HIRDLS

PM-HIR-184B

HIGH RESOLUTION DYNAMICS LIMB SOUNDER

Originator: J. Loh

Date: 98-02-18

Subject/Title: **Responses to PDR Action Items**

Description/Summary/Contents:

Changes made in revision B are indicated by a change bar in the right hand margin.

Keywords:

Purpose of this Document:

Oxford University
Atmospheric, Oceanic &
Planetary Physics
Parks Road
OXFORD OXI 3PU
United Kingdom

University of Colorado, Boulder
Center for Limb Atmospheric Sounding
3300 Mitchell Ln., Suite #250
Boulder, CO 80301

EOS

CHANGE RECORD PAGE

Revision	Date	Pages Affected	Description of Change	Revised by
N/C	97-11-06	All	Initial Release	--
A	98-01-13	1 - P. 6 2 - P. 8 3 - P. 4 4 - P. 9 5 - P. 13 6 - P. 20 7 - P. 20 8 - P. 21 9 - P. 26 10 - P. 29 11 - P. 30 12 - P. 31 13 - P. 32 14 - P. 33 15 - P. 34 16 - P. 35 17 - P. 36	1 - Changed FMECA to FMEA 2 - Corrected missing word in Item 3, WAS: "...a warm (non-destructive) of the IPU processor." IS: "...a warm (non-destructive) reboot of the IPU processor." 3 - Provided path for retrieval for TC-HIR-169E for preliminary response to RFA#002. 4 - GSFC provided revised mass and power allocations in response to RFA#007. 5 - Provided response to part 3 of RFA#010. 6 - Provided response to part 1b of RFA#015. 7 - New target date for response to part 2 of RFA#015. 8 - Provided response to RFA#016. 9 - Added advisory #001 and response. 10 - Added advisory #002 and response. 11 - Added advisory #003 and response. 12 - Added advisory #004 and response. 13 - Added advisory #005 and response. 14 - Added advisory #006 and response. 15 - Added advisory #007 and response. 16 - Added advisory #008 and response. 17 - Added advisory #009 and response.	
B	98-02-18	1 -P. 4 2 - P. 6 3 - P. 11 4 - P. 18 5 - P. 20-21 6 - P. 22 7 - P. 24 8 - P. 38-41	1 - Summarized TC-HIR-169E rather than just a reference to retrieval path on the clas server. 2 - Added last sentence to Project Response. 3 - GSFC provided Project Response. 4 - Modified response, WAS: "To complete this action item, the HIRDLS program needs a clear definition of the orientation of the spacecraft/HIRDLS during "off-nominal pointing". Is this the spacecraft survival mode (rotisserie around X axis) or does HIRDLS define a survival case where there is a direct solar flux into the electroincs compartment. The HIRDLS Program is in the process of defining this with TRW and GSFC. Once the orientation is defined, this action item can be closed within 6 weeks." 5 - Provided response to Part 2 of RFA #015. 6 - WAS: "This document is available on the clas server, path for retieval is clas/documents/tc/tc-bll-051.doc" IS: "... TC-BLL-051, which is enclosed in Appendix A." 7 - Last sentence WAS: "A complete.....by February, 1998." IS: "A complete....by mid-March, 1998." 8 - Added Appendix A, TC-BLL-051.	

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: POWER Number: 001

Responsibility:
001-1 LOC Elec. System Engineer (Interim: Dials)
001-2 To be handled with RFA #003
001-3 LOC Elec. System Engineer (Interim: Dials)

Action Requested

The Project should conduct a review of the instrument power system and address the following concerns as a minimum:

1. Protection from powering "un-powered" circuits through the interface circuitry.
2. The noise generated by numerous un-synchronized power converters. (Will be handled w/003)
3. Instrument power-up control is unclear. Quiet Bus A&B as well as noisy Bus A&B functioning needs to be clearly shown for the IPS and PCU.

Provide a summary of results.

Supporting Rationale

The power system could use some additional system level engineering! It appears to be far too complex and several key issues have not been addressed. My experience is that electrical/mechanical parts (i.e. relays) fail more often than most electrical parts. The power issue and instrument electrical system documentation are the two most important electrical issues.

Project Response

A response to this Action Item will be available by March 20, 1998.

Date Closed:
Residual Risk:
Originator: M. DAVIS

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: POWER Number: 002
Responsibility: LOC Elec. System Engineer (Interim: Dials)

Action Requested

The Project should generate and provide copies of the following instrument systems documentation:

1. Instrument level grounding diagram.
2. Instrument level diagram showing redundancy & cross-strapping.
3. Instrument level diagram showing all the electrical interconnections.

Supporting Rationale

It appears as if the systems level electrical design could use some additional attention. Use of the above listed documentation is an easy way to insure that every designer is working from the same interfaces. This and the power converter issue are the two most important electrical issues.

Project Response

Responses to this Action Item will be provided on the following schedule:

Preliminary response: Updated TC-HIR-169E is summarized as follows:

This TC addresses the HIRDLS instrument power switching configuration and sequence required for compatibility with both the current Instrument Mode and Subsystem State definitions and the proposed Instrument Commands and Activation sequences being developed for the Flight Operations scenario. Power system grounding, Noisy Bus and Servival Heater Bus usage and other details are also addressed.

Final response: by March 20, 1998

Date Closed:
Residual Risk:
Originator: M. DAVIS

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: EMI/EMC Number: 003
Responsibility: LOC Elec. System Engineer (Interim: Dials)

Action Requested

The Project should review the instrument noise control plan with respect to frequency “beating”. The seven (7) power converters inside the PCU are not synchronized. The loads are high, which will produce FET switching current spikes on the chassis, (due to capacitive coupling of the FET to chassis). The converters can “beat” producing lower frequency noise. The other converters in the power system are of equal concern.

Provide a summary of results from the review.

Supporting Rationale

This is a critical issue due to the “late in the schedule” testing of subsystem interaction.

Project Response

A response to this Action Item will be available by March 20, 1998.

Date Closed:
Residual Risk:
Originator: M. DAVIS

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: RELIABILITY Number: 004
Responsibility: LOC - Lee Stewart

Action Requested

It is not clear whether FMEA's will be performed in a timely enough manner or to a sufficient level of detail to productively influence the design. The pace of FMEA's should be accelerated so that they are completed in time to influence the CDR. Along with the FMEA's, a criticality analysis should be performed in order to prioritize areas where redundant elements or operational workarounds should be provided. Also, attempts should be made to ensure graceful degradation of the instrument and its critical subsystems.

Supporting Rationale

A considerable portion of the instrument is single-string with many possibilities of single point failures. This is coupled with a 5 year mission requirement which increases the possibility that random failures will occur. Reliability efforts should concentrate on design robustness rather than on parts count methods.

Project Response

FMEA's for the instrument and most subsystems have been or are being performed. Their current status and level of detail varies for different subsystems. As this work continues, the emphasis will be to focus attention on problem areas, as indicated by the higher level FMEA's, to do more detailed FMEA analyses and help in the choice of design options. Preliminary FMEAs will be given to the Chemistry for review, and final FMEA results will be presented at the CDR.

Date Closed:
Residual Risk:
Originator: J. REMEZ, S. SCOTT

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: Software Number: 005
Responsibility: LOC - Jerry Drake

Action Requested

The Project should develop and provide the following documentation:

1. A copy of the design documents for each software CSCI and a traceability matrix tracing design implementations to software requirements.

2. A traceability matrix tracing software requirements for each CSCI to the tests that will be used to verify them.

Supporting Rationale

1. It is not clear that all requirements are being met and that the design presented addresses all the requirements.

2. It is not clear that all requirements are being met and that the design presented addresses all the requirements.

Project Response

1. The HIRDLS team will develop and provide design documents for each CSCI containing a traceability matrix tracing design implementations to software requirements. This document is due at the time of the CDR.

2. The HIRDLS team will develop and provide traceability matrices tracing the software requirements for each CSCI to the tests that will be used to verify the requirements. These matrices will be included in Appendices to the Software Test Plan which will describe Test Cases for each environment in which requirements will be verified. These appendices will be developed as needed throughout the software development process and will be available 30 days

prior to each test. They will not formally be released for Program approval until PFM testing is initiated; they will be informally developed during the EM development and test.

Date Closed:
Residual Risk:
Originator: S. SCOTT

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: SOFTWARE Number: 006
Responsibility: LOC - Jerry Drake

Action Requested

The Project should provide a list of all processor interrupts on the IPU RAD6000 and indicate how they are being used and serviced by the flight software.

Supporting Rationale

No such list was provided as is typically the case at PDR. It is important to know if interrupt priorities are assigned logically and correctly.

Project Response

The following three interrupts are being planned for use under normal operations in the flight software:
1. System tick: The system tick interrupt will nominally be 80 Hz. It will be used at all times for the VxWorks operating system fundamental clock. In the absence of the chopper rotation interrupt, the system tick will be used to initiate the main loop in the IPU software.
2. Chopper rotation: When the chopper motor is running and is selected as the synchronization signal, it will be used to initiate the main loop in the IPU software. All science operations are synchronized to the chopper motor rotation which is nominally 83 Hz but is changeable over a narrow range. During science operations, the chopper motor will be running and generating this signal and will be selected as the external interrupt source.
3. Watchdog timer: Once per system tick (80 Hz) the watchdog counter will be reset. If the watchdog counter expires (5 second time-out), an interrupt is generated which initiates a warm (non-destructive) reboot of the IPU processor.

In addition, there are a number of PSA-32 processor board interrupts which will be serviced as exceptions. These include EDAC memory error, memory violation error, unrecoverable bus error, unauthorized instruction error and communication error. Arithmetic overflow, underflow, etc. internal interrupts will also be treated as exceptions. Treatment of the exceptions is addressed in the document TC-LOC-212, HIRDLS Autonomous Fault Management.

Date Closed:
Residual Risk:
Originator: S. SCOTT

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: SYSTEMS ENG. Number: 007
Responsibility: GSFC

Action Requested

The Chem Project should address the overall mass and power margins that are available (taking into account contingency held by the Project). Assuming there are unallocated reserves available, how will the Project manage these resources to keep pressure on the contractor, but not so much that cost/schedule suffer needlessly.

Supporting Rationale

The mass and (to a lesser degree) power margins presented are not adequate at this point in the development. Reserves held by the Project (if any exist) were not presented.

Project Response

GSFC provided revised mass and power allocations to the instruments on Dec 11, 1997. The new mass and power allocations for HIRDLS are 200 kg, and 220 W (239 W peak).

Date Closed:
Residual Risk:
Originator: G. BANKS

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: MECHANISMS Number: 008
Responsibility: SSG - Dave Kane

Action Requested

Can the flex pivot "snubber" (load shunt) clearance be monitored after assembly?

Supporting Rationale

Checking the natural frequency after vibration, as stated, proves only that some of the initial 25 micron clearance remains. Loss of this clearance is a single point failure.

Project Response

The snubber clearance can be reliably monitored in an indirect manner after assembly. This technique has been developed on the prototype scanner currently in test.

The Bendix flexures are e-beam welded to their respective flanges. The load shunt is an extension of one of the flanges which limits radial motion to 25 micrometers. After the initial welding assembly, the gap is visually inspected under a microscope with the aid of a 25 micrometer tungsten wire used as a feeler gauge. Those assemblies that pass the inspection are then installed in the elevation axis drive motor. Once these are installed in the HIRDLS scanner, the flexures are no longer be accessible for visual inspection.

The load shunt gap however, can still be monitored after assembly both before and after vibration testing by and indirect method that exploits the natural decentration of the flexure as a function of rotation angle. The flexure decentration varies as the square of the angular deflection; at a rotation angle of +/- 7.5 degrees, well beyond the normal mirror travel in flight, the decentration becomes 25 micrometers. The solid contact at this angle is very noticeable by feel without incurring any damage. By noting the angles on each side of the neutral position where the flexure halves come into contact, the gap at neutral position can be inferred.

Experiments on the flexures used to test the load shunt concept have verified the utility of this approach. Examination of the flexures before and after shake ascertained that the above angular limit was not changed by the shake test. These tests also confirmed that onset of this engagement is readily determined by feel of the motion without damage to the flexure.

Date Closed:
Residual Risk:
Originator: G. BANKS

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: MECHANICAL Number: 009
Responsibility: GSFC

Action Requested

Consider modeling the kinematic mounts (s/c interface) differently (as bars). The way it is presently modeled does not allow for bending of the bottom plate, only for shear. This will affect the margins of safety of the support plate. Recompute the margins of safety after updating the model.

Supporting Rationale

By modeling the mounts more realistically, degrees of freedom will be released and most likely the natural frequency will be lower than 50.2 Hz.

Project Response

For the FEM responses documented in the RFP package, the HIRDLS Project indicates that the interface grid points are constrained with the kinematic hardware. Therefore, the kinematic mount modeling approach currently being used is realistic, as is, and no change in modeling concept is necessary. (Note: This RFA response was prepared by the Chemistry Project mechanical systems engineer, R. Carter, who had extensive discussions with all interested parties that included the HIRDLS Project, TRW, the PM Project, and the RFA author.)

Date Closed:
Residual Risk:
Originator: C. CONATY

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: MECHANISMS Number: 010

Responsibility: 010-1 UCB - Joanne Loh
010-2 LOC - Wally Opyd
010-3 MMS - Martin Humphries

Action Requested

The Project should consider:
1. Testing the Engineering Model (EM); vibrate, thermal cycle and life test. If schedule does not allow for a life test of the EM scanner, perform life tests on spare components in "flight-like" conditions (temp, loading, etc.). For the encoder, perform the life test over the min/max laser current, as well as temperature.
2. Vibrating the chopper mechanism at the component level.
3. Incorporating a life test for the sunshield deployment mechanism. Also, address qualification of the space view aperture mechanism and SMA wobble sensors from a life-time reliability standpoint.

Also, please provide details of the scan mirror and chopper life test programs.

Supporting Rationale

1. The scan mechanism is a single point failure. The mechanism has a large # of cycles (2.5 million in 5 years). The motors are not redundant and the life of the encoder laser is a concern.
2. Problems would be discovered earlier in the I&T phase, allowing more time for correction, and less impact to the schedule. I have a concern with the Be shaft; Beryllium is brittle and has to be carefully machined and heat relieved.
3. Life requirement for this mechanism is about 30,000 cycles with no life test planned.

Statistically meaningful life test results for the chopper and scan mirror are required to really address reliability concerns.

Project Response

1. The current plan does not include a life test of the scanner. The breadboard Scan Mirror Assembly (SMA) can be re-furbished for a life test. The current plan is that the yoke and the mirror of the breadboard SMA will be used on the EM. The breadboard SMA can be re-furbished with an aluminum yoke and dummy mirror for a life test. The estimated cost for this is approximately $300,000. The HIRDLS Program is evaluating budget and schedule to determine if this test can be accommodated.

2. Vibration of the chopper at the component level was not originally considered since bearing protection was designed in with an axial preload, and the chopper will be vibrated at the subsystem level (optical bench assembly) and at the instrument level. To identify potential problems early, in order to minimize impact on integration and test, the chopper engineering model (EM) will be vibrated at the component level. This will require an additional two weeks in the chopper EM development schedule for vibration fixture fabrication, pre-vibration performance check, vibration, and post-vibration performance check. The performance check will characterize chopper phase stability and bearing drag.

Four sets of bearings (two bearings per set) mounted in cartridges simulating the chopper are currently running under high vacuum. These cartridges have a range of axial preloads and speeds to allow for accelerated life testing, as summarized in the table below. All are to be tested for a 50,000 hour life.

HIRDLS Chopper Bearing Cartridge Life Tests

Cartridge Number	Axial Preload	Test Speed	Composite Acceleratio n Factor	Current Effective Hours (4 Nov 97)
1	1x	1x	1x	2,881
2	3x	2x	6x	17,286
3	2x	2x	4x	11,524
4	2x	2x	4x	11,524

Each cartridge is assembled with the flight load of Nye 2001 lubricant (GSC21595). A labyrinth and barrier film (Nyebar type K) are used to limit lubricant loss. The acceleration factors listed in Table 10-1 are conservative, since acceleration with preload is super-linear, with the exponent dependent upon whether life is limited by lubricant deterioration of fatigue. The acceleration factors are also conservative in that the higher speed cartridges are running warmer which increases lubricant vapor pressure. The higher temperature is primarily due to motor losses, and not bearing friction, which is on the order of 0.42 millinewton-meters (0.06 oz-in).

3. A life test will be conducted on the SSH subsystem. The project is planning on building a life test model (LTM) for this purpose. Prior to the start of the life test, the mechanism will undergo a vibration test to simulate the launch environment. The life test will exercise the door opening mechanism approximately 60, 000 times, which is a factor of two on the predicted on-orbit

operations. During the course of the life test the output from the potentiometer will be recorded along with the power consumed by the motor. Following the life test the bearings will be examined for signs of wear.

Date Closed:
Residual Risk:
Originator: C. CONATY

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: RELIABILITY Number: 011
Responsibility: LOC - Lee Stewart

Action Requested

Describe how mechanical parts (mechanisms & rotating parts) are being accommodated in the reliability assessment?

Supporting Rationale

The presentation indicates assessment methodology to be in accordance with MIL HDBK 217 parts count method. This methodology does not provide failure rate data for mechanical parts/mechanisms. This would lead one to believe that the reliability assessment includes only electrical/electronic parts, making it somewhat optimistic.

Project Response

Reliability assessments do include mechanical parts. Estimating failure rates for mechanical parts is not as clear cut as it is with electronic parts. Test and operational data are used when available. There is some information available in handbooks and data books, but often this information is hard to evaluate unless it is for the specific part under consideration. Engineering judgment is usually required.

Date Closed:
Residual Risk:
Originator: J. REMEZ

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: TESTING Number: 012
Responsibility: LOC - Eric Johnson

Action Requested

Describe how instrument performance requirements, including optics thermal stability and LOS accuracy, will be verified/assessed for the expected worst case orbital temperature extremes and variations. NOTE: Please show verification matrix at CDR.

Supporting Rationale

Instrument thermal control is passive except for lens assemblies. It was unclear if the I&T plan provides for adequate test verification of thermal/optical performance during thermal balance and thermal vacuum testing. NOTE: Current prediction of maximum LOS error exceeds specification.

Project Response

Generally speaking the description of how performance requirements will be verified is covered in a combination of several documents: Performance Verification Specification (SP-LOC-085), Performance Verification Plan (TP-HIR-008), Instrument Analysis Plan (Doc # TBD), PFM Instrument Test Plan (TP-LOC-204), and the EM Instrument Test Plan (TP-LOC-243). The Performance Verification Specification (PVS) defines the verification method (Inspection, Analysis, Test, Demonstration), level, and sequence to be used in verifying each ITS level requirement. The Performance Verification Plan (PVP) describes the general approaches to be used and traces these verification requirements to the lower level documents (IAP, PFM ITP, EM ITP, or subsystem specifications). The Instrument Analysis Plan describes what analysis must be performed for each requirement being satisfied by analysis and defines any supporting tests required, either at the subsystem or instrument level. The PFM Instrument Test describes in detail how each test will be will be performed on the PFM and the EM ITP does the same for the EM.

As far as assessment of Instrument performance against the thermal environment, all Instrument requirements can be placed into one of three categories: Functional in nature, Line-of-Sight in nature, and Radiometric in nature. Those instrument requirements which are functional in nature will be verified during the traditional Thermal-Vacuum testing of the PFM which is required. The PVS, section 4.3.2.7, defines the testing required during Thermal-Vacuum testing. Characterization and validation of the thermo-elastic effects on LOS are more complicated. This is the one area currently identified where EM testing will be used directly to validate PFM performance.

All performance related LOS requirements on the HIRDLS instrument are contained within the Optical Bench Assembly (OBA). The Instrument LOS is decoupled from the outer structure and space environment by design. The OBA is protected from the space environment by two MLI blankets, one on the outside of the Instrument (outside the Structural Thermal Subsystem), protecting the OBA and Instrument from space, and one blanket on the outside of the OBA (between the OBA and STH), protecting the OBA from space and HIRDLS internal electronics. Thus the OBA thermal variations are strongly decoupled from the outside environment. This minimizes but does not completely eliminate thermal effects; there is still a thermo-elastic effect on LOS which must be understood. The significance of the decoupling is that it makes verification difficult. In order to get significant and measurable changes in the OBA temperatures and temperature gradients, which are required for thermo-elastic model verification, very large temperatures and rates of change must be imparted onto the outside of the instrument, in many cases these temperatures would exceed the design requirements for the outer boxes. To avoid this problem and produce better more reliable test data a thermo-elastic test will be performed on the EM.

The Optical Bench Assembly for the EM will be flight identical. Additional test heaters and sensors will be attached to numerous areas of the OBA. The increased numbers of sensors will be installed to improve correlation with the model beyond what the instrument sensors themselves would allow. With the EM instrument in vacuum these heaters will be exercised while carefully monitoring the LOS. The correlation between OBA temperature, temperature gradients, and LOS will be compared against thermo-elastic model predictions and any inconsistencies will be resolved. The reason this test will not be performed on the PFM is that removal of the heaters and temp sensors would required Instrument disassembly. However, since the EM will be flight identical in this area this approach of verification by similarity is valid. Further, to ensure proper linking between the EM, PFM, and the thermo-elastic model, the PFM will undergo extensive LOS performance testing in both Air and Vacuum with certain tests being targeted to confirm the EM to PFM similarities.

The Radiometric accuracy will undergo extensive thermal related testing. The testing at the Instrument Integrator, LMMS, is designed to prove Radiometric Calibratibility - i.e. Stability. For those ITS Radiometric performance requirements which have been identified as temperature sensitive, the PFM will be evaluated under varying thermal environments during the Vacuum Performance testing defined in the PVS and PVP. This pre-thermal-vacuum testing is required because the constraints of a traditional thermal-vacuum survivability test are dissimilar to the testing required to verify radiometric stability. This Vacuum Performance testing will also be repeated after the Thermal-Vacuum survivability testing as described in the PVP and PVS.

Additionally, during Instrument Radiometric Calibration in Oxford, the instrument will be exposed to extensive thermal testing including orbital thermal cycling type environments.

Date Closed:
Residual Risk:
Originator: A. SEIVOLD

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: THERMAL Number: 013
Responsibility: UCB - Mike Dials

Action Requested

Verify that all system electronics will have a detailed thermal analysis down to the circuit card and/or component level to determine maximum operating temperatures vs. derated limits. All circuit cards should be assessed to determine heat dissipations and adequacy of heat sink designs.

Supporting Rationale

It was unclear if there was a project requirement for thermal modeling of electronics to the detailed level. This analysis is needed to determine if heat sinking of components is adequate or if enhanced techniques are required.

Project Response

All system electronics will have a detailed thermal analysis down to the circuit card and/or component level to determine maximum operating temperatures vs. derated limits. All circuit cards will be assessed to determine heat dissipations and adequacy of heat sink designs. Results will be presented at CDR.

Date Closed:
Residual Risk:
Originator: A. SEIVOLD

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: THERMAL Number: 014
Responsibility: LOC - Liz Osborne

Action Requested

The Project should evaluate the "open cavity" electronics enclosure thermal design for effect of solar entrapment during off-nominal pointing.

Supporting Rationale

The GIRD requires that each instrument be able to withstand 4 continuous hours of arbitrary pointing attitude, which could include direct sun on the open electronics cavity. This case needs to be evaluated.

Project Response

The HIRDLS Program is in the process of defining "off-nominal pointing" with TRW and GSFC. Also, the three organizations are working the larger issues of survival power and thermal models.

Once these issues are resolved, this action item can be closed within 6 weeks.

Date Closed:
Residual Risk:
Originator: G. GREER

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: CONTAMINATION Number: 015

Responsibility: 015-1a RAL - Tony Richards
015-1b LOC - Syndie Meyer
015-2 OXF - Chris Palmer

Action Requested

The Project should:
1a. Provide justifications on how HIRDLS particulate contamination requirements and budgets were established. Level 370 was established for the scan and primary mirrors. Also, provide analysis to show the relationship between the optical degradation and particulate levels.
1b. Level 200 was stated for the exterior surfaces of detector subsystem and warm filter carrier. Show requirements and budget flowdown. Explore the feasibility of preventative contamination control methods (materials, covers, purge, assembly process) and cleaning procedures to possibly preclude the need for such stringent requirements.
2. Assess the molecular contamination effects on the mirror surfaces, detectors, cryocooler. Establish molecular contamination requirements and budgets by analysis and/or tests.

Supporting Rationale

1. The required cleanliness levels on mirror surfaces will affect the cleanroom selection, cleanroom operations, and operational cost. Establishing reasonable particulate contamination requirements, allocating achievable contamination budgets, and applying preventative techniques will reduce operational cost.
2. The molecular contamination requirements were briefly mentioned at PDR. No rationales were provided.

Project Response

1a. The action requests **justification** of cleanliness levels and the **analysis** relating the optical degradation (as measured by the uncalibrated residual scatter signals expected in each channel) to the particulate contamination expected.

Justification and analysis can be found in various project technical communications (TCs). The following TCs address the above concerns:

TC-RAL-057 This note goes into considerable detail on how multiplying mirror BRDFs results in increments to the residual scatter fractions which limit measurement accuracy. The APART/MATHCAD analysis on which the scatter fractions are based is sketched out.

TC-RAL-061 This note includes discussion on how published BRDF models used in the HIRDLS straylight analysis are related to 'particulate contamination levels', when the latter are parameterised using 'cleanliness class ' numbers and when class numbers are used in published formulae.

TC-RAL-075 This note details how the 'final' recommended upper limit (360 + or - 10) to scan- and primary mirror contamination levels, as parameterised by surface cleanliness level numbers, were reached.

A complete set of RAL straylight analysis references would include **TC-RAL-58** and **TC-RAL-66** with the above documents.

1b. Regarding Level 200 Requirement and flow-down: All hardware contamination allocations presented at PDR were obtained from Instrument Technical Specification (SP-HIR-013P) §3.12.7, Baseline Cleanliness Levels and Table 3.12.7-1, Baseline Cleanliness Levels for Subsystems at Delivery.

Regarding preventative contamination control methods: Preventative covers, packaging, and handling are required per HIRDLS Instrument Contamination Control plan (PA-LOC-103) and LMMS is working with LMIRIS to assure that the CCP is implemented in all phases of the DSS design, fabrication and assembly, shipment and integration; this includes the implementation of the approach. Protective covers, containers, procedures, and methods are all specified in the HIRDLS Instrument CCP. LMMS continues to work internally and with LMIRIS to assure that protections of all appropriate sorts are included in all phases of the DSS and instrument hardware-flow to assure that instrument performance and mission requirements are met.

2. Mirrors and Lenses: See TC-OXF-186, available on clas/documents/tc. This TC derives an expression for the change in reflectivity of an interface between two media resulting from contamination at the interface, and establishes requirement(s) for molecular contamination.

Detector/Cooler cryo-surfaces: This is not an issue which affects optical throughput or spectral performance per se. The cryo-surfaces are exposed to the space environment and will accrete ice at a rate which will decrease with time into the mission.

The instrument design includes a significant cooling margin to allow for this. The Coolers will normally be operated in a constant (cold tip) temperature mode, and as the ice accretes, the

Cooler power will slowly increase*, until the margin is used up, at which point the cold tips will begin to warm up.

At this point the Instrument will be commanded to “decontaminate”, i.e. the cooling will be inhibited for up to 18 hours (TBV) to allow the accreted ice to sublime to space, a process which will begin onc the cryo-surfaces have warmed up to about 150K.

The Instrument will then be commanded back into Mission Mode and normal operation will be resumed within 24 hours from the start of decontamination. Following launch, it is expected that the period between decontaminations will increase fairly rapidly, from around 3 weeks to >4 months.

Thus, the only impact on performance will be the occasional decontamination days, averaging around 3-4 per year during the mission. More frequent instrument outages are expected as a result of spacecraft “events”, and where possible, advantage will be taken of these to perform decontamination, in order to minimize operational time lost solely for decontamination reasons.

* this has been allowed for in the HIRDLS mean power estimates

Date Closed:
Residual Risk:
Originator: P. CHEN

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: THERMAL Number: 016
Responsibility: BLL - Dan Berry

Action Requested

The Project should evaluate the CSS test program with required to the following:
1. Temperature dependency of cryo-cooler vibration characteristics and the need to perform cooler performance tests in a vacuum chamber with a simulated orbital heat sink environment.
2. Cold start-up at expected safe-hold temperatures and the need for T/V verification of the new control loop design implemented for HIRDLS.
3. Vibration effects of the asymmetric radiant heat sink environment for the compressor and displacer which utilize the +Y side of the component body as well as the surrounding radiator surface to dump heat to space.
4. If performance testing in T/V is required, does Ball have a chamber with vibration isolation?

Supporting Rationale

1. Control PROMS will be burned-in based on ground test results and algorithm constants modified/uploaded if required during instrument calibration or after on-orbit operation has been evaluated. However, changes may also require expensive additional ground testing of a similar CSS model If vibration characteristics are temperature dependent, as determined for the similar 30 K cooler design, it behooves us to "get it right" before instrument level I&T and on-orbit operation.
2. The Ball 30 K cooler experienced a cold start-up problem at -30C and the control loop control was redesigned for HIRDLS.
3. If the HIRDLS heat sink environment produces significant thermal gradients across the compressor or displacer, the effect on mechanical clearances should be evaluated. The concern is that a relatively large radial delta T may cause bending that distorts internal mechanisms and results in loss of proper gapping, increased friction, particle generation and premature failure.
4. Isolation is required because of T/V chamber background vibration.

Project Response

The response to this RFA is provided in the Ball document, TC-BLL-051, which is enclosed in Appendix A.
Date Closed:
Residual Risk:
Originator: A. SEIVOLD, G. GREER, S. CASTLES

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: SOFTWARE Number: 017
Responsibility: LOC - Jerry Drake

Action Requested

The Project should consider making it a requirement that flight s/w in each processor have the ability to preserve state of system at time of a failure (reboot) so that it may be telemetered to ground at a later time for troubleshooting.

Supporting Rationale

If all traces of a failure are destroyed, troubleshooting may be impossible.

Project Response

The two RAD6000 processors (TEU and IPU) do preserve the system state at the time of a failure (reboot). The CSS processor does not maintain the system state at the time of a failure (reboot).

Date Closed:
Residual Risk:
Originator: W. MOCARSKY

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: MECHANICAL Number: 018
Responsibility: LOC - Wayne Rudolf

Action Requested

Provide a summary table of design load factors for each major subsystem. Describe briefly how they were derived.

Supporting Rationale

This information was not provided for all subsystems at the review.

Project Response

HIRDLS is asking GSFC for clarification of what is being requested with respect to load factors. The following answer is a response based on our interpretation before receiving any clarification. Definition of load factors for each subsystem for the random environment as defined in the GIRD requires flow down through an accurate structural model of the instrument. This model is currently being assembled from inputs from the various responsible organizations (RO's). Preliminary results have been generated for the optical bench assembly (OBA), the detector subsystem, (DSS), and gyro mechanical unit (GMU), and the inflight calibrator blackbody (IFC BB). A complete table of the subsystem design loads is expected to be available by mid-March, 1998.

Date Closed:
Residual Risk:
Originator: M. CLARK

Systems Review Office
Code 301-GSFC

Request for Action

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Topic: TESTING Number: 019
Responsibility: LOC - Art Kraemer

Action Requested

Provide plans for vibro-acoustic tests (random, sine, shock) and structural qualification (including subsystem/spacecraft interfaces) for all major subsystems. For structural qualification by analysis provide "no test" design factors of safety for yield and ultimate.

Supporting Rationale

It was stated that subsystem environmental testing is at the discretion of the responsible organization. The review team would like to know which subsystems will be exposed to vibro-acoustic environments for the first time at the instrument level.

Project Response

Subsystem Environmental testing is optional only for the Engineering Model (EM). Such testing is required for the Proto-flight Model (PFM) as shown in the attached table (Table 9-0 from the HIRDLS Performance Verification Plan, TP-HIR-008). Plans for random, sine, and shock are shown for each proto-flight subsystem with an additional breakout for the TSS due to its complex mix of structural and electro-optical units. Structural qualification is shown in this table as Static Load Test.

Date Closed:
Residual Risk:
Originator: M. CLARK

Subsystem	Modal Survey (MAR 3.4.1)	Static Load/ Strength (MAR 3.4.1)	Random Vibration (MAR 3.4.2)	Sine Sweep (MAR 3.4.3)	Shock (MAR 3.4.4)	Life Testing (MAR 3.4.5)	Pressure Profile (MAR 3.4.6)	Mass Properties (MAR 3.4.7)	EMI/ EMC (MAR 3.5.2)	Thermal Vacuum (MAR 3.6.1)	Thermal Balance (MAR 3.6.2)	Temperature - Humidity Trans & Storage (MAR 3.6.3)	Leakage (MAR 3.6.4)	T-Vac Bakeout (MAR 9.4)
STH	X	X	X	X				X						X
SSH			X	X		X		X	X	X				X
TSS			X	X				X		X	X			X
OBA	X	X	X	X		X		X	X	X	X			X
EEA			X	X				X	X	X	X			X
WSEA			X	X				X		X	X			X
TEU			X	X				X		X	X			X
Passive Isolators		X												X
Chop Mech Unit			X	X		X		X	X	X	X			X
DSS			X	X				X	X	X	X		X	X
CSS	X		X	X		X		X	X	X	X		X	X
IFC			X	X				X		X	X			X
GSS			X	X		X		X	X	X	X		X	X
IPS			X	X				X	X	X	X			X
PSS			X	X				X	X	X				X

Table 9-0
Subsystem Environmental Test Requirements

Systems Review Office
Code 301-GSFC

Advisory

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Responsibility: Number: A-001

There is a general concern with respect to the use of the new (improved) formulation of Nextel black paint in the IFC and the external black body source. The new formulation (Nextel 811-21) is currently not space qualified. Oxford is conducting independent tests; however, it is recommended that a backup paint which is already space qualified should be chosen in case the Nextel paint does not meet requirements. The adhesion, particle generation, and material outgassing properties must be determined. Also, handling and cleaning procedures need to be established. (P. Maymon and P. Chen)

Project Response

The suitability of Nextel 811-21 as a high emissivity coating for the HIRDLS IFC black body (IFCBB) will be confirmed in the following way:

a) Spectral hemispherical reflectance measurements from about 2.5 to 56 microns.
b) Paint thickness measurements.
c) Adhesion and particle generation measurements.
d) Outgassing measurements.

Notes on the preceding items.

a) The spectral hemispherical reflectance measurements will be carried out at, and by, the National Physical Laboratory, Teddington, England. The measurements will be made on 50 mm square aluminum coupons painted at the same time as the flight equipment (same batch properties). In all respects, the coupons will replicate the materials properties, the surface finish and the cleanliness state of the IFCBB cavity after painting.

Measurements already carried out on a sample have shown that the spectral hemispherical reflectance of Nextel 811-21 meets the radiometric design requirements for a high emissivity black coating.

b) The paint thickness will be determined by:

i) over-spraying kapton tape applied to a test coupon, and by

ii) multiple surface profile measurements across the boundary between painted and unpainted areas on a test coupon.

The test coupon for measurements i) and ii) could be one and the same. The thickness of paint on the kapton will be determined by multiple micrometer measurements.

c) Paint adhesion will be determined by the tape lift test using the procedure outlined in specification ESA PSS-01-713 (Measurement of the Peel and Pull-Off Strength of Coatings and Finishes with Pressure-Sensitive Tapes).

Particle generation depends on adhesion, and so the tape lift sampling of the surface is an appropriate procedure subject to the adhesive on the tape being 'low tack' to lift loose particles only and not to pull them off. The paint adhesion test (ESA PSS-01-713) covers both aspects of paint quality, i.e. high pull-off strength and low particle generation.

Adhesion measurements will be made before and after vacuum baking to verify that thermally cycled coatings suffer no loss of adhesion.

d) The outgassing of vacuum baked Nextel coatings will be determined according to specification ESA PSS-01-702 (A Thermal Vacuum Test for the Screening of Space Materials). The measurements will be carried out by ESA's Materials and Processing Division, Noordwijk, Netherlands.

Prior to the formal outgassing measurements, a number of samples will be tested by T.S. Space Systems. The equipment and methods used by this company conform to those specified by NASA (ASTM-E-595), although the facility needs to qualified and/or certified in its new location. The preliminary measurements will be used to verify the efficacy of the vacuum baking procedure.

Neither adhesion/particle generation or contamination are considered to be an issue. Long experience of using Nextel has demonstrated its excellent adhesion to a variety of substrates (copper, aluminum, stainless steel etc.), with no measurable particle generation. Use of Nextel 2010 in the department's thermal vacuum chambers included monitoring using a residual gas analyzer (200 amu range, real-time monitoring) and calcium fluoride windows (infrared absorption, discrete off-line monitoring). The painted panel areas were/are typically a few square meters and no measurable volatile contaminants were detected. The Nextel formulation 811-21 differs from 2010 only in that the silica ballitini (used in 2010) have been replaced by polyurethane ballitini.

It should be noted that the previous formulation, Nextel 2010, was used as a high emissivity coating in the construction of:

i) the large external targets for the test and calibration of the Along Track Scanning Radiometer (ATSR),

ii) the large external targets for the test and calibration of the Improved Stratospheric and Mesospheric Limb Sounder (ISAMS), and

iii) the environment walls for the department's thermal vacuum chambers, including the ATSR, ISAMS and Cassini Composite Infra-red Spectrometer, (CIRS) chambers.

It should be noted that the painted surface area under discussion is no more than 110 cm^2, which may be visualized as a painted 4" square area.

<u>Handling and cleaning</u>

After painting and assembly the cavity will be protected by a dust shield. Painted surfaces will not be handled and the dust shield should prevent any significant particulate contamination. However, procedures for cleaning contaminated surfaces will be investigated.

<u>Alternative coating.</u>

A possible alternative coating that is already space qualified, called Chemglaze 306, is being investigated for its suitability for use in the in-flight calibration black body (IFCBB).

Systems Review Office
Code 301-GSFC

Advisory

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Responsibility: Number: A-002

PDR information on the Signal Processor Unit power system (Page 19 of the PDR presentation) should be verified. The power dissipated in the linear regulator does not appear to be consistent with the estimate provided. (M. Davis)

Project Response

Design audits were conducted on all the electronics and power subsystems post-PDR. All estimates and dissipated power were, and will continued to be, reviewed for correctness and consistency as part of the on-going design work.

Systems Review Office
Code 301-GSFC

Advisory

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Responsibility: Number: A-003

The Project should develop and maintain a risk database which tracks the cost, schedule, and performance risks. Work is being coordinated from many geographically dispersed elements. It is very important to track and publish (on a regular basis) a list of risks that the Project is carrying. This will help ensure that the most important risk issues are being addressed and will allow their implementations to be assessed by all parties. (S. Scott)

Project Response

The HIRDLS Program has implemented an organization structure and management system that addresses this concern. The HIRDLS program has implemented a Coordinating Team which coordinates work amongst all the HIRDLS organizations. This Team is chaired by the HIRDLS Program Manager and includes the US and UK Project Managers, the HIRDLS Technical Manager, the HIRDLS System Engineer and is supported by the Project Managers of the HIRDLS Responsible Organizations. This Team meet by telecon once a week to status the program and address the “top ten” issues. Minutes of these telecons are documented and distributed to all HIRDLS personnel (including the HIRDLS Technical Officer at GSFC). High priority items are also published and tracked in the HIRDLS Action Item List, available to all program personnel on the clas server.

Systems Review Office
Code 301-GSFC

Advisory

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Responsibility: Number: A-004

There is a concern with respect to the currently planned use of a brush type motor to operate the space view aperture mechanism. Brush motors tend to fail after only 10's or 100's of cycles in vacuum due to brush lubricant leaching out and subsequent brush debris shorting out motor commutator bars. Consider using an Astro stepper motor as used for the sunshield mechanism. (R. Sharma)

Project Response

The brushed dc motor was chosen for the following reasons:

1. Simple design requiring no complex drive electronics.
2. Number of operations limited to much less than 200 (including ground operation).
3. This type of motor has been used successfully on previous space missions (Hubble Space Telescope).

Following the PDR, MMS have learnt of a DPA done by GSFC on a similar motor. We believe that the results from the GSFC DPA indicate that the wear on the brushes was not considered to be a cause for concern. The contact at GSFC for this DPA is Charles E. Powers, Materials Laboratory.

Systems Review Office
Code 301-GSFC

Advisory

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Responsibility: Number: A-005

Repeatability of interface thermal conductances should be considered in the thermal design of components that may be disassembled during I&T. Heat flow repeatability and consistency is necessary to preserve thermal analysis validity. (G. Greer)

Project Response

The HIRDLS program is fully aware of the criticality of this issue and due consideration will be given to repeatability of interface thermal conductances in the thermal design.

Systems Review Office
Code 301-GSFC

Advisory

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Responsibility: Number: A-006

Turnover fixture design: The need to access the +Y mounted cryo-cooler assembly should be assessed and considered in the design of the turnover stand. It may be prudent to provide such flexibility in addition to providing access to the -Y connector bulkhead. (G. Greer)

Project Response

All HIRDLS ROs, in particular MMS, and LMMS, are working closely to ensure that any Instrument Mechanical GSE are designed to allow required access.

Systems Review Office
Code 301-GSFC

Advisory

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Responsibility: Number: A-007

At CDR, please present EMI/EMC control elements including internal and external aspects of the design; grounding, shielding, decoupling, isolation, filtering, etc. Although details of the EMI/EMC control plan were not presented, off-line discussion seemed to show an understanding of the issues and a reasonable approach. (P. Bryant)

Project Response

EMI/EMC control elements will be presented at CDR.

Systems Review Office
Code 301-GSFC

Advisory

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Responsibility: Number: A-008

For the shipping container, consider using a shock recording device that also provides frequency information. In addition, review all materials (gaskets, paints, etc.) to ensure compliance with contamination requirements. (M. Clark)

Project Response

The instrument transport container will have a platform mounted on vibration isolators, on to which the instrument will bolt. The isolators have been chosen so that the platform will have a first rigid body mode at 4.5Hz. Any load applied externally to the container, which has a frequency content higher than 6.6Hz, will be attenuated. The shock monitoring equipment will be mounted on the isolated platform.

Since the PDR, another low-cost shock recording system has been found. This uses accelerometers to monitor vibration levels, and has a solid state electronics system capable of sampling the signal at 4KHz. The accelerometers have a high frequency cut-off at 200Hz. Although shock loads can contain very high frequency components, the attentuation of these components will be approximately -20dB (at 200Hz) depending on the damping of the isolators. Therefore, it is considered unnecessary to monitor transient loads with higher frequency components.

The shock monitor is manufactured by Lamerholm Fleming Ltd (UK), model number RD298.

On the outside of the container, MMS are planning to use “drop ‘n’ tell” indicators. Three ranges will be used; 5g max, 15g max and 25g max. These will provide a quick visual means of determining what loads the container had seen during transit.

MMS and LMMS are working closely to ensure that the materials used in the transport container comply with the HIRDLS cleanliness requirements.

Systems Review Office
Code 301-GSFC

Advisory

Review:	PDR - Preliminary Design Review
Project:	EOS -EARTH OBSERVING SYSTEM
Spacecraft/Observatory:	CHEMISTRY
Instrument:	HIRDLS
Launch Vehicle:	
Ground System:	

Responsibility: Number: A-009

Please present more details of the GSE (IEGSE) design at the CDR. (W. Mocarsky)

Project Response

Detailed design of the IEGSE will be presented at the CDR. GSFC personnel are also reminded that they are welcome to attend the HIRDLS program Critical Design Audits of these subsystems prior to the CDR.

HIRDLS

HIGH RESOLUTION DYNAMICS LIMB SOUNDER

Originator: Dan Berry Date: 4-Dec-97

Subject / Title: PDR Action Item 016 Response

Contents / Description / Summary:

This TC is in response to PM-HIR-184 DRAFT Responses to PDR Action Items, action item number 016.

Key Words: PDR, Action, 016

Purpose (20 characters maximum):

BALL AEROSPACE & TECHNOLOGIES CORP.
P.O. BOX 1062
BOULDER, CO 80306
UNITED STATES OF AMERICA

The Project should evaluate the CSS test program with attention to the following:

AI 1. The temperature dependency of cryo-cooler vibration characteristics and the need to perform cooler performance tests in a vacuum chamber with a simulated orbital heat sink environment.

Answer 1.

The cooler specification SP-HIR-034B DRAFT, paragraph 3.3.7.2, requires the CMU resultant exported force to be .33N in the X-Y plane and .22N in the Z direction. These coordinates are in the Instrument Reference Coordinate Frame (IRCF). The forces apply at the interface of the cooler radiator to the STH. Verification of the force requirement is planned to be completed by analysis with data from the HIRDLS cooler on a 6-axis dynamometer at room temperature. The resulting data set will be the driving force input into our NASTRAN model.

During T/V we plan to perform a Comprehensive Functional Test at +35 ^{o}C and another at -15 ^{o}C. As specified in the cooler technical specification, +35 ^{o}C is the maximum normal operating temperature and -15 ^{o}C is the minimum normal operating temperature. This test is described in TP-BLL-018, Project Test Plan CDRL 010. The Comprehensive Functional Test is a 16 hour test which includes vibration control either "on" or "off" but does not measure the vibration cancellation performance levels.

The cooler vibration is due to modes as experienced on the 30K Phase IV unit, these modes do not have a strong sensitivity to environmental temperature. The vibration is more a function of how hard the cooler must work to maintain the cold node set point. It is fair to say the cooler will have more vibration when the heat rejection temperature is at the maximum and visa versa. We feel the exported vibration level difference between the hot and cold case is not significant and should not exceed the requirement. We are in the process of trying to acquire GSFC measured exported vibration data from the 30K Phase IV unit on the dynamometer. This unit is installed in a vacuum chamber with the thermal interface temperature controlled by a circulating cooling loop plate between the compressor and displacer thermal interface flanges and the dynamometer.

One approach to verify the resultant force requirement in T/V with the cooler integrated to the radiator, is to characterize a Kistler 3 axis force table over the T/V range and adapt the cooler radiator assembly to the force table. The force table would then be adapted to our seismic mass (see answer 4) and supply signal information which would result in X-Y and Z axial force knowledge. However, with the additional seismic mass in the chamber, extended ramp rates will increase the overall T/V time. The recovered force levels will be different in this test verses the levels when the radiator is attached to the STH. This test will only verify the difference in the hot and cold force levels. The NASTRAN model with a representative STH model, and our measured force data, is the only practical method of the requirement verification.

AI 2. Cold start-up at expected safe-hold temperatures and the need for T/V verification of the new control loop design implemented for HIRDLS.

Answer 2.
The new control loop design is being developed under Ball funding and is not complete or performance verified. The development schedule does not support implementing the new control loop into the EM CCU. The control loop being developed considers both a software and electronic implementation. The CCU can accommodate the software implementation with no changes at this point. The electronic implementation may or may not be a viable option for HIRDLS. Current concerns include sufficient space, power, mass, reliability and cost.

The cooler technical specification specifies the minimum operating temperature of -15 ^{o}C for the EM and -5 ^{o}C for the PFM, verses the 30K at -30 ^{o}C. We may or may not see the problem at the HIRDLS specified temperatures. In any event, we plan to start the cooler at the specified minimum operating temperature to verify normal start-up.

AI 3. Vibration effects of the asymmetric radiant heat sink environment for the compressor and displacer which utilize the +Y side of the component body as well as the surrounding radiator surface to dump heat to space.

Answer 3.
We do not anticipate this to be a problem since the compressor drive mechanism is not strongly coupled to the common housing/dome assembly. The symmetry of the compressor domes allows for symmetric loads acting in opposite directions upon the common housing. The drive mechanism internal to the domes is predicted to be very isothermal due to the mixing of the helium gas within the dome. The heat transfer to the domes is due to helium conduction and is not dominated by radiation to the thermal gradient effected dome.

A similar case is true for the displacer except for the symmetric domes. However the stress of thermal expansion goes directly into the robust displacer body and mounting bosses to the radiator bracket. The displacer mechanism is not strongly coupled to the displacer body for this reason.

We have established that the displacer rejects 3.7W or 7% of the total rejected heat. This value is changing due to thermal treatment changes and reducing the overall size of the radiator. During the upcoming radiator redesign effort we will have the analysis opportunity to insulate the displacer. By covering it with MLI, keeping it from rejecting the ~3.7W, we can determine the affect on the thermal tab interface temperature. This data point will provide the program with the option of insulating the displacer in the event the asymmetric radiant heat sink environment is a problem.

AI 4. If performance testing in T/V is required, does Ball have a chamber with vibration isolation?

Answer 4.
Yes, Ball has a chamber which the CSS will fit into named RAMBO, this is a NASA 4 Thermal Vacuum Chamber. This chamber has the capability to accommodate a 2268 kg aluminum seismic mass. The chamber background vibration has been characterized over all practical

chamber equipment operations.. The acceleration rms background data shows the chamber background vibration in the range of $.195 \times 10^{-6}$ m/sec^2 rms to 4.11×10^{-6} m/sec^2 rms, these values exclude pump down vibration since we will not be operating during this phase of T/V.

If we are to measure .22 N minimum, we should have the capability to measure .02 N. The worst case seismic mass background noise force rms can be determined. Using the measured worst case rms acceleration of 4.11×10^{-6} m/sec^2, and F=ma, with m as the seismic mass, then Frms=.009 N, about two times better than the needed measurement capability.

Programs such as HRS, HARDI, SNOE, STIS and TIR, which are critical optical alignment programs, have used this chamber with the seismic mass.

HIRDLS

TC-HIR-186

HIGH RESOLUTION DYNAMICS LIMB SOUNDER

Originator: Loh

Date: 97-12-26

Subject/Title: **HIRDLS Optical Procedures in Response to PDR Requests**

Description/Summary/Contents: Various inputs to respond to questions originating in PDR..

Task Flow for HIRDLS Monte-Carlo Tolerance Budget Analysis
Imager Optics Tolerance Budget
Optical Design Status
HIRDLS Channel-to-Channel Focus Error
HIRDLS Optical Alignment Procedure

Keywords:

Purpose of this Document:

Oxford University
Atmospheric, Oceanic &
Planetary Physics
Parks Road
OXFORD OXI 3PU
United Kingdom

University of Colorado, Boulder
Center for Atmospheric Sounding
3300 Mitchell
Boulder, CO 80301

EOS

Response to Request for Existing Information

Howard Morrow, November 11, 1997

Reference document dated October 10, 1997 from 301/Chairman, HIRDLS Review Team

The contents collected herein are in response to the **Request For Existing Documentation:**

1. Details of the HIRDLS optical bench assembly (TSS) optical alignment and test philosophy, procedures, and error budgets (by P. Maymon)

The optical alignment strategy was developed as an essential part of the total optical tolerance budget for the imager path. Each alignment to be performed is treated as a ***compensator*** in the tolerance budget. Furthermore, each alignment has its own assigned tolerance reflecting the notion that perfect alignments cannot be achieved. This approach was developed in close communication with SSG, the subcontractor responsible for fabrication and test of the individual elements, mounting and alignment of the optical system bench, and limited testing of the OBA optical assembly. Final alignment of some subsystems will be done at LMATC, with further testing to verify optical performance.

A summary of the tolerance budget along with results of Monte-Carlo testing of the fabrication and alignment errors will be presented in TC-LOC-140 at a later date.

The following pages are offered as exhibits related to this work during 1997 to date. Relevant material has been extracted from the SSG PDR and CDR presentations created by the author. Any out-of-date data containing errors subsequently corrected has been omitted. Other materials included have been assembled for internal distribution to the several participating parties.

SSG has recently revised the relay lens alignment plan with one offering greater precision. This is presented last.

Task Flow for HIRDLS Monte-Carlo Tolerance Budget Analysis

Final design, Howard Morrow, Jan. 20, 1997

Three "Independent" Suites, written in OPTIMA Macro language

Macro TOLSET (Creates perturbed imagers)

Get unperturbed imager		Lean version for tolerancing
Call	FABTEL	Telescope element fabrication errors
	FABLEN	Relay element fabrication errors
	FABFLT	Filter fabrication errors
	FABDET	Detector narrow dimension & height error
	FIGSCN	Scan mirror figure error
	FIGPRI	Primary mirror figure error
	FIGSEC	Secondary mirror figure error
	FIGL1	Germanium lens equivalent figure error
	FIGL2	Ge lens 2 equivalent figure error
	LOCTEL	Telescope element installation errors
	LOCLEN	Relay element installation errors

Macro ALINEM (Aligns the perturbed imagers)

Get perturbed imager		Created using TOLSET
Call	COLPDB	Aligns "Collimator" to PDB, with errors
	ANGPRI	Tilts primary for best image, with errors
	OFFPRI	Puts best primary image in FS1 center, with errors
	ADJSEC	Best conjugation, FS1 on FS2, with errors
	SETILS	Adjusts ILS onto PDB image, with errors
	DOFOLD	Tilts Fold mirror, ILS image on SAS, with

Macro CHEKEM (Analyses the perturbed imagers)

Get each perturbed imager		Created by TOLSET, aligned by ALINEM
Call	INFFS1	Quality/alignment of infinity in FS1
	PDBILS	Alignment/margin of PDB image on ILS
	FS1FS2	Alignment of image of FS1 on FS2
	INFFS2	Quality/alignment of infinity in FS2
	ILSSAS	Alignment/margin of image of ILS on SAS
	FS2DET	Alignment and quality of image of FS2 on Detector
	INFDET	Alignment and geometric quality of infinity

Imager Optics Tolerance Budget

Process to Create the Imager Tolerances

- **Monte-Carlo simulation (not a traditional WFE "tree")**

  WFE is not an official performance item for HIRDLS
  "Tree" would not easily address internal imager performance concerns
  Tolerance budget relieved by alignment plan ("compensators")
  Even a tree-derived tolerance budget may need Monte-Carlo confirmation

- **Rigorous tolerance simulation runs in OPTIMA, under Macro control**

  One "run" creates 10 - 30 perturbed and aligned prescriptions of the imager
  First macro suite applies all fabrication and installation tolerance errors
  Second macro suite performs the 8-step alignment *with alignment tolerances*
  Third macro suite checks the characteristics and performance of each imager
  (Auxiliary data provides diagnostic information)

- **Goal is to adjust the tolerance budget values until good imagers (almost) always result.**

  One problem area with L1 is currently under investigation

SSG HIRDLS PDR Imager Optics Tolerance Budget

Eight-step Alignment Plan and tolerances

- **Telescope and Relay aligned independently, then integrated, dewar added**
- **Telescope alignment to temporary FS2**

  1: Autocollimate to optical flat placed over PDB (<15 arcseconds)
  (This defines the HIRDLS Imager POA and axial ray)
  2: Align primary in angle (2 DOF only) to get best point image (.010 deg α; .005 deg β)
  3: Align primary in offset (3 DOF) to place image in FS1 center (.1 mm x,y; .05 mm z)
  4: Adjust secondary with 5 DOF to place image in FS2 center (xyz, $\alpha\beta$, same as above)
  5: Adjust ILS (2 DOF) until centered on image of PDB edge (.1 mm x,y)

- **Relay alignment from temporary ILS**

  6: Adjust fold mirror (2 DOF) until image of ILS centered on SAS (.01 deg $\alpha\beta$)
  (This is done in Infrared, and may be the most challenging alignment to see)

- **Telescope/relay integration**

  7: Integrate by matching at FS2 and ILS (.1 mm xyz at FS2; .2 mm x,y at ILS)
  8: Fine focus & center (4 DOF) Dewar ass'y (.1 mm x; .05 mm y; .025 mm z; .05 deg rot)

Sample run results: EFL and Aperture area

First-order characteristics for the HIRDLS imager

Lib Nbr	Teles EFL	Relay Mag.	-10.6 microns(Center)- EFL	Ap.Area	F/nbr	----- Channel 17 ----- EFL	Ap.Area	F/nbr
9	1282.	-0.191	**245.3**	**0.203E-01**	1.44	**237.2**	**0.193E-01**	1.43
10	1285.	-0.196	**251.5**	**0.209E-01**	1.46	**243.1**	**0.198E-01**	1.44
11	1283.	-0.190	**243.9**	**0.199E-01**	1.45	**235.6**	**0.189E-01**	1.43
12	1284.	-0.192	**246.5**	**0.205E-01**	1.44	**238.9**	**0.195E-01**	1.43
13	1285.	-0.190	**243.7**	**0.200E-01**	1.44	**235.4**	**0.190E-01**	1.43
14	1285.	-0.192	**246.6**	**0.205E-01**	1.44	**239.2**	**0.195E-01**	1.43
15	1285.	-0.192	**246.7**	**0.206E-01**	1.44	**239.0**	**0.196E-01**	1.43
16	1278.	-0.192	**245.8**	**0.204E-01**	1.44	**236.8**	**0.192E-01**	1.42
17	1285.	-0.191	**245.5**	**0.203E-01**	1.45	**238.1**	**0.193E-01**	1.43
18	1281.	-0.192	**245.9**	**0.204E-01**	1.44	**236.8**	**0.192E-01**	1.43
19	1281.	-0.191	**245.3**	**0.199E-01**	1.46	**237.4**	**0.188E-01**	1.45
20	1277.	-0.193	**247.0**	**0.209E-01**	1.43	**238.7**	**0.198E-01**	1.41

EFL spec range is 245 - 250 mm. Lib Nbr 9 is UNPERTURBED control prescription.

SSG HIRDLS PDR Imager Optics Tolerance Budget

Sample run results: Problem with image of ILS on SAS

ILS(T) on SAS: Geometric Alignment and Clearance

	--------- On Axis ---------			-------- Min Clearance --------			
Lib Nbr	to Best Focus	Y Centroid	X Centroid	Chan 8	Chan 10	Chan 17	Chan 18
9	0.001	0.000	0.000	0.616	0.605	0.565	0.556
10	**-6.603**	-0.140	0.134	-0.886	**-0.572**	**-0.662**	**-0.183**
11	2.999	0.117	0.139	0.802	0.873	0.787	0.752
12	-0.101	0.141	0.130	0.278	0.520	0.207	0.300
13	3.112	-0.134	0.207	0.875	0.695	0.812	0.779
14	-2.264	0.156	0.007	0.498	0.163	**-0.032**	0.020
15	0.012	-0.096	0.135	0.214	0.325	0.349	0.543
16	0.386	-0.050	0.060	0.644	0.427	0.632	0.389
17	0.684	0.150	-0.030	0.715	0.538	0.545	0.402
18	-3.626	-0.072	-0.054	0.203	**-0.042**	0.324	0.037
19	2.696	-0.140	0.058	0.750	0.726	0.673	0.741
20	**-6.060**	-0.145	0.084	-0.765	**-0.476**	**-0.925**	**-0.385**

Negative clearance indicates failure to fully “stop”, background leak, vignetting

Sample run results: VRP data

Vertical Response data for **Channel 4**
Detector height for this Channel is 0.082

Lib Nbr	Plt.Sc (km/mm)	FWHM (km)	IVR* FWHM	SLOPE* (@50%)	IVR .75km	IVR 1.0km	IVR 2.0km	IVR 3.0km
9	12.22	1.011	0.8494	3.091	0.9476	0.9660	0.9878	0.9940
10	11.92	0.988	0.8452	3.095	0.9467	0.9662	0.9880	0.9942
11	12.28	1.016	0.8483	3.046	0.9469	0.9659	0.9878	0.9941
12	12.16	1.007	0.8489	3.099	0.9476	0.9661	0.9878	0.9940
13	12.30	1.018	0.8484	3.044	0.9467	0.9657	0.9878	0.9941
14	12.14	1.006	0.8457	3.064	0.9460	0.9657	0.9879	0.9941
15	12.15	1.006	0.8443	3.017	0.9455	0.9661	0.9879	0.9940
16	12.21	1.011	0.8469	3.042	0.9467	0.9659	0.9878	0.9941
17	12.18	1.009	0.8457	3.039	0.9454	0.9658	0.9879	0.9941
18	12.21	1.011	0.8455	3.029	0.9460	0.9657	0.9878	0.9941
19	12.21	1.011	0.8468	3.041	0.9463	0.9655	0.9876	0.9940
20	12.13	1.004	0.8477	3.090	0.9468	0.9663	0.9880	0.9942
Spec	(none)	.9-1.05	>.80	(none)	0.9378	0.9611	0.9825	0.9890

*IVR is Integrated Vertical Response (see: ITS 3.3.2).
*SLOPE of normalized (peak = 1) VRP at half-max, /km.

Sample run results: RMS WFE data for SSG

Infinity on Detector: Wavefront Quality at 10.6 microns
RMS WFE and MTF-y @ 6.25 lp/mm, 5 locations, all at 10.6
(Pupil & ref. surface is PDB) (Tracing 4000 rays, 5 field points)

Lib Nbr	Center WFE	Best Focus	Center WFE	10 WFE	8 WFE	18 WFE	17 WFE
9	0.0015	-0.001	0.0012	0.0106	0.0106	0.0132	0.0132
10	0.0331	0.017	0.0212	0.0442	0.0409	0.0467	0.048
11	0.0472	0.029	0.0180	0.0435	0.0627	0.0505	0.0678
12	0.0294	0.019	0.0065	0.0528	0.0539	0.0391	0.0380
13	0.0342	-0.020	0.0164	0.0580	0.0174	0.0383	0.0138
14	0.0346	-0.018	0.0221	0.0274	0.0342	0.0194	0.0385
15	0.0462	-0.025	0.0270	0.0384	0.0331	0.0410	0.0381
16	0.0344	-0.016	0.0244	0.0446	0.0302	0.0310	0.0168
17	0.0326	0.021	0.0086	0.0521	0.0459	0.0497	0.0450
18	0.0427	0.023	0.0251	0.0507	0.0660	0.0449	0.0605
19	0.0237	0.013	0.0149	0.0386	0.0327	0.0327	0.0329
20	0.0356	-0.016	0.0253	0.0401	0.0357	0.0326	0.0169

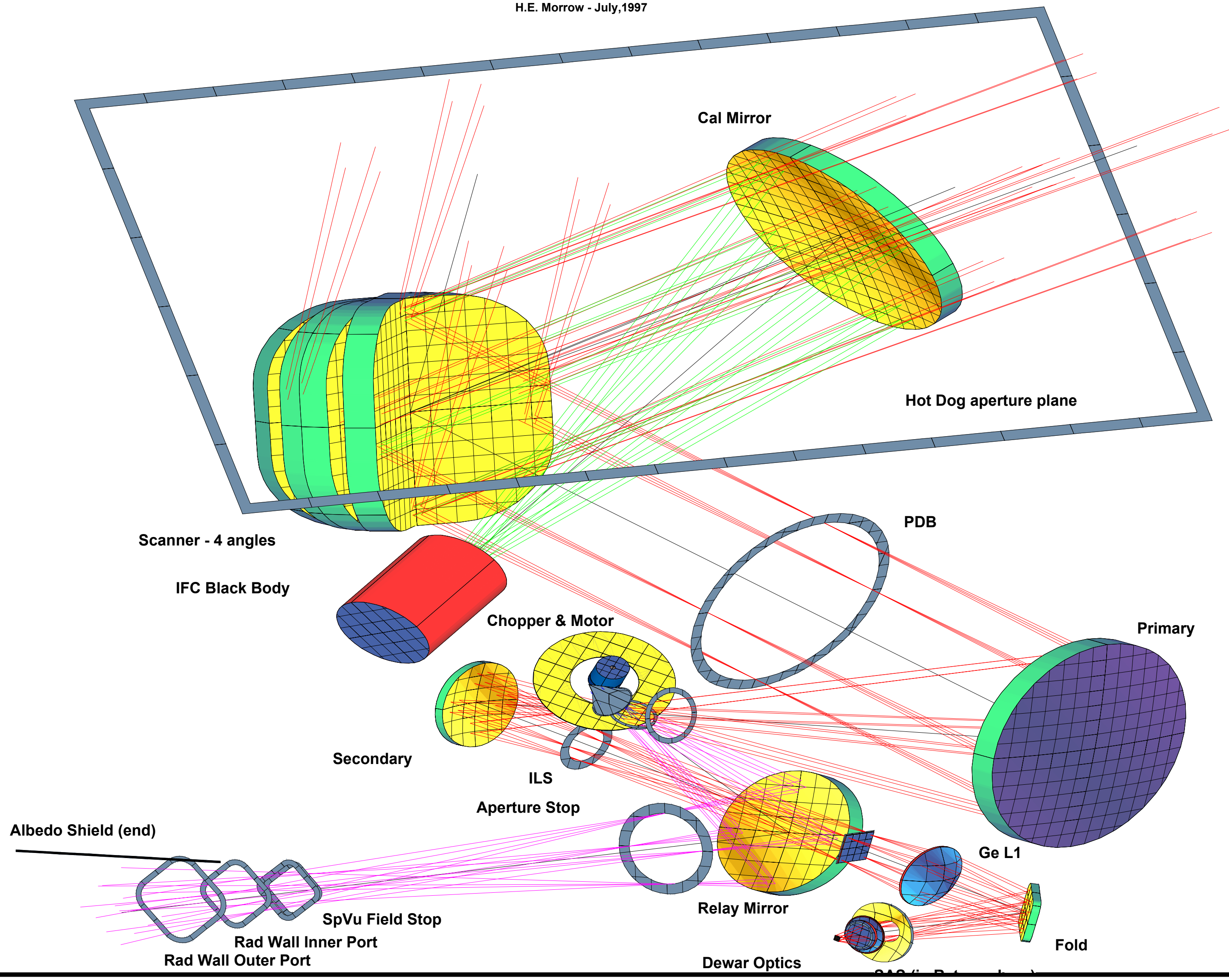
Suggested WFE spec for SSG: <.08 waves RMS @ 10.6 microns
(Lib Nbr 9 is unperturbed reference channel)

SSG HIRDLS CDR

Optical Design Status

HIRDLS GOAT 4C

H.E. Morrow - July,1997



HEM

What's New in the Optical Design?

- Only minor refinements since PDR
  - OOF Baffle moved 20 mm toward imager primary, and resized
  - Some mechanical apertures reset per SSG suggestions
  - Final focal plane layout:

    Final Cold Filter Assembly & lower mask concept
    Final Warm Filter Assembly
    Interim FS2 mask geometry
    (Final mask depends on hardware measurements)
- Tolerance budget analysis is final; summary results presented here

SSG optical design/interface work carried forward from PDR

Item	Status
• Hot Dog aperture specification	Done
• Tolerance budget refinement and analysis	Done
• ILS on SAS alignment sensing	Needs more work
• FS1 - chopper housing decision: independent or integrated?	?
• Cal mirror manufacturability	?
• Germanium substrate characterization	On schedule
• Electrolytic gold n & k measurement?	Unresolved

Optical Tolerance Budget Status

- Several refinements in focal plane/dewar area
  - Detailed model of Channel to Channel focus error
  - Tilt error of focal plane to Dewar flange
  - Tilt error of OBA to dewar flange
- New asymmetric Germanium L1 tolerances work well
  - Image of ILS on SAS now always clears
  - Vendor selected (probably) to fab the Germanium L1
- Most specifications can be met, but some may need to be changed

Optical Tolerance Budget Status

- **Channel-to-channel focus error expectation (units are in mm)**

Source	Error	Focus error	(Comments)
Detector height			
(Within a clip)	±0.0005	±0.0005	(Due to etch variations)
(Clip-to-clip)	±0.009	±0.009	(Due to substrate & glue variations)
FPA tilt wrt dewar flange	0.1 deg	±0.0049	(For corner detectors at R=2.83)
Cold filter thickness	±0.010	±0.0075	
Sub totals for Dewar Assy			
(Worst case)		±0.0219	(Mainly applies to corners)
(RSS)		±0.0127	
Next assembly:			
OBA flange tilt	0.1 deg	±0.0049	(Corner detectors, again)
Fine focus tolerance	±0.025	±0.025	(Evenly applied over FPA)
Totals for System			
(Worst case)		**±0.0518**	**(Mainly applies to corners)**
(RSS)		**±0.0285**	

- **Summary results of Monte Carlo optical tolerance budget tests**

- **Distribution of errors applied was very “pessimistic” (close to $\pm$ 1)**
- **21 perturbed and aligned imager prescriptions was prepared**
- **Results are presented in two segments:**
    - **SSG-only optical system specifications**
    - **System-level performance (after dewar integration)**

Sample Monte-Carlo run results summary

SSG-only optical system specification: Imager EFL, center, 10.6 microns (3.2.1.1.1.2.1)

Spec value	Nominal	Min	Max	Margin/Comments
245.4 ± 3.0	245.3	239.1	244.3	May not meet spec

This result is probably due to to the asymmetric tolerance assigned to the Germanium L1. It will not be a technical problem, and should not be permitted to be a serious program issue.

For information, here are the results for the Ge L1 EFL :

Spec value	Nominal	Min	Max	Margin/Comments
NA	140.49	142.41	143.55	Within tolerance !

Sample Monte-Carlo run results summary

SSG-only optical system specification: Relay (Image/FS2) Magnification (3.2.1.1.1.2.1.1)

Spec value	Nominal	Min	Max	Margin/Comments
0.191 ± .010	- .191	-.187	-.190	In Spec

SSG-only optical system specification: Aperture size (entrance pupil area) (3.2.1.1.1.2.2)

Spec value	Nominal	Min	Max	Margin/Comments
.018 m^2	(ch2) .0203	.0194	.0200	OK
	(ch17) .0193	.0183	.0189	Probably OK

Sample Monte-Carlo run results summary

SSG-only optical system specification: Wavefront error, 10.6 microns (3.2.1.1.1.2.7)

Spec: WFE < .08 waves at 10.6 microns

The following table is excerpted from the analysis of the Monte-Carlo run:

	----- ON AXIS -----			---- RMS WFE @ FOUR CORNERS ----			
Lib Nbr	RMS WFE	del-z Best	BEST WFE	CH 10	CH 8	CH 18	CH 17
Nominal	0.0015	-0.001	0.0012	0.0106	0.0106	0.0132	0.0132
Averages	0.035514	-0.00705	0.020633	0.036343	0.037243	0.035662	0.039119
Min	0.0186	-0.027	0.012	0.0147	0.0097	0.0123	0.0155
Max	0.0513	0.031	0.0295	0.0886	0.0706	0.0883	0.0846
Std Dev	0.008458	0.018951	0.005591	0.018424	0.015059	0.01874	0.017676

Conclude that the manufactured WFE will probably be within the stated spec assuming that the optical surface figures and alignment are within the tolerance budget.

Sample Monte-Carlo run results summary

SSG-only optical system specification: Specified Internal Alignments

Spec item: FS1 to PDB (3.2.1.1.1.2.9.1)

Spec value	Nominal	Min	Max	Comments
.100 (x,y)	0,0,	-.098	+.094	Full range
.05 (z)	0	-.054	+.052	Sl. > full range

Spec item: FS2 to FS1 (3.2.1.1.1.2.9.2)

Spec value	Nominal	Min	Max	Comments
.100 (x,y)	0,0	-.78	+.70	This is a mystery
.05 (z)	0	-1.08	+1.00	Very mysterious
.05 deg clock	Not checked			

Spec item: ILS to PDB (3.2.1.1.1.2.9.4)

Spec value	Nominal	Min	Max	Comments
>.100 to edge	.38	.41	.57	Closest ray

Spec item: SAS to ILS (3.2.1.1.1.2.9.5)

Spec value	Nominal	Min	Max	Comments
.150 of edge	.56	.57	1.03	Closest ray

Sample run results with Dewar and Detectors: VRP data, FWHM

Vertical Response: FWHM (km)
Results of Monte-Carlo Tolerance Budget Test

Channel Number	Spec Value	Nominal Value	Range Min	Range Max	Margin
1	.9 - 1.05	0.9748	0.9606	1.0322	OK
2	.9 - 1.05	0.9771	0.9508	1.0410	OK
3	.9 - 1.05	0.9776	0.9521	1.0396	OK
4	.9 - 1.05	0.9766	0.9476	1.0469	OK
5	.9 - 1.05	0.9764	0.9513	1.0378	OK
6	.9 - 1.05	0.9768	0.9377	1.0429	OK
7	.9 - 1.05	0.9729	0.9363	**1.0456**	Caution
8	.9 - 1.05	0.9706	0.9373	1.0393	OK
9	.9 - 1.05	0.9737	0.9335	1.0370	OK
10	.9 - 1.05	0.9726	0.9331	**1.0471**	Caution
11	.9 - 1.05	0.9798	0.9427	1.0334	OK
12	.9 - 1.05	0.9738	0.9395	1.0294	OK
13	.9 - 1.05	0.9694	0.9324	1.0378	OK
14	.9 - 1.05	0.9758	0.9280	1.0359	OK
15	.9 - 1.05	0.9746	0.9281	1.0315	OK
16	.9 - 1.05	0.9764	0.9393	1.0375	OK
17	.9 - 1.05	0.9749	0.9328	1.0304	OK
18	.9 - 1.05	0.9785	0.9508	1.0368	OK
19	.9 - 1.05	0.9775	0.9492	**1.0487**	Caution
20	.9 - 1.05	0.9714	0.9471	1.0428	OK
21	.9 - 1.05	0.9754	0.9385	1.0380	OK

Sample run results with Dewar and Detectors: VRP data, Integ under FWHM

Vertical Response: Integrated Vertical Response under FWHM
Results of Monte-Carlo Tolerance Budget Test

Channel Number	Spec Value	Nominal Value	Range Min	Range Max	Margin
1	> .80	0.8313	0.8219	0.8353	OK
2	> .80	0.8395	0.8282	0.8420	GOOD
3	> .80	0.8434	0.8304	0.8467	GOOD
4	> .80	0.8460	0.8306	0.8493	GOOD
5	> .80	0.8483	0.8292	0.8515	GOOD
6	> .80	0.8313	0.8458	0.8720	V GOOD
7	> .80	0.8674	0.8404	0.8738	GOOD
8	> .80	0.8679	0.8398	0.8732	GOOD
9	> .80	0.8739	0.8443	0.8792	GOOD
10	> .80	0.8794	0.8519	0.8850	V GOOD
11	> .80	0.8889	0.8659	0.8902	EXCEL
12	> .80	0.8966	0.8709	0.8957	EXCEL
13	> .80	0.8999	0.8739	0.9058	EXCEL
14	> .80	0.9077	0.8758	0.9079	EXCEL
15	> .80	0.9086	0.8756	0.9101	EXCEL
16	> .80	0.9093	0.8719	0.9106	EXCEL
17	> .80	0.9116	0.8702	0.9107	EXCEL
18	> .80	0.9145	0.8773	0.9126	EXCEL
19	> .80	0.9138	0.8898	0.9130	EXCEL
20	> .80	0.9156	0.8981	0.9175	EXCEL
21	> .80	0.9257	0.8870	0.9252	EXCEL

Sample run results with Dewar and Detectors: VRP data, Integ under .75 km

Vertical Response: within +/- .75 km
Results of Monte-Carlo Tolerance Budget Test

Channel Number	Spec Value >	Nominal Value	Range Min	Range Max	Margin Value	Margin Comment
1	0.9305	0.9419	0.9351	0.9414	-0.0046	Negative!
2	0.9342	0.9455	0.9383	0.9444	-0.0041	Negative!
3	0.9360	0.9469	0.9400	0.9463	-0.0040	Negative!
4	0.9378	0.9478	0.9409	0.9470	-0.0031	Negative!
5	0.9401	0.9486	0.9368	0.9477	0.0033	OK?
6	0.9517	0.9574	0.9508	0.9569	0.0009	V Small
7	0.9526	0.9577	0.9513	0.9573	0.0013	Small
8	0.9547	0.9580	0.9497	0.9587	0.0050	OK
9	0.9567	0.9602	0.9535	0.9598	0.0032	OK?
10	0.9600	0.9628	0.9572	0.9626	0.0028	OK?
11	0.9611	0.9655	0.9602	0.9654	0.0009	V Small
12	0.9646	0.9698	0.9644	0.9695	0.0002	V Small
13	0.9669	0.9719	0.9675	0.9721	-0.0006	Negative!
14	0.9679	0.9732	0.9697	0.9732	-0.0018	Negative!
15	0.9685	0.9739	0.9700	0.9737	-0.0015	Negative!
16	0.9690	0.9741	0.9694	0.9739	-0.0004	Negative!
17	0.9703	0.9748	0.9680	0.9742	0.0023	Small
18	0.9716	0.9757	0.9689	0.9752	0.0027	OK?
19	0.9716	0.9763	0.9708	0.9759	0.0008	V Small
20	0.9730	0.9776	0.9743	0.9774	-0.0013	Negative!
21	0.9751	0.9794	0.9749	0.9793	0.0002	V Small

SSG HIRDLS CDR

Optical Design Status

Sample run results with Dewar and Detectors: VRP data, Integ under 1 km

Vertical Response: within +/- 1.0 km
Results of Monte-Carlo Tolerance Budget Test

Channel Number	Spec Value >	Nominal Value	Range Min	Range Max	Margin Value	Margin Comment
1	0.9566	0.9623	0.9599	0.9620	0.0033	OK?
2	0.9588	0.9644	0.9616	0.9641	0.0028	OK?
3	0.9600	0.9653	0.9630	0.9651	0.0030	OK?
4	0.9611	0.9664	0.9640	0.9661	0.0029	OK?
5	0.9625	0.9667	0.9633	0.9660	0.0008	V Small
6	0.9698	0.9724	0.9705	0.9720	0.0007	V Small
7	0.9704	0.9726	0.9707	0.9723	0.0003	V Small
8	0.9717	0.9725	0.9700	0.9724	-0.0017	Negative!
9	0.9729	0.9742	0.9716	0.9738	-0.0013	Negative!
10	0.9750	0.9758	0.9739	0.9756	-0.0011	Negative!
11	0.9757	0.9777	0.9758	0.9776	0.0001	V Small
12	0.9779	0.9803	0.9787	0.9801	0.0008	V Small
13	0.9793	0.9817	0.9805	0.9817	0.0012	V Small
14	0.9799	0.9826	0.9815	0.9825	0.0016	Small
15	0.9803	0.9830	0.9820	0.9829	0.0017	Small
16	0.9806	0.9832	0.9819	0.9830	0.0013	V Small
17	0.9814	0.9836	0.9817	0.9833	0.0003	V Small
18	0.9823	0.9844	0.9828	0.9842	0.0005	V Small
19	0.9823	0.9848	0.9835	0.9846	0.0012	V Small
20	0.9831	0.9856	0.9847	0.9856	0.0016	Small
21	0.9845	0.9869	0.9855	0.9868	0.0010	V Small

Sample run results with Dewar and Detectors: VRP data, Integ under 2 km

Vertical Response: within +/- 2.0 km

Results of Monte-Carlo Tolerance Budget Test

Channel Number	Spec Value	Nominal Value	Range Min	Range Max	Margin Value	Margin Comment
1	0.9804	0.9865	0.9861	0.9866	0.0057	Larger
2	0.9815	0.9871	0.9866	0.9870	0.0051	Larger
3	0.9820	0.9873	0.9869	0.9873	0.0049	Larger
4	0.9825	0.9878	0.9874	0.9877	0.0049	Larger
5	0.9831	0.9876	0.9871	0.9874	0.0040	Larger
6	0.9864	0.9897	0.9894	0.9897	0.0030	Med
7	0.9867	0.9897	0.9893	0.9896	0.0026	Med
8	0.9872	0.9895	0.9891	0.9895	0.0019	Small
9	0.9878	0.9902	0.9898	0.9902	0.0020	Small
10	0.9887	0.9907	0.9904	0.9907	0.0017	Small
11	0.9891	0.9917	0.9913	0.9916	0.0022	Small
12	0.9900	0.9928	0.9925	0.9927	0.0025	Med
13	0.9907	0.9933	0.9931	0.9933	0.0024	Small
14	0.9909	0.9937	0.9936	0.9937	0.0027	Med
15	0.9911	0.9939	0.9936	0.9938	0.0025	Med
16	0.9913	0.9939	0.9937	0.9939	0.0024	Small
17	0.9916	0.9940	0.9937	0.9939	0.0021	Small
18	0.9920	0.9944	0.9942	0.9943	0.0022	Small
19	0.9920	0.9946	0.9944	0.9946	0.0024	Small
20	0.9924	0.9949	0.9948	0.9950	0.0024	Small
21	0.9930	0.9956	0.9953	0.9957	0.0023	Small

Sample run results with Dewar and Detectors: VRP data, Integ under 3 km

Vertical Response: within +/- 3.0 km
Results of Monte-Carlo Tolerance Budget Test

Channel Number	Spec Value	Nominal Value	Range Min	Range Max	Margin Value	Margin Comment
1	0.9877	0.9936	0.9934	0.9936	0.0057	Larger
2	0.9884	0.9937	0.9935	0.9937	0.0051	Larger
3	0.9887	0.9937	0.9935	0.9937	0.0048	Larger
4	0.9890	0.9941	0.9939	0.9940	0.0049	Larger
5	0.9894	0.9938	0.9935	0.9936	0.0041	Larger
6	0.9915	0.9948	0.9946	0.9948	0.0031	Med
7	0.9916	0.9947	0.9945	0.9947	0.0029	Med
8	0.9920	0.9945	0.9943	0.9946	0.0023	Small
9	0.9924	0.9949	0.9947	0.9949	0.0023	Small
10	0.9929	0.9952	0.9949	0.9952	0.0020	Small
11	0.9931	0.9958	0.9956	0.9958	0.0025	Med
12	0.9937	0.9964	0.9963	0.9964	0.0026	Med
13	0.9942	0.9968	0.9966	0.9967	0.0024	Small
14	0.9943	0.9970	0.9969	0.9970	0.0026	Med
15	0.9944	0.9970	0.9969	0.9970	0.0025	Med
16	0.9945	0.9971	0.9970	0.9971	0.0025	Med
17	0.9948	0.9971	0.9969	0.9971	0.0021	Small
18	0.9950	0.9974	0.9972	0.9973	0.0022	Small
19	0.9950	0.9975	0.9974	0.9975	0.0024	Small
20	0.9952	0.9977	0.9976	0.9977	0.0024	Small
21	0.9956	0.9980	0.9979	0.9983	0.0023	Small

Sample run results with Dewar and Detectors: LOS data

LOS (wrt IRCF) depends on the FPA centering, as well as optical fabrication and alignment. The following table shows the LOS results for the 21-case analysis.

LOS Error of the POA in the PDB Space
(Ref. surface is SAS, Image surface is DET)

Lib	ON AXIS				ALIGNMENT CHANNEL			
	Elevation		Azimuth		Elevation		Azimuth	
Nbr	Angle (deg)	Error (secs)	Angle (deg)	Error (secs)	Angle (deg)	Error (secs)	Angle (deg)	Error (secs)
(21 cases)								
Nominal	-25.3	-0.90	0.123	444.5	-24.62	0.4	0	0
Averages	-25.3	3.13	0.065	235.6	-24.60	50.48	0.002	8.10
Min	-25.34	-127	-0.060	-215.4	-24.65	-101.7	-0.061	-221.3
Max	-25.26	142	0.158	568.0	-24.56	199	0.055	198.6
Std Dev	0.027	99.13	0.075	268.7	0.029	105.87	0.035	125.6

Recommended Exceptions to Specifications (SSG only)

- **Imager EFL should be changed to 242 $\pm$ 4 mm**
- **Relay Magnification should be changed to -.188 $\pm$ .015.**

SSG HIRDLS CDR
Optical Design Status
HIRDLS Channel-to-channel focus error

Howard E. Morrow, July 17, 1997

The tabulation below shows the current values of each component contributing to inter-channel focus error. The errors in this list are included in the Monte-Carlo tolerance budget, with apparently satisfactory results on most measures of performance. The few performance exceptions would not be significantly improved by tighter focus tolerance.

Unless otherwise stated, all units are mm.

Source	Error	Focus error	(Comments)
Detector height			
(Within a clip)	±0.0005	±0.0005	(Due to etch variations)
(Clip-to-clip)	±0.009	±0.009	(Due to substrate & glue variations)
FPA tilt wrt dewar flange	0.1 deg	±0.0049	(For corner detectors at R=2.83)
Cold filter thickness	±0.010	±0.0075	
Sub totals for Dewar Assy			
(Worst case)		±0.0219	(Mainly applies to corners)
(RSS)		±0.0127	
Next assembly:			
OBA flange tilt (Corner detectors, again)	0.1 deg	±0.0049	
Fine focus tolerance	±0.025	±0.025	(Evenly applied over FPA)
Totals for System			

(Worst case)	±0.0518	(Mainly applies to corners)
(RSS)	±0.0285	

SSG HIRDLS CDR
Optical Design Status

HIRDLS Imager Tolerance Budget (Fabrication first, Alignment second)

July,1997 (Last run before SSG CDR)

(The following are selected and Pasted from the TOLSET Macro Suite)

```
MACRO FABTEL
C,TOLERANCE LIST, GEOMETRIC, MM, +/-
C,NONE FOR THE SCANNER (see macro FIGSCN)
PDBRAD = .050  {Radius of inner aperture, SSG 11/12/96
PRIRD = 1.0    {Radius of curvature, SSG 10/15/96. 38 microns edge sag
PRICC = .001   {Conic constant, SSG 10/15/96. 1.33 microns edge sag error
PRIOFF = .085  {Vertex to mech center offset, SSG 10/15/96
FS1AP = .025   {FS1 aperture
C,Secondary Rd and CC tolerances are controled by
C,'df' and 'd1' tolerances. Not possible to compute unique
C,Rd and CC tolerances from these controls. (ref notes)
DF = 260       {Separation of foci
DFTOL = .5     {Tolerance on DF (mm)
D1 = 130       {Vertex to first focus
D1TOL = .6     {Tolerance on D1 (mm)
SECOFF = .085  {Vertex to mech center offset, SSG 10/15/96
ILSRAD = .040  {Radius of inner aperture, SSG 11/12/96
C,NONE FOR FS2T Because only a temporary 'empty' FS2 is used now.

MACRO FABLEN
C,TOLERANCE LIST, GEOMETRIC, MM, +/-
ILSRAP = .040  {Rad. of inner aperture, SSG 10/15/96
c,None for FS2R because only a temporary 'empty' one is used now.
L1S1RD = .076  {More concave only, tol to be only NEGATIVE
L1TH = .050    {Thinner only, tol to be only NEGATIVE
L1S1CC = .0006 {Conic Const, SSG 10/15/96
L1S2RD = .026  {Less convex only, tol to be only POSITIVE
L1WEGE = .025  {Tot. Indic. Runout (Wedge), mm, SSG 10/15/96
SASRAD = .05   {Aperture radius
L2S1RD = .026  {Rad of cv, incl 1 fr power. SSG 10/15/96
L2TH = .050    {Center Thk, SSG 10/15/96
L2S2RD = .15   {2-nd rad of curv, SSG 10/15/96
L2S2CC = .0017 {Conic Const, SSG 10/15/96
```

SSG HIRDLS CDR
Optical Design Status

L2WEGE = .020 {Tot. Indic. Runout (Wedge), mm, SSG 10/15/96
WINDTH = .1 {Center Thk.
WINWEG = .01 {Window wedge (T.I.R.)

MACRO FABFLT
C,TOLERANCE LIST, GEOMETRIC, MM, +/-
WFTH = .075 {Thickness tolerance
WEDANG = 40 {Wedge angle in ArcSeconds
WEDEG = WEDANG/3600 {Wedge angle in Degrees
CFTH = .010 {C.F. Thickness Tolerance

SSG HIRDLS CDR
Optical Design Status

MACRO FABDET
C,TOLERANCE LIST, GEOMETRIC, MM, +/-
GRPHT = .003 {Aperture tolerance 'clip to clip', LMIRIS wanted .005.
LOCL = .001 {Aperture variation within a 'clip', LMIRIS wanted .0025
GRPZ = .009 {Focus tolerance clip-to-clip, .007 clip, .002 bond
LOCZ = .0005 {Focus tolerance within a 'clip'
C,For channels 1-5, the .100 BFD will be reduced by .002 (Thicker detectors)

MACRO FIGSCN
C,TOLERANCE LIST, GEOMETRIC, MM, +/-
C,Pk-to-pk deformation, 1/4 wave, surface, @.6328 microns. SSG, 12Nov96:
PKPK = .25*.000633 {pk-pk in mm

MACRO FIGPRI
C,TOLERANCE LIST, GEOMETRIC, MM, +/-
PKPK = .0001 {Initial max 'Z' sag for each term
C,Pk-pk figure error, 1/4 wave, surface, @.6328 microns. SSG, 12Nov96:
C,RMS = PKPK/4, agreement with SSG, 12Nov96. PRIRMS = .6328/8 microns
C,G-release = .167 waves @ .633 pkpk, Bi-metallic = .200 same units
C,Fig RMS = .25*.000633/4 = .00004 mm, Spec surface RMS in system units (mm)
C,G-rel RMS = .167*.0006328/4 = .0000264 mm
C,Bi-met RMS = .200*.0006328/4 = .0000316 mm
C,All-up RMS = sqrt[.00004^2+.0000264^2+.0000316^2]
PRIRMS = .000057 {All-up surface RMS in system units (mm)
MAXORD = 4 {MAXIMUM ORDER FOR THE ZERNIKE TERMS

MACRO FIGSEC
C,TOLERANCE LIST, GEOMETRIC, MM, +/-
PKPK = .0001 {INITIAL MAX 'Z' SAG FOR EACH TERM
C,Pk-pk deformation, 1/4 wave, surface, @.6328 microns. SSG, 12Nov96:
C,RMS = PKPK/4, agreement with SSG, 12Nov96. SECRMS = .6328/8 microns
C,G-release = .100 waves @ .633 pkpk, Bi-metallic = .200 same units
C,Fig RMS = .25*.000633/4 = .00004 mm, Spec surface RMS in system units (mm)
C,G-rel RMS = .100*.0006328/4 = .0000158 mm
C,Bi-met RMS = .200*.0006328/4 = .0000316 mm
C,All-up RMS = sqrt[.00004^2+.0000158^2+.0000316^2]
SECRMS = .000053 {All-up surface RMS in system units (mm)
MAXORD = 4 {Maximum order for the Zernike terms

SSG HIRDLS CDR
Optical Design Status

```
MACRO FIGL1
C,TOLERANCE LIST, GEOMETRIC, MM, +/-
PKPK = .0001          {Initial max 'Z' sag for each term
C,The Target surface RMS is for a combination of 3 deformations,
C,for BOTH surfaces and inhomogeniety.  Surf irreg each surface
C,is 2 FRINGES (1 wave),(@.5461), Pk-Valley.  SSG, 12Nov96.
C,Inhomog is .02 waves RMS WFE @ 3.39 microns.  SSG, 12Nov96.
C,RMS Surf. figure is 1*.55/4 = .1375 (agreed that RMS = pkpk/4)
C,Surf. Equiv. Inhomo. is .02*3.39/(n-1) = .0226 microns RMS.
C,Thus Equiv Surf RMS = sqrt[2*(.1375)^2 + (.0226)^2].
L1RMS = .000196      {Target surface RMS in system units (mm)
MAXORD = 3          {Maximum order for the Zernike terms
```

```
MACRO FIGL2
C,TOLERANCE LIST, GEOMETRIC, MM, +/-
PKPK = .0001            {Initial max 'Z' sag for each term
C,The Target surface RMS is for a combination of 3 deformations,
C,for BOTH surfaces and inhomogeniety.  Surf irreg each surface
C,is 2 FRINGES (1 wave),(@.5461), Pk-Valley.  SSG, 12Nov96.
C,Inhomog is .02 waves RMS WFE @ 3.39 microns.  SSG, 12Nov96.
C,RMS Surf. figure is 1*.55/4 = .1375 (agreed that RMS = pkpk/4)
C,Surf. Equiv. Inhomo. is .02*3.39/(n-1) = .0226 microns RMS.
C,Thus Equiv Surf RMS = sqrt[2*(.1375)^2 + (.0226)^2].
L2RMS = .000196      {Target surface RMS in system units (mm)
MAXORD = 3           {Maximum order for the Zernike terms

C,(Assume the FOLD mirror and the Vacuum WINDOW have negligibla figure
errors

MACRO LOCTEL
C,Installation Tolerance list, +/- mm and degrees
C
SCNX = .1  {Scanner will not be dislocated (see BRU NOSCNR
SCNY = .1  {because 1) It doesnt affect optical performance
SCNZ = .1  {2) Need to keep a handle on the IRCF location
SCNB = .01 {3) It probably will not be present during alignment
SCNC = .01 {4) Only it's FIGURE is important (macro FIGSCN)
C
PDBX = .1    {ALIGNMENT coordinate system origin
PDBY = .1    {Offsets from ideal locations
PDBZ = .1
PDBB = .03   {Tilts (~.1/200) from ideal orientstion
PDBC = .03
PDBA = .03
C
PRIX = .1
PRIY = .1
PRIZ = .1
PRIA = .023   {= 1.4 arcmin, RSS of 1 arcmin for element fab
PRIB = .023   {and 1.0 arcmin mount fab errors.
PRIC = .023
```

SSG HIRDLS CDR
Optical Design Status

C
FS1X = .1
FS1Y = .1
FS1Z = .1
FS1A = .05 {local gamma only, B & C tilts not used
C
SECX = .1
SECY = .1
SECZ = .1
SECA = .023 {= 1.4 arcmin, RSS of 1 arcmin for element fab
SECB = .023 {and 1.0 arcmin mount fab errors.
SECC = .023
C
ILSTX = .1 {This is the final ILS for the system
ILSTY = .1
ILSTZ = .1 {No ILST tilt errors
C
FS2TX = .1 {This is temporary FS2 'tooling' for
FS2TY = .1 {the Telescope segment only
FS2TZ = .1
FS2TA = .05 {local gamma only, B & C tilts not used

MACRO LOCLEN
C,Installation Tolerance list, +/- mm and degrees
c,All errors wrt IRCF GLOBAL coordinates
C
ILSRX = .1 {This is temporary ILS tooling for relay alignment
ILSRY = .1
ILSRZ = .1 {No ILSR tilt errors applied
C
FS2RX = .1 {This is the Final FS2
FS2RY = .1
FS2RZ = .1
FS2RA = .05 {LOCAL gamma rot. wrt IRCF X
C
L1X = .1 {Germ L1 location error
L1Y = .1
L1Z = .1
L1B = .01

SSG HIRDLS CDR
Optical Design Status

```
L1C = .01    {No L1 LOCAL gamma error, (IRCF rX)
C
FLDX = .1    {Fold mirror location error
FLDY = .1
FLDZ = .1
FLDA = .01   {Fold angle will be adjusted during alignment
FLDB = .01
FLDC = .01   {Compound rot error wrt IRCF
C
SASX = .1
SASY = .1
SASZ = .1    {No SAS tilt errors
C
L2X = .1    {Germ L2 location error
L2Y = .1
L2Z = .1
L2A = .01
L2C = .01    {No L2 LOCAL gamma error, (IRCF rY)
C
C,          No inst. errors modeled for the ZnSe window
C
c,Dewar assembly will be adjusted (x,y,z,rot) during alignment
DEWA = .1   {Alpha, beta tilt of DEWar assy due to SSG
DEWC = .1   {flange angle tolerance, degrees.
C
CSHX = .1    {Cold Shield location error
CSHY = .1
CSHZ = .1
CSHA = 0
CSHB = .2    {Just 'gamma' rotation
CSHC = 0
C
DETA = .1   {Alpha, beta tilt of Detector assy w.r.t.
DETC = .1   {LMIRIS dewar flange error, degrees
```

(The following are selected and Pasted from the ALINEM Macro Suite)

```
MACRO COLPDB
C,For HIRDLS, sets up a 'Collimator' with axial ray
```

C,almost normal to the PDB, by tilting dummy surf 1.
Note: no tolerance is applied because the error in collimating
is much less than ther error already in the PDB tilts.

MACRO ANGPRI
C,Tolerance list for alignment targets ** TOLERANCE LIST **
ALFA = .010*TM {Degrees of uncertainty for ALPHA settability
BETA = .005*TM {Degrees of uncertainty for BETA settability
C,Above values need to be substantiated/confirmed.

MACRO OFFPRI
C,Tolerance list for alignment targets **** TOLERANCE LIST ****
DELX = .1*TM {mm uncertainty in x-centering in FS1
DELY = .1*TM {mm uncertainty in x-centering in FS1
DELZ = .05*TM {mm uncertainty in x-centering in FS1
C,The above DELZ value needs to be substantiated/confirmed

MACRO ADJSEC
C,Tolerance list for alignment targets **** TOLERANCE LIST ****
DELX = .1*TM {mm uncertainty in X-centering in FS2
DELY = .1*TM {mm uncertainty in Y-centering in FS2
DELZ = .05*TM {mm uncertainty in Z-centering (focus) in FS2
ALFA = .010*TM {Deg of uncertainty for ALPHA setability
BETA = .005*TM {Deg of uncertainty for BETA setability
C,The above DELZ, ALFA, BETA values need to be substantiated/confirmed

MACRO SETILS
C,Tolerance list for alignment targets **** TOLERANCE LIST ****
DELX = .1*TM {mm uncertainty in x-centering in ILS
DELY = .1*TM {mm uncertainty in x-centering in ILS

MACRO DOFOLD
C,Tolerance list for alignment targets **** TOLERANCE LIST ****
ALFA = .010*TM {Deg of uncertainty for ALPHA setability
BETA = .005*TM {Deg of uncertainty for BETA setability
C,The above values need to be substantiated/confirmed

MACRO INTEG
C,Tolerance list for alignment targets **** TOLERANCE LIST ****

SSG HIRDLS CDR
Optical Design Status

DELX = .1*TM {mm uncertainty in X-matching the FS2s
DELY = .1*TM {mm uncertainty in Y-matching the FS2s
DELZ = .1*TM {mm uncertainty in Z-matching (focus direction)the FS2s
ALFA = .05*TM {Deg. of uncertainty for ALPHA setability
BETA = .05*TM {Deg. of uncertainty for BETA setability
C,The above DELZ, ALFA, BETA values need to be substantiated/confirmed

MACRO FINFOC
C,Tolerance list for alignment targets **** TOLERANCE LIST ****
DELX = .1*TM {mm uncertainty in X-centering the detector
DELY = .05*TM {mm uncertainty in Y-centering the detector
DELZ = .025*TM {mm uncertainty in Z-focus of the detector
GAMA = .05*TM {Deg. of uncertainty for ALPHA setability

(End of Fabrication and Alignment Tolerance Budget list)

HIRDLS

Optical
Alignment Procedure

- Lens Assembly Integration

SSG HIRDLS CDR
Optical Design Status

Kris E. Kosakowski
7/1/97

DOGLEG ASSEMBLY PROCEDURE

1. The lens tubes will be manufactured to less than 0.0005″ (OD tube centration with respect to lens mount, and surface parallelism) and all interface surfaces will be lapped. The mechanical parts will be inspected and dimensions identified.

2. Inspect the optical components (FM-4, Lens-1 and Lens-2) and identify optical dimensions.

3. Generate fabrication adjustment and relocate optical components in the Z-direction.

1. Mount the FM4 housing on the rotary table and align the ID of the Lens-2 leg to the rotation axis of the table. Couple the lens-2 tube to the cube and aligned with respect to the center of rotation and parallel to the mounting flange with respect to the air bearing table surface. Error in motion radial, axial and tilt of the air-bearing table is < 1 micro-inch, < 1 micro-inch and < 0.1 micro-radian.

1. Lens-2 mounting flange, which contains the SAS (3), will be installed with centration and parallelism to 0.0005″ with respect to the lens tube. Once centration is established the flange will be fastened to the lens tube.

2. Clock the cube 90° and align the lens-1 leg to the rotation axis of the table. Couple the lens-1 tube to the cube and aligned with respect to the center of rotation and parallel to the mounting flange with respect to the air bearing table surface.

1. Two flat alignment glasses (etched with cross hairs identifying the center of the diameter) will be temporarily mounted with the rotary air-bearing table, at lens-1 and lens-2 location to 0.0005″ centration.

SSG HIRDLS CDR
Optical Design Status

2. The alignment telescope will be position at glass-1 such that it is perpendicular and aligned to the cross hairs.

3. The fold mirror (4) will be installed and then align so the two cross hairs of each alignment glass are superimposed.

4. Install and align surrogate warm filter housing on the rotary air-bearing table.

5. Install the FS2 alignment mask (Crosshatches at the center of every field point) using the air-bearing table. FS2 will be aligned with respect to the center of rotation of the tube, which is boresighted to the SAS and parallel to the mounting flange. Pin the FS2 housing which contains the mask to the filter mount and check for repeatability.

6. Steps 13 through 16 will be implemented after the dogleg has been aligned to the Louis Tube.

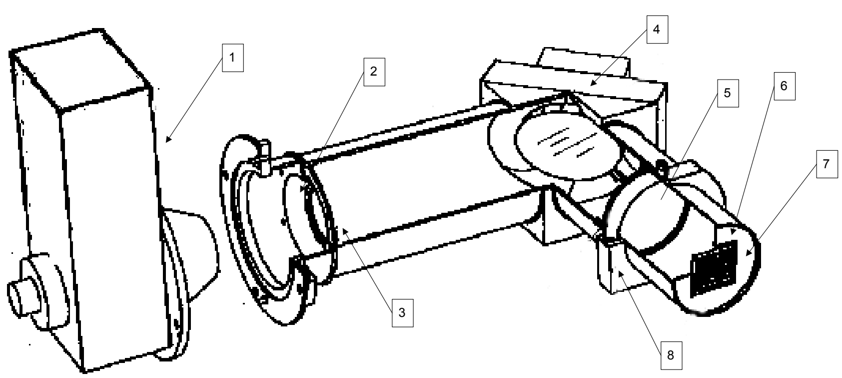
SSG HIRDLS CDR
Optical Design Status

7. Alignment glass will be removed and lens-1 (2) and lens-2 (5) will be installed with the rotary air-bearing table.

8. The Filter-FS2 housing will be placed vertically on the air-bearing table. The tube will be aligned with respect to the center of rotation and parallel to Lens-1 tube mounting flange.

9. The warm filter housing will be aligned on the rotary air-bearing table with respect to the center of rotation and parallel to Lens-1 tube mounting flange.

10. Install the FS2 (Crosshatches at the center of every field point) using the air-bearing table. FS2 will be aligned with respect to the center of rotation of the tube, which is boresighted to the SAS and parallel to the mounting flange. Pin the FS2 housing which contains the mask to the filter mount and check for repeatability.



SSG HIRDLS CDR

Optical Design Status

Filters and Lenses

@ 10.6uM

Item	Motion for Sensitivity	RMS WFE Sensitivity		Laboratory Motion	Resultant Sentivity	Square of Sentivity
Center of Field						
ΔX Filter 1	0.010	0.000		0.001	0.0000	0.00E+00
ΔY Filter 1	0.010	0.000		0.001	0.0000	0.00E+00
ΔZ Filter 1	0.010	0.000		0.001	0.0000	0.00E+00
Δα Filter 1	0.010	0.000		0.001	0.0000	0.00E+00
Δβ Filter 1	0.010	0.000		0.001	0.0000	0.00E+00
Δγ Filter 1	0.010	0.000		0.001	0.0000	0.00E+00
ΔX LENS 1	0.010	0.004		0.001	0.0004	1.60E-07
ΔY LENS 1	0.010	0.004		0.001	0.0004	1.60E-07
ΔZ LENS 1	0.010	0.001		0.001	0.0001	1.00E-08
Δα LENS 1	0.010	0.003		0.001	0.0003	9.00E-08
Δβ LENS 1	0.010	0.003		0.001	0.0003	9.00E-08
Δγ LENS 1	0.010	0.000		0.001	0.0000	0.00E+00
ΔX Fold 1	0.010	0.000		0.001	0.0000	0.00E+00
ΔY Fold 1	0.010	0.000		0.001	0.0000	0.00E+00
ΔZ Fold 1	0.010	0.006		0.001	0.0006	3.60E-07
Δα Fold 1	0.010	0.014		0.001	0.0014	1.96E-06
Δβ Fold 1	0.010	0.019		0.001	0.0019	3.61E-06
Δγ Fold 1	0.010	0.000		0.001	0.0000	0.00E+00
ΔX LENS 2	0.010	0.004		0.001	0.0004	1.60E-07
ΔY LENS 2	0.010	0.004		0.001	0.0004	1.60E-07
ΔZ LENS 2	0.010	0.000		0.001	0.0000	0.00E+00
Δα LENS 2	0.010	0.021		0.001	0.0021	4.41E-06
Δβ LENS 2	0.010	0.021		0.001	0.0021	4.41E-06
Δγ LENS 2	0.010	0.000		0.001	0.0000	0.00E+00
ΔX Filter 2	0.010	0.000		0.001	0.0000	0.00E+00
ΔY Filter 2	0.010	0.000		0.001	0.0000	0.00E+00
ΔZ Filter 2	0.010	0.000		0.001	0.0000	0.00E+00
Δα Filter 2	0.010	0.001		0.001	0.0001	1.00E-08
Δβ Filter 2	0.010	0.001		0.001	0.0001	1.00E-08

SSG HIRDLS CDR

Optical Design Status

Δγ Filter 2	0.010	0.000		0.001	0.0000	0.00E+00
ΔX Filter 3	0.010	0.000		0.001	0.0000	0.00E+00
ΔY Filter 3	0.010	0.000		0.001	0.0000	0.00E+00
ΔZ Filter 3	0.010	0.000		0.001	0.0000	0.00E+00
Δα Filter 3	0.010	0.000		0.001	0.0000	0.00E+00
Δβ Filter 3	0.010	0.000		0.001	0.0000	0.00E+00
Δγ Filter 3	0.010	0.000		0.001	0.0000	0.00E+00
					Sum of the	1.56E-05
					Squares	
					RSS Value	**0.0039**

Hardware List:

- Mirror Fixture: Double plate with ultra-fine threaded screws
- Barrel clamp for lens tube
- Optical Alignment Telescope
- Translation stages
- CMM
- Air Bearing table
- Etched Optical Flat (BK7)
- Gauge Pins