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Midcourse Space Experiment Data Certification and Technology Transfer

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Prepared for
NASA

by
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INTRODUCTION

The University of Alabama in Huntsville contributes to the Technical Management of the Midcourse Space Experiment Program, to the Certification of the Level 2 data produced by the Midcourse Space Experiment's suite of in-orbit imaging radiometers, imaging spectra-radiometers and an interferometer and to the Transfer of the Midcourse Space Experiment Technology to other Government Programs. The Technical Management of the Midcourse Space Experiment Program is expected to continue through out the spacecraft's useful life time, 5 years after its 1996 launch. The Transfer of Midcourse Space Experiment Technology to other government elements is expected to be on a demand basis by the United States Government and other organizations. The University of Alabama Huntsville' contribution specifically supports the Principal Investigator's Executive Committee, the Deputy Principal Investigator for Data Certification and Technology Transfer team, the nine Ultraviolet Visible Imagers and Spectrographic Imagers (UVISI) and the Pointing and Alignment of all eleven of the science instruments. The science instruments effectively cover the 0.1 to 28 micron spectral region. The Midcourse Space Experiment spacecraft, launched April 24, 1996, is expected to have a 5 year useful lifetime with a 12 month lifetime for the cryogenically cooled IR sensor. A pre-launch, ground based calibration of the instruments provided a basis for the pre-launch certification of the Level 2 data base these instruments produce. With the spacecraft in-orbit the certification of the instruments' Level 2 data base is being extended to the in-orbit environment

SCOPE

This final report is for the work done between 22 June 1996 and 29 September 1996. Quarterly Reports are for the work done on this Task Order, Number 153, up through 21 June 1996.

BACKGROUND

All analyses and products from the Midcourse Space Experiment data are reviewed to ensure that misinterpretation and incorrect analytical results do not disseminate from the program. In the past, resources were wasted as hurried analyses, misinterpreted results and incorrect analyses were release from parties working on past space programs. This led to mistrust of the program's results, contradictory conclusions from the same data, and duplication of effort. The Midcourse Space Experiment program structure was designed to guard against this.

The Midcourse Space Experiment program structure was developed to ensure all processes are reviewed from the collection of data to the analysis and interpretation of data. The Data Certification and Technology Transfer certification is part of the overall certification of all the scientific results of the Midcourse Space Experiment data. The Midcourse Space Experiment Data Management Teams verifies the flow

of the data, the Data Certification and Technology Transfer Team certifies the processes which convert the bits to engineering units and the Principal Investigator Executive Committee certifies the proper interpretations and analyses derived from the data. Thereby, all processes are reviewed from data collection to data interpretation to ensure that all Midcourse Space Experiment products benefits from the overall program's knowledge.

There are several other responsibilities of the Data Certification and Technology Transfer data certification process. The Data Certification and Technology Transfer certification process provides the Midcourse Space Experiment Principal Investigator teams with reliable sensor and spacecraft data, provide future users with valid databases and procedures for accessing and understanding the Midcourse Space Experiment data, and provide the community with correct analysis of instrument performance data products

PHILOSOPHY

The Midcourse Space Experiment program generates several terabytes of raw data. The Data Certification and Technology Transfer can not review each byte individually to certify this vast database. The review technique used is similar to a method of process certification used in manufacturing. The Data Certification and Technology Transfer certifies the ground calibration and the sensor performance within the expected in-orbit operational environment. Within these bounds, the process by which the sensor raw data is converted to scientific and engineering units is certified by the Data Certification and Technology Transfer. This process is called the CONVERT process. In-orbit measurements of standard calibration sources are used to modify the CONVERT processes by the sensor engineering teams. The Data Certification and Technology Transfer participates in these modification procedures, reviews the suggested changes, tests the altered process against standard data sets and certifies the changed process. The irradiance from the standard sources, both on the ground and in-orbit are certified by the Data Certification and Technology Transfer. To certify the Level 2 database many processes must be reviewed and understood by the Data Certification and Technology Transfer. The major areas of review for the Data Certification and Technology Transfer certification plan are sensor calibration review, Convert software review, and verification the sensor operated within its nominal operating bounds.

At all stages through the certification process the Data Certification and Technology Transfer reviews the error allocation budget. The amount of error associated with the calibration process is divided up between all the calibration processes in order to met the program requirements for the calibration and characterization of the sensors.

IMPLEMENTATION

An entire team cannot perform a detailed review of every Midcourse Space Experiment scientific instrument. Therefore, the Data Certification and Technology Transfer delegates a member of its team, an instrument 'watchdog', to perform a detailed review of a single instrument and have that Data Certification and Technology Transfer member report back to the entire group.

DEPUTY PRINCIPAL INVESTIGATOR

MISSION PLANNING

Reviews of the Data Certification and Technology Transfer's Monthly Objectives and scheduled experiments are performed each four weeks. This time period is a Mission Month for Planning purposes. Specific options for the Data Certification and Technology Transfer Experiment plans being planned for that period are selected and formally provided to the Mission Planning Team. Aperiodically the Mission Planning Team meets with the Data Certification and Technology Transfer Watchdogs and the Science Instrument Performance Assessment Teams to adjust the data collection activities.

The Planned Data Certification and Technology Transfer Data Collection Events for the in-orbit mission are listed as Attachment 1. The Reflective Reference Sphere, Experiment Plan DC-23, was finalized and provided to the Mission Planning Team. The Monthly Objectives and Schedules from the Mission Planning team for Mission Months 4, 5, 6, and 7 were reviewed and adjusted. The in-orbit operations data planning is functioning on the schedule as conceived and is effective to get the Data Collection Events command sequence reports up linked and the data collected per the Experiment Plans.

MISSION PLANNING TEAM MEETINGS

JUNE 19

The Data Certification and Technology Transfer team was directed to scale back its experiment planning by about ten Data Collection Events per month. The Data Collection Events made available by this scale back are to be allocated on a priority basis with the Earthlimb and the Celestial Team having the higher priority.

The Pointing and Alignment Watchdog was directed to report the science instruments pointing and alignment status to the Principal Investigators at the July 9 Executive Committee meeting.

SEPTEMBER 11

Two meetings were held. The Pointing Performance Assessment Team met to assess the spacecraft pointing and each science instrument's pointing and alignment to the

spacecraft. At a joint Mission Planning Team - Data Certification and Technology Transfer Performance Assessment Team met to assess the execution progress of planned experiments and to identify changes required to Mission Planning for the Midcourse Space Experiment to meet its program objectives.

There has been no execution of a Pointing and Alignment Experiment, DC-29, since July 10, 1996 and there is a critical need to assess the Pointing and Alignment Processes while the spacecraft is slewing. The ones scheduled for August and September were preempted by higher priority data collection events. A request was made to the Mission Planning Team to schedule a modified DC-29 as soon as practical. one had been scheduled for execution in September. The modification includes spacecraft slewing as a replacement element for a segment of the experiment where the spacecraft executed an inertial stare.

SPIRIT III CERTIFICATION

Meetings with Space Dynamics Laboratory Utah State University SPIRIT III Performance Assessment Team provide and opportunity to set priorities for the SPIRIT III Calibration data analysis and to coordinate the schedules for the CONVERT and Pointing CONVERT Software's completion and release to the Principal Investigator Team.

JULY 26

The SPIRIT III CONVERT software continues to undergo updates and changes. The current Version is 3.2.12. It's release is imminent. Further updates to the Instrument Products and to the algorithms are to be in the Version 4.0. An agenda provided the discussion guide.

A one second timing bug precludes a backward compatibility of CONVERT Version 3.2.11 with earlier versions. The timing bug has been eliminated for CONVERT Versions 3.2.11. The nature of the bug is a one second offset in the time used to process the data in CONVERT and Pointing CONVERT.

A part of three of eleven baseline performance Data Collection Events, DC-44s and DC-43s, give anomalous pointing results. The Data Collection Event DC.44.02.00008.01 gives a milli-radian sized pointing bias when the star is observed with the Definitive Attitude, DA, correction applied. The Data Collection Event DC.44.01.00009.01 gives a milli radian sized pointing bias whether or not the Definitive Attitude correction is applied. The Definitive Attitude does make a minor change in the pointing but there remains a milli radian sized pointing bias.

The UVISI Instrument IVN was operated during the Data Collection Events where an anomalous pointing result was obtained. This instrument's observations of the stars Alpha Lyra and Alpha Her can provide additional insight as to the possible

causes for the anomalies.

The A Band root mean square responsivity over the sensor's field of regard (FOR) from a Flat Field Mirror Scan mode Data Collection Event, a DC-33, divided by the mean responsivity times one-hundred is 6.7%. For the B Band the equivalent number is about 9%. A histogram plot and data analysis of all radiometric calibration star observations shows a mean of -0.89 and a variance of 3.7. The basis for this latter result is the truth value provided to the SPIRIT III team by the Data Certification and Technology Transfer for the calibration star Alpha Boo and is the statistical result from the average result over the field-of-regard for the other calibration stars. The Long Term Trend and the Short Term Trend repeatabilities when root sum squared give a mean of -0.11 and a variance of 3.7.

The change to the Side B spacecraft power raises a question as to what are the correct detector temperature bounds for the Side B spacecraft power. This issue arises because of the limited valid temperature range, about 1.5 K, the digitization temperature, tens of milli-K, the exponential increase in dark noise, tens to hundreds of counts per milli-K, as the arrays approach their respective cut-off temperature and the relatively large temperature changes encountered as the sensors heat load varies as the sensor makes its observations.

CONVERT Version 4.0 is to have final algorithms implemented and will have updated Instrument Products. The Data Certification and Technology Transfer review and approval of this software can proceed as the algorithms are finalized and the Instrument Products are produced. The major algorithm changes expected are for column co-alignment (the B array appears to be shifted about 20 μr), the scan mirror transfer function update, the Point Source Extraction over the Field of Regard. A handout attached to the trip report for this meeting lists the others.

A continued analysis of the auto-collimator data has produced no new conclusions. The uncertainty of whether or not one of the auto-collimator's measurement axes went into and out of saturation coupled with the fine tuning required of the Definitive Attitude estimation process leaves little or no room for further meaningful analysis.

It is estimated the one second timing error's impact on the Pointing and Alignment data processed thus far will not introduce a sufficiently large error to warrant the data be re-processed through CONVERT. A constant one second clock error is a 73 μr earth centered inertial pointing bias. This is sufficiently small, less than a single pixel, to warrant using already created data as is. A note for the record, however, needs to inform users of this condition.

The UVISI Data for the Alpha Her observations, Data Collection Event DC.44.02.00008.01, indicate the

spacecraft actually had a milli radian sized pointing bias during this observation. The UVISI Data for the Alpha Lyra observations, Data Collection Event DC.44.02.00009.01, imply the Definitive Attitude has a milli-radian size bias.

The SPIRIT III Performance Assessment Team is to develop a table which shows the elements of the sensor's Radiometric Measurement Precision buildup to a composite Radiometric Measurement Precision for the MSX Technical Interchange Meeting. The bias for the single calibration Data Collection Event with the truth value for the star Alpha Boo root sum squared with the bias will be used to obtain a Radiometric Measurement Accuracy. The Data Certification and Technology Transfer will provide the Certification results from the remaining calibration stars, Alpha Canis Majoris and Alpha Lyra. A Radiometric Measurement Precision and any residual bias will be root sum squared to provide a Radiometric Measurement Accuracy.

It is concluded the Detector Temperature bounds from the Ground Calibration 2 will be used although there is some residual uncertainty of the temperature due to uncertainty of the RASP voltages on the Side B power. It is estimated this approach provides the most accurate usage of the sensor.

The Data Certification and Technology Transfer will test and incrementally approve the algorithms and the Instrument Products as they are delivered to reduce the flow time to approve the completed CONVERT 4.0 prior to its delivery for distribution to the broader MSX community.

For the archive the Ground Calibration 1 and 2 tapes, the Report in Support of CONVERT Version 3.0, and the calibration procedures along with a cover letter are to be sent to the Program Office. The Program Office sends the material with a letter of transmittal to the Backgrounds Data Center where these calibration material are to be archived.

It is agreed to open the auto-collimator's bounds to preclude anomalous Uncertified Process flags being set, to await improvements to the Definitive Attitude along with additional analyses, and assess the utility of a digital filter on the auto-collimator's data before a decision to include the auto-collimator's data in the normal data reduction flow of the SPIRIT III DPC's Pipeline CONVERT and Pointing CONVERT.

SEPTEMBER 18

The Program Office Chief Scientist, the Data Certification and Technology Transfer Principal and Deputy Principal Investigator and SPIRIT III Watchdog planned the technical effort at the Space Dynamics Laboratory in concert with the SPIRIT III Performance Assessment, Calibration and Data Processing Center Teams.

The updated radiometer and the interferometer Instrument Products used in the CONVERT data reduction software are ready to be released. The updates need to be tested.

The autocollimator's Y-axis' drifted, May 9, 1996 to September 6, 1996, from -4 mr to -0.25 mr, a 3.75 mr change. The SPIRIT III boresight alignment to the spacecraft fiducial, another measurement of the same dimension, has shown changes an order of magnitude smaller than this for the same time period. It is suspected gain changes in the interferometer's measurement processes are causing the changes and the actual boresight drift is less than the 3.75 mr reported by the autocollimator output. Over a shorter time period, for example a nominal 20 to 30 minute data collection event or possibly an hour or so, the autocollimator's output may provide a precise short term trend of the SPIRIT III's boresight alignment to the spacecraft fiducial.

The Data Certification and Technology Transfer is scheduled to Certify the SPIRIT III sensor's virtual Level 2 database output from CONVERT Version 4.0 at the Principal Investigator's Meeting near the end of October, 1996. The updated Instrument Product files for the radiometer must be delivered to the Data Certification and Technology Transfer by October 4, 1996 and the interferometer files a week later to meet this schedule. A fix the Pointing CONVERT is required for Version 4.0 to read a new Instrument Product file format. It will require about a week to get this change out to the Watchdog for tests.

A new and still in evolution requirement to flat field the radiometer's output to << 1% necessitates a carefully designed experiment to select a region of the celestial sphere as a source and to account the dark offset driven temperature effects inherent the warming focal planes as the solid hydrogen sublimes.

The requirement to flat field the radiometer's response assures CONVERT Version 5.0 will be a post-cryogen activity. There simply are adequate resources and remaining cryogen lifetime to accomplish this for the October completion of Version 4.0.

An additional complexity for the remaining cryogen lifetime introduced by the exponential dependence of Dark Offset with focal plane array temperature is the need to calibrate this temperature region in-orbit. The ground calibration and characterization tests were completed before the magnitude of this effect was completely understood.

All data taken since the beginning of the in-orbit mission will need to be reprocessed with the new Instrument Product files to achieve certified performance. The principal error source is the Dark Offset correction. This primarily affects low signal to noise ratio measurements which have been made. Fortunately, this is a time

consuming and resource expenditure but a rather straight forward task to accomplish. The Level 1a data is archived and the Pipeline and CONVERT processes are documented and controlled.

The Ground Calibration Data is pending delivery to the Background Data Center. It can be shipped in segments.

A CONVERT Version 3.X, tailored operate on a specific platform and Operating System of the Early Midcourse Co-Investigators, created outside the Data Management control processes needs to be brought under control. Certification of the MDT II data reduction with this untested code is at issue.

The Data Certification and Technology Transfer reviewed their SPIRIT III Certification briefing, planned for presentation at the Principal Investigator's meeting the following week, with the SPIRIT III teams at this meeting. The radiometric and the goniometric uncertainties and accuracies are reasonable and consistent with the analyses done by the SPIRIT III PAT.

A video of the first Emissive Reference sphere release in-orbit clearly shows the sphere is near the center of the field of view. This is significant in that the spacecraft was commanded on a pre-planned time to maneuver in an open loop manner and to keep the sphere centered in the field of view. It speaks well for the attitude command and control processes of the spacecraft and the dedicated effort put forth by all involved with a successful execution of this experiment.

The Data Certification and Technology Transfer's Certification Letter will show the new Instrument Product file version number. A correction to the Instrument Product file numerical identification, the certification flags will be set and a new version number will be assigned the release of the new radiometer Instrument Product file. The clock sampled processing, a few percent change in an uncertified output, is out of synch with the interferometric calibration report. An updated Instrument Product file, to be delivered to the Data Certification and Technology Transfer Watchdog by September 23, 1996, will handle clock sampled data. A separate letter sent to the Principal Investigator's will inform them the interferometer's non-aligned and clock sampled data will remain uncertified.

The autocollimator's output data will continue to be monitored. No further specific action is planned at this time.

CONVERT Version 4.0 is to be delivered to the Data Certification and Technology Transfer by October 1,1996. The Data Certification and Technology Transfer Certification of CONVERT Version 4.0 will continue toward the scheduled end of October completion date. A test data, file to confirm a user has correctly installed and is correctly executing this release, are to be provided with it when it is released.

This file, data from a DC-29 Pointing and Alignment Experiment, will include the control file to execute data reduction with CONVERT will also include a point source map.

The experiment design to flat field to << 1% is pending the completion and release of CONVERT 4.0. While the data must be acquired prior to cryogenic end of life, the implementation of the algorithms to accommodate the changes are to implemented in Convert 5.0. New Macros are being designed to obtain the Dark Offset and responsivity changes which occur as the focal plane arrays warm above the ground calibration upper temperature limits. Algorithm changes to accommodate the modified Macros will also be implemented in CONVERT 5.0. It is thought a DC-43 or DC-44 Experiment is the most promising experiment to obtain the required flat field data.

Level 1a data reprocessing will start with the MDT II data. The Operational Limits bounds for both the Side A and the Side B spacecraft power configurations are acceptable to start data reprocessing. The hardwired uncertified flags will be removed from the CONVERT when the data is reprocessed. It was agreed to use the first or last sequentially good Dark Offset measurement when there is a missing or bad Dark Offset measurement.

A list of the Calibration Material to be archived will be included in a letter to the Backgrounds Data Center in accordance with the a letter of agreement between the Space Dynamics Laboratory and the Background Data Center. The letter will be coordinated with the Data Certification and Technology Transfer Watchdog.

A letter from the Early Midcourse Principal Investigator which documents the modified code tests and the results obtained from those tests will be used to tie the code to code which has been Data Certification and Technology Transfer tested and certified. The tests should include those done at the Space Dynamics Laboratory also. This will provide a credible basis to certify the MDT II data processing done at the Early Midcourse Data Analysis Center with the untested code.

PRINCIPAL INVESTIGATORS EXECUTIVE COMMITTEE

JULY 10

The Principal Investigator Executive Committee reviewed the Programs technical status, some preliminary data analysis results and coordinated the remaining in-orbit data collection time.

The Deputy Data Certification and Technology Transfer Principal Investigator participated in the Executive Committee's Reviews and technical coordination. The

Data Certification and Technology Transfer UVISI Watchdog team met and coordinated the Data Certification and Technology Transfer Certification Pipeline data processes for the UVISI Instruments. The Pointing Performance Assessment Team Chairman and the Data Certification and Technology Transfer Pointing Watchdog prepared and presented the Pointing and Alignment Status to the Executive Committee.

Executive Committee's Reviews and Technical Coordination - Maj Peter Kurucz replaces Maj Ralph McLain in the MSX Program Office. He will be performing those administrative duties of his predecessor.

The SPIRIT III sensor is not being operated in the South Atlantic Anomaly (SAA) at all. The Data Collection Event, DC-28 pass 4, planned was canceled and is not rescheduled pending a resolution of the cause for the SPIRIT III system's power problem. A Space Dynamics Laboratory tiger team is studying the problem. A report is expected from them in about 3 weeks. The other instruments will continue to be operated in the SAA.

A UVISI only, a SBV only and a joint UVISI SBV post cryogen mission is being investigated. There are no takers at the moment but, Massachusetts Institute of Technology Lincoln Laboratory is seeking fiscal year 98 funds. The Ballistic Missile Defense Office (BMDO), Technology and National Missile Defense, is planning to fund a basic one-shift spacecraft operation beginning in fiscal year 97. In principle the data would be "sold" to users. The Contamination Team's work is important at the end of cryogen life to monitor the out gassing of the SPIRIT III sensor and to provide insight to the safety and usefulness of the UVISI and SBV instruments. This team would provide valuable "weather reports" on the ambient spacecraft environment during this time period.

The minimum number of Data Collection Events to be performed during the 12 month mission instead of the 16 month mission should be revisited by each Principal Investigator to make sure we are making the best use possible of the remaining cryogen time. If there are Data Collection Events which need to be eliminated because there will be an incomplete data set collected they need to be identified and eliminated.

Data Management reports the secure website to peer review images is operational. Multiple scientists reported easy access. The secure certificate necessary for encrypted transmissions is ordered. It is expected in the near future.

The Principal Investigator presentations at the Technical Interchange Meeting are to be of a format to show who each team is; what each teams analysis products are; what data is being collected and some "whistle wetter" Data Collection Events identified. The typical quad chart, Principal Investigator Team, Experiment Plans

and products and images to date would be included.

The contamination team requests any blurs seen by anyone be identified to them with the time of their observation. They haven't the ability to review all the data to identify contamination effects which will contribute to their analyses.

A UVISI focal plane array has been tested to about 10 E4 above the saturation level for the most sensitive gain mode. A decrease in the responsivity was observed but the noise level did not increase. This should clear the way for the SBV team to utilize the IVN instrument in conjunction with the SPIRIT III and the SBV instruments for multiple instrument / color Space Surveillance activities.

A number of Letters of Intent to Propose have been sent to NASA. The intent is to analyze MSX data. This information was obtained at a CEDAR Meeting.

The ephemeris of the MSX spacecraft's orbit is currently estimated with an uncertainty of about 30 meters. This provides about a 20% uncertainty in the nominal hydrogen gas vent flow from the SPIRIT III's dewar at 2.15 mg / s. This is slightly higher than the nominal 1.9 mg / s predicted by a SDL/USU thermal model. When the ephemeris uncertainty is reduced to the 10% level the hydrogen mass flow rate uncertainty will concomitantly be less uncertain.

The MDT II target mission scheduled for a primary five day window of opportunity beginning July 25, there are four additional secondary days, is going to be executed with the spacecraft inertially pointed. The S-band receiver tests have shown a 0.2 to 03 degree pointing uncertainty. This is too large to usefully keep certain key SPIRIT III pixels from becoming saturated at some times during the target observation period. This would cause some loss in the target data's radiometric accuracy and precision. Additional difficulties are the availability of Cobra Judy, the target preparations are about 10 days behind schedule and the SPIRIT III sensor's fragility.

Pointing & Alignment status presented - The spacecraft points and the instruments are sufficiently aligned that any instrument can be pointed in earth centered inertial coordinates with an error $<0.1° \pm 3$ pixels.

Data Collection History

1994 (pre-dewar rupture) at Vandenberg Air Force Base
1996 January at Vandenberg Air Force Base
1996 May 6, May 17, May 23, June 6, June 23, July 10 in-orbit Pointing and Alignment Experiments (DC-29s)
June 5 - in-orbit SPIM Alignments (DC-16)

Attitude History Files delivered to the Attitude Processing Center

1996 May 6: SPIRIT III, IVW, IVN, IUN

May 17: IUN, IUW, IVW, IVN, SPIM 4
May 23: IUN, IUW, IVN, IVW, SPIM 4, SPIM 5

Sensor Alignment Files to the Data Processing Centers

1994	All sensors	
1996	January	All sensors
	May 6	SPIRIT III, IVW, IVN, IUN
	May 17	IVW, IVN, IUN, IUW, SPIM 4

Sensor Alignment Estimation Files Validated by PAT

1996	May 6	SPIRIT III

Instrument Off-sets to Operations

1996	May 6	SPIRIT III

Action is needed by the SPIRIT III & the UVISI Performance Assessment Teams to validate the sensor alignments. The SBV Data Processing Center needs to create attitude history files which have multiple frames of data instead of a composite answer to support alignment of the sensor to the spacecraft. The Attitude Processing Center needs to refine the definitive attitude filter so that is does not introduce virtual spacecraft motion and to evaluate the spacecraft's commaned vs: the as-flown attitude.

AUGUST 19

The Principal Investigators Executive Committee met to conduct the Program's Technical affairs at the Johns Hopkins University Applied Physics Laboratory. The Midcourse Space Experiment Technical Interchange Meeting with the Department of Defense Community also took place at the Johns Hopkins University Applied Physics Laboratory from August 20 to August 22. Separate audiences with the Ballistic Missile Defense Organization and another with Rear Admiral West took place at the Pentagon August 22 and August 23, respectively.

Preparations for the next MDT II target mission continue. The Attitude Processor2 has been updated but Attitude Processor1 is planned for the MDT II mission. The Command Processor 1 has been upset but the Command Processor 2 has not. There is one more beacon receiver test using the Poker Flats test range. There will be no changes to the spacecraft software between the dry run and the actual mission. Two sets of eyes are to review the processes for MDT II. An Attitude Processor-Tracking Processor, a UVISI and a SPIRIT III check out event will precede the MDT II mission. The Attitude Processor 2 and the Tracking Processor2 could be used as hot spares were there adequate resources to implement them. The star camera had a 0,4 degree capture zone tolerance input last Friday, August 16, 1996. A report, "Where MSX Was Pointed", on the attitude upset prior to the MDT II mission attempt is in work. It is estimated the spacecraft was looking at the earth for about 80 minutes.

The attitude system data is sub-commutated and there is no gyro data when the tape recorders are off, as they were in preparation for the MDT II launch. It takes about 60 star camera attempts before the coarse sensors take over and command the spacecraft. A single recovery procedure is now in place. The procedure includes a power cycle on the Attitude Processor to reset all the constants. The Neutral Mass Spectrometer is to be powered off to reduce the risk to the filament in case a power cycle is necessary. The MDT II dry run is scheduled for August 27 th. The data tape is to be archived. There will be no blinks, the S-band receiver will be off and only one tape recorder is to be used for the dry-run.

The Space Based Visible team continued their peer review from the February meting. This included an error analysis and the precision ephemeris.

The accuracy and the uncertainty of the spacecraft's estimated Pointing is being studied. The Definitive Attitude, the DA, has been planned to provide the most precise and the most accurate spacecraft pointing. However, there is data to indicate the on-board attitude, known as the ADS, the Attitude Determination System's attitude, may be providing a more precise, more accurate pointing estimate. Multiple issues arise. The respective science instrument Pointing CONVERT use the Definitive Attitude to estimate the instrument's pointing. This results in a more uncertain and less accurate pointing estimate than is possible. Possible if there are revisions made to the Kalman filter process used to produce the Definitive Attitude from the ADS. The current situation is such that the ADS would appear to provide a higher quality estimate of the spacecraft pointing than the DA. However, the ADS isn't a Level 1 data product and was not planned to be one.

A briefing, the Data Certification and Technology Transfer teams perspective of the Pointing and Alignment for the spacecraft and its multiple instruments, prepared and presented during the Spacecraft Portion of the Technical Interchange meeting, provides insight to and the status of the certification process which has been so successful in developing a fully functional spacecraft and instrument suite.

An agreement reached with the responsible Australians is the Midcourse Space Experiment data gathered during a recent cooperative experiment is to be released only to United States or Australian citizens.

An unsolicited acknowledgment of the benefit of the Pointing and Alignment Experiments executed came from the Space Based Visible Principal Investigator.

The listing of Major Attitude Events provide to the Data Management team is not yet posted to SCIES. Data Management plans to post it.

The change over date for SPIRIT III data is August 2, 1996. All data prior to this date, beginning of mission through August 1, 1996, will need to be reprocessed in

order for it to be certified. The reprocessing will be chronological beginning with the change over to the Side B spacecraft power bus on June 8, 1996. The data acquired with the Side A power bus will then be reprocessed in chronological order.

SEPTEMBER 23

The SPIRIT III sensor developed another over current problem on Friday September 20, 1996. A conference call was held to fully comprehend the situation, the participants being the PIs, the Program Office, the Johns Hopkins University Applied Physics Laboratory MSX Program personnel and the Space Dynamics Laboratory personnel. A discussion of status and a plan of action concluded with the approach to return to nearly normal spacecraft operations while trouble shooting the SPIRIT III problem.

Data Management presented an issue which has been discussed in some detail. It is the segmentation of files which arises as the Level 1 data is read from the spacecraft and processed into Level 1a data. The Definitive Attitude files are created from the Low Rate Wide Band down linked data and do not necessarily have their segmentation occur at the same time as the Level 1a data. This creates an issue for CONVERT users since they must have all the files loaded to process the data.

There are three conferences in January, 1997 at which the MSX Program plans to present papers. These are an AIAA, an IRIS and an IEEE conference.

The SMTS Program Office discussed a Technical Interchange meeting where the MSX's information, data and experience can transition to the SMTS Flight Demonstration System contractors. Such a Technical Interchange meeting would include the SBIRs contractors Hughes, Rockwell and TRW.

A briefing which discusses the Definitive Attitude issue and the plan of action was presented. The issue is the Definitive Attitude is introducing pseudo spacecraft motion. The result is a loss in pointing accuracy. The spacecraft isn't performing the motion ascribed to it by the Definitive Attitude and the goniometric star positions are reported up to hundreds of micro-radians away from their catalog positions. An effort is underway at the Attitude Processing Center to improve the Definitive Attitude quality by adjusting the weighting of the Kalman filter used to produce it. A copy of the briefing is attached.

The recovery plan is to sequentially turn on portions of the SPIRIT III sensor systems power during real time contacts with mission operations. The objective is to identify the problem circuits. Tests conducted over the duration of the Principal Investigator meeting appear to indicate the SPIRIT III's radiometer or interferometer can operated one at a time. The over current could be associated with the higher loads imposed when both portions of the instrument are operated simultaneously. The impact of the current situation is the SPIRIT III sensor will

probably be unavailable to acquire data for a total lunar eclipse later this month, an eclipse which occurs infrequently.

Data Management will coordinate between Operations and the Attitude Processing Center to arrive at a common solution for the file segmentation issue. This is should be a relatively straight forward task.

The Cooperative Targets Principal Investigator team's work completed a successful peer review.

The Data Certification and Technology Transfer previewed their Pipelined Certification of the SPIRIT III CONVERT Version 4.0. It appears to meet the needs of the Principal Investigator Teams and no changes to the process are planned.

A copy of the Definitive Attitude issue briefing is attached. The Program's Technical director will coordinate with the Johns Hopkins University Applied Physics Laboratory management to have processing notes published and stored at theBackground Data Center. These brief, ASCII format notes will document when there has been problem with the Definitive Attitude or with the Level 1a data. In effect, a user's note file. A place where a quick check can be made to ascertain whether or not there had been a problem during a Data Collection Event or with the creation of the Level 1a and Definitive Attitude data set.

UVISI WATCHDOG

PERFORMANCE ASSESSMENT TEAM MEETINGS

The Performance Assessment Team meets periodically to assess progress, coordinate activities and to identify and resolve issues.

AUGUST 1

It is imperative the UVISI Performance Assessment Team and the Data Certification and Technology Transfer coordinate the scope of and the detailed content of their respective briefings in preparation for the Technical Interchange Meeting between the MSX Program and other government agencies. The Technical Interchange Meeting is scheduled to begin August 22. Final form briefing material must be completed by August 6 in order that an adequate review be completed in accordance the Program's Data Release Policy.

The Data Certification and Technology Transfer Team and the Ultraviolet Visible Imagers and Spectrographic Imagers Performance Assessment Team coordinated their respective Technical Interchange presentation material.

Minor revisions to the draft Ultraviolet Visible Imagers and Spectrographic Imagers Performance Assessment Team briefing were suggested to and adopted by the Performance Assessment Team. Clean copies of the briefing are to be available August 6 for submittal to the Program Office for review and reproduction. Black and white copies are to be used for the reproduction process although color view graphs are used for the actual presentation itself.

AUGUST 8

UVISI CONVERT outstanding issues were reviewed with L. L. Suther. The difficulties the Celestial Team are having with the Level 1C data and CONVERT are being addressed by J. Eichert of the UVISI Data Processing Center.

The difficulties the Celestial Team are having with the UVISI CONVERT Level 1C data process is being personally investigated by J. Eichert. In order for this team to have technical results for presentation in two weeks they will need to have their work peer reviewed by the Principal Investigator Executive Committee. The Data Certification and Technology Transfer Team has been asking for the algorithms the Celestial Team plans to use for their analyses since 1994 and so far has not received them.

DATA CERTIFICATION AND TECHNOLOGY TRANSFER PIPELINE

The Data Certification and Technology Transfer's Certification Pipeline software for the nine UVISI sensor systems, whose development at the General Research Corporation International, Danvers, began last quarter output intial certification analysis results. A draft Certification of the UVISI CONVERT 3.2 process was prepared. However, only an approval letter was created pending the resolution of anomalous results.

Initial Imager and SPIM unertainties were developed. The statistics for each pixel of each instrument and for each filter setting was produced by the Data Certification and Technology Transfer 's Pipeline process. Each instrument's truth is taken from stellar spectra, spectral line shapes and an instruments spectral response as appropriate.

POINTING & ALIGNMENT WATCHDOG

POINTING REQUIREMENTS

GOAL ⇨ RECONSTRUCTED, POST MISSION:

- SINGLE FRAME
  - -SPIRIT III, < 9 μr (1/10 PIXEL)
  - -UVISI NFOV IMAGERS, < 45 μr (½ PIXEL)
  - -UVISI WFOV IMAGERS, < 450 μr (½ PIXEL)

-UVISI SPIMS, <450 μr (½ PIXEL)
- MULTI-FRAME
  -SBV: BORESIGHT POINTING, 2 μr (1/30 PIX) & STAR FIT, 6 μr (1/10 PIXEL)
- SPACECRAFT:
  - < 9 μr (SLOW) & < 18 μr (FAST) / 750 ms

ALIGNMENT LOG

Date	J2000 Time	DCE Identification	Rev #	W - S #	Duration	Conditi
02/20/93		At VAFB	0			Pre-Rup
11/16/95		At VAFB	0			Re-assemb
05/07/96	96:128:01:33:10	DC.29.01.00004.01	175	48	00:33:42	Sunlig
05/17/96	96:138:00:20:59	DC.29.01.00005.01	314	10	00:33:42	Sunlig
05/23/96	96:144:00:42:39	DC.29.01.00006.01	398	48	00:33:42	Sunlig
06/07/96	96:159:10:05:59	DC.29.01.00007.01	613	29	00 :33:42	Sunlig
06/24/96	96:176:00:43:04	DC.29.01.00008.01	845	48R	00:33:42	Sunlig
07/10/96	96:192:10:08:15	DC.29.01.00010.01	1074	48R	00:33:42	Sunlig

MAJOR SPACECRAFT POINTING EVENTS

DATE - EVENT - COMMENT

96.04.24 - Launch

96.05.07 - DC.29.01.00004 - First DC 29 for alignment

96.05.08 - Decreased star camera std. dev. in Definitive Attitude from 18 arcsec. to 4 arcsec - Smaller Def. Cov.; more representative of pointing uncertainty. Smaller values based on observed star camera noise.

96.06.03 - Began adding Park offset prior to event start time to collect star camera data on recorder. - Without star data, Definitive Attitude solution was initialized with coarse measurements only. Definitive Attitude for events prior to this time may show behavior that is poor relative to the on-board attitude. In particular, if the Definitive Attitude was not initialized with a star the attitude may show steps due to quantization of coarse sensors. Diagnostic: If event did not have star camera-based attitude the attitude covariance will be large relative to Data Collection Event with star identification.

96.06.03 - Uploaded VAFB-measured alignment of star camera to spacecraft fiducial frame. - Pointing should be more accurate. Prior Data Collection Events show offset of instrument boresights from desired pointing. Definitive Attitude (ground processing) used correct star camera alignment throughout. Comparison of on-board and Definitive Attitude show difference due to star camera alignment.

96.06.05 - DC.33.01.00005 - SPIRIT III sees stars near y-center of FOV (i.e.

small misalignments)
96.06.05 - DC.16.01.00008 - UVISI sees stars on boresight (i.e. small misalignments)
96.06.17 - SPIRIT III alignment (y-z offsets) for SPIRIT III Data Collection Events begins to be used. - Pointing for SPIRIT III should be more accurate. Offsets were determined from DC-29 #1 only. Will continue to monitor/update alignments.
Y Offset: -0.00181506 deg
Z Offset: -0.08180584 deg

POINTING PERFORMANCE ASSESSMENT TEAM MEETINGS

The Pointing Performance Assessment Team meets periodically to assess the pointing and alignment of the spacecraft and the science instruments and to devise a plan of action to resolve issues when they arise.

JUNE 18

The Pointing Performance Assessment Team meeting June 18 at Johns Hopkins University Applied Physics Laboratory was the second opportunity since the spacecraft's April 24 launch to assess the spacecraft's and the individual instrument's pointing and their respective alignments. Copies of the individual presentations are being distributed with a single copy to the principal at each institution. The data from multiple Data Collection Events (DCEs) and not just the Pointing and Alignment Experiments, DC-29, formed the analytical foundation for the results obtained and reported. Although the primary alignment experiment plan, DC-29, was successfully executed May 6, May 17, May 23, the pointing and the alignment results are still preliminary. The IVN, IVW and IUN have been aligned to the spacecraft twice. The IUW and SPIM 4 and the SPIRIT III sensor have been aligned only once. SBV and the remaining UVISI instruments are yet to be aligned the first time.

The On-Board Signal and Data Processor team had insufficient new results from the previous meeting to warrant the costs of travel to this meeting. They were timed out after about 10 seconds during the Data Collection Event for the DC-29 of May 23. They did report by phone prior to the meeting their streak detection work is on hold pending a resolution of the cause for multiple streaks reported out by the SPIRIT III sensor. The streaks are speculated to be caused by some sort of electronic strobe effect or spiking. They appear at an angle of 45 degrees relative to an image frame. The software patch they uploaded has worked fine.

The SPIRIT III sensor pointing appears to be nominally within half a pixel, about 45 micro radians, when the alignment from the first DC-29 is used to report the goniometric star positions for the second DC-29. However, anomalous results appear when radiometric star positions are reported from the DC-43, Source

Transfer, and DC-44, Benchmark and Dark Offset, Data Collection Events. For the same Data Collection Event, average angular ECI pointing errors as small as 76 micro radians and as large as 9141 micro radians are reported when Alpha Lyr and Alpha CMa, respectively, are observed. Similar in magnitude errors are reported for other Alpha Lyr - Alpha CMa, Alpha Lyr - Alpha Her observations. The cause is being investigated.

The number of stars visible to the SPIRIT III sensor with a signal to noise ratio greater than about 6 to 1, sufficiently well clustered to estimate the sensor's attitude is limited. The two fields used for these first three DC-29 Data Collection Events have either 5 for Band A with 2 for Band C or 8 for Band A and 1 for Band C stars visible to the sensor. The B, D and E Bands were not expected to "see" these stars. The IRAS 12 micron plate 032 reproduced in the SPIRIT III presentation material is for the 5 and 2 case. (An apparent trend in the SPIRIT III right ascension history plot, SPIRIT III Pointing Plot, DC.29.01.00005.01, included with this material, has been attributed since the Pointing Performance Assessment Team meeting to a velocity of light correction which is applied at the Attitude Processing Center but not at the SPIRIT III DPC).

The ultraviolet spectral intensity of the selected goniometric star fields, they were chosen primarily to provide star fields with an infrared intensity useful for the SPIRIT III sensor, has proven to give an inadequate signal to noise ratio to align the ultraviolet region SPIMs and the IUN to the spacecraft. The UVISI Performance Assessment Team used a radiometric calibration Data Collection Event, DC-16, executed May 23, to align the SPIMs to the IVN instrument. Although this process differs from the one planned with the DC-29 Data Collection Events it provides useful alignment data. An alternative alignment plan, wherein opportunistic data could be used to establish alignments, exists. Its execution relies upon a priori knowledge as to when the data is going to be produced in order for Mission Operations to make a non-normal delivery of spacecraft attitude history to the Attitude Processing Center. The spacecraft attitude data is routinely delivered when a DC-29 Data Collection Event is executed.

The spacecraft's attitude control system provided a platform which is inertially stable over a 700 ms interval to a mean value of 5.3 micro radians with an RMS of 8.2 micro radians during the 400 second interval of DC29010000601 on day 144 (May 23). The attitude covariance is a nominal 11 and 4 micro radians about the spacecraft's Y and Z axes respectively.

The error in the actual attitude flown and reported as the 20 hz definitive attitude (DA) post flight as compared to the attitude commanded is to be reported at a future Pointing Performance Assessment Team meeting. The PAC maintains an as-flown vs as-commanded attitude record for the spacecraft.

It was agreed to use Angular Measurement Precision (AMP) and Angular Measurement Accuracy (AMA) as goniometric measures of performance. The AMA includes the AMP and any biases. It isn't clear whether or not the AMA and the AMP are new products. Regardless the respective instrument team Data Processing Center or Performance Assessment Team is responsible for archiving a trend file of each instruments AMA and AMP.

The SBV sensor's CCD number 3 (the boresight CCD) preliminary results, 2.6 micro radian pointing uncertainty (angular measurement precision, AMP) and an angular measurement accuracy (AMA) of 8 micro radians, exhibited for multiple Data Collection Events, indicate the image quality is high and the pointing is stable. The performance is based upon the data for more than 300 star matches from the more than 2000 potential stars within the field of view for the Data Collection Event during a DC-29. The initial data analysis has concentrated upon the attitude estimation performance and the SBV team reports the data processing to meet their 5 micro radian pointing goal is identified. The sensor is in effect functioning as a star camera and estimates its own inertial attitude. The attitude history files necessary to create a sensor alignment estimation file which establishes this instrument's alignment to the spacecraft fiducial boresight are forthcoming when the 5 micro radian pointing knowledge is met.

A Sensor Alignment Estimation File release policy from the Attitude Processing Center to the Backgrounds Data Centerfor distribution to the MSX community is agreed upon by those in attendance at the meeting. The Data Processing Center for each instrument team, the Attitude Processing Center, Data Management and the Data Certification and Technology Transfer were represented at the meeting. The respective data processing centers are responsible for verification the Sensor Alignment Estimation File received from the Attitude Processing Center is valid before it can be released from the Attitude Processing Center. Upon notification from the Data Processing Center the Attitude Processing Center can distribute the Sensor Alignment Estimation File to the Background Data Center. The validation test is to reprocess the DC-29 Level 1 data, the data used to create the instrument's Attitude History File from which the Sensor Alignment Estimation File is created, and report the RA and DEC of the goniometric stars observed with the new Sensor Alignment Estimation File in place.

There are two improvements to the DC-29 Experiment Plan which need to be made and coordinated with the Instrument PATs. One is to increase the size of the pointing off-set used from the current value, 23 to 25 seconds of time in right ascension, to one which is sufficiently large to aid with the resolution of potential biases as being due to either an instrument or a star catalog error. The other is to assess the respective instrument pointing and alignment during spacecraft maneuvers equivalent to those expected during the MDT II dedicated mission. It is anticipated these changes can be made as redlines without an extensive document

re-write and there will be a minimal impact on the Operations Team to modify Command Sequence Reports.

A modified plan must be implemented to align and to trend the IUN and the SPIMs alignment's because of the low flux problem with the current DC-29 star fields. The plan developed is to use the DC-29 alignment procedure but implemented for the DC-16, UVISI Star Calibration, Staring Mode, data collection events. Trend records of pointing performance are then to be developed from observations of the Pleiades with all nine of the UVISI Instruments.

As an aside, the UVISI Performance Assessment Team reported the preliminary analyses done with the data from the IVN and the IVW sensors as they operated for about 28 minutes beginning at 96145085100.000 and passed essentially through the highest flux intensity region of the South Atlantic Anomaly on pass number 4. The average count rate in pow for a 101 by 101 pixel sample size increased from a nominal 40 dark count level to a peak of about 70 for the IVN sensor and from a nominal 20 to 25 dark count level to a peak of about 40 for the IVW instrument. More detail is included in the presentation material included with this report.

JULY 16

The alignment of the individual science instruments to the spacecraft and how well they individually are pointed in an earth centered coordinate system is a key requirement for the Midcourse Space Experiment (MSX) Program. Six data collection events have provided an adequate experimental data base to begin to identify the issues and to develop initial estimated pointing and alignment performance of the individual instruments and the pointing of the spacecraft itself. This is the third in a series of meetings for these purposes.

The individual instrument team presentations at the August, MSX Technical Interchange Meeting, the SPIRIT III, the UVISI and the SBV, will include the respective Pointing and Alignment reports on Day 2. The Attitude Processing Center and the Data Certification and Technology Transfer Pointing and Alignment will be reported on Day 1. Since the individual instrument pointing requirements are different it was agreed to have each instrument team report their performance within the context of their respective requirements. It was also agreed there is a strong need to make sure the audience does understand the context of angular measurement precision and accuracy statements. Specifically as to whether the numbers being quoted are appropriate for a single observation, the Ballistic Missile Defense Organizations performance requirement, or for multiple observations averaged. The BMDO requirement for the SPIRIT III sensor in this context is to post mission reconstruct the pointing with an uncertainty of 9 μ-rad.

DC-29 Experiment Plan Modifications - A redline change to the DC29 Experiment Plan is to be made upon the completion of its definition and a verification of its

feasibility. The redline change is to introduce an angular rate with a bounded angular amplitude for the spacecraft during the time data is being acquired. This motion, a new option, would be introduced instead of the Earth Centered Inertial fixed pointing currently used. The SPIRIT III sensor requires the motion be in the scan direction, i.e. a rotation about the Z- axis. The minimum number of SPIRIT III frames of data to make a reasonable estimate of attitude is thirty. Fifty frames are desired. It takes about seven seconds to acquire a frame of data. The spacecraft, rotated at its maximum angular rate of 0.1 degrees per second, would move somewhere between three and five degrees. The time duration would be between 2.5 minutes (two-hundred-ten seconds) and 5.8 minutes (three-hundred-fifty seconds). This is reasonable based upon a nominal twenty minute data collection event time. Acceleration time to get the spacecraft up to this rate needs to be added in. Attitude Processing Center personnel are to inquire of spacecraft operations the best approach to use to accelerate the spacecraft and record the desired data with a minimal impact on the Command Sequence Reports which must be created to execute this variation of a DC-29 Pointing and Alignment Experiment.

SBV

The SBV Sensor's Data Processing Center has improved the quality of their data reduction process with a distortion map, produced for the sensor from in-orbit data and incorporated in the data reduction process for this sensor. Pointing is estimated to be less than the RMS 5 μ-rad fit-to-the-observed-stars with an uncertainty of 2.4 μ-rad. Spacecraft jitter, as estimated in the SBV body centered coordinate system at a 1 Hz data rate is 1.6, 2.0 and 15 μ-rad respectively for the RA, the DEC and the roll. Note the RA is scaled by the cosine of the declination. The SPOCC has provided three Attitude History Files to the Attitude Processing Center. Sensor Alignment Estimation files have been produced by the Attitude Processing Center but, need to be validated by the Data Processing Center before they are released to the MSX Principal Investigator community for analysis purposes.

Definitive Attitude File Reconstruction

Prior to Julian day 1996:157, there are potential problems with the Definitive Attitude files. A time line of fixes which documents when changes have been made has been distributed to the MSX Data Management Community for further dissemination to the MSX Principal Investigator community. As required there is the possibility to either improve the quality of or to create a missing Definitive Attitude file compatible with Level 1A format. More or less work is involved dependent upon the process followed to create the Definitive Attitude file. The possibilities are summarized as: 1.) using the on-board attitude reformatted; 2.) Initialize the Kalman filter and reprocess a poor quality DA; 3.) Use a box-car filter to smooth an existing Definitive Attitude file.

What is Pointed?

It was agreed to continue with the initial SPIRIT III initial boresight correction

applied to the spacecraft fiducial as to what the Operations Team uses to Point the spacecraft. This is a marked change from the agreed upon plan. The plan had been to retain the pre-launch spacecraft fiducial as invariant and for Operations to apply a pointing offset for a specific instrument when a request to point that instrument is made by a Principal Investigator team. There are consequences to this procedural change which must be explored and reported. For example, will the operations command sequence reports used to point the spacecraft need to be re-written to accommodate the coordinate system imposed by this shift of the spacecraft fiducial coordinate system to the SPIRIT III coordinate system? This is being investigated.

SPIRIT III

Three of eleven baseline pointing performance assessment observations made by the SPIRIT III sensor are giving anomalous results. Also, the post-data-collection-event data process appears to degrade the Z-axis attitude estimates' standard deviation. The data and the data processing is for the SPIRIT III sensor and the SPIRIT III CONVERT and Pointing CONVERT. The issue is illustrated by the chart titled "SPIRIT III Pointing Statistics" included in the SPIRIT III team's presentation which is included with this report, see Event ID DC.44.02.00008.01, DC.44.02.00009.01 and DC.43.01.00013.01. The Z - axis attitude estimates' standard deviation degradation is presented by this chart also. The UVISI sensor, IVN, should have been gathering data simultaneously with the SPIRIT III sensor and an analysis of the data it acquired is to be used to as initial investigate the source of the problems. This effort begins immediately.

Autocollimator - The SPIRIT III team reports the utility of the autocollimator data is questionable. They report the data appears to improve on occasion and to degrade on occasion the quality of the SPIRIT III's pointing estimate. The autocollimator's data will continue to be collected and processed by both the SPIRIT III Data Processing Center and the Attitude Processing Center. The SPIRIT III alignment files will be created with the autocollimator's rotation matrix set to unity pending analyses which demonstrate the benefit of including the autocollimator data in the sensor's attitude estimate.

SPIM Alignments

All nine of the UVISI instruments have at least a fundamental alignment to the spacecraft fiducial coordinate system. The DC16 Data Collection Event used to align the SPIMs 1 ,2 and 3 had only a single star visible to these SPIMs. The data analysis results in an ambiguous alignment of the rotation of the field of view about the line of sight to the observed star. The spacecraft - star alignment was essentially constant during the Data Collection Event. The spacecraft's attitude was commanded to be inertial fixed. The remaining six instruments have been aligned from data acquired during the DC-29 Pointing and Alignment Experiment plan Data Collection Events. A DC16 star field observation is planned where all nine of the UVISI instruments would observe multiple stars and their respective alignment to

the spacecraft and to each other can be estimated.

Alignment Trends

Although incomplete, an alignment trend file exists for eight of the eleven science instruments, all but the SPIMs 1, 2 and 3. The trend file, created from the DC29 Data Collection Events and the SPIRIT III sensor's attitude estimation process, appear to be essentially anomaly free for these Data Collection Events. The SPIRIT III's alignment has changed less than two pixels in either Y or Z angle, beginning with the pre-launch alignment. This is less than 180 μ-rad. The SPIRIT III sensor's orientation about the X - axis, i.e. roll about the spacecraft's fiducial, shows a significant shift for the alignment estimated from the data acquired on day 96:144. It is on the order of more than 4 milli-rad. However this rotation is back within one to two pixels of the previous values for the day 96:176 measurements. It is known the Definitive Attitude as well as the spacecraft's literal attitude may have anomalously large errors prior to day 96:155. Because of this potential for anomalous results prior to day 96:155, the day 96:144 roll change is noted but, further analysis and investigation requires additional information.

ON-BOARD SIGNAL & DATA PROCESSOR

The On-Board Signal and Data Processor team reports by phone message they are continuing with their data analysis. They are still awaiting the SPIRIT III scan mirror transfer function and optical distortion map to update their processing software. They report unaccountable perturbations are appearing in the SPIRIT III data frames. The perturbation is described as a streak or a spike which simultaneously appears on multiple detectors. Something which is incompatible with a readily conceivable optical process.

SEPTEMBER 10

The purpose of this fourth working level meeting: to report on Definitive Attitude anomalies; to resolve the responsibilities and the schedules to verify the DC-29 Level 1a data; and, to arrive at updated Sensor Alignment Estimation file for the Data Processing Centers resulted in an agreement to distribute to the Background Data Center the Sensor Alignment Estimation files for four of the DC-29s and to intensify efforts to improve the Definitive Attitude. Engineering analysis shows the Definitive Attitude is lower quality than the on-board attitude estimate under certain spacecraft conditions. The magnitude of the degradation is on the order of one to two hundred micro-radians, but can be much worse under some conditions. The errors appear strongest when the spacecraft is changing its ECI attitude vs inertial stares. As an example, there have been Data Collection Events in which the sun angle is unfavorable for detecting stars by the star camera. When this happens, the Definitive Attitude converges very slowly to the commanded attitude. Even when the spacecraft is inertially pointed, the Definitive Attitude estimate is worse than the spacecraft attitude stability as estimated by the SBV, the IVN and the SPIRIT III sensors by about an order of magnitude from a nominal less-than-ten micro-radians

to greater than a hundred micro-radians. The Attitude Processing Center with the support of the Mission Processing Center, the Systems Performance Assessment Center teams and JHU/APL Management are addressing this issue. The Data Management team is involved also for coordination. A recommendation and a schedule are forthcoming.

TECHNICAL INTERCHANGE MEETING

The Data Certification and Technology Transfer Pointing and Alignment Watchdog prepared and presented "The Data Certification and Technology Transfer Team's Perspective of the Pointing and Alignment" for the spacecraft and its multiple instrumentsat the Spacecraft Portion of a Technical Interchange meeting held August 20 at the Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland. The proceedings are published by the Program Office.

DCATT Mission Plan Inputs																																				
* indicates "free" inherent DCE																																				
** indicates doesn't count against 4DCE/day limit																																				
25-Jun-96		Mission Month																																		
OPS plan		1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16				
Number	Experiment Plan Title	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	total p1
																																				0
DC-03 **	SPIRIT III Standard Turn-On/Turn-Off Sequence (SOO)																																			0
DC-04 *	SP3 Sensor Short Internal Stimulator Sequence (SISS)	0	2	2	2	2																														4
DC-05 *	SP3 Sensor Long Internal Stimulator Sequence (LISS)	2			2	2																														4
DC-08	SP3 Earthlimb OFVR	3	3	3																								3	3	3						12
DC-09 *	SBV Internal Characterization	2	1	1		1		1			1		1		1		1		1		1		1		1		1		1		1		1		1	5
DC-10	SBV Initial Cover Opening	1																																		1
DC-11	SBV Landolt Star Field	2	1	3	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1			22
DC-12	SBV Lunar OFVR	1		1		1		1		1		1		1		1		1		1		1		1		1		1		1		1				16
DC-13	SBV Earthlimb OFVR	1		1		1		1		1		1		1		1		1		1		1		1		1		1		1		1				16
DC-14	UVISI Internal Characterization	1		2	1	1		1		1			1	1			1	1			1	1			1	1			1	1				1		11
DC-16	UVISI Star Calibration: Staring Mode	2	1	4	2	2	1	1		1		1		1		1		1		1		1		1		1		1		1		1				21
DC-17	UVISI Star Calibration: Scanning Mode	1		4	2	1		2	1	1		1		1		1		1		1		1		1		1		1		1		1				20
DC-18	UVISI Lunar OFVR Characterization			1		1		1			1	1			1	1			1	1			1	1			1	1			1	1				9
DC-19	UVISI Earthlimb Calibration	1		2	1	1		1		1			1	1			1	1			1	1			1	1			1	1				1		11
DC-20	UVISI Point Source Track - Ground Target																																			0
DC-22	Emissive Reference Sphere							1		1				1				1				1														5
DC-23	Reflective Reference Sphere									1																										1
DC-24 *	OSDP Internal Characterization	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1			32
DC-25	OSDP Single Event Upset	4	2	2	1									2	1									2	1											10
DC-26 **	OSDP Technology Demonstration																																			0
DC-27 **	OSDP Power on and Power off																																			0
DC-28	South Atlantic Anomaly Mapping	3	1	1												1												1								6
DC-29	Pointing and Alignment	2	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19
DC-31	Small Angle OFVR Characterization	1		1			1	1			1				1					1	1			1			1	1			1				5
DC-32	Lunar OFVR Characterization	3		11		3		3						3						11				3						3						40
DC-33	SPIRIT III Flat Field Calibration - Mirror Scan Mode	3		4		2	1				1							1	1							1	1					2	1			13
DC-34	SPIRIT III Flat Field Calibration - Earthlimb Mode	3		2			1		1		1	1	1	1	1		1		1		1	1	1					1	1	1						10
DC-35	SPIRIT III Sensor Stellar Radiometric Calibration			4	2	3	1	2	1	2	1		1		1	2	1		1		1	1	1		2	1	1	1	1		1	1	1			17
DC-37	SPIRIT III Interferometer Wavelength Calibration		3	1	2	2	1					1	1					1										1			1					6
DC-38	SP3 Interferometer Spatial Domain Characterization	1	1	1			2	2									2	2															1			6
DC-39 **	SPIRIT III Data Collection Event Bracketing Sequence																																			0
DC-40 *	SBV functional test - (1alt 2)	2	1	2	1	2	1	2	1	2		2		2		2		2		2		2		2		2		2		2		2				32
DC-41	SPIRIT III Dark Offset Rev 2	9	5	8	6	3	1	5	2		1	1			2		2		1		1	2	3		1	1	1		1		1		1			29
DC-42 **	UVISI Standard turn-on turn-off procedure																																			0
DC-43	SPIRIT III source Transfer	6	1	4	1	4	2	4	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	3	2	4	2	2	2	2	2	2	2	3		42
DC-44	SPIRIT III Benchmark & Dark Offset	7	3	6	2	6	3	6	3	8	3	8	3	8	3	8	3	8	4	6	4	8	4	8	4	8	3	8	3	8	3	8	4			119
DC-61	SPIRIT III Sensor Cover Monitor (CME)	84	42																																	84
DC-62 *	SPIRIT III Sensor Cryostat Hydrogen Flowmeter (CHF)	2	1	2	1	1		1		1		1		1		1		1		1		1		1		1		1		1		1				18
DC-63	SPIRIT III Radiometer Initial Turn-on (IRT)	4	2																																	4
DC-64	SPIRIT III Interferometer Carriage Release (ICR)	1																																		1
DC-65	SPIRIT III Interferometer Initial Turn-on (IIT)	4	2																																	4
DC-66	SP3 Cover Release and First Light Performance (CRE)	1																																		1
DC-71	SBV initial Power Up	1																																		1
DC-72 *	SBV Functional Test - 16kbps																																			0
DC-73 *	SBV Functional test - 5alt2	1		1		1		1		1		1		1		1		1		1		1		1		1		1		1		1				16
DC-81	UVISI Initial Turn-On	9	4																																	9

DC-82	UVISI AGC Scan Mirror Image Quality	2		2				1			1	1			1	1			1	1			1	1			1	1			1	1		11
DC-83	UVISI Cover Opening	3	1																																	3
																																		0
	grand total	175	79	81	29	45	18	43	14	28	16	27	14	31	17	27	17	29	17	34	16	29	19	29	19	27	14	32	17	31	15	28	17	696
	total counted against 4 DCE/day	**164**	73	71	22	**34**	16	**36**	12	**22**	14	**21**	12	**25**	15	**21**	15	**23**	15	**28**	14	**23**	17	**23**	17	**21**	12	**26**	15	**25**	13	**22**	15	585
		p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	p1	p2	
	Mission Month	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		

NOTES RE MISSION PLAN COMPRESSION:

1. Highest Priority is to keep 10 DC43/44 s each month
2. Next highest priority = DC41 early in the mission
3. Emphasize Earthlimb in DC35 timeline choices

LIST OF 32 ADDITIONAL PRIORITY 1 DCEs IN ORDER OF PRIORITY

PRIORITY	EXPERIMENT	TIMELINE
A	DC37	1
B	DC37	2A
C	DC37	2B
D	DC41	7
E	DC41	9
F	DC41	10
G	DC41	11
H	DC41	14
I	DC41	15
J	DC41	16
K	DC08	5
L	DC08	6
M	DC33	3 (SERVO 2)
N	DC33	1
O	DC35	5
P	DC38	1
Q	DC38	2
R	DC35	2
S	DC43	1
T	DC44	1A
U	DC35	2
V	DC43	1
W	DC44	1A
X	DC35	2
Y	DC43	1
Z	DC44	1A
AA	DC35	2
BB	DC43	1
CC	DC44	1A
DD	DC35	2
EE	DC43	1
FF	DC44	1A

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