DNA 5806F

PLACES TV-TRACK, IONOSONDE, AND MAGNETOMETER OPERATIONS

Norman J. F. Chang

SRI International
333 Ravenswood Avenue
Menlo Park, California 94025

1 June 1981

Final Report for Period 1 April 1980—31 January 1981

CONTRACT No. DNA 001-80-C-0244

THIS WORK SPONSORED BY THE DEFENSE NUCLEAR AGENCY
UNDER RDT&E RMSS CODE B322080462 I25AAXHX64213 H2590D.

Prepared for

Director
DEFENSE NUCLEAR AGENCY
Washington, D. C. 20305

Destroy this report when it is no longer needed. Do not return to sender.

PLEASE NOTIFY THE DEFENSE NUCLEAR AGENCY, ATTN: STTI, WASHINGTON, D.C. 20305, IF YOUR ADDRESS IS INCORRECT, IF YOU WISH TO BE DELETED FROM THE DISTRIBUTION LIST, OR IF THE ADDRESSEE IS NO LONGER EMPLOYED BY YOUR ORGANIZATION.

627104

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: DNA 5806F	2. GOVT ACCESSION NO.: AD-A109690	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): PLACES TV-TRACK, IONOSONDE, AND MAGNETOMETER OPERATIONS	5. TYPE OF REPORT & PERIOD COVERED: Final Report for Period 1 Apr. 80—31 Jan. 81
	6. PERFORMING ORG. REPORT NUMBER: SRI Project 1635
7. AUTHOR(s): Norman J. F. Chang	8. CONTRACT OR GRANT NUMBER(s): DNA 001-80-C-0244
9. PERFORMING ORGANIZATION NAME AND ADDRESS: SRI International, 333 Ravenswood Avenue, Menlo Park, California 94025	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Subtask I25AAXHX642-13
11. CONTROLLING OFFICE NAME AND ADDRESS: Director, Defense Nuclear Agency, Washington, D.C. 20305	12. REPORT DATE: 1 June 1981
	13. NUMBER OF PAGES: 16
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE: N/A

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This work sponsored by the Defense Nuclear Agency under RDT&E RMSS Code B322080462 I25AAXHX64213 H2590D.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

TV-tracking	Ionosonde
Barium release	Magnetometer
Slow-scan TV	Ionogram

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the TV tracking system, the slow-scan TV system, the KEL ionosonde, and the magnetometer that were operated in support of the PLACES experiment conducted at Eglin AFB, Florida in December 1980. A procedure for determining the proper launch time and aim point for both the beacon rockets and the probe rocket was developed after post-mission analysis of the first two releases. This procedure contributed to a successful beacon occultation for Event IRIS, and a successful probe penetration for Event JAN.

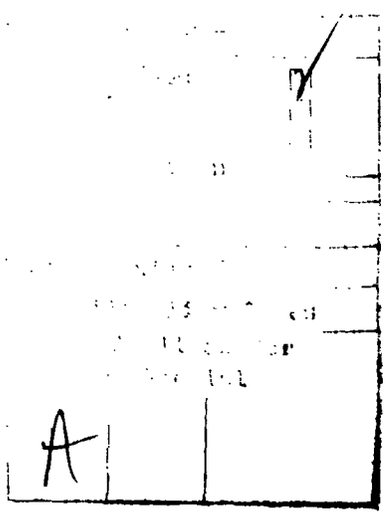
DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

TABLE OF CONTENTS

Section		Page No.
I	INTRODUCTION	3
II	EQUIPMENT SETUP IN FLORIDA	4
III	RESULTS	6
	A. TV Tracking	6
	B. Slow-Scan TV	6
	C. Ionogram	7
	D. Magnetometer	7
IV	CONCLUSIONS AND RECOMMENDATIONS	8



I INTRODUCTION

The PLACES experiment, conducted at Eglin AFB, Florida in December 1980 was designed to test the effects on radio signals that are propagated through field-aligned electron-density enhancements (striations). Specifically, the test was designed to validate the prediction of serious degradation caused to phase-coherent systems by striation-induced phase effects. It was intended that these effects be demonstrated on signals from the LES 8/9 satellites. The striations were produced by 48-kg barium payloads released at approximately 185 km in the F-region of the ionosphere on four separate days. In addition to the satellite measurements made by an aircraft vectored to the proper location by a ground controller, there was a rocket-borne beacon transmission experiment, an in-situ probe experiment, and ground support instrumentation.

The primary data for aiming both the beacon rockets and the probe rocket and for aircraft vectoring were obtained from TV tracking of the barium cloud from two stations (A-15 and D-3). To coordinate TV aiming points and to aid in determining launch times for both beacon and probe rockets, a slow-scan TV system was constructed and operated with TV displays at CCF and at A-15. These displays provided images of the barium cloud seen by both TV tracking cameras. This report addresses operation of the TV tracking system, the slow-scan TV system, the KEL ionosonde, and the magnetometer.

II EQUIPMENT SETUP IN FLORIDA

SRI International personnel and equipment from Menlo Park, California arrived at Eglin, Florida by 10 November 1980 as scheduled. Setup of the TV tracking and the slow-scan TV systems commenced shortly after. Considerable difficulties were encountered with the data lines connecting A-15 with CCF, C-6, and D-3. Most of the problems, however, were resolved by 2 December 1980, the first scheduled launch day.

The TV tracking system was completely operational by the first launch day, although for Event GAIL a noisy data line between D-3 and A-15 caused bad pointing angles to be passed occasionally to the Sandia computer. This problem was corrected for subsequent launches by lowering the baud rate for data transmission between D-3 and A-15 from 1200 baud to 300 baud. On the second event, HOPE, the graphic board at D-3, which was used to provide the electronic boresight, failed shortly before launch. A boresight was manually located on the TV monitor and calibrated against the sun and a few known reference points. At the conclusion of the event the boresight was checked against the stars and both elevation and azimuth at the D-3 site were found to be in error by approximately two degrees. Drift in the TV monitor was believed to be the primary cause of this error.

The TV tracking systems at D-3 and A-15 were completely recalibrated following HOPE, and no other problems were encountered for Event IRIS and JAN. Calibration checks for the last two events indicate that the TV-track pointing angles at both D-3 and A-15 were accurate to within a few tenths of a degree.

The slow-scan TV system was also fully operational on 2 December, but because of data line problems, slow-scan displays were provided only to A-15 and CCF. When the data line problems between A-15 and C-6 were corrected toward the end of the PLACES experiment the slow-scan system was not installed at C-6 as planned. The reasons for this were that the

slow-scan displays were not required for the particular operating mode used for the FPS-85, and that the system intended for C-6 was being used at A-15 tc provide D-3 cloud images needed for cloud tracking and launch decisions.

The KEL ionosonde was shipped directly to Florida from Australia without the receiver. The receiver was hand carried to Florida by Mr. Terry Kelly and Mr. Derrick Horton of KEL Aerospace, who arrived on 29 November 1980. The ionosonde was checked out and the antenna was installed by the two KEL engineers. The ionosonde was fully operational by 1 December 1980.

The magnetometer was operational by 1 December 1981 and was continuously operated to monitor magnetic field variations. Magnetic activity was visually monitored by means of the meters on the magnetometer and periodic strip chart recordings. Continuous recording of the magnetic field variations was not done, due to the excessive speed of the chart recorder. From meter readings and occasional recordings we estimate that the magnetic activity was quiet during the entire PLACES experiment.

III RESULTS

A. TV Tracking

Tracking data from D-3 and A-15 were provided to the Sandia computer and recorded at approximately 3-Hz rate. Digital tapes for each of the four events contain time of day and pointing angles from the two sites. These data were recorded for documentation and possible post-mission analysis. In particular, the tracking data would be useful for designing and testing barium cloud tracking algorithms.

Video information from each site was also recorded for each of the releases. These video tapes were extremely usefor for post-mission critique. The quality of the video was sufficient to show the development of the barium cloud, and for Event JAN the flashing beacon aboard the probe rocket can be seen on the A-15 video tapel.

With the experience gained from GAIL and HOPE, the following procedure evolved to provide good tracking data:

(1) After tracking has stabilized (about 10 to 15 s after release), a two-station solution is used to determine the release height.

(2) After calculating the release height, the station providing the "best" track is used for cloud location (single station solution).

(3) After the initial release, the TV track operator should estimate the location of the ion cloud and move slowly to its projected position. When the cloud is sufficiently developed to permit an assessment of the point tracked, a correction should be made if necessary. If a significant change is required, the tracking filter should be reinitialized.

B. Slow-Scan TV

The slow-scan TV system consisted of four separate units for each of four sites--CCF, C-6, A-15, and D-3. The units at CCF and C-6 were two-hannel, receive only, while the unit at D-3 was provided with a

single-channel transmit capability. The A-15 unit had a single-channel receive and a single-channel transmit capability, but a timing problem prevented the A-15 slow-scan unit from operating in both transmit and receive modes. Hence, it was necessary to use the C-6 unit to receive slow-scan transmissions from D-3.

Each channel of the slow-scan TV system consisted of a CROMENCO SCC (single-card computer) system. The SCC is a Z-80, S-100 bus microprocessor. Each was interfaced with a Digital Video Systems CAT-100/C (computer assisted television system). With this configuration a television frame could be digitized at a 21-MHz rate. The resolution of each frame was 240 x 256 pixels (4-bits per pixel), but only 240 x 128 pixels were transmitted, in order to maintain a reasonable update time for each frame. With the 1200-baud telephone line used, a complete television frame was transmitted in approximately 70 s.

The four-bit quantization of each pixel provides a 16-level gray scale. To enhance the digitized image, the digitization range was adjusted to provide the best picture. This feature was added after Event GAIL and produced a significant improvement in picture quality.

C. Ionogram

Verbal readings of the F-layer critical frequency were provided on request to Dr. Victor Gonzalez at the FPS-85. Ionograms were also recorded every 20 s for Event GAIL. These ionograms showed returns from the barium ion cloud starting at approximately 2305 UT and ending at approximately 0150 UT. Because of interference to another experiment operating at A-15, the ionosonde was not operated during Event HOPE except when necessary to provide a reading of f_oF_2. The ionosonde was operated on a 15-minute schedule for Events IRIS and JAN, but because of a film jam, ionograms are not available for these events.

D. Magnetometer

Permanent records were not kept of the magnetometer output since it was used only as a real-time indicator of magnetic conditions.

IV CONCLUSIONS AND RECOMMENDATIONS

Considerable difficulties were encountered in tracking the barium ion cloud and in determining the proper launch time and aim point for both beacon and probe rockets. Most of the difficulties stemmed from the requirement that the beacon occult, or that the probe penetrate, the highest-density and most structured part of the barium ion cloud. To accomplish this in the limited optical window available, both the time and location of the properly developed ion cloud must be predicted in real time based on optical information. The slow-scan images were valuable for providing two near simultaneous views of the barium cloud at one site to enable decisions on launch time and TV tracking points to be made.

The following recommendations are made for future PLACES-type experiments:

(1) The single-station solution (adopted partly because of the experience gained from the STRESS experiment) proved to be a viable procedure and is recommended for any future PLACES-type beacon or probe launches.

(2) The tracking algorithm used during PLACES was unduly restrictive in that it required a long period of "good" tracking data. Other types of tracking algorithms should be investigated based on the experience gained during PLACES. Candidate algorithms could be assessed by use of the actual PLACES digital tracking data.

DISTRIBUTION LIST

DEPARTMENT OF DEFENSE

Assistant Secretary of Defense
Comm, Cmd, Cont & Intell
ATTN: Dir of Intelligence Sys, J. Babcock

Command & Control Technical Center
ATTN: C-650, G. Jones
ATTN: C-312, R. Mason
3 cy ATTN: C-650, W. Heidig

Defense Communications Agency
ATTN: Code 480
ATTN: Code 480, F. Dieter
ATTN: Code 810, J. Barna
ATTN: Code 205
ATTN: Code 101B

Defense Communications Engineer Center
ATTN: Code R410, N. Jones
ATTN: Code R123

Defense Intelligence Agency
ATTN: DT-1B
ATTN: DB-4C, E. O'Farrell
ATTN: DB, A. Wise
ATTN: Dir
ATTN: DC-7B

Defense Nuclear Agency
ATTN: NAFD
ATTN: STNA
ATTN: RAEE
ATTN: NATD
3 cy ATTN: RAAE
4 cy ATTN: TITL

Defense Technical Information Center
12 cy ATTN: DD

Field Command
Defense Nuclear Agency
ATTN: FCP, J. T. McDaniel

Field Command
Defense Nuclear Agency
Livermore Branch
ATTN: FCPRL

Interservice Nuclear Weapons School
ATTN: TTV

Joint Chiefs of Staff
ATTN: C3S, Evaluation Office
ATTN: C3S

Joint Strat Tgt Planning Staff
ATTN: JLA
ATTN: JLTW-2

National Security Agency
ATTN: R-52, J. Skillman
ATTN: B-3, F. Leonard
ATTN: W-32, O. Bartlett

Under Secretary of Defense for Rsch & Engrg
ATTN: Strategic & Space Sys (OS)

DEPARTMENT OF DEFENSE (Continued)

WWMCCS System Engineering Org
ATTN: R. Crawford

DEPARTMENT OF THE ARMY

Assistant Chief of Staff for Automation & Comm
Department of the Army
ATTN: DAAC-ZT, P. Kenny

Atmospheric Sciences Laboratory
U.S. Army Electronics R & D Command
ATTN: DELAS-EO, F. Niles

BMD Advanced Technology Center
Department of the Army
ATTN: ATC-T, M. Capps
ATTN: ATC-O, W. Davies

BMD Systems Command
Department of the Army
2 cy ATTN: BMDSC-HW

Deputy Chief of Staff for Ops & Plans
Department of the Army
ATTN: DAMO-RQC

Harry Diamond Laboratories
Department of the Army
ATTN: DELHD-I-TL, M. Weiner
ATTN: Chief Div 20000
ATTN: DELHD-N-RB, R. Williams

U.S. Army Chemical School
ATTN: ATZN-CM-CS

U.S. Army Comm-Elec Engrg Instal Agency
ATTN: CCC-EMEO-PED, G. Lane
ATTN: CCC-CED-CCO, W. Neuendorf

U.S. Army Communications Command
ATTN: CC-OPS-W
ATTN: CC-OPS-WR, H. Wilson

U.S. Army Communications R&D Command
ATTN: DRDCO-COM-RY, W. Kesselman

U.S. Army Foreign Science & Tech Ctr
ATTN: DRXST-SD

U.S. Army Materiel Dev & Readiness Cmd
ATTN: DRCLDC, J. Bender

U.S. Army Missile Intelligence Agency
ATTN: YSE, J. Gamble

U.S. Army Nuclear & Chemical Agency
ATTN: Library

U.S. Army Satellite Comm Agency
ATTN: Document Control

U.S. Army TRADOC Sys Analysis Actvy
ATTN: ATAA-PL
ATTN: ATAA-TDC
ATTN: ATAA-TCC, F. Payan, Jr

DEPARTMENT OF THE NAVY

COMSPTEVFOR
Department of the Navy
ATTN: Code 605, R. Berg

Joint Cruise Missiles Project Ofc
Department of the Navy
ATTN: JCMG-707

Naval Air Development Center
ATTN: Code 6091, M. Setz

Naval Air Systems Command
ATTN: PMA 271

Naval Electronic Systems Command
ATTN: PME 117-211, B. Kruger
ATTN: PME 106-4, S. Kearney
ATTN: PME 106-13, T. Griffin
ATTN: PME 117-2013, G. Burnhart
ATTN: Code 501A
ATTN: PME 117-20
ATTN: Code 3101, T. Hughes

Naval Intelligence Support Ctr
ATTN: NISC-50

Naval Ocean Systems Center
ATTN: Code 532, R. Pappert
ATTN: Code 532, J. Bickel
ATTN: Code 5322, M. Paulson
3 cy ATTN: Code 5323, J. Ferguson

Naval Research Laboratory
ATTN: Code 4780, S. Ossakow
ATTN: Code 7950, J. Goodman
ATTN: Code 7550, J. Davis
ATTN: Code 4187
ATTN: Code 4700, T. Coffey
ATTN: Code 7500, B. Wald

Naval Space Surveillance System
ATTN: J. Burton

Naval Surface Weapons Center
ATTN: Code F31

Naval Telecommunications Command
ATTN: Code 341

Office of Naval Research
ATTN: Code 420
ATTN: Code 465
ATTN: Code 421

Office of the Chief of Naval Operations
ATTN: OP 981N
ATTN: OP 941D
ATTN: OP 65

Strategic Systems Project Office
Department of the Navy
ATTN: NSP-2141
ATTN: NSP-43
ATTN: NSP-2722, F. Wimberly

DEPARTMENT OF THE AIR FORCE

Aerospace Defense Command
Department of the Air Force
ATTN: DC, T. Long

Air Force Geophysics Laboratory
ATTN: OPR, H. Gardiner
ATTN: OPR-1
ATTN: LKB, K. Champion
ATTN: OPR, A. Stair
ATTN: S. Basu
ATTN: PHP
ATTN: PHI, J. Buchau
ATTN: R. Thompson

Air Force Weapons Laboratory
Air Force Systems Command
ATTN: SUL
ATTN: NTYC
ATTN: NTN

Air Force Wright Aeronautical Lab
ATTN: W. Hunt
ATTN: A. Johnson

Air Logistics Command
Department of the Air Force
ATTN: OO-ALC/MM

Air University Library
Department of the Air Force
ATTN: AUL-LSE

Air Weather Service, MAC
Department of the Air Force
ATTN: DNXP, R. Babcock

Assistant Chief of Staff
Studies & Analyses
Department of the Air Force
ATTN: AF/SASC, C. Rightmeyer
ATTN: AF/SASC, W. Keaus

Ballistic Missile Office
Air Force Systems Command
ATTN: ENSN, J. Allen

Deputy Chief of Staff
Operations Plans and Readiness
Department of the Air Force
ATTN: AFXOKS
ATTN: AFXOXFD
ATTN: AFXOKT
ATTN: AFXOKCD

Deputy Chief of Staff
Research, Development, & Acq
Department of the Air Force
ATTN: AFRDS
ATTN: AFRDSP
ATTN: AFRDSS

Electronic Systems Division
ATTN: DCKC, J. Clark

DEPARTMENT OF THE AIR FORCE (Continued)

Electronic Systems Division
Department of the Air Force
ATTN: OCT-4, J. Deas

Electronic Systems Division, Dept of AF
ATTN: YSM, J. Kobelski
ATTN: YSEA

Foreign Technology Division
Air Force Systems Command
ATTN: TQTD, B. Ballard
ATTN: NIIS, Library

Headquarters Space Division
Air Force Systems Command
ATTN: SKA, D. Bolin
ATTN: SKY, C. Kennedy

Headquarters Space Division
Air Force Systems Command
ATTN: YZJ, W. Mercer

Headquarters Space Division
Air Force Systems Command
ATTN: E. Butt

Rome Air Development Center
Air Force Systems Command
ATTN: OCS, V. Coyne
ATTN: TSLD

Rome Air Development Center
Air Force Systems Command
ATTN: EEP

Strategic Air Command
Department of the Air Force
ATTN: DCXT
ATTN: DCXR, T. Jorgensen
ATTN: NRT
ATTN: XPFS
ATTN: DCX

OTHER GOVERNMENT AGENCIES

Central Intelligence Agency
ATTN: OSWR/NED

Department of Commerce
National Bureau of Standards
ATTN: Sec Ofc for R. Moore

Department of Commerce
National Oceanic & Atmospheric Admin
ATTN: R. Grubb

Institute for Telecommunications Sciences
National Telecommunications & Info Adm'n.
ATTN: A. Jean
ATTN: L. Berry
ATTN: W. Utlaut

DEPARTMENT OF ENERGY CONTRACTORS

EG&G, Inc
Los Alamos Division
ATTN: J. Colvin
ATTN: D. Wright

DEPARTMENT OF ENERGY CONTRACTORS (Continued)

Lawrence Livermore National Lab
ATTN: L-339, R. Ott
ATTN: L-31, R. Hager
ATTN: Technical Info Dept, Library

Los Alamos National Laboratory
ATTN: D. Simons
ATTN: E. Jones
ATTN: C. Westervelt
ATTN: P. Keaton
ATTN: MS 670, J. Hopkins
ATTN: R. Taschek
ATTN: MS-664, J. Zinn

Sandia National Laboratories
Livermore Laboratory
ATTN: B. Murphey
ATTN: T. Cook

Sandia National Lab
ATTN: Org 4241, T. Wright
ATTN: D. Thornbrough
ATTN: Org 1250, W. Brown
ATTN: 3141
ATTN: D. Dahlgren
ATTN: Space Project Div

DEPARTMENT OF DEFENSE CONTRACTORS

Aerospace Corp
ATTN: R. Slaughter
ATTN: J. Straus
ATTN: V. Josephson
ATTN: I. Garfunkel
ATTN: D. Olsen
ATTN: T. Salmi
ATTN: N. Stockwell
ATTN: S. Bower

University of Alaska
ATTN: Technical Library
ATTN: N. Brown
ATTN: T. Davis

Analytical Systems Engineering Corp
ATTN: Radio Sciences

Analytical Systems Engineering Corp
ATTN: Security

Barry Research Corporation
ATTN: J. McClaughlin

BDM Corp
ATTN: L. Jacobs
ATTN: T. Neighbors

Berkeley Research Associates, Inc
ATTN: J. Workman

Betac
ATTN: J. Hirsch

Boeing Co
ATTN: M/S 42-33, J. Kennedy
ATTN: G. Hall
ATTN: S. Tashird

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Booz-Allen & Hamilton, Inc
ATTN: B. Wilkinson

University of California at San Diego
ATTN: H. Booker

Charles Stark Draper Lab, Inc
ATTN: J. Gilmore
ATTN: D. Cox

Communications Satellite Corp
ATTN: D. Fang

Computer Sciences Corp
ATTN: F. Eisenbarth

Comsat Labs
ATTN: R. Taur
ATTN: G. Hyde

Cornell University
ATTN: M. Kelly
ATTN: D. Farley, Jr.

E-Systems, Inc
ATTN: R. Berezdivin

Electrospace Systems, Inc
ATTN: H. Logston

ESL, Inc
ATTN: J. Marshall

General Electric Co
ATTN: M. Bortner
ATTN: A. Harcar

General Electric Co
ATTN: C. Zierdt
ATTN: A. Steinmayer

General Electric Co
ATTN: F. Reibert

General Electric Co
ATTN: G. Millman

General Research Corp
ATTN: J. Ise, Jr
ATTN: J. Garbarino

Harris Corp
ATTN: E. Knick

Horizons Technology, Inc
ATTN: R. Kruger

HSS, Inc
ATTN: D. Hansen

IBM Corp
ATTN: F. Ricci

University of Illinois
ATTN: K. Yeh

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Institute for Defense Analyses
ATTN: E. Bauer
ATTN: H. Wolfhard
ATTN: J. Aein
ATTN: J. Bengston

International Tel & Telegraph Corp
ATTN: Technical Library
ATTN: G. Wetmore

JAYCOR
ATTN: J. Sperling

JAYCOR
ATTN: J. Doncarlos

Johns Hopkins University
ATTN: T. Potemra
ATTN: J. Phillips
ATTN: T. Evans
ATTN: J. Newland
ATTN: P. Komiske

Kaman Tempo
ATTN: DASIAC
ATTN: T. Stephens
ATTN: W. McNamara
ATTN: W. Knapp

Linkabit Corp
ATTN: I. Jacobs

Litton Systems, Inc
ATTN: R. Grasty

Lockheed Missiles & Space Co, Inc
ATTN: W. Imhof
ATTN: M. Walt
ATTN: R. Johnson

Lockheed Missiles & Space Co, Inc
ATTN: Dept 60-12
ATTN: D. Churchill
ATTN: C. Old

M.I.T. Lincoln Lab
ATTN: D. Towle

Martin Marietta Corp
ATTN: R. Heffner

McDonnell Douglas Corp
ATTN: N. Harris
ATTN: J. Moule
ATTN: W. Olson
ATTN: G. Mroz
ATTN: R. Halprin

Meteor Communications Consultants
ATTN: R. Leader

Mitre Corp
ATTN: G. Harding
ATTN: C. Callahan
ATTN: A. Kymmel
ATTN: B. Adams

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Mission Research Corp
ATTN: R. Kilb
ATTN: Tech Library
ATTN: R. Hendrick
ATTN: F. Fajen
ATTN: R. Bogusch
ATTN: S. Gutsche
ATTN: D. Sappenfield

Mitre Corp
ATTN: M. Horrocks
ATTN: W. Foster
ATTN: J. Wheeler
ATTN: W. Hall

Pacific-Sierra Research Corp
ATTN: F. Thomas
ATTN: E. Field, Jr
ATTN: H. Brode

Pennsylvania State University
ATTN: Ionospheric Research Lab

Photometrics, Inc
ATTN: I. Kofsky

Physical Dynamics, Inc
ATTN: E. Fremouw

Physical Research, Inc
ATTN: R. Deliberis

R & D Associates
ATTN: R. Lelevier
ATTN: R. Turco
ATTN: C. Greifinger
ATTN: B. Gabbard
ATTN: M. Gantsweg
ATTN: W. Karzas
ATTN: H. Ory
ATTN: W. Wright
ATTN: F. Gilmore
ATTN: P. Haas

R & D Associates
ATTN: B. Yoon

Rand Corp
ATTN: E. Bedrozian
ATTN: C. Crain

Riverside Research Institute
ATTN: V. Trapani

Rockwell International Corp
ATTN: R. Buckner

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Rockwell International Corp
ATTN: S. Quilici

Santa Fe Corp
ATTN: D. Paolucci

Science Applications, Inc
ATTN: E. Straker
ATTN: L. Linson
ATTN: C. Smith
ATTN: D. Hamlin

Science Applications, Inc
ATTN: SZ

Science Applications, Inc
ATTN: J. Cockayne

SRI International
ATTN: R. Leadabrand
ATTN: R. Livingston
ATTN: D. Neilson
ATTN: J. Petrickes
ATTN: C. Rino
ATTN: G. Price
ATTN: R. Tsunoda
ATTN: A. Burns
ATTN: M. Baron
ATTN: G. Smith
ATTN: W. Chesnut
ATTN: W. Jaye
4 cy ATTN: N. Chang

Sylvania Systems Group
ATTN: I. Kohlberg
ATTN: R. Steinhoff

Technology International Corp
ATTN: W. Boquist

Tri-Com, Inc
ATTN: D. Murray

TRW Defense & Space Sys Group
ATTN: R. Plebuch
ATTN: D. Dee

Utah State University
ATTN: K. Baker
ATTN: L. Jensen
ATTN: J. Dupnik

Visidyne, Inc
ATTN: C. Humphrey
ATTN: J. Carpenter