DELTA PRE-SHIP REVIEW REQUEST FOR ACTION NO. 1

Project:	**EOS**
Spacecraft/Observatory:	**Aura**
Instrument:	**HIRDLS**
REVIEW	**Delta Pre-Ship Review**
Date:	**21 November 2002**

Reviewer: D. Dillman, C. Mutlow
Phone #: 301-286-7237/44-011-1235-44-6525
Organization: NASA GSFC c300/RAL

Subject Area: Pointing Stability (Issues/Section 3/p. 3-12)

SPECIFIC REQUEST:

1) Request: Provide a technical note on the science impact of the jitter phenomenon seen at Oxford. Also include jitter amplitude and frequency thresholds where science is impacted.

2) Request: Describe what testing and/or analysis will be done at TRW with HIRDLS mated to the Observatory that will assure us that the jitter phenomenon is not a concern for flight.

3) Request: Describe if/how jitter can be measured on-orbit.

SUPPORTING RATIONALE:

Science impact was described as anything from "can be processed out" to "severely degraded or useless" depending on amplitude and frequency of the jitter. Need to understand how jitter will affect science and if/how much jitter is present once the HIRDLS is mated to the Observatory.

DELTA PRE-SHIP REVIEW REQUEST FOR ACTION NO. 2

Project:	**EOS**
Spacecraft/Observatory:	**Aura**
Instrument:	**HIRDLS**
REVIEW	**Delta Pre-Ship Review**
Date:	**21 November 2002**

Reviewer: Richard Schoolar
Phone #:
Organization: Aerospace Corporation

Subject Area: Cryodiode Anomaly

SPECIFIC REQUEST:

What is the plan for using the D0 cryodiode? Shouldn't it be declared a failed part and replaced with D1 as primary?

SUPPORTING RATIONALE:
D0 cryodiode showed a step function at LM. It has also shown some instabilities during calibration at Oxford. In my opinion D0 should not be counted on for inflight operations, not even as backup. This should be addressed to the program office, not a calibration issue.

DELTA PRE-SHIP REVIEW REQUEST FOR ACTION NO. 3

Project:	**EOS**
Spacecraft/Observatory:	**Aura**
Instrument:	**HIRDLS**
REVIEW	**Delta Pre-Ship Review**
Date:	**21 November 2002**

Reviewer: Robert Kichak
Phone #: 301-286-1199
Organization: NASA/GSFC/560

Subject Area: Telemetry Loss/QB Current Increase

SPECIFIC REQUEST:

Regarding Issue #17 "Tlm loss/QB current Increase."

a) add EGSE ground fault monitor (e.g.strip chart channel) to monitor for possible current to structure.

b) Once TV chamber is open, carefully examine setup cabling, particularly those inside the chamber. Insulation resistance, hi-pot, visual inspection, possible x-ray, and partial dissambly for detailed inspection of power wiring terminations would appear to be appropriate.

SUPPORTING RATIONALE:

DELTA PRE-SHIP REVIEW REQUEST FOR ACTION NO. 4

Project:	**EOS**
Spacecraft/Observatory:	**Aura**
Instrument:	**HIRDLS**
REVIEW	**Delta Pre-Ship Review**
Date:	**21 November 2002**

Reviewer: Robert Kichak
Phone #: 301-286-1199
Organization: NASA/GSFC/560

Subject Area: Electrical Issues on Page 3.8 & 3.13

<u>SPECIFIC REQUEST:</u>

Provide information regarding the resolution of the following issues:

#13. IFC Telemetry Jumps

#20. CS02 Resets

<u>SUPPORTING RATIONALE:</u>

DELTA PRE-SHIP REVIEW REQUEST FOR ACTION NO. 1

Project:	**EOS**
Spacecraft/Observatory:	**Aura**
Instrument:	**HIRDLS**
REVIEW	**Delta Pre-Ship Review**
Date:	**21 November 2002**

Reviewer: D. Dillman, C. Mutlow
Phone #: 301-286-7237 / 44-011-1235-44-6525
Organization: NASA GSFC c300/RAL

Subject Area: Pointing Stability (Issues/Section 3/p.3-12)

SPECIFIC REQUEST

1) Request: Provide a technical note on the science impact of the jitter phenomenon seen at Oxford. Also include jitter amplitude and frequency thresholds where science is impacted.

2) Request: Describe what testing and/or analysis will be done at TRW with HIRDLS mated to the Observatory that will assure us that the jitter phenomenon is not a concern for flight.

3) Request: Describe if/how jitter can be measured on-orbit.

SUPPORTING RATIONALE

Science impact was described as anything from "can be processed out" to "severely degraded or useless" depending on amplitude and frequency of the jitter. Need to understand how jitter will affect science and if/how much jitter is present once the HIRDLS is mated to the Observatory.

INSTRUMENT TEAM RESPONSE

Author: B. Mankin/A. Lee/M. Dials
Phone #: 303-497-1403/-8068/-8067
Organization: NCAR/UCB-CLAS

Section 1.

Request: Provide a technical note on the science impact of the jitter phenomenon seen at Oxford. Also include jitter amplitude and frequency thresholds where science is impacted.

Early in the calibration of HIRDLS at Oxford, it was observed that the signal varied cyclically at a frequency of 39 Hz when viewing targets with steep radiance gradients. Investigation indicated that the line of sight (LOS) was varying approximately sinusoidally with an amplitude of about 5 arcsec (or perhaps 10 as an extreme upper bound), p–p relative to the source. Simultaneous determination of the elevation encoder readings showed that the scan mirror was vibrating by an amount corresponding to 2 arcsec p–p LOS motion. The additional apparent motion is most likely due to a resonance of some part of the test equipment. The excitation for the jitter is clearly the mechanical coolers; it is at just the drive frequency of the coolers, and disappears if the coolers are switched off briefly. The resonance is indicated by the fact that the amplitude of the jitter in the LOS is reduced substantially by reducing the cooler drive frequency from 39 to 38 Hz. Design, analysis, and testing all indicate no resonances in the HIRDLS instrument at frequencies this low.

It is believed that the only component of the LOS jitter which will be present in orbit is that represented by motion of the scan mirror, indicated by the encoder readings. However, the purpose of this document is to show the impact of jitter on the scientific observations if jitter were present with the magnitude observed in calibration. Section 3 below indicates a way to measure and remove jitter effects in orbit if it is necessary.

Let *N(z)* represent the atmospheric radiance at height *z* in some HIRDLS channel, convolved with the (instantaneous) HIRDLS field of view. The signal at time *t* will be

$$S(t) = \int_{-\infty}^{t} N(t')R(t-t')dt' \qquad (1)$$

where *R* is the impulse response function of the signal processing chain. Since *N(t)* is *N(z(t))*, where *z(t)* is the tangent height of the instantaneous line of sight, and *z(t)* is (for present purposes) a linear scan plus a jitter term.

$$z(t) = \alpha t + \beta \cos(2\pi f_j t) \qquad (2)$$

where α is the linear scan rate, 15.7 km/sec in global mode, and β is the amplitude of the jitter, about .05(TBV) km with the observed amplitude during calibration, and f_j is the jitter frequency, which is the same as the cooler operating frequency, 39 Hz.

At any time *t*, we expand the radiance at the line of sight in a Taylor series about the nominal line of sight position at *z(t)*, so that

$$N(t) = B(\alpha t) + \beta \cos(2\pi f_j t) dB/dz + \tfrac{1}{2}\left(\beta \cos(2\pi f_j t)\right)^2 d^2B/dz^2 + \ldots \qquad (3)$$

plus higher order terms in the expansion, which will be seen to be negligible. Neglecting the higher order terms, and expanding the $\cos^2$ function, we obtain

$$N(t) = B(\alpha t) + \beta \cos(2\pi f_j t) dB/dz + (\beta^2/4) d^2B/dz^2 + (\beta^2/4)\cos(4\pi f_j t) d^2B/dz^2 \qquad (4)$$

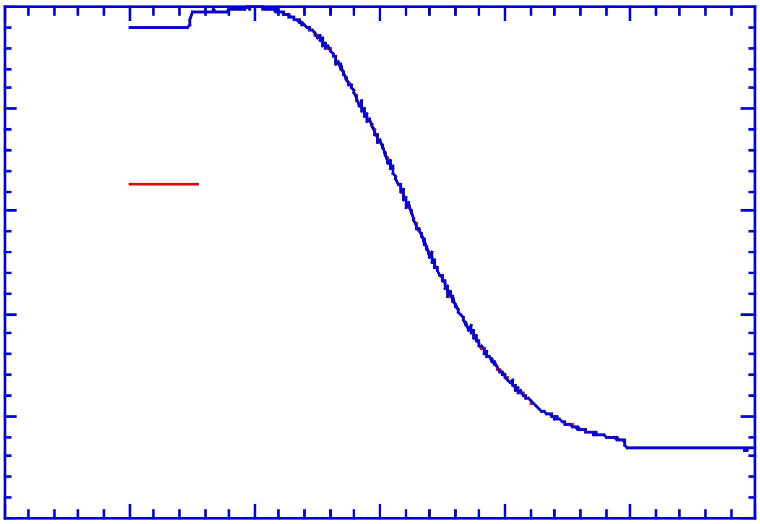
Then the signal as a function of time becomes

$$S(t) = \int_{-\infty}^{t} [B(\alpha t') + \beta \cos(2\pi f_j t') dB/dz + (\beta^2/4) d^2B/dz^2 + (\beta^2/4)\cos(4\pi f_j t') d^2B/dz^2] R(t-t') dt' \qquad (5)$$

The impulse response function is largely dominated by the FIR digital filter, primarily a low pass filter. When the convolution with the impulse response function is taken, the harmonically varying time dependent terms go to zero because the transmission of the FIR filter is sensibly zero at 39 Hz. Basically, since the highest atmospheric signal frequency (at the global scan rate) is approximately 9.8 Hz (1.6 km wavelength) and the jitter frequency is 39 Hz, we can filter out the jitter without loss of atmospheric signal.

Therefore the fractional error term is just $B^{-1}(z)(\beta^2/4)d^2B/dz^2$. Since $d^2 \ln(B)/dz^2 \sim (1/H)^2$, where H is the scale height, we have that the fractional error in the radiance is $\sim(\beta/2H)^2$. For β = 50 meters and H = 6 km, this has a numerical value of $1.7\text{x}10^{-5}$, totally negligible in relation to our required precision of 0.5%. Thus in the global mode, the jitter would have to reach 1200 meters p–p, or 80 arcsec p–p , to make an error of 0.25% in the measured radiance, the level at which it would begin to have an impact on the science.

To verify these calculations, we have run simulations with the HIRDLS Radiometric Model (HIRAM). We used channel 2, one of the temperature sounding channels, because these have the highest precision requirements. We simulated the generation of the measured radiance profile at global scan rate for the standard HIRDLS fiducial radiance profile, using specified detector noise and no jitter; then we ran the simulation again with a jitter term added to the pointing with a p–p amplitude of 140 arcsec p–p, a factor of 28 greater than observed at Oxford, so that the offset errors, 780 times larger than for 5 arcsec, as indicated above, would be large enough to see. The difference in the simulated measurements is shown, along with the radiance profile in Fig. 1. Note that as expected, the effect, as a percent of signal, is largest at the altitude where the radiance profile is changing most rapidly. The error is about 0.45% at 53 km. Scaling the result to 5 arcsec of jitter, the error is 0.0006% of the signal at an altitude of 53 km; this error is only 0.01% of the measured radiometric noise. Both of these values have a negligible science impact.



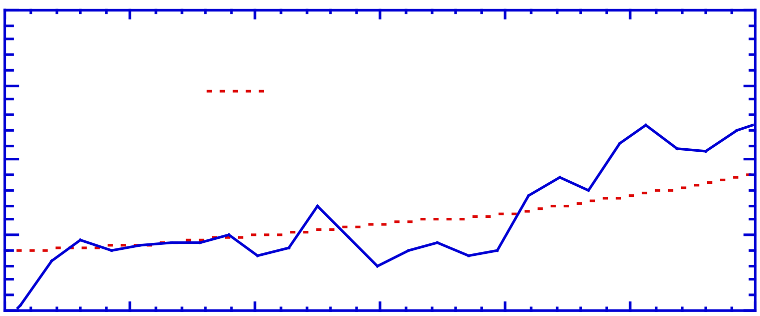


Figure 1. Simulations of the effect of 2.2 km p-p jitter at 39 Hz on the retrieved radiance profile in Channel 2. Simulations were performed using HIRAM (HIRDLS Radiometric Model). The lower panel shows a magnified view of the fractional error near the top of the scan where the error is largest, along with the values calculated from the equations above.

Section 2.

Request: Describe what testing and/or analysis will be done at TRW with HIRDLS mated to the Observatory that will assure us that the jitter phenomenon is not a concern for flight.

Given the results of Section 1, we believe that there is no need for any special testing at TRW with HIRDLS mated to the Observatory. We will continue to monitor the encoder data, which we now have characterized, for jitter trending.

Section 3.

Request: Describe if/how jitter can be measured on-orbit.

In the global mode of operation, the sample frequency is 83 Hz, so the sampling theorem says that the highest frequency that can be measured unambiguously (i.e., without other frequencies aliasing to the same measurement) is half that, or 41.5 Hz. We use a finite impulse response digital filter to filter out higher frequencies. Because the filter cannot be made infinitely sharp, it attenuates severely at 39 Hz, the nominal jitter frequency. By opening up the digital filter (making the cutoff frequency greater than the Nyquist frequency), we can see the signal at the jitter frequency, but with aliases which increase the noise and make the frequency ambiguous. If there is significant jitter, however, we should be able to remove the frequency ambiguity with the additional knowledge that the source of the jitter is the cooler, and being essentially monochromatic, we should easily pick out the amplitude of the jitter from the noise, since if the amplitude is sufficiently small that it cannot be seen clearly above the noise, it will have no impact on the data. We can then use additional filtering on the ground to remove the jitter frequencies and the aliased noise from the data, provided that $83 - f_D > f_S$, where f_D is the cutoff frequency of the digital filter onboard and f_S is the highest frequency of interest in the signal.

Alternatively, we can sample at up to 500 Hz for a limited number of channels, allowing measurement of signals up to 250 Hz without alias. In this high sample rate mode, we could measure the jitter in the data stream. Using the fact that the signal at the jitter frequency is the product of the jitter amplitude and the gradient of the atmospheric radiance, which is determined from the data, we can determine the jitter amplitude and phase and compare it with signals at the jitter frequency from the elevation encoder. This will allow measurement at a single time, but we expect that the jitter will be relatively constant as long as the cooler conditions (stroke, power, frequency) remain the same; in this case the jitter amplitude can be used to correct the data for the d.c.

effect of jitter amplitude squared. We obviously would want to use this measurement mode sparingly since it sacrifices the data from most of the channels.

DELTA PRE-SHIP REVIEW REQUEST FOR ACTION NO. 2

Project:	**EOS**
Spacecraft/Observatory:	**Aura**
Instrument:	**HIRDLS**
REVIEW	**Delta Pre-Ship Review**
Date:	**21 November 2002**

Reviewer: Richard Schoolar
Phone #:
Organization: Aerospace Corporation

Subject Area: Cryodiode Anomaly

SPECIFIC REQUEST

What is the plan for using the D0 cryodiode? Shouldn't it be declared a failed part and replaced with D1 as primary?

SUPPORTING RATIONALE

D0 cryodiode showed a step function at LM. It has also shown some instabilities during calibration at Oxford. In my opinion D0 should not be counted on for inflight operations, not even as backup. This should be addressed to the program office, not a calibration issue.

INSTRUMENT TEAM RESPONSE

Author: Douglas M. Woodard
Telephone Number: 303-497-8064
Organization: University of Colorado at Boulder - Center for Lower Atmospheric Studies

HARDWARE STATUS

1. Cryotip temperature measurement using the cryodiode D0 channel must be considered a failed function, although, as of this writing, it is again functioning normally; isolation of the failure to a particular component has not been undertaken due to the highly invasive, and therefore high risk, nature of the required disassembly that would be required for a more detailed failure diagnosis.

2. The D1 cryotip temperature measurement channel functioned normally throughout calibration operations at Oxford and was fully functional as of the BAT preceding shipment to TRW.

RECOMMENDATION

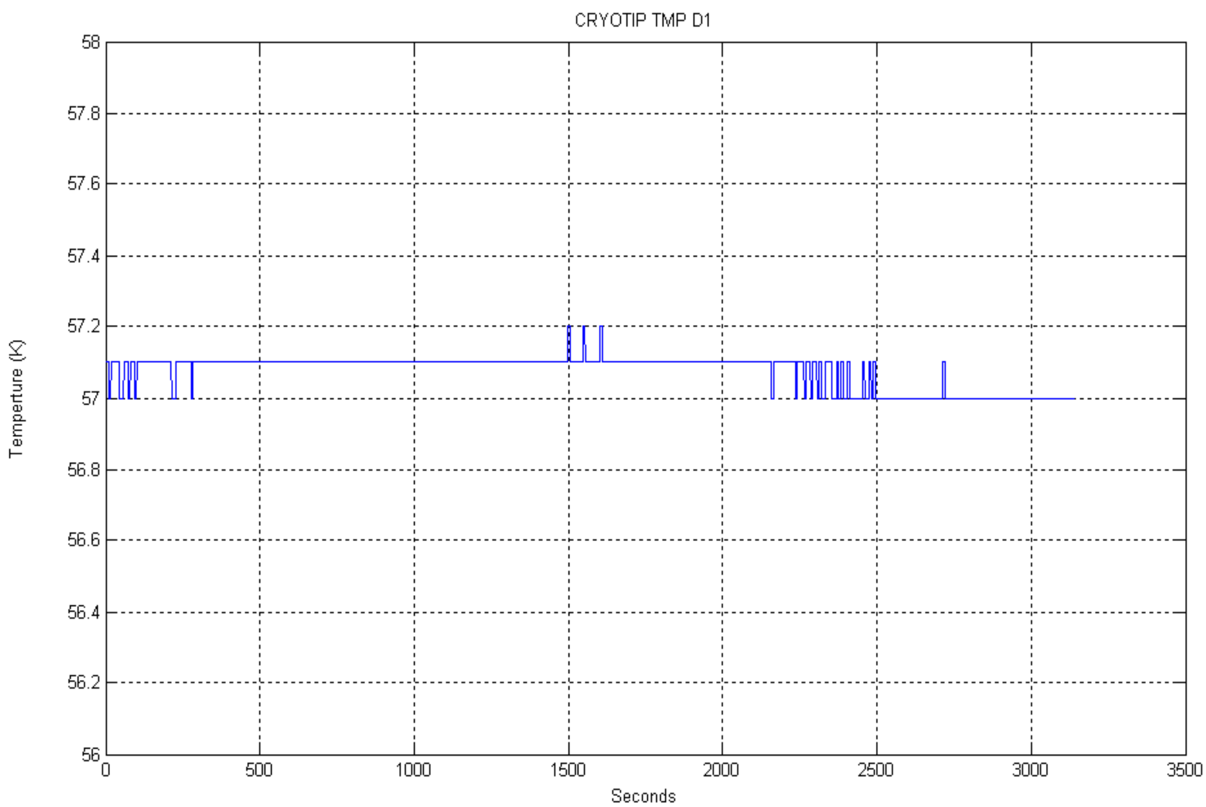
Use as is with the D1 sensor channel as primary and with appropriate operational workarounds in hand should the D1 channel fail in flight.

JUSTIFICATION FOR RECOMMENDATION

1. The cryotip temperature sensors are needed only for closed-loop control of the cryotip temperature using the Temperature Control Mode option of the Cooler Control Unit. The D0 and D1 sensors are not needed for knowledge of focal-plane temperature as there are redundant, and currently fully functional, Cernox temperature sensors mounted on the focal-plane substrate for this purpose.

2. In the event of failure of both cryotip temperature sensor channels, the Cooler Control Unit can be operated in the Commanded Stroke mode, wherein the cooler stroke is set by either ground commands or commands issued by an onboard SAIL task. Manual stroke control has been demonstrated under simulated orbital conditions.

The graph below shows the cryotip temperature as sensed by D1 over a 53 minute period on day 2002_310; the cooler stroke was manually set to a constant value over this period. Note that the cryotip temperature remained constant over this period to within +/- one quantization level (0.1 K), which is as good as can be achieved with CCU closed loop control.



*** D R A F T ***

February XX, 2002

TO: 301/Systems Review Office/Dennis Dillman

FROM: 424/EOS Aura Project/Glenn Jackson

SUBJECT: HIRDLS Delta Pre-Ship Review (DPSR) RFA #5 Response

Request for Action:
For the HIRDLS In Flight Calibrator (IFC) Telemetry Jumps, determine the root cause. If a design problem is confirmed to be the root cause, as has been postulated, implement the appropriate circuit fix and retest as required or explain how the IFC can be used as is (i.e. what viable work-arounds can be implemented if both IFCs were to develop glitches on orbit).

Rationale:
The IFC successive approximation logic design implementation uses combination logic outputs to control flip-flops. Dependent on timing, it appears that this design approach can be prone to "glitches". It is not apparent that the observed glitching, although so far only seen on the "A" side and at ambient pressure conditions, could not possibly shift with normal on-orbit factors including part aging, cumulative radiation dose, and voltage variations such that the effect might worsen, occur in the instrument normal operating range, and possibly occur on both the A and B sides. It appears that a hardware fix for this ultimately most likely will be needed if it is verified that the telemetry jumps are the manifestation of a fundamental design issue, since such glitches will be most likely not be able to be successfully characterized with any degree of certainty. A digital deglitching circuit fix, if implemented, would in itself not seem to be an issue that would necessitate instrument re-calibration. This is most important and should be verified ASAP. An appropriate circuit fix could be relatively simple, and should to be requalified through component-level testing. The problem was seen in instrument ambient testing, so extended ambient testing at the instrument level coupled with normal observatory integration and testing should be adequate to confirm the fix when coupled with a full box-level test. The issue of instrument disassembly, reassembly, and penalty testing would, however, need to be addressed dependent on the level of difficulty in IFC removal and replacement.

Originator:
Robert Kichak

Executive Summary:

The HIRDLS Instrument Team has decided to use the In Flight Calibrator system as-is without finding root cause to the temperature telemetry jump anomaly. This RFA response contains a description of the HIRDLS instrument system and how the IFC subsystem fits into the larger HIRDLS instrument system and operation. Investigation results to date are presented along with details regarding the disassembly procedure and risks involved with further investigation. Inaddition, three stages of viable in orbit work arounds are planned if the anomaly appears providing sufficient reassurance that Mission Success is still achievable. In summary, the HIRDLS Team's conclusion is the risk to the mission from the current anomaly is less than that due to trying to investigate to find root cause and correcting it.

HIRDLS Instrument and the In-Flight Calibrator Subsystem

The High Resolution Dynamics Limb Sounder (HIRDLS) measures radiance from the Earth's Limb and uses an onboard black body system for measuring the gain between the observed limb radiance and a calibrated radiance. This black body system is known as the In-Flight Calibrator (IFC). A simplistic schematic of the IFC inside the larger instrument system is shown in Figure X. The Detector Sub System (DSS) converts limb radiation to an analog signal, which is then converted to a digital signal in the Signal Processor Unit (SPU). The IFC consists of two parts: 1) Black Body Electronics Unit (BEU) and 2) the Black Body (BB). (Figures X and Figure X contain photos of these units). The analog temperature signal from the BB is converted to a digital signal in the BEU. The Instrument Processor Unit (IPU) gathers both the SPU and BEU digital signals and places the data in a telemetry stream for the spacecraft to read via a 1553 communication bus. During on the ground post-processing, the radiance gain is computed using the temperatures measured on orbit from the IFC and the calibration measurement data gathered at Oxford University in late 2002.

Figure X. IFC Black Body. Photo courtesy of Oxford University.

Figure X. IFC Black Body Electronics Unit (BEU). Photo courtesy of Oxford University.

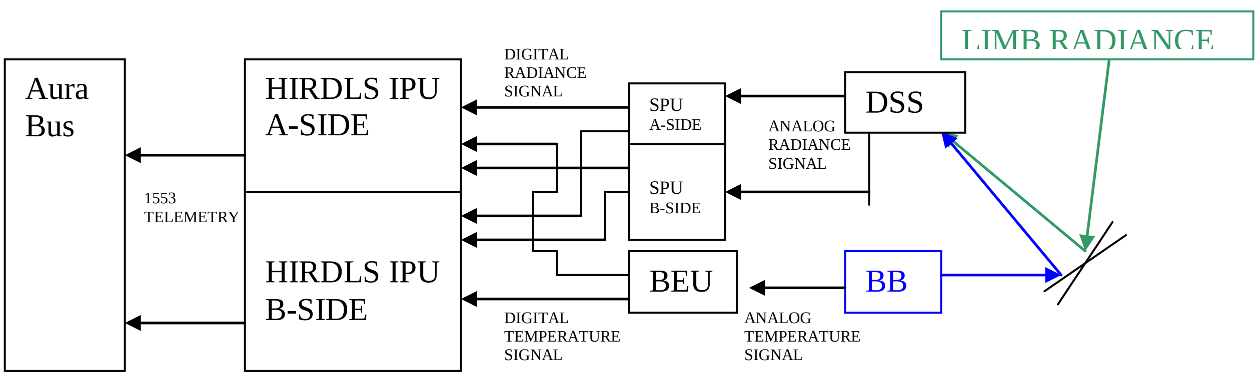


Figure X. Instrument Photon-to-Analog-to-Digital Flow Schematic. The SPU is cross strapped to both sides of the instrument, but the BEU is not. A scanning system (not shown) alternates the DSS field-of-view between the Limb, space and the on-board BB.

The in orbit IFC temperature is controlled directly in response to the heater duty cycle which is set by command. The thermodynamic response is slow, for example several hours when just a few degrees above the ambient. The electronic unit (BEU) temperature is not controllable, but reaches a thermal equilibrium with electronic component generated heat flux relative to the surrounding environment located inside the instrument.

Key to accurate operation of the in-flight calibration system is to achieve temperatures on the calibration optics and the black body as close as possible. Through testing it was found this is achievable via closed loop control and by letting the optics and black body settle to ambient temperature conditions.

In a physical or mechanical perspective, the entire IFC system is located inside the instrument near the optic train. The BB is located inside the instrument's compartment containing contamination sensitive electronics while the BEU is located in the adjacent instrument section bolted to an internal structural panel. Figure X and Figure X show the instrument and the location of the BEU.

INSERT FIGURE X. INSTRUMENT ISOMETRIC VIEW.

INSERT FIGURE X. INSTRUMENT WITH –Y PANEL OFF SHOWING BEU LOCATION.

Nature of the IFC anomaly:
Under certain operating conditions errors in the IFC temperature measurement have been observed. The errors manifest themselves as jumps to temperature levels, which in a majority of cases, have a binary code that ends with either a sequence of all “0s” or all “1s”. This behavior in data acquisition is usually caused by errors in an A/D successive approximation process. The anomaly consists of one bit of the raw telemetry for an IFC temperature measurement being incorrect. Because of the way that the A-D convertor works, the lower order bits should then all be in the sense which attempts to correct the error, so they will all be 0 or 1 depending upon whether the incorrect bit has cause the apparent value to be too high or too low. The affect bit varies. It is also possible that more than one bit could be affected simultaneously. Figure X is a plot of typical IFC temperature telemetry anomaly.

INSERT FIGURE X. TYPICAL ANOMALY PLOT. BB TEMP TELEM VS TIME.

The certain operating conditions for the error to appear to date include operation at ambient temperatures, in ambient pressures, and in A-side mode. No anomalies have been encountered on the B-side or in vacuum or at non-ambient temperatures.

Anomaly Investigation Activity to Date:

To date the investigation into this anomaly involved data mining of instrument telemetry from box level testing, instrument level testing and calibration testing. This anomaly was first seen after thermal vacuum testing at Lockheed Martin in Palo Alto, California (See Appendix X and X). It only appeared in ambient temperature and pressure conditions on the A-side of the instrument. It re-appeared in ambient temperature and pressure testing conditions in Oxford, England during tests, and once again only on the A-side of the instrument. The anomaly has not occurred during spacecraft I&T todate.

Through schematic review and data examination by Ike Orlowski (J&T Electronic Controls Engineer), a theory was put forth that the data errors observed were indicative of a problem with the BEU’s successive approximation process. “This is indicated by the fact that in the majority of cases the coversion in error end in sequences of all “0s” or a sequence of all “1s”. In fact, if the converter output value is higher than the expected value, the output ends in all “0s” in the LSBs after the error. If however an underestimate is made, the remaining bits are set to all “1s” in a vain attempt to correct the underestimate.” (J&T Tech Note, Orlowski, Dec. 20, 2002, See Appendix X).

During the week of the Delta Pre Ship Review in Oxford, England, Ike Orlowski, Steve Graham, and Andy Klack simulated this behavior on Oxford’s BEU flight spare hardware. “The two sample counters tested on the [flight spare] board, did not produce any spontaneous decoder glitches. A 33 pf capacitor has to be added to the state counter output, in order to produce a glitch on one of the decoder outputs. Measurment of the state counter output skew showed that for the two parts tested, the skew favored generation of glitches on the odd decoder outputs in preference to the even decoder outputs. Thus the situation observed in the [flight spare] breadboard, was not an exact match of what is required to produce the observed errors, but it was demonstrated, that with an adjustment of the output skew in the range of 4 ns, will generate error causing glitches." (J&T Tech Note, Orlowski, Dec. 20, 2002, See Appendix X).

Recognition of the IFC anomaly In Orbit & Viable Work Arounds:

Each side of the IFC has 3 separate temperature sensors; the thermal design (with a thermally massive cavity to which each sensor is very well bonded) is such that their temperatures are all within a few mK of each other. The sensors have slightly different calibration coefficients, so should always generate significantly different raw telemetry values (equivalent to of order 100 mK difference) even if they are identical temperatures. Consequently, if the calibrated temperatures do not agree within some tolerance (e.g. 20 mK TBV), then it implies that some or all of raw values are incorrect. E.g. if all of the sensors are affected by the anomaly so produce identical incorrect raw values, then this value will lead to different calibrated temperatures which will indicate that there is a problem. This test would need to allow for temporal changes since the sensors are not read out simultaneously. It should be noted that many of the IFC temperatures displayed in graphs have been calibrated with identical coefficients so display a spread of temperatures (of about 0.1 to 0.2 deg), but when calibrated correctly they are much closer to each other.

Work-arounds In-Orbit:

I. Temperature Range Variation
Experience with the anomaly has suggested that it affects certain temperature ranges; the first defence would be to change the IFC temperature to another value (i.e. the temperature of the thermostatted cavity). This would be achieved by changing the thermostatting control point. That value should not be so high that the IFC mirror temperature cannot be made to match it (since there is a requirement that they be at the same temperature within 1 deg). The maximum available IFC mirror heater power will limit this temperature to be about 20-30C above ambient, which should be well below the maximum safe IFC operating temperature (of approximately 320-330 K). The change necessary would depend upon the telemetry bit which is affected, but when the anomaly has been observed the range affected was a few degrees.

II. Power-off IFC
If (1) is impossible or unacceptable, the IFC heaters could be left in a powered-off state. This should be acceptable, since the IFC is intended to operate at the same temperature as the IFC mirror which itself can be operated very close to ambient. The temperataure sensor on the IFC front plate would then be used to indicate the temperature of the cavity. The front plate is part of the IFC outer structure to which the IFC cavity is coupled weakly, so in the long-term (hours) if unheated, the cavity will reach that outer structure temperature. [The only other thermal connection being radiative through the aperature to the instrument ambient surrounding; this aperature is relatively small so providing very weak coupling.] During pre-launch calibration the IFC heater was in the off-state for long periods of perfectly valid operation, and there is a large body of data which can be used to intercalibrate the IFC cavity and front plate sensors.

III. Switch Instrument Sides

As an alternative to (2), if (1) is impossible or unacceptable, then the instrument could be powered down and restarted on the other side. To-date the anomaly has been seen on the A-side but not the B-side.

__In-orbit considerations:__

Intercorrelate IFC Sensors.
It will be important to intercorrelate the IFC cavity and front plate sensors for periods with the IFC heater powered off. This should be done during the initial out-gassing period with the Sun Shield Door closed since this will tend to produce an isothermal cavity where the front plate will be very close in temperature to the cavity. It should also be done after the SSH door has been opened. This intercomparison should be done anyway (irrespective of any concern about this anomaly) to gather data on how the various sensors in the front end of the optics intercompare.

Operator Display Alarms.
It would be advantageous to detect any problem as quickly as possible. It may be possible to provide alarms on the operator display to warn if calibrated cavity temperatures differ by more than a certain interval, after allowing for temporal trends. If necessary a SAIL task could be provided, or an existing task extended, to make this test every few tens of seconds. The task would set a flag in the Engineering Telemetry which would be detected and cause the operator to be alerted (all SAIL tasks have provision for setting flags for this purpose). The task could also inhibit the IFC thermostatting task from attempting to control the heater temperature.

__Further Investigation to Root-Cause and Hardware Fix:__

It was determined that further investigation in the anomaly requires opening the instrument and investigating the phenomenon insitu. Assuming that this approach might be desirable, then the next set of steps would need to be completed at the Observatory I&T site and in a suitable Class 100 cleanroom.

1. De-mate qyt=6 and qty=2 1553 cables from the spacecraft interface panel.
2. Disconnect the ground wire from the spacecraft
3. Connect long ground strap for move operation
4. De-mate qty=7 kinematic mounts.
5. Remove instrument from Aura bus.
6. Move to Class 100 cleanroom in NGST facility in Redondo Beach, CA or in LM’s facility in Palo Alto, CA.
7. Remove the –Y and the FSS Support MLI blankets and retain all fasteners.
8. Partially remove the FSS, +X, and - X MLI blankets and retain all fasteners.
9. Remove –Y to baseplate screws.
10. Remove –Y panel to SSH L-bracket screw and the bracket attached to the –Y panel.
11. Remove the panel-to-panel ground straps attached to the front and rear of the –Y panel
12. Remove the ground stud from the Baseplate that is near the bottom center of the –Y panel and retain for re-installation process.
13. Remove all remaining panel-to-panel screws. Make sure all screws are removed before continuing.

14. Carefully remove the –Y panel from the instrument. This is a tight fit and may require two people to gently rock it out.
15. Remove BEU cables, Winchester connections.
16. Remove BEU fasteners.
17. Remove the BEU. Be cautious when removing BEU as not to disturb the two small rectangular gaskets on the mating surface of the BEU to the Mid-wall panel.

Once out, the BEU can be operated with the EM IPU or the IPU subset attached to Black Body EM hardware. This set-up would be used to try to replicate the anomaly on the bench so that further root-cause investigation could be conducted.

If root cause was found and corrected, the BEU would undergo box level regression testing and calibration based on what the root cause problem was found to be and what hardware was corrected. Instrument level regression testing, and observatory level regression testing would have to be evaluated as necessary based on the what portion of environmental testing was missed due to BEU box investigation, modification and calibration.

Summary and Conclusion:

The HIRDLS Team recommends not opening the instrument and investigating the IFC temperature telemetry anomaly. The question is a balance of risk. Since the work would be very invasive involving:

1. Removal of the instrument from the Observatory
2. Disassembly of the instrument structure
3. Demating and movement of fragile analog cabling
4. Breaking staking within the Black Body Electronics Unit
5. Re-assembly, regression testing, and possible re-calibration of the previously mentioned systems

Figure X. Single Side of BEU Electronics On Assembly Fixture Before Folding. Assembly requires careful folding of analog wiring between boards and inductors.

Through that process, any number of problems could arise (damage to the wiring) affecting impedance, continuity, which could manifest as a missing bit over the range of the bridge for example. The interior of the BEU is very tight and the analog wiring is very sensitive (see Figure X and Figure X). The BEU-BB cable is most fragile and it's impedance could change with poor handling.

While investigations to date on flight spare hardware have confirmed a possible design feature that explains part of the anomaly, there are still anomaly instances that cannot be explained. Even after opening the BEU, there is no guarantee that a root cause could be found without invalidating the calibration effort.

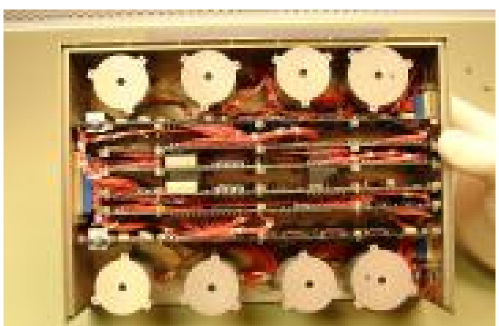


Figure X. Top-Down View of BEU After Assembly. Top cover of BEU secures inductor cans in-place.

Viable in orbit workarounds have been thought-out which involve

I. Increasing IFC system temperature by increasing electrical loading

II. Turn off of IFC heaters and operate system at ambient temperatures

III. Switch sides of the instrument

The HIRLDS Team conclusion is the risk to the Mission Success from the current anomaly is less than that due to trying to investigate to find root cause and correcting it.

Appendix A. Lucy Lanham Memo.

Appendix B. Marion Barker Memo.

Appendix C. Ike Orlowski Memo from December 20, 2002.

Appendix D. BEU Removal Notes, MV-LOC-1266.