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SwRI Project No. 15-1518
March 25, 1992

A Final Report for

P.142

The Cyclotron Energization Through Auroral Wave Experiments (CENTAUR 2B)

Submitted to:

National Aeronautics and Space Administration
Goddard/Wallops Flight Facility
Industry Assistance and Procurement Analysis Office
Code 200.3
Wallops Island, VA 23337

Submitted by:

Dr. J. D. Winningham
Southwest Research Institute
San Antonio, Texas

SOUTHWEST RESEARCH INSTITUTE
Instrumentation and Space Research Division
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APPROVED:

James L. Burch, Vice President
Instrumentation and Space Research Division

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INTRODUCTION

The CENTAUR 2B mission, a dual payload program, is in many aspects the same as the previous missions from Cape Perry and Norway in 1985. The principal investigator is Dr. David Winningham of Southwest Research Institute (SwRI). It is planned that these payloads will be launched from Andoya, Norway, November of 1989 from the Universal II launcher. The payloads are identical, but will be launched at different azimuths as far north and as far west as possible. The 17-inch diameter payloads will house a total of nine different instruments, a horizon sensor, an attitude control system, a three-link telemetry section, and a forward eject nose-cone with a lateral eject ogive system. Payload weight is approximately 450 pounds with an overall length of 130 inches.

Particle experiments include the angular resolving energy analyzer (AREA), the fast ion mass spectrometer (FIMS), the spectrographic particle imager (SPI), and finally, the differential ion flux probe (DIFP). SwRI is responsible for the scientific payload, which includes the power supplies, the power supply interfacing, the manipulating of the data from the instruments to format it for the telemetry system, all mechanical structure and restraint mechanisms, and the payload subskin. SwRI is also responsible for the AREA, FIMS and the SPI scientific instruments.

PROJECT STATUS

A project design review was held January 31, 1989 at Wallops Space Flight Center and was attended by Wallops personnel as well as SwRI personnel. A copy of the design review notes is included as the Appendix.

A brief synopsis of the status of the CENTAUR payloads can be found in the following lists.

1. All power supplies (low, voltage, high voltage and switching) have been built, tested and integrated.

2. The power interface and data interface electronics have been built and tested. They are in the process of being integrated with the PCM system at this time.

3. The GSE, the software for automated checkout during integration, and the special purpose interface board for the PC are complete and checked out.

4. The cable harness for each of the payloads has been built and rung out.

5. Eighty percent of the miscellaneous brackets and mechanical parts of the payloads have been machined.
6. The magnesium for the deckplates and the struts has been received. One set of struts and deckplates has been machined, weight reduced, chem filmed, and assembled.

As stated previously, Southwest Research is also responsible for three of the instruments on the CENTAUR payloads. The status of the AREA instrument is:

1. The electronics boards needed for one payload have been built and tested. The boards for the second payload will be identical and thus will use the same layout and simply need to be reproduced.

2. The mechanical parts have been designed and are ready to be machined.

3. The micro-channel plates for both payloads have been received by MSSL, and are ready to be assembled with the analyzer here at SwRI.

4. The intra-instrument cabling and the connector interface box has been built and tested for each of the payloads.

The status of the FIMS instrument is:

1. The electronics boards needed for both payloads are 90% complete. The testing and integration of these boards is the main task remaining.

2. The flight software has been written. It is now being implemented and debugged.

3. The mechanical parts for both payloads are complete. The only mechanical task remaining is final assembly.

4. The power supplies, low voltage, high voltage and switching, are 80% complete. Final testing is anticipated to take 4 weeks.

5. Calibration of the flight instrument is scheduled to take 4 weeks.

The status of the SPI instrument is:

1. The instrument has been fully modeled using computer ray tracings and simulations.

2. The mechanical layout of the instrument is approximately 80% complete.

CENTAUR Budget Status

The CENTAUR program was initially funded as a three-year grant. At this time, SwRI has received funds for the first two years of the grant for the period of performance of December 1, 1986 through December 1, 1988. No funds have been received for the third year of funding. As of March 1989, since no funds had been received and because the program had gone approximately $226,000 negative, a stop-work order was put on the program by SwRI. Work was continued into the third year in good faith, expecting to be funded by Wallops for the rest of the grant as initially outlined. As stated previously, during this time period a project-wide design review was held at WSFC on January 31, 1989, a full two months after the second year period of performance and funding ended. The fact that the design review was held after the second year funding cycle was complete inferred that third year funding would be received. As of this date, none of that funding has been received, and SwRI has written-off the loss.

At this time, the CENTAUR payload, as well as the CENTAUR instruments are in storage in the Instrumentation and Space Research Building and Southwest Research Institute, awaiting further funding for completion of the program.

PROJET CENTAUR

II B,C

DESIGN REVIEW
FOR
35.011 UE & 35.026 UE

January 31, 1989

PROJECT TEAM 35.011 UE & 35.026 UE

Southwest Research Institute:

Dr. David Winningham	Principal Investigator
John Sherrer	
Roy Welch	
Alton Blevins	
Nick Eaker	

Wallops:

John van Overeem	NASA/WFF/841.3	Project Manager
Marvin Alstatt	NASA/WFF/CSC	Flight Analysis
Bob Hickman	NASA/WFF/CSC	Mechanical Systems
Jim Diehl	NASA/WFF/CSC	Instrumentation
Mike Smolinski	NASA/WFF/CSC	Electrical Systems
Dick Matthews	NASA/WFF/CSC	Magnetic ACS
Dave Lang	NASA/WFF/CSC	Magnetic ACS

January 11, 1989

TO: Review Panel Members

FROM: 841.0/Head, Sounding Rocket Projects Branch

SUBJECT: Design Review for Black Brant X 35.011 CE and 35.026 CE (Winningham/SwRI/Norway/November 1989)

A Design Review for 35.011 CE and 35.026 CE is scheduled for January 31, 1989, in the third floor conference room of Building E-108 at 0900 hours.

A panel comprised of the following persons is appointed to perform this review:

Bob Patterson - Chairman
W. W. West
Hartwell Taylor
Jim Hardin
Wayne Gunter
Thang Quach

The presentation agenda and personnel assignments for this review are given in the enclosed memorandum.

The Review Chairman shall conduct the proceedings, establish action items as required, and document the review proceedings and corrective measures initiated or taken.

L. Warren Gurkin

Enclosure: 1

CONCUR:

Larry J. Early, Chief 1/11/89 Date
Projects Division

James W. Gray, Chief 1/12/89 Date
Engineering Division

cc: w/o enclosure
J. W. Gray/820.0
W. H. Parker/821.0
Z. B. Barfield/821.1
J. C. Bowman/821.2
W. D. Ward/821.3
T. J. Savage/822.0
W. W. West/822.3
D. F. Melvin/822.4
R. A. Burns/823.0

F. R. Sawyer/824.0
G. G. Morris/824.0
J. L. Parks/824.1
R. T. Duffy/830.0
C. F. Milliner/830.0
J. R. Duke/833.0
E. B. Jackson/834.0
R. H. Pless/840.0
G. D. Paterson/841.0
D. F. Detwiler/841.1
C. W. Ballance/841.2
F. M. Boykin/841.3
S. M. Onions/CSC
J. Smolinski/CSC
M. Altstatt/CSC
Project Team
Review Panel Members
SRPB Files w/enclosure

January 4, 1989

TO: 841.0/Head, Sounding Rocket Projects Branch

FROM: 841.3/Attitude Control and Guidance Section

SUBJECT: Request for Design Review - 35.011 CE and 35.026 CE

It is requested that a Design Review for the subject payloads, be scheduled for January 31, 1989 at 0900 hours in an appropriate conference room.

The Project Team is prepared to present the following agenda:

Introduction	John van Overeem
Science, Success Criteria	Dr. David Winningham, SWRI
Experiment Mechanical	John Scherrer, SWRI
Experiment TM-Electrical	Roy Welsh, SWRI
Flight Analysis	Marvin Alstatt
Mechanical Systems	Jay Scott
Instrumentation	Jim Diehl
Electrical Systems	Mike Smolinski
Magnetic ACS	Dick Matthews

John van Overeem

John van Overeem

INTRODUCTION

JOHN VAN OVEREEM

JANUARY 31, 1989

DESIGN REVIEW
35.011 UE AND 35.026 UE

INTRODUCTION

Centaur II-B mission is in many aspects the same as the previous missions from Cape Parry and Norway '85. The Principal Investigator is Mr. David Winningham of Southwest Research Institute.

It is planned that these payloads be flown from Andoya, Norway November 1989 from the Universal-2 launcher. The payloads are identical but will be launched at different azimuth as far North and as far West as possible. The 17-inch payloads will house a total of nine instruments and a Horizon Sensor, a Magnetic Control System, a Telemetry Section with 3 TM links, FDM and a forward eject nose cone with a L.E.O. System. Payload weight is approximately 450 lbs. with a length of 130 inches.

TABLE 1

INSTRUMENTS

INSTRUMENT NAME	ACRONYM	AGENCY	EXPERIMENTER
AC ELECTRIC FIELD	ACEF	DSRI	DR. E. UNGSTRUP
AC MAGNETOMETER	ACM	DSRI	DR. E. UNGSTRUP
AC LANGMUIR FIELD	ACLP	UIO	DR. G. HOLMGREN
DC MAGNETOMETER	DCM	DSRI	DR. F. PRIMDAHL
DC VECTOR ELECTRIC FIELD	VEF	RIT	DR. C.G. FALTHAMMER DR. L. BLOCK DR. G. MARKLUND
FAST ION MASS SPECTROMETER	FIMS	SwRI	DR. J.L. BURCH
ANGLE RESOLVING ENERGY ANALYZER	AREA	MSSL	DR. A.D. JOHNSTONE
SPECTROGRAPHIC PARTICLE IMAGER	SPI	SwRI MSSL	DR. J.D. WINNINGHAM DR. A.D. JOHNSTONE
DIFFERENTIAL ION FLUX PROBE	DIFP	MSFC	DR. N. STONE

AGENCY

DANISH SPACE RESEARCH INSTITUTE (DSRI)
DENMARK

ROYAL INSTITUTE OF TECHNOLOGY (RIT)
STOCKHOLM

SOUTHWEST RESEARCH INSTITUTE (SwRI)
SAN ANTONIO, TX 78284

UPPSALA IONOSPHERIC OBSERVATORY (UIO)
UPPSALA, SWEDEN

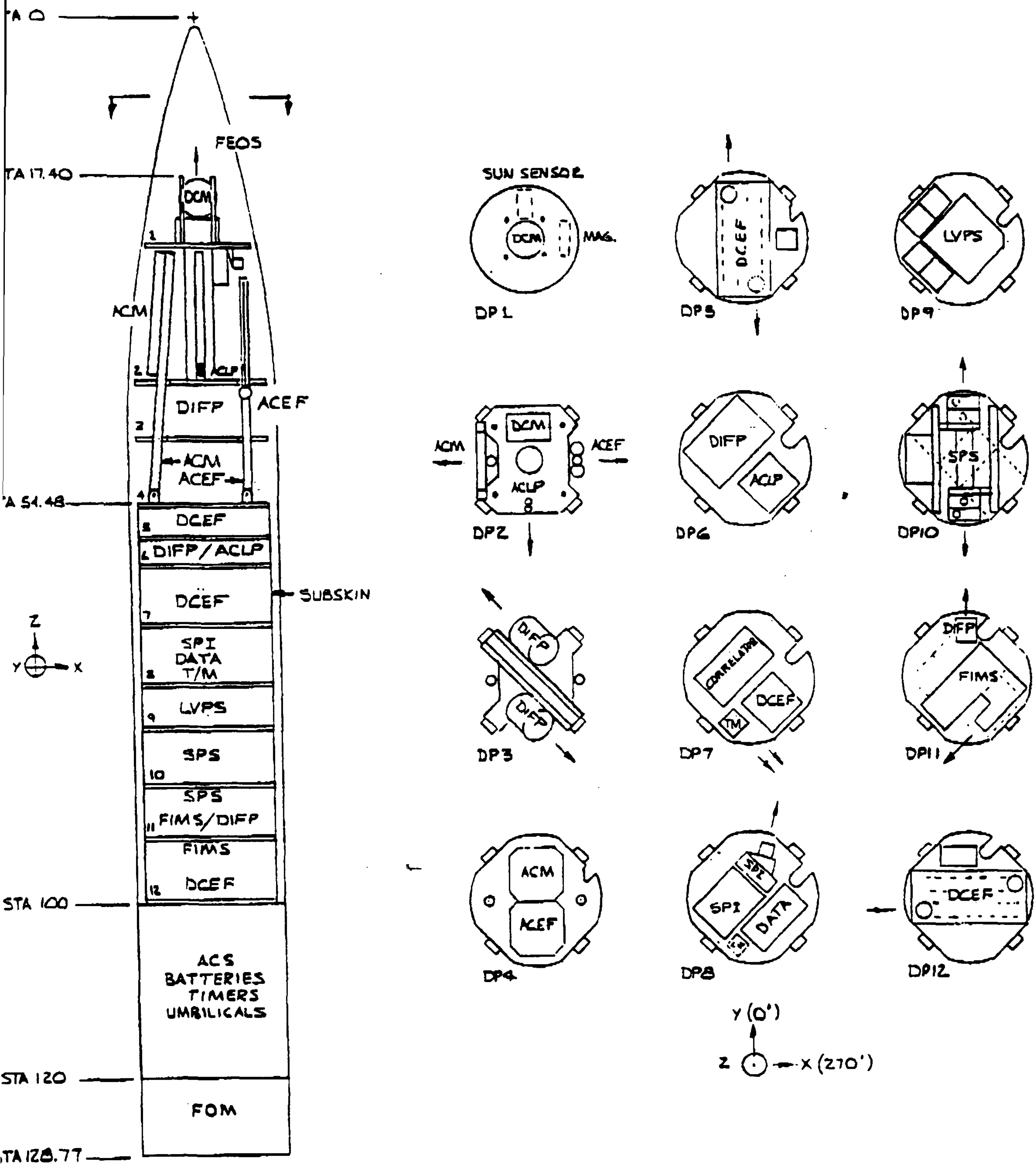
MULLARD SPACE SCIENCE LABORATORY (MSSL)
HOLMBURY, ST. MARY, ENGLAND

MARSHALL SPACE FLIGHT CENTER (MSFC)
HUNTSVILLE, AL 35812

EXPERIMENT

MECHANICAL: JOHN SCHERRER

MECHANICAL DESIGN


FEOS
TA 17.40
DCM
ACM
ACLP
DIFP
ACEF
ACM
ACEF
'A 54.48
DCEF
DIFP/ACLP
DCEF
SUBSKIN
SPI
DATA
T/M
LVPS
SPS
SPS
FIMS/DIFP
FIMS
DCEF
STA 100
ACS
BATTERIES
TIMERS
UMBILICALS
STA 120
FOM
Z
Y
X
SUN SENSOR
DCM
MAG.
DP1
D.C.E.F
DP5
LVPS
DP9
DCM
ACLP
ACM
ACEF
DP2
DIFP
ACLP
DP6
SPS
DP10
DIFP
DIFP
DP3
CORRELATOR
DCEF
TM
DP7
DIFP
FIMS
DP11
ACM
ACEF
DP4
SPI
SPI
DATA
DP8
DCEF
DP12
Y (0')
Z
X (270')

Weight

Weight: The previous Centaur Payload of very similar design had a weight of 418 lbs. Centaur IIB & C will increase in weight by an estimated 21 lbs. This is due to:

Experiment Section:

- additional PCM stack
- additional power supply complexity
- additional cabling for PCM

ACS/Telemetry Section:

- additional telemetry components
- additional skin length for S-band antenna
- separate joint for ACS can
- battery pack for ACS can
- additional wiring

Weight Reducing

- Weight reduce struts
- Weight reduce electronics boxes
- Minimize staking and potting compounds
- Pay special attention to joint with Nika motor

C.G.

The C.G. of the previous payload was 43-3/4" up form the top of the ACS can. With the additional "skin" length for the S-band antenna, the C.G. will probably be ~ 2" lower. The C.G. will be measured during integration.

M.I.

The M.I. of the previous payload along the roll axis with no booms extended was 1.918 slug-ft^2. With booms extended, the M.I. was 4.7 slug-ft^2. On Centaur IIB & C, the SPS instrument which deployed 12" radially, will be replaced by the AREA instrument which only deploys 3". This change should reduce the MI slightly.

STRUCTURE

- Twelve 3/8 thick deckplates. Plates extensively weight reduced.
- Four weight reduced aluminum gussets attaching DP1 and DP2.
- Four 1/2 x 1-1/2 magnesium struts attaching DP2 through DP12. Struts extensively weight reduced.
- DP1 through DP11 electrically isolated from 3 struts.
- Subskin between DP4 and DP12. Subskin electrically isolated from three struts and deckplates DP4 through DP11.
- Four posts on top of DP1 for FEOS ejection spring rest (500 pound force).
- O-ring around P1 to support top of payload with FEOS.
- Four payload attach brackets (attached to DP12 and struts) at bottom of payload.
- 1/16 x 1/2 electrically conductive rulon strips attached to struts for FEOS glide from DP12 to DP1.
- Two similar Centaur payloads vibrated to BBV protoflight qual. levels (19.1 GRMS) and launched with BBX in 1981. Primary structural difference was the struts were aluminum.
- Another similar payload vibrated to vehicle level two (BBX) levels (12.7 GRMS) and launched with BBX in 1985.

NOSECONE

- Nosecone for 35.010 was a Bristol Aerospace Limited 680-04028 FEOS modified to allow ejection spring rest at station 17.40.

INTERFACE WITH ACS CAN

- Payload attach bracket 15-7616-227 will conform to requirements of WFF drawing D-35-13477 as modified by Bob Hickman via telecon on 5-23-84. These brackets were successfully used on the previous Centaur payload.

- Station 100 deckplate machined at 90° and 270° to clear cutter housings as defined on WFF sketch received 5-21-84.

DEPLOYABLES

- DCM sensor deployed forward on spring driven telescoping mast. Sensor released by cutting cable with bellows squib operated guillotine then mast released with trigger operated by redundant bellows squibs.

- ACEF sensors deployed radially on drop-down mast by centrifugal force and positioned on spring-operated swing-out arms. Mast released simultaneously with ACEF and ACLP masts then sensor released by a cable cut by a Holex 2800.

- ACLP sensor deployed radially on two-section hinged mast by centrifugal force. Mast released simultaneously with ACEF and ACM masts.

- VEF sensors deployed radially on telescoping masts with spring start and centrifugal force. Sensors are released by cutting cable with Holex 2800 guillotine then masts are released with trigger operated by redundant bellows squibs.

- DIFP sensors deployed radially on three-section slides by centrifugal force. Slides are released by cutting cable with Holex 2800 guillotine. Starter springs will be used.

- Area sensors deployed radially on single-section slides with spring start and centrifugal force. Slides are released by cutting restraint cable with Holex 2800 guillotine.

- CLEANLINESS CONTROL
  - Payload Handled with white gloves.
  - Payload maintained in an anti-static bag during non-working periods.
  - Payload (including ACS) fabricated with non-magnetic materials where possible.
  - Low outgassing material should be used where possible.
  - Payload purged with zero-grade dry nitrogen.

Choice of Restraint Mechanisms

- After much debate, it has been decided by SwRI to continue to use cable restraints. Reasons for this include:

  1. Cable restraint mechanisms are reliable and have flown on countless missions.

  2. Cable restraint mechanisms are simple and thus inexpensive.

  3. Most importantly, the use of a cable restraint mechanism is the most light weight form of restraint possible.

Methods to Ensure Reliability of Restraint Mechanisms

1. The nylon coating on the stainless steel cable will be removed to assure a good metal-to-metal crimp.

2. Two crimps will be used in all locations for redundancy.

3. When possible, the restraint cable complete with crimps, will be assembled on a work bench using a jig rather than in place on the payload. This will ensure more repeatability and higher reliability.

4. When possible, the restraint cables will be pull tested to at least 2 times the calculated maximum load.

FLIGHT ANALYSIS

MARVIN ALSTATT

JANUARY 31, 1989

PERFORMANCE AND ANALYSIS

DESIGN REVIEW

FOR

BLACK BRANT X 35.011 UE

MARVIN C. ALTSTATT
AEROSPACE ENGINEER

JANUARY 31, 1989

ABSTRACT

This report presents the results of a preflight mission analysis on the following flight:

Name of Mission: Black Brant X 35.011 UE

Location of Launch Site: Andoya, Norway

Launcher: Universal II, 40 ft. rail travel

Proposed Date of Launch: December 1, 1989

Principal Scientific Investigator: Dr. David Winningham, SWRI

Payload Manager: Mr. John van Overeem

Purpose of Mission: Ion acceleration studies.

Estimated Payload Weight: 439 Lbs

Predicted Apogee for Flight: 724.2 Km

Predicted Ballistic Impact Range for Flight: 768.1 Km

Minimum Rigid Static Margin for Flight and Time of Occurrence: 4.8 cal or 83.0 in at 0.0 sec

Aerodynamic Heating Index: 1.68×10^{8} ft-lb/ft^2

Apogee-Altitude 2σ Dispersion: 50.2 Km

2σ Low Apogee Altitude: 674 Km

Impact-Range 2σ Dispersion: 266.3 Km

The comprehensive success criteria is 400 Km horizontal travel above 500 Km altitude. This is met by the nominal trajectory. The minimum success criteria is 200 Km above 500 Km altitude which is met by the 2σ deviation from the nominal trajectory.

SECTION 2 - LAUNCH VEHICLE DESCRIPTION

2.1 VEHICLE CONFIGURATION

Payload Configuration: Figure 2-1

Launch Configuration: Figure 2-2

2.2 PHYSICAL PROPERTIES

Payload/Vehicle Physical Properties: Table 2-1

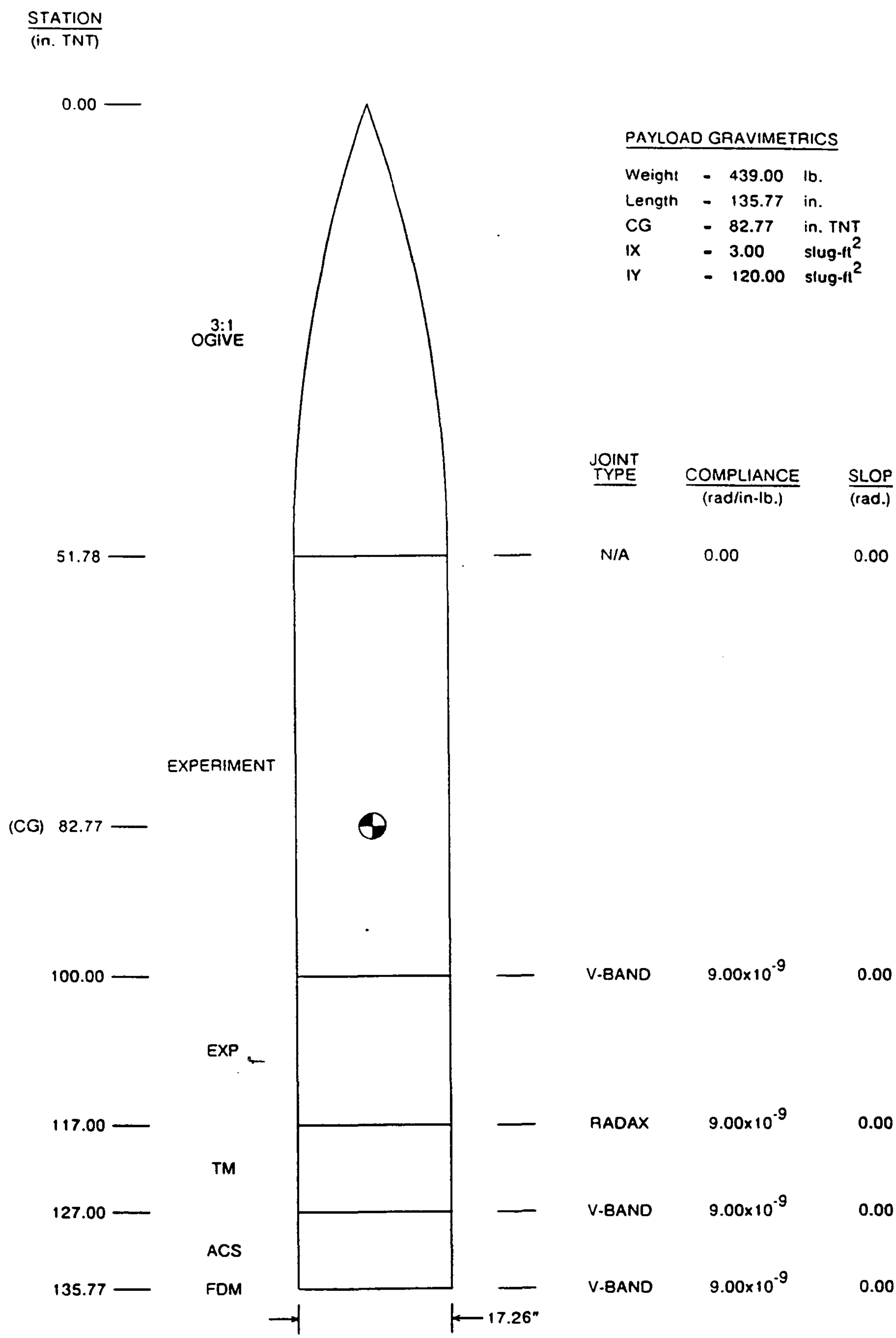


Figure 2-1. Black Brant X 35.011 UE Payload Configuration

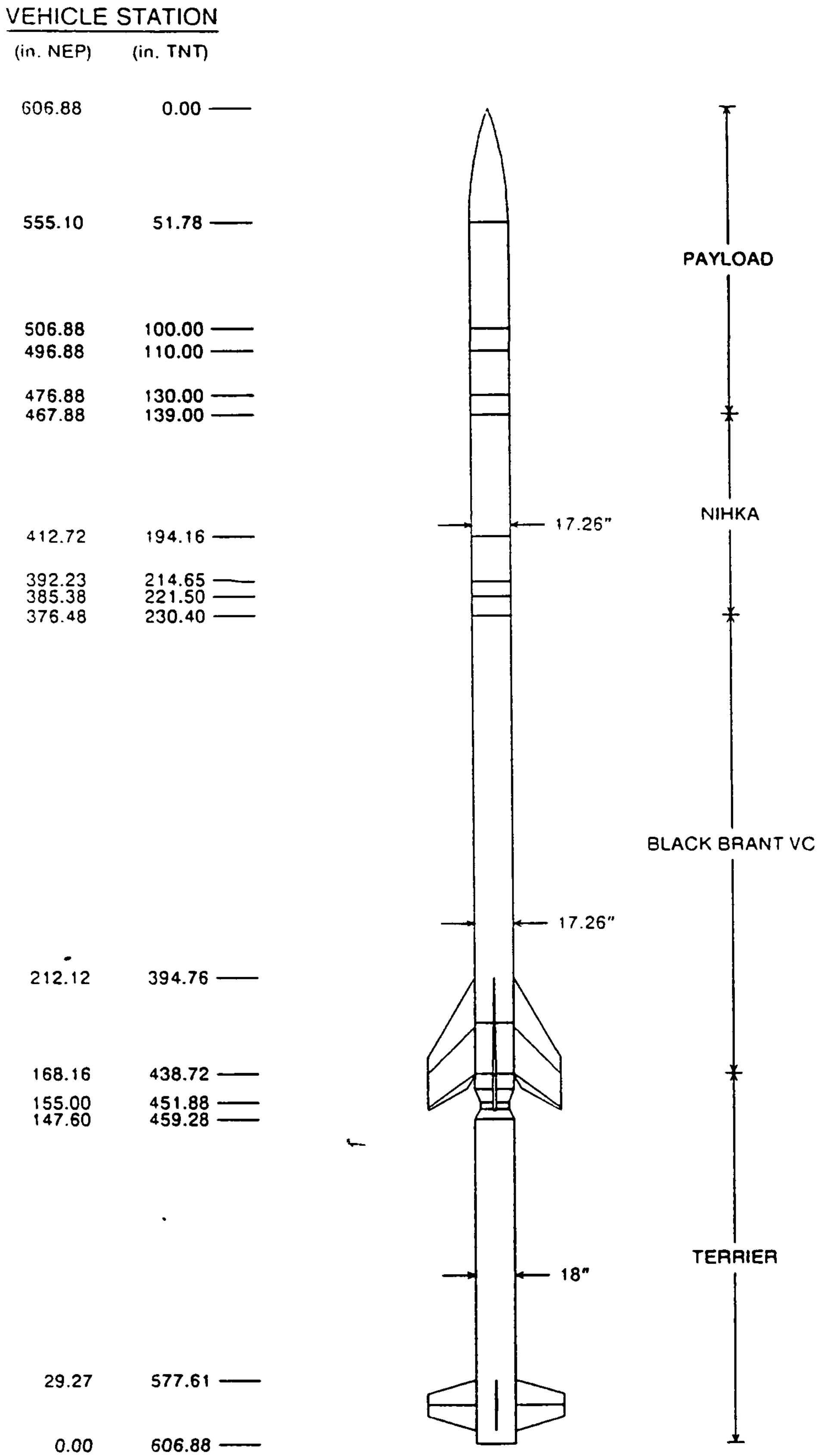


Figure 2-2. Black Brant X 35.011 UE
Launch Configuration

Table 2-1. Black Brant X 35.011 UE
Physical Properties

* * * P H Y S I C A L   P R O P E R T I E S   P R O G R A M - Rev 1.Ø * * * Ø1/25/89 12.713

****
* PHYSICAL PROPERTIES SUMMARY *   BLACK BRANT X
****

BBX 35.Ø11

```
PAYLOAD WEIGHT = 439.ØØ lb.
        LENGTH = 135.77 in.
            CG =  53.ØØ in. from p/l base
            IY = 12Ø.ØØ slug-ft^2
            IX =   3.ØØ slug-ft^2
```

PHYSICAL PROPERTIES - LAUNCH CONFIGURATION
total length = 6Ø3.65 inches

TIME (sec)	TOT. WT. (lb.)	CG (in nep)	CG (ft nep)	CG (in nose)	CG (ft nose)	IYY (sl-ft^2)	IXX (sl-ft^2)
.ØØ	6113.11	258.38	21.53	345.27	28.77	26669.94	73.85
1.ØØ	5844.7Ø	266.34	22.2Ø	337.31	28.11	26789.65	71.81
2.ØØ	5576.29	275.14	22.93	328.51	27.38	24697.74	69.76
3.ØØ	53Ø7.88	284.83	23.74	318.82	26.57	2242Ø.ØØ	67.72
4.ØØ	5Ø39.47	295.57	24.63	3Ø8.Ø8	25.67	19876.7Ø	65.68
4.4Ø	4932.Ø2	3ØØ.23	25.Ø2	3Ø3.42	25.29	1878Ø.8Ø	64.86

PHYSICAL PROPERTIES - SECOND STAGE
total length = 435.49 inches

TIME (sec)	TOT. WT. (lb.)	CG (in nep)	CG (ft nep)	CG (in nose)	CG (ft nose)	IYY (sl-ft^2)	IXX (sl-ft^2)
12.ØØ	4174.66	171.45	14.29	264.Ø4	22.ØØ	9325.44	44.15
14.ØØ	4Ø25.26	173.4Ø	14.45	262.Ø9	21.84	9145.Ø5	43.71
16.ØØ	3877.66	175.52	14.63	259.97	21.66	8944.43	43.27
18.ØØ	3727.16	177.74	14.81	257.75	21.48	8758.Ø3	42.55
2Ø.ØØ	3576.16	18Ø.28	15.Ø2	255.21	21.27	8549.25	41.84
22.ØØ	3423.66	183.Ø2	15.25	252.47	21.Ø4	8317.75	4Ø.83
24.ØØ	3267.76	186.19	15.52	249.3Ø	2Ø.77	8Ø95.3Ø	39.83
26.ØØ	3111.76	189.6Ø	15.8Ø	245.89	2Ø.49	7842.62	38.53
28.ØØ	2958.56	193.3Ø	16.11	242.19	2Ø.18	7568.51	37.24
3Ø.ØØ	28Ø9.86	197.18	16.43	238.31	19.86	7333.7Ø	35.74
32.ØØ	2664.16	2Ø1.63	16.8Ø	233.86	19.49	6995.14	34.24
34.ØØ	2519.86	2Ø6.27	17.19	229.22	19.1Ø	67Ø6.7Ø	32.53
36.ØØ	2377.16	211.79	17.65	223.7Ø	18.64	6356.1Ø	3Ø.83
38.ØØ	2236.56	217.33	18.11	218.16	18.18	6026.25	28.97
4Ø.ØØ	21Ø2.76	224.Ø6	18.67	211.43	17.62	5618.98	27.11
42.ØØ	1994.96	228.58	19.Ø5	2Ø6.91	17.24	5393.84	25.85
44.ØØ	1933.36	233.14	19.43	2Ø2.35	16.86	5118.28	24.59
45.ØØ	1929.76	233.65	19.47	2Ø1.84	16.82	5Ø62.91	24.54

PHYSICAL PROPERTIES - THIRD STAGE
total length = 211.42 inches

TIME	TOT. WT.	CG	CG	CG	CG	IYY	IXX

(sec)	(lb.)	(in nep)	(ft nep)	(in nose)	(ft nose)	(sl-ft^2)	(sl-ft^2)
82.00	1338.80	73.06	6.09	138.36	11.53	624.20	11.20
86.00	1201.16	75.73	6.31	135.69	11.31	596.69	10.92
90.00	1033.88	80.17	6.68	131.25	10.94	555.49	10.19
94.00	862.06	86.59	7.22	124.83	10.40	500.03	8.90
98.00	687.52	96.77	8.06	114.65	9.55	415.05	6.82
99.80	630.10	101.09	8.42	110.33	9.19	380.45	5.31

THIS REFLECTS BBVC, NIHKA II, AND INTERSTAGE WEIGHTS PER B.A.L. LETTER DATED 21 FEB 1986. INTERSTAGE LENGTH PER WFF MEASUREMENTS. 5-14-87/MSS

SECTION 3 - VEHICLE PERFORMANCE

3.1 PERFORMANCE ANALYSIS RESULTS

Source: GEM 5-D

Launch Parameters: Payload Weight: 439 Lbs
After Nose Cone Separation: 386 Lbs
Launch Angles: 84^{0} QE, 327^{0} AZ
Launcher: Universal II, 40 ft rail travel
Launcher Latitude: 69.294186 Longitude: 16.020680

3.1.1 Nominal Trajectory

Nominal Events Sequence at Key Points of Flight: Table 3-1

Nominal Vehicle Performance: Figures 3-1 through 3-9

Apogee Altitude: 724.2 Km

Time at Apogee Altitude: 485 Sec

Ballistic Impact Range: 768.1 Km

Time at Ballistic Impact: 910 Sec

3.1.2 Aerodynamic Heating Index

Aerodynamic Heating Index: 1.68×10^{8} ft-lb/ft^{2}

3.1.3 Drag Separation Analysis

Drag Separation Analysis: Table 3-2

Source: DRGSEP - Drag Separation Analysis Program

3.1.4 Experimenter's Success Criteria

The comprehensive success criteria is 400 Km horizontal travel above 500 Km altitude. This is met by the nominal trajectory. The minimum success criteria is 200 Km above 500 Km altitude which is met by the 2σ deviation from the nominal trajectory.

Table 3-1. Black Brant X 35.011 UE
Nominal Sequence of Events

439 lb. p/l, 84° QE, 327° AZ, Norway

Event	Time (Sec)	Altitude (Km)	Range (Km)	Velocity (Mps)	Mach No.	Q (Psf)	Fl.El. (Deg)
Liftoff	0.00	0.0	0.0	0.3	.0	0.0	90.00
Terrier Burnout	4.40	0.8	0.1	402.0	1.2	1904.1	83.01
BBVC Ignition	12.00	3.5	0.5	297.8	.9	802.2	81.33
BBVC Burnout	44.42	33.6	6.9	1721.5	5.6	328.2	76.70
Nose Cone Eject	69.00	71.7	16.5	1485.8	5.1	1.6	74.64
Nose Cone Sidekick	71.50	75.3	17.5	1462.7	5.2	.9	74.40
BBVC-Nihka Separation	78.00	84.2	20.0	1402.7	5.2	.2	73.72
Nihka Ignition	82.00	89.5	21.6	1366.0	5.1	.1	73.28
Nihka Burnout	100.14	128.1	33.6	3351.1	12.4	.0	72.14
DCEF Cable Release	103.00	137.2	36.4	3325.4	12.3	.0	72.02
DCEF Cal.	104.00	140.3	37.5	3316.5	12.3	.0	71.98
Despin	105.00	143.5	38.5	3307.5	12.3	.0	71.93
Payload Separation	110.00	159.1	43.5	3263.0	12.1	.0	71.72
DCEF Boom Deploy	113.00	168.3	46.5	3236.4	12.0	.0	71.58
Experiment Backup Pwr On, DIFP ON	113.00	168.3	46.5	3236.4	12.0	.0	71.58
S/P Release	116.00	177.5	49.5	3209.9	11.9	.0	71.45
DCM Strap Release	116.00	177.5	49.5	3209.9	11.9	.0	71.45
ACLP Cal., Scan	117.00	180.6	50.5	3201.0	11.9	.0	71.40
DCM Spring Release	119.00	186.6	52.4	3183.4	11.8	.0	71.31

Table 3-1.
(Continued)

Event	Time (Sec)	Altitude (Km)	Range (Km)	Velocity (Mps)	Mach No.	Q (Psf)	Fl.El. (Deg)
Experiment HV On, SPS & DIFP Deploy	120.00	189.7	53.4	3174.6	11.8	.0	71.27
ACLP, ACEF, ACM Boom Deploy	120.00	189.7	53.4	3174.6	11.8	.0	71.27
ACEF & ACM Antenna Deploy	124.00	201.6	57.4	3139.6	11.7	.0	71.08
ACS #1 On	127.00	210.5	60.4	3113.5	11.6	.0	70.93
ACS #1 Off	177.00	346.4	108.8	2691.0	10.0	.0	68.18
Apogee	485.08	724.2	383.0	956.9	3.6	.0	0.00
ACS #2 On	514.30	720.9	408.1	984.1	3.7	.0	-13.43
ACS #2 Off	563.00	700.4	450.2	1137.2	4.2	.0	-32.48
3rd Stage Ballistic Impact	909.00	1.4	770.4	-	-	-	-73.73

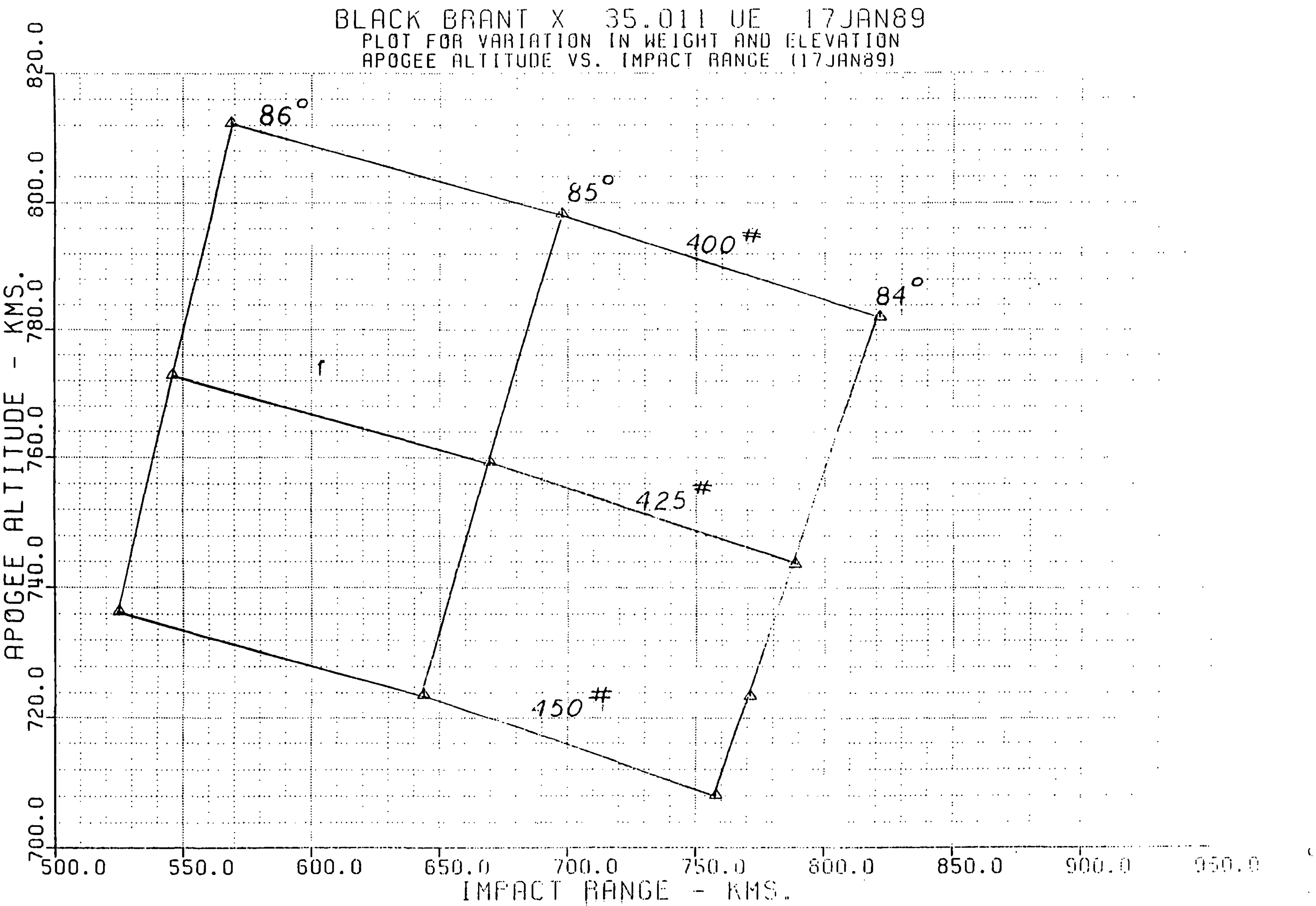


Figure 3-1. Apogee Altitude vs. Impact Range

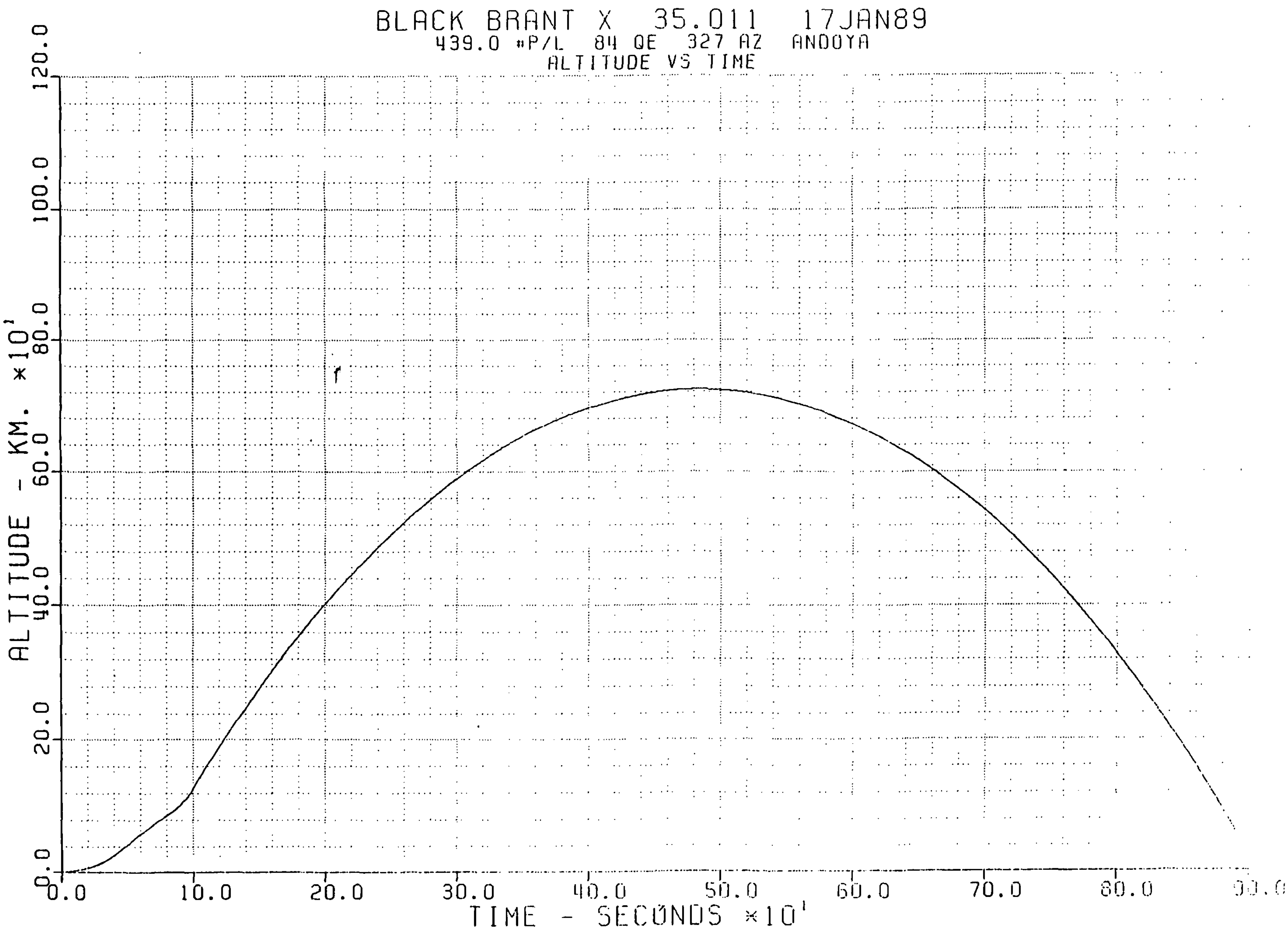


Figure 3-2. Altitude vs. Time

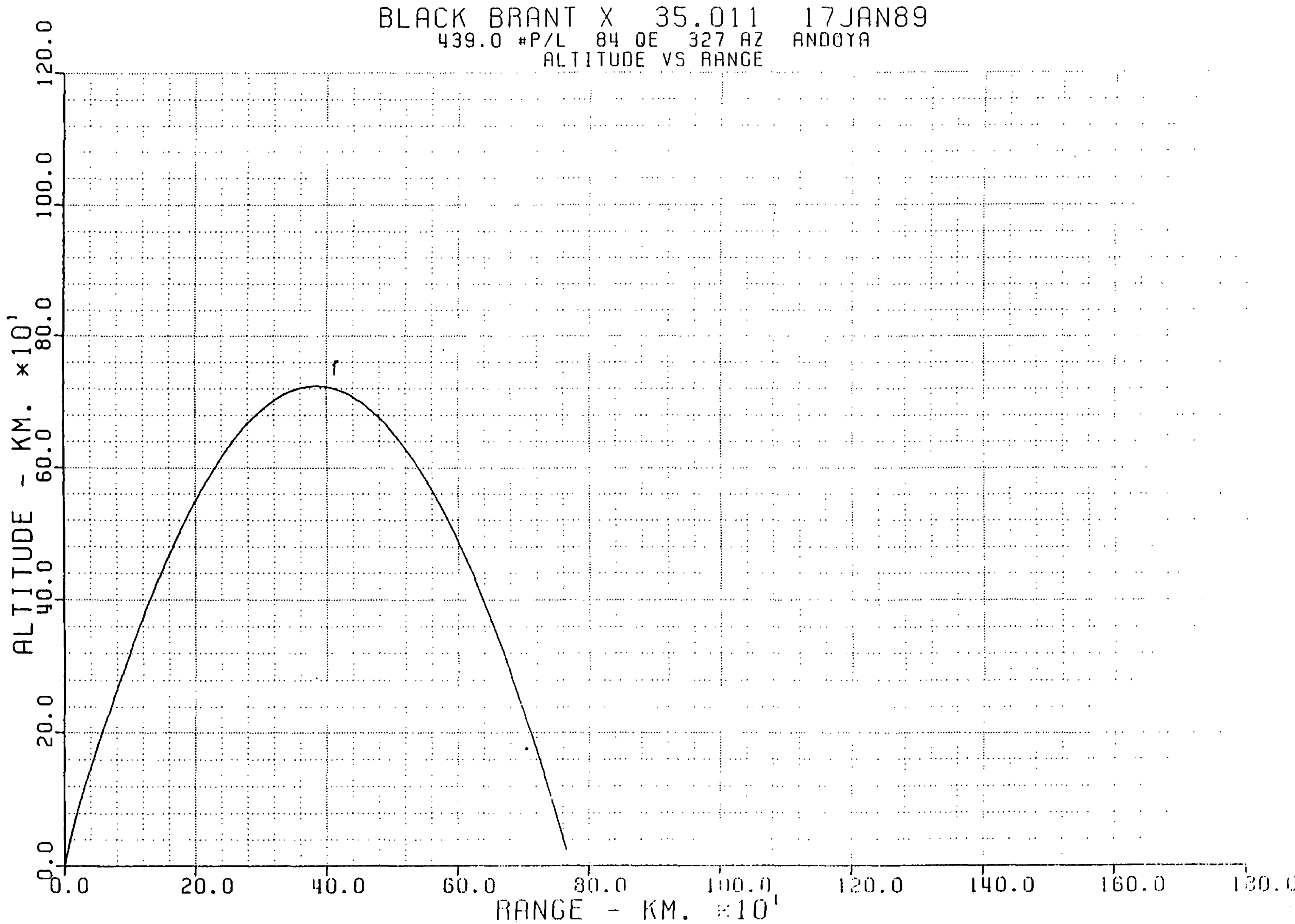


Figure 3-3. Altitude vs. Range

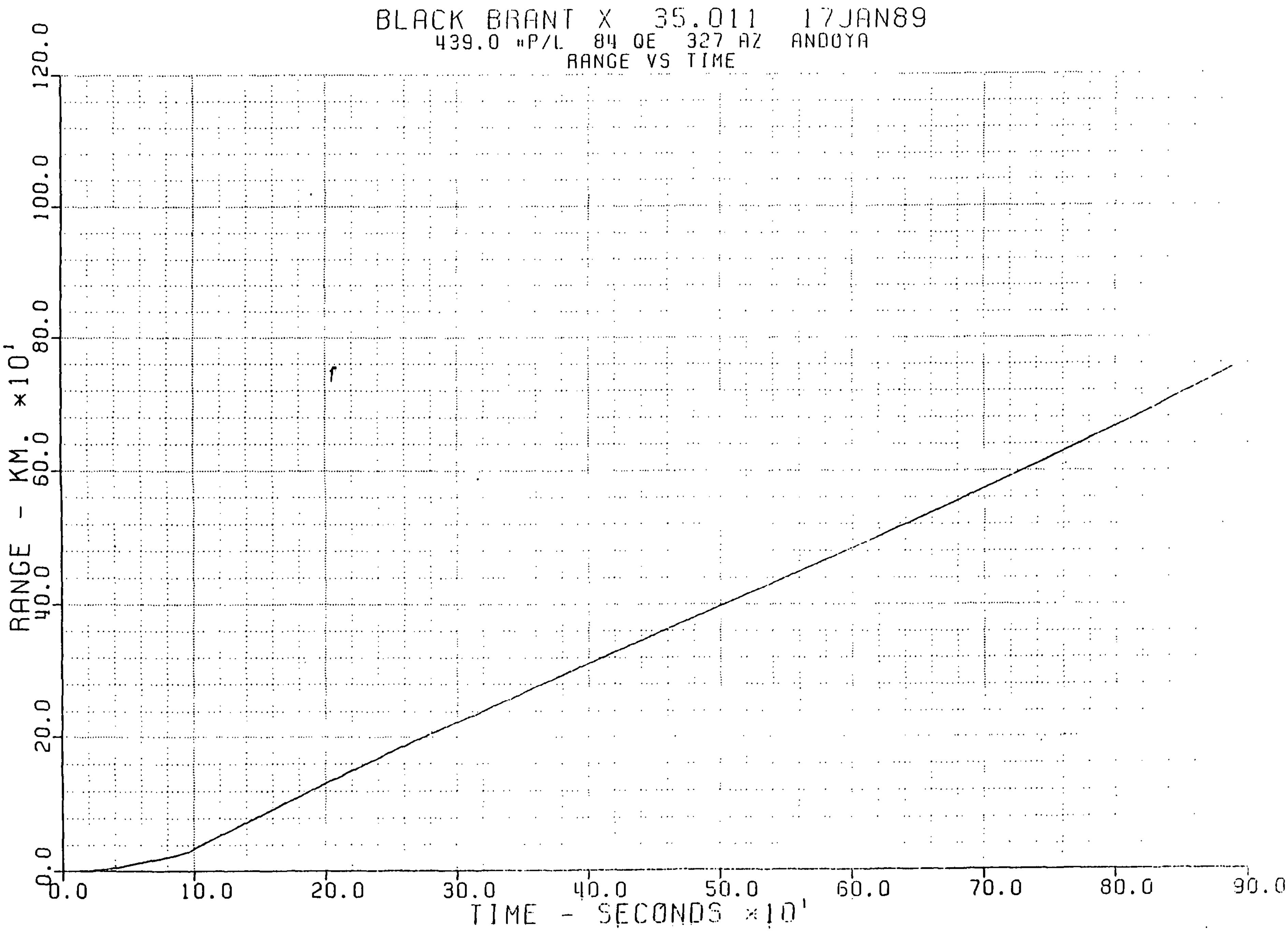


Figure 3-4. Range vs. Time

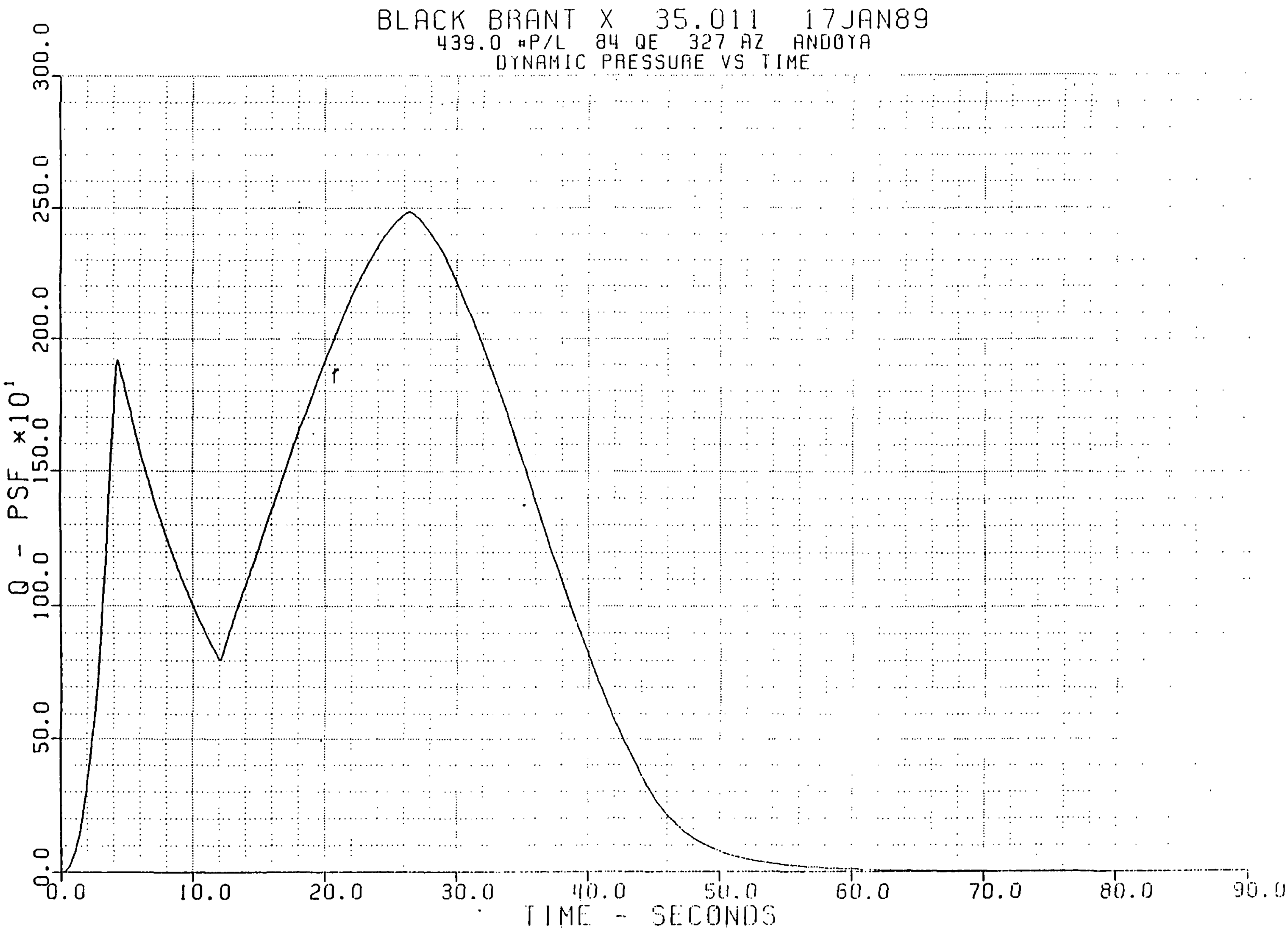


Figure 3-5. Dynamic Pressure vs. Time

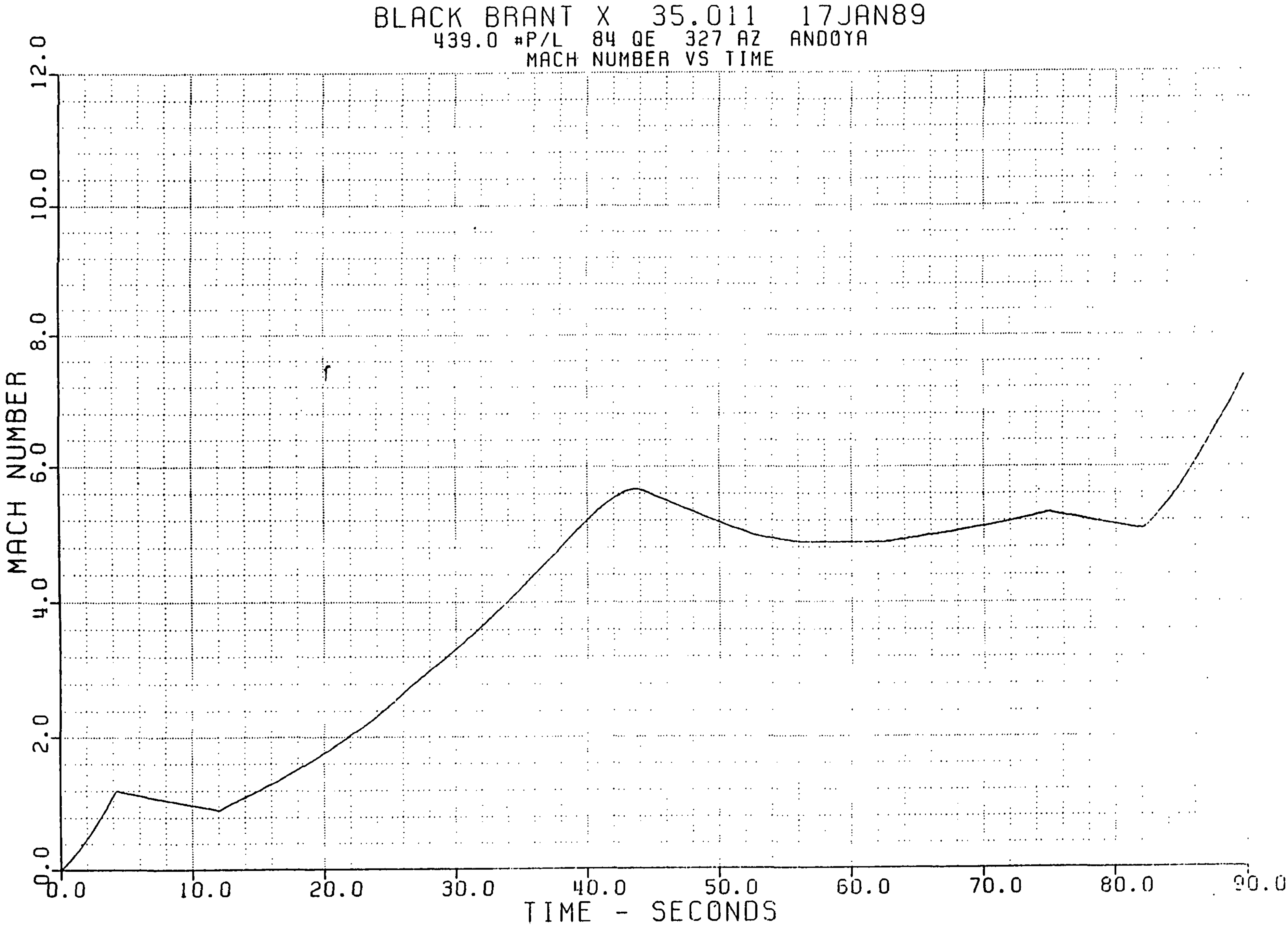


Figure 3-6. Mach Number vs. Time

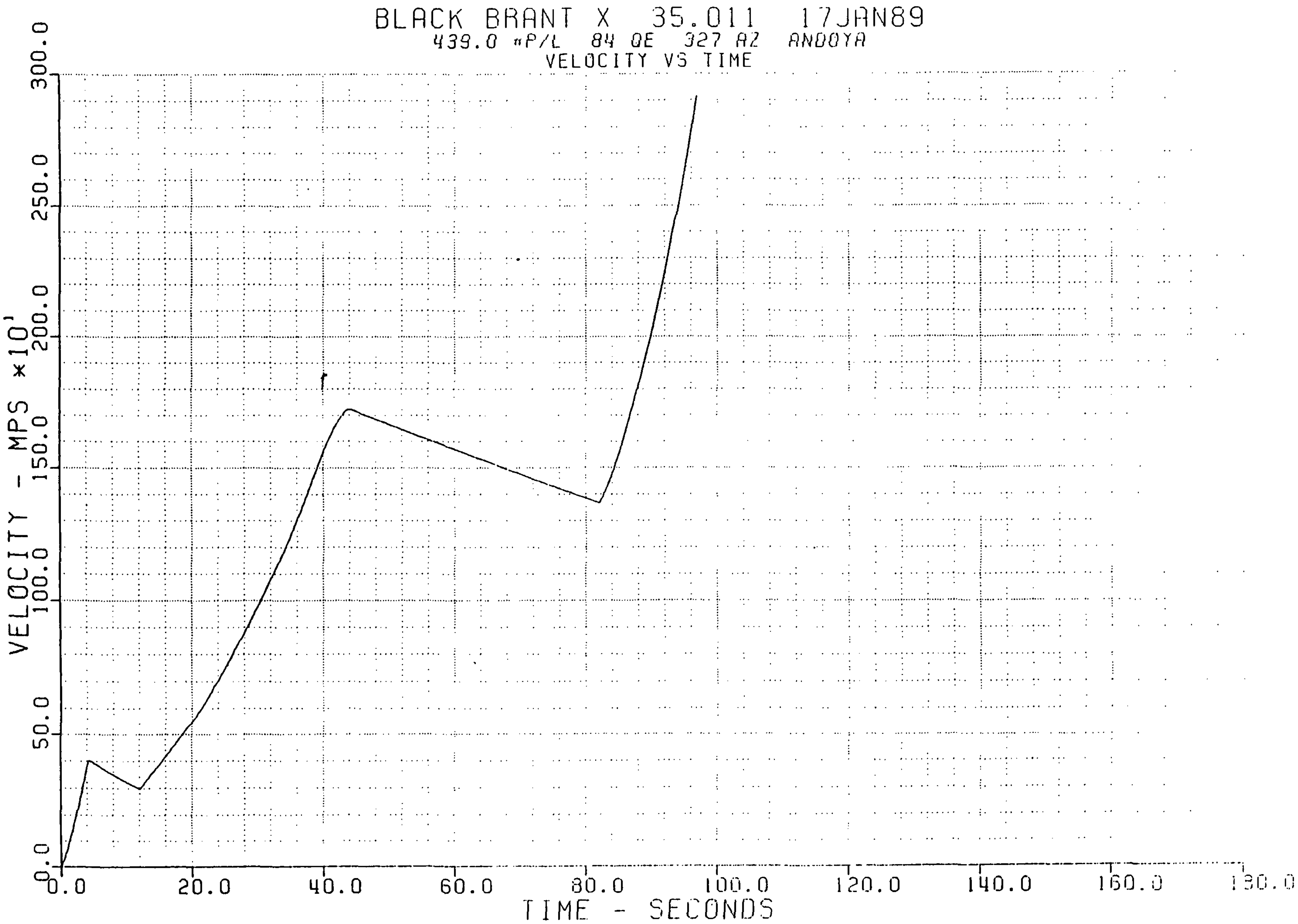
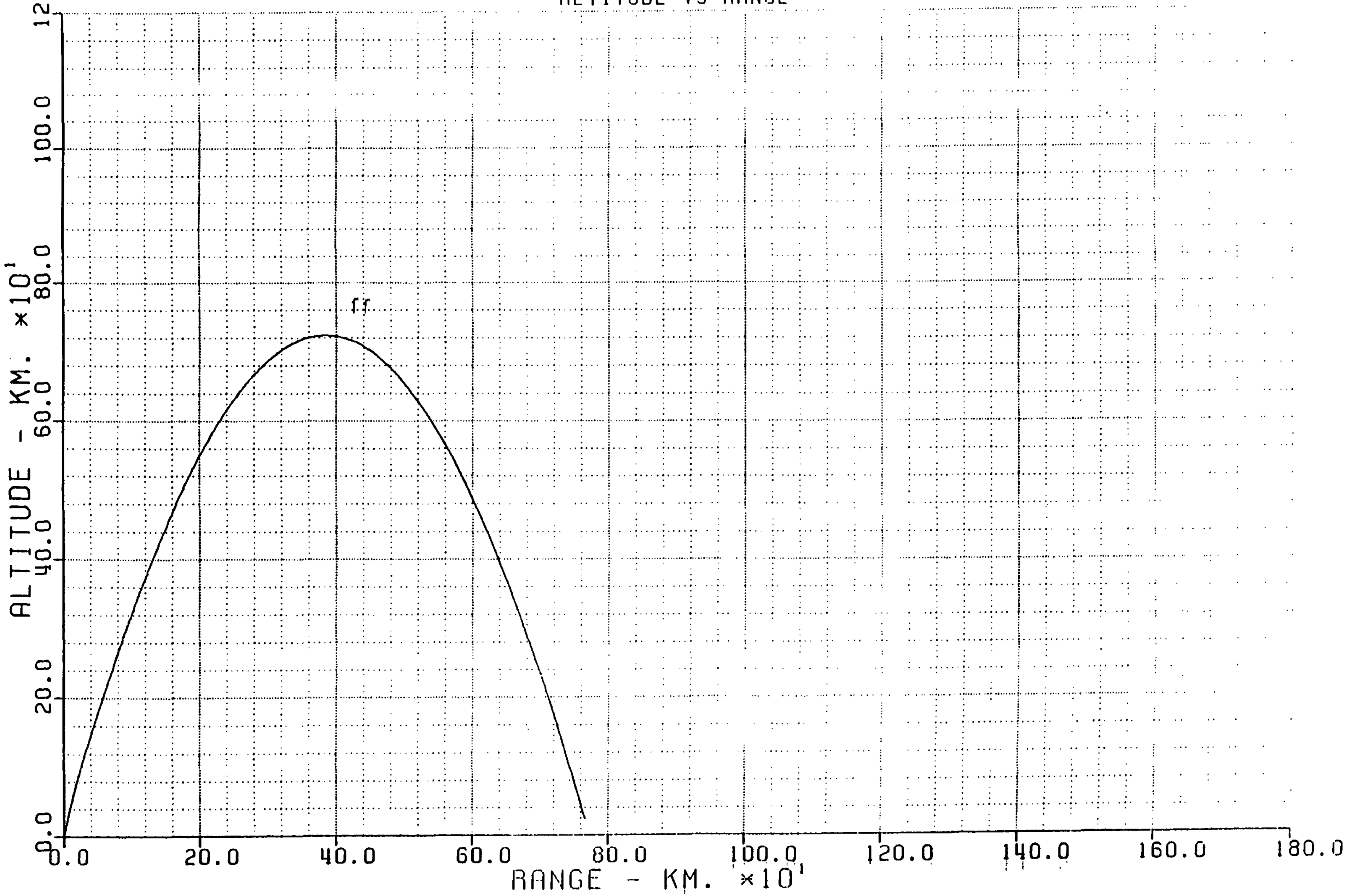
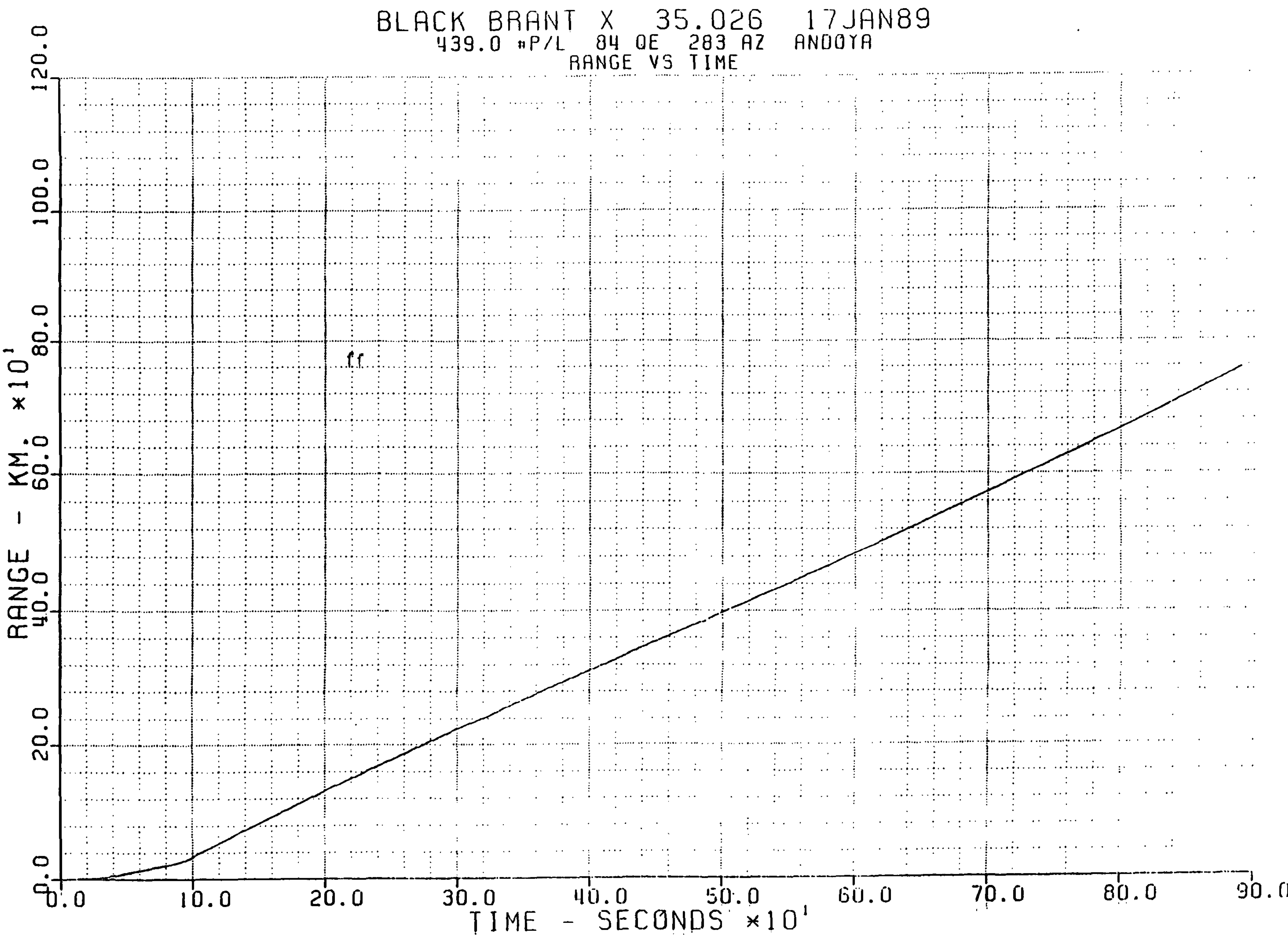


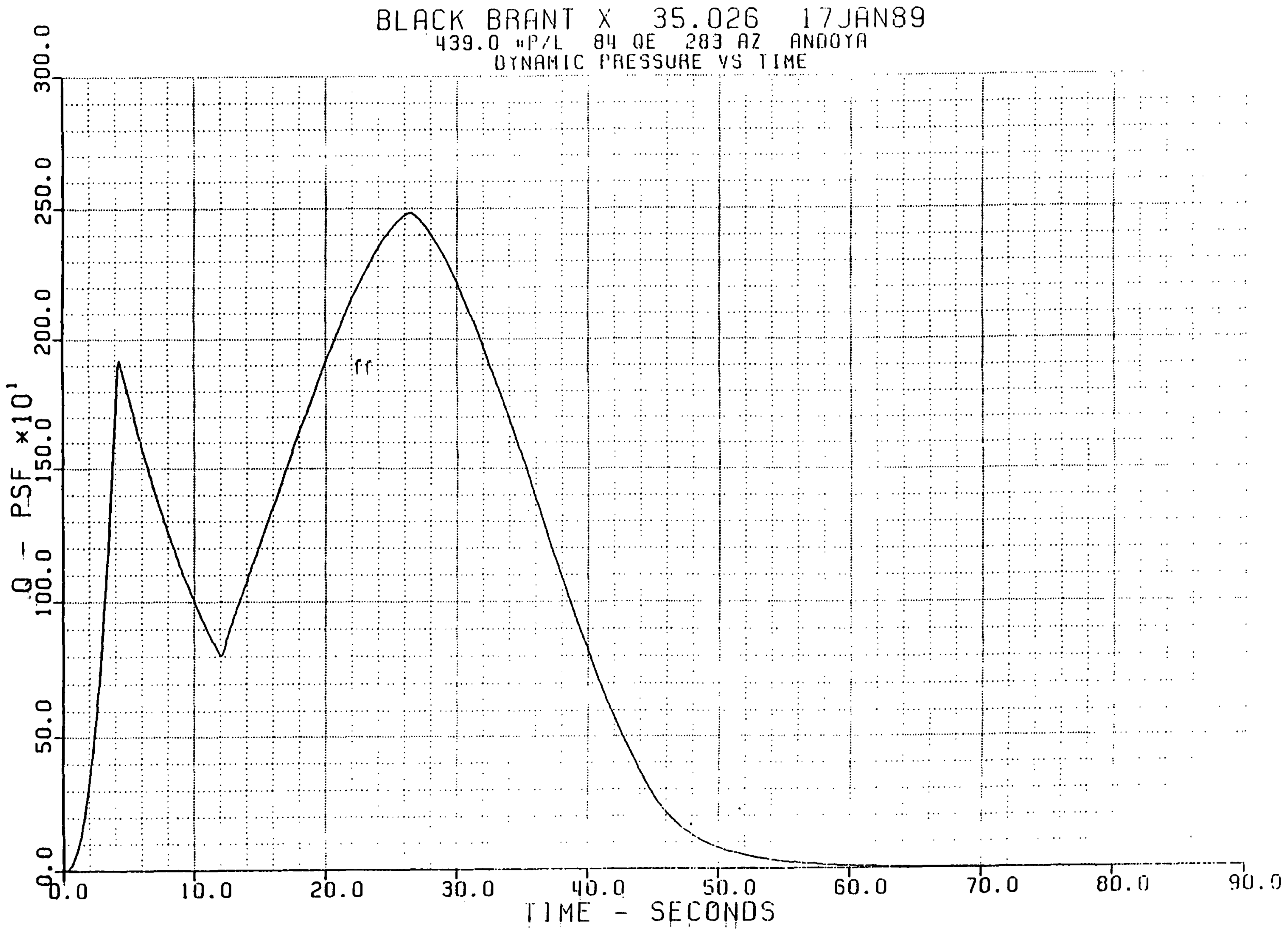
Figure 3-7. Velocity vs. Time

BLACK BRANT X 35.026 17JAN89
439.0 #P/L 84 QE 283 AZ ANDOYA
ALTITUDE VS RANGE

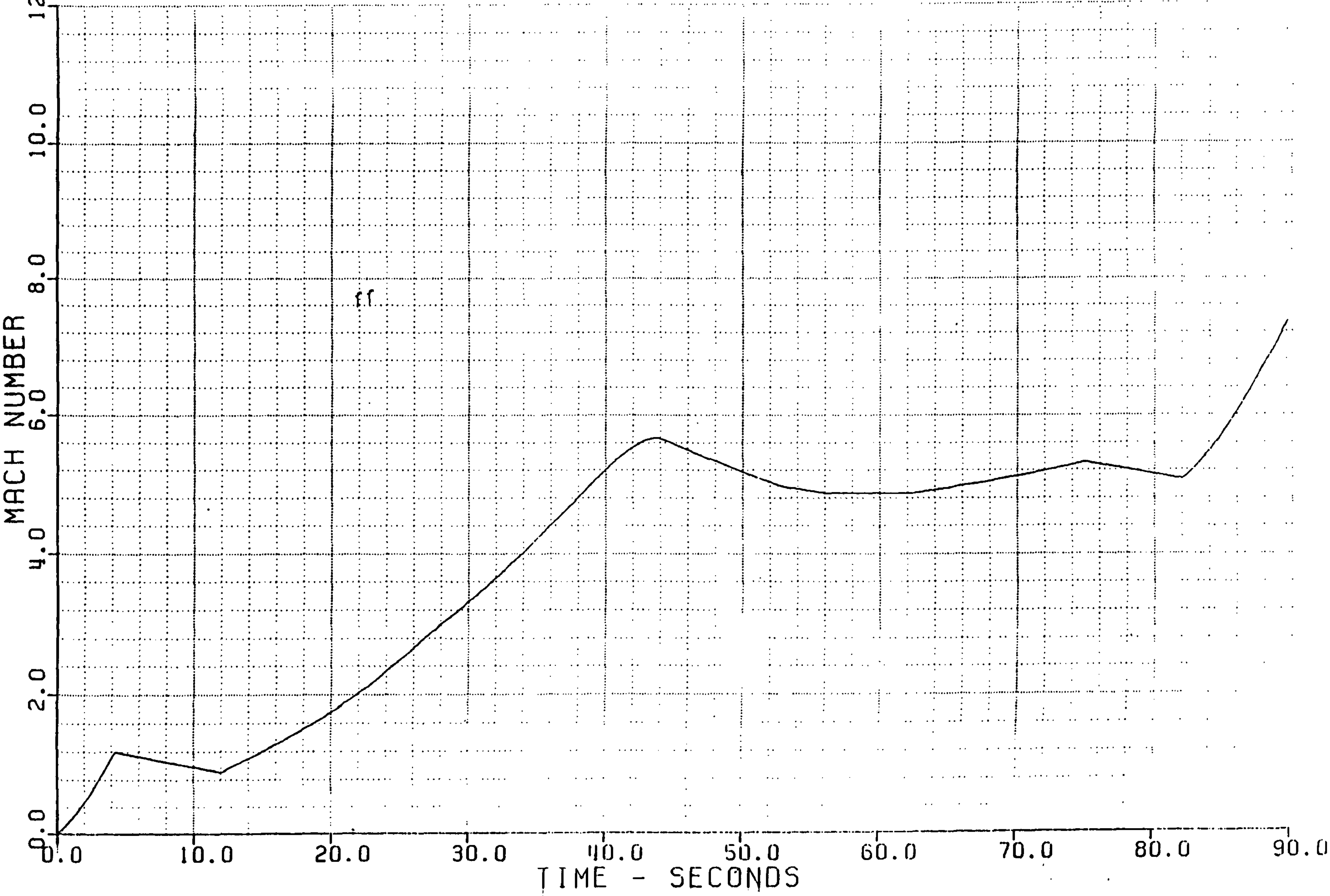


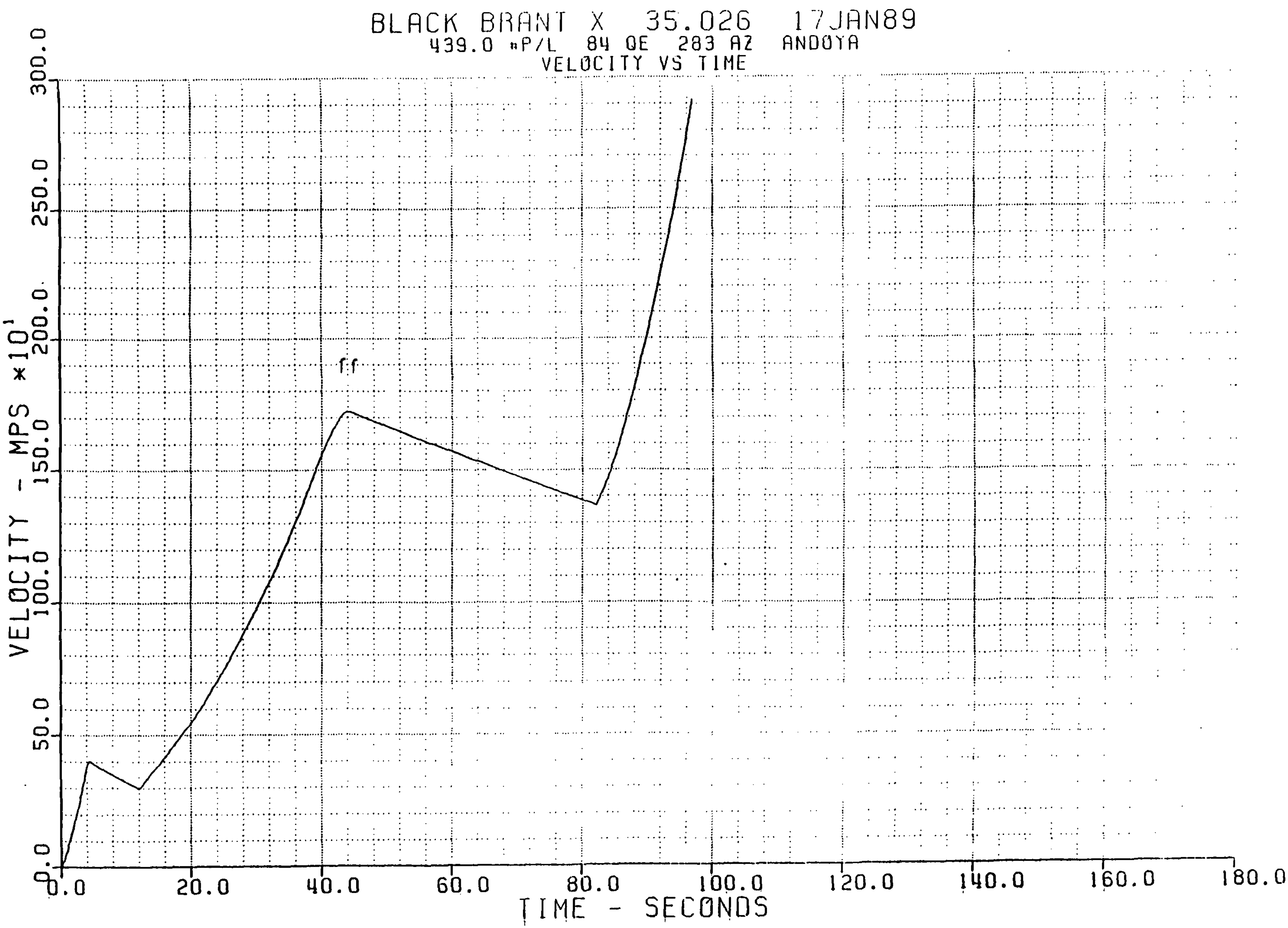


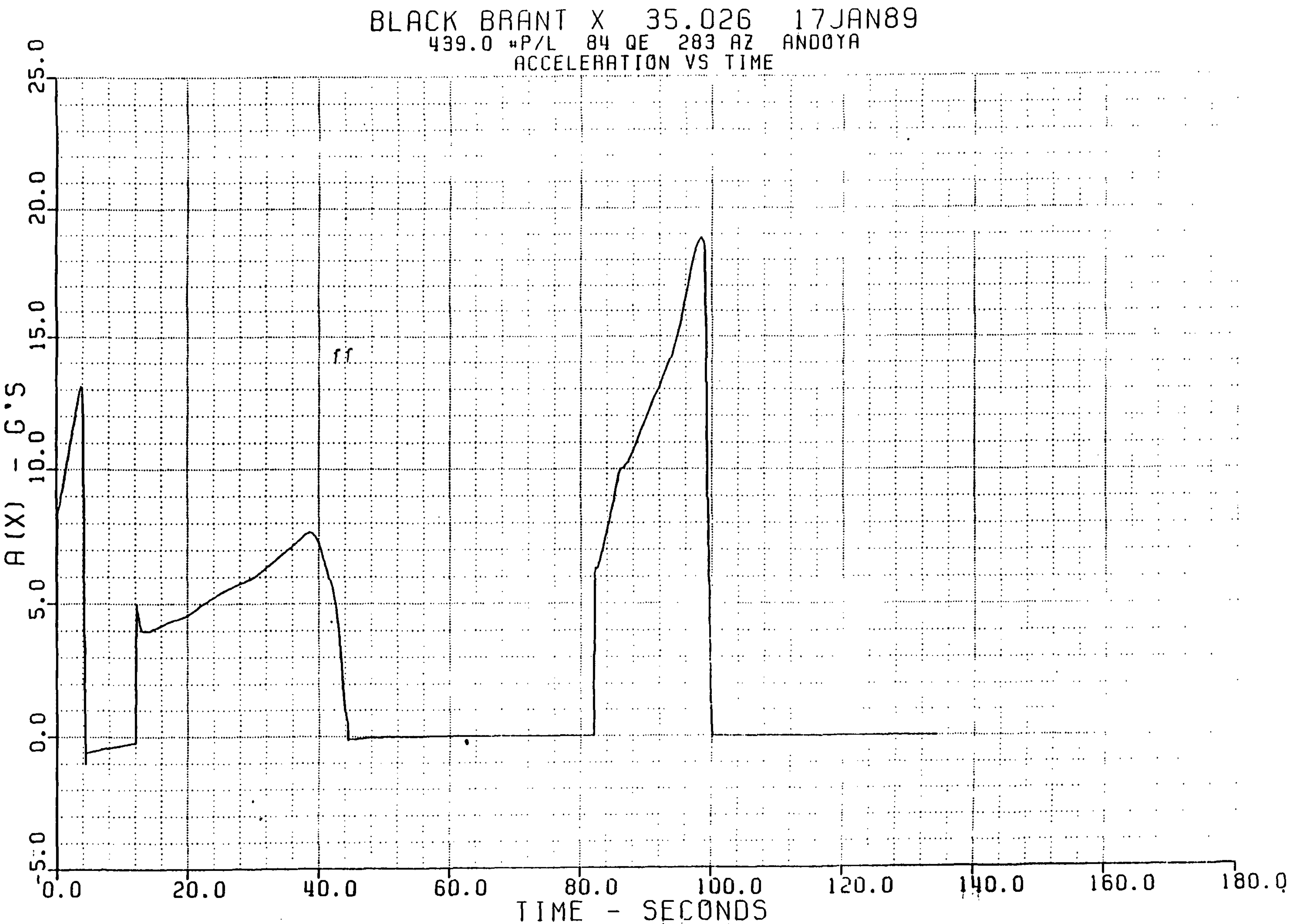
BLACK BRANT X 35.026 17JAN89
439.0 #P/L 84 QE 283 AZ ANDOYA
RANGE VS TIME
RANGE - KM. ×10¹
TIME - SECONDS ×10¹
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
120.0


BLACK BRANT X 35.026 17JAN89
439.0 #P/L 84 QE 283 AZ ANDOYA
DYNAMIC PRESSURE VS TIME
Q - PSF ×10¹
0.0
50.0
100.0
150.0
200.0
250.0
300.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
TIME - SECONDS

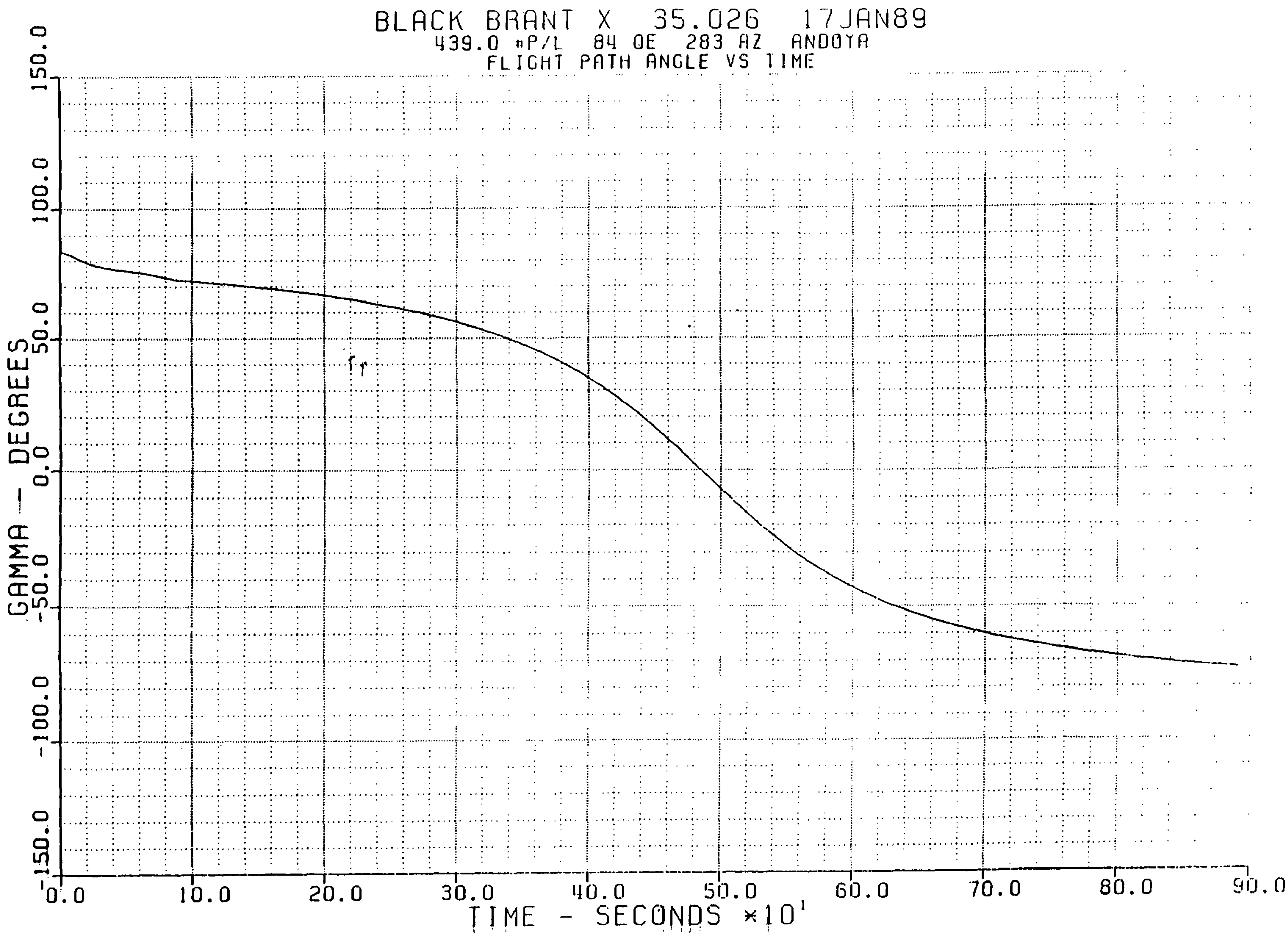
BLACK BRANT X 35.026 17JAN89
439.0 #P/L 84 QE 283 AZ ANDOYA
MACH NUMBER VS TIME




BLACK BRANT X 35.026 17JAN89
439.0 #P/L 84 QE 283 AZ ANDOYA
VELOCITY VS TIME
VELOCITY - MPS *10¹
TIME - SECONDS
0.0
50.0
100.0
150.0
200.0
250.0
300.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0


BLACK BRANT X 35.026 17JAN89
439.0 #P/L 84 QE 283 AZ ANDOYA
ACCELERATION VS TIME
A(X) - G'S
TIME - SECONDS
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0

178


BLACK BRANT X 35.026 17JAN89
439.0 #P/L 84 QE 283 AZ ANDOYA
FLIGHT PATH ANGLE VS TIME
GAMMA — DEGREES
150.0
100.0
50.0
0.0
-50.0
-100.0
-150.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
TIME - SECONDS *10¹

```
***************************************
*Drag Separation Analysis, Version 1.Ø*
***************************************

Vehicle i.d.: 35.Ø11 12JAN88

Staging Event: TERRIER / 8BVC SEPARATION
----------------------------------------------------------
Time =   4.4ØØ
--------------
Altitude =     2787.ØØØ ft.       Velocity =  1319.ØØØ fps.
       Q =     19Ø4.2Ø7 psf.      Mach No. =     1.193

Total Vehicle Thrusting Cd =   1.744, Sref =    1.625
     Sustainer Coasting Cd =    .813, Sref =    1.625

Total Vehicle Weight =   4932.ØØØ lb.
    Sustainer Weight =   4175.ØØØ lb.

  Booster Acceleration =  -3.8Ø g's
Sustainer Acceleration =   -.6Ø g's

Separation Criterion =   3.ØØ g's
  Delta Acceleration =   3.2Ø g's
```

SECTION 4 - STABILITY AND DYNAMICS

4.1 STABILITY ANALYSIS

4.1.1 Rigid Body Stability

Source: GEM

Xcg and Xcp vs. Time (launch configuration): Figure 4-1

Minimum Rigid Static Margin (launch configuration): 4.8 Cal @ 0 Sec
83 In
14% of vehicle length

Xcg and Xcp vs. Time (second stage): Figure 4-2

Minimum Rigid Static Margin (second stage): 5.3 Cal @ 38 Sec
92 In
21% of vehicle length

First and Second Stage Static Margin vs. Time: Figure 4-3

4.1.2 Flexible Body Stability

A flexible body analysis will be conducted prior to the Mission Readiness Review.

4.2 DYNAMIC ANALYSIS

4.2.1 Pitch-Frequency/Roll-Rate History

Pitch-Frequency/Roll-Rate History: Figure 4-4

Dynamic Pressure/Angle of Attack: Figure 4-5

Aerodynamic Load Indicator: Figure 4-6

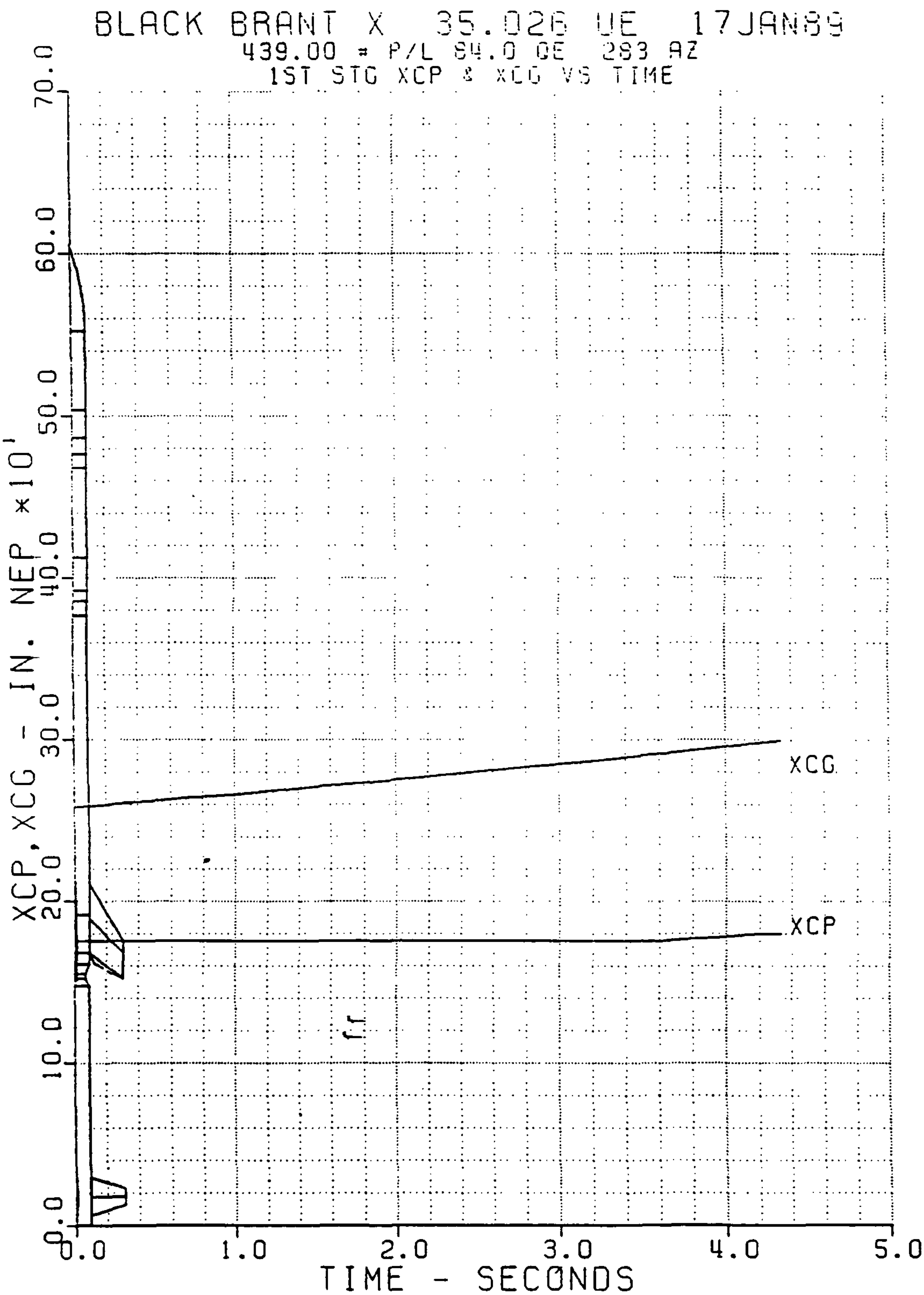
Offsets, Misalignments, Eccentricities: Table 4-1

First Stage Fin-Cant Setting: $\leq$90 Min

Second Stage Fin-Cant Setting: 21.5 Min

Roll Rate First Stage Burnout: 2.5 Cps

Roll Rate Second Stage Burnout: 3.5 Cps



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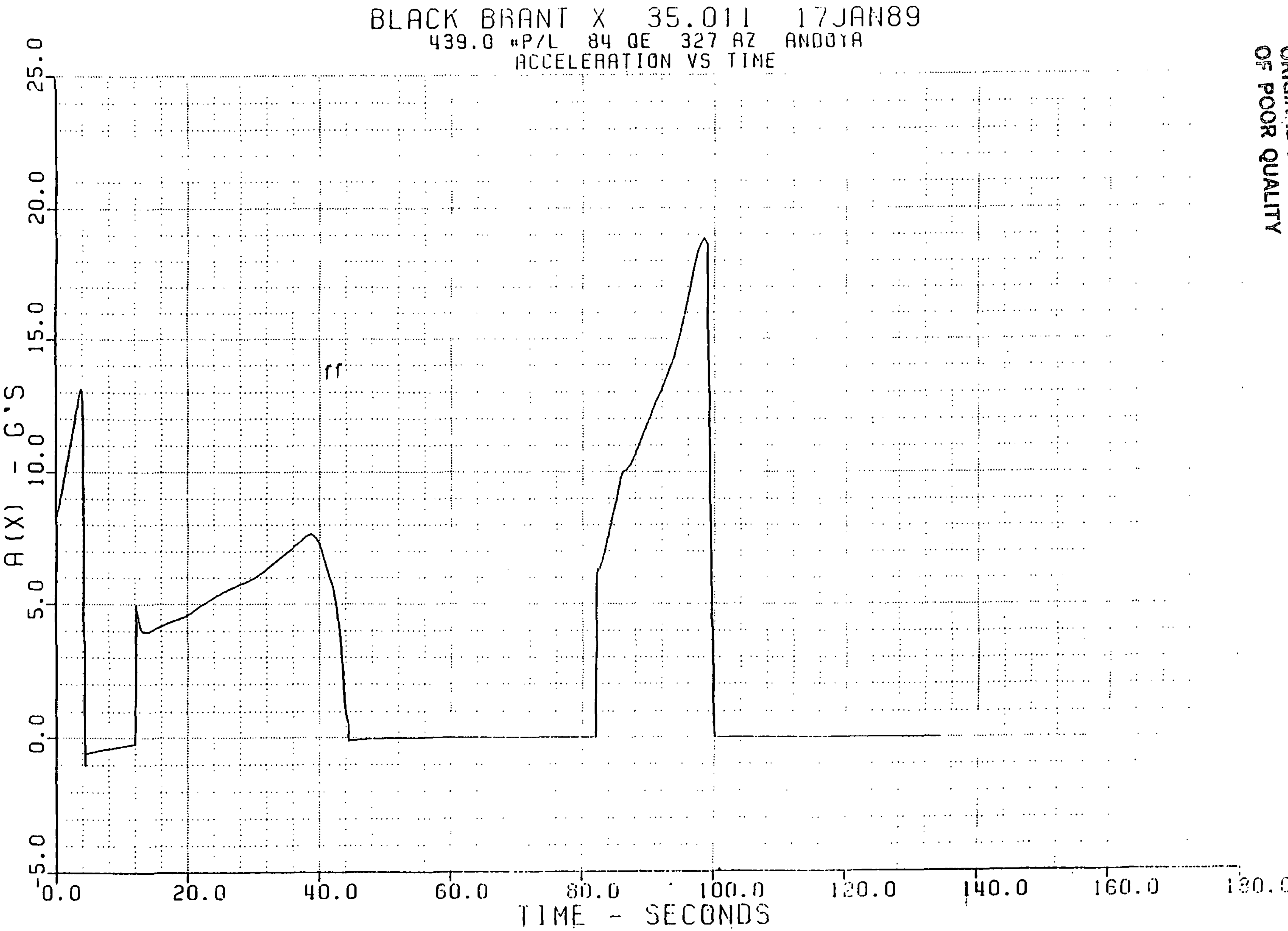

Figure 3-8. Acceleration vs. Time

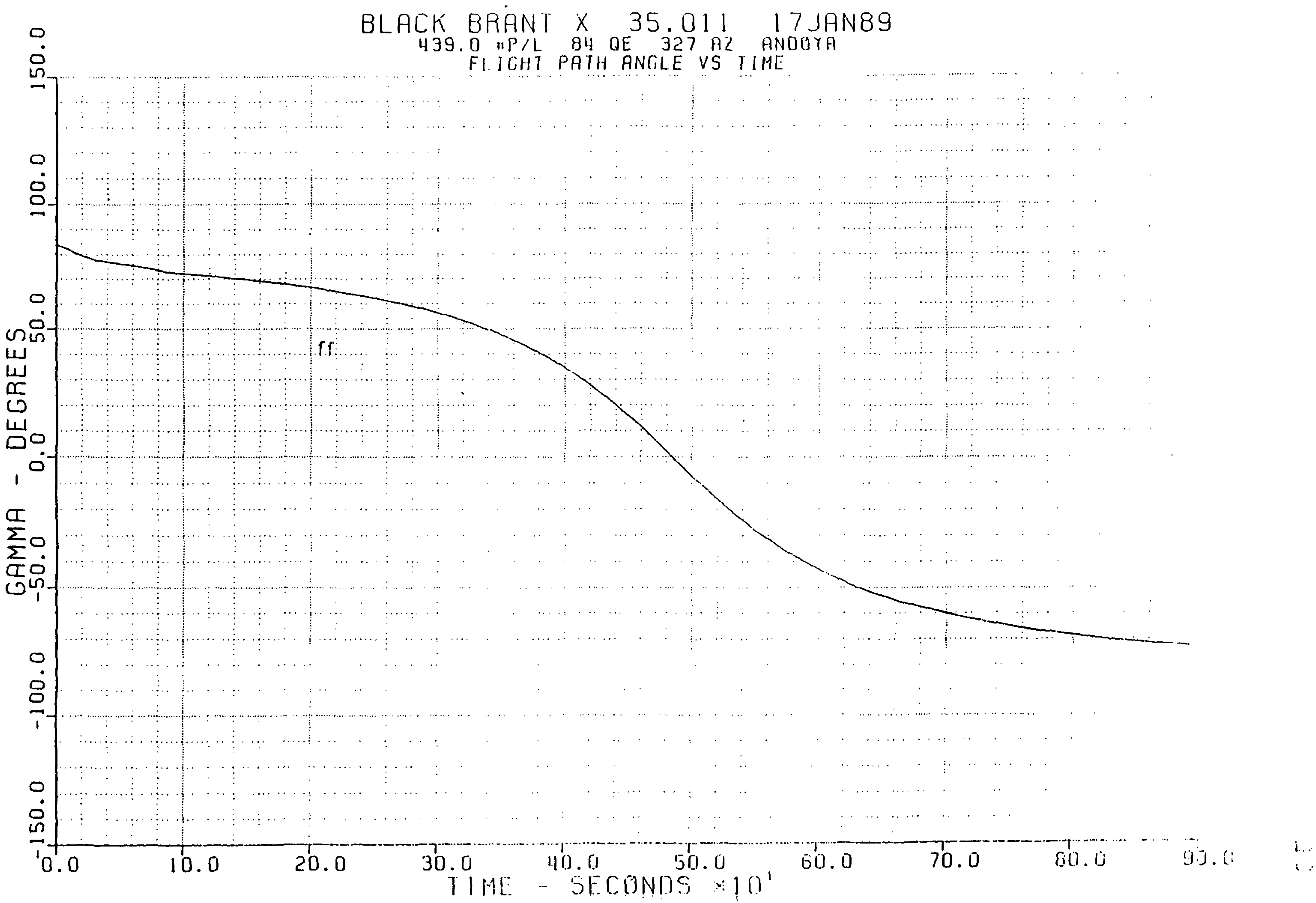

Figure 3-9. Flight Path Angle vs. Time

Table 3-2. Drag Separation Analysis

```
****************************************
*Drag Separation Analysis. Version 1.0*
****************************************

Vehicle i.d.: 35.011 12JAN88

Staging Event: TERRIER / BBVC SEPARATION
-----------------------------------------------------------
Time =   4.400
--------------
Altitude =     2787.000 ft.       Velocity =  1319.000 fps.
       Q =     1904.207 psf.      Mach No. =      1.193

Total Vehicle Thrusting Cd =   1.744,  Sref =    1.625
     Sustainer Coasting Cd =    .813,  Sref =    1.625

Total Vehicle Weight =    4932.000 lb.
    Sustainer Weight =    4175.000 lb.

  Booster Acceleration =  -3.80 g's
Sustainer Acceleration =   -.60 g's

Separation Criterion =    3.00 g's
  Delta Acceleration =    3.20 g's
```

SECTION 4 - STABILITY AND DYNAMICS

4.1 STABILITY ANALYSIS

4.1.1 Rigid Body Stability

Source: GEM

Xcg and Xcp vs. Time (launch configuration): Figure 4-1

Minimum Rigid Static Margin (launch configuration): 4.8 Cal @ 0 Sec
83 In
14% of vehicle length

Xcg and Xcp vs. Time (second stage): Figure 4-2

Minimum Rigid Static Margin (second stage): 5.3 Cal @ 38 Sec
92 In
21% of vehicle length

First and Second Stage Static Margin vs. Time: Figure 4-3

4.1.2 Flexible Body Stability

A flexible body analysis will be conducted prior to the Mission Readiness Review.

4.2 DYNAMIC ANALYSIS

4.2.1 Pitch-Frequency/Roll-Rate History

Pitch-Frequency/Roll-Rate History: Figure 4-4

Dynamic Pressure/Angle of Attack: Figure 4-5

Aerodynamic Load Indicator: Figure 4-6

Offsets, Misalignments, Eccentricities: Table 4-1

First Stage Fin-Cant Setting: 90 Min

Second Stage Fin-Cant Setting: 21.5 Min

Roll Rate First Stage Burnout: 2.5 Cps

Roll Rate Second Stage Burnout: 3.5 Cps

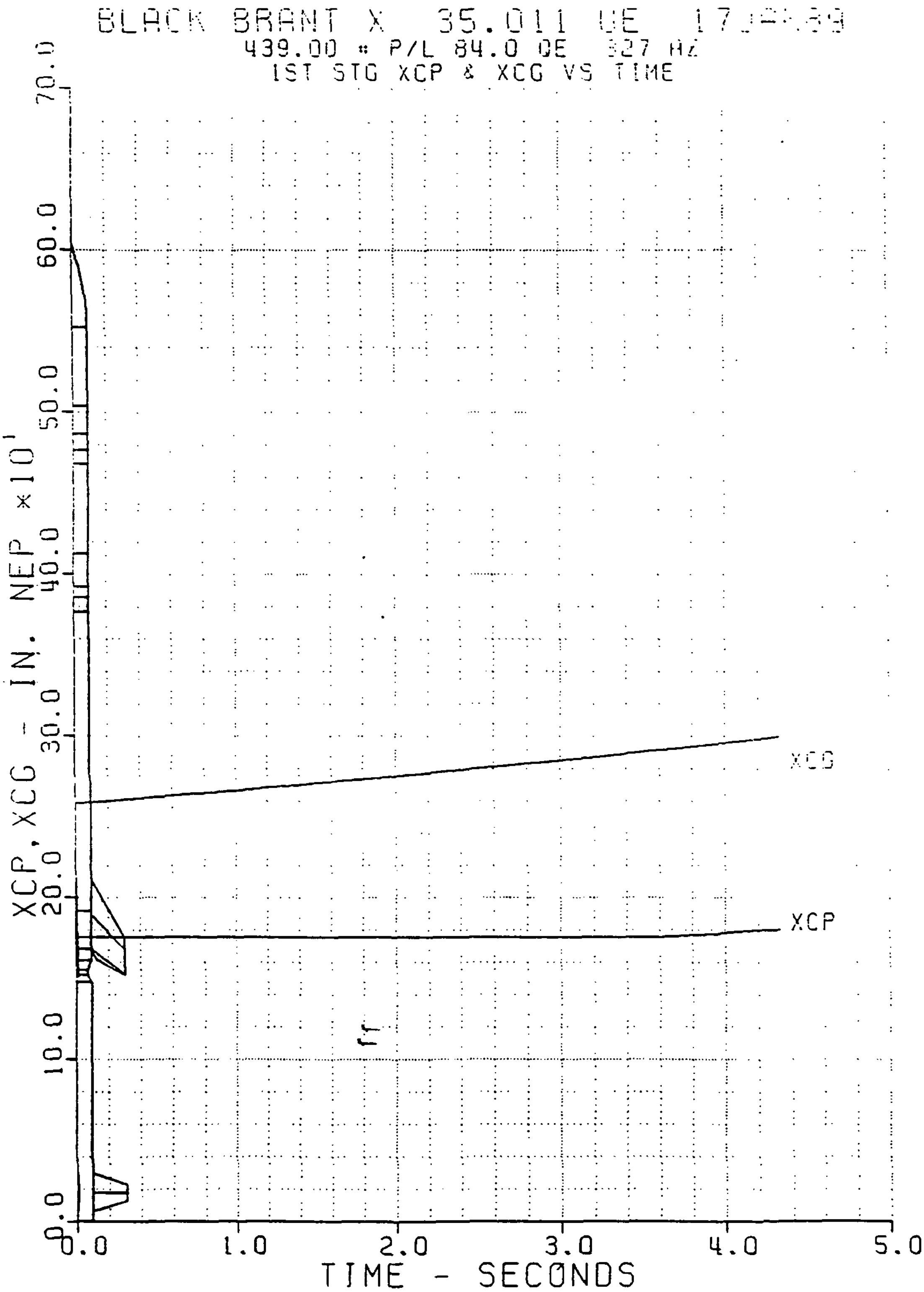

Figure 4-1. First Stage Xcp and Xcg vs. Time

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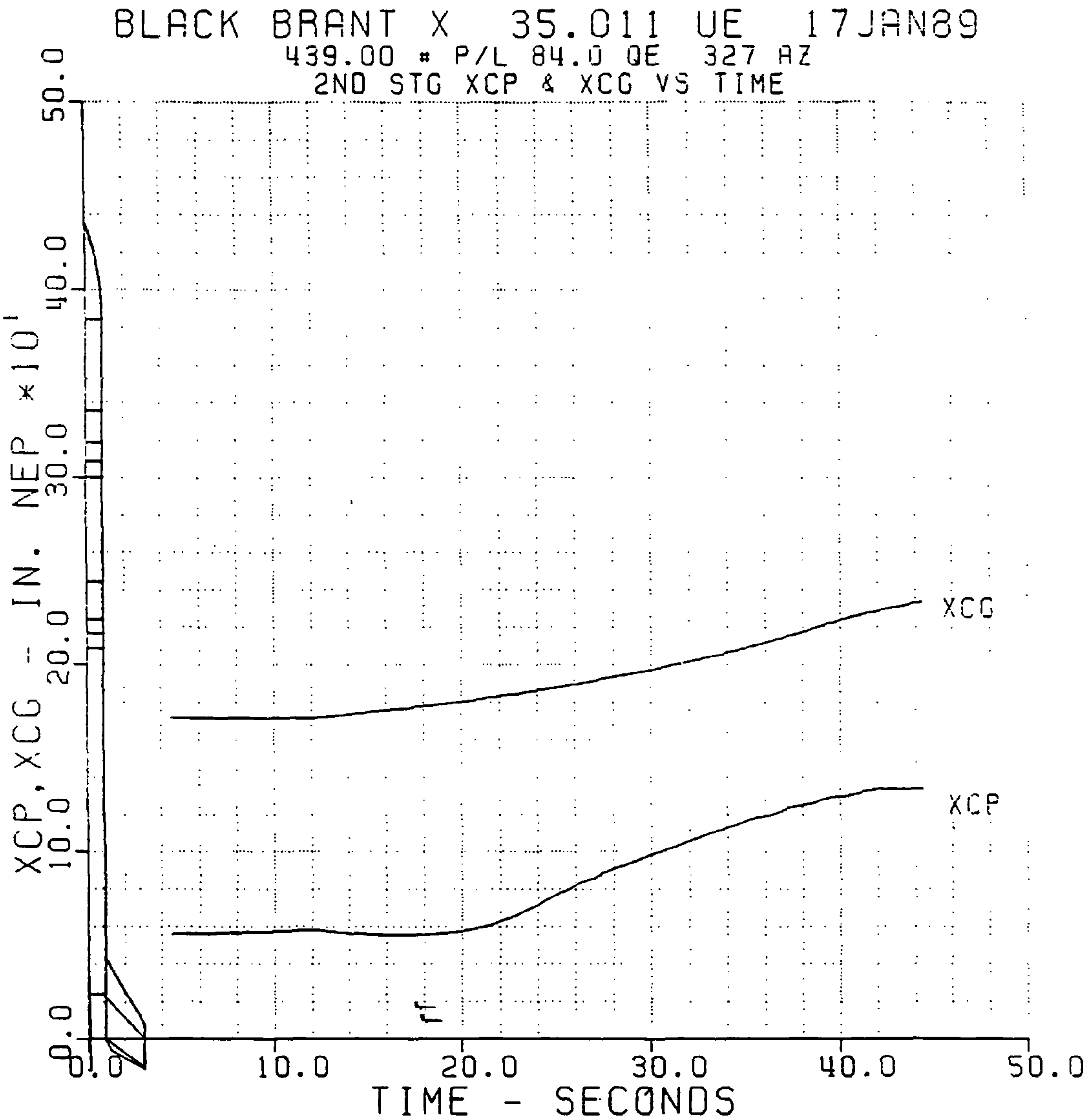

Figure 4-2. Second Stage Xcp and Xcg vs. Time

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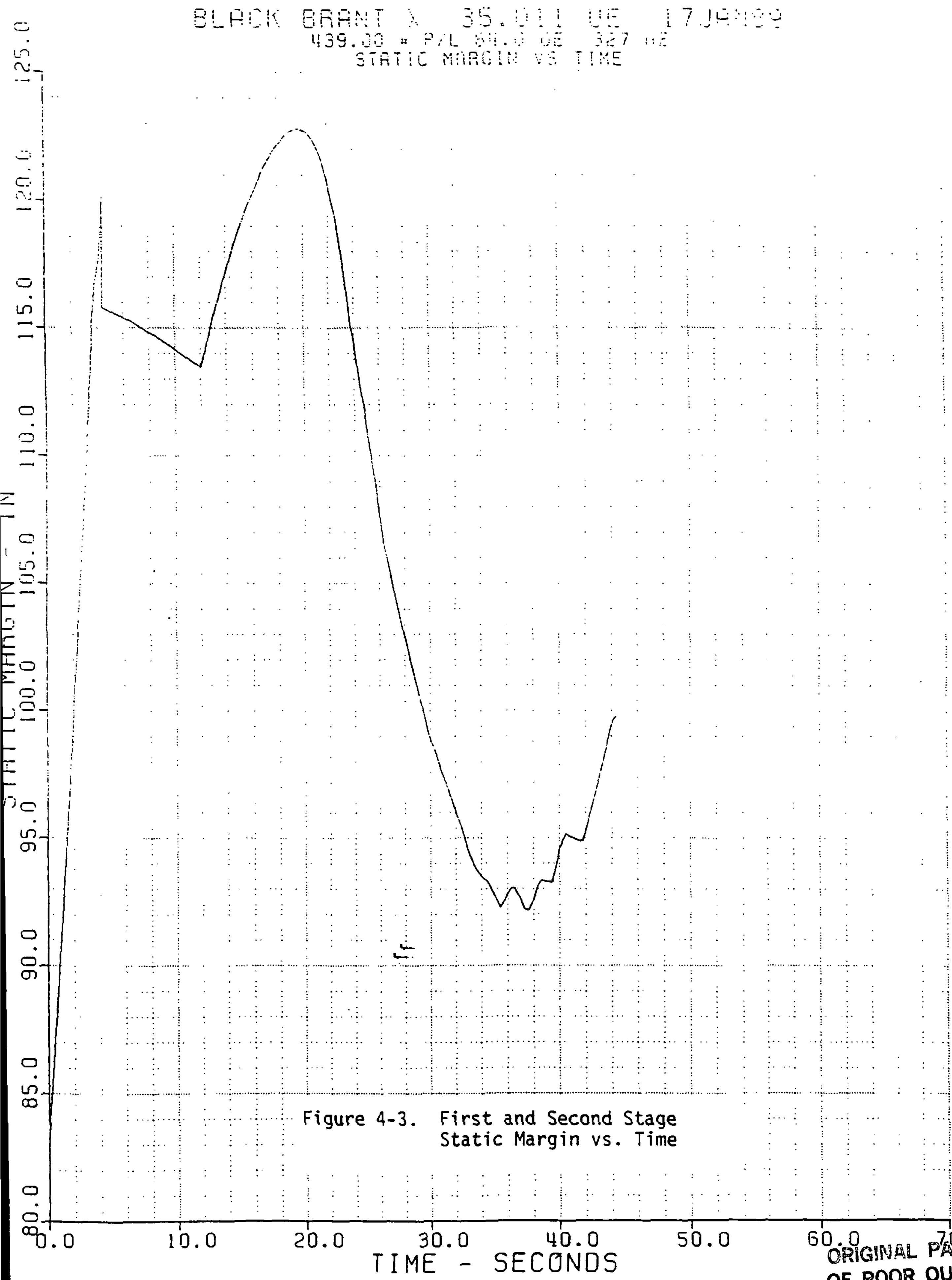


Figure 4-3. First and Second Stage Static Margin vs. Time

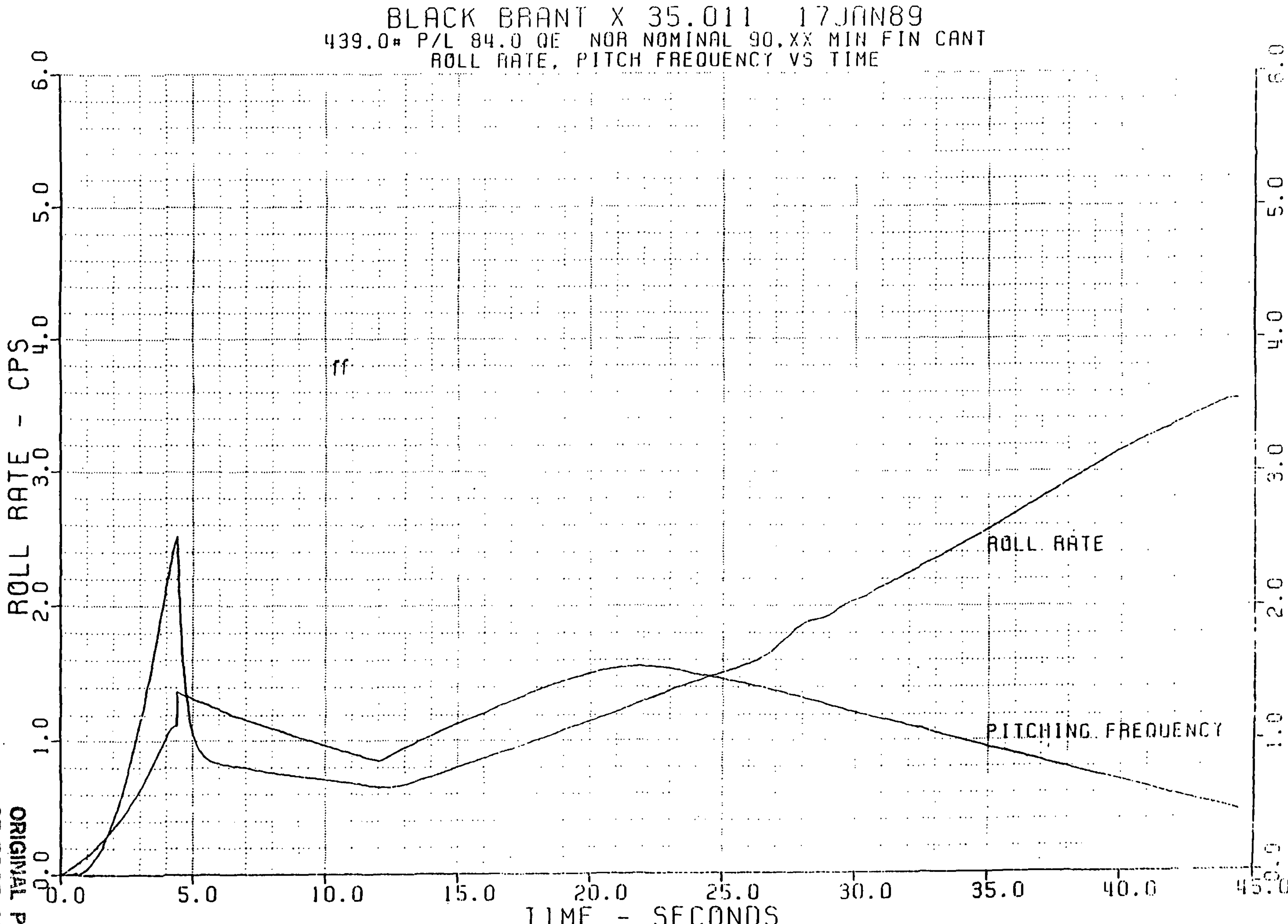


Figure 4-4. Roll Rate/Pitch Frequency vs. Time

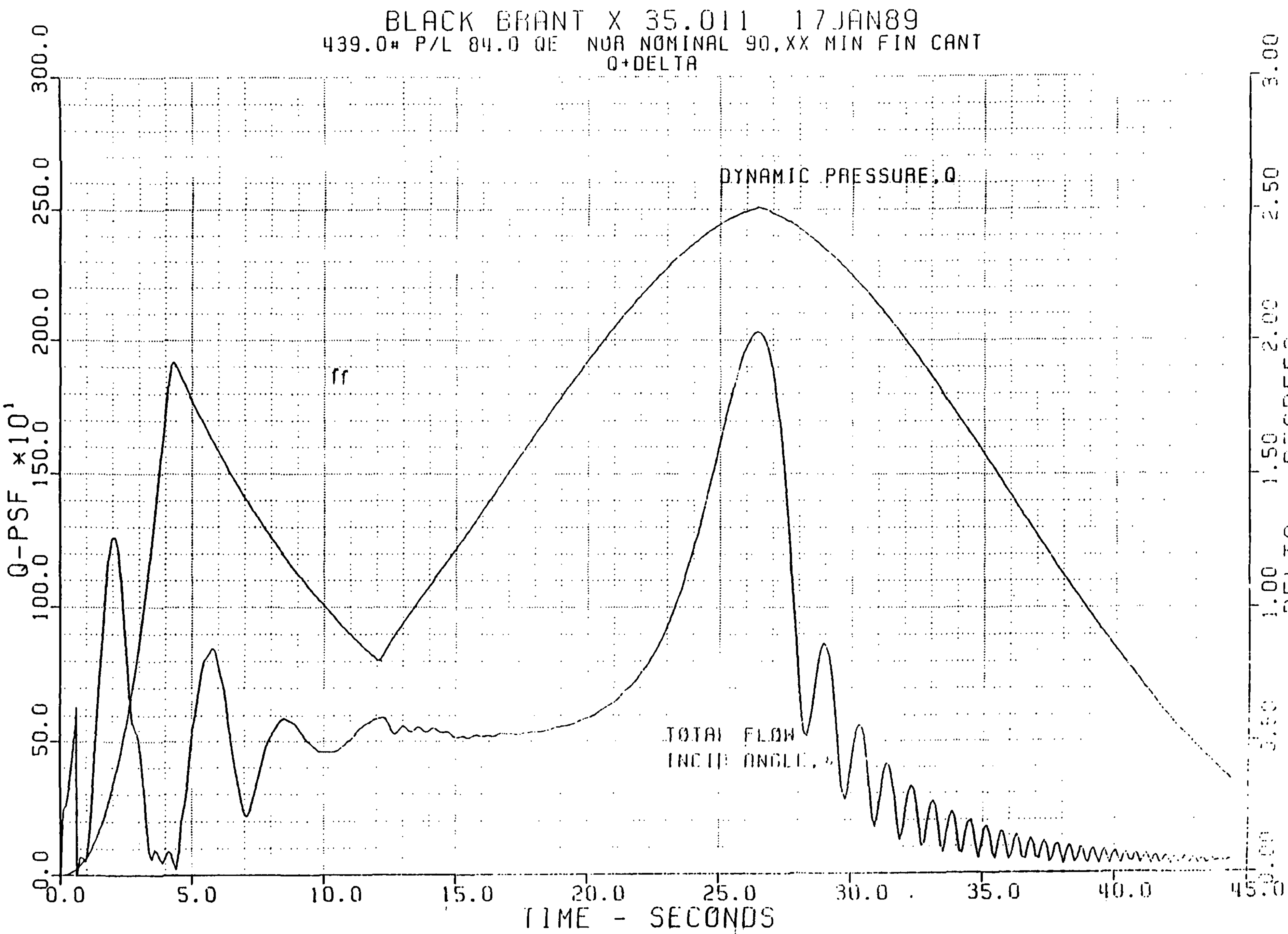


Figure 4-5. Dynamic Pressure, Delta vs. Time

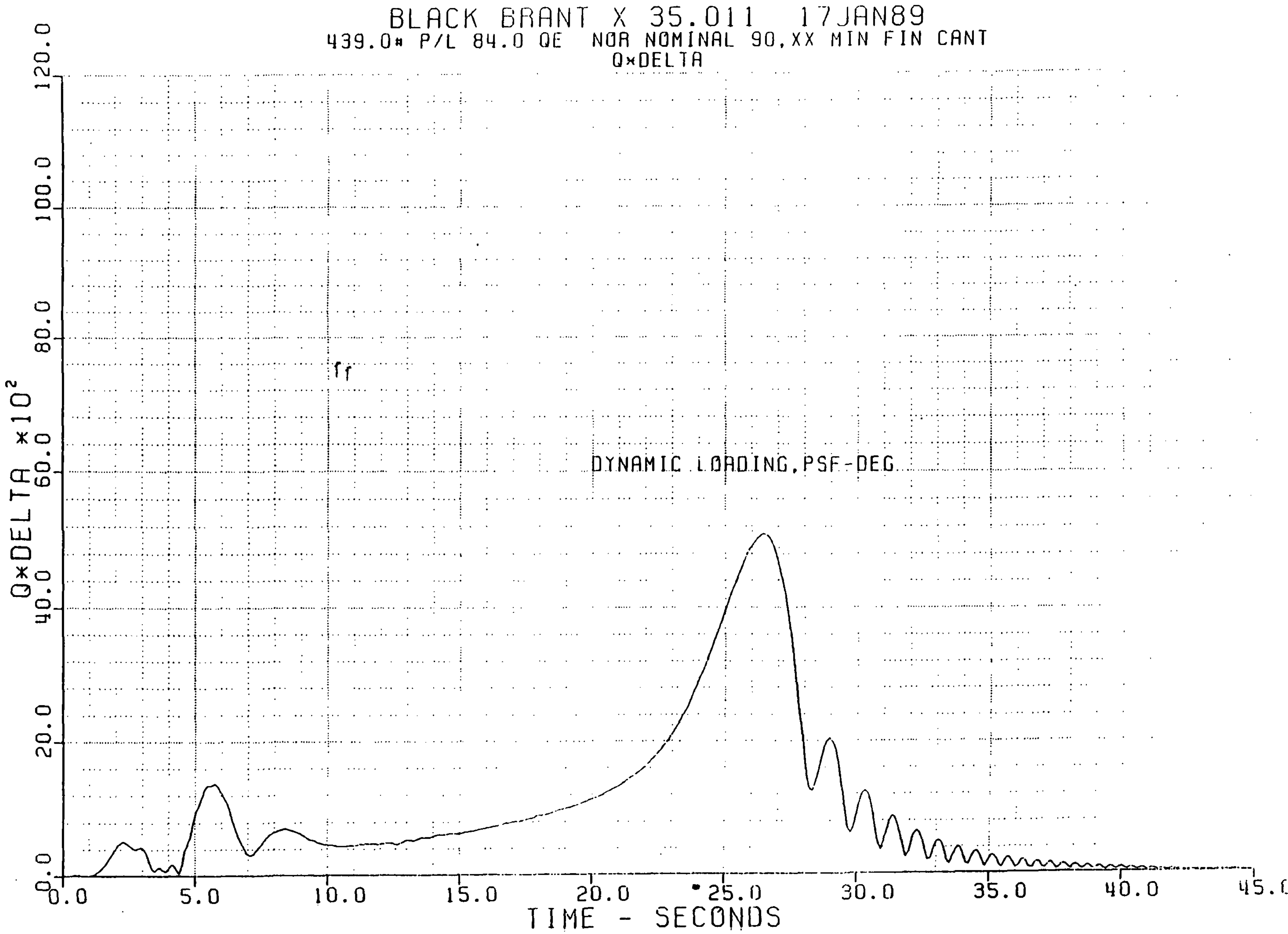


Figure 4-6. Dynamic Pressure Times Delta vs. Time

Table 4-1. Black Brant X 35.011 UE Misalignments, Offsets, and Eccentricities

LAUNCH CONFIGURATION

Thrust Misalignment:	$.2^{o}$
CG Offset in Z Axis:	+.23 in
Thrust Offset in Y Axis:	-.23 in
Thrust Offset in Z Axis:	+.23 in
Tail Misalignment:	$.2^{o}$

SECOND STAGE

Thrust Misalignment:	$.2^{o}$
CG Offset in Z Axis:	+.23 in
Thrust Offset in Y Axis:	-.23 in
Thrust Offset in Z Axis:	+.23 in
Tail Misalignment:	$.2^{o}$

Pitch/Roll Crossing Occurs at: 24.5 Sec

Pitch/Roll Crossing Frequency: 1.5 Cps

4.2.2 Despin Analysis

Source: Wallops Flight Facility Despin Program

Physical Properties/Roll-Rate Parameters: Table 4-2

Resulting Despin Weights Required (each): 119.8 grams/wt

Table 4-2. **Black Brant X 35.011 UE Despin of Payload, Physical Properties and Roll-Rate Parameters**

Initial Roll Rate:	4.0 cps
Ixx of Payload and Motor Minus Nose Cone:	4.91 sl-ft^2
Final Roll Rate:	2.04 cps
Cable Density:	0.029 lb/ft
Cable Length:	7.91 ft (1.75 wrap)
Wrap Radius:	0.713 ft
Required Despin Weight:	.2641 lb/wt (119.8 gms/wt)

Ixx Booms Stowed = 2.3 sl-ft^2

Ixx Booms Deployed = 4.7 sl-ft^2

Booms despin payload to 1 cps nominally.

Initial Roll Rate = 5 = Final = 1.25 cps

Initial Roll Rate = 3 = Final = 0.75 cps

SECTION 6 - DISPERSION ESTIMATES

6.1 THEORETICAL DISPERSION

Source: "Theoretical Dispersion Study of First, Second, and Third Stages of the Black Brant X Unguided Sounding Rocket Vehicle", Carole Flores and James Andrews, NASA/GSFC/WFF.

Nominal Apogee Altitude: 724.2 Km

2σ Apogee Altitude Dispersion (about the nominal): 52.6 Km

2σ Low Apogee Altitude: 671.6 Km

Altitude vs. Time for 2σ Low Flight: Figure 6-1

2σ Impact Range Dispersion: 299.8 Km

6.2 DATA BASE DISPERSION

Source: Data Base

Nominal Apogee Altitude: 724.2 Km

Apogee Altitude Mean Displacement: -5.8 Km

Apogee Altitude 2σ Dispersion (about the mean): 50.2 Km

2σ Low Apogee Altitude: 674 Km

Altitude vs. Time for 2σ Low Flight: Figure 6-1

Cross Range Mean Displacement: 51.2 Km
Cross Range 2σ Dispersion (about the mean): 277.0 Km

Down Range Mean Displacement: -27.4 Km
Down Range 2σ Dispersion (about the mean): 283.1 Km

Dispersion Summary for 35.XXX Vehicle Family: Appendix A

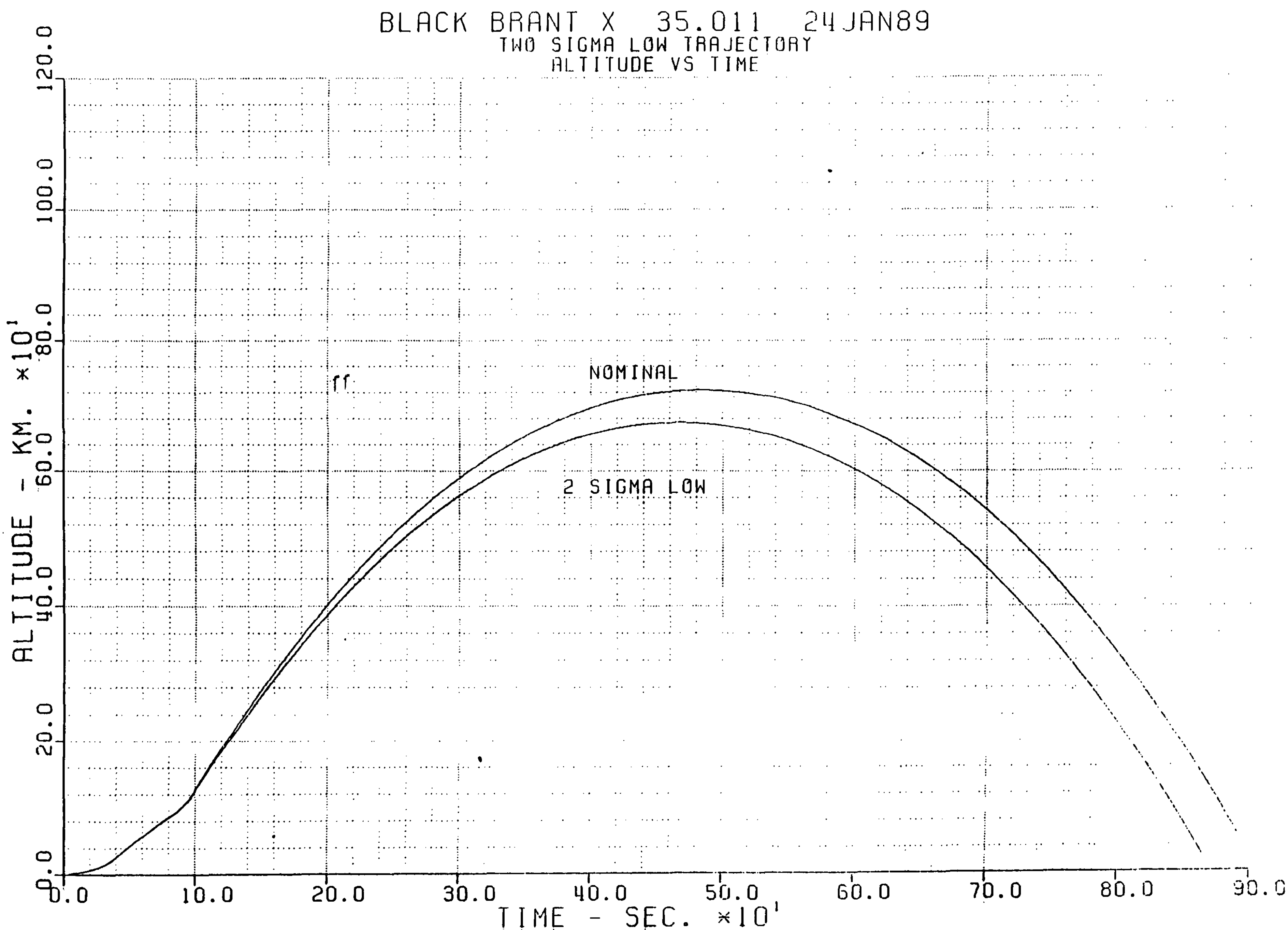


Figure 6-1. Two Sigma Low Trajectory - Altitude vs. Time

APPENDIX A

DISPERSION DATA

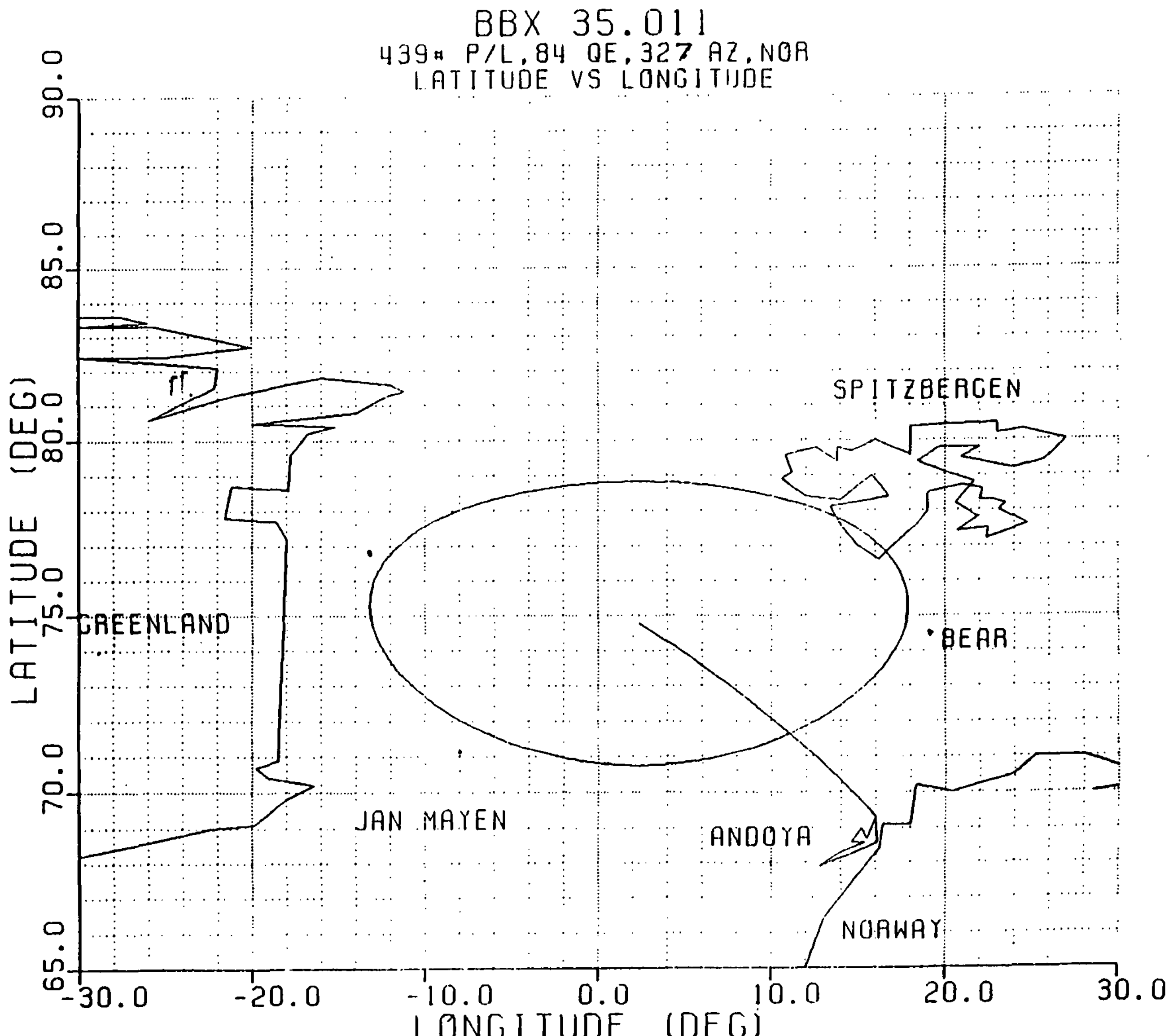


Figure A-1. Latitude vs. Longitude

Table A-1. Historical Dispersion Data for Similar Vehicles

Ø1/1Ø/89

				**** PREDICTED ****			******* FLIGHT *******				
VEHICLE NUMBER	P/L WGT. (LBS)	LAUNCH DATE	LAUNCH SITE	QE (DEG)	APOGEE ALTITUDE (KM)	IMPACT RANGE (KM)	APOGEE ALTITUDE (KM)	IMPACT RANGE (KM)	DOWN RG MISS (KM)	EFFECTIVE CROSS RG MISS (KM)	COMMENTS
35.Ø13	398.ØØ	Ø4/22/86	WI	81.Ø	679.5Ø	1Ø91.2	689.4Ø	1Ø67.Ø	-27.55	-83.59	
35.Ø14	767.ØØ	Ø5/13/86	WI	85.7	425.63	371.71	4Ø3.2Ø	425.ØØ	49.2Ø6	-64.41	
35.Ø15	293.ØØ	Ø4/Ø1/86	FB	83.5	96Ø.5Ø	962.8Ø	913.4Ø	12Ø4.5	192.32	333.81	
35.Ø16	293.ØØ	Ø4/13/86	FB	83.5	96Ø.5Ø	962.8Ø	963.78	812.88	-152.6	44.36Ø	
35.Ø17	289.25	Ø1/19/88	FB	82.9	923.15	1Ø61.4	927.5Ø	1Ø8Ø.4	2.Ø8Ø	19Ø.52	
35.Ø23	26Ø.ØØ	Ø3/Ø4/88	FB	83.1	1Ø74.3	119Ø.1	11Ø7.4	823.2Ø	-371.5	1Ø5.96	

* - DENOTES VEHICLES THAT WERE NOT INCLUDED IN THE IMPACT DISPERSION
** - DENOTES VEHICLES THAT WERE NOT INCLUDED IN THE APOGEE DISPERSION
*** - DENOTES VEHICLES THAT WERE NOT INCLUDED IN APOGEE OR IMPACT DISPERSIONS
N/R - DENOTES DATA NOT RECEIVED FROM MISSION ANALYST
N/A - DENOTES DATA NOT AVAILABLE (SEE COMMENTS)

PERFORMANCE AND ANALYSIS

DESIGN REVIEW

FOR

BLACK BRANT X 35.026 UE

MARVIN C. ALTSTATT
AEROSPACE ENGINEER

JANUARY 31, 1989

ABSTRACT

This report presents the results of a preflight mission analysis on the following flight:

Name of Mission: Black Brant X 35.026 UE

Location of Launch Site: Andoya, Norway

Launcher: Universal II, 40 ft. rail travel

Proposed Date of Launch: December 1, 1989

Principal Scientific Investigator: Dr. David Winningham, SWRI

Payload Manager: Mr. John van Overeem

Purpose of Mission: Ion acceleration studies.

Estimated Payload Weight: 439 Lbs

Predicted Apogee for Flight: 721.7 Km

Predicted Ballistic Impact Range for Flight: 782.1 Km

Minimum Rigid Static Margin for Flight and Time of Occurrence: 4.8 cal or 83 in at 0 sec

Aerodynamic Heating Index: 1.68×10^8 ft-lb/ft^2

Apogee-Altitude 2σ Dispersion: 50.0 Km

2σ Low Apogee Altitude: 671.7 Km

Impact-Range 2σ Dispersion: 265.4 Km

The comprehensive success criteria is 400 Km horizontal travel above 500 Km altitude. This is met by the nominal trajectory. The minimum success criteria is 200 Km above 500 Km altitude which is met by the 2σ deviation from the nominal trajectory.

SECTION 2 - LAUNCH VEHICLE DESCRIPTION

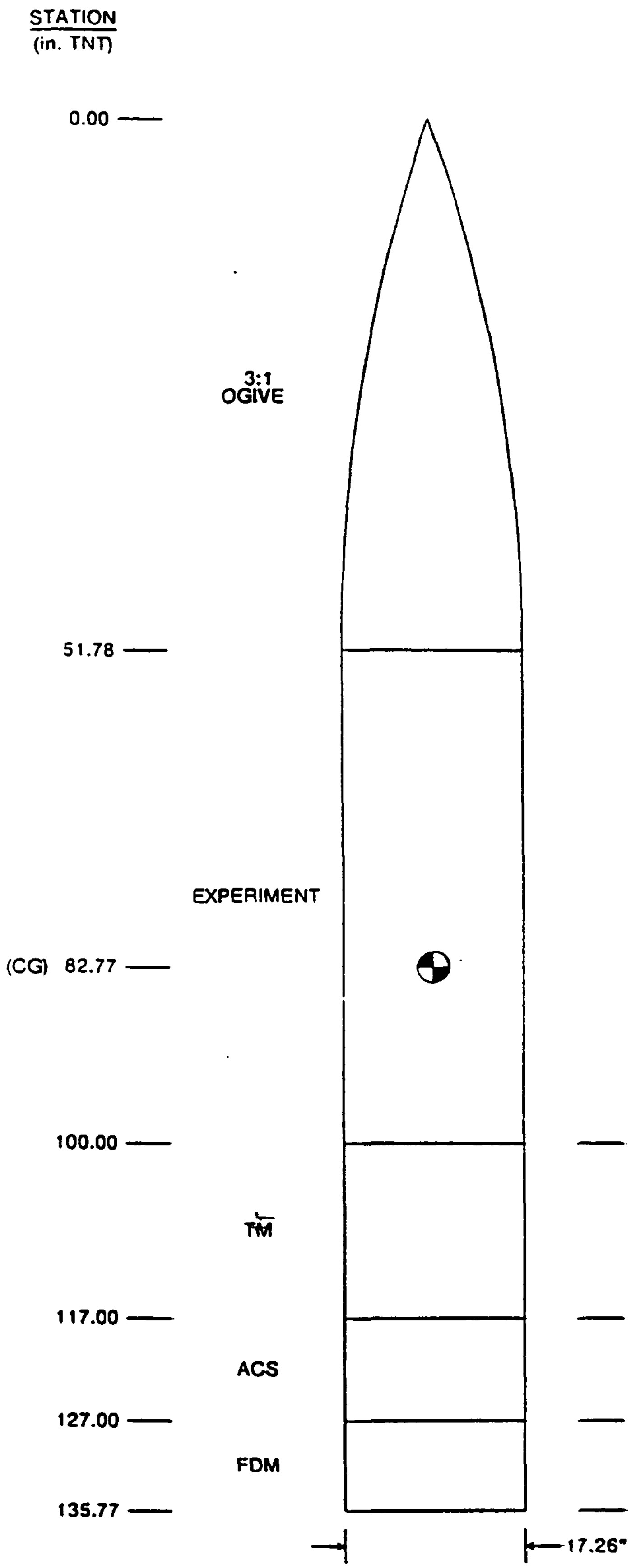
2.1 VEHICLE CONFIGURATION

Payload Configuration: Figure 2-1

Launch Configuration: Figure 2-2

2.2 PHYSICAL PROPERTIES

Payload/Vehicle Physical Properties: Table 2-1



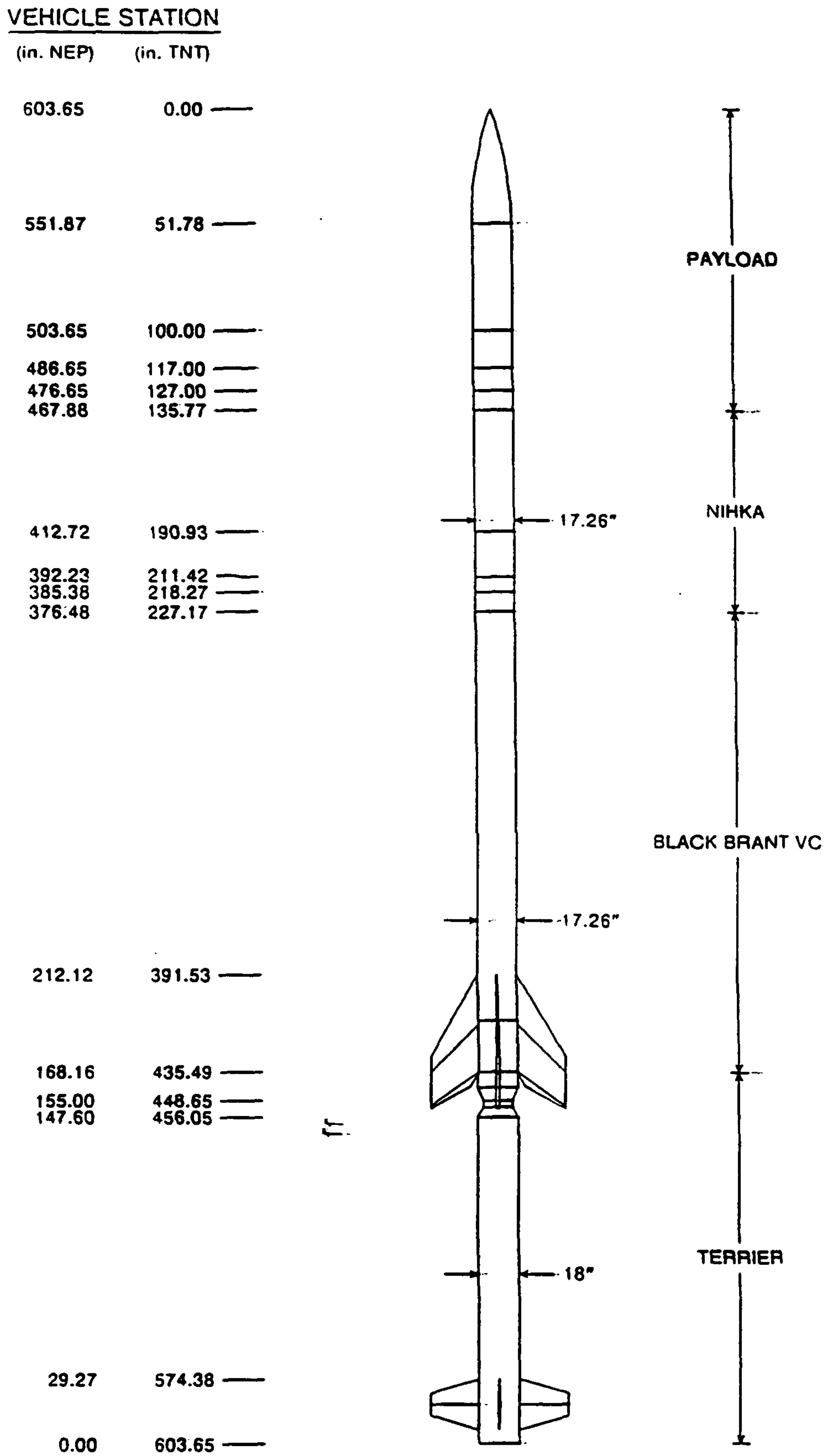
PAYLOAD GRAVIMETRICS

Weight	-	439.00	lb.
Length	-	135.77	in.
CG	-	82.77	in. TNT
IX	-	3.00	slug-ft^2
IY	-	120.00	slug-ft^2

STATION	JOINT TYPE	COMPLIANCE (rad/in-lb.)	SLOP (rad.)
100.00	V-BAND	9.00×10^{-9}	0.00
117.00	RADAX	9.00×10^{-9}	0.00
127.00	V-BAND	9.00×10^{-9}	0.00
135.77	V-BAND	9.00×10^{-9}	0.00

BLACK BRANT X 35.026 UE WINNINGHAM

Payload Configuration



BBX 35.026 UE 9JAN89

Launch Configuration

* * * P H Y S I C A L   P R O P E R T I E S   P R O G R A M - Rev 1.0 * * * 01/25/89 12.713

****
* PHYSICAL PROPERTIES SUMMARY * BLACK BRANT X
****

BBX 35.026

PAYLOAD WEIGHT = 439.00 lb.
LENGTH = 135.77 in.
CG = 53.00 in. from p/l base
IY = 120.00 slug-ft^2
IX = 3.00 slug-ft^2

PHYSICAL PROPERTIES - LAUNCH CONFIGURATION
total length = 603.65 inches

TIME (sec)	TOT. WT. (lb.)	CG (in nep)	CG (ft nep)	CG (in nose)	CG (ft nose)	IYY (sl-ft^2)	IXX (sl-ft^2)
.00	6113.11	258.38	21.53	345.27	28.77	23669.94	73.85
1.00	5844.70	266.34	22.20	337.31	28.11	26789.65	71.81
2.00	5576.29	275.14	22.93	328.51	27.38	24697.74	69.76
3.00	5307.88	284.83	23.74	318.82	26.57	22420.00	67.72
4.00	5039.47	295.57	24.63	308.08	25.67	19876.70	65.68
4.40	4932.02	300.23	25.02	303.42	25.29	18780.80	64.86

PHYSICAL PROPERTIES - SECOND STAGE
total length = 435.49 inches

TIME (sec)	TOT. WT. (lb.)	CG (in nep)	CG (ft nep)	CG (in nose)	CG (ft nose)	IYY (sl-ft^2)	IXX (sl-ft^2)
12.00	4174.66	171.45	14.29	264.04	22.00	9325.44	44.15
14.00	4025.26	173.40	14.45	262.09	21.84	9145.05	43.71
16.00	3877.66	175.52	14.63	259.97	21.66	8944.43	43.27
18.00	3727.16	177.74	14.81	257.75	21.48	8758.03	42.55
20.00	3576.16	180.28	15.02	255.21	21.27	8549.25	41.84
22.00	3423.66	183.02	15.25	252.47	21.04	8317.75	40.83
24.00	3267.76	186.19	15.52	249.30	20.77	8095.30	39.83
26.00	3111.76	189.60	15.80	245.89	20.49	7842.62	38.53
28.00	2958.56	193.30	16.11	242.19	20.18	7568.51	37.24
30.00	2809.86	197.18	16.43	238.31	19.86	7333.70	35.74
32.00	2664.16	201.63	16.80	233.86	19.49	6995.14	34.24
34.00	2519.86	206.27	17.19	229.22	19.10	6706.70	32.53
36.00	2377.16	211.79	17.65	223.70	18.64	6356.10	30.83
38.00	2236.56	217.33	18.11	218.16	18.18	6026.25	28.97
40.00	2102.76	224.06	18.67	211.43	17.62	5618.98	27.11
42.00	1994.96	228.58	19.05	206.91	17.24	5393.84	25.85
44.00	1933.36	233.14	19.43	202.35	16.86	5118.28	24.59
45.00	1929.76	233.65	19.47	201.84	16.82	5062.91	24.54

PHYSICAL PROPERTIES - THIRD STAGE
total length = 211.42 inches

TIME	TOT. WT.	CG	CG	CG	CG	IYY	IXX

(sec)	(lb.)	(in nep)	(ft nep)	(in nose)	(ft nose)	(sl-ft^2)	(sl-ft^2)
82.00	1338.80	73.06	6.09	138.36	11.53	624.20	11.20
86.00	1201.16	75.73	6.31	135.69	11.31	596.69	10.92
90.00	1033.88	80.17	6.68	131.25	10.94	555.49	10.19
94.00	862.06	86.59	7.22	124.83	10.40	500.03	8.90
98.00	687.52	96.77	8.06	114.65	9.55	415.05	6.82
99.80	630.10	101.09	8.42	110.33	9.19	380.45	5.31

THIS REFLECTS BBVC, NIHKA II, AND INTERSTAGE WEIGHTS PER B.A.L. LETTER DATED 21 FEB 1986. INTERSTAGE LENGTH PER WFF MEASUREMENTS. 5-14-87/MSS

SECTION 3 - VEHICLE PERFORMANCE

3.1 PERFORMANCE ANALYSIS RESULTS

Source: GEM 5-D

Launch Parameters: Payload Weight: 439 Lbs
After Nose Cone Separation: 386 Lbs
Launch Angles: 84^{o} - 0E, 283^{o} AZ
Launcher: Universal II, 40 ft. rail travel
Launcher Latitude: 69.294186 Longitude: 16.020680

3.1.1 Nominal Trajectory

Nominal Events Sequence at Key Points of Flight: Table 3-1

Nominal Vehicle Performance: Figures 3-1 through 3-9

Apogee Altitude: 721.7 Km

Time at Apogee Altitude: 484 Sec

Ballistic Impact Range: 782.1 Km

Time at Ballistic Impact: 907 Sec

3.1.2 Aerodynamic Heating Index

Aerodynamic Heating Index: 1.68×10^{8} ft-lb/ft^{2}

3.1.3 Drag Separation Analysis

Drag Separation Analysis: Table 3-2

Source: DRGSEP - Drag Separation Analysis Program

3.1.4 Experimenter's Success Criteria

The comprehensive success criteria is 400 Km horizontal travel above 500 Km altitude. This is met by the nominal trajectory. The minimum success criteria is 200 Km above 500 Km altitude which is met by the 2σ deviation from the nominal trajectory.

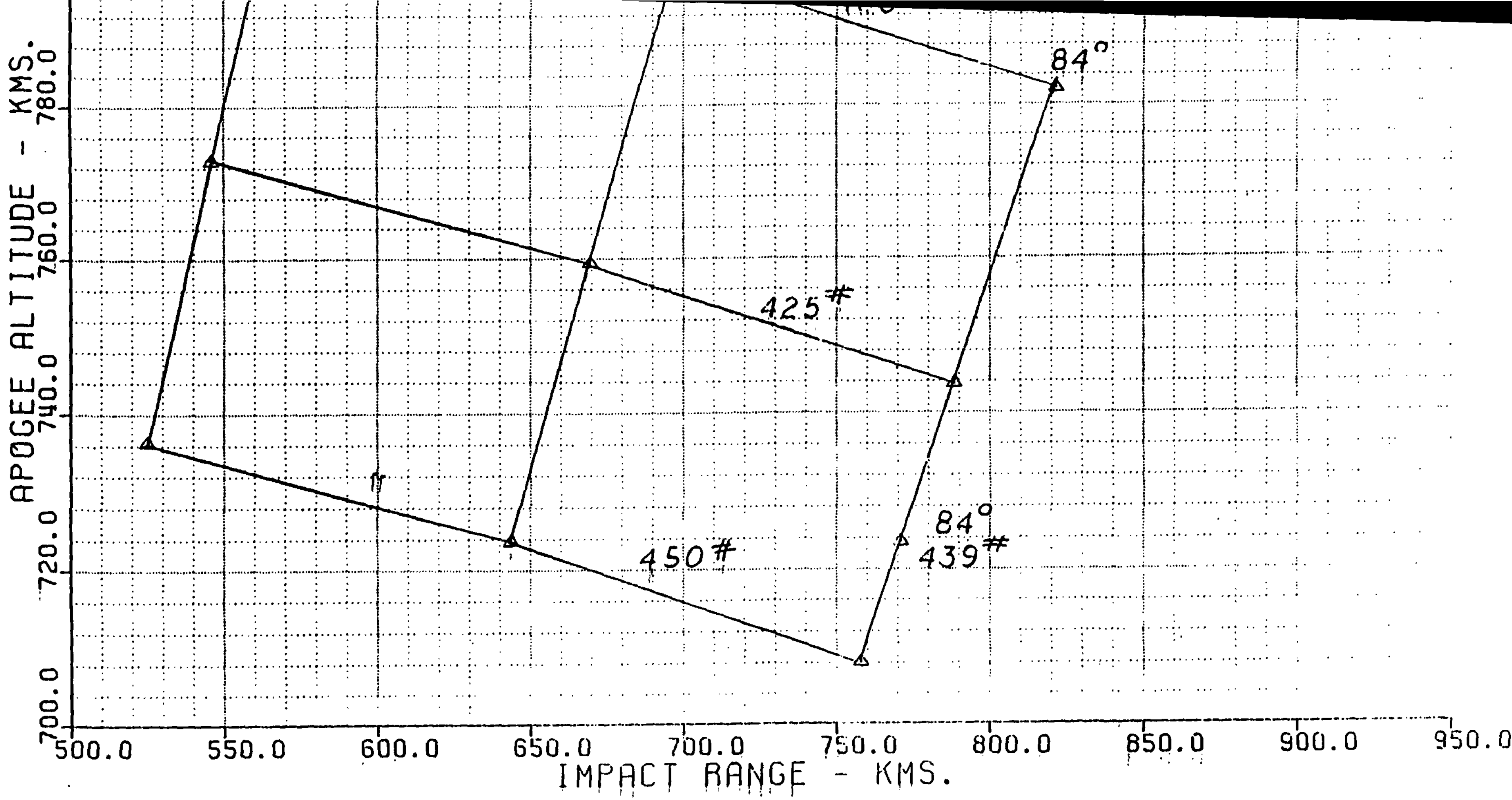
Table 3-1. Black Brant X 35.026 UE
Nominal Sequence of Events

439 lb. p/l, 84° QE, 283° AZ, Norway

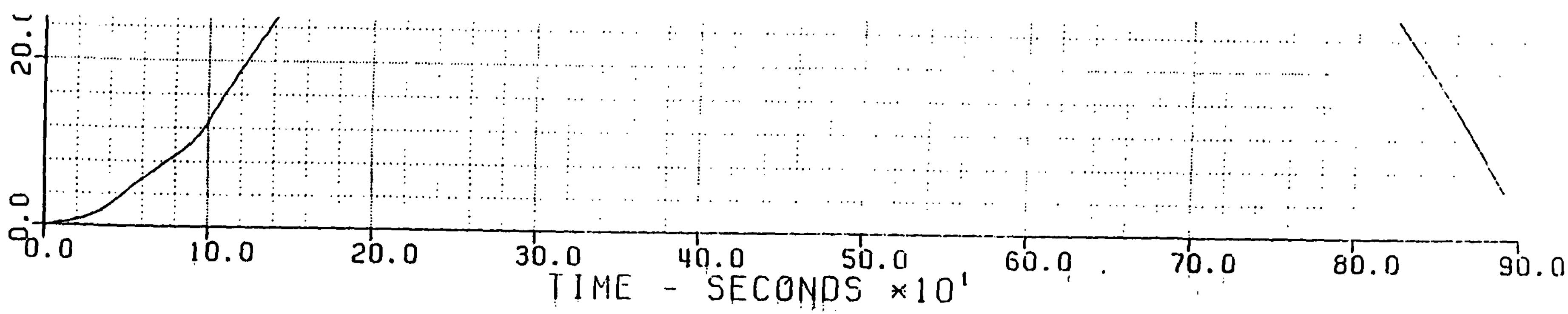
Event	Time (Sec)	Altitude (Km)	Range (Km)	Velocity (Mps)	Mach No.	Q (Psf)	Fl.El. (Deg)
Liftoff	0.00	0.0	0.0	0.3	.0	0.0	90.00
Terrier Burnout	4.40	0.8	0.1	402.0	1.2	1904.1	83.01
BBVC Ignition	12.00	3.5	0.5	297.8	.9	802.2	81.31
BBVC Burnout	44.42	33.5	6.9	1721.5	5.6	328.5	76.62
Nose Cone Eject	69.00	71.7	16.6	1485.9	5.1	1.6	74.52
Nose Cone Sidekick	71.50	75.2	17.6	1462.8	5.2	.9	74.27
BBVC-Nihka Separation	78.00	84.2	20.2	1402.9	5.2	.2	73.59
Nihka Ignition	82.00	89.5	21.7	1366.2	5.1	.1	73.14
Nihka Burnout	100.14	128.0	33.8	3351.5	12.4	.0	71.97
DCEF Cable Release	103.00	137.1	36.7	3325.8	12.3	.0	71.84
DCEF Cal.	104.00	140.2	37.7	3316.9	12.3	.0	71.80
Despin	105.00	143.4	38.7	3307.9	12.3	.0	71.75
Payload Separation	110.00	159.0	43.8	3263.5	12.1	.0	71.53
DCEF Boom Deploy	113.00	168.2	46.8	3236.9	12.0	.0	71.39
Experiment Backup Pwr On, DIFP ON	113.00	168.2	46.8	3236.9	12.0	.0	71.39
S/P Release	116.00	177.4	49.9	3210.4	11.9	.0	71.25
DCM Strap Release	116.00	177.4	49.9	3210.4	11.9	.0	71.25
ACLP Cal., Scan	117.00	180.5	50.9	3201.5	11.9	.0	71.20
DCM Spring Release	119.00	186.5	52.9	3184.0	11.8	.0	71.11

Table 3-1.
(Continued)

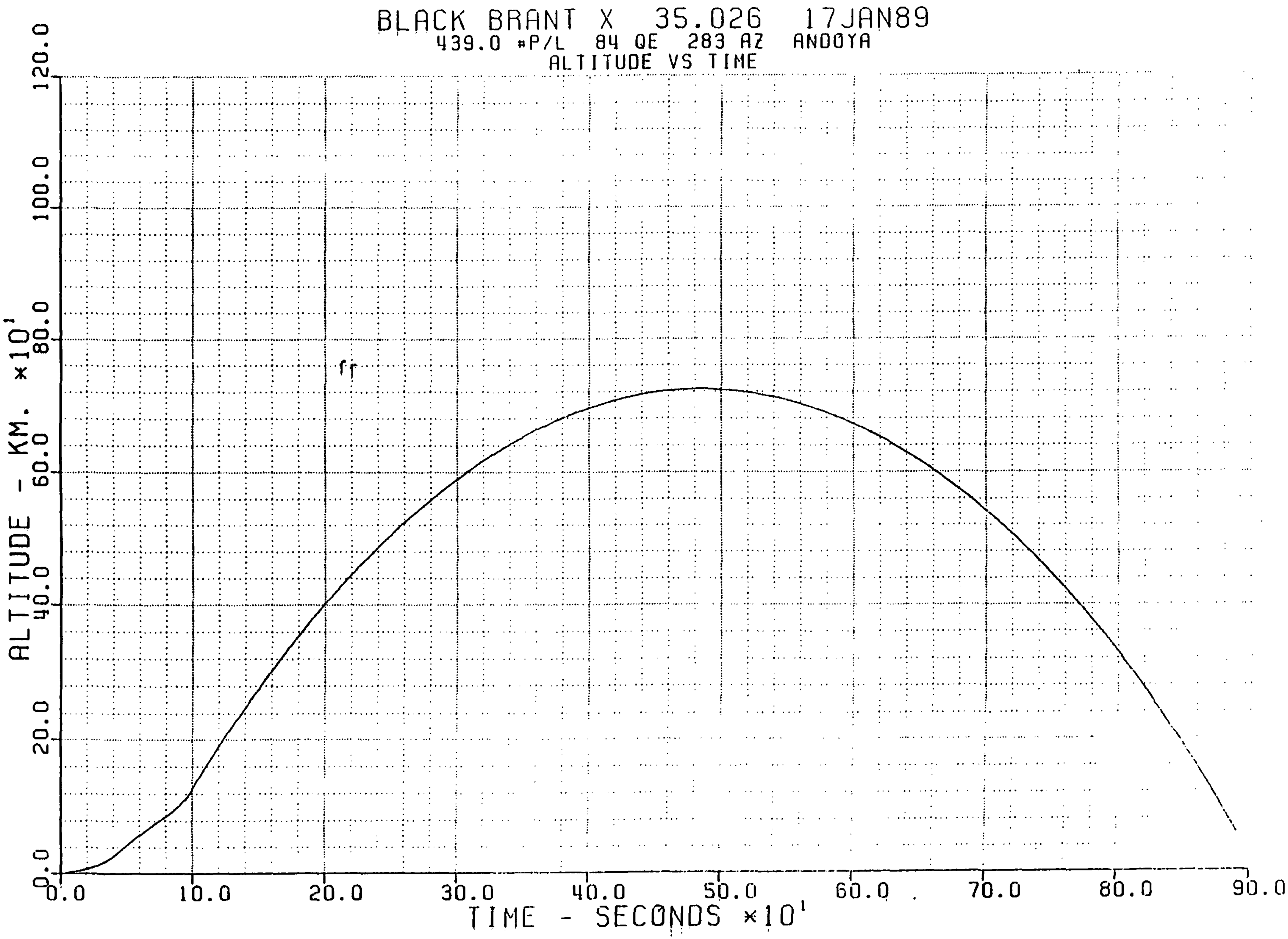
Event	Time (Sec)	Altitude (Km)	Range (Km)	Velocity (Mps)	Mach No.	Q (Psf)	Fl.El. (Deg)
Experiment HV On, SPS & DIFP Deploy	120.00	189.6	53.9	3175.2	11.8	.0	71.06
ACLP, ACEF, ACM Boom Deploy	120.00	189.6	53.9	3175.2	11.8	.0	71.06
ACEF & ACM Antenna Deploy	124.00	201.5	57.9	3140.2	11.7	.0	70.86
ACS #1 On	127.00	210.3	60.9	3114.1	11.6	.0	70.71
ACS #1 Off	177.00	346.0	109.9	2692.3	10.0	.0	67.86
Apogee	483.78	721.7	388.5	979.2	3.6	.0	0.00
ACS #2 On	514.30	718.0	415.4	1008.4	3.7	.0	-13.73
ACS #2 Off	563.00	697.0	458.4	1162.2	4.3	.0	-32.39
3rd Stage Ballistic Impact	907.00	0.2	782.1	--	--	--	-73.66

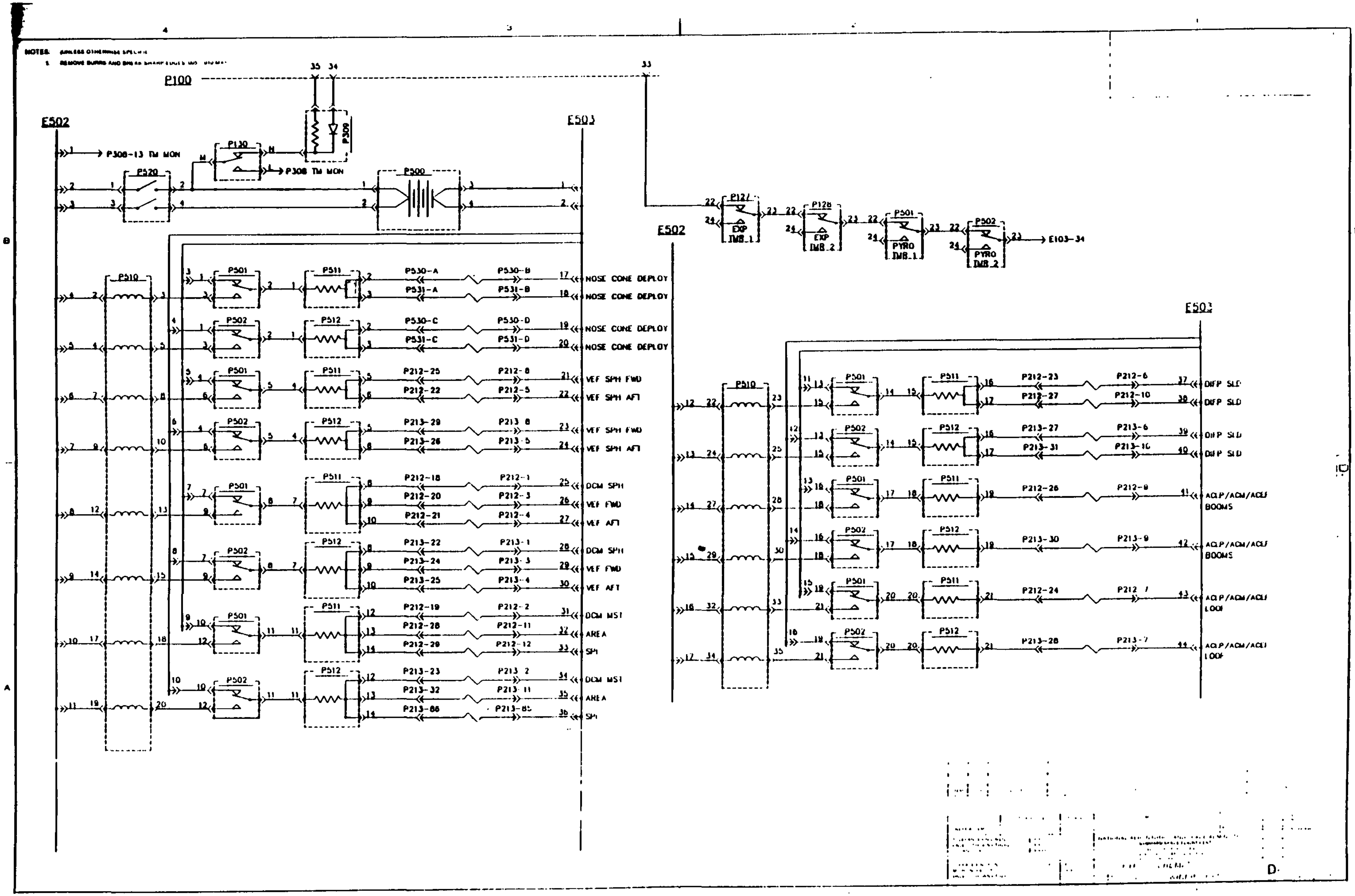


84°
425#
450#
84°
439#
APOGEE ALTITUDE - KMS.
700.0
720.0
740.0
760.0
780.0
500.0
550.0
600.0
650.0
700.0
750.0
800.0
850.0
900.0
950.0
IMPACT RANGE - KMS.

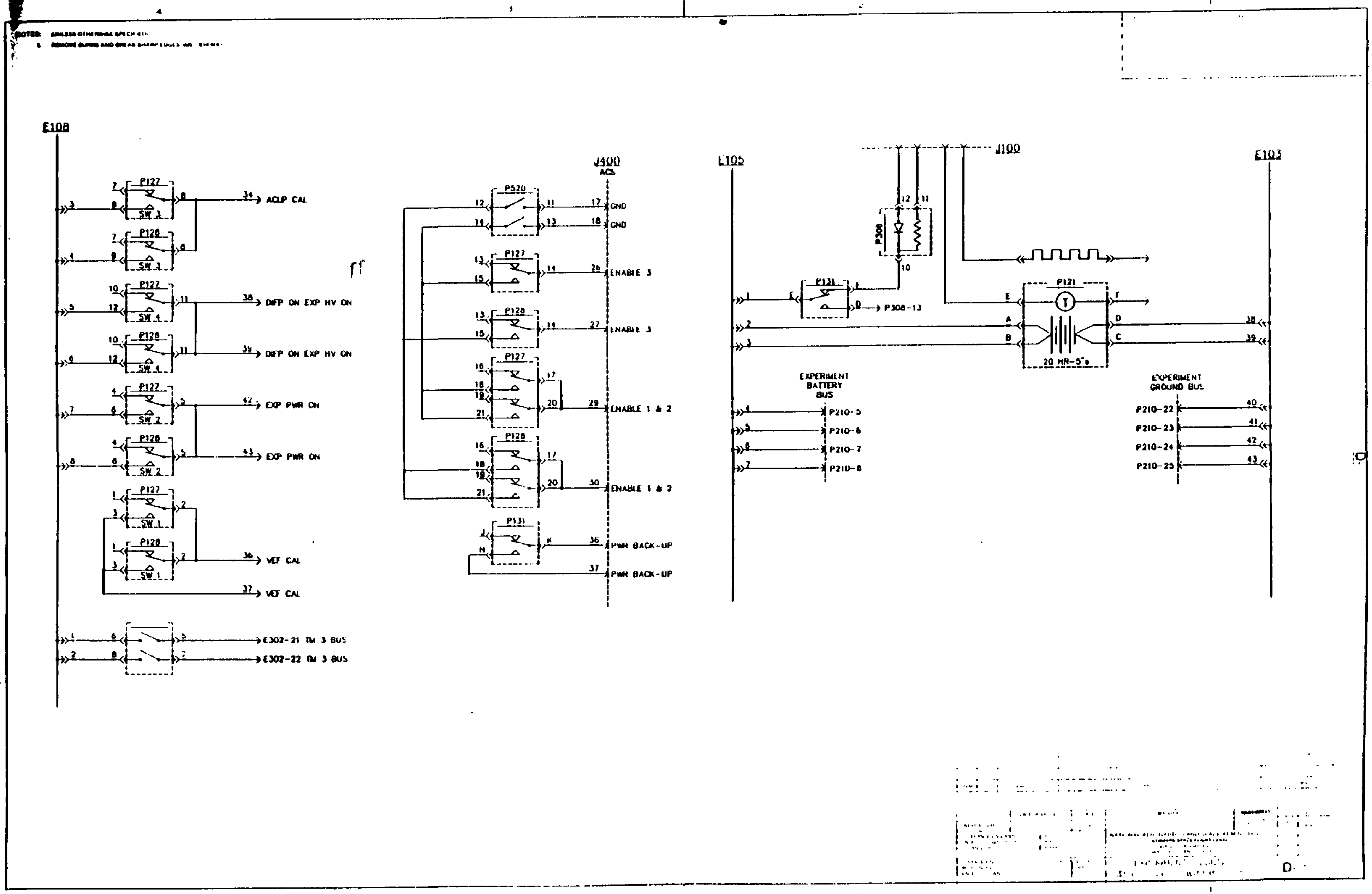


0.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
TIME - SECONDS ×10¹


BLACK BRANT X 35.026 17JAN89
439.0 #P/L 84 QE 283 AZ ANDOYA
ALTITUDE VS TIME
ALTITUDE - KM. ×10¹
TIME - SECONDS ×10¹
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
120.0



NOTES:
P100
E502
E503
P308-13 TM MON
P308 TM MON
P130
P309
P520
P500
P510
P501
P502
P511
P512
P530-A
P530-B
P531-A
P531-B
P530-C
P530-D
P531-C
P531-D
NOSE CONE DEPLOY
VEF SPH FWD
VEF SPH AFT
DCM SPH
VEF FWD
VEF AFT
DCM MST
AREA
SPI
P127
P128
EXP IMB.1
EXP IMB.2
PYRO IMB.1
PYRO IMB.2
E103-34
DIFP SLD
ACLP/ACM/ACLI BOOMS
ACLP/ACM/ACLI LOOP



NOTES: UNLESS OTHERWISE SPECIFIED
E108
P127
SW 3
P128
SW 4
SW 2
SW 1
ACLP CAL
DIFP ON EXP HV ON
EXP PWR ON
VEF CAL
E302-21 TM 3 BUS
E302-22 TM 3 BUS
J400
ACS
P520
P131
GND
ENABLE 3
ENABLE 1 & 2
PWR BACK-UP
E105
J100
P308
P308-13
P121
20 HR-5°s
E103
EXPERIMENT BATTERY BUS
P210-5
P210-6
P210-7
P210-8
EXPERIMENT GROUND BUS
P210-22
P210-23
P210-24
P210-25

MAGNETIC CONTROL SYSTEM

DICK MATTHEWS

JANUARY 31, 1989

COMPUTER SCIENCES CORPORATION

APPLIED TECHNOLOGY DIVISION 804, 824-5671

ROUTE 175 AT ROUTE 798 WALLOPS ISLAND, VIRGINIA 23337

January 12, 1989

TO: Design Review Chairman

FROM: Richard P. Matthews, CSC/ACGS

SUBJECT: Design Review 35.011/Winningham

Two magnetic ACS systems are to be flown from Norway in November of 1989. Each system is to align the vehicle with the negative magnetic field line. That is, to point the nose of the vehicle toward the South Magnetic Pole along the field line. The maneuvers are to be done early in flight - there will be boom deployments during maneuvering. There will be fixed time intervals for the maneuvers provided by the TM timer, instead of a deadband controller. There will be an initial pitch maneuver and an update near apogee. There will be only the initial roll maneuver. The telemetry timer will provide the timing for the maneuvers.

The ACS package consists of a pneumatics and an electronic section and is self contained. The pneumatics section consists of a high pressure gas vessel (nitrogen gas is to be used), and the required solenoid valves, nozzles, pressure regulator, and monitoring transducers. The electronics system, which provides driving signals to the solenoid valves, consists of a battery power system, a three axis magnetometer, a single axis rate gyro, and associated electronic cards.

The magnetometer and rate gyro provide servo input signals. The electronic servo system "precesses" the spinning vehicle to the desired attitude by properly timed and phased gas jets. The timing and phasing have been determined and will be verified by "operational" air bearing tests.

Sensor orientation can be seen in Figure I. The electronic system block diagram is Figure II.

R.P. Matthews

Richard P. Matthews, AGCS

PRELIMINARY

35.011 Winningham Gas Budget

Given:

1. Worse case cone (ha) expected at ACS turnon of 10 degrees

2. Maximum misalignment to field angle of 30 degrees

3. Roll dispersion of .75 to 1.25 RPS

4. Tank pressure of 4060psia and regulator pressure set to give valve inlet pressure of 300psia. Orifice to be .056 in.

5. In the beginning control configuration;

   Pitch Moment of Inertia = 76 Slug-ft^2

   Roll Moment of Inertia = 4.8 Slug-ft^2

   Ratio = 76/4.8 = 15.8

   Pitch Moment Arm = 3.5 ft

$$\text{Mass} = \frac{4060\ \text{lbf/IN}^2 \times 140\ \text{IN}^3 \times \text{ft}}{1.05 \times 55.15\ \text{ft-lbf/lbm-}{}^0\text{R} \times 560\ {}^0\text{R} \times 12\ \text{in}} = 1.46\ \text{lbm}$$

At 300psia Mass =(300 x 140)/(55.15x560x12) = 0.11 lbm

Impulse available = (1.46 - 0.11)65 = 87.8 lbf-sec

Assuming that a Pitch transverse acceleration of $2.8^0/\text{sec}^2$ is confirmed by air bearing runs

Thrust required is

$$\text{Lbf} = 76\text{Slug-Ft}^2/3.5\text{Ft} \times 2.8^0/\text{sec}^2 \times 3.1416/180\ \text{deg}$$

Thrust = 1.1 lbf

Assuming a 26.8 second pointing maneuver, again confirmed by air bearing runs

Impulse required is then 1.1lbf x 20 sec valves = 22 lbf-sec for the pitch maneuver.

Assuming an initial roll rate of 1.25 RPS and a roll CCW thrust of 3.14 lbf,

$$\text{Accel} = (3.14 \times .75/4.7) \times 180/3.1416 = 28.7 \text{ deg/sec}^2$$

$$\text{Time} = (450 - 360)/28.7 = 3.1 \text{ sec}$$

Allowing a factor of two for roll valve cycling

$$\text{Impulse} = 3.14 \times 3.1 \times 2 = 19.5 \text{ lbf-sec}$$

Total impulse required equals

$$22 + 19.5 = 41.5 \text{ lbf-sec}$$

Safety margin for flight is then

$$(87.8/41.5) - 1 = 1.12 \text{ or } 112 \text{ percent.}$$

Schematics are attached.

ELECTRONIC COMPONENTS

Delvelco 3-Axis Magnetometer Model #9200C

Wallops Rate Gyro Package using a Honeywell GN90C1 Rate Gyro

Electronic Control Cards of Wallops Manufacture

Battery Pack of Wallops Manuf, 24 Af cells at 0.8 Ampere Hours

Power Switching Relay, Potter Brumfield TL17-0624

ENVIRONMENTAL TESTING

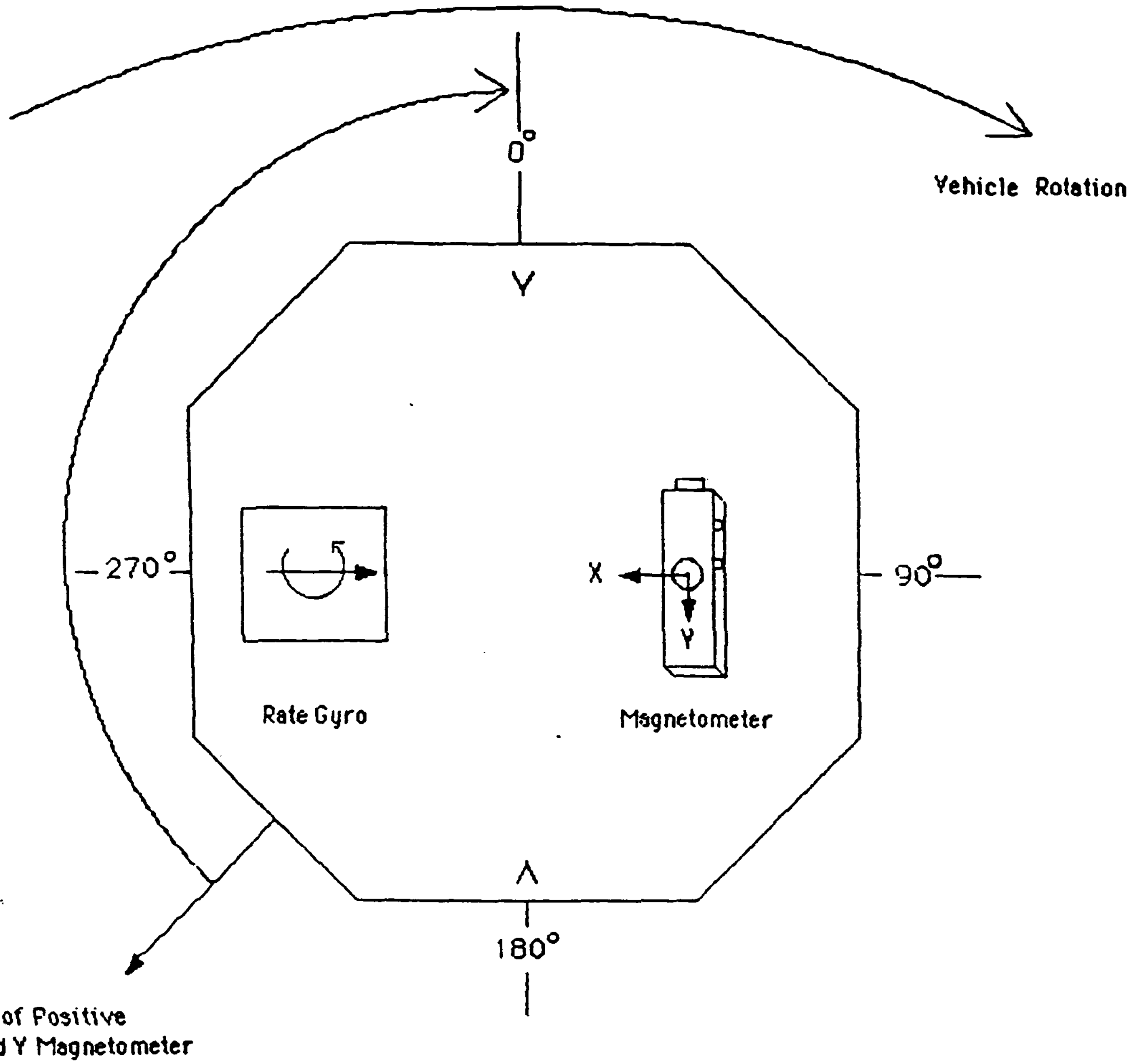
All spares will be tested for function.

All spare electronic components will be vibrated to "spares" levels and retested for function and calibration.

Flight components will be vibrated with the payload and be retested for function and calibration.

Function testing will included bench testing where applicable and air bearing tests.

[illegible] 33.011



Aft Looking Forward

The motor is separated, CG is forward of the ACS. To push the payload toward the -B vector, we want to push the ACS Can towards the +B vector. This is accomplished by firing a nozzle when it is 135 degrees past the direction we want to go.

FIGURE 1

Winningham 35.011

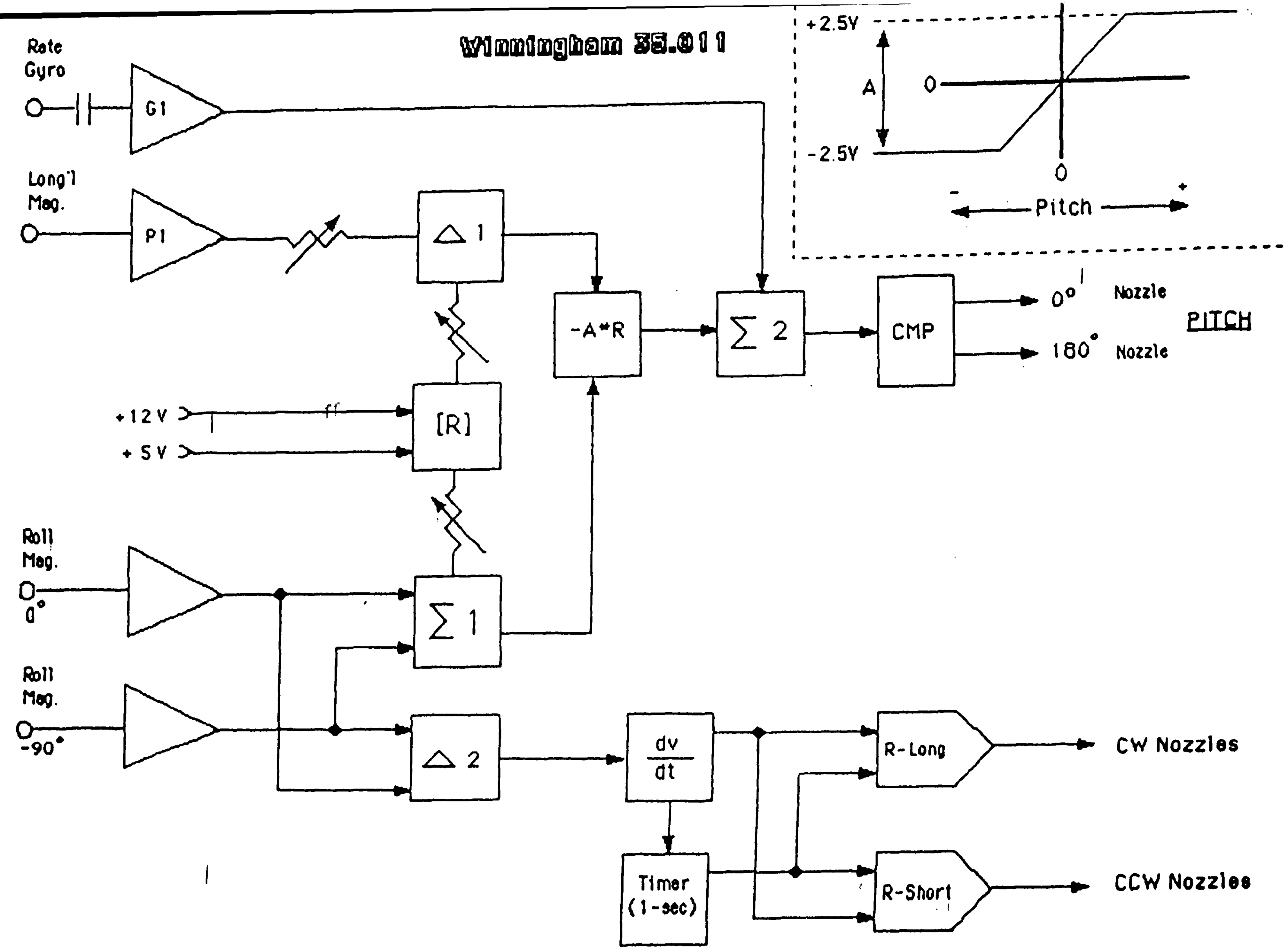
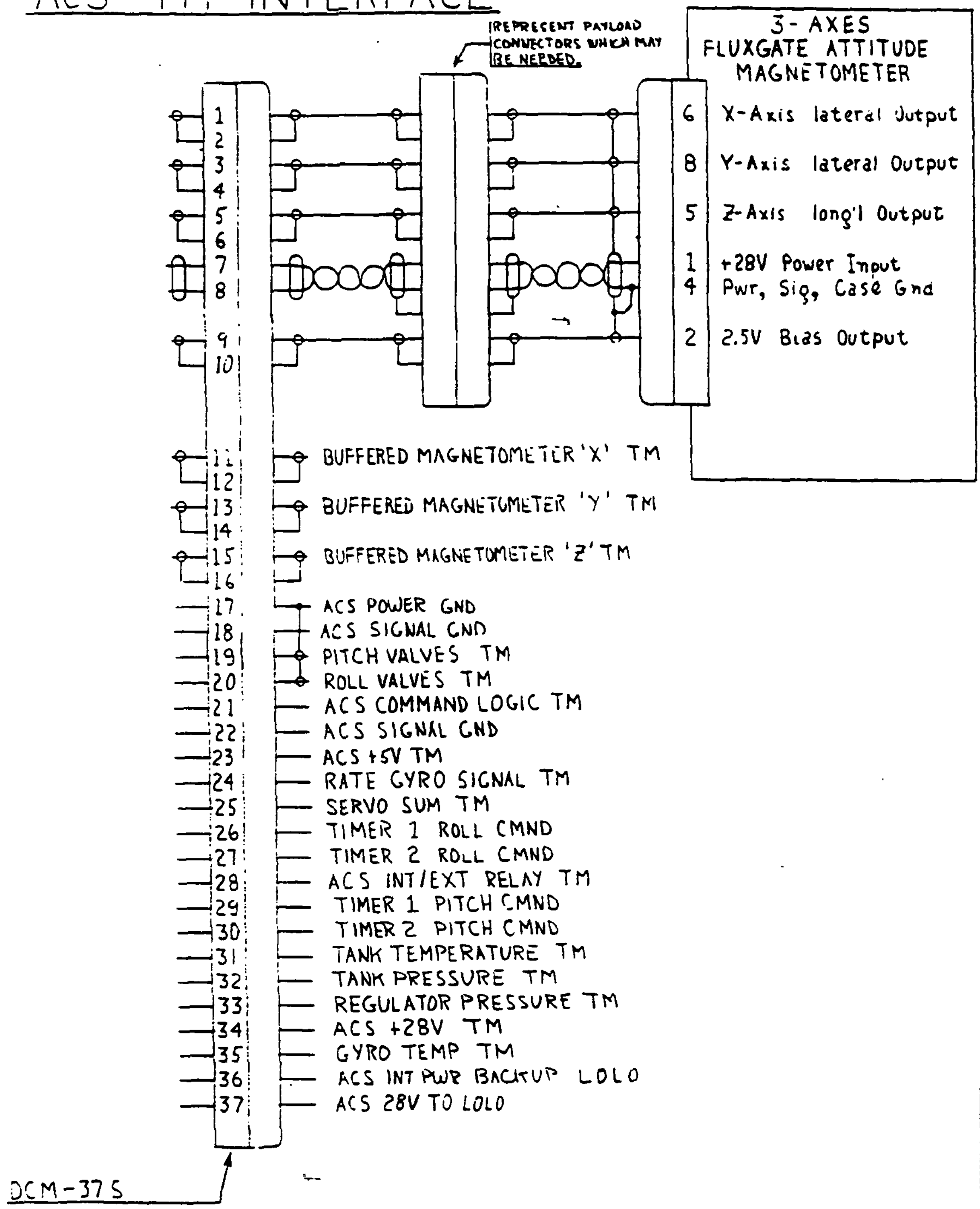


FIGURE 2

ACS-TM INTERFACE



NOTES:

1. THE SHIELDS ON THE VALVE TM MONITORS ARE PRIMARILY FOR PAYLOAD PROTECTION.
2. THE LOLO IS USUALLY A LIFT-OFF LANYARD SWITCH WHICH CLOSES PIN 36 TO PIN 37.

NOTES: UNLESS OTHERWISE SPECIFIED
1. REMOVE BURRS AND BREAK SHARP EDGES .005-.010 MAX.

DATE	LTR	REVISION	
11/23/88	A	ADD THE +28V BATT OUT ON PIN 37	RPM

MAGNETIC ACS-TM INTERFACE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA 23337

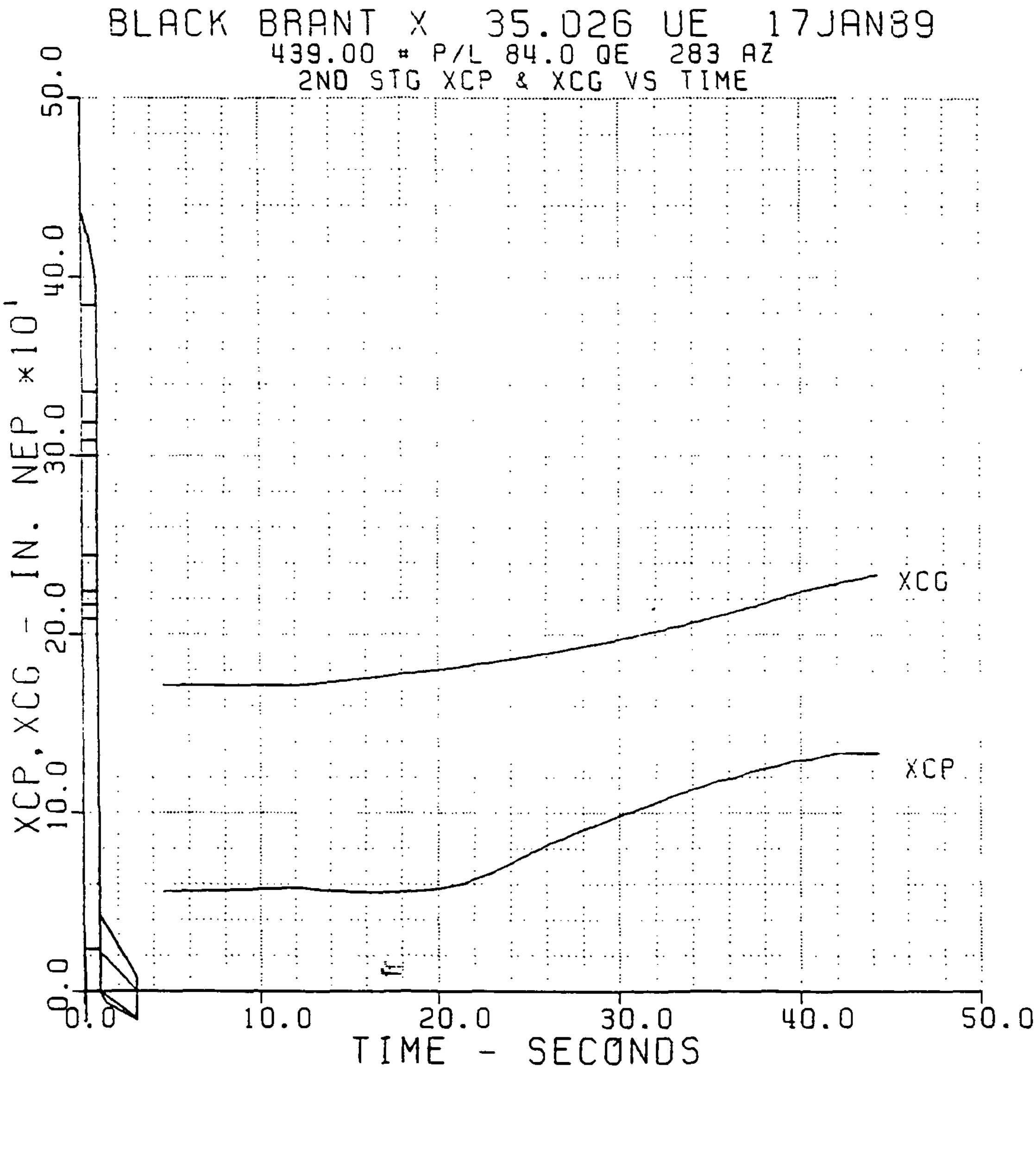
DR. RPM 11/21/88

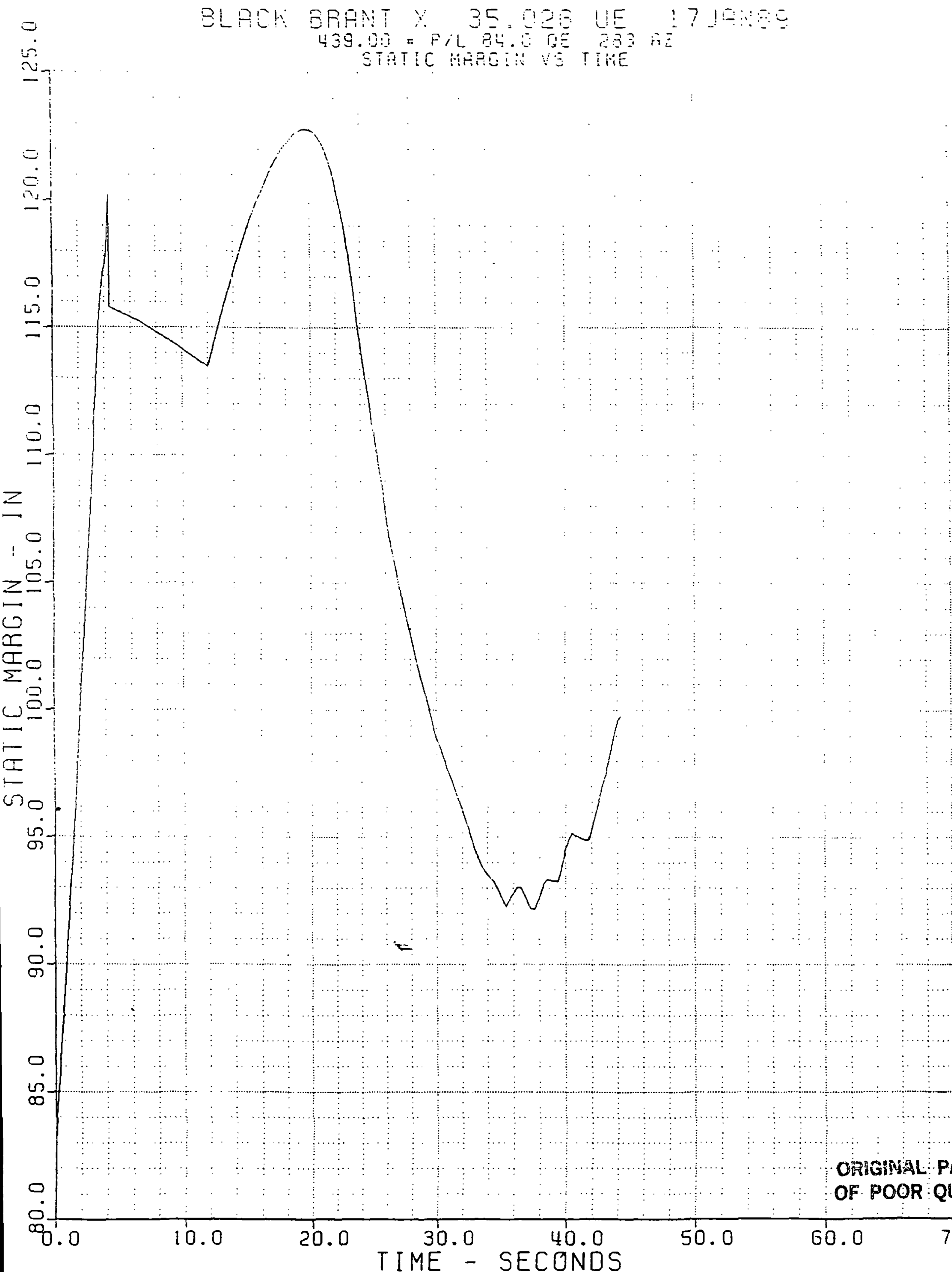
C-ACS-GEN-0072

CENTAUR II B & C SCHEDULE OF EVENTS

(PLANNED NOMINAL TIME)

		SECONDS AFTER LIFT OFF
A.	FEOS DEP	73
1.	VEF CAL. (24 SEC. HIGH OR CLOSED)	104
B.	DESPIN	107
C.	PAYLAOD DEP.	111
2.	VEF CABLE RELEASE	113
3.	VEF BOOMS DEPLOY, POWER ON PULSE, DCM STRAP RELESAE, ACLP CAL. (ACLP CAL. MUST HAVE A DURATION OF 8 SEC. OR LONGER)	115
4.	DCM BOOM DEPLOY, AREA DEPLOY	120
5.	DIFP DEPLOY, DIFP ON, SPI, SIMS & AREA HIGH VOLTAGE ON (24 SECONDS)	121
6.	ACLP, ACM & ACLP BOOMS DEPLOY	124
7.	ACEF, ACM & ACLP (2ND ANTENNA) DEPLOY	127
D.	ACS ENABLE	130
E.	ACS DISABLE	180
F.	2ND ACS ENABLE	APOGEE
G.	2ND ACS DISABLE	50 SEC LATER
H.	IMPACT	


BLACK BRANT X 35.026 UE 17JAN89
439.00 # P/L 84.0 QE 283 AZ
2ND STG XCP & XCG VS TIME
XCP, XCG - IN. NEP *10¹
TIME - SECONDS
XCG
XCP
0.0
10.0
20.0
30.0
40.0
50.0



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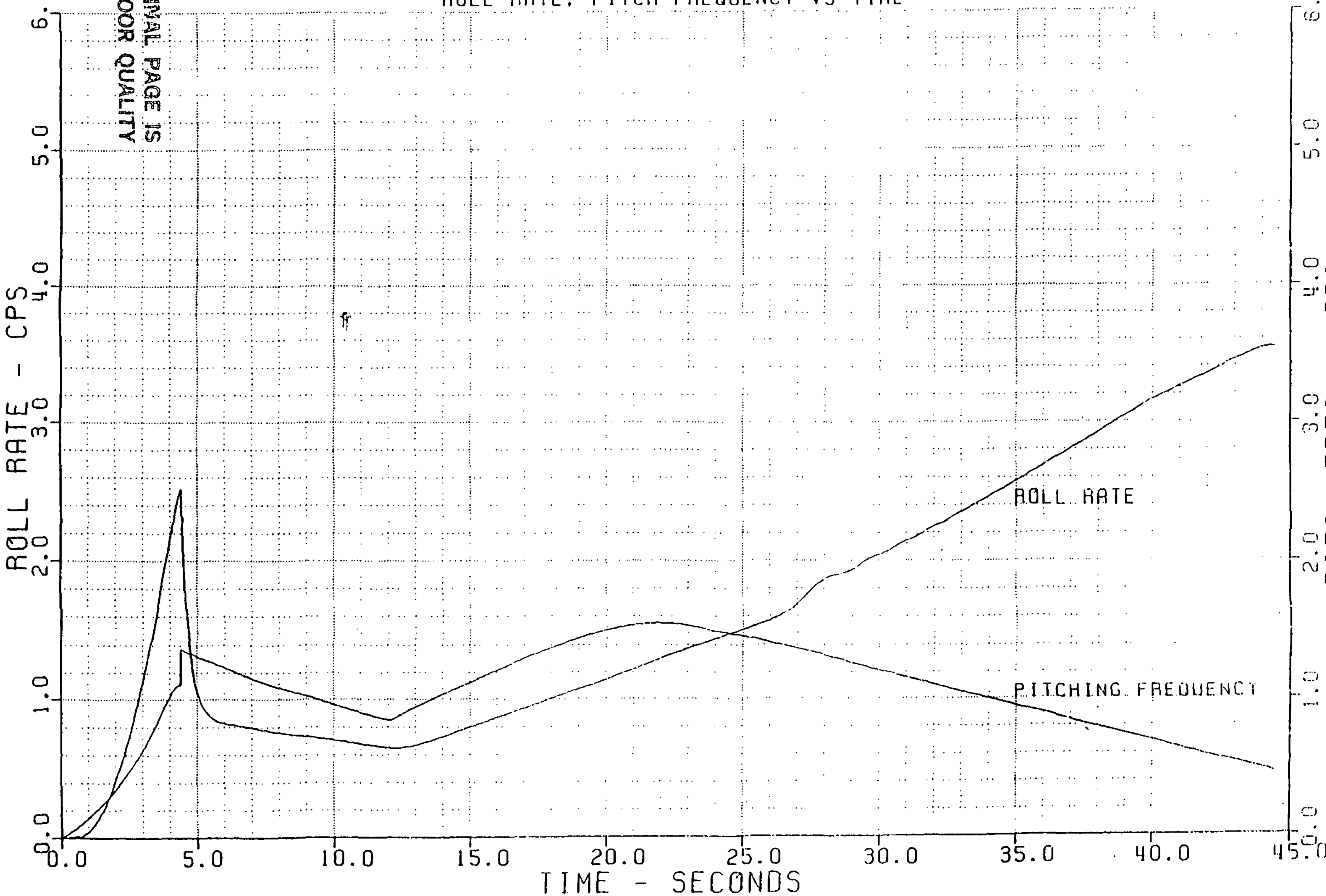
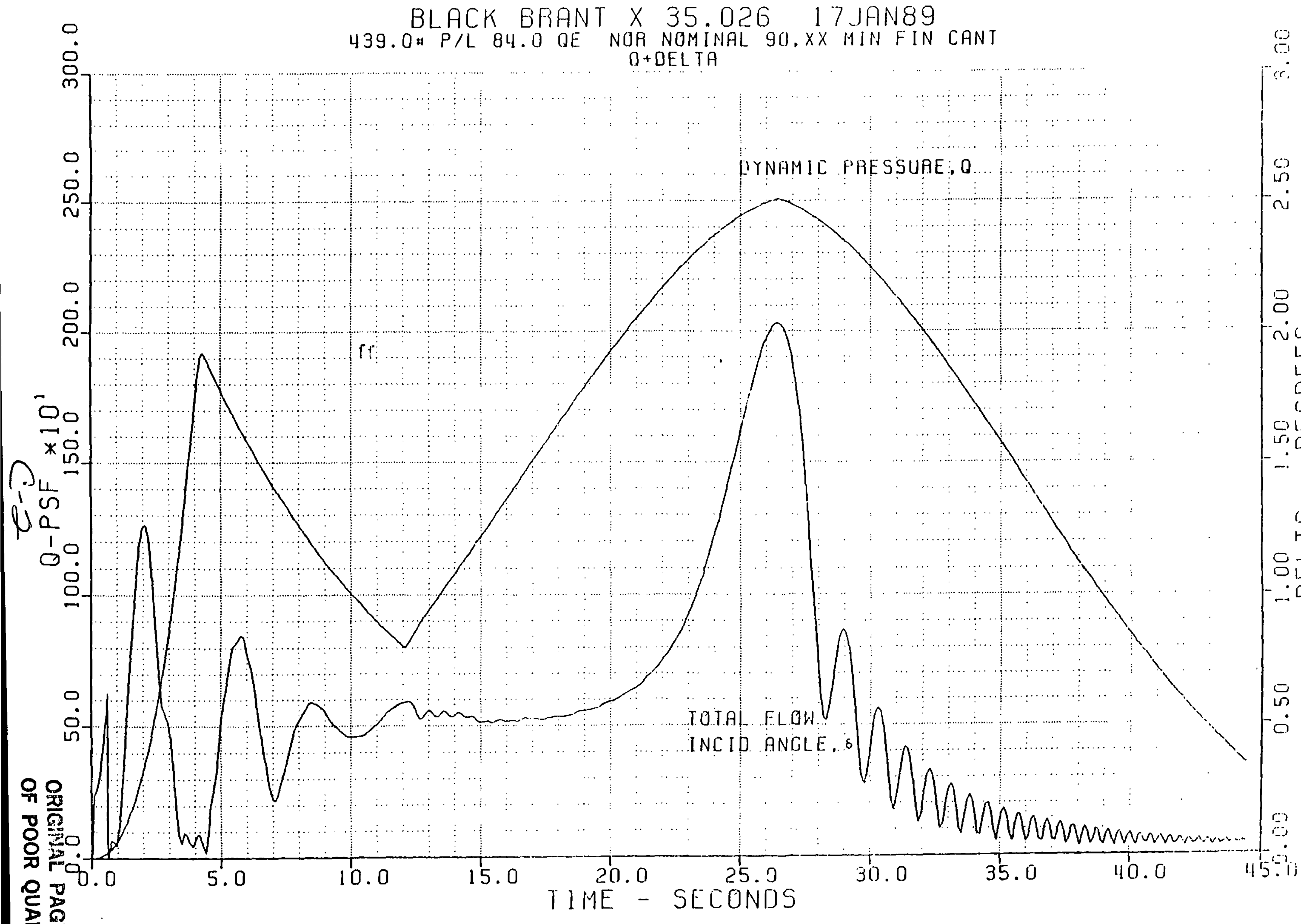
BLACK BRANT X 35.026 17JAN89
439.0# P/L 84.0 QE NOR NOMINAL 90.XX MIN FIN CANT
ROLL RATE, PITCH FREQUENCY VS TIME




BLACK BRANT X 35.026 17JAN89
439.0# P/L 84.0 QE NOR NOMINAL 90,XX MIN FIN CANT
Q+DELTA
DYNAMIC PRESSURE,Q
TOTAL FLOW
INCID ANGLE,δ
Q-PSF *10[1]
DELTA - DEGREES
TIME - SECONDS
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
100.0
150.0
200.0
250.0
300.0
0.00
0.50
1.00
1.50
2.00
2.50
3.00

C-2

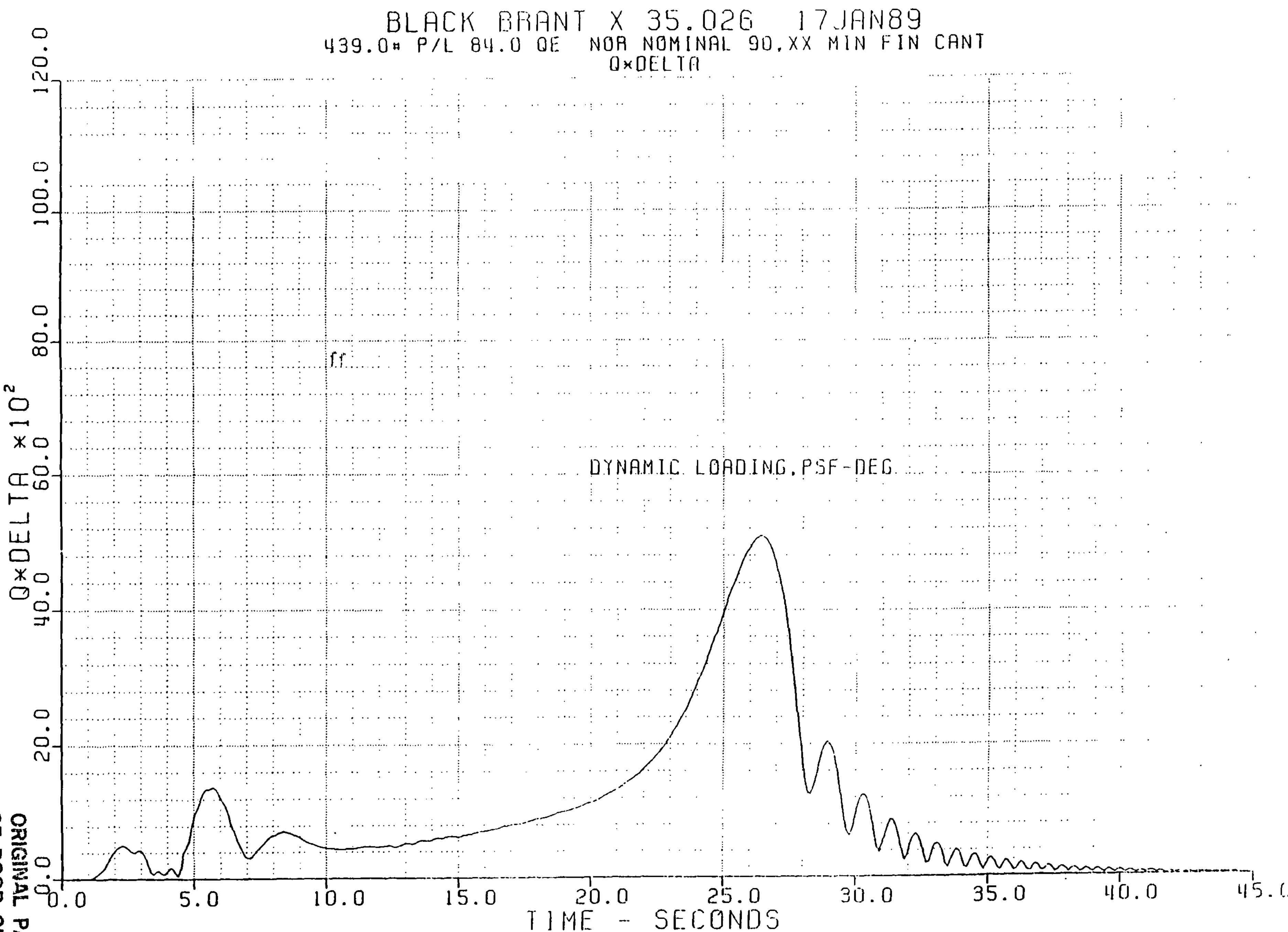


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Table 4-1. Black Brant X 35.026 UE Misalignments, Offsets, and Eccentricities

LAUNCH CONFIGURATION

Thrust Misalignment:	$.2^{\circ}$
CG Offset in Z Axis:	+.23 in
Thrust Offset in Y Axis:	-.23 in
Thrust Offset in Z Axis:	+.23 in
Tail Misalignment:	$.2^{\circ}$

SECOND STAGE

Thrust Misalignment:	$.2^{\circ}$
CG Offset in Z Axis:	+.23 in
Thrust Offset in Y Axis:	-.23 in
Thrust Offset in Z Axis:	+.23 in
Tail Misalignment:	$.2^{\circ}$

Pitch/Roll Crossing Occurs at: 24.5 Sec

Pitch/Roll Crossing Frequency: 1.5 Cps

4.2.2 Despin Analysis

Source: Wallops Flight Facility Despin Program

Physical Properties/Roll-Rate Parameters: Table 4-2

Resulting Despin Weights Required (each): 119.8 grams/wt

Table 4-2. **Black Brant X 35.026 UE Despin of Payload, Physical Properties and Roll-Rate Parameters**

Initial Roll Rate:	4.0 cps
Ixx of Payload and Motor Minus Nose Cone:	4.91 sl-ft^2
Final Roll Rate:	2.04 cps
Cable Density:	0.029 lb/ft
Cable Length:	7.91 ft (1.75 wrap)
Wrap Radius:	0.713 ft
Required Despin Weight:	.2641 lb/wt (119.8 gms/wt)

Ixx Booms Stowed = 2.3 sl-ft^2

Ixx Booms Deployed = 4.7 sl-ft^2

Booms despin payload to 1 cps nominally.

Initial Roll Rate = 5 = Final = 1.25 cps

Initial Roll Rate = 3 = Final = 0.75 cps

SECTION 6 - DISPERSION ESTIMATES

;PERSION

Dispersion Study of First, Second, and Third Stages of
3rant X Unguided Sounding Rocket Vehicle", Carole Flores
ndrews, NASA/GSFC/WFF.

ide: 721.7 Km

spersion (about the nominal): 52.4 Km

e: 669.3 Km

2σ Low Flight: Figure 6-1

rsion: 298.8 Km

RSION

de: 721.7 Km

)isplacement: -5.8 Km

;persion (about the mean): 50.0 Km

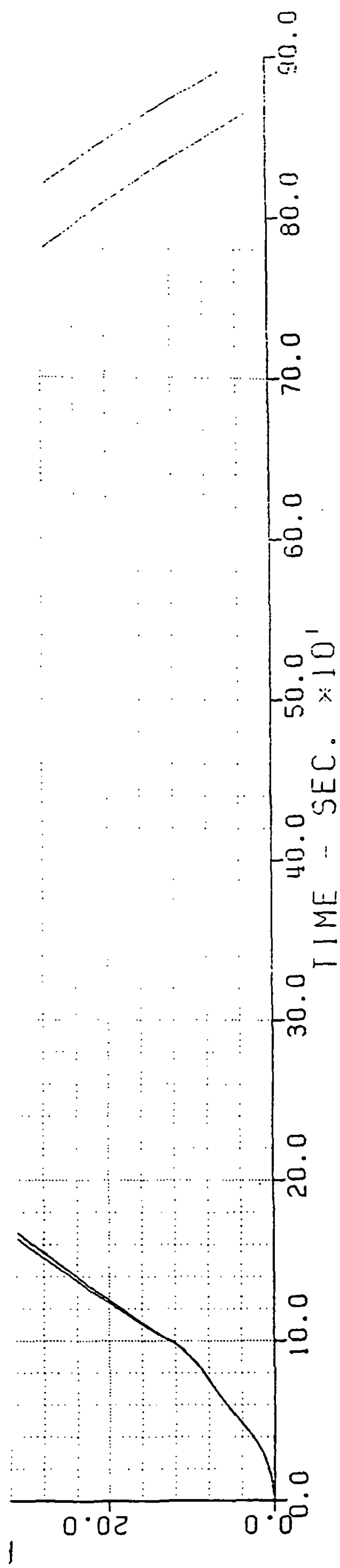
: 671.7 Km

2σ Low Flight: Figure 6-1

acement: 51.2 Km
ion (about the mean): 276 Km

cement: -27.4 Km
on (about the mean): 282.1 Km

35.XXX Vehicle Family: Appendix A



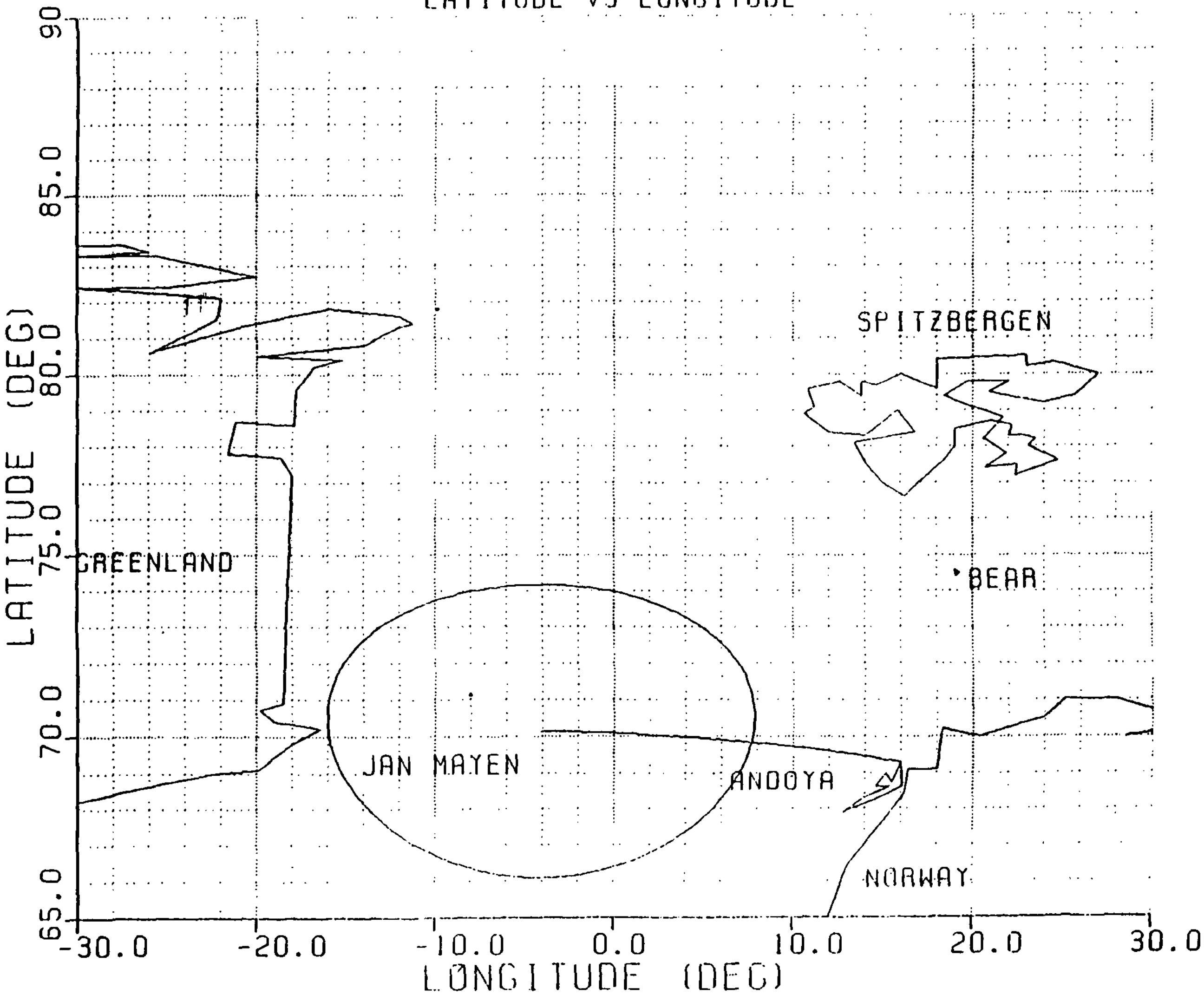
APPENDIX A

DISPERSION DATA

BBX 35.026

439# P/L, 84 QE, 287 AZ, NOR

LATITUDE VS LONGITUDE



January 23, 1989

1

or 35.011 UE (Winningham/

nted so that a horizon
ed to the B vector and
ry of this crossing (see
angle of the sensor, the
altitude related horizon
critical in the present case
s, and the large difference,
izon depression angles

e between these altitude
is to be angled aft of the
sion angles. An angle of

ch window for his mid-
problem for the horizon
luded to avoid exposing the
shows that, in addition to
aperture of the sensor
ion. Since ±5 degrees as a
ervative figure was provided
lusions are shown in the

Event

indow opens
10^o sensor band edge
5^o sensor band edge
5^o sensor band edge
10^o sensor band edge
window

or from direct sunlight, it
:02 UT be excluded from the

based on preliminary
while at apogee was
tory. However, since the
he zenith angle of the B

35.Ø13	398.ØØ	Ø4/22/86	VI	81.Ø	679.5Ø	1Ø91.2	689.4Ø	1Ø67.Ø	-27.55	-83.59
35.Ø14	767.ØØ	Ø5/13/86	VI	85.7	425.63	371.71	4Ø3.2Ø	425.ØØ	49.2Ø6	-64.41
35.Ø15	293.ØØ	Ø4/Ø1/86	FB	83.5	96Ø.5Ø	962.8Ø	913.4Ø	12Ø4.5	192.32	333.81
35.Ø16	293.ØØ	Ø4/13/86	FB	83.5	96Ø.5Ø	962.8Ø	963.78	812.88	-152.6	44.36Ø
35.Ø17	289.25	Ø1/19/88	FB	82.9	923.15	1Ø61.4	927.5Ø	1Ø8Ø.4	2.Ø8Ø	19Ø.52
35.Ø23	26Ø.ØØ	Ø3/Ø4/88	FB	83.1	1Ø74.3	119Ø.1	11Ø7.4	823.2Ø	-371.5	1Ø5.96

* - DENOTES VEHICLES THAT WERE NOT INCLUDED IN THE IMPACT DISPERSION
** - DENOTES VEHICLES THAT WERE NOT INCLUDED IN THE APOGEE DISPERSION
*** - DENOTES VEHICLES THAT WERE NOT INCLUDED IN APOGEE OR IMPACT DISPERSIONS
N/R - DENOTES DATA NOT RECEIVED FROM MISSION ANALYST
N/A - DENOTES DATA NOT AVAILABLE (SEE COMMENTS)

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vector and since this angle is relatively insensitive to expected trajectory changes, these results should be considered final.

Robert Patterson
Bob Patterson

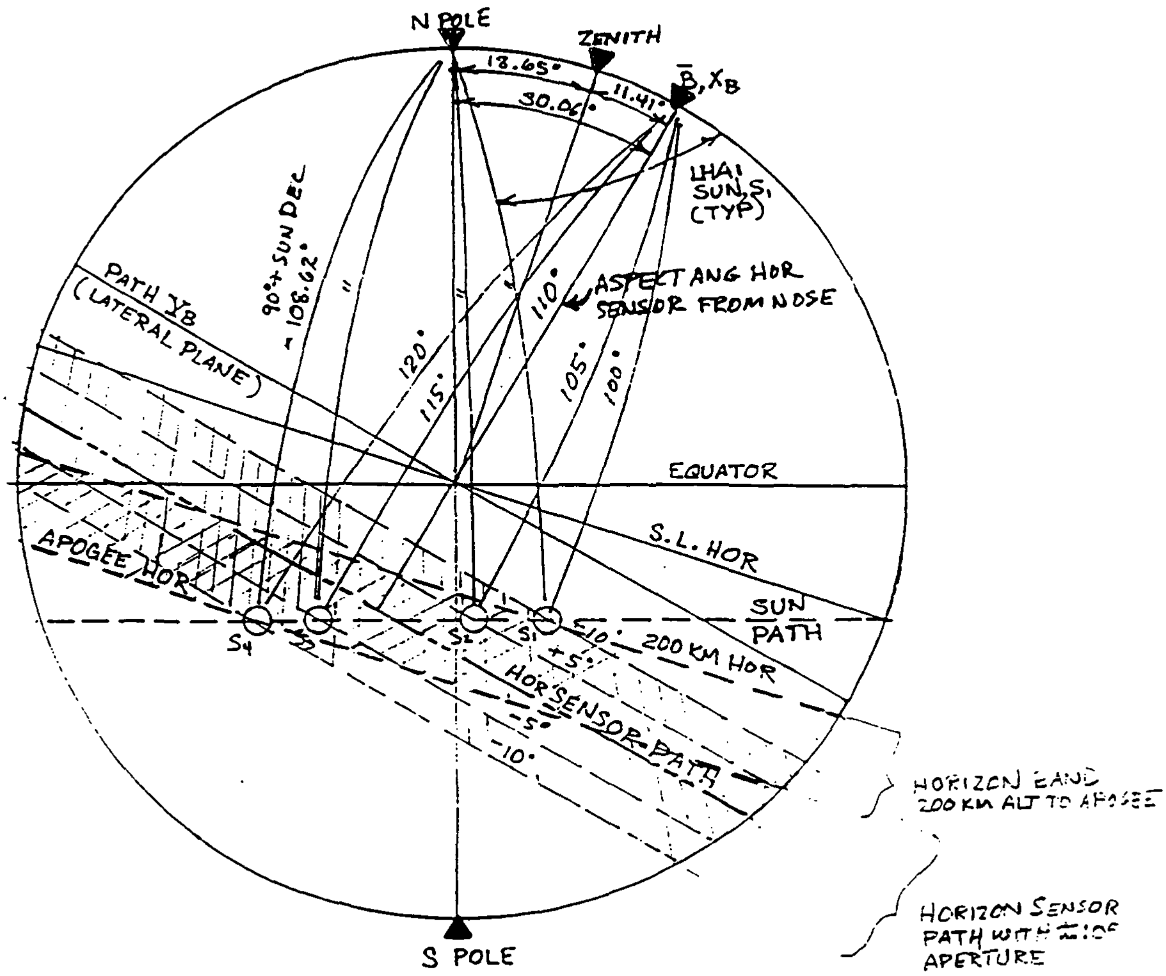
Enclosure: 1

cc: R. A. Burns/823.0
L. W. Gurkin/841.0
D. F. Detwiler/841.1
M. Altstatt/CSC
J. Diehl/CSC
B. Hickman/CSC

DATA : • 35.011 UE LAUNCHED NOR MID NOV '89 439# P.L 84°QE / 320° AZ
8 MIN AFTER LAUNCH, PL AT APOGEE 723.6 KM ALT, 71.3479° LAT 10.44667° λ

- B VECTOR FROM WALLOPS MAGVEC PROGRAM FOR APOGEE POSITION:
  200 KM ALT, EL -78.559°, AZ 354.664, MAG 0.479 GAUSS
  723.6 KM ALT, EL -78.622°, AZ 352.369, MAG 0.391 GAUSS

- HORIZON DEPRESSION ANGLE AT ALTITUDE
  200 KM ALT, 14.16° BELOW S.L. HOR
  723.6 KM ALT, 26.09° BELOW S.L. HOR



CELESTIAL SPHERE SHOWING ASPECT ANGLES BETWEEN HOR SENSOR AND SUN
35.011 UE

SAMPLE CALCULATION FOR SUN POSITION S₁ WHERE SUN CROSSES HORIZON SENSOR +10° BAND EDGE

$$LHA_1 = \cos^{-1}\left[\frac{\cos 100° - \cos 108.62° \cos 30.06°}{\sin 108.62° \sin 30.06°}\right] = 77.495° \text{ OR } 5^h 10^m$$

SINCE FOR LONGITUDE OF 10.44667 EAST, RELATION BETWEEN UT AND LHA IS UT = LHA + 11ʰ 15ᵐ, WE HAVE UT OF 16:26. ALLOW 8 MIN FLIGHT TIME TO APOGEE THEN SUN WOULD BE AT SENSOR +10 BAND EDGE IF VEHICLE WAS LAUNCHED AT 16:20 UT

MECHANICAL SYSTEMS

BOB HICKMAN

JANUARY 31, 1989

MECHANICAL SYSTEMS HANDOUT
FOR DESIGN REVIEW OF 35.011 & 35.026

The 35.011 and 35.026 payloads will be flown from Norway in the winter campaign of 1989-90 and will be a continuation of the Centaur I program flown from Cape Parry in December 1981 and the failed Centaur II campaign launched from Norway in January 1986. The experimenter is Dr. Winningham from Southwest Research. No recovery is planned. The following information is supplied in the format of Enclosure 1:

1. SYSTEM STATUS

   The design of all WFF supplied systems is complete with the exception of the TM section. The nose cone and ignition sections woll be ordered soon.

2. WFF PROVIDED MECHANICAL SYSTEMS

   Wallops will supply the following mechanical systems and hardware:

   a. A standard magnetic ACS section with aft pullaway connector cover. The 2 TRADAT antennas will be located on this section.

   b. A TM skin section containing 2 component decks plus two 61 pin umbys, 2 S-band antennas, TRADAT antennas (2), timer access door, and a Bristol style V-band joint on both ends with a WFF design separation cutting mechanism for the forward joint. The experiment section will fasten to the front of this skin with eight (8) 1/4-28 socket head shoulder screws.

   Wallops will supply, from Bristol, a modified FEOS nose cone with LEO system and a standard ignition and separation housing.

   The experiment section to be enclosed in the ejectable nose cone is supplied by and will be discussed by Southwest Research.

   A drawing list for this project is supplied as Enclosure 2.

3. ASSEMBLY DRAWINGS AND PHYSICAL PROPERTIES

   See WFF Dwg. D-35-16922

4. SEPARATION DEVICES

   The only Wallops supplied separation design is the V-band cutter mechanism for the nose cone release system. The V-band is a standard Bristol design with two halves held together by four #6 screws. These four screws are severed by two blades

90° and 270° on the payload. The cutting of the
achieved by the use of one 6104 Holex cartridge in
e two cutter housings (B-GEN-13481). The cutter
re a threaded design developed by Wallops but very
the Bristol and Sandia cutters. This cutter design
successfully on 29.091, 35.006, 31.041, 31.036,
d 35.010. It should be noted that for this flight,
e for 35.010, the thread on the cutter housing has
ed from 1/2-13 to 1/2-20 thread to allow a larger
a at the weakest part of the cutter.

ration devices in the payload included the standard
t X separation system and the despin system, both in
r housing; and the nose cone deployment (spring)
o supplied as standard Black Brant hardware. The
ation springs will push off from the ACS component
h will house the separating ignition connector and
rap" cover.

YSIS

al joints on this payload are standard 17.26 in. dia.
sign V-band joints which have flown successfully many
should be noted that the shear lip diameter for the
I.D. joint has been increased by .027 in. to allow
ance in the front end (See WFF Dwg. D-35-16938).
lso done on the 35.006 and 35.009 Mczer BBX payloads
successfully and the failed 35.010 Centaur I

SYSTEMS

ew design Wallops supplied system for this payload is
tion. This section is composed of two telemetry and
deck plates. The two deck plates contain the
as presented in Enclosure 3. The two decks are
ogether by four 3/4 in. square stand offs. The
k is fastened radially through the skin by eight (8)
shoulder bolts. The skin section is 17 in. long and
.100 in. thick. The skin contains cutouts for a
ss door, lift off switches, two (2) 61 pin umby
Also mounted to the skin section are the 2 S-band
d antennas, and the deployment gun mounting blocks.

mechanical systems, i.e., nose cone and igniter
ction, are standard Bristol systems and each will
s own separation system. Using information supplied
, the following separation velocities have been
:

.n.
:otal
/sec.
c.
sec.

./in.

/sec.
./sec.
./sec.

h the payload

ns
(non-

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ENCLOSURE 2

A-

Dwg. NO.	Rev.	Name
A-30-11077		Ralay Brk't.
A-GEN-11168		2 Timer Brk't.
A-GEN-12748-6		Connector Brk't. (6-25 pin)
A-29-12935		G-siwtch Door
A-35-134		V-band Cutter Mount Block
B-31-12977	B	Deployment Bund Blade
B-GEN-13481	D	V-band cutter Gun Threaded
D-35-16922		Physical Properties P/L Only
B-GEN-14018		Pnewmatic Connector Adpater
C-GEN-10363		Monitor Box
C-34-13294-3 Sh. 1 & 2	A	Nicad 'AA' (Pyro) Battery Box
C-GEN-13529		Accelerometer Brk't.
C-GEN-14588		ACS Component Plate
D-27-11798	E	BB Test Fixture
D-38-12471-1	C	V-band Assy.
D-GEN-13935		37 Pin Umby Brk't .
D-GEN-14029		61 pin Umby Brk't. 17.26 Dia P/L
D-35-14051		Winningham FEOS N/C Mods
D-GEN-14125		Lanyard Switch
D-35-16938		TM Section
D-35-16939		TM Deck #1
D-35-16940		TM Deck #2

	DATE	LET.	REVISION	BY		Hickman
NEXT ASSEMBLY	UNIT OR PROJECT 35.026 & 35.011	SCALE	MATERIAL	HEAT TREAT	DR.	
					DES.	
TOLERANCE ON DIMENSIONS UNLESS SHOWN OTHERWISE ANGULAR ±	FRACTIONAL DIMENSIONS ± .010 DECIMAL DIMENSIONS ± .005		NATIONAL AERONAUTICS AND SPACE ADMINISTRATION WALLOPS FLIGHT CENTER WALLOPS ISLAND, VIRGINIA 23337		CHK.	
					GL.	
					AP.	
SURFACE FINISH IN MICROINCHES RMS UNLESS SHOWN OTHERWISE		EST. FIN WEIGHT	DRAWING LIST WINNINGHAM		A-	

ENCLOSURE 2

INSTRUMENTATION

JIM DIEHL

JANUARY 31, 1989

Computer Sciences Corporation
Applied Technology Company

January 10, 1989

MEMORANDUM

TO: John Van Overeem, Payload Manager

FROM: James K. Diehl, Instrumentation Engineer

SUBJECT: Instrumentation System Design for Payloads 31.011 & 35.026
Winningham/SwRI

Introduction

Payloads 35.011 & 35.026 are to be launched from Andenes, Norway in December 1989. The instrumentation system on each payload will telemeter scientific data from nine onboard experiments. Also included will be ACS data, vehicle performance data and housekeeping data. Both payloads will be aligned to the magnetic field by a magnetic ACS. Both payloads are identical in design, and similar to payload 35.010.

Telemetry System Description

The telemetry system contains three downlink S-Band systems, one being an FM/FM link @ 2251.5 MHz and the others are two PCM/FM links @ 2265.5 MHz & 2279.5 MHz. The FM/FM link contains IRIG channels 8 through 17, F, H, J, & L. Both the PCM/FM links will operate at 800 Kbits/Sec (BIØ-L). Both PCM encoders will be located in the experiment section of the payload, due to the large volume of interfacing harness. A TRADAT ranging system is used for trajectory data. The following are some of the parameters of these systems.

TM #1 FM/FM

Carrier Frequency	2251.5 MHz
Carrier Deviation	±750 KHz
I.F. Bandwidth	3.3 MHz
Video Bandwidth	750 KHz
RF Safety Factor	7.3 dB

TM #2 PCM/FM

Carrier Frequency	2265.6 MHz
Carrier Deviation	±800 KHz
I.F. Bandwidth	3.3 MHz
Video Bandwidth	2 MHz
RF Safety Factor	5.3 dB

TM #3 PCM/FM

Carrier Frequency	2279.5 MHz
Carrier Deviation from PCM	±800 KHz
Carrier Deviation from TRADAT	±200 KHz

Building F-10/WFF
Wallops Island, Virginia 23337
804.824.1298

Combined Carrier Deviation	±860 KHz
I.F. Bandwidth	3.3 MHz
Video Bandwidth	2 MHz
RF Safety Factor	4.3 dB

<u>TRADAT</u>

Uplink Carrier Frequency	550 MHz
Uplink Carrier Deviation	±40 KHz
Tradat Modulation	3.906 Kbit BIØ-L
Uplink Transmitter Power	200 Watts Min.
RF Uplink Safety Factor	7.9 dB

Trajectory data will be obtained from TRADAT which will be combined with PCM using a TRADAT/PCM video combiner. The amplifiers in the standard combiner design, will have to be upgraded for the combiner to operate properly at 800 Kbit.

Acceleration data will be measured in three axis using Setra accelerometers. The thrust axis accelerometer will be conditioned to a +40G, -10G range. Both lateral accelerometers will be conditioned to a ±5G range.

Attitude data will be obtained from two sources; one a three axis magnetometer for magnetic aspect angle, and two a horizon sensor for horizon crossing aspect angle. Together these two attitude sources will give absolute attitude data. The horizon sensor data will be telemetered in both analog and digital form. The digital horizon sensor data will include high resolution "time event" data defining sky/earth and earth/sky horizon crossings. Magnetometer calibrations are planned at Greenbelt, Maryland.

Housekeeping data will consist of the usual squib current, bus voltage, bus current, transmitter temperatures, and other miscellaneous monitors.

Two Wallops wraparound S-Band antennas will be used. TM links #1 and #3 will be diplexed to one antenna and TM link #2 will be transmitted via the other antenna. The Tradat uplink will be received with a pair of PSL stub antennas, which will be mounted on the ACS skin.

The following is a list of attachments:

1. FM Measurement List
2. FM Pre-Emphasis Analysis
3. PCM #1 Measurement List
4. PCM #2 Measurement List
5. PCM Formats
6. PCM Stacking Arrangements
7. RF Downlink Analysis
8. RF Uplink Analysis
9. Instrumentation Components List

James K. Diehl

James K. Diehl

1/9/89

35.011 & 35.026
SWRI/Winningham

FM Measurement List TM #1

IRIG Chan	Center Freq. (KHz)	Data Description	Nom. Freq. Resp. (Hz)	Actual Filter Used (Hz)	Mod Index
L	560	ACM/ACEF BB1	16,800	16,800	5
J	300	ACM/ACEF BB2	9,000	16,800	2.7
H	165	ACLP LIAC 2	4,950	12,395	2
F	93	ACLP LIAC 1	2,790	6,970	2
17	52.5	Horiz Sen Analog	790	790	5
16	40	Thrust Accel. +40G, -10G	600	600	5
15	30	X-Axis Accel. ±5G	450	450	5
14	22	Y-Axis Accel. ±5G	330	330	5
13	14.5	3rd Stage Mtr Press	220	220	5
12	10.5	2nd Stage Mtr Press	160	160	5
11	7.35	Mag X Roll #1	110	110	5
10	5.4	Mag Y Roll #2	81	81	5
9	3.9	Mag Z Pitch	59	59	5
8	3.0	Tradat Receiver AGC	45	45	5

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35.011 & 35.026
SWRI/Winningham

FM Pre-Emphasis Schedule

IRIG Chan	Center Freq	Actual Filter Used	Mod Index	$\frac{F_n \sqrt{B_n}/MI_n}{F_1 \sqrt{B_1}/MI_1}$	RF Dev	DB Ref Level	Xmitt Dev Ratio	S/N Ratio @ Disc. Outpu @ Apogee
L	560 KHz	16,800 Hz	5.0	3606.7	234.5	0 dB	.427	47.6 dB
J	300	16,800	2.679	3606.7	234.5	0	.798	47.6
H	165	12,395	2.0	2282.0	148.4	-4.0	.918	47.6
F	93	6,970	2.0	964.5	62.7	-11.4	.688	47.6
17	52.5	790	5.0	73.3	7	-30.5	.133	50.7
16	40	600	5.0	48.7	7		.175	54.3
15	30	450	5.0	31.6	7		.233	
14	22	330	5.0	19.8	7		.318	
13	14.5	220	5.0	10.7	7		.482	
12	10.5	160	5.0	6.6	7		.667	
11	7.35	110	5.0	3.8	7		.952	
10	5.4	81	5.0	2.4	7			
9	3.9	59	5.0	1.49	7			
8	3.0	45	5.0	1.0	7	-30.5		
				10,459.9	750 KHz			

I.F. Bandwidth = 3.3 MHz

Carrier Deviation = ±750 KHz

S_f = 7.3 dB + 12 dB = 19.3 dB Carrier S/N @ Apogee

35.011 & 35.026
SWRI/Winningham

PCM #1 Measurement List TM #2

Format Label	Data Description	WD	Time Slot WD INT	FM	FM INT	Sample Rate (SPS)
S1-1	DCM X-Comp MSB	4	32	0	0	2500
S1-2	DCM X-Comp LSB	5	32	0	0	2500
S2-1	DCM Y-Comp MSB	6	32	0	0	2500
S2-2	DCM Y-Comp LSB	7	32	0	0	2500
S3-1	DCM Z-Comp MSB	8	32	0	0	2500
S3-2	DCM Z-Comp LSB	9	32	0	0	2500
S4-1	Correlator 1	27	0	0	0	1250
S4-2	Correlator 2	28	0	0	0	1250
S4-3	Correlator 3	29	0	0	0	1250
S4-4	Correlator 4	30	0	0	0	1250
S5-1	Area		0	0	0	1250
S5-2	Area		0	0	0	1250
S5-3	Area		0	0	0	1250
S5-4	Area		0	0	0	1250
S5-5	Area		0	0	0	1250
S5-6	Area		0	0	0	1250
S5-7	Area		0	0	0	1250
S5-8	Area		0	0	0	1250
S5-9	Area		0	0	0	1250
S5-10	Area		0	0	0	1250
S5-11	Area		0	0	0	1250
S5-12	Area		0	0	0	1250
S6-1	SPI		0	0	0	1250
S6-2	SPI		0	0	0	1250
S6-3	SPI		0	0	0	1250
S6-4	SPI		0	0	0	1250
S6-5	SPI		0	0	0	1250
S6-6	SPI		0	0	0	1250
S6-7	SPI		0	0	0	1250
S6-8	SPI		0	0	0	1250
S6-9	SPI		0	0	0	1250
S6-10	SPI		0	0	0	1250
S6-11	SPI		0	0	0	1250
S6-12	SPI		0	0	0	1250
S6-13	SPI		0	0	0	1250
S6-14	SPI		0	0	0	1250
S6-15	SPI		0	0	0	1250
S6-16	SPI		0	0	0	1250
S6-17	SPI		0	0	0	1250
S6-18	SPI		0	0	0	1250
S6-19	SPI		0	0	0	1250
S6-20	SPI		0	0	0	1250
S7	Major Frame Count LSB	2	0	5	16	78
S8	Major Frame Count MSB	2	0	6	16	78

35.011 & 35.026
SWRI/Winningham

PCM #1 Measurement List (cont.)   TM #2

Format Label		Data Description	WD	WD INT	FM	FM INT	Sample Rate (SPS)
			Time Slot				
T1A		Horizon Sensor Reg 1 LSB	2	0	1	32	39
T1B		Horizon Sensor Reg 1 MSB	3	0	1	32	39
T2A		Horizon Sensor Reg 2 LSB Alt	2	0	15	32	39
T2B		Horizon Sensor Reg 2 MSB Alt	3	0	15	32	39
T3A		Horizon Sensor Reg 3 LSB Alt	2	0	31	32	39
T3B		Horizon Sensor Reg 3 MSB Alt	3	0	31	32	39
P1		(Bit) Parallel Dig Mon A	2	0	2	16	78
	MSB	1 ACEF 18V					
		2 ACM 18V					
		3 Data 5V					
		4 Data 15V					
		5 5V Reg					
		6 SPI 15V					
		7 SPI 5V					
		8 Area 5V					
		9 DCM 18V					
		10 DCM 8V					
P2		(Bit) Parallel Dig Mon B	2	0	3	16	78
	MSB	1 ACM BB1 Mux					
		2 ACM BB2 Mux					
		3 Lift Off Mon					
		4 DCM Boom Deploy					
		5 Area HVPS					
		6 Area PPS					
		7 SPI HVPS					
		8 SPI 5/200V					
		9 ACM Boom Release					
		10 ACM Boom Deploy					
P3		(Bit) Parallel Dig Mon C	2	0	4	16	78
	MSB	1 ACEF Boom Release					
		2 ACEF Boom Deploy					
		3 ACEF ESA Pos					
		4 ACEF ESB Pos					
		5 ACM Loop Release					
		6 ACM Loop Deploy					
		7 Area +Y Release					
		8 Area +Y Deploy					
		9 Area -Y Release					
		10 Area -Y Deploy					

35.011 & 35.026
SWRI/Winningham

PCM #1 Measurement List (cont.) TM #2

Format Label	Data Description	Time Slot WD	WD INT	FM	FM INT	Sample Rate (SPS)
A1	(D) ACM B/E	10	0	2	4	312
A2	(D) ACM Log 'B	11	0	2	4	312
A3	(D) ACM Log 'E	12	0	2	4	312
A4	(D) ACM Log ES	10	0	3	4	312
A5	(D) ACM Log EL	11	0	3	4	312
A6	(D) ACM Log B	12	0	3	4	312
A7	(D) ACEF ELF V1-V2	31	0	0	0	1250
A8	(D) ACEF ELF V3-V1	32	0	0	0	1250
A9	(D) ACEF ELF V4-V3	33	0	0	0	1250
A10	(D) ACEF ELF ES	34	0	0	0	1250
A11	(D) ACEF ELF V2-V4	35	0	0	0	1250
A12	Area PPS Cur Mon	3	0	2	8	156
A13	Area PPS +V Mon	3	0	3	8	156
A14	Area PPS -HV Mon	3	0	4	8	156
A15	Area PPS -V Mon	3	0	5	8	156
A16	Area HVPS Cur Mon	3	0	6	16	78
A17	Area HVPS +V Mon	3	0	7	16	78
A18	Area HVPS -V Mon	3	0	8	16	78
A19	Area HVU 28V Mon	10	0	4	8	156
A20	Area HVU 28V Cur Mon	11	0	4	8	156
A21	SPI +5V Mon	3	0	9	16	78
A22	SPI +15V Mon	3	0	14	16	78
A23	SPI 200V Mon	3	0	16	16	78
A24	SPI -200V Mon	2	0	14	16	78
A25	SPI 2200V Mon	2	0	16	16	78
A26	Thermistor Data I/F	2	0	7	16	78
A27	Thermistor Power Supply	2	0	8	16	78
A28	Thermistor Fwd Deck	2	0	12	16	78
A29	Thermistor Aft Deck	2	0	13	16	78
A30	Exp Battery Mon	2	0	9	16	78
A31	Exp +5V Reg Mon	2	0	10	16	78
A32	0-5V Auto Calibrator	2	0	11	16	78
A33	Mag Roll X-Axis (270)	10	0	1	4	312
A34	Mag Roll Y-Axis (180)	11	0	1	4	312
A35	Mag Pitch Z-Axis	12	0	1	4	312
A36	Horizon Sensor Pre-Amp	13	0	1	2	625
A37	Horizon Sensor Analog	13	0	2	2	625
A38	Experiment Spare	12	0	4	8	156
A39	Experiment Spare	10	0	8	8	156
A40	Experiment Spare	11	0	8	8	156
A41	Experiment Spare	12	0	8	8	156
A42	Experiment Spare	2	0	17	32	39
A43	Experiment Spare	3	0	17	32	39
A50	Thrust Accel. +40G, -10G	14	0	1	2	625
A51	X-Axis Accel ±5G	14	0	2	4	312
A52	Y-Axis Accel ±5G	14	0	4	4	312

35.011 & 35.026
SWRI/Winningham

PCM #2 Measurement List TM #3

Format Label	Data Description	WD	Time Slot WD INT	FM	FM INT	Sample Rate (SPS)
S1-1	VEF V12	3	16	0	0	5000
S1-2	VEF V34	4	16	0	0	5000
S1-3	VEF V13	5	16	0	0	5000
S1-4	VEF V24	6	16	0	0	5000
S1-5	VEF Ext	7	16	0	0	5000
S2-1	VEF V12f	9	16	0	0	5000
S2-2	VEF V34f	10	16	0	0	5000
S2-3	VEF V13	11	16	0	0	5000
S2-4	VEF V24	12	16	0	0	5000
S2-5	VEF Ext	13	16	0	0	5000
S3	VEF Housekeeping	15	0	0	0	1250
S4	FIMS B Data (Muxed)	56	0	0	0	1250
S5	FIMS B EA PPS STEPS	33	0	0	0	1250
S6	FIMS B MA PPS STEPS	34	0	0	0	1250
S7	Major Frame Count LSB	46	0	5	16	78
S8	Major Frame Count MSB	46	0	6	16	78
T1A	Horizon Sensor Reg 1 LSB	46	0	1	32	39
T1B	Horizon Sensor Reg 1 MSB	47	0	1	32	39
T2A	Horizon Sensor Reg 2 LSB Alt	46	0	15	32	39
T2B	Horizon Sensor Reg 2 MSB Alt	47	0	15	32	39
T3A	Horizon Sensor Reg 2 LSB Alt	46	0	31	32	39
T3B	Horizon Sensor Reg 3 MSB Alt	47	0	31	32	39
P1	(Bit) Parallel Dig Mon A	24	0	0	0	1250
	1 DIFP Head 3 Mode					
	2 DIFP Mode					
	3 DIFP Gain					
	4 DIFP Head 3 Gain					
	5 DIFP Head 1/2					
	6					
	7					
	8 ACLP 18V A					
	9 ACLP 18V B					
	10 ACLP Sweep					

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PCM #2 Measurement List (cont.)   TM #3

Format Label		Data Description	Time Slot WD	WD INT	FM	FM INT	Sample Rate (SPS)
P2	(Bit)	Parallel Dig Mon B	46	0	3	16	78
	1	VEF 8V					
	2	VEF 24V					
	3	Data 5V					
	4	Data 15V					
	5	5V Reg					
	6						
	7	Attitude Sensor					
	8	FIMS 5V					
	9	FIMS 15V					
	10	DIFP 28V					
P3	(Bit)	Parallel Dig Mon C	46	0	4	16	78
	1	FIMS HVPS					
	2	FIMS PPS					
	3	DIFP +X Release					
	4	DIFP +X Deploy					
	5	DIFP -X Release					
	6	DIFP -X Deploy					
	7	ACLP Boom Release					
	8	ACLP Boom Deploy					
	9	VEF Lift Off Mon					
	10						

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PCM #2 Measurement List (cont.)   TM #3

Format Label	Data Description	Time Slot WD	WD INT	FM	FM INT	Sample Rate (SPS)
A1	VEF Boom Fwd +Y Pos	47	0	17	32	39
A2	VEF Boom Fwd -Y Pos	47	0	18	32	39
A3	VEF Boom Aft +X Pos	47	0	19	32	39
A4	VEF Boom Aft -X Pos	47	0	21	32	39
A5	DIFP Temp Mon	30	0	4	4	312
A6	DIFP Input I Mon	31	0	4	4	312
A7	(D) DIFP Data Defl Rtd	16	32	0	0	2500
A8	(D) DIFP Data Current	17	32	0	0	2500
A9	(D) DIFP Data Head 3 Cur	18	32	0	0	2500
A10	FIMS Mass PPS+	47	0	2	32	39
A11	FIMS Mass PPS-	47	0	3	32	39
A12	FIMS Energy PPS+	47	0	5	32	39
A13	FIMS Energy PPS-I	47	0	6	32	39
A14	FIMS Bias H.V. 1	47	0	7	32	39
A15	FIMS Bias H.V. 2	47	0	9	32	39
A16	FIMS -5V Mon	47	0	10	32	39
A17	FIMS +15V Mon	47	0	11	32	39
A18	FIMS -15V Mon	47	0	13	32	39
A19	FIMS +28V Mon	47	0	14	32	39
A20	ACLP LIDC1	14	0	0	0	1250
A21	Exp Spare	46	0	2	32	39
A22	Exp Spare	46	0	12	32	39
A23	Exp Spare	46	0	13	32	39
A24	Exp Spare	46	0	14	32	39
A25	Exp Spare	46	0	16	32	39
A26	Thermistor Data I/F	46	0	7	16	78
A27	Thermistor Power Supply	46	0	8	16	78
A28	Thermistor Fwd Deck	46	0	17	32	39
A29	Thermistor Aft Deck	46	0	18	32	39
A30	Exp Battery Mon	46	0	9	16	78
A31	Exp +5V Reg Mon	46	0	10	16	78
A32	0-5V Auto Calibrator	46	0	11	16	78
A33	Mag Roll X-Axis (270)	30	0	1	4	312
A34	Mag Roll Y-Axis (180)	30	0	2	4	312
A35	Mag Pitch Z-Axis	30	0	3	4	312
A36	Horizon Sensor Pre-Amp	8	0	1	2	625
A37	Horizon Sensor Analog	8	0	2	2	625
A38	ACS Servo Sum	31	0	1	4	312
A39	ACS Rate Gyro	31	0	2	4	312
A40	ACS Pitch Valves	31	0	3	4	312
A41	ACS Roll Valves	47	0	4	4	312
A42	ACS Tank Pressure	47	0	22	32	39
A43	ACS Reg Pressure	47	0	23	32	39
A44	ACS Gyro Temp	47	0	25	32	39
A45	ACS Tank Temp	47	0	26	32	39
A46	ACS Cmd Logic	47	0	27	32	39

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PCM #2 Measurement List (cont.)   TM #3

Format Label	Data Description	WD	WD INT	FM	FM INT	Sample Rate (SPS)
			Time Slot			
A47	ACS +28V Buss V	47	0	29	32	39
A48	ACS +5V Buss V	47	0	30	32	39
A49	ACS Relay Mon	46	0	28	32	39
A50	Thrust Accel +40G, -10G	2	0	0	0	1250
A51	X-Axis Accel ±5G	40	0	1	2	625
A52	Y-Axis Accel ±5G	40	0	2	2	625
A53	TM #1 +28V Buss V	32	0	1	32	39
A54	TM #2 +28V Buss V	32	0	2	32	39
A55	TM #3 +28V Buss V	32	0	3	32	39
A56	Exp +28V Batt V/Lanyard Sw #2	32	0	4	32	39
A57	TM #1 +28V Buss Current	32	0	5	32	39
A58	TM #2 +28V Buss Current	32	0	6	32	39
A59	TM #3 +28V Buss Current	32	0	7	32	39
A60	Exp +28V Batt Current	32	0	8	32	39
A61	Pyro Pwr Buss V	32	0	9	32	39
A62	TM +5V Buss V	32	0	10	32	39
A63	TM #1 Transmitter Temp	32	0	11	32	39
A64	TM #2 Transmitter Temp	32	0	12	32	39
A65	TM #3 Transmitter Temp	32	0	13	32	39
A66	Nose Cone Breakwire	32	0	14	32	39
A67	TM Systems Relay Mon	32	0	15	32	39
A68	2nd Stage Motor Press	32	0	16	32	39
A69	3rd Stage Motor Press	32	0	17	32	39
A70	2nd Stage SCM #1	32	0	18	32	39
A71	2nd Stage SCM #2	32	0	19	32	39
A72	3rd Stage SCM #1	32	0	20	32	39
A73	3rd Stage SCM #2	32	0	21	32	39
A74	Nose Cone Eject SCM	32	0	22	32	39
A75	VEF Sphere Release SCM	32	0	23	32	39
A76	DCM Sphere/VEF Boom Deploy SCM	32	0	24	32	39
A77	DCM Mast/Area/SPI Deploy SCM	32	0	25	32	39
A78	DIFP Slide Deploy SCM	32	0	26	32	39
A79	ACLP/ACM/ACEF Booms Deploy SCM	32	0	27	32	39
A80	ACLP/ACM/ACEF Loop Deploy SCM	32	0	28	32	39
A81	Exp Pwr B/U Cmd Mon	32	0	29	32	39
A82	ACLP Cal Cmd Mon	32	0	30	32	39
A83	Exps HV Cmd Mon	32	0	31	32	39
A84	Lanyard Switch #1 Mon	32	0	32	32	39
A85	Spare	46	0	29	32	39
A86	Spare	46	0	30	32	39
A87	Tradat Receiver AGC	46	0	32	32	39

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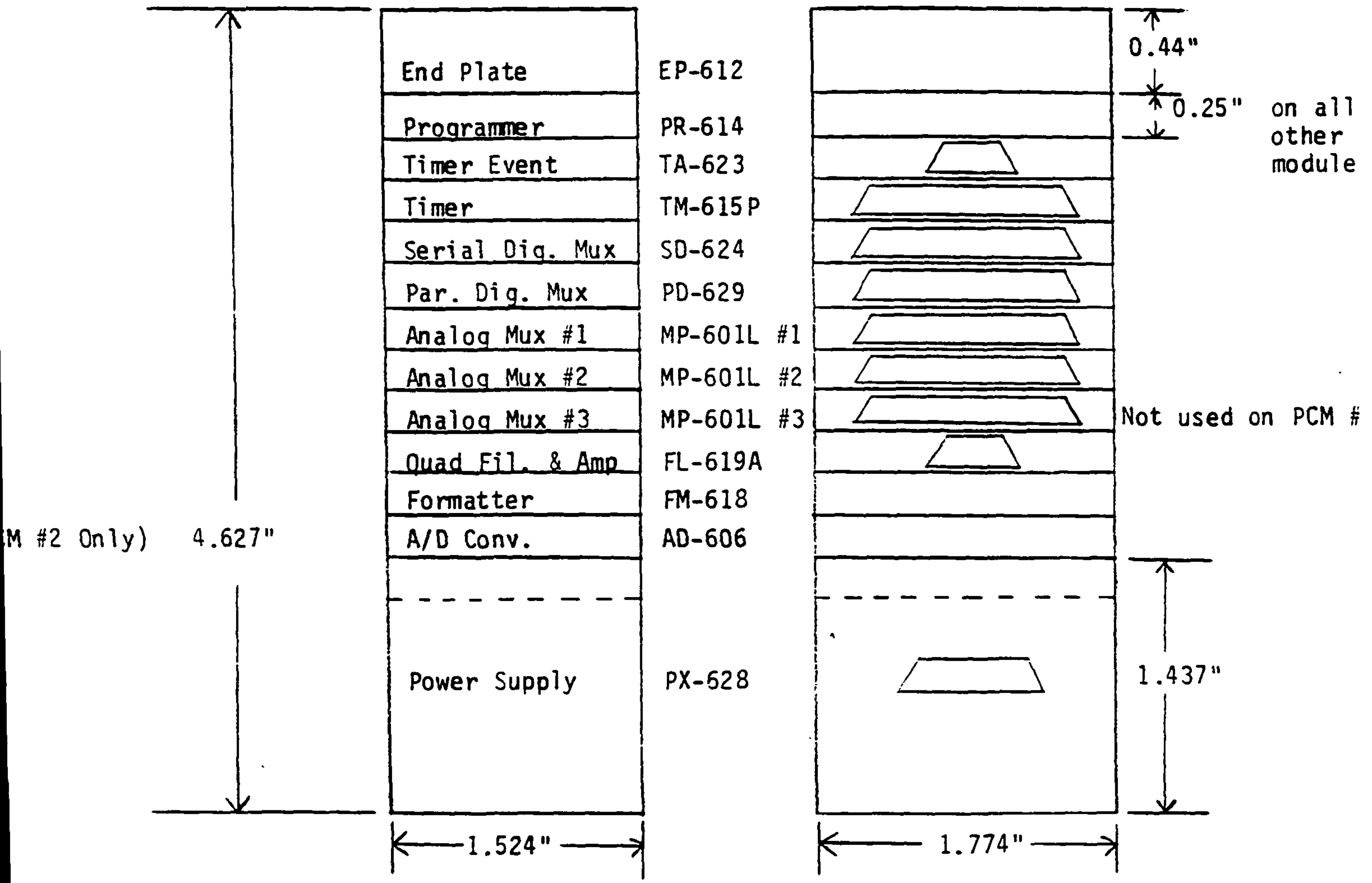
PCM Stacks #1 & #2
Stacking Arrangement



PCM #1 will have 1 less module so total length for PCM #1 will be 4.377".

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RF Downlink Analysis

$S_f = P_t + G_t + G_r - S/N - B_f - P_L - D_f$

S_f = Safety Factor (dB's)

P_t = 8 Watts (Min) = 9 dBw (Transmitter Power)

G_t = -6 dB ≅ S-Band Wraparound Antenna Gain

G_r = 43.2 dB for 20' Dish @ 2265.5 MHz = 40.2 dB @ 50% Efficiency
-3 dB for Polarization Mismatch (Linear to Circular) = 37.2 dB

S/N = 15 dB for PCM/FM @ 1×10^{-6} BER

= 12 dB for FM/FM

$B_f = 10 \log_{10} KT_sB$ $K = 1.38 \times 10^{-23}$ joules/°K

B = 3.3 MHz IF Bandwidth

B_f = -138.2 dB T_s = 331°K @ 15 dB/°K G/T
Measured T_s ≅ 191°K @ 16.8 dB/°K

P/L = Path Loss = $20 \log_{10} [(4\pi FR)/C]$

F = 2265.5 MHz

R = 800 Km Max Slant Range

C = 2.997925×10^8 Meters/Sec

P_L = 157.6 dB

D_f = 0.5 dB for loss between antenna and pre-amp on conical scan converter
+1.0 dB for diplexer insertion loss = 1.5 dB

S_f = 9 dB + (-6 dB) + 37.2 dB - 15 dB - (-138.2 dB) - 157.6 dB - 1.5 dB = 4.3 dB

S_f = +4.3 dB for TM #3 (PCM #2 800 Kbit Diplexed)

S_f = 9 dB + (-6 dB) + 37.2 dB - 15 dB - (-138.2 dB) - 157.6 dB - 0.5 dB = 5.3 dB

S_f = +5.3 dB for TM #2 (PCM #1 800 Kbit)

S_f = 9 dB + (-6 dB) + 37.2 dB - 12 dB - (-138.2 dB) - 157.6 dB - 1.5 dB = 7.3 dB

S_f = +7.3 dB for TM #1 (FM/FM Diplexed)

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RF Up-Link Analysis
for TRADAT

S_f = $P_t + G_t + G_r - S/N - B_f - P_L$

S_f = Safety Factor (dB's)

P_t = Power Transmitted = 25 Watts = 14 dBw or 200 Watts = 23 dBw

G_t = Transmitting Antenna Gain for Helix = 9 dB - 3 dB (Polarization Mismatch) = 6 dB

G_r = Payload Receiving Antenna Gain = -9 dB for PSL Stubs on 17" Dia. Skin

S/N = 13 dB for (Tradat) = 1×10^{-5} BER

B_f = $10 \text{ Log}_{10} KT_sB$

K = 1.38×10^{-23} joules/°K

B = 150 KHz I.F. Bandwidth

T_s = $(N_f - 1) \times 290°K$

N.F. = Noise Figure = 7 dB Max

N_f = Noise Factor

N.F. = $10 \text{ Log}_{10} N_f$

N_f = 5.012

T_s = 1163°K

B_f = -146.2 dB = Noise Pwr Bandwidth

P_L = Path Loss = $20 \text{ Log}_{10} [(4\pi FR)/C]$

F = 550 MHz

R = 800 Km Max Slant Range

C = 2.997925×10^8

P_L = 145.3 dB

S_f = 14 dB + 6 dB + (-9 dB) - 13 dB - (-146.2 dB) - 145.3 dB = -1.1 dB

Sf = -1.1 dB for 25 Watt Transmitter

S_f = 23 dB + 6 dB + (-9 dB) - 13 dB - (-146.2 dB) - 145.3 dB = +7.9 dB

S_f = +7.9 dB for 200 Watt Transmitter

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Instrumentation Components List

Item	Mfg	Model No.	Component Description	Comments	Current
1	Vector	T105S	8W Xmitter 2251.5 MHz	750 KHz Resp.	2.2 A
2	Vector	T105S	8W Xmitter 2265.5 MHz	1.2 MHz Resp	2.2A
3	Vector	T105S	8W Xmitter 2279.5 MHz	1.2 MHz Resp	2.2A
4	Bayshore	TDS-203	RF Diplexer	Two way	--
5	Quanta	R104P	Tradat Range Receiver	550 MHz	60 mA
6	WFF	--	PCM/Tradat Combiner	800 Kbit	20 mA
7	Setra	141A	Accelerometer	Thrust	--
8	WFF	--	Accel. Sig. Conditioner	+40G, -10G	15 mA
9	Setra	141A	Accelerometer	X-Axis	--
10	WFF	--	Accel. Sig. Conditioner	±5G	15 mA
11	Setra	141A	Accelerometer	Y-Axis	--
12	WFF	--	Accel. Sig. Conditioner	±5G	15 mA
13	F.W. Bell	1020	Current Sensor	TM #1 Buss	--
14	F.W. Bell	1020	Current Sensor	TM #2 Buss	--
15	WFF	--	Curr. Sensor Sig. Cond.	0-5 Amp	75 mA
16	F.W. Bell	1020	Current Sensor	TM #3 Buss	--
17	F.W. Bell	1020	Current Sensor	Exp Batt.	--
18	WFF	--	Curr. Sensor Sig. Cond.	0-5A,0-10A	75 mA
19	ARC	AHS-1	Horizon Sensor	in Exp Sect	
20	Tempo	93068	FM Calibrator	fly w/o Pwr	--
21	Vector	MMM-655-16	VCO Mount	16 position	--
22	Vector	MMA-12	Mixer Amplifier	>750 KHz Resp.	10 mA
23	Vector	MMO-11	VCO (560 KHz) ±15%	IRIG L	10 mA
24	Vector	MMO-11	VCO (300 KHz) ±15%	IRIG J	10 mA
25	Vector	MMO-11	VCO (165 KHz) ±15%	IRIG H	10 mA
26	Vector	MMO-11	VCO (93 KHz) ±15%	IRIG F	10 mA
27	Vector	MMO-11	VCO (52.5 KHz) ±7.5%	IRIG 17	10 mA
28	Vecto	MMO-11	VCO (40 KHz) ±7.5%	IRIG 16	10 mA
29	Vector	MMO-11	VCO (30 KHz) ±7.5%	IRIG 15	10 mA
30	Vector	MMO-11	VCO (22 KHz) ±7.5%	IRIG 14	10 mA
31	Vector	MMO-11	VCO (14.5 KHz) ±7.5%	IRIG 13	10 mA
32	Vector	MMO-11	VCO (10.5 KHz) ±7.5%	IRIG 12	10 mA
33	Vector	MMO-11	VCO (7.35 KHz) ±7.5%	IRIG 11	10 mA
34	Vector	MMO-11	VCO (5.4 KHz) ±7.5%	IRIG 10	10 mA
35	Vector	MMO-11	VCO (3.9 KHz) ±7.5%	IRIG 9	10 mA
36	Vector	MMO-11	VCO (3.0 KHz) ±7.5%	IRIG 8	10 mA
37	WFF	17" Dia.	S-Band Antenna	TM 1 & 3	--
38	WFF	17" Dia.	S-Band Antenna	TM 2	--
39	PSL	23.024	Tradat Rec. Antennas	2/payload	--
40	WFF	--	TM Monitor Box		
41	WFF	--	Elec. Monitor Box		
42	WFF	--	Pyro Monitor Box		--
43	Fenwall	Isocurve	Xmitter Thermistors	3 per P/L	15K ohm
44	Vector	MMP-600	Micro PCM Encoder #1	800 Kbit	500 mA
45	Vector	MMP-600	Micro PCM Encoder #2	800 Kbit	500 mA

35.011 & 35.026
SwRI/WINNINGHAM

PCM #1(TM #2)

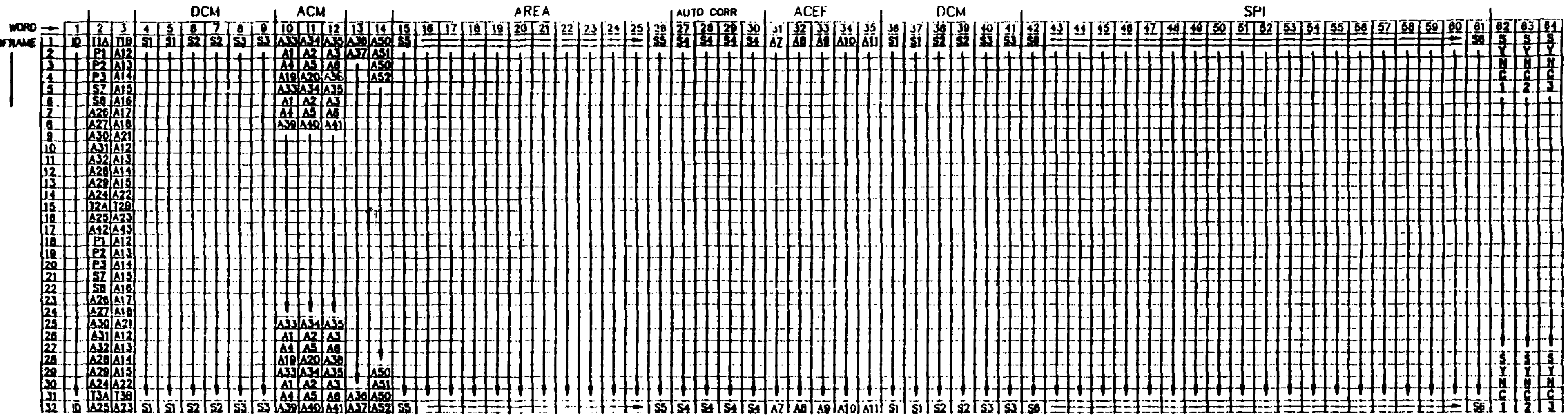
BIT RATE: 800K BIT/SEC
WORD LENGTH: 10 BITS/WORD
WORD RATE: 80K WORDS/SEC
FRAME RATE: 1250K FRAMES/SEC
PCM CODE: BIO-L
BIT ALIGNMENT: MSB FIRST

SYNC 1: 1111101011
SYNC 2: 1100110011
SYNC 3: 0100000000
FRAME SYNC PATTERN: 30 BITS

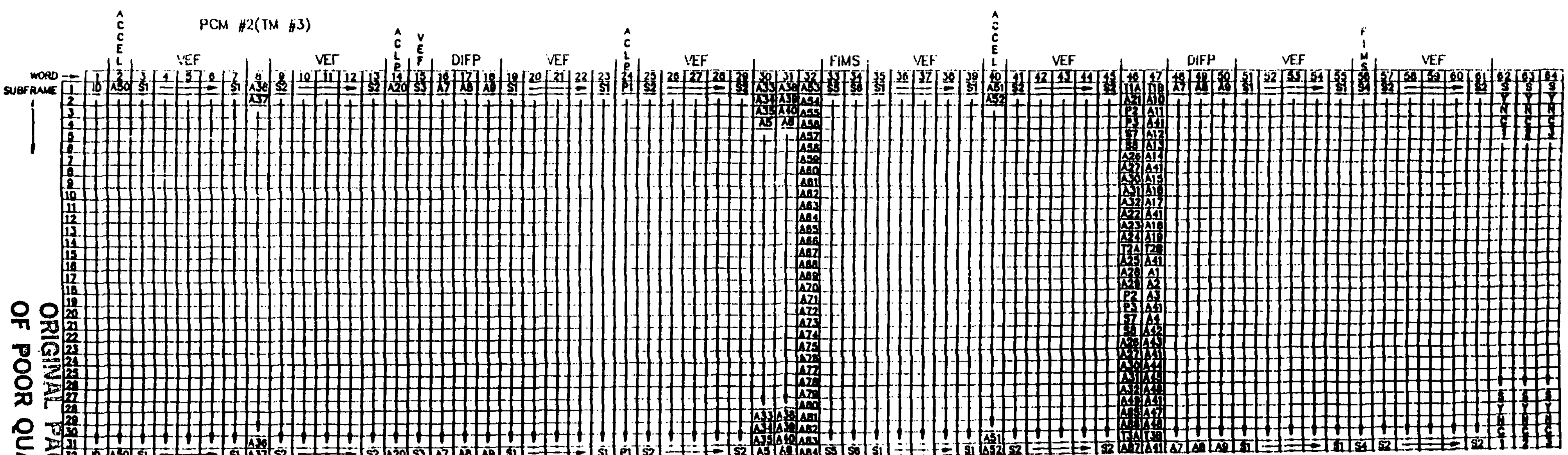
SUBFRAME ID: WORD 1
SFID PATTERN: $0002^4 2^3 2^2 2^1 2^0 0 0_{LSB}$
SFID: MSB FIRST & COUNTS UP

REVISED 10/20/88

PCM FORMAT:



PCM #2(TM #3)



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ELECTRICAL SYSTEMS

MIKE SMOLINSKI

JANUARY 31, 1989

Computer Sciences Corporation
Applied Technology Company

January 18, 1989

MEMORANDUM

TO: Payload Manager 35.011 & 35.026

FROM: Electrical Systems Engineer, Mike Smolinski

SUBJECT: Design Review Input

Changes Since Last Flight

1. Removed scan motor battery and control circuits.
2. Added power control circuits for TM Link #3.
3. Changed pyro circuits to accommodate mission requirements.

Power Requirements

System	Current (Amps)	Batt. Type (Silver Cells)	Capacity (Minutes)
TM 1, TM 2, TM 3	7.5A	HR5DC-6	>60
Experiment	7.0A	HR5DC-6	>60

Pyro System

The pyro functions will be fired from 24 "Af" Ni-cads with Raymond timers. Pyro inhibit will be accomplished with 50K altitude switches.

Power Back-Up

All systems will be backed up with Lanyard lift-off switches. These switches will also remove all voltage potential from the umbilical pins.

Timer Functions

Experiment Timers	Pyro Timers
VEF Cal	N/C Deploy
Expt Pwr Back-up	VEF SPH Fwd/Aft
ACLP Cal	DCM SPH, VEF Booms
DIFP On Expt HV On	DCM SPH, Area SP1
ACS Roll	DIFP SLD
ACS Pitch 2	ACLP/ACM/ACEF Booms
ACS Pitch 1	ACLP/ACM/ACEF Loop
Reset Monitor	Reset Monitor

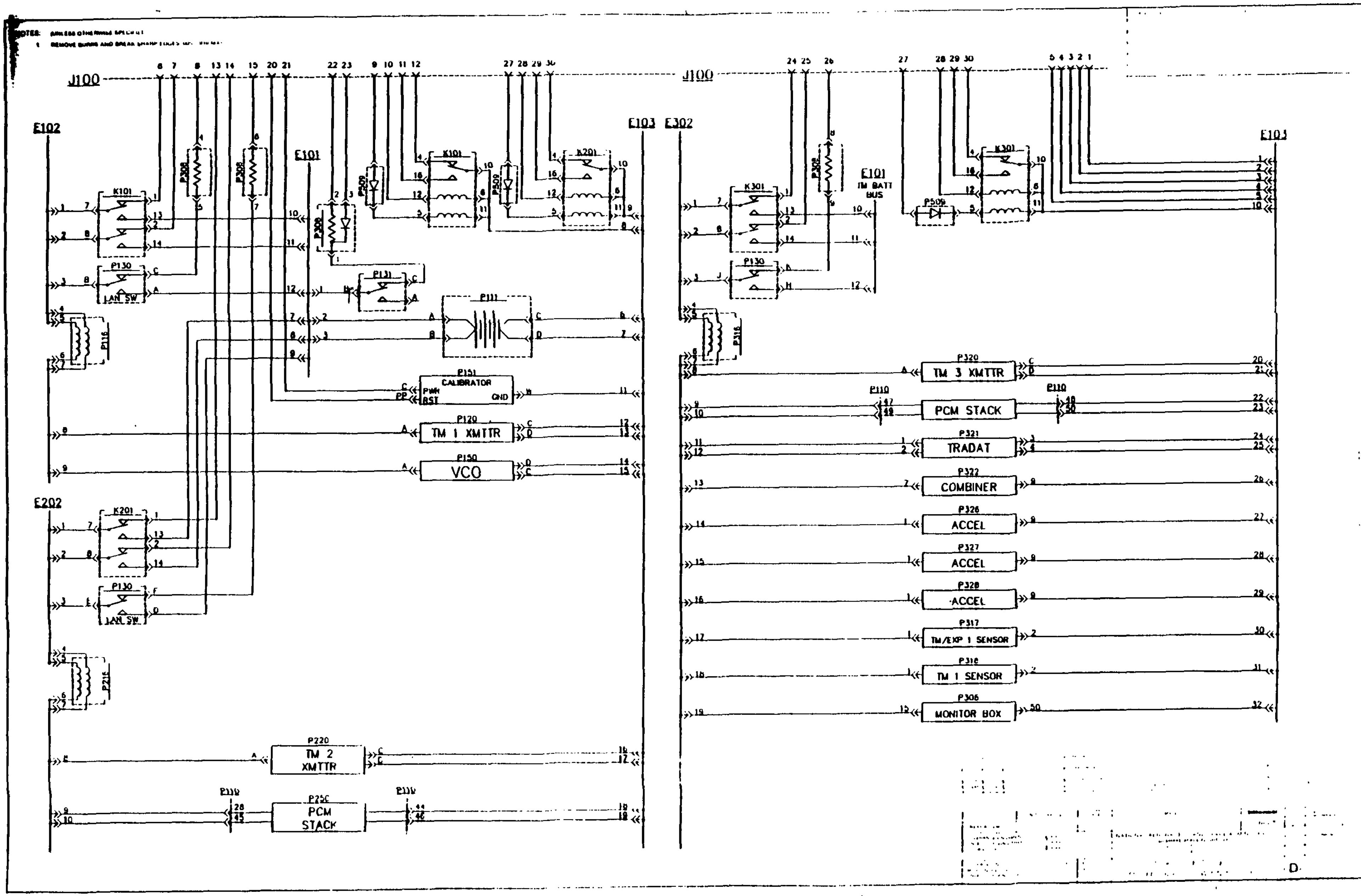
Building F-10/WFF
Wallops Island, Virginia 23337
804.824.1298

Associated Drawings

Wiring Diagram	A-35.011
TM Power Schematic	D-35.011 Sheet 1
Expt Power Schematic	D-35.011 Sheet 2
Pyro Control Schematic	D-35.011 Sheet 3

M. Smolinski

Mike Smolinski


NOTES: UNLESS OTHERWISE SPECIFIED
1. REMOVE BURRS AND BREAK SHARP EDGES
J100
E102
E101
E103
E302
E101 TM BATT BUS
E202
E105
K101
K201
K301
P130 LAN SW
P131
P116
P216
P316
P308
P309
P509
P111
P151 CALIBRATOR
PWR RST
GND
P120 TM 1 XMTTR
P150 VCO
P220 TM 2 XMTTR
P250 PCM STACK
P110
P320 TM 3 XMTTR
PCM STACK
P321 TRADAT
P322 COMBINER
P326 ACCEL
P327 ACCEL
P328 ACCEL
P317 TM/EXP 1 SENSOR
P318 TM 1 SENSOR
P306 MONITOR BOX

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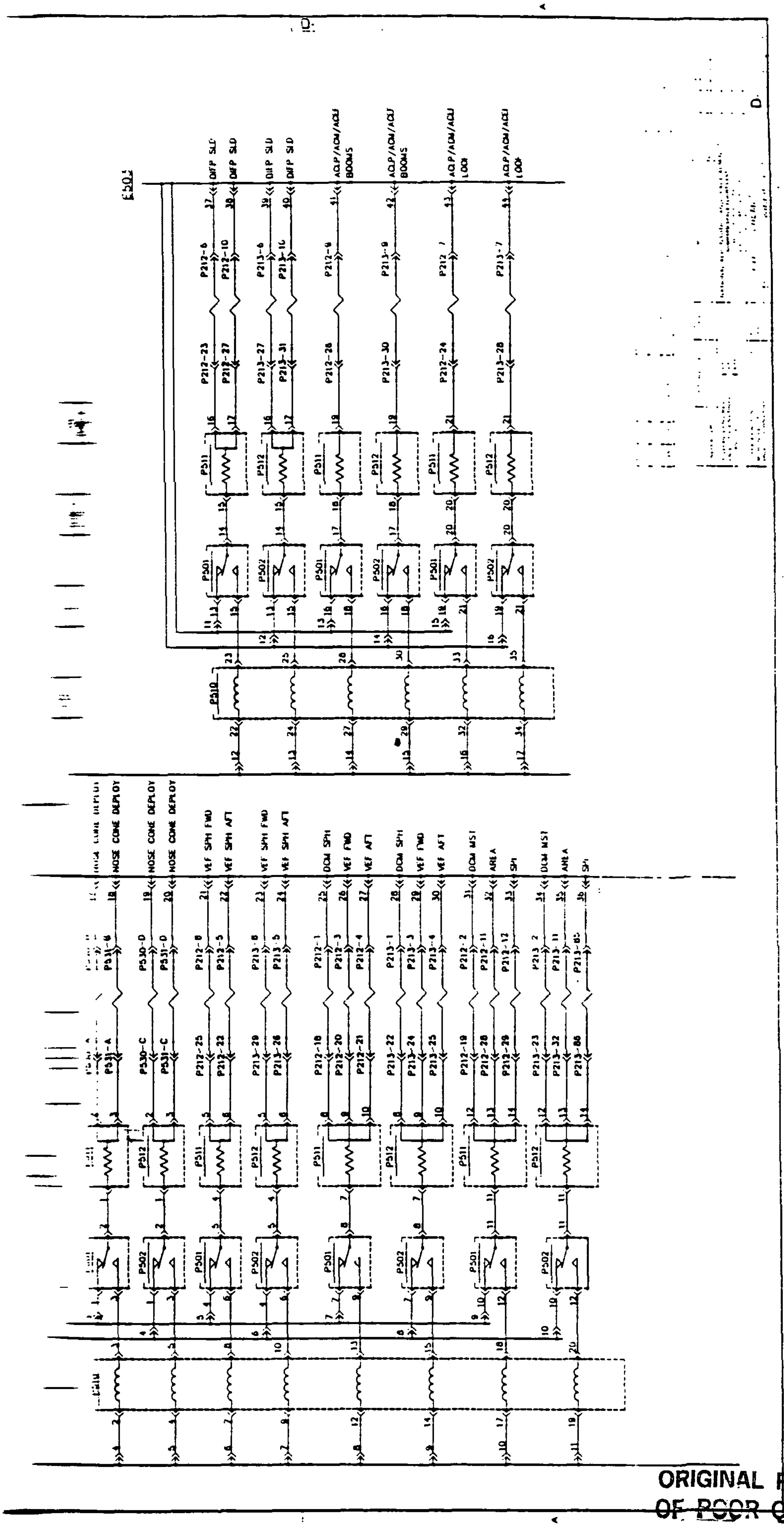

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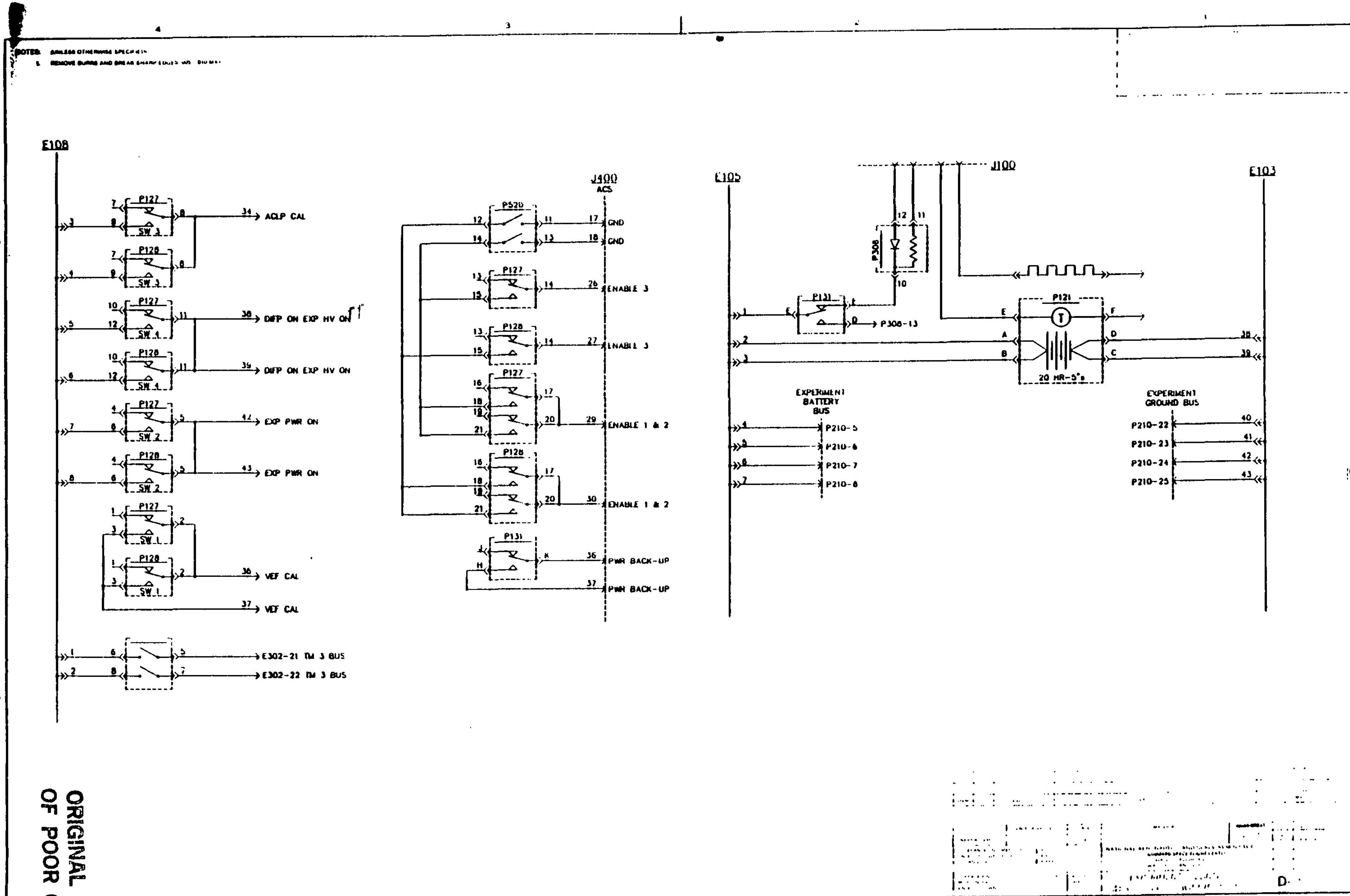


E108
P127
SW 3
P128
SW 3
ACLP CAL
SW 4
DIFP ON EXP HV ON
SW 2
EXP PWR ON
SW 1
VEF CAL
E302-21 TM 3 BUS
E302-22 TM 3 BUS
J400
ACS
P520
GND
ENABLE 3
ENABLE 1 & 2
P131
PWR BACK-UP
E105
J100
P308
P308-13
P121
20 HR-5°a
EXPERIMENT
BATTERY
BUS
P210-5
P210-6
P210-7
P210-8
E103
EXPERIMENT
GROUND BUS
P210-22
P210-23
P210-24
P210-25

MAGNETIC CONTROL SYSTEM

DICK MATTHEWS

JANUARY 31, 1989

COMPUTER SCIENCES CORPORATION

APPLIED TECHNOLOGY DIVISION 804, 824-5671

ROUTE 175 AT ROUTE 798 WALLOPS ISLAND, VIRGINIA 23337

January 12, 1989

TO: Design Review Chairman

FROM: Richard P. Matthews, CSC/ACGS

SUBJECT: Design Review 35.011/Winningham

Two magnetic ACS systems are to be flown from Norway in November of 1989. Each system is to align the vehicle with the negative magnetic field line. That is, to point the nose of the vehicle toward the South Magnetic Pole along the field line. The maneuvers are to be done early in flight - there will be boom deployments during maneuvering. There will be fixed time intervals for the maneuvers provided by the TM timer, instead of a deadband controller. There will be an initial pitch maneuver and an update near apogee. There will be only the initial roll maneuver. The telemetry timer will provide the timing for the maneuvers.

The ACS package consists of a pneumatics and an electronic section and is self contained. The pneumatics section consists of a high pressure gas vessel (nitrogen gas is to be used), and the required solenoid valves, nozzles, pressure regulator, and monitoring transducers. The electronics system, which provides driving signals to the solenoid valves, consists of a battery power system, a three axis magnetometer, a single axis rate gyro, and associated electronic cards.

The magnetometer and rate gyro provide servo input signals. The electronic servo system "precesses" the spinning vehicle to the desired attitude by properly timed and phased gas jets. The timing and phasing have been determined and will be verified by "operational" air bearing tests.

Sensor orientation can be seen in Figure I. The electronic system block diagram is Figure II.

R. P. Matthews

Richard P. Matthews, AGCS

PRELIMINARY

35.011 Winningham Gas Budget

Given:

1. Worse case cone (ha) expected at ACS turnon of 10 degrees

2. Maximum misalignment to field angle of 30 degrees

3. Roll dispersion of .75 to 1.25 RPS

4. Tank pressure of 4060psia and regulator pressure set to give valve inlet pressure of 300psia. Orifice to be .056 in.

5. In the beginning control configuration;

   Pitch Moment of Inertia = 76 $Slug\text{-}ft^2$

   Roll Moment of Inertia = 4.8 $Slug\text{-}ft^2$

   Ratio = 76/4.8 = 15.8

   Pitch Moment Arm = 3.5 ft

$$\text{Mass} = \frac{4060\ lbf/IN^2 \times 140\ IN^3 \times ft}{1.05 \times 55.15\ ft\text{-}lbf/lbm\text{-}^0R \times 560\ ^0R \times 12\ in} = 1.46\ lbm$$

At 300psia Mass =(300 x 140)/(55.15x560x12) = 0.11 lbm

Impulse available = (1.46 - 0.11)65 = 87.8 lbf-sec

Assuming that a Pitch transverse acceleration of $2.8^0/sec^2$ is confirmed by air bearing runs

Thrust required is

$$Lbf = 76Slug\text{-}Ft^2/3.5Ft \times 2.8^0/sec^2 \times 3.1416/180\ deg$$

Thrust = 1.1 lbf

Assuming a 26.8 second pointing maneuver, again confirmed by air bearing runs

Impulse required is then 1.1lbf x 20 sec valves = 22 lbf-sec for the pitch maneuver.

Assuming an initial roll rate of 1.25 RPS and a roll CCW thrust of 3.14 lbf,

Accel = (3.14 x .75/4.7) x 180/3.1416 = 28.7 deg/sec^2

Time = (450 - 360)/28.7 = 3.1 sec

Allowing a factor of two for roll valve cycling

Impulse = 3.14 x 3.1 x 2 = 19.5 lbf-sec

Total impulse required equals

22 + 19.5 = 41.5 lbf-sec

Safety margin for flight is then

(87.8/41.5) - 1 = 1.12 or 112 percent.

Schematics are attached.

ELECTRONIC COMPONENTS

Delvelco 3-Axis Magnetometer Model #9200C

Wallops Rate Gyro Package using a Honeywell GN90C1 Rate Gyro

Electronic Control Cards of Wallops Manufacture

Battery Pack of Wallops Manuf, 24 Af cells at 0.8 Ampere Hours

Power Switching Relay, Potter Brumfield TL17-0624

ENVIRONMENTAL TESTING

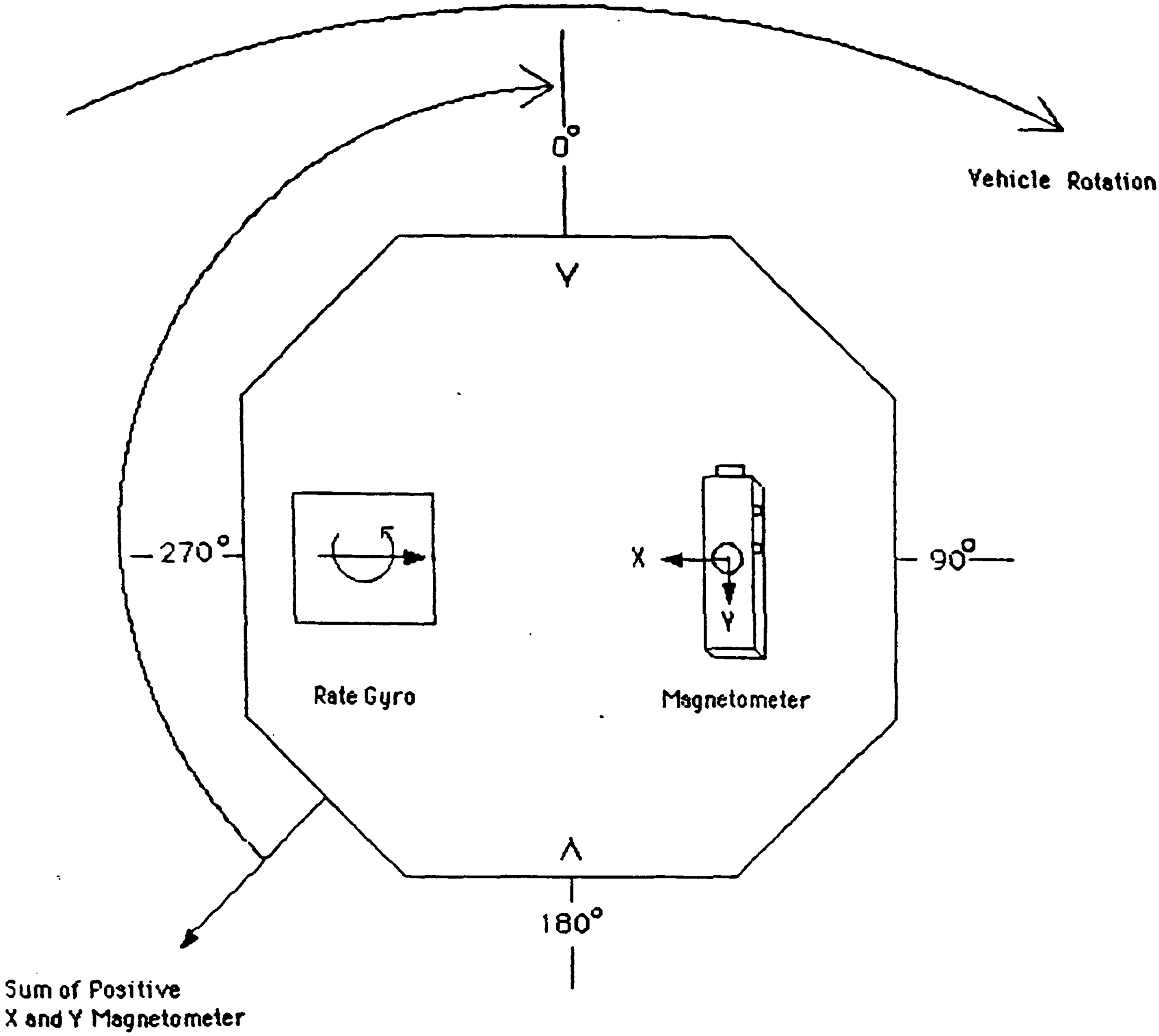
All spares will be tested for function.

All spare electronic components will be vibrated to "spares" levels and retested for function and calibration.

Flight components will be vibrated with the payload and be retestec for function and calibration.

Function testing will included bench testing where applicable and air bearing tests.

Winningham 35.011



Aft Looking Forward

The motor is separated, CG is forward of the ACS. To push the payload toward the -B vector, we want to push the ACS Can towards the +B vector. This is accomplished by firing a nozzle when it is 135 degrees past the direction we want to go.

FIGURE 1

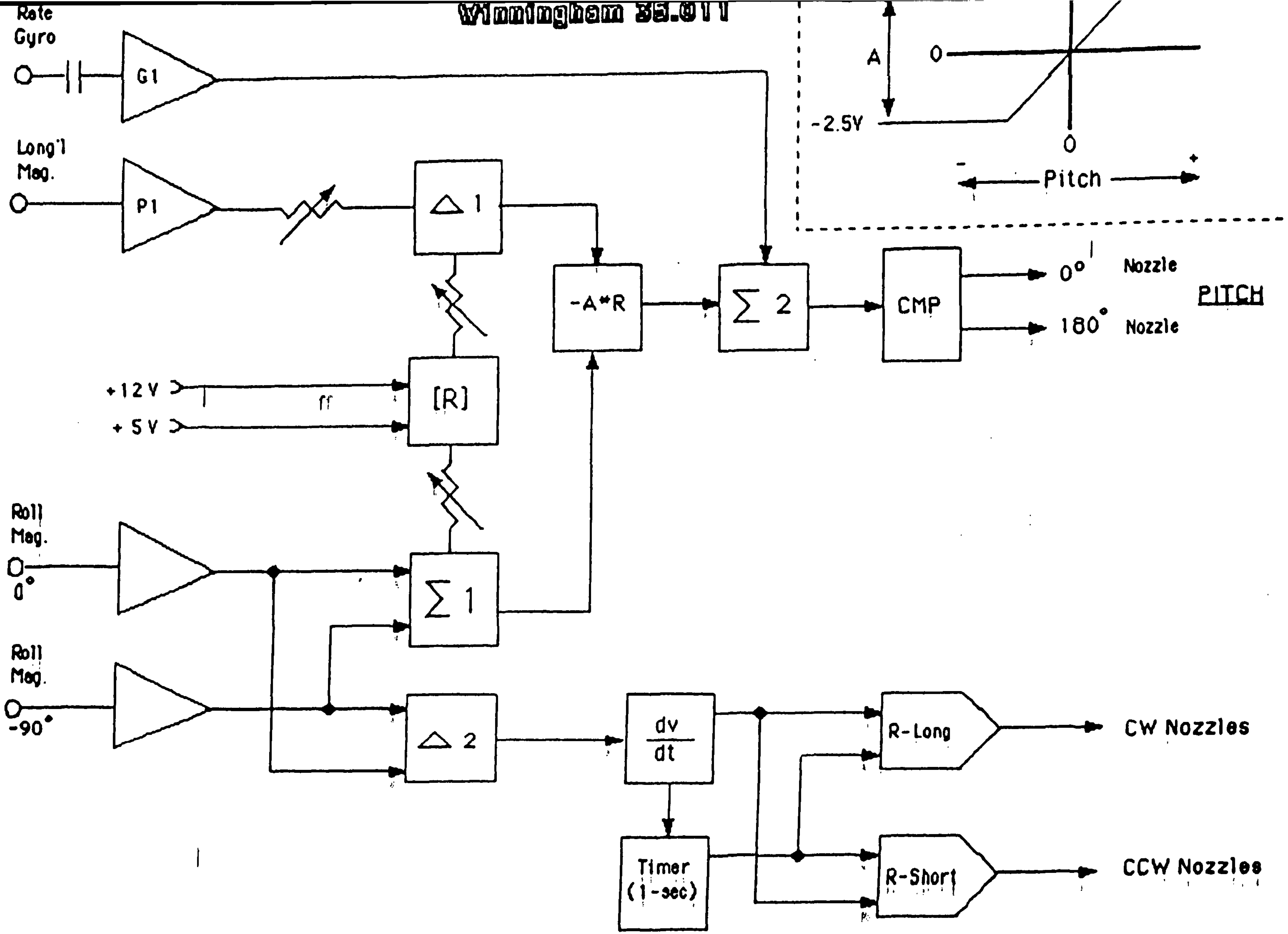
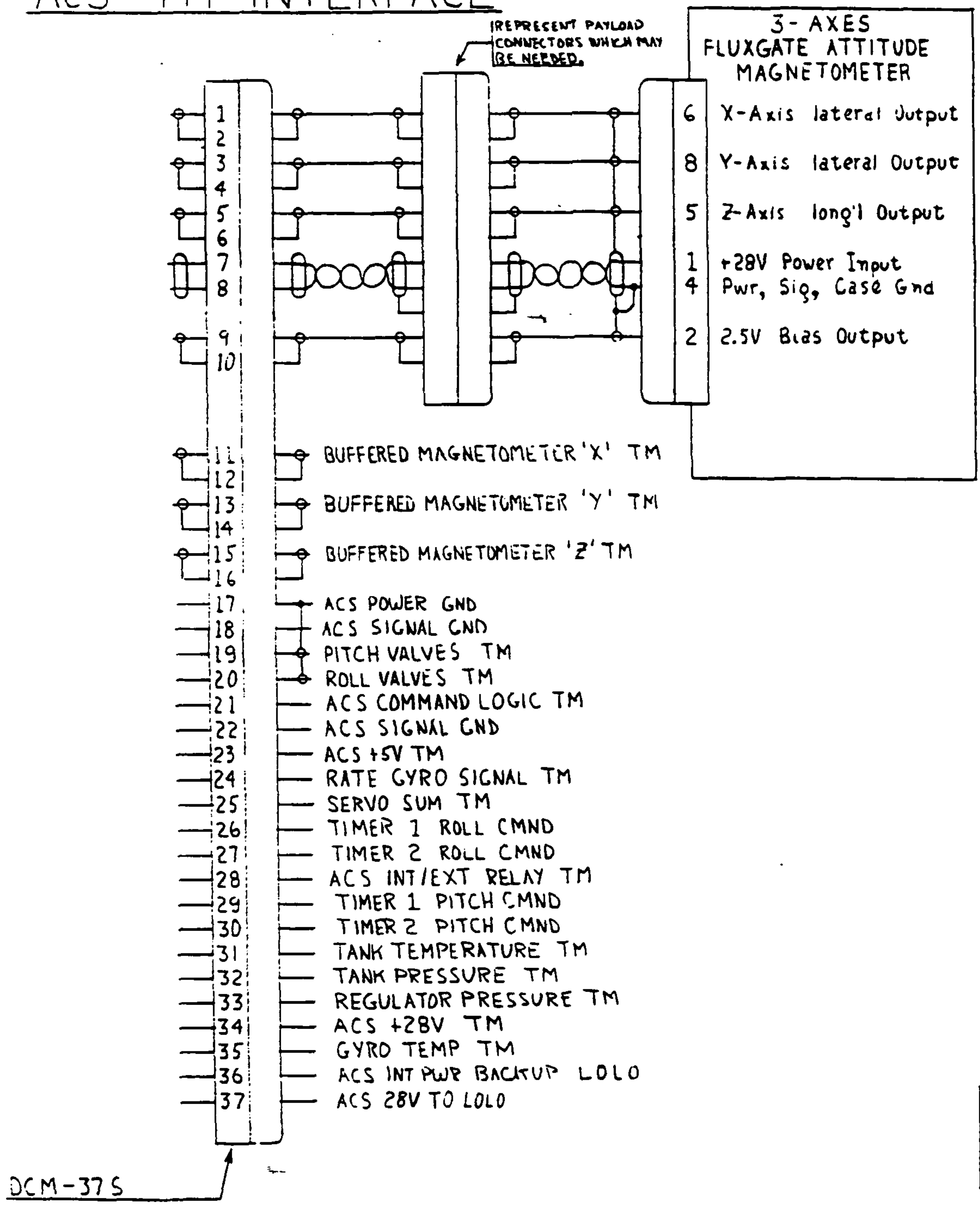

Rate
Gyro
G1
Long'l
Mag.
P1
+12 V
+5 V
ff
Roll
Mag.
0°
Roll
Mag.
-90°
△ 1
[R]
∑ 1
△ 2
-A*R
∑ 2
CMP
0° Nozzle
180° Nozzle
PITCH
A
0
-2.5V
0
Pitch
dv/dt
Timer
(1-sec)
R-Long
R-Short
CW Nozzles
CCW Nozzles

FIGURE 2

ACS-TM INTERFACE



NOTES:

1. THE SHIELDS ON THE VALVE TM MONITORS ARE PRIMARILY FOR PAYLOAD PROTECTION.
2. THE LOLO IS USUALLY A LIFT-OFF LANYARD SWITCH WHICH CLOSES PIN 36 TO PIN 37.

MAGNETIC ACS-TM INTERFACE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

DR. RPM 11/21/84
DES. RPM 11/21/84

C-ACS-GEN-0072

REMOVE BURRS AND BREAK SHARP EDGES .005 - .010 MAX

ORIGINAL PAGE IS OF POOR QUALITY

C-ACS-GEN-0072

CENTAUR II B & C SCHEDULE OF EVENTS

(PLANNED NOMINAL TIME)

		SECONDS AFTER LIFT OFF
A.	FEOS DEP	73
1.	VEF CAL. (24 SEC. HIGH OR CLOSED)	104
B.	DESPIN	107
C.	PAYLAOD DEP.	111
2.	VEF CABLE RELEASE	113
3.	VEF BOOMS DEPLOY, POWER ON PULSE, DCM STRAP RELESAE, ACLP CAL. (ACLP CAL. MUST HAVE A DURATION OF 8 SEC. OR LONGER)	115
4.	DCM BOOM DEPLOY, AREA DEPLOY	120
5.	DIFP DEPLOY, DIFP ON, SPI, SIMS & AREA HIGH VOLTAGE ON (24 SECONDS)	121
6.	ACLP, ACM & ACLP BOOMS DEPLOY	124
7.	ACEF, ACM & ACLP (2ND ANTENNA) DEPLOY	127
D.	ACS ENABLE	130
E.	ACS DISABLE	180
F.	2ND ACS ENABLE	APOGEE
G.	2ND ACS DISABLE	50 SEC LATER
H.	IMPACT	