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ONGOING DATA REDUCTION, THEORETICAL STUDIES, AND SUPPORTING RESEARCH IN MAGNETOSPHERIC PHYSICS

Principal Investigator: F. L. Scarf
Co-Investigator: E. W. Greenstadt

FINAL REPORT

Contract NASW-3087
National Aeronautics & Space Administration
Washington, D.C. 20546

24 September 1982
Our customer has extended the period of performance of the subject contract, so the enclosed Close-out Request is cancelled.
PROJECT TITLE: Ongoing Data Reduction, Theoretical Studies, and Supporting Research in Magnetospheric Physics

PROJECT ASSIGNMENTS:

PROJECT MANAGER: Fredrick L. Sari

REVIEWING AUTHORITY: J. F. Friichtenicht

REMARKS:

Amendment 3:
Third Year Follow-On
Customer: NASA Headquarters
Contract No: NASW-3087
LOB: 35 SGRS
Total period of performance:
Cost Share Program

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<td>120,000</td>
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</table>

APPROVAL:
OPERATION MANAGER: [Signature]  DATE: 7/15/80
DIVISION MANAGER (IF REQ'D):  DATE:
I. INTRODUCTION

In August 1979, we anticipated that NASW-3087 would come to an end, and we submitted a report (No. 31219-6013-RU-00) entitled "Final Report". It turned out that NASW-3087 was extended to September 30, 1982, and the present "Final Report" covers the period October 1979 through September 1982.

This second contractual period was an extremely busy and productive one. The TRW investigators (Scarf, Greenstadt, Fredricks, Taylor) published a very large number of space science research papers, and in almost all cases these papers involved correlative multi-spacecraft studies that were supported in part by NASW-3087. Thus, the main part of our Final Report consists of a tabulation of these research papers (Section II).

We also include as Section III copies of our regular Quarterly Progress Reports for the second contractual period.
II. SPACE SCIENCE RESEARCH PAPERS

Scientific Papers Published
Scientific Papers In-Press
Abstracts of Oral Presentations
SCIENTIFIC PAPERS PUBLISHED
(October 1979 through September 1982)

F. L. SCARF


E. W. GREENSTADT


R. W. FREDRICKS


SCIENTIFIC PAPERS IN-PRESS

(As of September 1982)

F. L. SCARF


The Electrical Activity of the Atmosphere of Venus (L.V. Ksanfomality and W.W.L. Taylor, 1st & 3rd authors), submitted to Venus (Univ. of Arizona Press), April 1982.


E. W. GREENSTADT


W W. L. TAYLOR

The Electrical Activity of the Atmosphere of Venus (L.V. Ksanfomality and F.L. Scarf, 1st & 2nd authors), submitted to Venus (Univ. of Arizona Press), April 1982.
ABSTRACTS OF ORAL PRESENTATIONS
(October 1979 through September 1982)

F. L. SCARF


Spatial and Temporal Studies of Jovian Kilometric Radiation (W.S. Kurth and D.A. Gurnett, 1st & 2nd authors), EOS, 60, 918, 1979.


Sources of Turbulence at the Ionopause of Venus (R.E. Daniell and H.A. Taylor, 1st and 2nd authors), EOS, 61, 1018, 1980.

Titan as a Radio Source (W.S. Kurth and D.A. Gurnett, 1st and 2nd authors), EOS, 62, 373, 1981.

On the Shape of the Electron Velocity Distribution Function at and Behind the Terrestrial vs Giant Planet Bow Shocks (J.D. Scudder, E.C. Sittler, Jr., and A.J. Klimas, 1st, 2nd & 3rd authors), EOS, 62, 379, 1981.


Voyager Plasma Wave Observations Near Saturn (W.S. Kurth and D.A. Gurnett, 1st and 2nd authors), IAGA Bulletin No. 45, 468, August 1981.


The Interplanetary Wake of Venus (A. Barnes, J.D. Mihalov, and C.T. Russell, 1st, 2nd, & 3rd authors), An International Conference on the Venus Environment, 82, November 1981.


Lightning Activity on Jupiter (W.J. Borucki, A. Bar-Nun, and A.F. Crook, II, 1st, 2nd, & 4th authors), EOS, 62, 940, 1981.


Stochastic Acceleration of Ions and Electrons in the Venus Ionosheath and Magnetotail (S.A. Curtis and L.H. Brace, 1st and 2nd authors), An International Conference on the Venus Environment, 81, November 1981.


Science Return from ISEE-3 at Comet Giacobini-Zinner (E.J. Smith and R.W. Farquhar, 2nd & 3rd authors), to be presented to the International Conference on Cometary Exploration, Budapest, Hungary, November 1982.


Electrostatic Waves in the Saturnian Magnetosphere (W.S. Kurth and D.A. Gurnett, 1st & 2nd authors), Saturn Program and Abstracts, 45, May 1982.


The Magnetosphere of Saturn, presented to the 18th General Assembly of the International Astronomical Union, Patras, Greece, August 1982.


Narrowband Electromagnetic Emissions from the Jovian Magnetosphere (W.S. Kurth and D.A. Gurnett, 1st & 2nd authors), to be presented to the Fall Meeting of the American Geophysical Union, San Francisco, December 1982.


E. W. GREENSTADT


Laminar and Quasi-Laminar Bow Shocks: Upstream and Downstream Waves (M.M. Mellott [Hoppe] and C.T. Russell, 1st & 2nd authors), for presentation to the Fall Meeting of the American Geophysical Union, San Francisco, December 1982.

R. W. FREDICKS


Theoretical Model for the VLF Sheath Admittance of a Monopole or Dipole Antenna in a Plasma, URSI Trans., URSI Program and Abstracts, H1-4, 24, 1981.

W. W. L. TAYLOR

III. QUARTERLY PROGRESS REPORTS

(for 2nd Contractual Period)
National Aeronautics & Space Administration  
Headquarters, Bldg. F, Rm. 5039  
Washington, D.C. 20546

Attention:  Dr. Michael J. Wiskerchen, Code ST-5

Subject:  Contract No. NASW-3087  
Quarterly Progress Report

In accordance with Article III of the subject contract, enclosed herewith are four (4) copies of the 10th Quarterly Progress Report for Ongoing Data Reduction, Theoretical Studies and Supporting Research in Magnetospheric Physics, dated 9 August 1982, covering the quarter ending 31 July 1982. Additional distribution is indicated below.

TRW INC.  
SPACE & TECHNOLOGY GROUP

M. E. Moss  
Contract Manager  
Applied Technology Division  
Telephone: 213/535-5506  
Mail Station: 01/1050

WGS:bc

Encl.

cc:  NASA/S&TIF (Repro + 2)  
NASA/HQ/Code KT (1)  
AFPRO/TRW (w/o encl)  
NASA/HQ/D. Andreotta (w/o encl)

TRW Program Manager:  
F. L. Scarf
Quarterly Progress Report

ONGOING DATA REDUCTION, THEORETICAL STUDIES, AND SUPPORTING RESEARCH IN MAGNETOSPHERIC PHYSICS

Principal Investigator: F. L. Scarf
Co-Investigator: E. W. Greenstadt

Contract NASW-3087

NASA Headquarters
Washington, D.C. 20546

9 August 1982
(Covering Quarter Ending 31 July 1982)
During this quarter, there were many activities that involved joint data analysis programs, mission definition, and supporting research.

In May, Dr. Scarf returned from the Soviet Union and prepared a trip report which was circulated to numerous personnel at NASA Headquarters. Also in May, Dr. Scarf attended the Saturn Conference at Tucson and presented a talk entitled "Plasma Distributions and Wave-Particle Interactions in Saturn's Inner Magnetosphere". Mr. Greenstadt attended the May COSPAR Meeting held in Ottawa, at which he presented two talks on the subjects "Advances in Shock Physics" and "Computer Constructed Imagery of Distant Plasma Interaction Boundaries".

In June, Dr. Scarf attended a second meeting at NASA Headquarters on ISEE reprogramming to the Earth's tail and to Comet Giacobini-Zinner; he also participated in a presentation on this subject at the National Academy of Sciences. During this month, Dr. Scarf attended the AMPTE Joint Science Working Group meeting held in Munich; Mr. Greenstadt attended the National Computer Graphics Association meeting in Anaheim, and he presented a talk on Bow Shock Structure at the Workshop on Space and Astrophysical Plasmas at the University of California, Santa Barbara.

Several papers were completed or published during the past quarter, as follows:


The paper "Sounds from Space" was prepared in association with the production of a TRW record entitled "Sounds of Saturn". 15,000 copies of this record have been donated to The Planetary Society, and they will be given away during the next quarter.
SOUNDS FROM SPACE*

by

Frederick L. Scarf

June 1982

NASA Headquarters Contract No. NASW-3087

*To be submitted to The Planetary Report

Applied Technology Division
Bldg R-1, Rm 1176
TRW Space and Technology Group
One Space Park
Redondo Beach, California 90178
(213) 536-2015
Abstract. Wide separations up to more than 1 Rg between ISEE 1 and 2 during the second half of 1978 have been used to measure the correlation length of magnetic pulsations in quasi-parallel shocks. When the two spacecraft were less than a few hundred km apart, magnetic oscillations measured by magnetometers on both spacecraft exhibited virtually identical waveforms, but at distances of several thousand km the two time series of field variation showed no detailed similarity at all. The correlation coefficients of the pulsations dropped from close to 1.0 for spacecraft separations of less than 100 km to 0.2 for separations of greater than 800 km. A correlation length of several hundred km may be related to the gyroradius of return protons with energy typical of the peaks of diffuse and beam ion distributions.

Introduction

Simultaneous measurements by two or more instruments at different locations within the Earth's bow shock and foreshock regions constitute the essential tool for distinguishing temporally from spatially varying structures. So far, analysis of data from the satellites pair ISEE 1 and 2 has emphasized the mutual consistency of their measurements. Indeed, one of the striking features of the earliest data from the magnetometers of ISEE 1 and 2 was the detailed similarity, under normal conditions, of waveform at the two vehicles even in the highly-irregular, large-amplitude perturbations of the quasi-parallel shock, of which examples are shown in this report. A high, of course, even the quasi-perpendicular profile differs from one spacecraft to the other [Russell and Greenstadt, 1979]. Signal correlation, because of its obvious application to timing the motions of waves and boundaries between the satellites, has therefore received much attention, and, in fact, one study has successfully defined propagation vectors and velocities of ULF waves in the foreshock [Hoppe and Russell, 1980; Hoppe et al., 1981]. The limits of correlation are equally of interest, however.

In contrast to most of the early data from the ISEE project, which were obtained when the satellites were close together (i.e., within a few hundred km of each other), the data from the second half of 1978 offer the first opportunity to examine directly the extent of signal correlation, hence spatial variation, in the local plasma environment when the two spacecraft passed through bow shock distances at varying separations up to several thousand km. This report presents the first documented change of correlation with distance for a magnetic constituent of the shock structure and discusses a possible relationship of correlation length to ion gyroradius. Our examples are all quasi-parallel, by which we mean the angle between the interplanetary magnetic field and the local model shock normal was less than about 50° and large-amplitude field oscillations were recorded.

Variable Correlation

Figure 1 offers a visual display of the variations in wave correlation observable in the running 12-second averages (plotted every four seconds) between ISEE 1 and ISEE 2. In 1(a), the two traces of magnetic-field magnitude exhibit almost identical waveforms. Moreover, the similarities of changing field pattern occurred in both the ULF foreshock waves (e.g., around 0015 and 0030) and in the larger-amplitude waves and pulses defining the outer edges of the quasi-parallel shock structure, as seen between 0020 and 0024. The fidelity of wave duplication at the two spacecraft persisted at higher resolution, illustrated in Figure 2, where we see unaveraged data with samples recorded every 0.25 second. A segment of the data from Figure 1(a) is shown in Figure 2(a). While not identical in every detail, or exactly alike in amplitude, the two waveforms share essentially the same pattern for periods of a few seconds or longer, and the occurrence of higher-frequency bursts was almost simultaneous at both satellites in the illustrated examples. Figure 2(b) is an overlay of ISEE 1 and ISEE 2 data for a section of 2(a), showing clearly the close similarity of the two signals, albeit with slightly variable delay from one satellite to the other.

Returning to Figure 1, we note that in 1(b) the similarity of the two field plots is considerably less pronounced than in 1(a). Indeed,
Abstract. Some interplanetary shocks detected by ISEE-3 are preceded by many hours of strongly-enhanced plasma wave noise at a few kHz, while others have essentially no wave precursors above background. It has been shown that these extremes correspond to quasi-parallel and quasi-perpendicular shocks, respectively, based on the instantaneous orientation angle $\theta_{Bn}$ of the interplanetary magnetic field (IMF) to the shock normal at the time the shocks crossed the spacecraft. We show that precursor wave noise level is correlated with field orientation and an extrapolated $\theta_{Bn}$ throughout the preshock observation interval for two contrasting active and quiet cases, and that intermediate, variable noise levels correspond to intermediate, variable IMF orientations. We infer that foreshocks are an intrinsic part of the structure of quasi-parallel interplanetary shocks.

Introduction

Knowledge of the macrostructure of the Earth's bow shock helps to organize one class of solar wind events; namely, the enhancement of kilohertz-range plasma wave electrical signals upstream (ahead) of quasi-parallel, but not quasi-perpendicular, interplanetary (IP) shocks (Kennel et al., 1982). We perceive these events as interplanetary counterparts of analogous extended bow shock structures, and as a potential tool for illuminating an unsettled question in bow shock phenomenology.

Figure 1 displays four of the examples of Kennel et al. (1982) spanning the range of pre-shock conditions, from noise-free (25 December) to almost continuously noisy (12 November), with two intermediate cases of fluctuating noise levels, one occasionally above background (8 November) and one consistently above background (27 August). The multiband signatures of these examples, displayed by Kennel et al., showed that the average electric field in the 3 kHz channel is a representative diagnostic for plasma waves in the 1-10 kHz frequency range. The number at the upper left in each panel gives the angle $\theta_{Bn}$ between the local shock normal and the IMF at the time each interplanetary shock crossed the spacecraft. The normals were determined by the combined field and plasma method of Abraham-Schrauner and Yun [1976]. The correspondence of small $\theta_{Bn}$ with enhanced upstream $E_x$ suggests that the presence or absence of plasma wave noise was related to the quasi-parallel or quasi-perpendicular structure of the approaching shock, implying the existence of interplanetary foreshocks similar to the foreshock-outside the Earth's curved, non-uniform bow shock (Greenstadt and Fredricks, 1979).

The distinctions among plasma wave activity levels visible in Figure 1 depended however on the presence or absence of noise for hours preceding shock encounter, while the lone $\theta_{Bn}$ calculated for each shock was based on the instantaneous IMF immediately before shock encounter. Since the IMF direction is variable, it does not necessarily follow that the field line containing enhanced plasma waves, say, three hours before encounter was traceable to a connection with the oncoming shock at the same $\theta_{Bn}$. Also, it is always possible, unless demonstrated to the contrary, that plasma wave noise at ISEE-3 was simply a manifestation of the Earth's foreshock resulting from downwind connection of the IMF to the bow shock. We attempt, here, to add confidence to the structural explanation by filling in the pattern of preshock field behavior in several cases.

Method of Analysis

We have used the ISEE-3 data pool tapes, together with computational graphic techniques, to illustrate the approximate relationships of spacecraft, IMF, wave noise, IP shocks, and bow shock. The data pool supplies plasma wave fields, IMF vectors, and solar wind velocity, among other measurements, averaged every 128-seconds. In a given 128-second interval, we take the average IMF as a single vector to represent the field segment $\mathbf{B}_i$ during that interval, but we wish to represent it as a small vector $\mathbf{B}_i$ in metric space whose length is proportional to $\mathbf{B}_1$. The metric vector's
National Aeronautics & Space Administration
Headquarters, Bldg. F, Rm. 5039
Washington, D.C. 20546

Attention: Dr. Michael J. Wiskerchen, Code ST-5
Subject: Contract No. NASW-3087
Quarterly Progress Report

In accordance with Article III of the subject contract, enclosed herewith are four (4) copies of the 10th Quarterly Progress Report for Ongoing Data Reduction, Theoretical Studies and Supporting Research in Magnetospheric Physics, dated 11 May 1982, covering the quarter ending 30 April 1982. Additional distribution is indicated below.

TRW INC.
SPACE & TECHNOLOGY GROUP

M. E. Moss
Contract Manager
Applied Technology Division
Telephone: 213/535-5506
Mail Station: 01/1050

WGS:bc
Encl.

cc: NASA/S&TIF (Repro + 2)
NASA/HQ/Code KT (1)
AFPRO/TRW (w/o encl)
NASA/HQ/D. Andreotta (w/o encl)

TRW Program Manager:
F. L. Scarf
During this quarter, there were many activities that involved joint data analysis programs, mission definition, and supporting research.

On March 23-24, 1982, Dr. Scarf participated in a presentation at NASA Headquarters involving the possible diversions of ISEE-3 to the Earth's geomagnetic tail and to Comet Giacobini-Zinner.

On April 18, 1982, Dr. Scarf left the United States for a two-week visit with Soviet scientists at the Institute for Cosmic Research in Moscow. The discussions to be held during this trip involved ISEE data, analysis of Venus lightning and solar wind interaction measurements, and Voyager observations at Jupiter and Saturn.

From February 8-10, 1982, Mr. Greenstadt attended the ISEE SWT Meeting at Goddard Space Flight Center, and he was responsible for having prepared the Agenda for the Shock Workshop held on February 10.

During this period, two manuscripts were revised: "Plasma Wave Levels and IMF Orientations Preceding Observations of Interplanetary Shocks by ISEE-3 (Greenstadt Scarf, Kennel, Smith, and Fredricks)," which has been returned to Geophysical Research Letters for publication; and "Large-Amplitude Magnetic Variations in Quasi-Parallel Shocks: Correlation Lengths Measured by ISEE 1 and 2 (Greenstadt, Hoppe, and Russell)," which is being prepared for publication in Geophysical Research Letters.
Throughout the quarter, Mr. Greenstadt prepared material for an invited review paper to be presented at the IMS Symposium of COSPAR to be held in May, 1982, at Ottawa.
PLASMA WAVE LEVELS AND IMF ORIENTATIONS
PRECEDING OBSERVATIONS OF INTERPLANETARY SHOCKS BY ISEE-3

by

E. W. Greenstadt¹, F. L. Scarf¹, C. F. Kennel²,

E. J. Smith³, and R. W. Fredricks¹

¹Applied Technology Division, TRW Defense & Space Systems Group,
Redondo Beach, California 90278

²Department of Physics and Institute of Geophysics and Planetary Physics,
University of California, Los Angeles, California 90024

³Jet Propulsion Laboratory, California Institute of Technology,
Pasadena, California 91109

November 1981

(Revised February 1982)

Space Sciences Department
Bldg R-1, Rm 1176
TRW Defense & Space Systems Group
One Space Park
Redondo Beach, California 90278

(Submitted for publication in Geophysical Research Letters)

01-079-82
LARGE-AMPLITUDE MAGNETIC VARIATIONS IN QUASI-PARALLEL SHOCKS: 
CORRELATION LENGTHS MEASURED BY ISEE 1 AND 2 

by 

E. W. Greenstadt 
Space Sciences Department 
TRW Space and Technology Group 
Redondo Beach, California 90278 

M. M. Hoppe 
C. T. Russell 
Institute of Geophysics and Planetary Physics 
University of California at Los Angeles 
Los Angeles, California 90024 

January 1982 
(Revised March 1982) 

(submitted to Geophysical Research Letters) 

Space Sciences Department 
Bldg R-1, Rm 1176 
TRW Space & Technology Group 
One Space Park 
Redondo Beach, California 90278
National Aeronautics & Space Administration
Headquarters, Bldg. F, Rm. 5039
Washington, D.C. 20546

Attention: Dr. Michael J. Wiskerchen, Code ST-5

Subject: Contract No. NASW-3087
Quarterly Progress Report

In accordance with Article III of the subject contract, enclosed herewith are four (4) copies of the 10th Quarterly Progress Report for Ongoing Data Reduction, Theoretical Studies and Supporting Research in Magnetospheric Physics, dated 11 February 1982, covering the quarter ending 31 Jan. 1982. Additional distribution is indicated below.

W. G. Sanders
Contract Administrator
Applied Technology Division
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Mail Station: R1/2004

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TRW Program Manager:
F. L. Scarf
Quarterly Progress Report

ONGOING DATA REDUCTION, THEORETICAL STUDIES, AND SUPPORTING RESEARCH IN MAGNETOSPHERIC PHYSICS

Principal Investigator: F. L. Scarf
Co-Investigator: E. W. Greenstadt

Contract NASW-3087
NASA Headquarters
Washington, D.C. 20546

11 February 1982
(Covering Quarter Ending 31 January 1982)

Applied Technology Division
Bldg R-1, Rm 1176
TRW Space and Technology Group
One Space Park
Redondo Beach, California 90278
During this quarter, Dr. Scarf attended the Space Science Advisory Committee Meeting held at NASA Headquarters (November 16-19, 1981); the OPEN Science Working Group Meeting held at NASA Goddard Space Flight Center (January 13-15, 1982); and the Annual Meeting of the American Physical Society held in San Francisco (January 25-28, 1982).

Dr. Scarf and Dr. Taylor both attended the International Conference on the Venus Environment held in Palo Alto (November 4-6, 1981), and the Pioneer Venus Science Steering Group Meeting held at NASA Ames Research Center (January 24-27, 1982).

Dr. Scarf, Dr. Fredricks, and Mr. Greenstadt all attended the Winter Meeting of the American Geophysical Union held in San Francisco (December 7-9, 1981).

A number of talks were given at the scientific meetings, and their titles appear on the list attached.

During this period, six scientific papers were completed, and their titles are also listed on the attachment.

Five abstracts were submitted for the upcoming COSPAR Meeting and for the International Conference on Cometary Exploration. Details are covered on the attachment.
PRESENTATIONS


COMPLETED PAPERS


ABSTRACTS SUBMITTED


National Aeronautics & Space Administration
Headquarters, Bldg. F, Rm. 5039
Washington, D.C. 20546

Attention: Dr. Michael J. Wiskerchen, Code ST-5

Subject: Contract No. NASW-3087
Quarterly Progress Report No. 10

In accordance with Article III of the subject contract, enclosed herewith are four (4) copies of the 10th Quarterly Progress Report for Ongoing Data Reduction, Theoretical Studies and Supporting Research in Magnetospheric Physics, dated 12 NOV 1981, covering the quarter ending 31 OCT 1981. Additional distribution is indicated below.

TRW INC.
DEFENSE & SPACE SYSTEMS GROUP

W. G. Sanders
Contract Administrator
Applied Technology Division
Telephone: 213/536-3837
Mail Station: R1/2004

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NASA HQ/D. Andreotta (w/o enc1)

TRW Program Manager:
F. L. Scarf
Quarterly Progress Report

ONGOING DATA REDUCTION, THEORETICAL STUDIES, AND SUPPORTING RESEARCH IN MAGNETOSPHERIC PHYSICS

Principal Investigator: F. L. Scarf
Co-Investigator: E. W. Greenstadt

Contract NASW-3087
NASA Headquarters
Washington, D.C. 20546

12 November 1981
(Covering Quarter Ending 31 October 1981)

Applied Technology Division
TRW Defense & Space Systems Group
One Space Park
Redondo Beach, California 90278
During this period, F. L. Scarf gave a report at the APS Plasma Physics Division Meeting in New York, and he participated in activities of the US/USSR Working Group on Near Earth, Space, and Planets; the ISEE Comet Working Group; and the SSAC subcommittee on the Space Platform. E. W. Greenstadt met with ISEE co-investigators and ground magnetic-observatory scientists in Edinburgh and London to plan some joint programs of satellite and surface data analysis.

A report comparing "Plasma Wave Turbulence at Planetary Bow Shocks" by Scarf, Gurnett, and Kurth was published in Nature (292, 747, 20 Aug 1981). Audio techniques were developed by Scarf for synthesizing sounds of plasma waves and were applied to data from ISEE-3, Pioneer Venus, and Voyager to produce recordings of interplanetary shocks, planetary shocks, Jovian and Saturnian magnetospheric phenomena, and the Saturnian ring-plane crossing. It was shown by Greenstadt that interplanetary shocks have plasma wave foreshocks compatible with quasi-perpendicular/quasi-parallel distinction at $\theta_{Bi} = 50^\circ$ in local shock geometry familiar at the earth's bow shock, and that the sudden appearance of the earth's ULF foreshock immediately after a tangential discontinuity in the solar wind is explained as enclosure of the observation point in a pre-existing upstream region exposed
when the discontinuity sweeps across the bow shock. Also, Greenstadt and co-workers discovered and measured a correlation length of about 1000 km for large-amplitude quasi-parallel bow shock pulsations. The length seems to be related to the distributions of gyroradii of reflected ions.
Quarterly Progress Report

ONGOING DATA REDUCTION, THEORETICAL STUDIES, AND SUPPORTING RESEARCH IN MAGNETOSPHERIC PHYSICS

Principal Investigator: F. L. Scarf
Co-Investigator: E. W. Greenstadt

Contract NASW-3087

National Aeronautics & Space Administration
Washington, D.C. 20546

12 August 1981
(Covering Quarter Ending 31 July 1981)

Space Sciences Department
TRW Defense & Space Systems Group
One Space Park
Redondo Beach, California 90278
During this period, E. W. Greenstadt attended the Gordon Research Conference on Collisionless Shocks and the IAGA General Assembly, while F. L. Scarf participated in meetings of the NASA Space Science Advisory Council and the ISEE Science Working Team and Workshop on TYPE II Solar Radio Bursts and Interplanetary Shocks.

A number of new and promising multi-spacecraft investigations were recently initiated. Scarf and his co-workers identified interplanetary shocks detected on ISEE-3 and the Pioneer Venus Orbiter (see Figure 1) and they showed that the corresponding foreshock regions contained very similar ion acoustic wave turbulence. Greenstadt started to apply his terrestrial ISEE-1,2 three-dimensional foreshock program to analyze interplanetary shock phenomena. Figure 2 shows one important example in which this analysis demonstrates that the B-Field in front of the solar wind shock never intersected the earth's magnetosphere; thus the ISEE-3 measurements of plasma waves certainly represented detection of interplanetary shock precursors, rather than observations related to the earth's foreshock.
Figure 1

ISEE-3
DEC 13-14, 1978

PIONEER-VENUS
DEC 13, 1978

$E, \text{v/m(Hz)}$

$B, \text{gamma}$

$10^{-5}$

$10^{-8}$

$1/2$

$3.16 \text{kHz}$

$5.4 \text{kHz}$

$10^{-4}$

$10^{-7}$

$B, \text{gamma}$

$0\quad 80$

$2000\quad 0000\quad 0400$

$0\quad 40$

$0415\quad 0815\quad 1215$
INTERPLANETARY B-FIELD

ISEE 3

EARTH'S MAGNETOSPHERE

PLASMA WAVE SHOCK PRECURSORS

INTERPLANETARY SHOCK

Xb_end = 3690674.53847  Yb_end = -19402.2891201  Zb_end = -1462655.78596
PHANTOM SHOCK INTERSECTION WITH X-AXIS AT 3838426.57748
IP SHOCK INTERSECTION WITH X-AXIS AT 9113864.03801

FIGURE 2

ORIGINAL PAGE IS OF POOR QUALITY
National Aeronautics & Space Administration  
Headquarters, Bldg. F, Rm. 5039  
Washington, D.C. 20546

Attention: Dr. Michael J. Wiskerchen, Code ST-5

Subject: Contract No. NASW-3087  
Quarterly Progress Report No. 10

In accordance with Article III of the subject contract, enclosed herewith are four (4) copies of the 10th Quarterly Progress Report for Ongoing Data Reduction, Theoretical Studies and Supporting Research in Magnetospheric Physics, dated 13 May 1981, covering the quarter ending 30 April 1981. Additional distribution is indicated below.

TRW INC.  
DEFENSE & SPACE SYSTEMS GROUP

W. G. Sanders  
Contract Administrator  
Applied Technology Division  
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cc: NASA/S&TIF (Repro + 2)  
NASA/HQ/Code KT (1)  
AFPRO/TRW (w/o encl)  
NASA/HQ/D. Andreotta (w/o encl)

TRW Program Manager:  
F. L. Scarf
Quarterly Progress Report

ONGOING DATA REDUCTION, THEORETICAL STUDIES, AND SUPPORTING RESEARCH IN MAGNETOSPHERIC PHYSICS

Principal Investigator: F. L. Scarf
Co-Investigator: E. W. Greenstadt

Contract NASW-3087
National Aeronautics & Space Administration
Washington, D.C. 20546

13 May 1981
(Covering Quarter Ending 30 April 1981)
Several projects are in progress at the end of this quarter:

1. We are examining the geometrical relationship between the orientations of interplanetary shocks, their plasma wave forerunners, and their pre-shock interplanetary field directions.

2. We are studying an apparent resonant geomagnetic pulsation in the dusk sector to determine both the local conditions governing the pulsation and the circumstances responsible for its occurrence. The study includes observations from three satellites and several stations on the earth's surface.

3. We are studying the response of the foreshock and shock to rapid changes, particularly tangential discontinuities in the interplanetary magnetic field.

4. We are investigating the details of plasma and field behavior under conditions of transition between quasi-perpendicular and quasi-parallel shock structure.

During the quarter, we completed several papers which have been submitted for publication (see Appendix 1). We attended meetings listed on Appendix 2. Preparation for the IAGA Assembly to be held in Edinburgh (August 1981) and for the Gordon Conference on Collisionless Shocks which will meet next month was made in this quarter.
Completed Papers:


Meetings:

March 1-5, 1981 - Dr. Scarf attended the Space Science Advisory Committee Meeting at NASA Headquarters, Washington, D.C.

March 16-18, 1981 - Dr. Taylor participated in the Active Experiments Working Group Meeting at the University of Alabama, Huntsville.

April 13-14, 1981 - Dr. Scarf took part in the Space Science Advisory Committee's Subcommittee on Space Platforms Meeting at the University of Alabama, Huntsville.

April 14-17, 1981 - Dr. Taylor presented a paper at the NRL Ionosphere Conference Symposium on the Effect of the Ionosphere Radio Wave System in Washington, D.C.
National Aeronautics & Space Administration  
Headquarters, Bldg. F, Rm. 5039  
Washington, D.C. 20546  

Attention: Dr. Michael J. Wiskerchen, Code ST-5  
Subject: Contract No. NASH-3087  
Quarterly Progress Report No. 9  

In accordance with Article III of the subject contract, enclosed herewith are four (4) copies of the 9th Quarterly Progress Report for Ongoing Data Reduction, Theoretical Studies and Supporting Research in Magnetospheric Physics, dated 12 February 1981, covering the quarter ending 31 January 1981. Additional distribution is indicated below.

Don Andreotta is requested to advise me by letter as to whether the current addressees of this report and the copied recipients noted below will be the same for future submittals of the subject report.

TRW INC.  
DEFENSE & SPACE SYSTEMS GROUP  

W. G. Sanders  
Contract Administrator  
Applied Technology Division  
Telephone: 213/536-3837  
Mail Station: R1/2004

WGS:bc

Enc1.

cc: nasa/S&TIF (Repro + 2)  
NASA/HQ/Code KT (1)  
AFPRO/TRW (w/o enc1)  
NASA/HQ/D. Andreotta (w/o enc1)

TRW Program Manager:  
F. L. Scarf
Quarterly Progress Report

ONGOING DATA REDUCTION, THEORETICAL STUDIES, AND SUPPORTING RESEARCH IN MAGNETOSPHERIC PHYSICS

Principal Investigator: F. L. Scarf
Co-Investigator: E. W. Greenstadt

Contract NASW-3087
National Aeronautics & Space Administration
Washington, D.C. 20546

12 February 1981
(Covering Quarter Ending 31 January 1981)

Space Sciences Department
TRW Defense & Space Systems Group
One Space Park
Redondo Beach, California 90278
The funding for this extension arrived at TRW in mid-January, 1981, and by the week ending January 23, we had set up the Project Plan and Schedule for the proposed supporting research and technology activities.

In the few weeks since January 23, very little has been accomplished that merits detailed reporting. We are analyzing plasma wave and magnetometer data from a number of operating spacecraft and performing multi-spacecraft correlation studies. We are also investigating new techniques for processing data in space and on the ground. More details will appear in the next report.
National Aeronautics & Space Administration
Headquarters
Washington, DC 20546

Attention: D. P. Cauffman, Code ST

Subject: Contract No. NASW-3087
Quarterly Progress Report No. 8

In accordance with Article III of the subject contract, enclosed herewith are four (4) copies of the 8th Quarterly Progress Report for Ongoing Data Reduction, Theoretical Studies and Supporting Research in Magnetospheric Physics, dated 9 October 1980, covering the period 1 July through 30 September 1980.

W. G. Sanders
Contracts Administrator
Applied Technology Division
Telephone: 213/536-3837
Mail Station: R1/2004

cc: NASA/S&TIF (Repro + 2)
    NASA/HQ/Code KT (1)
    AFPRO/TRW (w/o enc1)
    NASA/HQ/D. Martin (w/o enc1)

TRW Program Managers:
F. L. Scarf
E. W. Greenstadt
Quarterly Report No. 8

ONGOING DATA REDUCTION, THEORETICAL STUDIES, AND SUPPORTING RESEARCH IN MAGNETOSPHERIC PHYSICS

Principal Investigator: F. L. Scarf
Co-Investigator: E. W. Greenstadt

Contract NASW-3087
National Aeronautics & Space Administration
Washington, D.C. 20546

(Covering Period 1 July through 30 September 1980)

9 October 1980

Space Sciences Department
TRW Defense & Space Systems Group
One Space Park
Redondo Beach, California 90278
During the last quarter, Dr. Scarf participated in presentations on ISEE, OPEN, and other solar-terrestrial programs at NASA Headquarters. The presentations were primarily directed toward Dr. Mutch and Dr. Frosch. During this time there was also a considerable amount of research on the flight programs, ISEE, Pioneer Venus, and Voyager.

In addition, Dr. Scarf has been preparing to participate in the Space Science Advisory Committee meeting in October, 1980.

Mr. Greenstadt attended a MOWG meeting at Goddard Space Flight Center, and he participated in the Data Systems Users Working Group meeting in Huntsville, Alabama. He also gave a presentation at the UCLA Institute of Geophysics and Planetary Physics Workshop on Space Plasma Physics at Los Alamos Scientific Laboratory.

During this period Mr. Greenstadt continued investigation of the earth's foreshock, including comparison of ISEE and IMP-8 Ion data, and attempted to integrate recent results from numerous investigators into a single comprehensive phenomenology.
Effective 17 May 1982 the Contract Administrator for this contract is changed as follows:

from M. E. Moss
01/1050
x55506

to K. P. Stidham
01/1050
x63837
This revision is issued to modify only the following block numbers of the CONTRACT AUTHORIZATION:

This modification amends the Statement of Work to authorize TRW personnel to participate in activities with the Soviet Academy of Sciences. This modification increases the estimated cost and cost share as follows:

<table>
<thead>
<tr>
<th></th>
<th>Previous</th>
<th>This Mod.</th>
<th>New Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Cost</td>
<td>$568,000</td>
<td>$2,079</td>
<td>$570,079</td>
</tr>
<tr>
<td>TRW Share</td>
<td>5,737</td>
<td>21</td>
<td>5,758</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$573,737</td>
<td>$2,100</td>
<td>$575,837</td>
</tr>
</tbody>
</table>

Fully funded. All other terms and conditions remain the same.
This Modification amends the Statement of Work and increases the estimated cost and cost share totals.

a. ARTICLE I is amended to add, "The Contractor shall provide the personnel, facilities and material to participate in discussions on ISEE 1, 2, 3, Voyager 1, 2, the Pioneer Venus Orbiter and other NASA activities with the Soviet Academy of Sciences, placing special emphasis on the interchange of Venus lightning data and discussions of the US-Soviet Working Group on Near-Earth, the Moon and Planets. Such discussions shall be conducted during a visit to the Soviet Academy of Sciences in the USSR not later than May 15, 1982."

b. ARTICLE V is amended to increase the estimated cost of the contract to the Government by $2,079 from $568,000 to $570,079; the cost share amount by $21 from $5,737 to $5,758; and the total contract estimate by $2,100 from $573,737 to $575,837.

c. All other terms and conditions remain unchanged.
CONTRACT AUTHORIZATION

CHANGE OF ADMINISTRATOR

On May 15, 1982, the Contract Administrator for this contract is changed from W. G. Sanders R1/2004 to M. E. Moss 01/1050 x63837.

This revision is issued to modify only the following block numbers of the CONTRACT AUTHORIZATION:

Original page is of poor quality.
This authorization is being issued to correct C/A Rev. #11 to show the issue date thereof as 8 SEP 81 and the basis for issuance as Amendment No. 7. All other data remains the same as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Previous</th>
<th>This modification</th>
<th>New Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cost</td>
<td>$442,424</td>
<td>$131,313</td>
<td>$573,737</td>
</tr>
<tr>
<td>Total TRW Share</td>
<td>(4,424)</td>
<td>(1,313)</td>
<td>(5,737)</td>
</tr>
<tr>
<td>Total NASA Share Funded</td>
<td>$438,000</td>
<td>$130,000</td>
<td>$568,000</td>
</tr>
</tbody>
</table>

Contract is now fully funded.

W. G. Sanders
CONTRACT ADMINISTRATOR

DISTRIBUTION:
STANDARD DISTRIBUTION LIST 0-1 PLUS THE FOLLOWING:

<table>
<thead>
<tr>
<th>Name</th>
<th>BLDG./MAIL STA.</th>
</tr>
</thead>
<tbody>
<tr>
<td>F. Scarf</td>
<td>R1/1176</td>
</tr>
<tr>
<td>L. Calhoun</td>
<td>R1/1086</td>
</tr>
<tr>
<td>F. Friichtenicht</td>
<td>R1/1096</td>
</tr>
<tr>
<td>C. Chapman</td>
<td>R1/1096</td>
</tr>
<tr>
<td>P. Gentile</td>
<td>E1/4049</td>
</tr>
<tr>
<td>P. Herbert</td>
<td>E1/5052</td>
</tr>
<tr>
<td>D. Edwards</td>
<td>O1/1260</td>
</tr>
<tr>
<td>A. Williams</td>
<td>R1/2104</td>
</tr>
</tbody>
</table>

W. G. Sanders
CONTRACTS MANAGER
**AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT**

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. AMENDMENT/MODIFICATION NO.</td>
<td>Block 3</td>
</tr>
<tr>
<td>2. EFFECTIVE DATE</td>
<td>14 SEP 1981</td>
</tr>
<tr>
<td>3. ISSUED BY</td>
<td>NASA Headquarters Contracts &amp; Grants Division Washington, DC 20546</td>
</tr>
<tr>
<td>4. CONTRACTOR NAME AND ADDRESS</td>
<td>TRW, Inc. Defense Space Systems Group One Space Park Redondo Beach, CA 90278</td>
</tr>
<tr>
<td>5. MODIFICATION OF</td>
<td>N/A</td>
</tr>
<tr>
<td>6. DATE</td>
<td>7-1-77</td>
</tr>
<tr>
<td>7. DESCRIPTION OF AMENDMENT/MODIFICATION</td>
<td>Block 3 of Modification No. 7, dated 8-31-81, is canceled and replaced, &quot;D-61278&quot;, and substitute instead, &quot;10-26170&quot;.</td>
</tr>
</tbody>
</table>

**Signature of person authorized to sign**

**ORIGINAL PAGE IS OF POOR QUALITY**

**RECEIVED **

**CONTRACTS**
This revision is issued to modify only the following block numbers of the CONTRACT AUTHORIZATION: Spheric Physics.

This modification adds funding as follows:

<table>
<thead>
<tr>
<th>Previous</th>
<th>This Modification</th>
<th>New Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cost</td>
<td>$442,424</td>
<td>$131,313</td>
</tr>
<tr>
<td>Total TRW Share</td>
<td>$(4,424)</td>
<td>$(1,313)</td>
</tr>
<tr>
<td>Total NASA Share Funded</td>
<td>$438,000</td>
<td>$130,000</td>
</tr>
</tbody>
</table>

The contract is now fully funded.
This Modification increases the amount of funds obligated under the subject contract. The contract is now fully funded.
Allowable expenditure of cost is related to funding on this cost sharing contract as follows:

Total Cost: $442,424
Total TRW Share: (4,424)
Total NASA Share Funded: $438,000
(11) The period of performance is extended to 30 SEP 82.

(14, 15, 16) Cost, TRW Share, Total:

<table>
<thead>
<tr>
<th></th>
<th>Previous Totals</th>
<th>This Amend.</th>
<th>New Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cost</td>
<td>$321,192</td>
<td>$252,545</td>
<td>$573,737</td>
</tr>
<tr>
<td>Total TRW Share:</td>
<td>(3,192)</td>
<td>(2,545)</td>
<td>(5,737)</td>
</tr>
<tr>
<td>Total NASA Share</td>
<td>$318,000</td>
<td>$250,000</td>
<td>$568,000</td>
</tr>
<tr>
<td>Funding</td>
<td>$318,000</td>
<td>$120,000</td>
<td>$438,000</td>
</tr>
</tbody>
</table>

The contract is now funded through 9/30/81.

Reporting Requirements: Quarterly Progress Reports Repro + 7 2-18-81 thru 9-15-82

Final Report Repro + 7 9-30-82*

*This date is changed from 12/31/80. The final report is to cover the period 25 June 1980 through 30 September 1982.
AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. AMENDMENT/MODIFICATION NO.  Six (6)

2. EFFECTIVE DATE  12-31-80

3. REQUISITION/PURCHASE REQUEST NO.  10-25012

4. PROJECT NO. (If applicable)

5. ISSUED BY  NASA Headquarters
   Contracts and Grants Division
   Washington, DC 20546

6. MODIFIED BY  AFFRO; TRW, Inc.
   One Space Park
   Redondo Beach, CA 90278

7. CONTRACTOR  TRW, Inc.
   Defense and Space Systems Group
   One Space Park
   Redondo Beach, CA 90278

8. MODIFICATION NO.  1
   DATED 7-1-77 (See block 9)

9. THIS BLOCK APPLIES ONLY TO AMENDMENTS OF SOLICITATIONS
   - The above numbered solicitation is amended as set forth in block 12. The hour and date specified for receipt of offers is extended, is not extended.
   - Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation, or as amended, by one of the following methods:
     (a) By signing and returning a copy of this amendment, (b) By acknowledging receipt of this amendment on each copy of the offer submitted, or (c) By separate letter or telegram which includes a reference to the solicitation and amendment number. FAILURE OF YOUR ACKNOWLEDGEMENT TO BE RECEIVED AT THE ISSUING OFFICE PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If, by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided such telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

10. ACCOUNTING AND APPROPRIATION DATA (If required)

   Obligation: $120,000
   Estimated Cost: $250,000
   Cost Share: 2.545
   385-36-01-19 ($60,000)
   170-36-55-18 ($60,000)

11. THIS BLOCK APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS
   (a)  This Change Order is issued pursuant to
   The Changes set forth in block 12 are made to the above numbered contract/order.
   (b)  The above numbered contract/order is modified to reflect the administrative changes (such as changes in payee, appropriation data, etc.) set forth in block 12.
   (c)  This Supplemental Agreement is entered into pursuant to authority of
       10 U.S.C. 2304(a)(11)

   DESCRIPTION OF AMENDMENT/MODIFICATION

The purpose of this Modification is to continue research under contract NASW 3087; to amend the Statement of Work; to increase the estimated cost; to extend the period of performance; to revise the reporting requirements for the final report; and to rstate the contract in accordance with current NASA procurement regulations.

(Continued on the next page)

ORIGINAL PAGE IS OF POOR QUALITY
a. Article I is amended to add the following:

"During the period of performance specified for Modification No. 6 to this contract, the contractor shall continue ongoing data reduction, theoretical studies and supporting research in magnetospheric physics initiated under Modification No. 3, and as more particularly described in the contractor's proposal nos. 31219.003, and 31219.004, dated July 1980 and September 1980, respectfully, both of which are incorporated herein by reference."

b. Article II is amended to add the following:

"The work to be performed under this modification shall be completed no later than September 30, 1982."

c. Article III is amended to add the following:

"The final report for the work to be performed under this modification and modification No. 3 shall be delivered no later than September 30, 1982."

d. Article V is amended by changing the total cost of performing the work under this contract and the total estimated cost to the Government from $321,192 and $318,000 to $573,737 and $568,000, respectively.

e. The work to be performed under this modification shall not be subject to the provisions and operations of Article XII, notwithstanding language in the Article to the contrary. References in the Article to a contract expiration date and completion of contract performance shall be construed to mean August 31, 1979, the end of performance date for Modification No. 2 to this contract.

f. Article XV, Options, is deleted.

g. Article XIV is amended to (1) Incorporate Modification No.2 to Basic Agreement NAS11-680(B), dated April 29, 1980, herein.

(2) Delete Clause A.5, Utilization of Small Business and Small Disadvantaged Business Concerns, (Sept. 1979) (1.707-3(a)), and substitute in its stead, Utilization of Small Business Concerns and Small Business Concerns Owned and Controlled by Socially and Economically Disadvantaged Individuals, (June 1980) (1.707-3(a)).

(3) Amend Clause A.6-3, Acquisition of Existing Government Equipment, by changing the date thereof to March 1980.

(4) Amend Clause A.12, Disputes, by changing the date thereof to June 1980.
Amendment of Solicitation/Modification of Contract
Modification No. 6 to NASW-3087
Block 12 Continued

(5) Amend Clause C.29, Allowable Cost, Fixed Fee and Payment, by changing the date thereof to May 1980.

(6) Add Clause C.3, Limitation of Liability - Service Contract.

(7) Add Clause C.20, Limitation on Withholding of Payments.

(8) Add Clause C.28, Stop Work Order.

(9) Add Clause C.31, Limitation of Government's Obligation.

h. The Schedule and all references thereof are amended to add the following:

"Article XV Limitation of Government's Obligation

Pursuant to the Clause of this contract, entitled, Limitation of Government's Obligation, funds in the amount of $120,000 are hereby allotted for the performance of this contract for the period January 1, 1981 through September 30, 1981."
NASA Headquarters
Contracts & Grants Division
300 - 7th Street, S.W., Room 723
Washington, DC 20546

Attention: Mr. Don Andreotta, Code HWC-2

Subject: NASA Contract NASW-3087
Proposals 31219.003 and 31219.004
Ongoing Data Reduction, Theoretical Studies
in Magnetospheric Physics

As indicated in my telephone call to you of 26 November 1980, TRW requests
that the modification resulting from the subject proposals provide that the
due date for the final report be changed to the end date of the added work.

TRW INC.
DEFENSE & SPACE SYSTEMS GROUP

W. G. Sanders
Contract Administrator
Applied Technology Division

WGS:bc
The Administrative Contracting Officer is changed to Sandra N. Rickman/TDM/RPE,

AFPRO/TRW/TM
One Space Park
Redondo Beach CA 90278

W. G. Sanders
CONTRACT ADMINISTRATOR
Assignment of Administrative Contracting Officer

1. Pursuant to the agreement between National Aeronautics and Space Administration and Department of Defense, dated 18 June 1969, and NASA Letter of Delegation, dated 25 June 1980, from NASA Contracting Officer, you are hereby assigned as Administrative Contracting Officer for the following Contract:

   Contract Number: NASW-3087
   Contractor: TRW Defense and Space Systems Group
             One Space Park
             Redondo Beach CA 90278
   Office of Administration: AFPRO/TRW/TM
                            One Space Park
                            Redondo Beach CA 90278

2. This assignment is limited to the performance of those field administration support functions set forth in referenced letter of Delegation. Functions not specified in referenced letter are reserved by the NASA Administrative Contracting Officer.

CHARLES G. WORTHINGTON, Lt Col, USAF
Principal Administrative Contracting Officer
(11) Period of Performance is extended to 31 December 1980.

DELIVERABLES:

Quarterly Progress Report       Repro + 7       10-15-80
Final Report                    Repro + 7       12-31-80
AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. AMENDMENT/MODIFICATION NO. Five (5)
2. EFFECTIVE DATE 9-30-80
3. ISED BY CODE HWC-2
4. ADMINISTERED BY 1/1) Other than block 5) CODE

Nasa Headquarters
Contracts & Grants Division
Washington, DC 20546
Attention: Donald J. Andreotta

TRW, Inc.
Defense Space Systems Group
One Space Park
Redondo Beach, CA 90278

7. CONTRACTOR NAME AND ADDRESS
   (Street, city, county, state, and ZIP Code)
   TRW, Inc.
   Defense Space Systems Group
   One Space Park
   Redondo Beach, CA 90278

9. THIS BLOCK APPLIES ONLY TO AMENDMENTS OF SOLICITATIONS
   This amendment applies only to contracts/orders identified in block 12. The hour and date specified for receipt of offers is extended.
   Offers must be submitted in accordance with the requirements specified in the amendment, or as amended, by any of the following methods:
   (a) By signing and returning copies of this amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted, or (c) By separate letter or telegram which includes a reference to the solicitation and amendment number. Failure of your acknowledgement to be received at the issuing office prior to the hour and date specified may result in rejection of your offer. If, by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided such telegram or letter makes reference to the solicitation and this amendment, and it is received prior to the opening hour and date specified.

10. ACCOUNTING AND APPROPRIATION DATA (If required)

   No Cost Extension

   This Change Order is issued pursuant to
   The changes set forth in block 12 are made to the above numbered contract/order.
   The above numbered contract/order is modified to reflect the administrative changes (such as changes in paying office, appropriation date, etc.) set forth in block 12.
   If applicable, Agreement is entered into pursuant to authority of the mutual agreement of the parties.

11. DESCRIPTION OF AMENDMENT/MODIFICATION

   Whereas, the Government has a requirement for extended services of TRW, Inc., to continue Ongoing Data Reduction, Theoretical Studies and Supporting Research in Magnetospheric Physics; and

   Whereas, the Contractor has agreed to continue research and analysis during the period September 30, 1980 through December 31, 1980;

   Now, therefore, in consideration thereof, Articles II and III are amended to change, "September 30, 1980", to, "December 31, 1980", therein.

   ORIGINAL PAGE IS OF POOR QUALITY
AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

Contract # D-04556

NASA Headquarters

contracts & Grants Division

Washington, DC 20546

Attention: Donald J. Andreotta

JPL, Inc.

Defense Space Systems Group

One Space Park

Redondo Beach, CA 90278

Date: 7-1-77

No Cost Extension

Whereas, the Government has a requirement for extended services of JPL, Inc., to continue ongoing data reduction, theoretical studies and supporting research in Magnetospheric Physics; and

Whereas, the Contractor has agreed to continue research and analysis during the period September 30, 1980 through December 31, 1980;

Now, therefore, in consideration thereof, Articles II and III are amended to be "September 30, 1980", to "December 31, 1980", therein.

Original page is of poor quality.
I have been talking to Dr. Roger Williamson, whose name you gave me, to trace through the PR for the FY 81 procurement. It turns out that nothing has been done yet. Don Andreotta received our proposal a couple of months ago and sent copies to Wiskerchen, but Wiskerchen never got them, so nothing has been done. Dr. Williamson will put his hand on a copy of our proposal tomorrow and will get the process started. He holds little hope that the PR will reach Andreotta in time to conclude negotiations by 30 September 80. Andreotta is going on a business trip on 22 September and will be on vacation in the subsequent two weeks. Dr. Williamson and I agreed to touch base again on Monday, 15 September, to review status. Williamson is now thinking in terms of contracting for two years since last year's review was good for three years. Our proposal for the second and third years will reach them about 17 September since the signoff cannot be completed this week.
On Going Data Reduction, Theoretical Studies, and Supporting Research in Magnetospheric Physics

F. Scarf

4351

SN 31219

Project Control
M. L. Calhoun

Contract Administrator
W. Sanders

On Going Data Reduction
F. Scarf

4351

WU A

Closed

On Going Data Reduction
F. Scarf

4351

WU B

Closed

On Going Data Reduction
F. Scarf

4351

WU C

Closed

3rd year F/O

F. Scarf

4351

WU D

JN 5079-73

3rd Year F/O

ICOM

4351

ICOM

JN 6101-47
(11) The period of performance is extended to 30 SEP 80.

(14) (15) (16) Cost, TRW Share, Total:

<table>
<thead>
<tr>
<th>Previous Totals</th>
<th>This Amend.</th>
<th>New Totals</th>
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</thead>
<tbody>
<tr>
<td>Total Cost:</td>
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<td>$121,212</td>
</tr>
<tr>
<td>Total TRW Share:</td>
<td>(1,980)</td>
<td>(1,212)</td>
</tr>
<tr>
<td>Total</td>
<td>$198,000</td>
<td>$120,000</td>
</tr>
</tbody>
</table>

Reporting Requirements: FINAL REPORT - due 30 SEP 80

ARTICLE XIV is amended to incorporate all changes to Basic Agreement NAS11-305 (B), dated April 23, 1976 and modifications, thereto, as incorporated in this contract, contained in Basic Agreement NAS11-680 (B), and Modification No. 1, thereto, dated August 7, 1979 and February 12, 1980, respectively. Additionally, Clause A-28, Inspection and Correction of Defects (April 1975), is deleted and Clause C-34-1, Inspection (Sept. 1962) (Short Form), is substituted in its stead.

Proposal for fourth year of contract - due 30 MAY 80.
Our customer has extended the period of performance of the subject contract, so the enclosed Close-out Request is cancelled.

DISTRIBUTION

Classified Material Control
Contract Accounting
Contract Close-Administrator
General Counsel
Patents Counsel
Project Manager
Procurement Close-out Coordinator
Property Management Office
Resident DCASR Office
Contracts Communication Center
This supplemental agreement is issued to change the procurement request number from 10-23665 (mod 3) to 10-23554.

ALL OTHER TERMS AND CONDITIONS OF THIS CONTRACT REMAIN THE SAME.
The purpose of this Modification is to continue research under contract NASW-3087; to amend the Statement of Work; to extend the estimated cost; to extend the period of performance; to revise the reporting requirements for the final report; and to restate the contract in accordance with current NASA Procurement Regulations.

a. Article I is amended to add the following:

"During the period of performance specified for Modification No. 3 to this contract, the contractor shall continue on going data reduction, theoretical studies and supporting research in magnetospheric physics, as more particularly described in the contractors proposal No. 36115.000, and revision r 1, thereto, dated August 1979 and April 11, 1980, respectfully, both of which are incorporated herein by reference.

Tasks shall include, but not be limited to: (SEE FOLLOWING PAGES)
a. FORESHOCK - Define and study the large scale structure of the foreshock and its dynamic behavior, using field, particle and plasma wave data from IMP 7, 8 and ISL E A, B. Data from Pioneer Venus and Voyager 1, 2 will be used to study the regions upstream from Venus and Jupiter in order to analyze different kinds of foreshock phenomena.

b. INTERPLANETARY TRANSIENTS - Conduct long baseline studies of traveling interplanetary phenomena using field, particle and plasma wave data from Pioneer Venus, ISLE A, B, C, IMP 7, 8 and Voyager 1, 2.

c. WAVE - PARTICLE AND WAVE - WAVE INTERACTIONS - Search current observational data base for examples of wave-wave interaction phenomena. Conduct theoretical studies to determine if these represent true mode coupling phenomena.

d. PLANETARY MAGNETOSPHERES - Conduct detailed comparative studies of lighting production and propagation paths through the ionosphere and magnetospheres of the planets.

e. RESEARCH ON SENSOR AND SPACECRAFT - Investigate the in-flight behavior of wave sensors on spacecraft; and problems related to spin modulated solar array noise detected at low frequencies with electric antennas.

ARTICLE XVII is amended to add the following:

The work to be performed under this modification shall be completed n. later than September 30, 1980.

ARTICLE XVIII is amended to add the following:

The final report for the work to be performed under this modification shall be delivered n. later than September 30, 1980.

ARTICLE XIX is amended by changing the total cost of performing the work under this contract and the total estimated cost to the Government from $198,000 and $198,000 to $121,192 and $318,000, respectively.

The work to be performed under this modification shall not be subject to the provisions and operations of ARTICLE XII, notwithstanding language in the article to the contrary. References in the article to a contract expiration date and completion of contract performance shall be construed to mean August 31, 1979, the end of performance date for Modification No. 2 to this contract.

The Schedule and all references thereto is amended to add the following:

"ARTICLE XV OPTIONS
Government Option to Extend the Term of the Contract for the Four and Fifth Years of Performance."
The period of performance of this contract may be extended at the option of the Government for two one year option periods, provided that the Contracting Officer shall have given preliminary notice of the Government's intention to extend at least sixty (60) calendar days prior to the expiration of this contract. (Such preliminary notice shall not be deemed to commit the Government to the exercise of any option).

Not later than 120 calendar days prior to the expiration of the performance period, the contractor shall submit a cost proposal for the option period under consideration.

In the event the parties cannot agree to an estimated cost the Government may direct the contractor to continue performance under the contract and the failure to agree shall be considered a dispute as defined under the Clause entitled "Disputes" of the General Provisions."

ARTICLE XII is amended to incorporate all changes to Basic Agreement NAS11-305 (B), dated April 23, 1976 and modifications, thereto, as incorporated into this contract, contained in Basic Agreement NAS11-680 (B), and Modification No. 1, thereto, dated August 7, 1979 and February 12, 1980, respectively. Additionally, Clause A-28, Inspection and Correction of Defects (April 1975), is deleted and Clause C-34-1, Inspection (Sept. 1962) (Short Form), is substituted in its stead.
This negotiation was conducted by telephone with Don Andreotta of NASA/HQ on 23 April 1980. This proposal was submitted on a cost sharing basis as an add-on to contract NASW-3087 (SN 31219). The negotiation is summarized as follows:

<table>
<thead>
<tr>
<th>Total Estimated Cost</th>
<th>$121,212</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Share</td>
<td>( \text{Cost Share} )</td>
</tr>
<tr>
<td>NASA Cost Share</td>
<td>$120,000</td>
</tr>
</tbody>
</table>

So that we could receive all of NASA's $120,000 of funding and leave room for reductions due to DCAA recommended rates, the proposal was submitted for a slightly larger amount:

<table>
<thead>
<tr>
<th>Base Cost</th>
<th>ICOM</th>
<th>Total Cost</th>
<th>TRW Cost Share</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed/ Adjusted</td>
<td>$120,120</td>
<td>$2,297</td>
<td>$122,417</td>
<td>($1,224)</td>
</tr>
<tr>
<td>Negotiated</td>
<td>118,908</td>
<td>2,304</td>
<td>121,212</td>
<td>(1,212)</td>
</tr>
<tr>
<td>Yield</td>
<td>99.0%</td>
<td>99.0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ICOM included in total cost = \$2,304
ICOM as a percent of base cost = 1.9%

The resulting contract modification (#3) will state that the level-of-effort clause will not be applicable to the negotiated work.

The basic agreement will be updated from NAS11-305(B) to NAS11-680(B). The same "A" and "C" clauses will be applicable except that A.28 (Inspection and Correction of Defects) will be deleted and C.34-1 (Inspection - Short Form) will be added. The Statement of Work will be paraphrased into five tasks.

The start date will be the date of the PCO's signature, unless Don can get permission for an earlier start date. The end date will be 30 September 1980.
NASA Headquarters  
Contracts & Grants Division, Code HWC-2  
300 - 7th Street, S. W.  
Room 723  
Washington, D. C. 20546  

Attention: Mr. D. Andreotta  

Subject: Proposal No. 36115.000RI  
A Proposal for Ongoing Data Reduction,  
Theoretical Studies, and Supporting  
Research in Magnetospheric Physics  

Enclosed is updated pricing for the subject proposal as discussed by  
telephone between you and Mr. Sanders of TRW on 8 April 1980. It is proposed  
that this work be added to Contract NASW-3087. We propose that this work  
not be subject to a level-of-effort provision. We understand that Dr. Wiskerchen agrees to this. Except for revised pricing and level-of-effort, our  
proposal is the same as previously submitted.  

This proposal is submitted on a cost sharing basis and is open to acceptance  
for a period of sixty days from the date of this letter. No changes to the  
terms and conditions are proposed except those noted above.  

Please address all official correspondence pertaining to this requirement  
to the attention of our Contracts Administrator, Mr. W. G. Sanders, who  
has been authorized to represent the Company for this program. Mr. Sanders  
may be reached by telephone 213/536-3837, or through Mail Station R1/2004.  

TRW INC.  
DEFENSE & SPACE SYSTEMS GROUP  

H. D. Wilkinson  
Division Manager of Contracts  
Applied Technology Division  

HDW:bc
NOTE:

"This document contains commercial or financial information, or trade secrets, of TRW Inc., which are confidential and exempt from disclosure to the public under the Freedom of Information Act, 5 U.S.C. 552 (b) (4), and unlawful disclosure thereof is a violation of the Trade Secrets Act, 18 U.S.C. 1905. Public disclosure of any such information or trade secrets shall not be made without the prior written permission of TRW Inc."
<table>
<thead>
<tr>
<th>DETAIL DESCRIPTION OF COST ELEMENTS</th>
<th>EST. COST ($)</th>
<th>TOTAL COST ($)</th>
<th>REASON ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. DIRECT MATERIAL (Include on Sheet A)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. PURCHASED PARTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. SUBCONTRACTED ITEMS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. OTHER - (I) RAW MATERIAL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. YOUR STANDARD COMMERCIAL ITEMS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. INTERMURAL AND EXTERNAL TRANSFERS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. MATERIAL OVERHEAD (See Sheet B)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. DIRECT LABOR (Specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENGINEERING LABOR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. LABOR OVERHEAD (Specify department or chart account)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. SPECIAL TESTING (Specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. SPECIAL EQUIPMENT (Specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. TRAVEL (Direct charges) (See item on attached schedule)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. CONULTANTS (Specify quantity purpose rate)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. OTHER DIRECT COSTS (Include on Sheet A)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL DIRECT COST AND OVERHEAD</td>
<td></td>
<td>109,165</td>
<td></td>
</tr>
<tr>
<td>10. GENERAL AND ADMINISTRATIVE EXPENSE (Specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of total element costs</td>
<td></td>
<td>13,252</td>
<td></td>
</tr>
<tr>
<td>11. ALLOCATION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. TOTAL ESTIMATED COST</td>
<td></td>
<td>122,417</td>
<td></td>
</tr>
<tr>
<td>13. PERCENT PROFIT</td>
<td></td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>14. TOTAL ESTIMATED COST AND PROFIT</td>
<td></td>
<td>122,417</td>
<td></td>
</tr>
</tbody>
</table>

This proposal is submitted for use in connection with the Office of the Administrator and the information which follows.

JAMES ADLER, MANAGER OF PRICING, ATD

DATE OF SIGNATURE: 4/11/82

[Signature]

TRW INC., DEFENSE AND SPACE SYSTEMS GROUP

FRA FORM 633-4 (MACA EDITION)
EXHIBIT A—SUPPORTING SCHEDULE (See Item 1 for exact item to which this schedule relates)

<table>
<thead>
<tr>
<th>COST ITEM NO.</th>
<th>ITEM DESCRIPTION (See Item 2)</th>
<th>EST COST (ID)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Technical Services</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Computing Services</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Cost of Money</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL OTHER COSTS</strong></td>
<td><strong>$6,407</strong></td>
</tr>
</tbody>
</table>

1. The purpose of this form is to provide a standard format by which the contractor submits the Government a summary of incurred and estimated costs (and attached supporting information) that are identified in cost and contract. For purposes of this column, the amount of cost resulting from this proposal is the total cost shall be the result of the amounts shown on NASPR Form 2270-3, to which are attached a Certificate of Costs or Pricing Data (see NASPR Form 2270-3). In addition, the contractor must submit with this form any information reasonably requested to explain the cost estimating process, including: a. the judgmental factors applied and the mathematical or statistical methods used in preparing these estimates, and b. the contingencies used by the contractor in his proposed price.

2. When attachments of supporting cost or pricing data to this form is impracticable, the data will be specifically identified and described (with schedules as appropriate), and made available on the contracting officer or his representative upon request.

3. The format for the “Cost Elements” is not intended to be rigid requirements. There may be presented in different format with the prior approval of the contracting officer if required for more effective and effective presentation. In all other respects this form shall be completed and submitted without change.

4. By submission of this proposal, the contractor, the contracting officer or his representative, the right to make, for the purpose of verifying the cost or pricing data submitted, these books, records, documents and other supporting data, permit adequate evaluation of such cost or pricing data, along with the computations and projections used therein. This right may be exercised in connection with any negotiations prior to contract award.

5. Indicate the rates used and provide an appropriate explanation. Thereafter has been reached with Government representative on the use of interest pricing rates, describe the nature of the agreement. Providing the method of computation and application of your own spread sheet, indicating cost breakdown and showing trends and budget data as necessary to provide a basis for evaluation of the reasonableness of proposed rates.

6. If the total amount cost entered herein is in excess of $10,000, provide a separate page (or on Form 723, Royalty Report) the following information on each unit line from which royalty or license fee: name and address of licensees, date of license agreements, patent numbers, patent application serial numbers, or other basis on which the royalty is payable, total description, including any payment per unit number of each unit of the license agreement, stock, and total dollar amount of royalties. In addition, if specifically requested by the contracting officer, a copy of the current license agreement and identification of applicable claims of specific patents shall be provided.

7. Provide a list of principal items within each category or class of items and description of each, quantity, unit price, composition obtained, basis of establishing source and contract amount of cost.

INSTRUCTIONS TO OFFERORS

Footnote

1. Enter in this column those necessary and reasonable costs which in the judgment of the contractor will properly be incurred in the performance of the contract. When any of the costs in this column have already been incurred (e.g., on a prior contract or change order), describe them on an attached supporting schedule. Identify all sales and transfers between your firm, divisions, or organizations under a common control, which are included at other than the fair cost of the original contractor or current market prices.

2. When space is not available to that column in Exhibit A, the schedule may be extended. This schedule may be extended on an attached supporting schedule. Identify all sales and transfers between your firm, divisions, or organizations under a common control, which are included at other than the fair cost of the original contractor or current market prices.

3. If the total amount cost entered herein is in excess of $10,000, provide a separate page (or on Form 723, Royalty Report) the following information on each unit line from which royalty or license fee: name and address of licensees, date of license agreements, patent numbers, patent application serial numbers, or other basis on which the royalty is payable, total description, including any payment per unit number of each unit of the license agreement, stock, and total dollar amount of royalties. In addition, if specifically requested by the contracting officer, a copy of the current license agreement and identification of applicable claims of specific patents shall be provided.

4. Provide a list of principal items within each category or class of items and description of each, quantity, unit price, composition obtained, basis of establishing source and contract amount of cost.
### Ongoing Data Reduction & Analysis

#### Original Page is of Poor Quality

#### Cost Estimate

**Engineering Labor**

<table>
<thead>
<tr>
<th>Rate</th>
<th>HOURS</th>
<th>AMOUNT</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.05</td>
<td>452</td>
<td>$9,515</td>
<td></td>
</tr>
<tr>
<td>17.40</td>
<td>452</td>
<td>$7,865</td>
<td></td>
</tr>
<tr>
<td>9.20</td>
<td>2240</td>
<td>$20,608</td>
<td></td>
</tr>
<tr>
<td>6.70</td>
<td>266</td>
<td>$1,782</td>
<td></td>
</tr>
</tbody>
</table>

**Total Engineering Labor**: $39,770

**Total Engineering Overhead**: $59,655

**Other Direct Costs**

<table>
<thead>
<tr>
<th>Rate</th>
<th>QTY</th>
<th>AMOUNT</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.02</td>
<td>20</td>
<td>$100</td>
<td></td>
</tr>
<tr>
<td>0.055</td>
<td>3,927</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td>235</td>
<td>7</td>
<td>1,645</td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>1.1</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>10.50</td>
<td>100</td>
<td>1,050</td>
<td></td>
</tr>
<tr>
<td>6.12</td>
<td>5</td>
<td>3,060</td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>10</td>
<td>790</td>
<td></td>
</tr>
<tr>
<td>12.50</td>
<td>5</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>96</td>
<td>1</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>4</td>
<td>316</td>
<td></td>
</tr>
<tr>
<td>12.50</td>
<td>1</td>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>

**Total Other Direct Costs**: $7,773

**Cost Before G & A**: $106,868

**G & A Expense**: 13,252

**Subtotal**: $120,120

**Cost of Money**: 2,297

**Total Estimated Cost**: $122,417

**TRW Cost Share**: (1,224)

**Total Cost Less TRW Cost Share**: $121,193
EXPLANATORY NOTES FOR BIDDING CATEGORIES

These notes are included to provide a definition of each bidding category. The following list includes the major bidding categories, however, all may not be applicable to this proposal.

TRW Inc., Defense and Space Systems Group believes that its current cost accounting practices used in estimating costs in pricing this proposal are consistent with the cost accounting practices disclosed in its submitted Cost Accounting Standards Board Disclosure Statements and revisions thereto. Additional Disclosure Statements or revisions may be in preparation and notification and submittal will be accomplished pursuant to ASPR 3-1205(b).

The data contained in this cost proposal has been prepared by C. W. Bolin, ATD Pricing Operations, TRW Inc., Defense and Space Systems Group, One Space Park, Redondo Beach, California 90278.

BIDDING CATEGORIES

TRW Inc., Defense and Space Systems Group operates under a policy of ACO bidding rate approval, subject to periodic review. The above Resident ACO normally reviews for approval those Compar/ established bidding rates for use in pricing contract proposals to the Government that are identified with an asterisk. The code numbers listed within the parentheses identify the account number used to accumulate the respective costs in the Company accounting system.

<table>
<thead>
<tr>
<th>BIDDING CATEGORIES</th>
<th>ESTIMATING BASIS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct</strong></td>
<td></td>
</tr>
<tr>
<td>Direct Labor*</td>
<td>Direct Labor Hours</td>
</tr>
<tr>
<td>Travel/Subsistence*</td>
<td>Trip/Days</td>
</tr>
<tr>
<td>Consultants</td>
<td>Days</td>
</tr>
<tr>
<td>Material</td>
<td>Material Item Cost</td>
</tr>
<tr>
<td>Major Procurements</td>
<td>Labor or Material Procurement</td>
</tr>
<tr>
<td>Customer Plant Equip.</td>
<td>Equipment Item Cost</td>
</tr>
<tr>
<td>Technical Services (Graphics Prod.)</td>
<td>Service Request</td>
</tr>
<tr>
<td>Configuration Adm. &amp; Data Mgmt.*</td>
<td>Service Request</td>
</tr>
<tr>
<td>Computing Services*</td>
<td>Service Hours/Units</td>
</tr>
<tr>
<td>Overtime Premium</td>
<td>Direct Labor Hours</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Indirect</strong></td>
<td></td>
</tr>
<tr>
<td>Overhead*</td>
<td>Direct Labor Dollars</td>
</tr>
<tr>
<td>Procurement*</td>
<td>Direct Procurement Dollars</td>
</tr>
<tr>
<td>General &amp; Administrative</td>
<td>Total Cost Prior to G &amp; A</td>
</tr>
<tr>
<td>Cost of Money Factors</td>
<td>Applied to the same bases as are used to allocate Indirect Expenses</td>
</tr>
</tbody>
</table>
## Status of Bidding Rates

The following table displays the bidding category, Pricing Manual reference, and status of Company established or cognizant Resident ACO approved bidding rates.

### Pricing Manual References

<table>
<thead>
<tr>
<th>Bidding Rates</th>
<th>Bidding Rates Section/Date/Rev.#</th>
<th>ACO Approval Letter Section/Date/Rev.#</th>
<th>Status of Bidding Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Labor</td>
<td>3.1.1, 2, 3, 4, 5/8 February 1980/Ver</td>
<td>3.2.1/8 February 1990/#7</td>
<td>Formally approved by the cognizant Resident ACO.</td>
</tr>
<tr>
<td>(Reprographic Services)</td>
<td>4.2.1/2 May 1977/#2</td>
<td>4.2.3/11 December 1974/New</td>
<td>Formally approved by the cognizant Resident ACO.</td>
</tr>
<tr>
<td>Subsistence</td>
<td>4.1.10/24 March 1980/#2</td>
<td></td>
<td>Company established bidding rates.</td>
</tr>
<tr>
<td>Configuration Admin. &amp;</td>
<td>4.3.1/3 March 1980/#12</td>
<td></td>
<td>Company established bidding rates.</td>
</tr>
<tr>
<td>Data Management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overhead, Procurement &amp; G&amp;A</td>
<td>5.1.1/10 January 1980/#25</td>
<td></td>
<td>Company established bidding rates.</td>
</tr>
<tr>
<td>1980-1982</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1983-1985</td>
<td>5.1.2/10 January 1980/#20</td>
<td></td>
<td>Company established bidding rates.*</td>
</tr>
<tr>
<td>Cost of Money Factors</td>
<td>5.1.3/27 March 1980/#10</td>
<td></td>
<td>Company established bidding rates.</td>
</tr>
<tr>
<td>1980-1982</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* It is the practice of the cognizant Resident ACO not to establish ACO approved Cost of Money Factors, Procurement or Overhead and G&A bidding rates beyond a three year period.
Direct labor costs are identifiable directly to a specific contract or project. The direct labor rates are developed by labor category, as identified and shown in this proposal, from historical data and the evaluation of industry wage and salary patterns, labor market conditions, and other relevant factors.

Direct labor bidding rates are subject to review and formal approval by the cognizant Resident Administrative Contracting Officer (Chief, Contract Administration Division). The actual direct labor rates are continually under review by TRW and the ACO. When a significant variance between the actual rates and the bidding rates or a change in the conditions upon which the bidding rates were based is identified, TRW or the ACO may request a revision of the direct labor bidding rates.

The proposed work will be accomplished during calendar year 1980.

The direct labor hours proposed are from detailed subtask estimates provided by the functional organizations responsible for the performance of specific tasks; These estimates have been reviewed and analyzed and are the basis for the proposed labor.

The direct labor rates applied in this proposal are for the calendar year(s) 1980.

On the following page are the Labor Category descriptions for the proposed project.
LABOR CATEGORY DESCRIPTION

Engineering B (100B) Top engineering and scientific personnel who are responsible for planning, organizing, and directing engineering programs and activities of outstanding importance.

Engineering C (100C) Senior engineering and scientific personnel whose duties and responsibilities require creativity, engineering judgment in solving unusual and complex engineering problems, determining program objectives and requirements, and developing standards and guides for diverse engineering and scientific activities.

Technicians (106) Non-exempt technical job classifications involving technical support of laboratory design, development, and test activities. Typical classifications are Electronic and Mechanical Technician, Laboratory Analyst and Research Assistant.

Clerical & Administrative Support (103) Non-exempt job classifications involving the performance of clerical and administrative duties.
INDIRECT EXPENSE RATES

Indirect expenses are incurred for the common benefits of all contracts and are not identifiable to a specific contract. A multiple burden pool system is employed for the collection and distribution of indirect expenses. The use of multiple burden pools recognizes that certain functional and organizational activities contribute to the performance of a contract in different ways and degrees depending upon the type of work or services they perform, and the pools are designed to accomplish the most equitable distribution of expenses.

Overhead consists of costs incurred by organizations involved in the day-to-day support of operating tasks necessary for fulfillment of all contracts and includes management support, payroll expenses, communications costs, etc. Expenditures for overhead tasks are charged to one of the burden pools of the multiple burden pool system. Distribution of the pools to contracts is based on direct labor dollars.

Procurement consists of all those indirect expenses generated by cost centers involved in purchasing, subcontracting, receiving, etc., of procurements. A rate is developed by dividing the total procurement pool costs by the total dollar value of procurements. The base for the application of the procurement rate is the dollar value of the procurements that are charged direct to the project.

General and Administrative (G & A) consists of expenditures for those functions which are identified with the overall management and sustenance of TRW Systems Group. The G & A rate is developed by dividing the G & A pool expenses by the cost of sales. The base for the application of the G & A rate to the project is the total cost of the project including all applicable direct and indirect costs.

Cost of Money consists of imputed interest costs determined by applying a cost of money rate to facilities capital employed in support of Company contracts. The base for the application of each cost of money factor used in this proposal is the same base as is used in applying the respective Overhead, Procurement or G&A burden rates.
## CONTRACT FACILITIES CAPITAL AND COST OF MONEY

**CONTRACTOR:** TRW Inc., Defense and Space Systems Group  
**BUSINESS UNIT:** DSSG - Applied Technology Division  
**ADDRESS:** One Space Park, Redondo Beach, California 90278

<table>
<thead>
<tr>
<th>OVERHEAD POOLS</th>
<th>COST ACCOUNTING PERIOD</th>
<th>CONTRACT OVERHEAD ALLOCATION BASE</th>
<th>FACILITIES CAPITAL COST OF MONEY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENGINEERING LABOR</strong></td>
<td>1980</td>
<td>39,770</td>
<td>.051199</td>
</tr>
<tr>
<td><strong>G &amp; A</strong></td>
<td>1980</td>
<td>106,868</td>
<td>.002439</td>
</tr>
</tbody>
</table>

6. **CONTRACT FACILITIES CAPITAL COST OF MONEY**  
   2,297

7. **FACILITIES CAPITAL COST OF MONEY RATE**  
   \[
   \frac{2,297}{7.7875\%} = 10.25\%
   \]

8. **CONTRACT FACILITIES CAPITAL EMPLOYED**  
   22,410