NASA-CR-200538

FINAL
IN-43-CR

Study and Demonstration of Planning and Scheduling Concepts for the Earth Observing System Data and Information System

NASA GSFC Contract NAG5-1931

CU Contract 153-1614

Final Report
Covering Period April 1992 through October 1993

Submitted to
National Aeronautics and Space Administration
Goddard Space Flight Center

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Overview

The University of Colorado's Laboratory for Atmospheric and Space Physics (CU/LASP), along with the Goddard Space Flight Center (GSFC), and the Jet Propulsion Laboratory (JPL) designed, implemented, tested and demonstrated a prototype of the distributed, hierarchical planning and scheduling system comtemplated for the Earth Observing System (EOS) project. No similar planning and scheduling system had ever been developed for a space science application. The planning and scheduling prototype made use of existing systems:

- CU/LASP's Operations and Science Instrument Support Planning and Scheduling (OASIS-PS) software package;
- GSFC's Request Oriented Scheduling Engine (ROSE);
- JPL's Plan Integrated Timeliner 2 (Plan-It-2).

Using these tools, four scheduling nodes were implemented and tied together using a new communications protocol for scheduling applications called the Scheduling Applications Interface Language (SAIL). An extensive and realistic scenario of EOS satellite operations was then developed and the prototype scheduling system was tested and demonstrated using the scenario. Two demonstrations of the system were given to NASA personnel and EOS Core System (ECS) contractor personnel. A comprehensive volume of lessons learned was generated and a meeting was held with NASA and ECS representatives to review these lessons learned. A paper and presentation on the project's final results was given at the American Institute of Aeronautics and Astronautics Computing in Aerospace 9 conference.

Description of Project

Planning and scheduling for the Earth Observing System missions will be distributed among scientists planning specific experiments and investigations, scientists and engineers charged with operating specific EOS instruments, and spacecraft controllers. Each of the three groups will have a computer system available to assist them in the planning and scheduling activities (as well as other operational activities):

1. Experimenters will initiate plans for individual experiments using an Instrument Support Terminal (IST).

2. The Principal or Facility Investigator team for each instrument will use the facilities of an Instrument Control Center (ICC) to coordinate the investigations for their instrument and to assure the health and safety of the instrument.

3. Spacecraft operators will use the facilities of the EOS Operations Center (EOC) to combine all of the instrument schedules into a single payload operations schedule, and then combine the payload schedule with the schedule for core spacecraft operations (accounting for limitations in spacecraft resources like power and data transmission bandwidth) into a single integrated operations timeline.

The goal of this project was to adapt and demonstrate advanced planning and scheduling techinques developed by CU/LASP, GSFC and other groups within the distributed EOS environment described above. Specifically, we wanted to:

1. Adapt planning and scheduling concepts for distributed payload operations to the Earth Observing System environment, with emphasis on how to properly partition planning and scheduling tasks among the IST, ICC and EOC.

2. Implement a joint testbed with GSFC and with JPL to demonstrate and evaluate the IST - ICC - EOC functionality.

3. Use the testbed to validate operations concepts for EOS.

4. Demonstrate and evaluate the integrated set of planned flight operations functions including planning and scheduling, command and control, DAR generation and integration.

5. Include and encourage user participation of the operations concepts and the ground system elements.

6. Include interactions with the real EOS platform users and the EOS Ground System and Operations project.

To achieve these goals, CU/LASP modified its OASIS-PS scheduling software package and installed the OASIS-PS software in two prototype ISTs. One IST was designed around an actual instrument selected for EOS: the Solar Stellar Irradiance Comparison Experiment (SOLSTICE). The second IST was designed for a fictitious instrument called HIRTER (the name coming from the fact that it combined aspects of two instruments contemplated for EOS: HIRIS and ASTER). The HIRTER IST interfaced with the HIRTER ICC implemented by JPL. The ICC in turn interfaced with the EOC. Communication between the ISTs, ICC and EOC was accomplished using the SAIL language.

and the other for the HIRIS instrument The SOLSTICE IST interfaced directly with EOC, while the HIRIS IST interfaced with a HIRIS with the SOLSTICE ICC and with the other stubbed portions of the EOS DIS deemed necessary for concept demonstration. The SOLSTICE ICC will interface with an EOC prototype developed by GSFC using the SAIL language and with other stubbed portions of the EOS DIS deemed necessary for concept demonstration. The HIRIS IST deveoped by CU/LASP will interface with a prototype ICC for HIRIS developd at JPL.

A detailed description of how the overall system was implemented can be found in the Distributed Planning and Scheduling Prototype Intercenter Plan, Revision 1, which is included as Appendix A. This report defines the functions performed at each node, details the communications messages between them, and lays out the scenario used to test and demonstrate the system.

A chronological description of CU/LASP's work on this project can be found in the semi-annual status reports that are included in the following sections of this document.

Major Project Accomplishments

This project was successful in implementing a distributed, hierarchical planning and scheduling system like that contemplated for the EOS project. Major accomplishments include:

- Tailoring three existing software packages — OASIS-PS, Plan-It-2 and ROSE for application to EOS scheduling problems.
- Demonstrating that a heterogenous scheduling system — one composed of different scheduling tools — could be successfully implemented for projects like EOS.

- Development of a comprehensive and detailed scenario of EOS scheduling (see Appendix A).

- Demonstration of the planning and scheduling system carrying out its functions in a realistic scenario. There were two demonstrations of the system to NASA and ECS personnel: an interim presentation in December 1992; and final presentation in May 1993. Appendix B contains the material that was presented in December 1992. Appendix C contains the material presented in May 1993.

- Generation of a comprehensive volume of lessons learned and presentations of key lessons learned to NASA and ECS personnel in July 1993. The lessons learned document is included as Appendix D.

- A paper and presentation on the project's final results at the AIAA Computing in Aerospace 9 conference in San Diego, CA in October 1993. A copy of the conference presentation is included as Appendix E.

Deliverables

The chief deliverables to this project were the following:

- The Intercenter Plan, documenting the scheduling system and the scenario to be followed.

- A full description of the SAIL communications protocol (See the document entitled "The Scheduling Applicatoins Interface Language (SAIL) Reference Manual", GSFC publication DSTL-91-021, Rev. 1, Dec. 1992).

- The demonstrations held at GSFC in December 1992 and May 1993.

- The lessons learned documents (draft version in May 1993 and the final version in June 1993) and the associated presentation on these lessons held at GSFC in July 1993.

- The presentation for the AIAA conference.

- Semi-annual reports (included below).

- Monthly status updates.

Semi-Annual Report

April 1992 through September 1992

The Earth Observing System Data Information System (EOSDIS) planning and scheduling prototype is a joint effort between the Goddard Space Flight Center (GSFC), the Jet Propulsion Laboratory (JPL), and the University of Colorado's Laboratory for Atmospheric and Space Physics (CU/LASP). The primary goal of this project is to investigate and evaluate concepts and issues associated with the distributed planning and scheduling of science observations within the EOSDIS Flight Operations Segment (FOS). The prototype will allow us to examine and demonstrate planning and scheduling activities at and between the EOS Operations Center (EOC), an Instrument Control Center (ICC), and several Instrument Support Terminals (ISTs). Lessons learned in this prototype should provide valuable information for the actual EOSDIS. This report describes the first six months of work that CU/LASP has performed for this project.

The EOC has overall responsibility for planning and scheduling the activities of EOS spacecraft. Some EOS instrument operations will be scheduled and controlled from ICCs and ISTs. Our prototype examines the division of responsibilities between the EOC, ICCs, and ISTs, the capabilities needed at each site, and how the sites communicate with one another. The testbed consists of four major elements: a prototype EOC planning and scheduling system is located at GSFC; an ICC for an instrument called HIRTER (a fictitious instrument that combines characteristics of two real instruments called HIRIS and ASTER) is located at JPL; ISTs for the HIRTER and SOLSTICE instruments are located at CU/LASP; and an IST for the MODIS-N instrument is located at GSFC. The SOLSTICE IST communicates directly with the EOC scheduler located at GSFC and receives a schedule from the EOC. The HIRTER IST communicates with the HIRTER ICC at JPL. The HIRTER ICC in turn sends and receives schedule information to and from the EOC.

Each element has used it's own planning and scheduling software. All three institutions are linked together using NASA's Science Network. A special communications interface has been designed using a package called the Open System for Coordination of Automated Resources (OSCAR) along with the Scheduling Applications Interface Language (SAIL) message protocol. The SAIL protocol is used in the testbed as a means for expressing the planning and scheduling information communicated between the testbed elements.

As noted above, CU/LASP is responsible for two IST's: the HIRTER IST and the SOLSTICE IST. Both of these ISTs use the Operations and Science Instrument

Support Planning and Scheduling (OASIS-PS) software package developed by CU/LASP. The OASIS-PS software is written is Ada and runs on VAXStation computers under VMS. The key components of the software are:

- The Timeline Manager which maintains the user interface for the package. The user interface is implemented using the X-11 and Motif standards.
- The Database Manager which controls a specialized relational database that contains planning and scheduling information.
- The Schedule Manager which oversees the production and modification of schedules.
- The Communications and Data Products Manager which controls the flow of information into and out of the OASIS-PS software.

Much of the capability of the OASIS-PS package is independent of application. However, the software is being modified and upgraded for use in this testbed. For example, an expert system scheduler for the SOLSTICE instrument is being prepared using the CLIPS expert system tool from NASA's Johnson Space Center. Once complete, this expert system will be connected to the rest of the package through the Schedule Manager to perform all SOLSTICE scheduling operations.

The SOLSTICE and HIRTER ISTs are designed specifically to represent the kinds of capabilities that we expect instrument scientists and instrument engineers will want when planning and scheduling instrument activities. This means, for example, that some new kinds of displays are being added to the OASIS-PS package to represent schedules in a way that will be easy for instrument scientists and engineers to understand. The TAE+ user interface software package from GSFC is used to develop this user interface.

The design and implementation of the prototype SOLSTICE IST began in April 1992, and wil continue through September. The SOLSTICE IST is being developed largely by updating capabilities that already existed for planning and scheduling the operations of a version of the SOLSTICE instrument flying aboard the Upper Atmosphere Research Satellite (UARS). We have modified the user interface, database, and communications subsystems of the OASIS-PS software to upgrade from the UARS SOLSTICE system to the EOS SOLSTICE system.

In the user interface, we added new timelines to display the instrument activities and the resource requirements for each activity. We updated menus to allow the user to create SAIL messages and ingest SAIL messages. We also defined the types of possible activities and sub-activities for the EOS SOLSTICE instrument.

The main activities planned are solar and stellar activities, with slews and observations compromising the subactivities.

The SOLSTICE IST database was updated with scheduling data for the time period 2001/081 to 2001/088. This is the target week to be used for a public demonstration of the prototype that is planned for December at GSFC. The scheduling data in the database includes SOLSTICE solar and stellar observations, slews, SOLSTICE activities and corresponding subactivities, activity resources, solar and stellar availability, orbit events, spacecraft events, and communication events. This data set has been used for on-going testing between the GSFC EOC and the SOLSTICE IST.

In May, GSFC distributed software for interpreting messages encoded in the SAIL protocol. They also provided software to implement the OSCAR mechanism for transferring SAIL messages between the testbed sites. After evaluating the SAIL message handling software provided by GSFC, we decided to implement our own SAIL handler because the messages created or processed by the IST are simple in format and the full capability of the SAIL protocol — which is expensive to implement — is not needed. In early SAIL message testing, before the completion of our own handler, we did use the GSFC SAIL handler as a stand-alone syntax checker. Our pared-down version of the SAIL message handler was integrated into the SOLSTICE IST in July. The OASIS-PS software takes planned SOLSTICE scientific observations and instrument activities and translates them into SAIL messages which are sent to the EOC for scheduling. Scheduling messages to the SOLSTICE IST from the EOC are received by our SAIL message handler and the information from the messages is extracted and placed into the database within the SOLSTICE IST.

Testing of schedule messages between the SOLSTICE IST and EOC began in August and is on-going. These tests consist of generating SAIL scheduling messages for a science activity plan that is generated by the expert system scheduler within the IST. These messages are then transferred as files (using the standard File Transfer Protocol — FTP) to the EOC at GSFC. The messages are processed by the EOC scheduler and the resultant schedule from the EOC is formatted into SAIL messages and transferred back to Colorado. These messages are ingested into the IST and the IST's activity schedule is updated. Overall the SAIL message processing tests have been successful both at GSFC and Colorado.

In July, testing of the OSCAR communications package began between CU and GSFC. This test was designed to verify the correct configuration and setup of OSCAR and to demonstrate the ability to transfer SAIL messages back and forth using OSCAR. These tests were successful; however, a performance problem was noted when transferring large files across the network. GSFC then did some performance testing in August and improved the performance somewhat. In general, the transfers between Sun computers is fast, but transfers between Sun and VAX computers is slow. Based on this testing we decided not to integrate the OSCAR software into the SOLSTICE IST, but to use it as a stand-alone package. If OSCAR performance is improved, the package can be easily integrated into OASIS-PS. For now, SAIL message files are transferred via FTP.

Design of the HIRTER IST began in June. To learn more about the science campaign and instrument operations for the HIRIS instrument (which is one of two models for the HIRTER instrument) we visited with Alex Goetz, who is the principal investigator for the HIRIS instrument. Dr. Goetz said the IST should be able to access the latest weather data and display this data to help the scientist make adjustments to the schedule for observations. Some observations, for example, might be dependent on the amount of cloud cover over a target, and the scientist may change or even cancel a scheduled activity based upon actual cloud cover. In general, it seems that there will likely be many cases where scientists want to evaluate and modify schedules based upon analysis of previous or current ancillary data.

Software development is currently underway to tailor and modify the OASIS-PS package to create the user display windows for the HIRTER ICC. This includes a Mercator map projection with an orbital ground track overlaid with cloud cover data. In addition, a display containing timelines for science and operational data has been designed and is under development. The communication and data interface between the HIRTER ICC at JPL and the HIRTER IST at Colorado will be worked out at a meeting at the end of September. The HIRTER IST is the last software element that needs to be completed by CU/LASP for the December demonstration.

On July 28-29, we attended an EOSDIS Planning and Scheduling Prototype project meeting at JPL. There were concerns raised about the performance of OSCAR. The OSCAR performance issues were investigated in August and testing results will be reported and a decision on whether to use it will be made at the next prototype meeting at the end of September. There was considerable discussion on the content and logistics for the upcoming demonstration in December. The demonstration will include all three centers and will demonstrate the baseline scenario developed by the project participants. There was also a discussion of how to resolve schedule conflicts and how to support coordinated observations involving multiple instruments.

Major activities in the upcoming months in preparation for the demonstration are: completion of all necessary instrument schedule data; continued testing between the three centers; refinement of demonstration scenarios; and implementation of conflict detection and resolution mechanisms.

In summary, the implementation of CU/LASP's portion of the prototype is underway and on schedule. Past milestones were met and current tasks are progressing on schedule. We expect to be fully ready for the demonstration in December at GSFC.

Semi-Annual Report

October 1992 through March 1993

This status report will focus on work performed by CU/LASP on the EOSDIS planning and scheduling prototype study from October 1992 to March 1993. CU/LASP's participation in this study includes the software prototyping of the SOLSTICE IST and the HIRTER IST scheduling tools. Both of these ISTs are implemented using the OASIS-PS software. OASIS-PS software has been tailored and modified for each IST. CU/LASP's work during this six month period centered on the software development of the HIRTER IST, in addition, to adding more functionality to the SOLSTICE IST. There was also much time allocated to schedule data development and data flow testing between the SOLSTICE IST and the EOC, as well as for the HIRTER IST and the HIRTER ICC. Schedule data sets were generated for the baseline and complex scenarios to be used in prototype demonstrations at GSFC in December 1992 and May 1993.

Backtracking a week into September, on September 24th and 25th, CU/LASP hosted the EOSDIS planning and scheduling working meeting. The meeting reviewed prototyping progress and schedules, re-examination of the EOS AM-1 spacecraft model, demonstrations of the EOC (ROSE) and SOLSTICE IST scheduling prototypes, a review of the baseline operations scenario, discussion of the December prototype demonstration at GSFC. There was considerable discussion and planning for the December demonstration. Planning for the demo started with a walk-thru of the baseline operations scenario. Discussion then focused how the ISTs, ICC, and EOC would each handle and support the instrument safing activity during the spacecraft orbit adjust window. Also expressed was the need for the ISTs and ICCs to be able to delete or replace scheduled activities at the EOC. Finally, action items were identified for the demo as well as for the on-going prototyping effort.

In October, we continued testing of schedule data generated by the SOLSTICE IST and sent to the EOC, and schedule data generated by the EOC and sent back to the SOLSTICE IST. Seven days of SOLSTICE activity requests were successfully processed by the EOC and SOLSTICE allocations were processed successfully by the SOLSTICE IST. SOLSTICE activity requests were updated to include CAUSE_VIBRATION and AVOID_VIBRATION resources to model SOLSTICE instrument vibration.

Randy Davis and Nancy Thalman travelled to JPL October 13th, to meet with Steve Peters and Susan Borutzki to discuss the functionality of the HIRTER IST and the HIRTER IST-ICC communications interface. This meeting was very productive. At this meeting we defined three types of activities that the HIRTER IST could request and the type of information contained in the request. The following types of observation requests could be created: a discrete target or point target, a global target which covers a large swath of land, and a special target which allows the user to define new targets of interest. These requests can be scheduled with any three telescopes or combination of VNIR, SWIR, or TIR telescopes. We also defined a SAIL-like format for the HIRTER IST requests and construed the type of data to send in the requests such as a three-letter target identifier, angle- to-target value, and start and stop times for the observations. Another requirement is for the HIRTER IST to process HIRTER allocations created by the EOC and display the activities on three separate timelines. These timelines contained observations, slews, and instrument states. We received from JPL the following data for the HIRTER IST: target availability for discrete and global targets and land-water boundary crossings. Two other features for the HIRTER IST are two displays, one containing a mercator projection with an orbital ground track, displaying all possible targets for a specified time period. The second display contains cloud weather data overlaid on a mercator projection.

Once we got back to Colorado and ingested the target availability and land-water boundary crossings (based on an EOS orbit used by JPL) into the HIRTER IST software system, we noticed a discrepency between the JPL and CU orbit events data (based upon the original orbit generated by Tom Sparn of CU/LASP) and the land day/night data. CU obtained the Keplarian orbital elements corresponding to JPL's data and re-generated the data several times using Tom Sparn's orbital generation software. CU was able to re-generate orbit events data within 30 secs to the JPL set and this time difference grew with each consecutive orbit. After several generations and about two weeks of effort on this task it was decided to use the best set of orbital data. The new orbit events data set was distributed to each center.

November was spent determining the data set for the demonstration, exercising the communications paths by flowing schedule data between the three centers, processing the data at each center, working out software bugs, and working out the details of the December demo scenarios during weekly teleconferences.

In December, Randy Davis and Nancy Thalman travelled to GSFC to participate in the EOSDIS planning and scheduling demonstrations from December 7-11. The first two days of the trip involved on-site setup, data flow tests, and dress rehearsals. Two successful and interesting demonstrations were given Wednesday and Thursday afternoon to NASA personnel. The demonstrations consisted of an overview of the prototyping task objectives, background information on spacecraft and instrument modelling, and s/w demonstration of the intercenter baseline operations scenario. This simulation of scheduling covered a three week time period, starting at three weeks before the target week or execution of activities. After the demonstrations were over, Friday morning a working group meeting was held to review prototyping progress, discuss future prototyping activities, and to establish a tentative schedule for January through June 1993.

In January 1993, work focused on generating seven days of SOLSTICE IST activities and noting any impacts of scheduling with seven days versus one day of instrument activities. Increased processing time by all centers was noted. Also, in January, a new rule-base for the automatic scheduling of solar and stellar observations was integrated into the SOLSTICE IST software. This new scheduler allowed a 24 hour observation and slew schedule to be generated in two minutes as opposed to 12 minutes previously.

In telecons during January, the centers discussed the handling of activity changes between the ICC/ISTs and the EOC. For example, how to send deletes and replaces of instrument activities to the EOC. In the SOLSTICE IST software, the replace operation was emulated by deleting the old activity and adding the new activity. When a request was generated by the IST the request contained a delete and add action, to emulate the replace action. EOC was able to process these two actions to emulate a replace for a SOLSTICE IST activity. Activity deletes were handle by a delete action followed by the activity name.

On January 28th, Steve Peters and Susan Borutzki came to Colorado to have a HIRTER IST/ICC interface meeting with the CU EOSDIS planning and scheduling prototype team. This meeting was very productive and it was agreed to make the following enhancements to the HIRTER IST/ICC:

- Display targets/orbits on a mercator projection and be able to select on a specific target and schedule target as an observation interval on the request timeline.

- Create five types of requests that the IST can send to the ICC. These include TOO's, SAFING, calibrations, target and global observations. Within the requests there are new kinds of information that can be included. This includes the preferred start and stop time that indicates the preferred time to schedule the activity. A relaxed start and stop time that when not equal to the preferred start and stop time infers a flexible window in which to schedule the activity.

- A prioritization scheme agreed to by CU and JPL will be used at the ICC to resolve conflicts between requests sent by the IST to the ICC.

- Actions on request messages that flow from the IST to the ICC are create and delete.

- For conflict resolution a constraint checker will be implemented to detect and identify target observations. Wherever targets are obscured by clouds these targets will be deleted and alternate targets will be sent to the ICC.

February and March were devoted to implementing the above functionality in the HIRTER IST in preparation for testbed s/w testing with all three centers at Colorado in March.

During the telecons in February and March, there was much discussion of conflict scenarios for the prototype. Two general kinds of conflict were agreed upon by the group. These were loss of a TDRSS event and instrument vibration. The handling of TDRSS loss was determined and a scenario worked out through telecons. A priority scheme was also worked out. This scheme assigned different priorities to the HIRTER and SOLSTICE instrument activities. These priorities were used at the EOC to identify HIRTER and SOLSTICE activities that could be deleted to help resolve tape recorder data volume conflicts when they occurred.

March 1st the preliminary draft of lessons learned were due at GSFC. CU submitted aproximately 20 lessons in the first version. Also during this month comments on lessons were submitted as well as a second rewrite and inclusion of old and new lessons.

March 22-24th, CU/LASP held another EOSDIS planning and scheduling prototype working group meeting. Several activities occurred during these three days. In the mornings, there were detailed discussions of lessons learned. Categories were decided upon in which to group lessons learned. The group also discussed some of the more interesting and controversial lessons written. In the afternoon, participants split off into two groups. The testbed implementors and tested schedule data according to the scenarios derived from the baseline and more complex scenarios discussed in previous telecons. The others discussed the May demo issues such as audience/objectives and logistics.

In summary, CU/LASP's implementation of enhancements in the HIRTER IST and updates in the SOLSTICE IST are progressing well. With the exception of a few software bugs that remain to be fixed, we are pretty much ready for the upcoming May demonstration which will mark the conclusion of software development on this project. In April and May, we will focus on completing our final set of lessons learned. We also expect to continue testing HIRTER IST and SOLSTICE IST software as well as testing of demo scenarios in coordination with the other centers.

Semi-Annual Report

April 1993 through September 1993

This is our final semi-annual report for the EOSDIS planning and scheduling prototype study, covering the period April to September 1993.

April and May were devoted to preparing the final version of the lessons learned document. Randy Davis wrote up a brief description of the categories decided upon at the March meeting and distributed to all. Everyone was responsible for categorizing their lessons into one of these categories. Comments were also provided by everyone and incorporated into the final version of the lessons learned document.

Testing, practicing and working out the details for the final May demonstration kept us busy in April. In particular the script for the TDRSS loss operations scenario was worked out during the telecons. We started practicing by each generating a days worth of SOLSITCE IST activities and sending the requests to the EOC. The EOC processed these requests and generated allocations which the IST processed. Once TDRSS tape recorder playback activities were known at the EOC, the EOC could detect whether the scheduled instrument activities were exceeding tape recorder capacity. For this scenario, when tape recorder data volume conflicts were detected by the EOC, it was decided that the EOC could delete low priority SOLSTICE activities at the EOC, and then notify the SOLSTICE IST as to which activities had been deleted. This action whereby the EOC deletes a SOLSTICE activity was allowed because realistically the EOC will need to have this priviledge, and the SOLSTICE IST did not model the tape recorder data volume.

The details of the second scenario where vibration conflicts could occur between the different instruments was worked out. Since the SOLSTICE IST did not ingest other instrument schedules, the SOLSTICE IST did not check for vibration conflict. We did generate a schedule where the IST produced several activities that caused vibration conflicts with other instruments.

For the HIRTER IST/ICC transactions during the baseline operations scenario, we decided to have the IST schedule a calibration and cordinated HIRTER-MISR target observation request, that would be inserted into the initial schedule at the ICC. For the variations scenario, during the final scheduling phase the IST would schedule a multiple-target opportunity and send delete requests for scheduled target observations that were obscured by cloud weather data.

During May 17-21, Randy Davis and Nancy Thalman werer at GSFC to participate in the final EOSDIS planning and scheduling prototype demonstration. Like the December demonstration, the first two days at GSFC involved on-site setup of the HIRTER IST and SOLSTICE IST software, preparation of schedule data, schedule data flow tests, and dress rehearsals.

Wednesday morning consisted of the prototype software demonstration. Highlights of this demo consisted of prototyping task goal and features, task objectives, spacecraft and instrument modelling, introduction of the different planning and scheduling software, and an overview of the baseline operations scenario. The demonstration of the baseline scenario was identical to the December demonstration and was presented to give the audience an understanding the EOSDIS PS operations.

Wednesday afternoon and Thursday morning were devoted to lively discussions of selected lessons learned with the ECS contractors, ASTER ICC attendees, GSFC attendees, and the EOSDIS PS prototyping team. Thursday afternoon the prototype software demonstration of the variations scenario was presented. This variations scenario was similar to the baseline scenario, but differed slightly in that two types of conflicts were introduced which caused more iterations of schedules between the EOC and the ICCs/ISTs. The deletion of TDRSS contacts by the NCC to dump spacecraft tape recorders caused a reduction in HIRTER and SOLSTICE activities. Activities were deleted or moved to a later opportunity. The second conflict introduced an instrument vibration conflict that occurs when instrument slews (HIRTER or SOLSTICE) interfere with instrument observations (HIRTER, SOLSTICE, or MISR). Responses to conflicts were to move the slew, move the observation, or accept degraded data.

The first draft of the lessons learned document was released in May. After reviews and revisions, the final version of the document was released in June. In July, Randy Davis travelled to GSFC to participate with Larry Hull and Steve Peters in a final briefing to approximately 25 NASA personnel and ECS contractors on the lessons learned during this activity. 65 lessons learned were selected for discussion, but most of the time was spent on just a few major issues and on a discussion of how the planning and scheduling process could be made better in the future.

During the summer of 1993, Larry Hull, Steve Peters and Randy Davis collaborated on a paper on the EOS Distributed Planning Scheduling Prototype" for the AIAA Computing in Aerospace 9 Conference that was held in San Diego, California in October of that year. On October 20, Randy Davis will travel to San Diego to present the paper at this conference, marking the conclusion of this project.

Appendix A

Intercenter Plan, Revision 1

December 1992