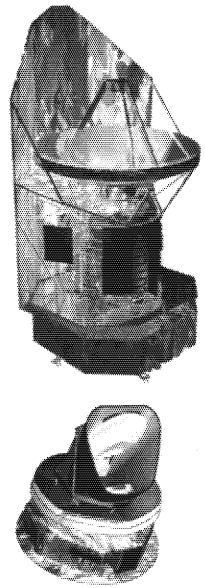


Utilisation of the I-EGSE at System Level

During system level activities, 3 ways of operating the I-EGSE are considered:

- Mode-1: I-EGSE OFF (or unavailable)
- Mode-2: I-EGSE in listening mode i.e. one way communication only from CCS to I-EGSE to dump Instruments HK and Science data
- Mode-3: I-EGSE involved in real time testing under the control of the CCS

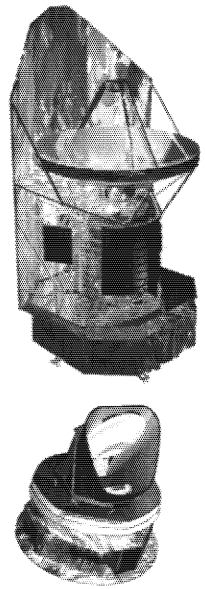
Regardless the selected mode, the CCS retains the control of the test activity. The I-EGSE cannot uplink commands to the spacecraft.



Approach to IST (1)

- Initial running of IST will require debugging of procedures and AIT SW with flexibility to fix quickly minor bugs
- Context saving and re-start may be normal practice (no night shift)
- ISTs to run initially with pre-defined Observation Plan and associated MTL both prepared in advance and available in the CCS.
- Failure cases can also be tested.
- **It might be necessary to re-use several time the same Observation Plan**
- **In this configuration the I-EGSE shall be in listening mode (Mode-2)**

A successful IST in this configuration ensures smooth transition between IST and routine operations phase with the CCS replacing the MOC.

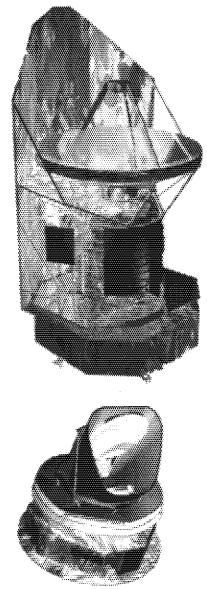


Approach to IST (2)

- IST also requires (Herschel) Instruments verification and consideration of the activities of the ICC@MOC during calibration and PV phase (T.O.)
- ISTs to run initially with pre-defined Observation Plan and associated MTL both prepared in advanced and available in the CCS.
- Real time involvement of the I-EGSE is requested in order to:
  - Evaluate science data
  - Provide updated Observation Plan as needed
  - Validate ground SW (HCSS), QLA, RTA .....
- **In this configuration the I-EGSE shall be involved in real time testing (Mode-3)**

A successful IST in this configuration ensures smooth transition between:

- IST and PV/ calibration phase with the CCS replacing the MOC and
- ILT and IST for all Instrument data processing



Approach to IST (3)

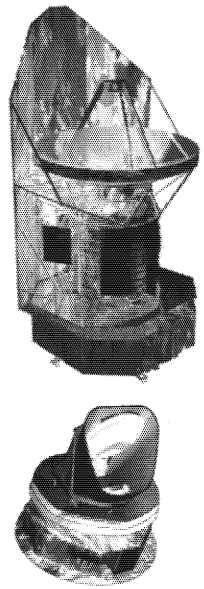
Interfaces required to support IST:

- EGSE I/F Requirements Spec H-P-1-ASPI-IS-0121 to be completed with RC/RM for I-EGSE and Observation Plan

  → normal work to be completed by end February (TBC)

- TC history files

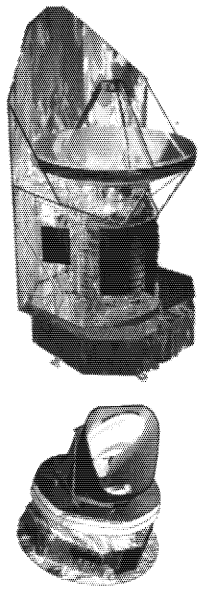
  → already implemented in the CCS and I-EGSE



Approach to IST (4)

On the whole smooth transition is supported by:

- Overall approach to IST as mentioned above
- Established EGSE functionalities and ICDs
- Common SDB
- EGSE (CCS and I-EGSE) and MOC based on SK 2000



Approach to IST (5)

What's next:

Detailed implementation of the IST to be defined in:

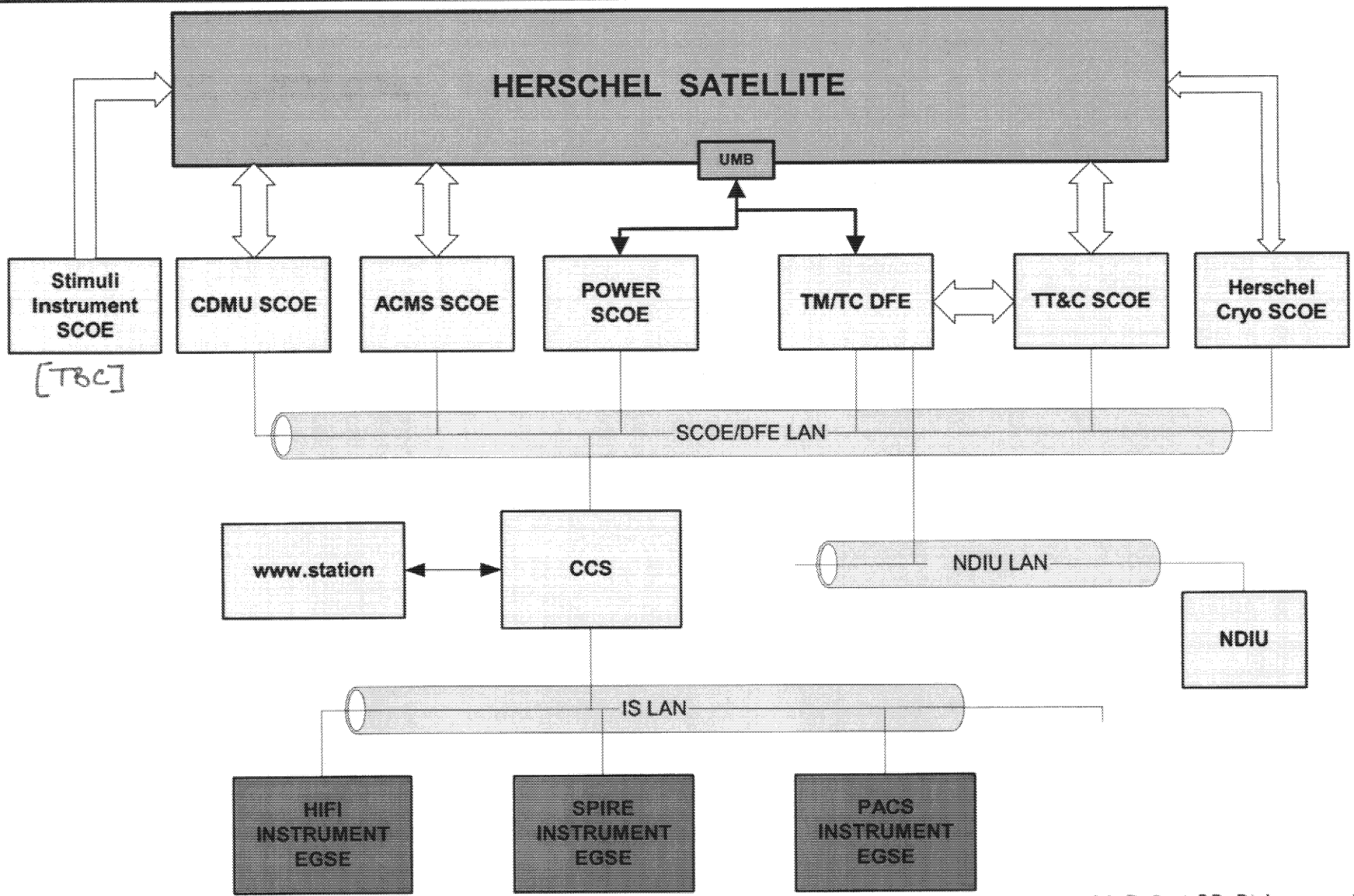
- **Herschel IST Specification**
- **Planck IST Specification**

both documents to be issued by Prime

ALCATEL SPACE

OVERALL HERSCHEL S/C Test Configuration

21-JAN-2003



H-P-1-ASP-PN-xxxx Page 1

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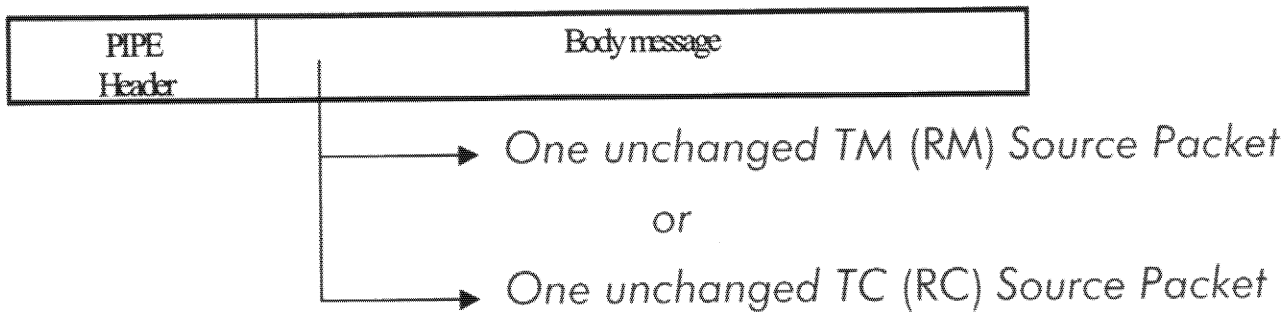
IA025-A

H-P-2-ASD-MN-0290 Issue 5

PIPE Protocol

▼ PIPE protocol allows to exchange Packets between CCS and EGSE items connected via LAN. The protocol is structured in such a way that *TM Source Packets* and *TC Source Packets* are transferred without any changes (Body Message). This is achieved by the attachment of an information header (*PIPE header*) containing additional information required for proper routing and processing of the Packets.



▼The main principle of PIPE protocol is to consider each SCOE as an Onboard equipment:

- Each SCOE receive TC packets from CCS (called **RC** - **R**emote **C**ommand)
- Each SCOE transmit Telemetry Packets to CCS (called **RM** - **R**emote **M**essage)

Refer to MIB CMD

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PIPE Messages for I.EGSE

- CCS shall receive from each I.EGSE at least one RM Packet every 60 seconds. (⇐> TM)
  The following Remote Messages shall be foreseen :
  - → Periodic RM packets containing vital data measured/acquired by each I.EGSE (if needed)

    AND/OR
  - → Asynchronous RM packets containing special events /errors/warning notification (if needed)

    AND/OR
  - → Alive RM Packets (empty packet used to control the link between CCS and I.EGSE)

- CCS will distribute to Each I.EGSE TM Source Packets according to the dispatch table.
  (The dispatch table contains the list (combination of APID/type/sub-type/structure) of TM Packet to be send to I.EGSE)

- Each I.EGSE shall receive from CCS TC Echo Packets.
  TC Echo Packets contain the re-constructed TC Source Packet sent by TM/TC to S/C)

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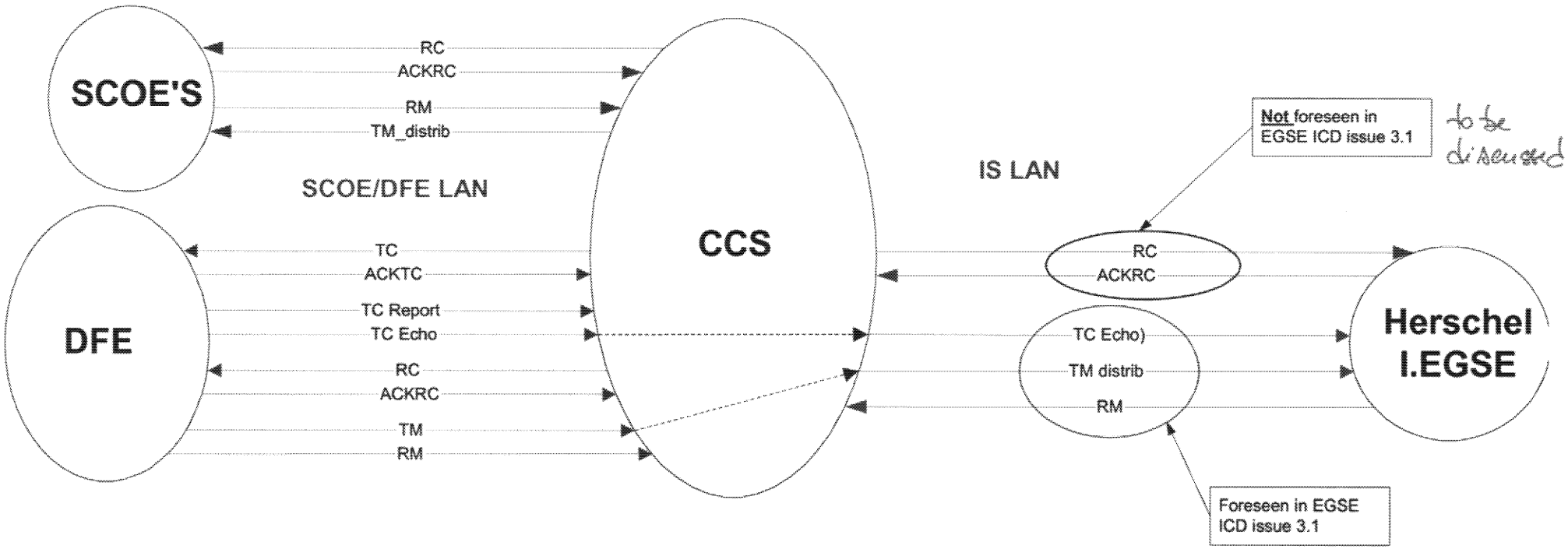
PIPE Messages exchange



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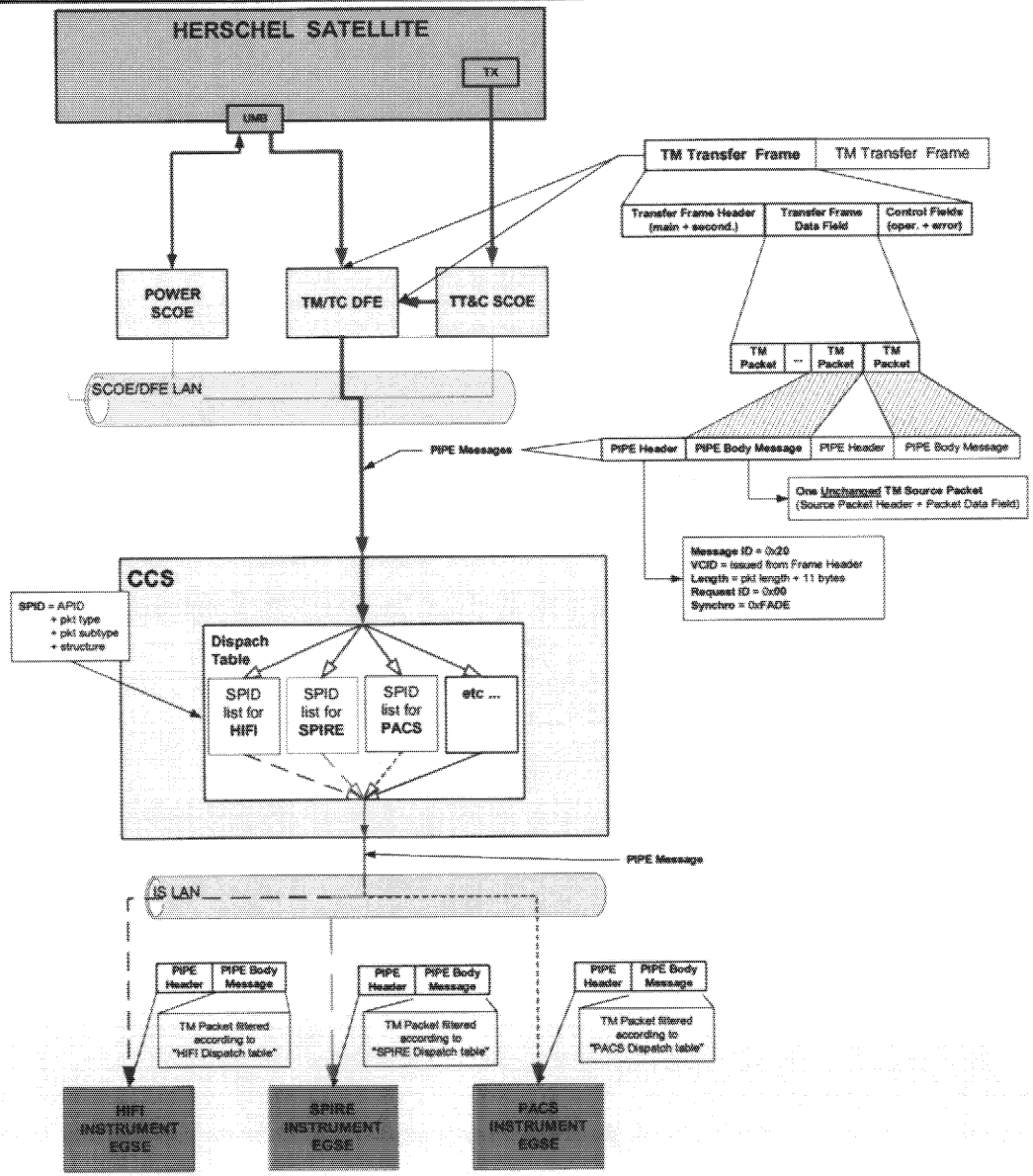
TM Flow Distribution

21-JAN-2003



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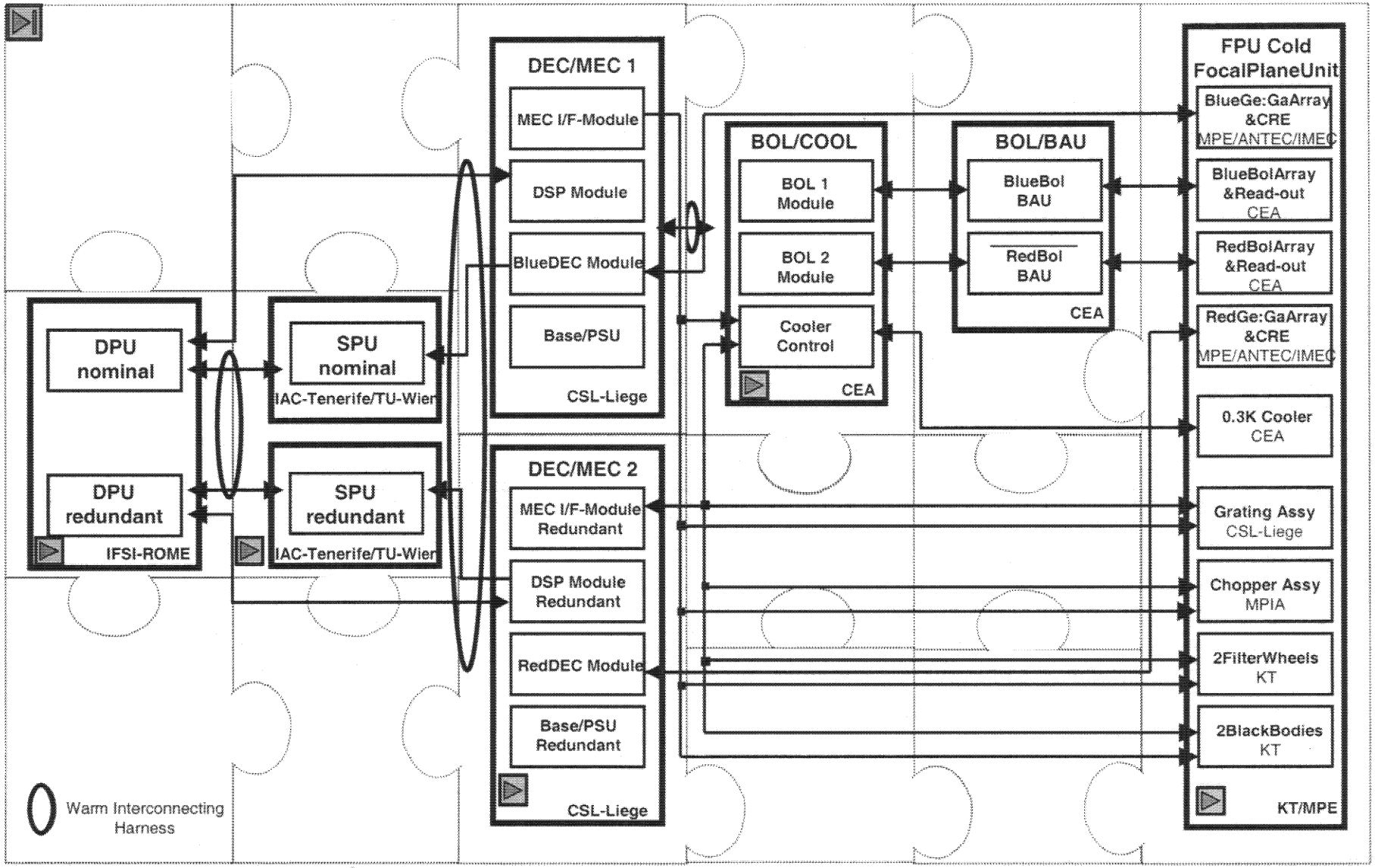
Instrument EGSE for IST and its Interfaces to CCS

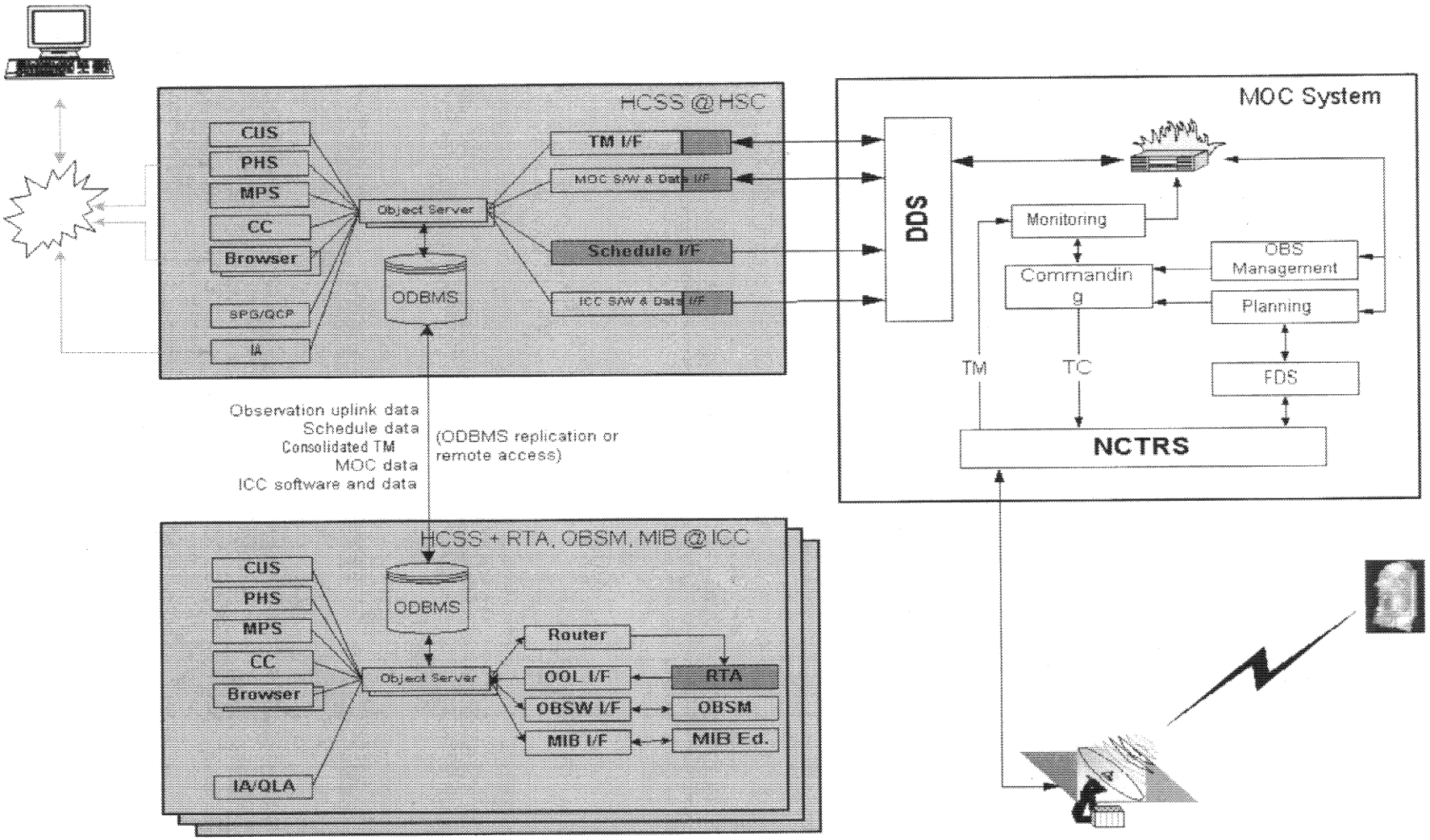
Otto H. Bauer
MPE Garching

HP-2-AIED-TN-0263
Annex 6

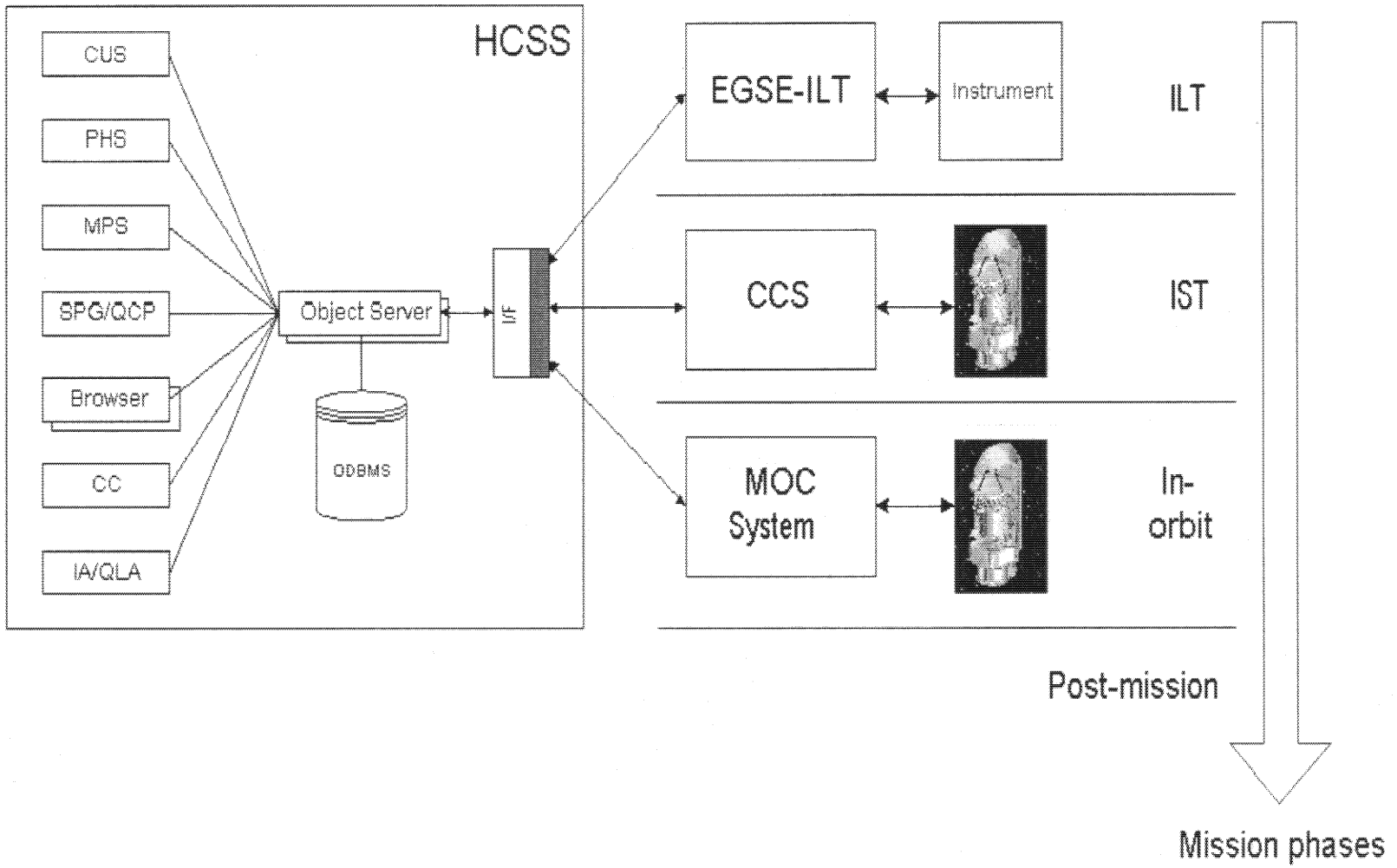
Instrument Overview and Subsystem Responsibilities



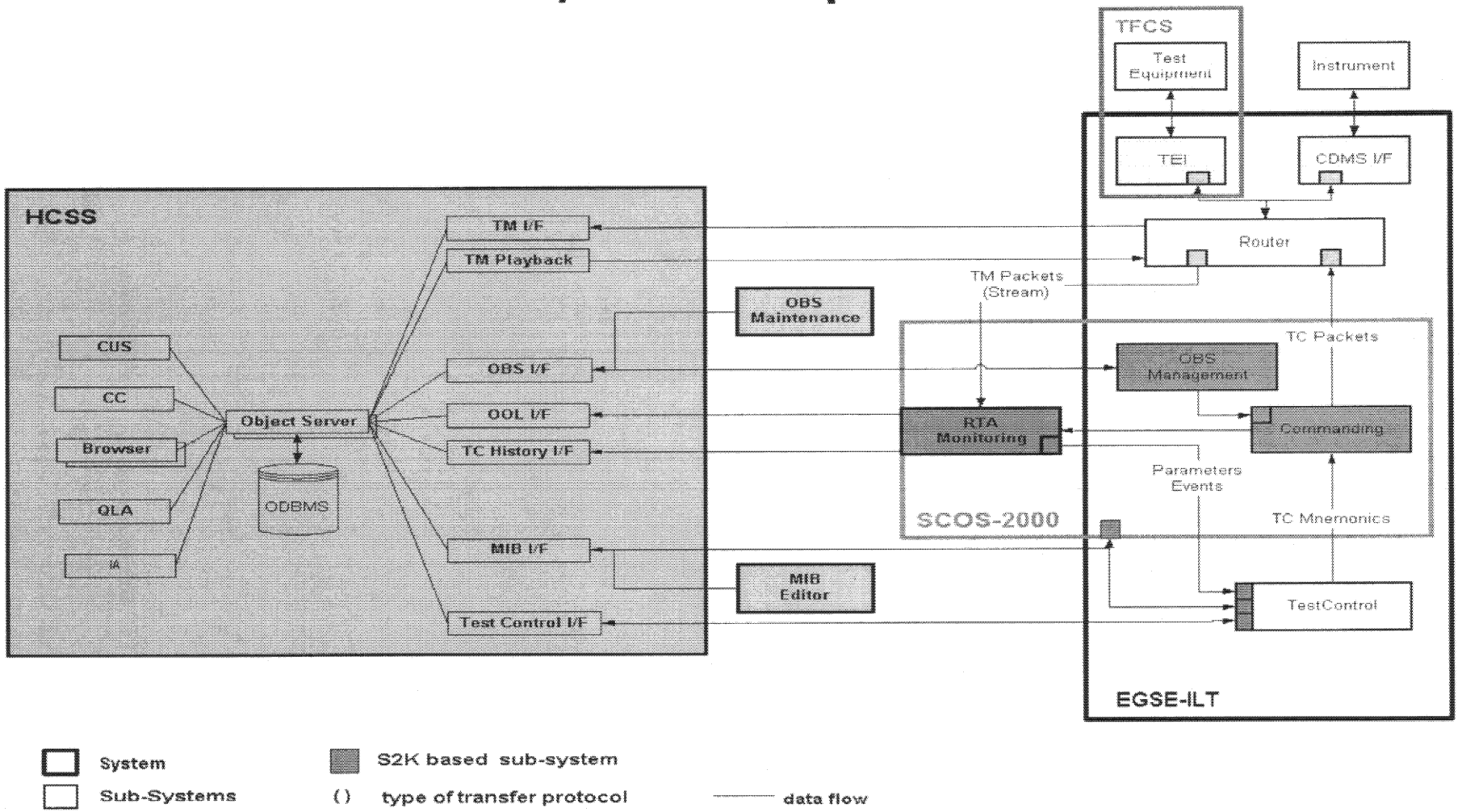
Starting Point: Routine Phase

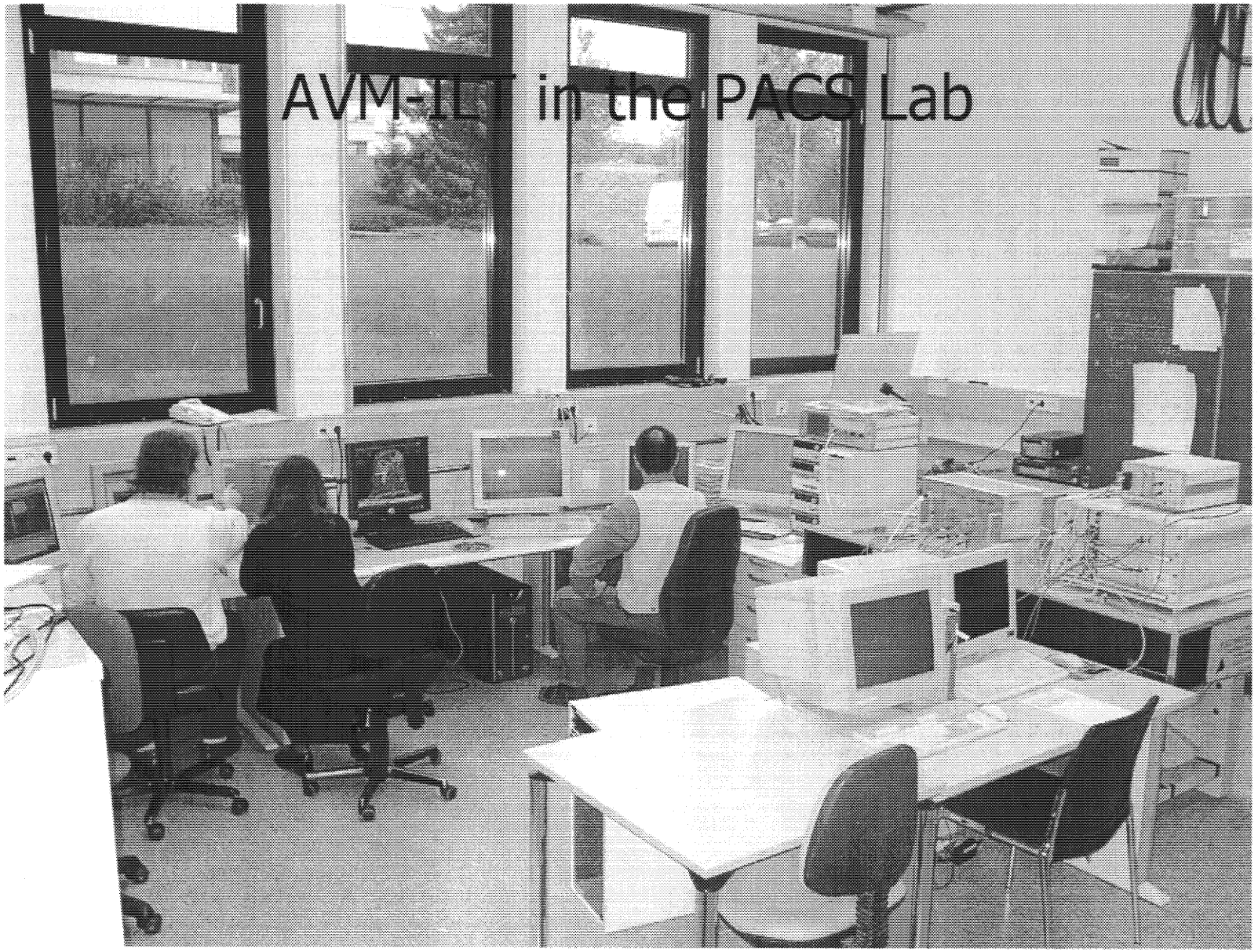


Major Goal: Smooth Transition between Mission Phases

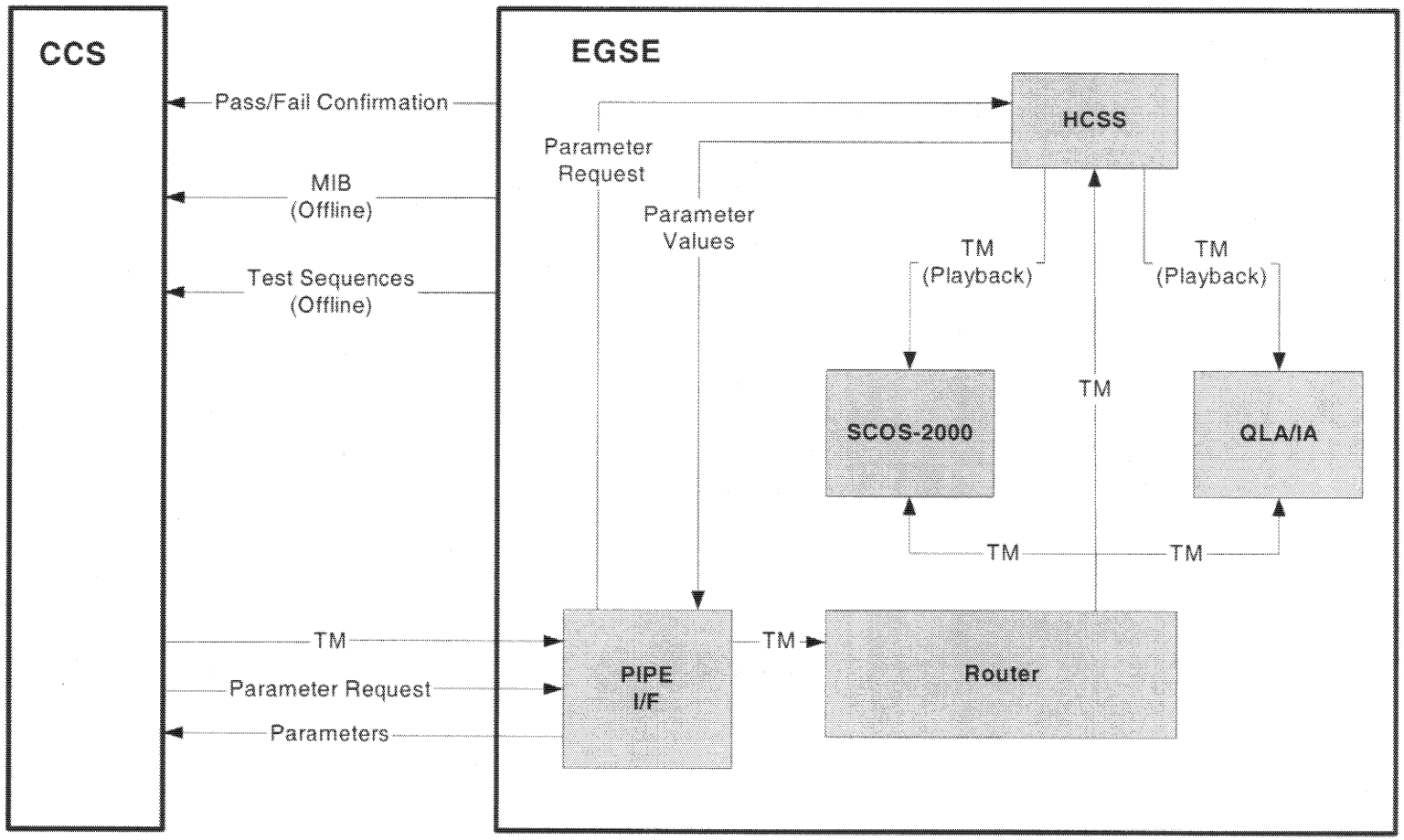


EGSE/HCSS Set-up for ILT

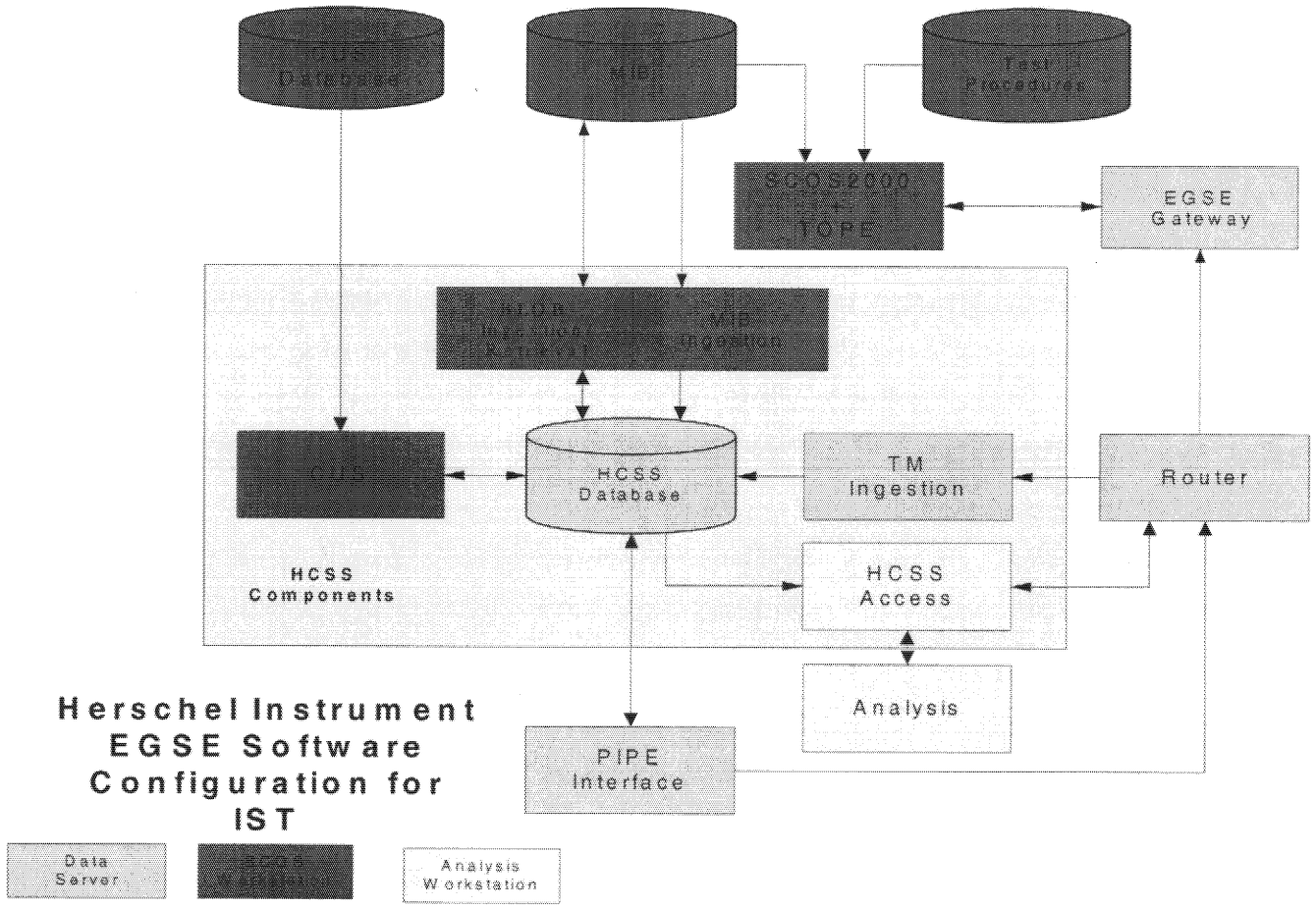



AVM-ILT in the PACS Lab

IEGSE for IST



IEGSE Software Configuration



PIPE Interface

- This component interfaces to the CCS using the PIPE protocol (RD02). It handles three types of interaction:
  1. Connection and setup of the interface.
  2. Reception of telemetry packets from the CCS and their transport to the IEGSE Router, which distributes them to the rest of the IEGSE.
  3. Reception of requests from the CCS for the values of parameters to be inserted into the command sequences, which are sent to the instrument. These requests are passed to the HCSS (CUS), which returns the values required and these are passed on to the CCS.

Definition of an Observation (Test Step)

The starting point is that TestControl sends a request for a certain observation (ObsMode, parameters) to CUS (HCSS) and CUS generates a TC sequence with relative timing. It also calculates the whole duration of this observation.

The output could be:

ObsMode (parameters)
TC-1, ObsId-x
TC-2, BbId-y
wait t1
TC-3, p1
wait t2
TC-4, p2, p3, p4
wait p5
TC-5, p6
TC-5, p7
wait t3
TC-6
wait t4

Variables and Execution

- ObsId-x will change in case of repetition. p1,..., p7 would be variables which could change of repetition. t1,..., t4 are fixed waiting times.
- The total duration would be T= t1+t2+ p5 +t3+t4 , e.g. T depends on p5 and this depends on either p2, p3 or p4.
- It also can be that we have the same TC with different parameters (TC-5 with param. p6 and p7) or commands without parameters (TC-6).

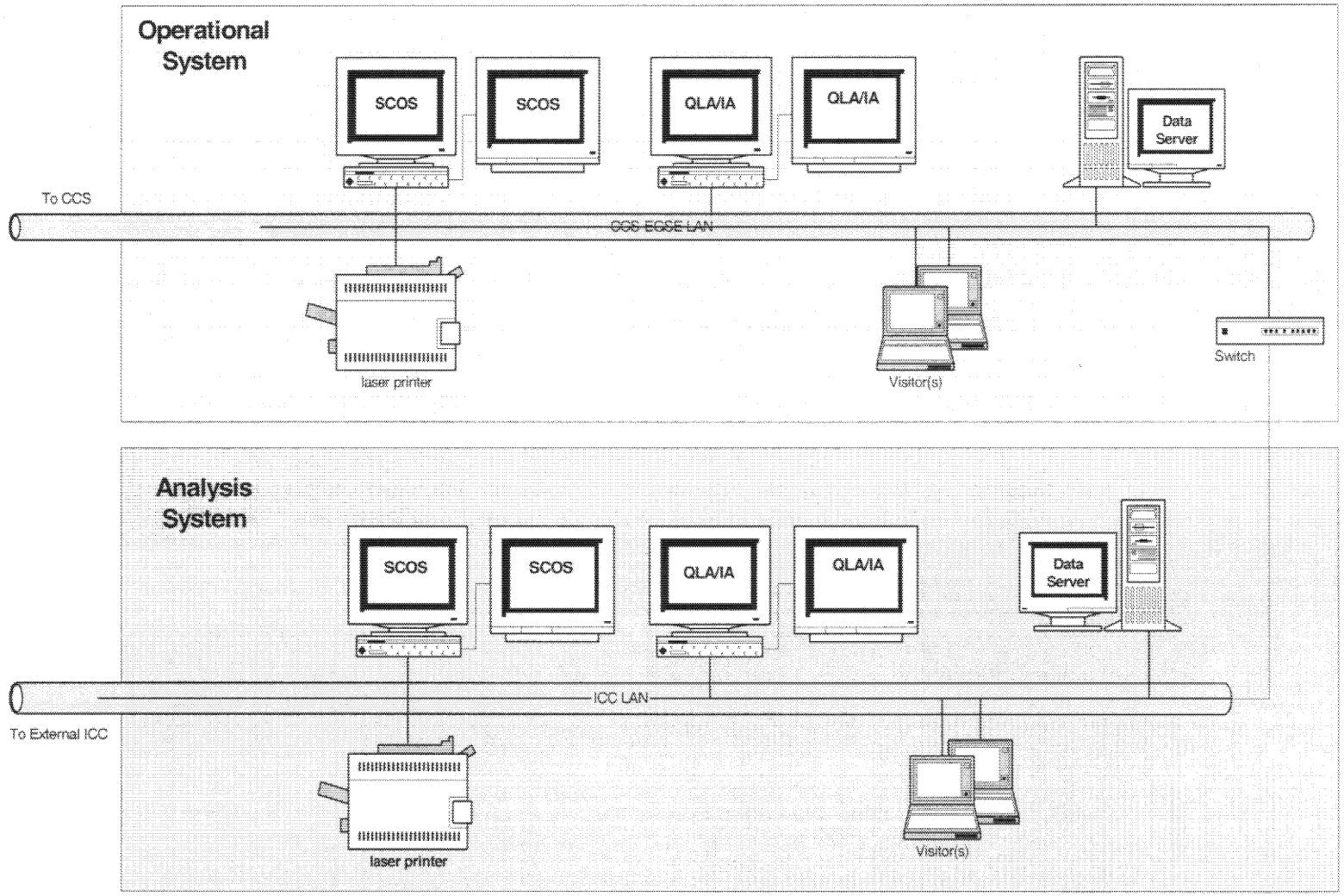
- During ILT CUS would delivery back to TestControl the instantiated TC sequence including duration T and
- TestControl would send it via TOPE to SCOS for execution.
- Such an instantiated TC sequence could be given to CCS for execution during short functional tests without instrument participation. In case of repetition of such a sequence ObsID-x could be increment by 1 in a predifined range.
- For the IST, and this could be implemented and tested during ILT, CUS has to be modified in such a way that it generates three outputs:
  (1) The instantiated TC sequence.
  (2) The parameterized TC sequence as shown above.
  (3) The corresponding parameter set
  (ObsId-x, p1, p2, p3, p4, p5, p6, p7)
- The parameterized TC sequence could be given to CCS and stored in SCOS. At the time of execution CCS/SCOS sends a request: ObsMode(parameters) to I-EGSE TestControl which starts CUS.
- TestControl will then send the complete parameter set to CSS/SCOS. CCS/SCOS parses the parameters and sends the TC sequence to the instrument.

IEGSE H/W Configuration

- Two complete IEGSE systems will be provided. One is operated in real time during the testing, while the other may be used for analysis of previous test results and acts as a backup for the operational system.

- 6 different items are identified:
  1. SCOS workstation – used primarily to run the SCOS-2000 software. This will be a PC running Linux with a dual display card driving two displays.
  2. Analysis workstation – used to run the instrument analysis software (QLA/IA/PCSS). This will be a PC running Linux with a dual display card driving two displays.
  3. Data Server – used primarily to run the HCSS software. This will be a PC running Linux with a single display and large disk drives with backup facility (to tape/CD TBD)
  4. Colour laser printer
  5. LAN switch - protects the Operational System from the Analysis System allowing access to the external internet from the Analysis System
  6. Laptops – used to run instrument specific analysis tools. These are not provided as part of the EGSE but may be used by instrument experts as necessary during testing.

Herschel Instrument EGSE Hardware Configuration for IST

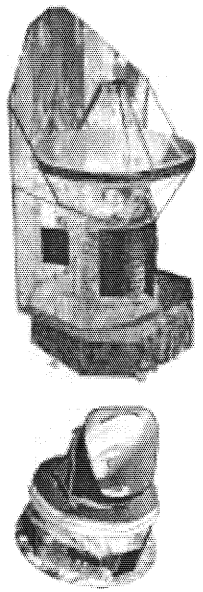


H/W Delivery to Industry

Item	Title	Description
IE-DS-01	Data Server 1	PC running Linux, one Display, keyboard, mouse
IE-DS-02	Data Server 2	PC running Linux, one Display, keyboard, mouse
IE-AN-01	Analysis 1	PC running Linux, two Displays, keyboard, mouse
IE-AN-02	Analysis 2	PC running Linux, two Displays, keyboard, mouse
IE-SC-01	SCOS 1	PC running Linux, two Displays, keyboard, mouse
IE-SC-02	SCOS 2	PC running Linux, two Displays, keyboard, mouse
IE-PR-01	Printer 1	Colour Laser Printer, Type TBD
IE-PR-02	Printer2	Colour Laser Printer, Type TBD
IE-SW-01	Switch	LAN Switch

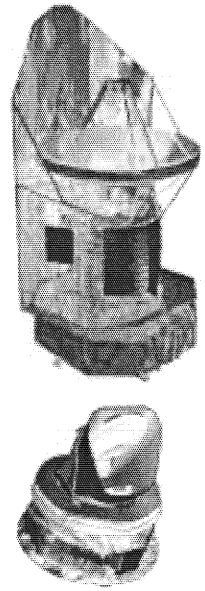
Support from Industry

- Industry will be responsible for providing consumables (printer paper, ink, tapes, CDs) used by the IEGSE
- Industry will be responsible providing a high speed access point to the internet.
- Industry will provide a simulator of the CCS to enable testing of the interface between the CCS and IEGSE. This simulator should:
  - Simulate the connection with the CCS
  - Simulate the protocol necessary to connect to and set up the IEGSE interface
  - Provide telemetry packets corresponding to an instrument executing a command sequence in a test procedure
  - Provide parameter requests corresponding to command sequences in a test procedure
  - Accept parameter values corresponding to the request made to the IEGSE



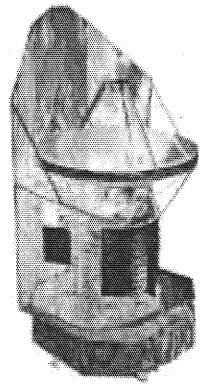
Role of Instrument EGSE at Payload and Satellite level

HP-2-ASED-AN-0265
Issue 2



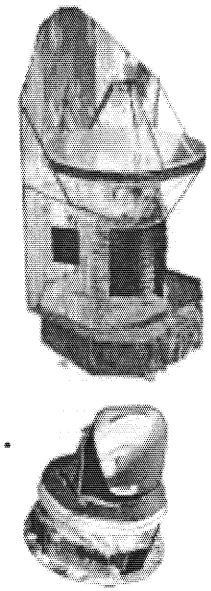
Types of test

- Instruments will be tested with Instrument teams present and absent
- This results in 3 modes of operation for the I-EGSE.
  - Mode 1: I-EGSE OFF (or unavailable)
  - Mode 2: I-EGSE in listening mode i.e. one way communication only from CCS to I-EGSE to dump Instruments HK and Science data
  - Mode 3: I-EGSE involved in real time testing under the control of the CCS
- For mode 1 and mode 2 a predefined set of Observation characteristics can be used (I.e. fixed set of test sequences), executed by CCS.
- For mode 3 the Instrument EGSE needs to be “in the loop”.



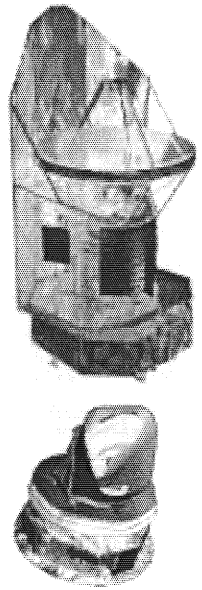
Problem areas

- If stopped for any reason,Instrument command sequences cannot be re-used and require new sets of Observation characteristics before continuing.
- The necessary telecommand data to command an instrument for a specific “observation” is known only to the instrument EGSE and is obtained from the HCSS database.
- Software to determine correct operation of the instrument is resident in the Instrument EGSE.
- Test philosophy demands that the CCS is the only source of telecommands, using a configuration controlled set of test sequences.
- A fixed set of commands with no variability in command data will not support correct operation of the I-EGSE data processing.



Problem areas

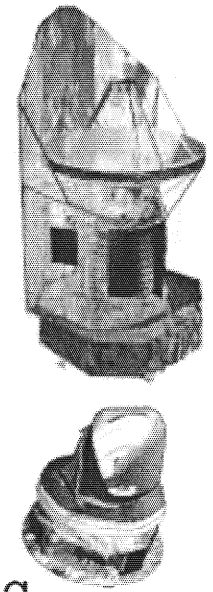
- "Smooth transition" requires that a high level of commonality is required between Instrument level (ILT) and higher levels of test (e.g. IST).
- For ILT the following logic applies:-
  1. start a (TOPE) test sequence
  2. call HCSS to obtain observation telecommand sequence (as another test sequence)
  3. execute the test sequence
  4. perform processing and test pass/fail logic on I-EGSE
  5. confirm pass/fail
  6. continue to next step if pass, else……
- This method cannot be used on the CCS



Reasons

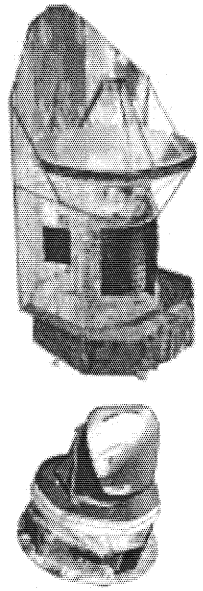
- Creating new test sequences dynamically, would bypass the test session management and configuration control mechanism of the CCS.

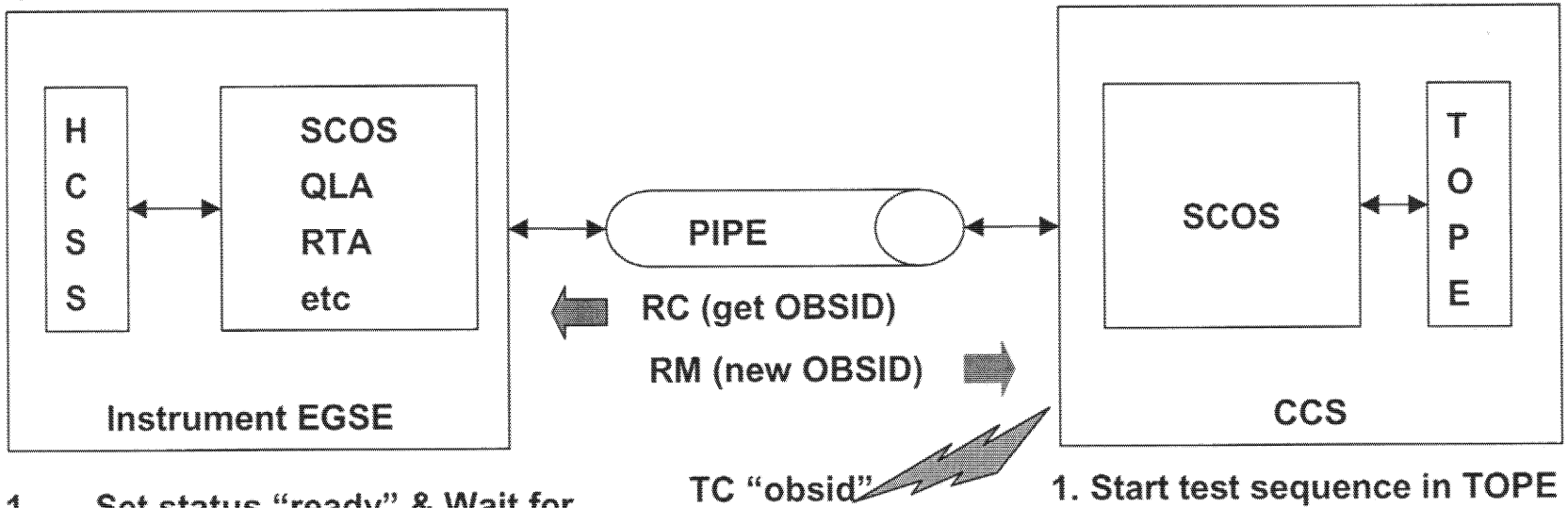
- The test sequence creation process is performed by the HCSS software inside the I-EGSE which implies:-
  - Either a file transfer of the source of the test sequence from Instrument EGSE to CCS, so that CCS can execute it,
  - Or execution of the sequence by the instrument EGSE resulting in giving it the capability and authority to send telecommands !



Solution

- CCS to request I-EGSE to initiate generation of observation data (using RC command of PIPE protocol).
- Allow I-EGSE to send observation data to CCS for use by CCS test sequences (RM packets of PIPE protocol).
- Use this data to construct “parameters” for a set of generic Instrument operational telecommands.
- CCS then retains commanding responsibility with predefined telecommands, whilst I-EGSE provides dynamic data and all instrument data processing.





1. Set status "ready" & Wait for PIPE messages
2. Receive RC (get obsid)
3. Request new observation from HCSS
4. Construct & send RM (obsid)
5. Wait for new observation data
6. Process and set completion status (by RM)

1. Start test sequence in TOPE and confirm/wait IEGSE status = ready
2. Request new observation data by sending RC command
3. Wait for update of parameter "obsid"
4. On arrival SENDTC with parameter "obsid"
5. Wait for completion status
6. Repeat for more observations.....

Instrument AIT Meeting

PACS Test Program Updates

Reinhard Katterloher
MPE

Annex 8

Modifications to the CQM+AVM ILT Program

- ✓ Delivery of CQM FPU to MPE is delayed to 25 August 2003
- ✓ Final delivery date of PACS to ESA is before Christmas 2003

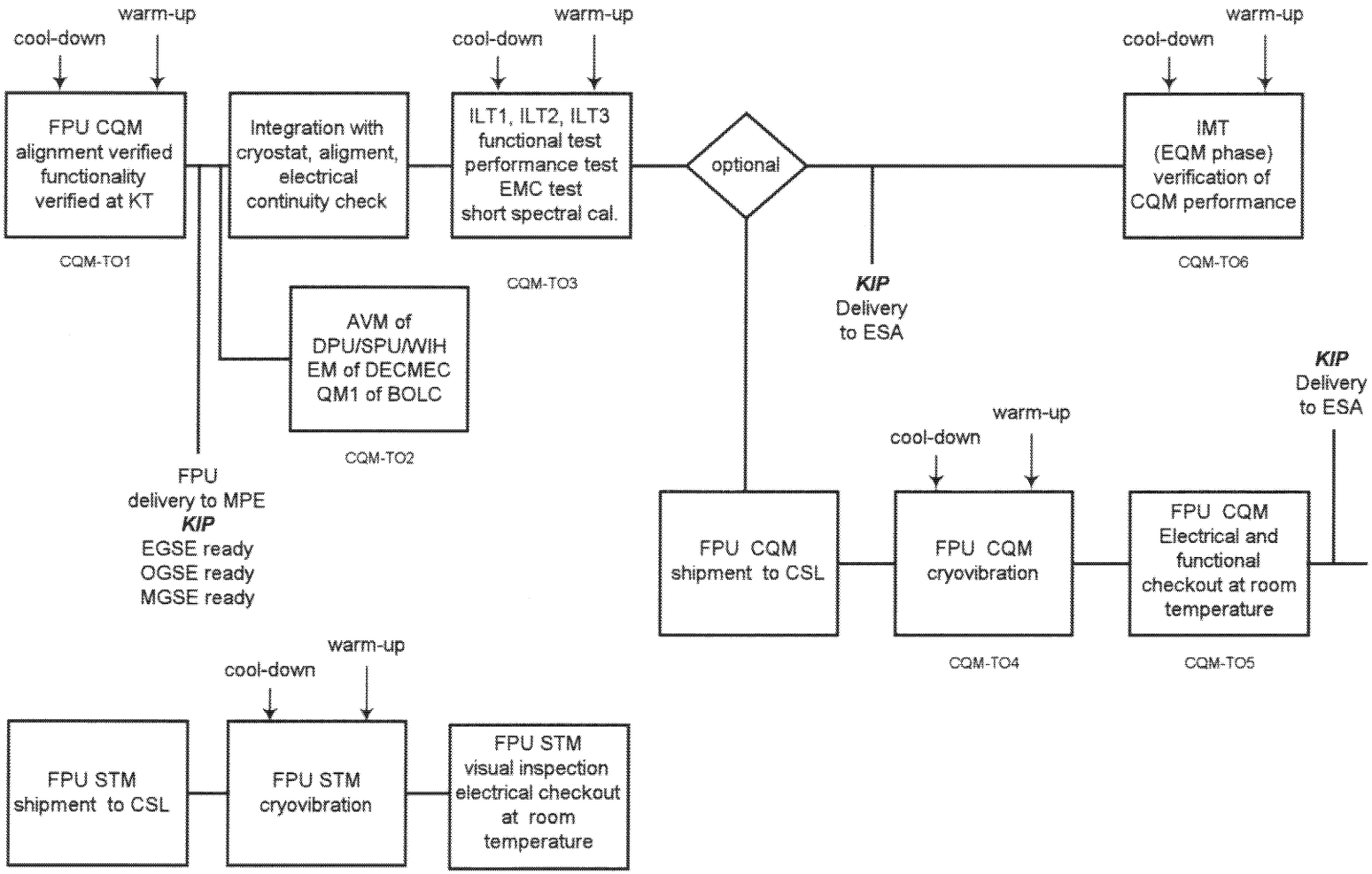
Proposal and Reasoning

Cryogenic qualification of the FPU will be done with the FPU STM
PACS FPU STM is a rather complete and detailed unit.
Vibration at RT successfully performed and finished yesterday
(minor deviation: lower first resonance in Z but RFW notch depth not exploited.
Final post test review with ESA expert requested)

CQM calibration activities are adapted to a limited but reasonable test time.
ILT phase comprising functional test, performance test and short spectral calibration can be extended from 1st of September to 19 December 03 (85 days)

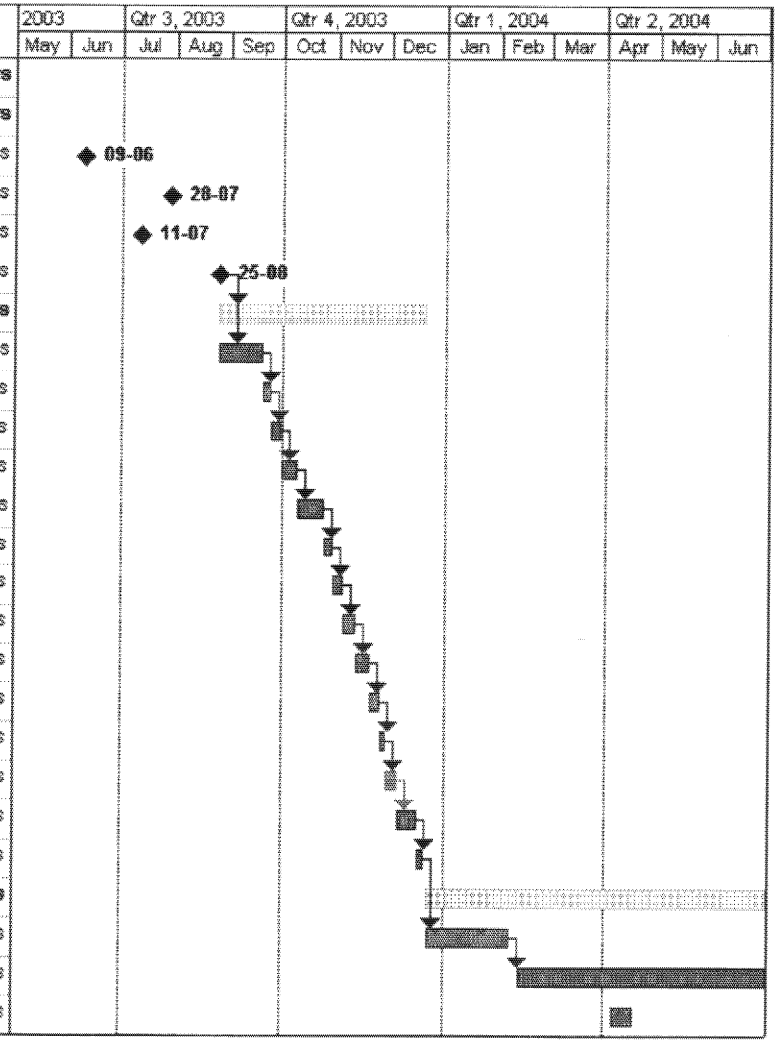
In case a cryovibration of the CQM is highly advisable, the verification of CQM performance needs to be moved to System Level EQM phase.
33 days test slot at CSL could be January 2004, final planning around June 2003

CQM+AVM ILT AIV Sequence



Modified CQM+AVM ILT schedule

ID	Task Name	Start	Finish	Duration
1	**PACS Master Schedule**	**09-06-03**	**15-12-04**	**398 days**
2	**CQM+AVM Phase**	**09-06-03**	**15-12-04**	**398 days**
3	Delivery Ge:Ga Detector arrays to KT	09-06-03	09-06-03	0 days
4	Delivery of BOLC to MPE	28-07-03	28-07-03	0 days
5	Test cryostat + TEI operational, alignment verified	11-07-03	11-07-03	0 days
6	FPU CQM Delivery from KT to MPE	25-08-03	25-08-03	0 days
7	**CQM ILT at MPE (sequence TBC)**	**25-08-03**	**19-12-03**	**85 days**
8	ILT1, 1.1-1.4 FPU Integr/cryostat, el check +cool dow	25-08-03	18-09-03	19 days
9	ILT1, 1.5 Functional Test + Cooler recycling	19-09-03	23-09-03	3 days
10	ILT 2 Performance Test Q2.1-Q2.4, Q2.5	24-09-03	29-09-03	4 days
11	Warm up + venting	30-09-03	08-10-03	7 days
12	ILT1, 1.1-1.4 FPU/TO re-alignment, cool down	09-10-03	23-10-03	11 days
13	ILT1, 1.5 Functional Test + Cooler recycling	24-10-03	28-10-03	3 days
14	ILT 2 Performance Test Q2.1-Q2.4	29-10-03	03-11-03	4 days
15	ILT EMC tests	04-11-03	10-11-03	5 days
16	ILT 2 Short spatial / spectral performance Q2.5, Q2.6	11-11-03	18-11-03	6 days
17	Calibration C3.1-3.5, 3.6 gas cell	19-11-03	24-11-03	4 days
18	Calibration C3.7, 3.10,	25-11-03	27-11-03	3 days
19	Margin	28-11-03	04-12-03	5 days
20	Warm up + venting	05-12-03	15-12-03	7 days
21	Preparation for shipment to ESA or CSL	16-12-03	19-12-03	4 days
22	**EQM Test Phase at ASPI (tentative)**	**22-12-03**	**15-12-04**	**258 days**
23	CQM cold vibration at CSL (tentative)	22-12-03	06-02-04	35 days
24	Incoming inspections/Integr. w. cryostat/Tests (TBC)	12-02-04	15-12-04	220 days
25	Verification of Functionality and Performance (TBC)	05-04-04	16-04-04	10 days



Unit	Model	Form	Fit	Function	Redundancy	Remark
DPU	AVM PFM	x x	x x	x x	No redundancy foreseen for AVM	PFM fully redundant
SPU	AVM PFM	Delivered as Rack, mountable on SVM TBC x	x x	x x	No redundancy foreseen for AVM	PFM fully redundant
DECMEC	EM PFM	Delivered as Rack, mountable on SVM TBC x	x x	x x	No redundancy foreseen for AVM	PFM partially redundant (MEC1, MEC2)
BOLC	QM1 PFM	Delivered as Rack, mountable on SVM TBC. Different mounting pattern. x	(x) x	Delivered without power supply External power supply needed. x	No redundancy foreseen for AVM	PFM partially redundant
	All AVM WE units are not black painted					
WHI	AVM PFM	x x	x x	x x	N.A. N.A.	Identical with PFM harness; back-shells to be discussed
FPU	CQM PFM	x x	x x	• Full optics • All mechanisms complete • Both Photoconductor arrays working, but only 2x12 modules integrated instead of 2x25 • Both bolometer arrays completely equipped, but only 50% in each array with full IR performance x	Same redundancy of mechanisms and temp sensors as PFM see CQM	

Status 21 January 2003

	Name	Dep./Comp.
	Alberti von Mathias Dr.	SM 34
	Alo Hakan	OTN/IP 35
	Barlage Bernhard	ED 11
X	Bayer Thomas	ED 541
X	Faas Horst	EA 65
	Fehringer Alexander	SM 33
	Frey Albrecht	ED 422
	Gerner Willi	ED 13
	Grasl Andreas	OTN/EN 64
	Grasshoff Brigitte	ED 521
	Hartmann Hans Dr.	ED 422
X	Hauser Armin	SM 31
	Hinger Jürgen	SM 31
X	Hohn Rüdiger	ED 541
X	Hölzle Edgar	ED 421
	Huber Johann	ED 543
	Hund Walter	SE 76
X	Idler Siegmund	ED 432
	Iványi von András	ACE 32
	Jahn Gerd Dr.	SM 31
X	Kalde Clemens	ED 532
	Kameter Rudolf	OTN/EN 64
X	Kersting Stefan	OTN/EN 63
	Kettner Bernhard	SM 34
	Knoblauch August	ED 531
X	Koelle Markus	ED 533
X	Kroeker Jürgen	ED 542
	Kunz Oliver	SM 31
	Lamprecht Ernst	OTN/SM 222
X	Lang Jürgen	SE 76
	Langfermann Michael	ED 541
	Mack Paul	OTN/EN 64
X	Moritz Konrad Dr.	ED 65
	Müller Lutz	OTN/EN 64
	Muhl Eckhard	OTN/EN 64
X	Pastorino Michel	ASPI Resid.
	Peitzker Helmut	ED 65
	Peltz Heinz-Willi	SM 33
X	Peters, Gerhard	ED 531
	Pietroboni Karin	ED 65
	Puttlitz Joachim	OTN/EN 64
X	Rebholz Reinhold	ED 541
	Reuß Friedhelm	ED 62
X	Rühe Wolfgang	ED 6
	Runge Axel	OTN/EN 64

	Name	Dep./Comp.
	Sachsse Bernt	ED 21
	Schäffler Johannes	OTN/EN 64
X	Schink Dietmar	ED 422
X	Schlosser Christian	OTN/EN 64
	Schweickert Gunn	SM 34
	Stauss Oliver	SM 33
	Steininger Eric	ED 422
X	Stritter Rene	ED 11
	Suttner Klaus	SM 32
	Tenhaeff Dieter	SM 34
	Thörmer Klaus-Horst Dr.	OTN/ED 65
	Wagner Adalbert	OTN/IP 35
	Wagner Klaus	SM 31
X	Wietbrock, Walter	ED 521
	Wöhler Hans	SM 34
	Zipf Ludwig	ACE 32
X	Alcatel	ASPI
X	ESA/ESTEC	ESA
	Instruments:	
X	MPE (PACS)	MPE
X	RAL (SPIRE)	RAL
X	SRON (HIFI)	SRON
	Subcontractors:	
	Air Liquide	AIR
	Alcatel Bell Space	ABSP
	Astrium Sub-Subsyst. & Equipment	ASSE
	Austrian Aerospace	AAE
	APCO Technologies S. A.	APCO
	Astrium GmbH Space Infrastr.	ASIP
	BOC Edwards	BOCE
	Dutch Space Solar Arrays	DSSA
	EADS CASA ESPACIO	CASA
	Eurocopter	ECDE
	HTS AG Zürich	HTSZ
	Linde	LIND
	Patria New Technologies Oy	PANT
	Phoenix, Volkmarsen	PHOE
	Rembe, Brilon	REMB
	SENER Ingenieria SA	SEN
	Stöhr, Königsbrunn	STOE