FINAL REPORT

Data Analysis and Interpretation of UVSP and Other Experiments on Board Solar Maximum Mission

Contract Number: NAS8-33526

Period of Performance: February 29, 1980 - February 28, 1987

Submitted To

Submitted By

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The University of Alabama in Huntsville

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TABLE OF CONTENTS

SUMMARY

Under this contract, there are two major parts; (i) programmatic aspect and (ii) scientific aspects. We shall summarize the activities about these two aspects as follow:

(i) Programmatic Aspects

In this aspect, nineteen workshops and meetings were organized and executed. There were eighty-eight scientist which received supported from this contract to participate these activities; Pinhole Occulter Facility (P/OF) and Solar Maximum Mission Workshop in which the P. I. served as group leader.

(ii) Scientific Aspects

In this aspect, we have investigated the solar flare energy buildup and release, coronal dynamics, energy and momentum transport from lower solar atmosphere to interplanetary space and numerical methods for the calculation of nonlinear force-free field and evolultion solar magnetic field. A total of eighteen papers concerning these subjects were published in national and international journals.

I. INTRODUCTION

During the period of this contract (February 29, 1980 - February 28, 1987) there were two major efforts; one is programmatic effort which was to coordinate scientific working groups and organize workshops in the solar physics discipline. The other part was to perform scientific research to investigate the fundamental physical mechanisms of the energy and momentum transport from the solar surface to interplanetary space. We shall summarize our achievements according to these catagories in the following sections; Section II will discuss the programmatic research, the scientific research will be discussed in Section III. Final concluding remarks will be presented in Section IV.

II. PROGRAMMATIC RESEARCH

In this effort, we have organized sixteen working group meetings in the discipline of solar physics and supported eighty-eight nationally and internationally known scientist and professors to participate in these meeting or to visit Huntsville and Marshall Space Flight Center for consultation. We shall list these meetings in the following and list the scientist and professors in appendix A.

P/OF Science Working Group Meeting, April 24-25, 1986 at MSFC. (see Appendix B for minutes)

P/OF Science Working Group Meeting, October 5-6, 1985 MSFC.

P/OF Workshop, May 8-10, 1985 at MSFC. (see Appendix B for agenda).

SMM Investigator Working Group Meeting, January 24, 1985 at GSFC.

SHAZAM Space Hazards Monitor Meeting, Feb 2 - Mar 1, 1984 at MSFC.

Solar Vector Magnetograph Conference, May 15-18, 1984 at MSFC, this meeting resulted in NASA Publication #2374 "Measurements of Solar Vector Magnetic Fields" (M. J. Hagyard ed.)

Advanced High Pressure O /H Technology Conference, June 27-29, 1984 at MSFC. This meeting resulted in NASA Publication #2372 "Advanced High Pressure 0 /H Technology" (S. Morea and S. T. Wu eds.)

Solar & Heliospheric Physics and Solar Terrestrial Neighborhood Meeting , December 12-13, 1984 at UAH. (see Appendix B for program)

SMM Workshop, February 13-17, 1984 at GSFC.

P/OF Science Working Group Meeting, Sept 7-8, 1983 at MSFC.

SMM Investigator Working Group Meeting, January 24, 1983 at GSFC. (see Appendix B for minutes).

SMM Investigator Working Group Meeting, June 9, 1983 at GSFC.

P/OF Science Working Group Meeting, Jan. 15-16, 1982 at Boulder, CO. (see Appendix B for minutes).

P/OF Science Working Group Meeting, Sept. 21-22, 1982 at UAH. (see Appendix B for minutes).

P/OF Science Working Group Session, Sept. 17-18, 1981 at MSFC. (see Appendix B for minutes).

P/OF Telescope Meeting, May 4-5, 1981 at MSFC. (see Appendix B for minutes).

III. SCIENTIFIC RESEARCH

The scientific objectives of this contract is to utilize data obtained from Solar Maximum Mission (SMM) satellite to understand the fundamental physical mechanisms of active region and its effects on solar interplanetary space. A total of nineteen paper were published in national and international journals and reputable conference proceedings. These achievements are summarized according to their catagory in the

following:

III.1. Lower Solar Atmosphere Dynamics

Under this subject, a total of nine paper are published.

Modeling of Energy Buildup for a Flare Productive Region, by S. T. Wu, Y. Q. Hu, K. R. Krall, M. J. Hagyard, and J. B. Smith, Jr., Solar Physics, 90, 117-131, 1984.

On the Numerical Computational of Nonlinear Force-Free Magnetic Fields by S. T. Wu, H. M. Chang and M. J. Hagyard, in NASA Conference Publication 2374 "Measurements of Solar Vector Magnetic Fields" 17-48, 1985.

Induced Mass and Wave Motions in the Lower Solar Atmosphere. II. Effects of Converginand Diverging and Photospheric Motions, by S. T. Wu, Y. Q. Hu, and Y. Nakagawa, and E. Tandberg-Hanssen, Astrophysical Journal, 306, 751-761, 1986

Magnetohydrodynamics (MHD) Modelling of Flare Energy Buildup, The Energy Release Phase, and Its Propagation into Heliospheric Space, by S. T. Wu and S. Panitchob Solar Maximum Analysis, pp 393-404, V. E. Stepanov & V. N. Obriko (EDS.) VNU Press, 1986.

Filament Formation Due to Photospheric Shear by S. T. Wu and Y. C. Xiao, Proceedings of the CPP Workshop (A. Poland ed.) NASA Special Publication # NASA SP 2442, p. 51-56, 1986.

MHD Analysis of the Evolution of Solar Magnetic Fields and Currents in an Active Region, by S. T. Wu, J. F. Wang, and E. Tandberg-Hanssen in Unstable Current Systems and Plasma Instabilities in Astrophysics, 487-490, M. R. Kundu and G. D. Holman (eds.), 1985, by the IAU.

Theory of Quadrupolar Sunspots and the Active Region of August 1972 by H.-S. Yang and H.-M. Chang, Solar Physics, 84, 139-151., 1983.

Numerical Simulation of Flare Energy Buildup and Release via Joule Dissipation by S. T. Wu, J. J. Bao and J. F. Wang, J. of Adv. Space Research, Vol. 6, No. 6, 53, 1986.

The MHD Description of the Dynamical Formation of the Prominence Magnetic Field Configuration by J. J. Bao, S. T. Wu and C. H. An.

In these papers, we have discussed the solar flare energy buildup, flare energy release, modeling of solar magnetic field based on MSFC's solar vector magnetograph data, filament formation, prominence formation, induced wave and mass motion due to photospheric converging and diverging motions and sunspot structures. Copies of these papers may be found in Appendix C.

III.2. Coronal Dynamics

There are three papers which were published in this catagory which include:

A Mechanism for a Class of Solar Coronal Disturbances, by S. T. Wu, Y. Q. Hu, S. Wang, M. Dryer and E. Tandberg-Hanssen, Astrophys. & Space Sci., 83, 189-194, 1982.

A Linear MHD Instability Analysis of Solar Mass Ejections with Gravity, by M. T. Song, S. T. Wu, and M. Dryer, 1987 (in press).

Dynamics of the Eruptive Prominence of 6 May 1980 and Its Relationship to the Coronal Transients, Astronomy & Astrophysics.

In these papers, we are the first to demonstrate numerically the separation of mass and wave motion in the corona. In the third paper listed above, we have utilized Solar Maximum Mission data to model the relationship between eruptive prominence and coronal transients. In the second paper, we have performed a thoroughly theoretical analysis on the linear MHD instability of solar mass ejections with gravitational effects. We have established theoretically the criteria of broken loops. Copies of these papers may be found in Appendix C.

III.3. Interplanetary Dynamics

In this subject, our emphasis is the solar/interplanetary coupling mechanisms to examine how the energy and momentum transport from the solar surface to the earth's environment through interplanetary space. There were five papers published in this area which include:

The Solar/Interplanetary/Magnetosphere/Ionosphere Connection: A stretegy for Prediction of Geomagnetic Storms by M. Dryer, S.-I. Akasofu, H. W. Kroehl, R. Sagalyn, S. T. Wu, T. F. Tascione, and Y. Kamide, in Proceedings of AAS/AIAA Astrodynamics Specialist Conference, Paper AAS-85-313, 1985.

Numerically-Simulated Formation and Propagation of Interplanetary Shocks by S. T. Wu in "Computer Simulation of Space Plasmas", D. Reidel Publishing Co., 179-201, 1984

The Solar Flare-Induced Earth's Environment by S. T. Wu, M. Dryer, and S. M. Han, Conference Paper presented at AAS/AIAA Astrodynamics Conference, August 12 -15, 1985.

Three-Dimensional, Time-Dependent MHD Model of A Solar Flare-Generated Interplanetary Shock Wave by M. Dryer, S. T. Wu and S. M. Han, Astrophysics and Space Science Library, D. Reidel Publishing Co., Dordrecht, The Netherlands, 1986.

A Transient, Three-Dimensional MHD Mode for Numerical Simulation of Interplanetary Disturbances by S. M. Han, S. T. Wu and M. Dryer in STIP Symposium in Retrospective Analysis and Future Coordinated Intervals (M. A. Shea and D. F. Smart Eds.) Bookcrafters Publishing Co., 1986.

III.4. Numerical Simulation Techniques

Under this subject a fundamental paper entitled "The Method of Projected Characteristics for the Evolution of Magnetic Arches" has been accepted for publication in Astronomy and Astrophysics. In this paper, we discussed a new method to solve initial boundary value problems. A copy of the galley proof for this manuscript is included in Appendix C.

IV. CONCLUDING REMARKS

In summary, the goals which we set up to accomplish have been achieved, in both parts, programmatic and scientific aspects. In the programmatic aspect, we have organized nineteen workshops and meeting and there were eighteen paper published in the scientific aspects. The contents of these publications range from photospheric to heliospheric space. Based on our study, we have concluded that future developments on magnetohydrodynamic (MHD) simulation is necessary to include higher order effects such as finite electric conductivity, thermal conductivity and radiation as well as realistic magnetic field configurations.

APPENDIX A

CONSULTANTS

CONSULTANTS

Attended and participated in scientific investigations, discussions and presentations at a meeting to develop scientific objectives and design parameters and recommend any required changes or modifications tomeet planned program concepts of the Pinhole Occulter Telescope Project. The meeting was held on October 6,7, 1980 at Boulder, CO.

Dr. Edward Fenimore, Los Alamos Scientific Laboratory.
Dr. Robert P. Lin, Space Science Lab., Univ. of California.
Dr. Gordon P. Garmire, Dept.of Astronomy, Pennsylvania State University.
Dr. John L. Kohl, Atomic, Molecular & Physics Dept. Harvard Smithsonian Center.
Dr. Gordon Hurford, Solar Astonomy, California Inst. of Technology.
Dr. Hugh Hudson, Center for Astrophysics & Space Science, Univ. of California.
Dr. S. P. Wilmore, Dept. of Space Res., Univ. of Birmingham, England.
Dr. F.Q. Orrall, Inst. for Astronomy, Honolulu, Hawaii.

Attend and participate in the Scientific Investigations, discussion, and presentations at a meeting to develop scientific objectives and design parameters and recommend any required changes or modifications to meet planned program condepts of the Phinole Occulter Telescope Project. The meeting will be held January 18-21, 1981 at MSFC/NASA.

Dr. Gordon P. Garmire, Dept.of Astronomy, Pennsylvania State University.
Dr. Edward Fenimore, Los Alamos Scientific Laboratory.
Dr. Robert P. Lin, Space Science Lab., Univ. of California.
Dr. Gordon Hurford, Solar Astonomy, California Inst. of Technology.
Dr. Richard H. Munro, High Altitude Observatory, Boulder, CO
Dr. F. Van Beek, Space Reserch Laboratory, The Netherlands
Dr. Hugh Hudson, Center for Astrophysics & Space Science, Univ. of California.
Dr. Gerald Skinner, Dept.of Space Research, University of Birmingham, England.

Dr. Ron T. Stewart, Astro-Geophysics Dept, University of Colorado Participate in the establishment of presentation materials, scientific investigations, and technical discussionrelating to engineering objectives, configuration and design parameters, and analysiss of the SMM Mission. February 19, 20, 1981.

Dr. A. Bhatnagar, Udaipur Solar Observatory - To provide P. I. with scientific evaluations, analysis and conclusions reached on ground base observation data collected at Udaipur Solar Observatory in relationto the SMM-UVSP Experiment, and planning of Pinhole X-ray Telescope Studies. February 12- 14, 1981.

Dr. Vladimir Osherovitch, High Altitude Observatory, Boulder, CO - To participatein technical discussions, and assist in the establishment of scientific and engineering materials relating to the parameters and analysis of the Sunspot model. April 6,7, 1981.

Attend and participate in the Scientific Investigations, discussion, and presentations at a meeting to develop scientific objectives and design parameters and recommend any required changes or modifications to meet planned program condepts of the Phinole Occulter Telescope Project. The meeting will be held May 4-5,1981 at MSFC/NASA.

Dr. Gordon P. Garmire, Dept.of Astronomy, Pennsylvania State University.
Dr. Kent Wood, Naval Research Lab, Washington, DC
Dr. Hugh Hudson, Center for Astrophysics & Space Science, Univ. of California.
Dr. Richard Munro, High Altitude Observatory, Boulder, CO.
Dr. R. P. Lin, University of California.
Dr. G. J. Hurford, California Inst. of Technology.
Dr. E. Fenimore, Los Alamos Scientific Lab.
Dr. J. L. Kohl, Harvard/Smithsonian Center for Astrophysics, Cambridge, MA.
Dr. P. Willmore, Dept. of Space Res., University of Birmingham, England.

Dr. Takashi Sukura, Harvard/Smithsonian, Cambridge, MA 02138
Attend and participate in technical discussions, presentations,and review of scientific and engineering objectives at a meeting to be held at UAH and MSFC on July 6/8, 1981. Examine the present space platform as defined under the present contracted studies and assess the capability of this program to accomplish the Sapce Science Research and operations requirements. Examine and refine the scientific requirements which have been establish by previous and ongoing contracted studies, review the present study efforts being accomplished by NASA to satisfy these needs, critique the engineering and operational modes under consideration, and make recommendations for alternate approaches if and where necessary.

Attend and participate in the Scientific Investigations, discussion, and presentations at a meeting to develop scientific objectives and design parameters and recommend any required changes or modifications to meet planned program condepts of the Phinole Occulter Telescope Project. The meeting will be held September 17-18,1981.

Dr. Peter Preiswerk, Astro Research Corporation, California
Dr. J. L. Kohl, Harvard/Smithsonian, Cambridge, MA
Dr. G. J. Hurford, Solar Astronomy, Calif. Inst. of Technology.
Dr. R. P. Lin, Space Science Lab., Univ. of Calif.
Dr. A. S. Krieger, Amer. Sci. & Eng. Co., Cambridge, MA.
Dr. Richard Munroe, High Altitude Observatory, Boulder, CO.
Dr. Gordon P. Garmire, Dept.of Astronomy, Pennsylvania State University.
Dr. F. Van Beek, Space Reserch Laboratory, The Netherlands
Dr. Hugh Hudson, Center for Astrophysics & Space Science, Univ. of California.
Dr. E. Fenimore, Los Alamos Scientific Lab.
Dr. P. Willmore, Dept. of Space Res., University of Birmingham, England.

Mr. Richard Aikens, Photometrics Ltd., Tucson, AZ, Attend and participate in scientificand engineering discussions at MSFC on December 1-2 concerning application of CCD Cameras for Solar Magnetograph Experiments.

Prof. Hai-Shou Yang, Kitt Peak National Lab., Tucson, AZ will participate in scientific discussions and evaluations required for application of the cellular convection theory due to Opikto calculate a model of solar convection zone whichmatches an empirical model. make calculations of the convection zones of stars of different types and write a report. November 7 -Jan 5, 1982.

Dr. Robert Roussel-DuPre', University of Hawaii, Attend and participate in the Scientific Investigations, discussion, and presentations at a meeting to develop scientific objectives and design parameters and recommend any required changes or modifications to meet planned program condepts of the Phinole Occulter Telescope Project. The meeting will be held January 25-26, 1982 at MSFC/NASA.

Attend and participate in the Scientific Investigations, discussion, and presentations at a meeting to develop scientific objectives and design parameters and recommend any required changes or modifications to meet planned program condepts of the Phinole Occulter Telescope Project. The meeting will be held January 15-16,1982, at Boulder, CO.

Dr. F. Van Beek, Space Reserch Laboratory, The Netherlands
Dr. F. Q. Orrall, Inst. for Astronomy, Honolulu, Hawaii
Dr. Hugh Hudson, Center for Astrophysics & Space Science, Univ. of California.
Dr. E. Fenimore, Los Alamos National Laboratory
Dr. G. J.Hurford, California Inst. of Technology
Dr. Sharad Kane, Univ. of California/Berkeley
Dr. R. P. Lin, University of California/Berkeley
Dr. John L. Kohl, Harvard/Smithsonian, Cambridge, MA.
Dr. E. Fenimore, Scientific Lab., Los Alamos, NM.
Dr. Gordon P. Garmire, Dept.of Astronomy, Pennsylvania State University.
Dr. Richard H. Munro, High Altitude Observatory, Boulder, CO
Dr. R. P. Lin, Space Science Lab., Univ. of Calif.
Dr. P. Willmore, University of Birmingham, Birmingham, England
Dr. H. S. Hudson, University of California

Dr. H. S. Hudson, University of California, San Diego
To attend and participate in scientific discussions and prestantations at meetings to develop scientific plans, objectives, and design parameters and make recommendations to meet project concepts of the Pinhole Occulter Project., February, 21-26, 1982.

William A. Baity, Center for AStrophysics & Space Science, Univ. of Calif., will edit, illustrate, typeset and prepare for publication the final report, Volume I, of the Science Working Group for the Pinhole/Occulter Facility (P/OF). Prepare a draft, submit it to members of the science working group, and incorporate changes requested prior to final preparation for printing. October 1, 1982 - April 30, 1983

Dr. Y. Nakagawa, Chibi Inst. of Technology, Tokyo, Japan, August 14 - Sept. 2, 1982.

Dr. Andrew Cheng, Rutger University, NJ will provide scientific services inthe area of High Energy Astronomy to S. T. Wu of UAH and MSFC personnel duringthe period November 26-30, 1982. Hew ill make a seminar/colloquium presentation and meet and discuss with scientists in x-ray, gamma ray and magnetospheric disciplines at UAH and SSL/MSFC.

Dr. Hugh S. Hudson, Univ. of California., will travel to Huntsville to meet with MSFC and UAH personnel and to NASA Headquarters in Washington, DC to visit OSSO Division of Astro Physics to persent findings of the Huntsville meeting. March 18, 1983.

Dr. E. Parker, University of Chicago, will consult with personnel of MSFC/NASA & UAH on solar physics in connection with the performance required under contract NAS8-33526 March 7-11 1983.

Prof. Samuel Cuperman, NOAA, Boulder, CO., May 17-20, 1983, will give a seminar and discuss astrophysical plasma problems with UAH & MSFC personnel.

Dr. Terry Forbes, Dept. of Primary Matematics, St. Andrews College, Scotland, will present a colliquium and consult with P.I. & NASA/MSFC personnel regarding the subjection matter of contract NAS8-33526, June 28 - July 1, 1983.

Dr. Fukuo Nagai, Huntsville, AL., will perform a one-dimensional loop calculation for the simulation of SMM results. July 11 - August 10, 1983.

Prof. R. Kress, University of Goettingen, West Germany will present a colloquium on solar-terrestrial topic at MSFC/NASA and UAH personnel, September 19-20, 1983.

Dr. Frank Van Beek, Space Research Laboratory, The Netherlands, will visit the UAH and MSFC to discuss the engineering aspects of the Pinhole development October 24-29, 1983.

To attend and participate in scientific discussions and prestantations at meetings to develop scientific plans, objectives, and design parameters and make recommendations to meet project concepts of the Pinhole Occulter Project. at the Noojin House, UAH, September 21-22, 1983.

Dr. H. S. Hudson, University of California, San Diego
Dr. P. Willmore, University of Birmingham, Birmingham, England
Dr. F. Van Beek, Space Reserch Laboratory, The Netherlands

Dr. Charles M. Telesco, Space Science Division, NASA Ames Reseach Center, Moffett Feild, CA 94035 to attend meeting in Huntsille December 16, 17, 1983 to present colloquium in areas ofastrophysics and solar terrestrial program and consult with P. I.

Discuss with other members of the SHAZAM workshop the possible instruments for space-bourne solar and interplanetary measurements with a demonstrated operational usefulness for solar-terrestrial environmental forecasting, February 28 - March 1, 1984, At The UAH.

Dr. K. T. Strong, Lockheed, Lanhan, Md
Dr. J. M. Davis, Newton, MA 02161
Dr. P. S. McIntosh, NOAA, Boulder, CO.
Dr. B. V. Jackson, Dept. of E.E., Univeristy of California.
Dr. David M. Rust, Johns Hopkin Univesity

Dr. S. M. Han, Dept. of M.E., Tennessee Tech., June 29, 1984 to consult with UAH personnel on numerical methods of computed solar magnetohydrodynamic (MHD).

Dr. S. M. Han, Dept. of M.E., Tennessee Tech., October 26,1984 to consult with UAH personnel on solar MHD calculations.

Dr. B. Schmieder, DASOP Observatory, France, to consult with P.I. on modeling prominence, April 14-19, 1986.

Dr. P. Simon, DASOP Observatory, France, to consult with P.I. on modeling prominence, April 14-19, 1986.

April 23-25, 1986, to attend and participate in Pinhole/Occulter Facility Science Working Group Meeting in Huntsville, AL.

Prof. Ho-chi Zhang,
Dr. F. Van Beek, Space Reserch Laboratory, The Netherlands
Dr. Tom Prince, California. Inst. of Technology
Dr. J. Kohl, Center for Astrophysics, Cambridge, MA
Dr. Gordon Hurford, Solar Astonomy, California Inst. of Technology.
Dr. Hugh Hudson, Center for Astrophysics & Space Science, Univ. of California.
Dr. E. Hildner, NCAR, Boulder, CO

APPENDIX B

MINUTES OF MEETINGS

MINUTES POFSWG
April 24, 25th 1986

The working group meeting was opened with introductory remarks and a welcome by Tandberg-Hanssen. Following this was a short discussion by Hugh Hudson of POF science goals, which are perceived to be essentially the same as set by the working group in the early '80's. These goals and many other facts and theories related to POF appear in the Workshop Proceedings (NASA CP-2421). The POFSWG commended Bob Wilson on his hard work in editing this useful volume. The major new data that have impacted our Solar Science objectives are the hard X-ray data from SMM and Hinotori, which have emphasized the importance of imaging in the higher energies and with higher resolution.

Hudson was followed by Joe Dabbs, who emphasized the relative maturity of the facility concept, and that feasibility of all the component systems has been established and confirmed by several studies. There are at least three conceptual designs that promise to satisfy the POF science objectives: 1) the original layout and design as established by MSFC in the inhouse phase A study of 1984, 2) some variations on that design as developed by MSFC and Teledyne Brown Engineering (TBE) in the Payload accomodation Study of 1985, and 3) the possibility of using the ASTRO Mission hardware to effect large programmatic and cost savings. The intention is to pursue development of the facility, but more effort is needed in the instrument development area.

Mickey Allen of the MSFC Payloads Office was next on the agenda. As the manager of the ASTRO Mission, his experience is very applicable to the POF program. The ASTRO Mission was only a few days from realization when the Challenger disaster put a halt to everything. The ASTRO Payload will fly, but the Halley Comet mission is lost. Some of Mr. Allen's observations are as follows:

* Coalignment was a problem that continually had to be worked on ASTRO. The main lesson learned here is that once mechanical references are set, all possible efforts should be made to prevent changes.
* Having a fixed mission date was a very valuable tool in managing costs and schedules.
* ASTRO profitted from the experience of Spacelab-II.
* The program office made no attempt to assure the operational reliability of the science instruments; only the safety and interfaces were controlled.
* The Program Scientist remained at GSFC when the program came to MSFC in 1982, but no difficulties were experienced from this arrangement
* MSFC was assigned the program with slightly over three years until launch time, causing the scheduling to be extremely tight and creating a very intense, goal-driven program.
* The experience of ASTRO supports the need for a 30% contingency in funding.
* The original Engineering cost estimates were well-maintained, but the Operations and Data Reduction cost estimates were

underestimated.

Copies of Allen's vue graphs are included as Appendix #2 of these minutes.

Tom Prince of Cal Tech was next on the agenda with a discussion of the Gamma Ray Imaging Device (GRID) design. Prince also discussed the plans for simulation of data deconvolution by computers. These plans involve simulating the response of the detector systems to a postulated image field. These sets of data will be sent to another laboratory to be deconvoluted with no prior knowledge of the image imbedded in the data. The vue graphs presented are included without further comment as Appendix #3.

Frank van Beek of the Technical University of Delft, the Netherlands, then described the work that he is directing at the Laboratory of Micro-Engineering. He produces subcollimator elements for Fourier-Transform Imagers by etching blades, rather then sheets of holes which have to be stacked. The blades are stacked side by side and cemented together. This technique promises to greatly reduce the manpower needed for precision alignment. The collimator elements demonstrated were 5 cm in height, with slots 50 micrometers wide by 10 cm long. The technology seems to be well in hand, but he did indicate that some support would help in procuring the materials for Tungsten grids. The developmental work so far has been done with spring steel, due to the cost of materials. See Appendix #4.

Ed Fenimore of Los Alamos National Laboratory (LANL) was next on the agenda with a discussion of his Spacelab experiment, which is a Uniform Redundant Array (URA) camera with a two atmosphere Xenon gas scintilation detector.

After lunch, the first item on the agenda was a presentation by Ernie Hildner of HAO. He presented a conceptual design of a White Light Coronagraph design for POF. The design is a result of preliminary work at HAO and Ball Aerospace. It is a Gregorian design with 50 cm optics and a 2 Solar radii FOV capable of viewing the full Solar disk. The design concept shown does not incorporate heat rejection mechanisms. Dave Bohlin commented on the ambitiousness of the design and commented that he had been hoping to see something more like a space qualified 7-inch Questar. The VG's shown by Hildner are incorporated in Appendix #5.

Next on the agenda was John Kohl of Harvard Observatory, who presented his UV Coronal Spectrometer. The instrument is a very mature design, having been proven on 3 rocket flights to date, and a similar design having been selected for a Spartan payload. The POF instrument is, in effect, just a scaled-up Spartan or rocket design. This current POF design incorporates the telescoping package concept proposed by the Ball Aerospace study. Additional work needs to be done in the areas of weight reduction, interaction of the POF pointing system and instrument pointing, stray light rejection, mirror coatings, and detector arrays. Kohl's VG's are included as Appendix #6.

Dave Bohlin of NASA Headquarters spoke on the view from Headquarters. He

started with a two-page synopsis of existing, or almost-existing, Solar programs, which are listed as Appendix #7. He then spent the rest of his presentation explaining the inter-relationships between programs. Not included on his list, but discussed in some detail, was the MAX 91 opportunity. He also mentioned that some support was supposed to be forthcoming from Space Station for definition of the Advanced Solar Observatory (ASO). Then, in response to a question from the working group, he explained how the sounding rockets, balloons, and Spartans are carried in his budget.

After a break, Hudson spoke on the Space Station and its potential impact on Solar Science. The dual keel design that has been adopted is a good indication that the science requirements are taken seriously at some level. However, it should not be assumed that science will automatically be accommodated, the majority of foreign programs in that area are commercially oriented. Some questions were raised about the Russian MIR space station, which is evidently about the size of Skylab. As a last resort, we should have some Solar telescope clusters on ASTRO type mounts accommodated on the Space Station. Bohlin said that he has had neither the time or resources to push Space Station science, but does feel that it needs pushing. Hudson was asked if he felt that the Banks Committee was listened to, and if so, why had there been so little support for attached payloads at the Edelson level?

Joe Howell of MSFC then discussed the in-house and contracted work that had been done concerning the accommodation of POF on the Space Station. It appears obvious that the only area of potential difficulty is in the pointing and stabilization. The status of the POF facility design was also covered. A question was raised concerning the possibility of heavier tip masses at the end of the boom to accommodate the additional mass needed for gamma ray imaging. It was decided that the most recent studies by TBE had used a mass of 134 kg, which should be sufficient. The VG's used are included in the Appendices.

A general discussion session occurred at this time and questions were raised concerning design layouts, coronal structures, and stray light problems. Hudson will make a point of attending the contamination session at the next COSPAR meeting.

A final discussion was held among the people interested in the question of Fourier-Transform Imaging techniques. This lasted well after 5:30 PM, allowing the group just enough time to drive to the wonderful and traditional POFSWG wine and cheese party given by the Tandberg-Hanssens.

Day two opened with a discussion of HESP by Hudson. The instrument complement will be selected within the next 6 months, and launch is planned in August 1991.

Brian Dennis of GSFC gave a MAX 91 overview, preceded by a recap of the imaging discussion held the afternoon before. The issue of how well an image can be deconvoluted by F-T techniques will be demonstrated by Ed Fenimore. Simulating instrument raw data which will be sent to Gordon Hurford at Cal Tech to be interpreted.

The discussion of MAX 91 then followed. A handout summarizing the material is included in the appendices. In addition, Dennis made available copies of the MAX 91 Working Group report, which are not included due to sheer bulk.

Dr. Gordon Emslie of the Univ. of Alabama, Huntsville (UAH) spoke on the science rational of MAX 91 and the current status of solar flare research. The VG's used by Dr. Emslie are contained in Appendix #10.

Marcos Machado, currently a NRC Fellow at MSFC from Buenos Aires, discussed results from the HXRBS instrument, and concluded that to resolve electron beam structure in loops and flares you need synergistic measurements in different energies.

Frank van Beek spoke concerning European plans. The EURECA platform will first be flown in 1989 as a microgravity material science payload, after which there is a chance that it may be utilized for a solar (or celestial) science mission. ESA has issued a letter requesting instrument suggestions. A version of GRID may be proposed, but there are pointing and weight capacity problems. The European Space community may propose the Solar Payload Elementent for Columbus Space Station (SPECS), which may, or may not, include a POF (due to the absence of European Investigators).

Next, Hudson opened a discussion to consider "What's New Under the Sun." A comparison was made of the current opportunities in Solar and heliospheric physics: HESP, HRSO, SOHO and POF. The group members voiced their support of HRSO, and Ernie Hildner was selected to draft a letter from the POFSWG to Dr. Pellerin of NASA Headquarters stating this. A copy of this letter is included as Appendix #11.

After lunch, Bill Roberts discussed the evolution of the Advanced Solar Observatory (ASO) as a payload for the Space Station. The Solar Optical Telescope has always been considered as the seed crystal for the ASO. The primary concerns for Space Station accommodation of science payloads are pointing and the contamination environment. These problems are being worked on and the ASO is one of the forcing functions setting requirements for the Space Station. Roberts' VG's are included as Appendix #12.

John Sharkey of MSFC discussed the existing Large Space Structure Ground Simulation and how it is planned to be extended on to a full scale POF simulation, and eventually an ASO simulation. He mentioned that there is considerable interest in the control community in POF, as it is generally considered to be the first Large Space Structure to actually fly. The purpose of their simulation is to refine and develop confidence in the control models to stabilize LSS. They hope to have the POF simulation up and running by next summer. Copies of Mr Sharkey's VG,s are included as Appendix #13.

Michael Greene of UAH spoke next on his proposed effort to model, characterize, and breadboard an optical sensor system for modal control of the POF. His VG's are included as Appendix #14.

Joe Howell of MSFC discussed the actual performance of the Instrument Pointing System (IPS) from the Spacelab II mission. The comparison indicating that actual performance was as good as predicted or better is summarized on two VG's given as Appendix #15.

There was a general discussion of the future and Dave Bohlin complimented the POFSWG on their dedication and progress to date, considering the low level of funding. There is a good possibility of getting POF started in the next couple of years, but it will depend on the resolution of the HRSO program.

No specific date was set for a subsequent POFSWG meeting. This meeting was felt by all participants to have been extremely fruitful.

Workshop on

SOLAR HIGH-RESOLUTION ASTROPHYSICS
USING THE PINHOLE/OCCULTER FACILITY

May 8-10, 1985
at
NASA-Marshall Space Flight Center, Alabama U.S.A.

Wednesday, May 8 (Invited Papers)

09:00	J. Kingsbury	Welcome
09:10	E. Tandberg-Hanssen	Day 1 Opening Remarks
09:15	R. Rosner	Solar Fine Structure
09:55	R. Canfield	Optical Imaging Spectroscopy
10:35	G. Withbroe	Corona and Solar Wind
11:15	N. Sheeley	SOLWIND Coronal Observations During 1979-1985
11:55	(LUNCH)	
13:30	B. Dennis	Results from the Solar Maximum Mission ✓
14:10	C. de Jager	X-ray Imaging of Flare Impulsive Phase ✓
14:50	Z. Svestka	X-ray Imaging of Flare Loops and Coronal Arches ✓
15:30	S. Tsuneta	Hard X-ray Imaging of Solar Flares from Hinotori
16:10	G. Emslie	Theoretical Considerations for Hard X-ray Imaging
16:50	R. Lin	Microflares, Coronal Flares, and Interplanetary Electrons
17:30	(ADJOURN)	
18:30		Reception at Tandberg-Hanssen's Residence

Thursday, May 9 (Invited Papers)

09:00	H. Hudson	Day 2 Opening Remarks ✓
09:15	M. Pick	Solar Radio Corona
09:55	G. Dulk	Radio Imaging of Flares
10:35	G. Hurford	High Resolution Solar Microwave Observations ✓
11:15	K. Wood	The P/OF as a Tool for X-ray Astronomy
11:55	(LUNCH)	
13:30	H. Hudson	P/OF Technical Concept
14:10	J. Dabbs/J. Howell	P/OF Engineering Study
14:50	J. D. Bohlin	Future Missions (Panel Discussion) ✓
	H. F. van Beek ✓	
	D. Neidig ✓	
16:30	E. Hildner ✓	Symposium Summary
17:00	(ADJOURN)	

Friday, May 10 (Poster Papers/Discussions/Working Sessions)

A.M.	R. Lin (Chairman)	X-ray Subpanel
	R. Munro (Chairman)	Coronal Subpanel
P.M.	E. Tandberg-Hanssen	Joint Session/Closing Remarks

HUNTSVILLE SOLAR-TERRESTRIAL NEIGHBORHOOOD MEETING
December 14, 1984

University of Alabama in Huntsville
University Union
Room 127

Program

8:30-9:00	Coffee and Donuts	
9:00-9:20	Dave Bohlin:	Prognosis for NASA's Solar & Heliospheric Physics Program
9:20-9:40	Dave Forrest:	The 155-Day Period in Flare Production
9:40-10:00	Dave Rust:	The Flare of 12 Novermber 1980
10:00-10:30	Coffee Break	
10:30-10:50	Pat Boruman and Jeff Linsky:	Turbulence as an Intermediate Storage Mechanism Between the Impulsive and Thermal Phases of Flares
10:50-11:10	George Doschek:	Impulsive-Flare Blue Shifts in Fe XV and Ca IXX
11:10-11:30	Werner Newpert:	Search for Thermal Wave Fronts in OSO-7 Flare Images
11:30-1:00	Lunch	
1:00-1:20	John Leibacher:	Global Oscillations Network Group
1:20-1:40	Jack Harvey: (tentative)	Sound Speed Inside the Sun
1:40-2:00	Dick Munro:	Interpretation of Coronal Synoptic Observations
2:00-2:30	Coffee Break	
2:30-2:50	Bob Rosner:	Structure of Coronal Magnetic Fields
2:50-3:10	Joe Hollweg:	Chromospheric Dynamics
3:10-3:30	Art Poland:	UVSP Spectral Observations of the Quiet Sun

The speakers are reminded to each prepare only 10 minutes of presentation so that we can have 10 minutes of questions and discussion during and after each talk.

The following Best Western motel is of medium cost and quality:

Carriage Inn
3811 University Drive NW
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If you need more information, please call Ron Moore (205) 453-0118 or FTS 872-0118.

Minutes of

TEAM E, FLARE ENERGETICS

FIRST SOLAR MAXIMUM WORKSHOP

January 23-28, 1983

NASA/GSFC
Greenbelt, Maryland

Prepared by S. T. Wu

The first meeting of the SMM Workshop was called to order by Professor M. Kundu and Dr. B. Woodgate on January 24, 1983. Following a general plenary session the various team meetings began.

Team E met in Building 26, Room 200. The team first discussed the agenda; then we developed a working plan for our study. In the following I shall summarize these discussions.

The goal of our study is to understand the rate of energy input and output, energy contents and energy budget of the Flare. In order to achieve this goal, we have divided our team into five subject areas. These subjects and their chairman are:

E1. Energy inputs and losses in the pre-flare phase
S. T. Wu

E2. Energetics of the impulsive phase
C. de Jager

E3. Gradual phase
K. Strong

E4. Energetics of extended coronal sources
H. Hudson

ED. Characterization of flare energy distribution
H. Hudson

Each member of team E is allowed to join only one study group, but the study of ED is a total team effort.

The activities for each group are summarized in the following:

E1. Energy inputs and losses in the pre-flare phase - Presently there are only two persons working in this group. This subgroup of team E will work closely with team A. Specifically, the effort will be in the area of the shear motion in relation to the flare energy buildup. Dr. M. Bruner will supply specific data for this study.

E2. Energetics of the impulsive phase - The major physical topics concerning this group are as follows:

1. How do we characterize the impulsive phase? In this question we shall study the fine structures in time and space. A question also arises concerning the speed of the energy input. Do all flares have an impulsive phase?

2. What is the total energy content of the flare in the impulsive phase? (E3, E1)

3. How important is the thermal component and the nonthermal component in the impulsive phase?

4. Is the energy content (input) in the impulsive phase sufficient for the later phase? (E3)

5. Do all the answers to the above questions depend on the scale of the flare?

The commitment of individual members for this group (E2) is included as Appendix I. The list of flares chosen for study by E2 includes:

	Character of Flare	Candidate Events
a)	2 ribbon flare with obvious impulsive phase	21 May 80
b)	2 ribbon flare with minor impulsive phase	1 Nov 80, 1910 5 Jul 80, 2232
c)	2 ribbon flare with no apparent impulsive phase	to be selected
d)	The most energetic flare with best coverage throughout entire electromagnetic spectrum	7 Nov 80, 1727 5 Nov 80, 2226 13 Jul 80, 1917
e)	Small flare at site where photospheric magnetic flux is high	3 Jul 80, 0021
f)	Small flare at site where photospheric magnetic flux is moderate or low	8 Jul 80, 1940 12 Jul 80, 1920 14 Jul 80, 0148 15 Jul 80, 2230 9 Aug 80, 2301

Other Flares of Interest for Overall Energetics	Candidate Events
g) Limb flares	6 Jul 80, 0007 24 Jul 80, 0010-0054 29 Jun 80, 1823
h) Flare with erupting filament or associated mass motions in a filament	2 Jul 80, 0023
i) Flare with obvious loops in H_α and soft x-rays	23 Sep 80, 1635 10 Aug 80, 2230, SE LIMB

E3. Gradual Phase - The physical topics to be studied by this group are:

1. How does thermal energy compare with known sources in the impulsive phase? (E2, E3)

2. Do we need intermediate energy storage mechanisms?

3. What are dominant cooling mechanisms at different stages of the gradual phase?

4. Do PFL need continual energy input?

5. How do the above questions/answers differ for compact (multiple events) and large events?

Events to be studied by E3 include:

27 Mar 80	10:40	?/Limb	Onset imaged
29 Mar 80	09:18	Compact/Disk	Well studied/v. hard
7 May 80		Compact/Disk	Modelled
21 May 80	21:00	Large/Disk	Well studied
25 Aug 80	13:09	Compact/Disk	X-ray xtal data
31 Aug 80(+)	12:50	Double Compact/Disk	Well studied
5 Nov 80	22:35	Large/Disk	Well studied/x-ray xtal
18 Nov 80	14:59	Large/Limb	Well observed (PFL)

Other input includes:

14-96 Å	LPARL Rocket Data	6×10^5 - 10^7 k plasma
NRL Code	(Jason)	
FTC Code	(Peter)	
B Code	(Roger)	

E4. Energetics of extended coronal sources - The physical topics to be investigated by this group include:

1. Are there extended, late flare-associated sources in the corona?
2. What is the energy content? Quantification?

   e.g., thermal, gravitational, magnetic, kinetic, etc.

3. What are the energy losses?

   e.g., conductive, radiative, enthalpy, etc.

4. Are these losses important to the energy budget of the flare?
5. What is the physical relation of these sources to the chromosphere?
6. What is the physical relation of these sources to coronal transients, solar proton acceleration, and radio sources?
7. What is the generic relation of these sources to LDE's and interconnecting loops?

Data sources for E4 projects are:

Flare of:

30 March 1980	Lantus et al., work in progress
21 May 1980	Svestka et al.
6 Nov 1980	Svestka et al., and work in progress
18 Nov 1980	Work in progress

Other input: Webb, Kundu -- LDE's
Simnett -- IP particles

ED. Characterization of flare energy distribution - The physical topics to be studied by this group are:

1. What is the lower limit on radiant energy from directly observed flux?
2. What is the estimated total radiant flux? Is it larger than the ACRIM upper limit?

3. How is the radiant energy released in different phases?

4. Can we determine the energy release function?

The energy components of energy release are tabulated as follows:

Radio - IR	7000 Å - ∞	✓ (data available)
Optical	3500 Å - 7000 Å	✓
UV	Lyα - 3500 Å	~
Great GAP	20 Å - Lyα	X
Soft x-ray	2 Å - 20 Å	✓
Hard x-ray	3.5 kev - ∞	✓
Coronal Interplanetary		✓

FLARE LIST FOR FULL CHARACTERIZATION

1980 May 21	2107	2B	X1
June 29	1826	BSL	M4
July 1	1628	1B	X2
July 5	2246	1B	M8
August 31	1248 -1252	SB	C3 M2
November 5	2236	1B	M4
November 18	1456	ASR	M3

We began our team study with observations. From observations we will deduce the physical mechanisms to answer our questions. Hopefully, appropriate model/models can be derived.

There are several housing items which are included as Appendices to these minutes. They are:

Appendix II	Team E Agenda
Appendix III	Team E Attendants List
Appendix IV	Workshop Agenda
Appendix V	Problems Mentioned in the Discussion
Appendix VI	Theoretician's View (Dr. G. Peres)
Appendix VII	Comments from P. Kaufmann
Appendix VIII	Time Table

ACTION ITEMS

Please note the following action items for the June meeting:

- Please send anything you would like to include in the forthcoming "Newsletter" to S. T. Wu before March 15, 1983.
- If you would like to present a short paper about your study at the June meeting, please let me know no later than April 20, 1983.
- Please give me your comments about the way the meeting was conducted so that I might better prepare for the next meeting.
- Let us work hard together so we might obtain our results.

PINHOLE/OCCULTER FACILITY SCIENCE WORKING GROUP (POFSWG)

MINUTES OF MEETING #5

January 15-16, 1982

I. Introduction

A meeting of the Pinhole/Occulter Facility Science Working Group (POFSWG) was held in the Damon Room of the National Center for Atmospheric Research Center at Boulder, Colorado, January 15-16, 1982. The meeting was cochaired by Hugh Hudson of The University of California, San Diego, and E. A. Tandberg-Hanssen of MSFC, Alabama. The following were in attendance:

H. Frank van Beek	Utrecht, The Netherlands
E. Chipman	NASA Headquarters
J. Dabbs	MSFC
E. Fenimore	Los Alamos Labs
H. Hudson	Univ. Calif, San Diego
G. Hurford	Calif. Tech
S. Kane	Univ. Calif, Berkeley
J. Kohl	Harvard College Observatory
A. Munro	High Altitude Observatory
F. Orrall	Univ. of Hawaii
J. Parker	MSFC
P. Willmore	Univ. of Birmingham, England
K. Wood	Naval Research Labs

This fifth meeting of the Working Group convened at 9:00 A.M. with E. Tandberg-Hanssen presiding. The tentative agenda was as follows:

TENTATIVE AGENDA

Friday, January 15

9:00	Introduction	Hudson/Tandberg Hanssen
10:00	Coronal X-Rays	Kane
11:00	Advanced Solar Observatory	Walker
1:00	Accommodation	Parker
2:00	Image Reconstruction Simulation	Fenimore/Hurford/Hudson
3:00	Aspect and Alignment	van Beek
4:00	Discussion of Final Report	Hudson

Saturday, January 16

9:00	Management Plan	Group
10:00	Workshop Plans	Group
11:00	Final Discussion	Group

In the introduction a brief discussion ensued which included the following:

--Hudson asked if February 15, 1982 was a reasonable due date for the final report.

--Kohl volunteered to complete the needed text for section 3.3 on Coronal Observation Requirements.

--Munro will work on the coronagraph strawman instrument configuration.

--Tandberg-Hanssen suggested that two report configurations are needed--a full and complete report of archival and technical interest which should be summarized in a brief and concise Executive Summary.

--Hudson will take responsibility for a first draft at summarizing the report for the executive summary.

--Hudson discussed the possibility of having a contracted phase A study

done to lend credibility to program cost estimates and general discussion indicated that such a study would enhance the visibility of the study.

--Lin suggested possible titles for the proposed POF workshop-- "Active Corona" or "The Non Thermal Corona"--a weakness common to these titles is that the X-ray astronomy might not be addressed directly. The group discussed the timing of the workshop and resolved to think further about the scientific emphasis.

Dabbs showed the most recent POF graphics showing a view of the Spacelab mission as seen from a point near the deployed occulter mast looking towards the Shuttle cargo bay. Several recommendations were made for improving the graphics and it was requested that an illustration be made showing a general configuation of the Advanced Solar Observatory (ASO).

The next item on the agenda was a discussion of coronal X-Rays by Kane. The observations discussed were stereoscopic views of hard X-Ray sources in solar flares made from the Pioneer Venus Orbitor and the ISEE-3 (Appendix A).

Next on the agenda was a discussion of the Advanced Solar Observatory (ASO) by Art Walker, chairman of the committee studying the ASO. The ASO has been endorsed as the highest priority for solar physics by the Field Committee. It has been proposed as a quasi permanent facility which would use the support systems of the platform to maximize cost effectiveness for long term solar observations.

As currently defined the ASO would consist of 4 components defined as follows:

1. A High Resolution Cluster which is the SOT canister containing the following instruments:

A. XUV Telescope

B. EUV Spectrometer Telescope

C. Solar Optical Telescope

D. Soft X-Ray Facility

2. Pinhole/Occulter Facility

3. Gamma ray facility--small instrument at first configured to fit into the SOT canister.

4. Low frequency radio antenna (Khz to Mhz).

The RF experiment is important to complement the POF, but it may create problems by imposing RFI requirements on other instruments.

Other possible instruments which may go into the High Resolution Telescope Cluster Canister are:

I. The Solar Internal Dynamics Facility (SIDF) - which may include the following instruments dedicated to solar global measurements.

A. Fourier Tachometer

B. Differential Radiometer

C. Total Irradiance Monitor

D. Spectral Irradiance Monitor

II. Guest Instruments such as:

A. X-ray Polarimeter

B. Hard X-ray Spectrometer

The development philosophy as seen by Walker is to provide as complete wavelength coverage as soon as possible in the evolutionary development of ASO. He described development of the soft X-ray facility as an example. The planned telescope would consist of seven nested pairs of Wolter Type I mirrors with a focal-plane carousel holding several of the twelve potential instruments. The earliest version might just consist

of one or two of the mirror pairs coupled with one or two focal plane instruments. This would allow early construction of the facility with orderly growth potential. He indicated that development on the XUV instrument was in abeyance. Frank van Beek commented that the GRIST instrument (Grazing Incidence Solar Telescope) is undergoing a low level of development in ESA. GRIST would work in the 70-1800 Å region with 1 arc sec resolution for a field of view of 4 arc min x 4 arc min.

Walker presented several view graphs which are included in Appendix B, and summarized by saying that the ASO report should be available by June.

After lunch, Joe Parker presented several charts representing the current layout, thermal and weight estimates for P/OF. These are included as Appendix C.

Some comments added by Parker were:

1. There were some minor discrepancies in subsystem weights, such as aspect system and a couple of others but they were relatively minor.

2. The P/OF would need to be tilted off the Spacelab z axis by at least 45^{o} to satisfy cargo bay thermal limits, but that angle would allow uninterrupted operation (at least thermally).

Kohl and Hudson remarked that coronagraph length and X-ray imaging system weight would probably need to be scaled upward somewhat.

Parker then proceeded to discuss the pointing system studies. He indicated two areas of possible concern. The phase additive control scheme proposed by Mike Green requires either knowledge of the modal behavior of the boom or a good prior estimate of it. We do not yet know how well we can predict this. Our studies have been predicated upon a

1 meter diameter boom but the largest diameter boom planned for development is currently a 30 inch partially double strapped or so called "Super boom."

Parker also is investigating studies being proposed on the SEPS Array (Solar Electric Propulsion System) and has written a letter supporting additional festering of the SEPS boom minus the "Solar Blankets." Hudson will contact J. B. Sesak of Convair in San Diego, who is one of the original developers of this type control scheme.

Hurford and Fenimore discussed imaging system and image deconvolution simulations in which they have been engaged. Their simulation models the Fourier Transformation X-ray imager with 100 sobcollimators in a total area of 58 cm x 58 cm. It is divided into four equal quadrants by a strong back that supports the counter window. The detector resolution is approximately 4 mm. The raw image data consists of multiple bands of fringe in each subcollimator, for which an amplitude and phase must be determined. It is often possible to evaluate the image type and location by "eye balling" the raw data, even though the proper analysis requires a two-dimensional Fourier transformer reconstruction. In these simulators Fenimore modeled a real solar event by considering the behavior of the detector using Monte Carlo computer techniques. He then sent the simulated raw data which also included background noise and system characteristics, to Hurford who would reconstruct the image. Image models ranged from a point source to an SMM soft X-ray event of November 5, 1980.

The simulation appeared to be quite successful, with image of both simple and complicated models. The group was impressed at the ability of the Fourier-transform images to work well with only a few counts per subcollimator. Hurford established the utility of his VLA software for the X-ray data analysis.

Frank van Beek opened his discussion of Aspect Sensing by discussing the HXIS (Hard X-ray Imaging Spectrometer) experiment on the SMM. He then reported on his continuing work towards defining a Facility Alignment and Aspect System. His report is summarized as Appendix D.

The meeting on Saturday, January 16, opened with an update on Agenda as follows:

Agenda (Iteration 2)

- Final discussion of Aspect System limits
- Comments on draft report layout
- Period of silence to contemplate above item
- Assignment of action items for Report
- Brief comments by Bob McQueen
- Discussion of ideas for workshop
- The future of P/OF

The first topic was a carry-over from Friday of the systems capability goals. After much discussion it was decided that the resolution of the Fourier Transform imaging system should be set at 0.2 arc sec for Solar imaging. The manufacture of masks with required thickness of tungsten can be accomplished by stacking plates. Resolution is limited by the state of the art of star tracker development for the celestial X-ray imaging. For the Solar observations we should have good tracker technology from the SOT program.

The group decided to agree upon a "final" set of parameters for the X-ray imaging instruments in the strawman configuration. The following table lists these parameters upon which the final report will be based.

Final Strawman Parameters

	Fringe Spacing	Resolution	Energy	Detector Spatial Resolution
Coded Aperture	4 arc min	4 arc sec	2-35 KeV	1 mm
Fourier Transform	20 arc sec	0.2 arc sec	2-80 KeV	4 mm

General discussion followed. Hudson said that Caltech had built a 50 cm square xenon proportional counter operating at 2 atmospheres. It was agreed that a counter with 20 cm-atm thickness having approximately 10% efficiency at 80 KeV could be considered. F. van Beek volunteered to send

further information. The group criticized the cosmic X-Ray chapter of the draft report. Willmore suggested that consideration be given to another section of the report which would emphasize how higher energy observations would complement other X-ray observations such as AXAF (Advanced X-ray Astronomy Facility). Hudson suggested that Jim Matteson be asked to comment on high energy observations of the Galactic Center. Comments have already been solicited from Josh Grindlay. Kent Wood feels that the report should emphasize how powerful is P/OF as an instrument.

Also mentioned was the possibility of a cosmic-only mission with greater counting area - this should be mentioned in the report. The group agreed that there was no reason to minimize the X-ray detector area in the full P/OF. In other words, having as many detector modules as will fit into the detector plane should be a baseline objective. Parker volunteered to find out how many modules of van Beek's specification would fit.

John Kohl and Dick Munro agreed to write up the coronographic science observational requirements. Kent Wood mentioned that coronal-type events have been seen in other stars and this should be mentioned as a possible common area. Some consideration should be given to such questions as how to respond to transient events; how the coronagraph knows where to point, and how to best coordinate observations by the FT imaging and roll maneuvers of the coronagraph. It appears that a rapid slew of brief duration would not jeopardize the coronal observations, and might make X-ray observations of the impulsive phase easier to achieve.

Bob McQueen welcomed the group and complemented the group on how well they worked together. He echoed Eric Chipman's feelings that the group should press for the most complete facility and not to compromise in hopes of getting earlier opportunities. He feels that P/OF is the "Best facility that NASA has going."

Several suggestions were made to improve the P/OF concept graphics which included:

1. Smoothing the edges of mask and possibly deleting part of the mask insulation to indicate position of Coded Aperture and Fourier Transform areas.
2. The SOT should look more realistic.
3. Shadows should be worked out better.
4. Additions should be made to the detector-plane instrumentation.

Discussion of future activities centered around the workshop. It was agreed that it should be at least a year or so away in order to maximize the circulation of the report and not to be premature. Another possible topic for the workshop was suggested - "Non-Thermal Effects of Corona." An advantageous time for the workshop might be after the AAS Meeting in California, June 1983, possibly at Big Bear Observatory.

Instrument costing was mentioned as being among the extremely important inputs needed by MSFC to complete their in-house study. The following agreed to input tentative costs to Joe Dabbs by mid-February.

UV Corongraph	John Kohl
WL Corongraph	Dick Munro
X-ray Imaging (All)	Hugh Hudson

The next meeting was scheduled for September 20-21, 1982 with location to be determined.

PINHOLE OCCULTER FACILITY SCIENCE

WORKING GROUP MEETING (P/OFSWG)

September 21 - 22, 1982

This sixth meeting of the P/OFSWG was held at the University of Alabama in Huntsville's Noojin House. The following attended the meeting:

H. F. van Beek	Utrecht, Holland
Dave Bohlin	NASA Headquarters
Carol Crannell	GSFC
Joe Dabbs	MSFC
Carmine DeSanctis	MSFC
Ed Fenimore	Los Alamos National Labs
Bill Fergurson	MSFC
Gordon Garmire	Penn State
Spencer Glasgow	MSFC
Micheal Greene	UAH
Ernest Hildner	MSFC
Hugh Hudson	MSFC
Gordon Hurford	Cal Tech
John Kohl	Harvard College Observatory
Robert Lin	UC Berkeley
Ron Moore	MSFC
Dick Munro	High Altitude Observatory
Joe Parker	MSFC
Bill Roberts	MSFC
E. Tandberg-Hanssen	MSFC
Peter Willmore	Univ. of Birmingham, England
Kent Wood	Naval Research Laboratories, D.C.

The meeting was called to order by Dr. Tandberg-Hanssen, who presented introductory comments. Then Dr. Hudson reviewed the purposes of this meeting and the proposed agenda.

High among the priorities for this meeting was to discuss the feasibility of an inhouse phase A study at MSFC and to discuss the organization and content of such a phase A study. Previous estimates have suggested a level of about 10 man years for inhouse manpower to do a comprehensive phase A study.

Dr. Hudson referred to the history of the POF definition effort. It started work in 1980 and has this year completed the Mission Science Definition. This is currently undergoing final editing by Dr. Hudson and will hopefully be published by early calender year 1983. Also endorsed by this group has been the strawman payload. The key scientific questions which the P/OF will address are listed in the Executive Summary of the POFSWG, as is also the strawman payload. A draft of this summary is enclosed as Appendix I to these minutes. The summary has been shipped off for printing and will be widely distributed in the near future.

Dr. Hudson then addressed the possibility of developing POF in an evolutionary manner to facilitate an earlier start. The group discussed developing a facility using an existing boom design such as the 105 ft. SEPS boom and existing or fully-designed instruments.

A question arose as to how the group should continue to operate. Dave Bohlin stated that the group will probably continue to operate as an informal ad hoc group until the program gets ready to go into phase B, at which time it will probably be reconstituted by Dear Collegue letters inviting formal participation.

Next on the program was Carmine DeSanctis of MSFC, who spoke concerning NASA's Space Station planning and the applicability of it to the POF. This material is summarized as Appendix II of this report.

One area of concern has been the availability of an Instrument Pointing System (IPS) and Mr. DeSanctis stated that NASA has been assured of at least 2-IPS in the system. The AGS is at a crossroad and several options exist for development of that system.

Joe Parker of MSFC spoke next concerning the engineering supporting effort. His data, which is included as Appendix III, was mostly updating material presented at the previous P/OFSWG meeting. The weight summary shows a small increase, as does the system weight for the IPS. He also commented that system weights may force POF to a two pallet configuration and that there will likely be a large increase in user charge per pallet in 1986. The question of IPS availibility and performance occasioned a good deal of discussion with the group. Mr. Parker introduced some vue graphs from an IPS overview presentation. These are included as Appendix IV.

Spence Glasgow spoke of present and past costing experience at MSFC. By use of traditional NASA costing formulsa the P/OF might fit into the $80M bracket, but with costing curves based upon recent Spacelab experience a figure of $25M might be more reasonable. Asked why there is such dispersion in costs, he replied that Spacelab experiments have made use of University-developed and built instruments which seem to be much less expensive. Mr. Glasgow's material is presented as Appendix V.

John Kohl asked that MSFC change the title of the UV instrument to UV Coronagraph-Spectrometer as being a more accurate description of the purposes of the experiment.

Bill Fergurson of MSFC spoke of the programmatics of getting something like P/OF started. He presented several charts showing various phases of

NASA planning. Dr. Bohlin of NASA Headquarters made several very useful comments concerning this area, such as the need for early timing on the experiment Announcement of Opportunities (AO) and made some very useful suggestions for interacting experiment requirements and facility design requirements. These suggestions are being incorporated into the current programmatic planning. Mr. Fergurson's material is included as Appendix VI.

Mike Greene reviewed his recent POF dynamics study in which he addressed the suitability of the AGS control system for controlling the POF. He ran parametric studies showing the sensitivity of the AGS Modal Filter system to uncertainties in system damping and natural frequencies. At first glance the AGS system without augmented software looked as though it might be marginally acceptable, but closer examination showed that any uncertainty in boom parameters rendered the pointing unacceptable. His figures are shown as Appendix VII.

Frank van Beek discussed his alignment system conceptual design. The system was described in the minutes of the last POFSGW meeting (January 1982), but another copy is included as reference in Appendix VIII. Dave Bohlin commented that the design goals seemed reasonable based upon some alignment system work that he had done a few years previously.

A general discussion of what would be entailed by a phase A study followed. The group endorsed the idea of analyzing the 105' SEPS boom to see just how much science could be accomplished using it. Mike Greene will start control analysis as soon as he can get dynamics data on the 105' boom.

The accommodation of instruments on the AGS (or IPS) needs to be examined to insure that the POF can be rolled about the line of sight enough to meet the requirements for all the coronagraph instruments.

The second day of the meeting opened with Dave Bohlin discussing the current status of planning both within the Solar office and also the Astrophysics Division. There have been a total of fourteen NASA planning studies since 1975, such as the Field Report and they have very overlapping recommendations. The problem is how to implement such planning in a very unfavorable political environment.

The future NASA budget is very much a shambles and the 1983 budget has only recently been passed. The 1984 budget has recently left the Agency and is currently in OMB. The content of the 1984 budget will not be public until January. In February Dr. Bohlin will start working the 1985 budget.

The only Astrophysics new start in the last three years was the Gamma Ray Observatory (GRO). Other potential new starts for the future were mentioned, but not in any implied order of priority, as follows:

- Venus Mapper which is a spin off of the VOIR
- Advanced Communication Satellite (ACS)
- Upper Atmosphere Research Satellite (UARS)
- Ocean Surface Mapping Satellite (TOPEX)
- Origins of Plasma in the Earth Neighborhood (OPEN)
- Advanced Astrophysics Facility (AXAF), which Frank Martin feels is probably next in line after ST.
- Large Deployable Retector (LDR)
- Solar Interplanetary Satellite (SIS)

Next came the Explorer programs which have grown to about $35M , or about $70M programs on two year centers. Explorer programs with high probability of new starts are:

- AMPTE - Active Magnetosphere Particle Tracer Explorer
- COBE - Cosmic Background Explorer
- EUVE - Extreme UV Explorer
- XTE - X Ray Timing Explorer
- GPB - Gravity Probe B, which is not really an explorer now, and if if it doesn't go this year, forget it.

Bohlin sees no likely new starts, other than these, until the 1990's. There is an attempt to get some large increase, by a faction of two or three, past this current spending level for Explorers, but Dr. Bohlin was not really optimistic about that.

Spacelab experiments appeared at one time to be the salvation for science, but many selected spacelab instruments are currently in abayence. One success was getting the Solar Optical Telescope started for a launch in 1988 or 1989. The Spacelab IR Telescope Facility (SIRTIF) may possibly get started in the next year (or the next). Then there is SL-2 which is mostly solar and will hopefully fly in 1984, but many other excellent experiments are waiting for development after being selected and then put on hold.

The most optimistic scenario is for two major new starts in 1984 if there is some supplementary funding. One possible source of budget augumentation would be if the military is directed (by Congress) to pay a more equitable share of Shuttle launches and if the operation funds thus saved were applied to science missions.

The bleakest picture is that of a level budget which would imply our going out of business.

The preceeding was an overview, as seen by Bohlin, of the Astrophysics Division's programs. He then proceeded to discuss the Solar Programs as he sees them.

For the present, there is high priority for the SMM Repair Mission in the first quarter of 1984, followed by flight of Space Lab 2 in 1984. There is a major concern on availability of the IPS at that time.

Then the SOT, which is under development, will fly in 1988 or 1989.

For the future we have the following:

- Solar Interplanetary Satellite - SIS, which is a flight of instruments developed for the Solar Polar Mission. There is, however, an extremely short fuse for development as it must fly by 1988 in order to enjoy synergism with the remaining Solar Polar Mission.
- Solar Corona Diagnostic Mission (which was previously the Solar Corona Explorer).
- Internal Dynamics Mission, which could be a joint mission with cosmic rays and isotopic abundances of solar wind studies.
- Advanced Solar Observatory, which would center around High Resolution Telescope Cluster for the SOT.
- Complementary experiments to SOT which could be either:
  - P/OF
  - X Ray Telescope
  - XUV and Soft X Ray Equipment

Bohlin divides Solar studies into several major areas as follows:

- Solar Interior
- Heliosphere
- Solar Atmosphere
- Optical Inner Corona
- Extended Corona

Questions extending across the above areas include:

- Solar Constant Measurements
- Solar Diameter Measurements

Commenting on the overall future of NASA, Bohlin made several comments. He sees Mark and Beggs doing a good job under extremely adverse conditions. He believes that in the next five years the Shuttle operations will be run by a commercial conglomerate. Any future for NASA in the present administration must be tied to National Interests such as defense or commercial exploitation. Also very important in the current trend is U.S. permanent presence in space, such as manned space stations. He placed strong emphasis on the upcoming Colgate Report for possible directions in solar physics.

Kent Wood then asked for guidance as to getting P/Of off the ground before all the working group members reach retirement age.

Bohlin replied that it is absolutely necessary to sell the solar community on the desirability of POF and to win favorable recommendations by major advisory groups such as the recent Field committee. Foreign involvement can be a plus, if not so extensive that it dilutes American participation. We at MSFC should start developing a cost plan and good cost figures. He emphasized the importance of credible cost figures.

The group then developed a list of items which are important for a phase A study. These were summarized by working group members in the following areas (lead responsibility listed first):

- Mechanical - Garmire, Willmore, van Beek
- Thermal - Hurford
- Contamination - Hildner, Kohl, Munro

- Aspect and Alignment - Hildner, van Beek
- Accommodations - Kohl for coronagraphs, Hurford for x ray
- Programmatics - Wood, Lin
- Data - Hildner, Munro
- Control Command Monitoring - Fenimore

A summary of suggested phase A issues is listed as Appendix IX.

For the four principle types of instruments the following contacts were named:

- White Light Coronagraph - Munro
- UV Coronagraph - Kohl
- Coded Aperture X Ray - Wood
- Fourier Transform X Ray - Hurford

The assumptions were that we would use all the above instruments as a straw-man complement with "soft tradeoff." The phase A study would start in March 1983 with a preliminary data dump to Headquarters in January or February 1983.

We are also aiming for having the full Science Working Group Report ready for publication by the end of October. Bill Baity of UCSD will continue to work on it in conjunction with Joe Dabbs while Hugh Hudson is out of the country.

The next meeting of the P/OFSWG will be held on January 20 - 21, 1983, at MSFC.

PINHOLE/OCCULTER FACILITY WORKING GROUP

MINUTES OF MEETING #4

Marshall Space Flight Center, Alabama 35899

September 17-18, 1981

I. INTRODUCTION

A meeting of the Pinhole/Occulter Facility Science Working Group (POFSWG) was held at MSFC on September 17 and 18, 1981. The meeting was cochaired by Hugh Hudson of the University of California, San Diego, and E. A. Tandberg-Hanssen of MSFC. The following members attended:

Richard Blake	LANL
Dave Bohlin	NASA Hq/SC-7
Joe Dabbs	MSFC/PS02
Tony deLoach	MSFC/ES51
Carmine DeSanctis	MSFC/PS02
Ed Fenimore	LANL
Gordon P. Garmire	Pennsylvania State Univ.
Hugh Hudson	Univ. of California, San Diego
Gordon Hurford	Caltech
John L. Kohl	SAO
Robert Lin	Univ. of California, Berkeley
Richard H. Munro	High Altitude Observatory
Joe Parker	MSFC/PD12
Peter Preiswerk	Astro Research Corp.
Gerry Skinner	Univ. of Birmingham, UK
Einar Tandberg-Hanssen	MSFC/ES01
H. Frank Van Beek	SRL/Utrecht
Peter Willmore	Univ. of Birmingham, UK
S. T. Wu	Univ. of Alabama in Huntsville

This fourth meeting of the working group convened at 8:30 a.m. and the agenda for September 17 was as follows:

AGENDA

8:30 a.m.	Introduction	- Hudson
9:00 a.m.	NASA Headquarters Overview	- Bohlin
10:00 a.m.	Soft X-Ray Observations of the Corona	- Krieger
11:00 a.m.	Tour of Payload Training Area	
12:00 p.m.	Lunch	
1:00 p.m.	Space Platform Briefing	- Powell
1:30 p.m.	AXAF Status	- Weiskoff
2:00 p.m.	Report on Alignment Sensing System Definition	- Van Beek
2:30 p.m.	Slides of Birmingham Instrument	- Willmore
3:00 p.m.	Discussion of Technical Progress & Desires	- All

The meeting was convened by Hugh Hudson as E. A. Tandberg-Hanssen was occupied giving Dr. Hans Mark (the new NASA Administrator) a tour of MSFC's Solar Magnetographics Observatory.

Hudson circulated copies of the current draft of the Science write-up which the group has been developing. He indicated the need to add a section on accumulated X-ray satellite experience to date. Also briefly discussed was a paper which he had circulated to the working group members describing a 20 meter scissors-type boom developed for Magsat. This boom and altitude reference system is less precise than the P/OF requirements, but is still capable of 20 arc sec accuracy. Apparently, NASA has considerable experience with booms and P/OFSWG should track down whatever information is available.

Dave Bohlin was then asked to describe NASA priorities and resources. He explained that as part of the current administration's cost cutting exercise, NASA has been directed to cut their budget by 11%. However, due to an added condition that none of this could come out of Shuttle development

and operation funds, that the actual cut allocated to the Office of Space Science was 28%. This budget has just gone to OMB and due to the budget figures, will not be available to the general public until January, 1982. He did state that NASA did not press for reinstatement of the U.S. Spacecraft for the International Solar Polar Mission (ISPM).

To explain future budget constraints, Bohlin divided proposed programs into three categories. These were:

1. Major programs requiring official new starts by Congress. These include GRO, VOIR, and a refurbishment mission for SMM.
2. Explorer Missions, such as IRAS, AMPTE, EUVE, COBE, XTE, and GP-B Currently the budget for Explorer Missions is $36 million, which at current costs is incapable of supporting one new Explorer per year. The Field Commitee recommended a level of $75 million per year, but under current conditions, this is unlikely.
3. Space Lab Instruments, generally of the types:
   A. Facility class instruments with costs roughly equivalent to those of Explorer Missions such as SOT or SIRTF.
   B. PI class instruments of which only 3 (out of 20 previously selected) survived the recent budget cuts. All 3 are in astrophysics.

He listed candidates for the next program of the "new start" category. These included OPEN, AXAF, GRO, and Star/Probe.

Listed as possible competitors for P/OF were the Solar Corona Explorer, the Solar Internal Dynamics Mission, the ASO, Solar Beacon, and Star/Probe. Bohlin did acknowledge the high priority given to P/OF by the Field Committee but indicated that the NASA budget is the real driver.

A study is now being made by President Reagan's science advisor, Keyworth, which should shed light on the current administration's policy towards space science. This study will be complete in December.

Next Al Kreiger discussed measurements of soft X-rays in the corona. In Skylab observations closed loop structures were observed extending out 1½ to 2 solar radii. Broad-band images out to at least 2 solar radii are desired. Emission lines are too restrictive since the flux is reduced by at least an order of magnitude over broad-band observations. Transient events in this region are important and it is believed that solar cosmic rays are accelerated in the shock waves at the heat of such events.

The Skylab instrument was sensitivity-limited by internal scattering. This can be improved by using modern polishing techniques. Kreiger cited a recently built X-ray microscope which reflects 95% of the incident radiation into the ray-tracing blur circle. He presented several viewgraphs (Appendix A) quantifying the improvements that could be anticipated.

In his presentation, Kreiger discussed possible application of a Fresnel Zone Plate imaging telescope with the 50 meter focal length made possible by the P/OF boom. Although the zone plates made to date have been of very small aperture, and they are inherently narrow-band, the advantages of long focal length may still be of interest. He will pursue the study.

Luther Powell reviewed the concepts which have culminated in the current Space Platform configurations. His viewgraphs are presented as Appendix B. Powell stated an interest in having his group sit in on Mike Greene's presentation, since the Space Platform is very concerned with stability of both the booms used to deploy the solar arrays and the inherently flexible platform structure itself.

Marty Weiskopf discussed the status and objectives of the AXAF program. He distributed several copies of the AXAF Science Working Group's Report to members of P/OFSWG who had not received it on previous mailings. It will possibly provide some suggestions for the Final P/OFSWG Report. His viewgraphs are included as Appendix C.

Frank Van Beek discussed his pointing and alignment measurement system, based upon his experience with the HXIS instrument on the Solar Maximum Mission. His system includes a coarse and fine system which will probably use a very low power GaAs laser (few milliwatts). As currently configured it involves lasers on the mask which violates the previous groundrule of no of no active instruments (using electrical power) on the mask. However, he sees no problem in removing the active elements to the detector plane. Viewgraphs are included as Appendix D.

Michael Green presented the results of his summer study program. His designs and simulations look extremely favorable, so much so that some members of P/OFSWG wondered why the boom length of the strawman was as short as 50 m. However, it was generally recognized that the idealization that Greene has been so successfully studying was ready for the next step of engineering development. Greene shocked P/OFSWG by quoting a typical cost for the software verification of an eighth-order controller in the Shuttle environment. He will work on lower-order simulations to see if these costs can be reduced. Greene's viewgraphs are in Appendix E.

The P/OFSWG also indicated a desire to have Dr. Greene define a possible hardware simulation using some scheme for unloading gravity-related loads from a sample beam so that his control scheme could be simulated, for at least a single axis to demonstrate the practicality of his scheme.

Peter Preiswerk followed with some general discussion of current and projected Astro Mast characteristics. No formal presentation was made.

Peter Willmore presented slides of his Spacelab instrument now in fabrication and testing. A surprising fact was that his flight experiment cost only approximately $2 million. After some general discussion of Willmore's experiment, the meeting was adjourned for the day.

On Friday, September 18, the P/OFSWG convened at 8:30 a.m. and the first order of business was to solidify that day's agenda as follows:

8:30 a.m.	Systems Analysis and Accommodation study	Parker
9:40 a.m.	Programmatic Issues	Bohlin
11:00 a.m.	Review Science Writeup	Group
12:00 p.m.	Lunch	
1:00 p.m.	Action Item Assignment	Hudson/Tandberg-Hanssen

Joe Parker presented a short summary of work done in-house by MSFC. This is summarized by the viewgraphs in Appendix . During this presentation, several potential problem areas were touched upon and are summarized as follows:

- Peter Willmore questioned as to how near to the ultimate capacity of the pallet is the current weight (6800 lbs) shown by Parker and how much growth are we allowed? Parker stated that the numbers were conservative, especially since they included the pallet and igloo.
- Is the photon rate being used for the X-Ray imaging detectors realistic? Even if they are conservative, the AGS data handling capability will not be overstressed.
- Parker mentioned a need to establish a desired orbital altitude as drag could raise problems.
- It was decided to look again at layouts of the UV and white light coronographs. The envelopes to date need more refinement. Munro and Kohl decided to work with Parker on this while at MSFC using the CADS computer graphic system.
- It is very probable that in the stowed position some of the P/OF instruments on other system components will overhang a second pallet,

but even so this will allow the use of a 3-pallet train containing the SOT to be used in conjunction with the P/OF. A full 5-pallet train can be accommodated in the Shuttle.

- During discussion of the aspect problem the suggestion was again made to utilize the white light coronograph as a star camera to obtain aspect information for the cosmic X-ray observation mode. A standard star tracker mounted so that it views perpendicular to the instrument line-of-sight will supply sufficiently sensitive roll information. An action item or memo will result in some assessment of this attractive idea.

Dave Bohlin was asked to comment on a list of areas of concern to the P/OFSWG as follows:

1. Final report of the P/OFSWG
2. Future meetings of the P/OFSWG
3. Phase A study for P/OF
4. Mission Workshop

He recommended a comprehensive study document as well as a slimmer executive-type summary report as final products. As to future meetings, he feels that the P/OFSWG should have an oversight capability if a phase A is performed. Such a study is important, but availability of funds is still an open question. He also feels a mission workshop is a desirable goal.

It was suggested that we pursue some sort of limited hardware demonstration to lend credibility to the whole concept. He suggested that the final scheduling of a workshop be deferred until the next P/OFSWG meeting.

In the action item discussion there were a number of assignments as follows:

Hudson:
1. Do a revision of the science writeup and send it to P/OFSWG members for comment in October.
2. Contact TRW for information on their Large Optical System study.

Dabbs:

1. Contact Luther Powell about the Space Platform test program and maintain contact to assure mutual benefit to both programs.
2. With Joe Parker, identify the sensor system in use for alignment of the solar-array test.

Parker:

1. Put the work on system accommodation into a form for inclusion in the P/OFSWG report.

Van Beek:

1. Make a conceptual design of a co-alignment system for instruments.

Munro: Look into implications of using the whitelight coronagraph as a star tracker.

Kreiger: Write a paper for inclusion in the final report on coronal soft X-Rays and Fresnel zone plate imaging.

Bohlin: Find enough funds to support all these good things.

The group decided that the next meeting would be in Boulder, Colorado on the 15th and 16th of January to take advantage of the most members' attendance at the AAS meeting.

PINHOLE/OCCULTER FACILITY WORKING GROUP

MINUTES OF MEETING #3

May 4-5, 1981

I. INTRODUCTION

A meeting of the Pinhole/Occulter Facility Science Working Group (POF SWG) was held at MSFC on May 4 and 5, 1981. The meeting was cochaired by Hugh Hudson of The University of California, San Diego, and E. A. Tandberg-Hanssen of MSFC. The following were in attendance:

E. Chipman	NASA Headquarters
J. Dabbs	MSFC
A. de Loach	MSFC
E. Fenimore	Los Alamos Labs
G. Fishman	MSFC
G. Garmire	Pennsylvania State Universtiy
M. Greene	Univ. of Alabama, Tuscaloosa
H. Hudson	UCSD
G. Hurford	CAL Tech
J. Kohl	Harvard College Observatory
R. Lin	Univ. of Calif., Berkeley
R. Munro	High Altitude Observatory
H. Pack	MSFC
J. Parker	MSFC
G. Skinner	Univ. of Birmingham, United Kingdom
W. Snoddy	MSFC
E. Tandberg-Hanssen	MSFC
P. Wilmore	Univ. of Birmingham, United Kingdom
K. Wood	NRL

This third meeting of the working group was convened at 8:30 a.m. and the agenda for May 4 was as follows:

AGENDA

8:30	Introduction	- Hudson
9:00	Dynamics of Boom Pointing System	- Greene
10:00	SEPS Boom Dynamics	- Pack
10:30	Break	
10:45	Angles (Definitions)	- Hudson
10:46	Boom Distortion Sensing	- Skinner
11:00	Discussion of Technology	
1:00	Introduction of New Report	- Hudson
1:30	Coronal Science	- Munro
2:15	Solar X-ray Science	- Hudson
3:00	Cosmic X-ray Science	- Garmire
3:30	Special Scientific Topics, including	
	Gamma-rays	
	Search for Extra-solar Planets	
	Relativity Experiments	
	Coronal Soft X-radiation	
4:00	"Overlap" Science	- Lin
4:30	Subgroup Meetings (as needed)	

Actually, preceding the introduction was a short demonstration of a small scale working model of an actual "Astro-Mast". The mast could not be fully deployed to its approximately 12-foot length due to the limited ceiling height. Tilting the canister allowed an 8-10 foot deployment and the universal reaction was surprise at the "stiff feeling" given by the structure.

The group discussed various strategic options for implementing the POF. Hugh Hudson will investigate the possibility of getting representation on a committee now forming to study the Advanced Solar Observatory, a mission recommended by the Astronomy Survey Committee.

II. SPECIAL SCIENTIFIC TOPICS

The possibility of a search for extra-solar planets, using externally occulted telescopes, was discussed by Hudson. Visual observation of nearby stellar system planets would require such a occulter at an enormous distance. It appears to be far more practical to utilize the unlighted lunar limb and the Space Telescope, according to a refinement by Elliot of Spitzer's original proposal. A short analysis is included as Appendix A to these minutes.

Gordon Hurford reported on relativity experiments using the externally occulted telescope to measure the deflection of starlight by the gravitational field of the Sun. Meaningful results would require accuracies on the order of 10 milliarc seconds. A brief summary of these conclusions is incorporated as Appendix B. Completing the special topics, Hugh Hudson developed a short paper concerning soft X-ray coronal observations, which is included in Appendix B1.

III. TECHNOLOGY

With regard to angle measurements, there ensued a discussion of the four vectors $\bar{m}$, $\bar{s}$, $\bar{d}$ and $\bar{t}$ and their relative importance to experiment parameters. Hudson identified $\bar{s}$, which is the vector connecting an arbitrary point on the detection plane with an arbitrary point on the mask plane, as the most important vector to X-ray imaging. It was noted

that studies at Utrecht may provide some information regarding a scheme(s) for the measurement of boom deflection.

Michael Greene described the pointing system compensation necessary to stabilize the boom-mounted POF as a "Phase Adding System" which torques the boom just enough out of phase with the detector plane to nullify the tip movement. The conclusion of his studies to date is that with proper compensation, the system can meet or exceed pointing requirements for an average of 94% of observing time. During severe thruster firings an excursion beyond acceptable pointing limits may be expected, but settling times will be less than six seconds. The worst case required pointing system torque motor outputs derived from the study were:

About X axis	-	17.6 n-m
About Y axis	-	18.5 n-m
About Z axis	-	1.0 n-m

Next on the agenda, Homer Pack of MSFC talked about a study intended to develop a dynamic model of the SEPS array. The deployment boom for SEPS is 14.4 inches in diameter and 105 feet in length. A flight experiment has been proposed for 1983 to use a shuttle pointing mount to investigate the dynamic response of a SEPS boom and solar array blanket. This experiment would be very useful to POF if the boom and array blanket could be separated and the dynamics of the boom investigated separately, but it is not presently configured that way. Although this appears to be both desirable and relatively simple, no cost for implementing such a change is available. Pack presented some dynamics and static tests of the SEPS boom characteristics. Based upon these tests, he cautioned that we should always place sizeable tolerance upon any anticipated dynamic characteristics. His handouts are included as Appendix B2.

Jerry Skinner presented the results (Appendix C) of some investigations which he had undertaken into the state-of-the-art of laser ranging systems. His conclusions are that current off-the-shelf commercial systems, for example, lasers with corner reflectors located at strategic locations can potentially measure relative position and twist of the POF detector and mask planes to the required accuracies. Although these systems are not intended for use in space, Skinner pointed out that it is reassuring that the technology exists.

Dick Munro stated that he has a scheme utilizing a pair of small lenses located on the mask viewing the limb of the Sun via small detector arrays on the detector plane platform. He noted that typical scale heights on the solar limb are on the order of 100 km. This contrasted with the fact that at the Sun 750 km subtends one arc second, encourages us to rely upon the level as a reference for solar pointing.

John Kohl asked if the shuttle alone could provide pointing of a hard-mounted boom and experiments to 60 arc seconds or less. The answer from Greene and Parker was that to achieve even 60 arc sec you would have to have a gimbal mount and having that, the control logic needed for arc-second pointing is trivial in cost.

Hugh Hudson mentioned that a workshop had been suggested for coded operative imaging to be held at JPL. The general consensus was that this represents too narrow a view for our purposes and we should continue with our plans for a POF workshop next year.

IV. DISCUSSIONS OF MAJOR SCIENTIFIC GOALS

Dick Munro and John Kohl presented detailed discussions of the scientific rationale for the coronagraphic observations to be addressed

by the POF (Appendix C and D). Kohl addressed the question of "What can the POF potentially do that existing instruments can't?" Angular resolution at Lyα is in principle greatly improved:

Resolution at HI Lyα

POF	Conventional
1 arc sec at 3 R_o	1 arc min at up to 3 R_o
3 arc sec at 4 R_o	
12 arc sec at 6 R_o	

In addition, a time resolution of 1 minute for HI Lα is possible for POF, as opposed to tens of minutes for conventional instruments. Finally the range of diagnostic information from POF would be comprehensive:

- T_p - kinetic temperature of protons
- T_e - kinetic temperature of electrons
- T_H - kinetic temperature of hydrogen
- n_e - electron density
- n_H - hydrogen density

Hudson reviewed the second draft of the solar X-ray scientific objectives.

Gordon Hurford discussed how microwave observation complements POF and he developed the following chart:

Observation	Capability	
	X-ray	Microwave
$\Delta t \sim 0.1$ sec	✓	✓
$\theta \sim 0.2$ arc sec	✓	✓
Spectral Resolution	*	✓

* Requires germanium detectors

Because the microwave and 10-100 kev X-ray observations generally result from non-overlapping parts of the (impulsive) non-thermal electron distribution, their information on these scales would be very complementary.

Gordon Garmire next presented the report of the cosmic X-ray caucus. This is included as Appendix F to these minutes.

It was recommended that a special invitation be extended to George Withbroe of SAO to attend the next POF SWG meeting.

Hugh Hudson suggested the group work towards having all the outstanding writing assignments finished, at least to the first draft level, this summer.

Ken Wood who recently joined the POF SWG was asked in what areas he would choose to contribute. He expects to participate primarily with the X-ray imaging caucus.

The group adjourned at 5:00 P.M.

The meeting on the second day began by breaking into the various caucus groups to discuss what writing assignments are still needed.

V. DISCUSSION OF PROGRAMMATICS

Eric Chipman was asked to give an assessment of how POF could fit within overall Headquarters planning. He did so by giving a short summary of the status of existing programs such as SOT and SIRTF.

The most realistic chance for a new facility would probably come after VOIR, OPEN, and AXAF, and would be very unlikely to have a new start before 1986-87. There would be several potential competitors and the best interests of POF would be served by having the working group prepare a complete package detailing science objectives, preliminary costs and feasibility arguments. In answer to a direct question, Chipman stated that there was no strong advantage in an evolutionary approach, as

opposed to an all-up first flight configuration, but he cautioned that he doesn't necessarily speak for George Newton on this matter. He feels that we should have a new Associate Administrator for Space Science within the next month and more pieces will begin to fall into line by then.

Einar Tandberg-Hanssen asked about support for POF SWG through next winter and support for a POF workshop. Einar gave general encouragement on that.

It was agreed by the groups that the main emphasis of this summer's efforts should be to develop a first cut at realistic costs.

Michael Greene answered some more questions concerning his summer study effort. He will derive the sensitivity of the pointing to parameters such as boom dynamics, boom damping, sensor characteristics and realistic pointing system behavior. There will be a central contact through Dick Munro for all sensor information. Mike Greene was encouraged to go ahead and contact Frank van Beek directly by phone to get his thoughts and inputs.

Gordon Garmire asked if we could address the feasibility of partially deploying the boom to provide a different field of view for cosmic observations. Mike promised to look into it. We also will try to get dynamic characteristics of the 30 meter SEPS boom to investigate use of it for a low cost experiment.

Eric Chipman talked to George Newton concerning our questions. He said that Newton has no problem with our running the POF SWG through 1983, and if necessary, we may be able to get funding for a contracted phase A study. He suggested that we develop schedules on a general format, i.e., year one, year two, etc. But if we feel that we have strong justification based upon the solar cycle, then we should go ahead.

After lunch, William Snoddy of MSFC presented a briefing on the Space Science and Applications Platform. He stressed the realistic nature of the planning and said that they are in phase B planning. This complicates discussion of specific technical details because of Circular A109. He stated that the platform shows excellent chances of pointing to within 1 arc second and if offset pointing tilt tables were provided, there would be no need for an IPS or AGS. His summary charts are enclosed as Appendix G.

A discussion of possible paths to a POF were discussed. These are as follows:

- POF Spacelab Facility
  - a) Incremental
  - b) Facility (need phase A study)
- Inclusion on ASO
- SMM Refly
- SCE Participation
- PI Route for Spacelab/Platform
- Other

To start the costing it is urgent that we have input from the members who have designed or thought about similar instruments for spacelab or rocket flights. Hugh Hudson will serve as a focal point for collecting such information. It should be sized for the strawman POF and should be in 1982 dollars.

Cost, size, weights, data rate, power and heat should be included if possible. These should be available by late June.

The meeting adjourned with the next meeting tentatively scheduled for September 17 and 18 at MSFC.

APPENDIX C

PUBLICATIONS

PUBLICATIONS

A Mechanism for a Class of Solar Coronal Disturbances, by S. T. Wu, Y. Q. Hu, S. Wang, M. Dryer and E. Tandberg-Hanssen, Astrophys. & Space Sci., 83, 189-194, 1982.

Modeling of Energy Buildup for a Flare Productive Region, by S. T. Wu, Y. Q. Hu, K. R. Krall, M. J. Hagyard, and J. B. Smith, Jr., Solar Physics, 90, 117-131, 1984.

The Solar/Interplanetary/Magnetosphere/Ionosphere Connection: A stretegy for Prediction of Geomagnetic Storms by M. Dryer, S.-I. Akasofu, H. W. Kroehl, R. Sagalyn, S. T. Wu, T. F. Tascione, and Y. Kamide, in Proceedings of AAS/AIAA Astrodynamics Specialist Conference, Paper AAS-85-313, 1985.

Numerically-Simulated Formation and Propagation of Interplanetary Shocks by S. T. Wu in "Computer Simulation of Space Plasmas", D. Reidel Publishing Co., 179-201, 1984

On the Numerical Computational of Nonlinear Force-Free Magnetic Fields by S. T. Wu, H. M. Chang and M. J. Hagyard, in NASA Conference Publication 2374 "Measurements of Solar Vector Magnetic Fields" 17-48, 1985.

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