SPAR

RADARSAT PRESENTATION

TO

GOVERNMENTS OF CANADA AND THE USA

JUNE 1988

RADARSAT PRESENTATION
JUNE 1988

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BACKGROUND

- APRIL 18 UK FORMAL WITHDRAWAL
- APRIL 21 SPAR'S CHAIRMAN OFFERS TO RESTRUCTURE PROGRAM AND IDENTIFY IMPACTS OF BUS PURCHASE
  - FINANCIAL PROPOSAL DUE 3RD JUNE - SUBMITTED
  - TECHNICAL PROPOSAL DUE 10TH JUNE - SUBMITTED
- REPORTING ON THE RESULTS OF OUR INVESTIGATIONS
- GENERALLY WE HAVE POSITIVE RESULTS TO REPORT
- OUTLINES CURRENT PROPOSAL TO CANADIAN GOVERNMENT

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THE BASELINE

- o GOVERNMENT AND INDUSTRY FUNDED
- o SHARED RISK - SPAR LOOK TO A FFP PROGRAM
- o PROGRAM RESTRUCTURED TO

  1. PURCHASE BUS
  2. FIT ON SMALLER LAUNCH VEHICLE
  3. REFLECT COMMERCIAL (ANIK) APPROACH TO PROGRAM
  4. REFLECT GREATER INDUSTRIAL COMMITMENT (FFP CONTRACT)
  5. INCREASED DATA COMPANY CONTRIBUTION
  6. MAINTAIN RADAR PERFORMANCE
  7. MAINTAIN BENEFITS

     - APPLICATION, TECHNOLOGY SPIN-OFF, SCIENTIFIC FOR RADAR AS BEFORE

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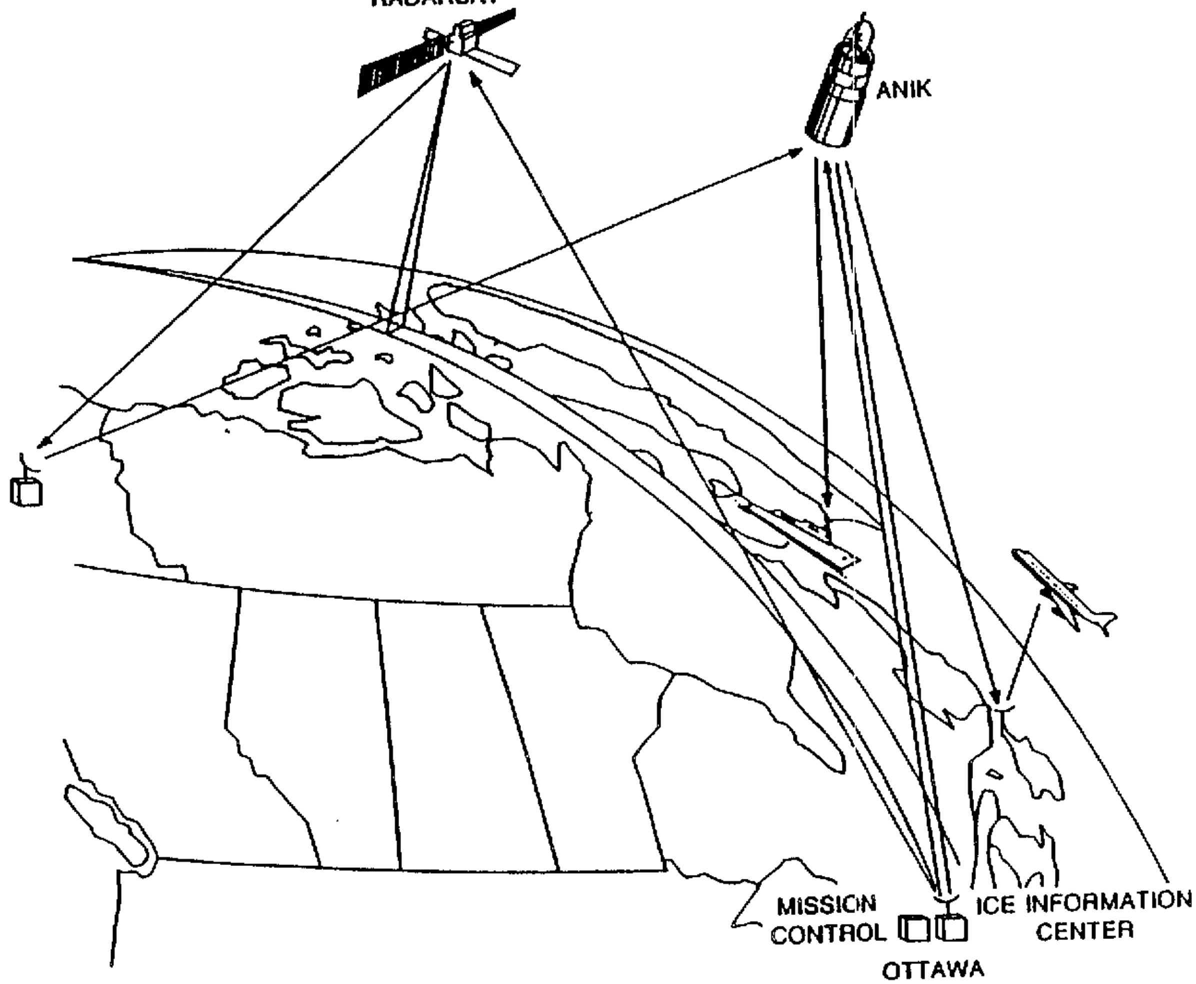
TECHNICAL BASELINE

- RADAR ONLY PAYLOAD
- PURCHASE SPACECRAFT BUS
- DAWN/DUSK ORBIT
- MLV (DELTA II) LAUNCH VEHICLE
- HIGH RATE RECORDING CAPABILITY

WHY A DAWN-DUSK ORBIT?

- o SIMPLER SPACECRAFT DESIGN
- o BETTER POWER RAISING CAPABILITY
- o MORE STABLE THERMAL DESIGN - ALSO MEANS LESS DEVELOPMENT HARDWARE
- o SOLAR ARRAY DO NOT HAVE TO ROTATE

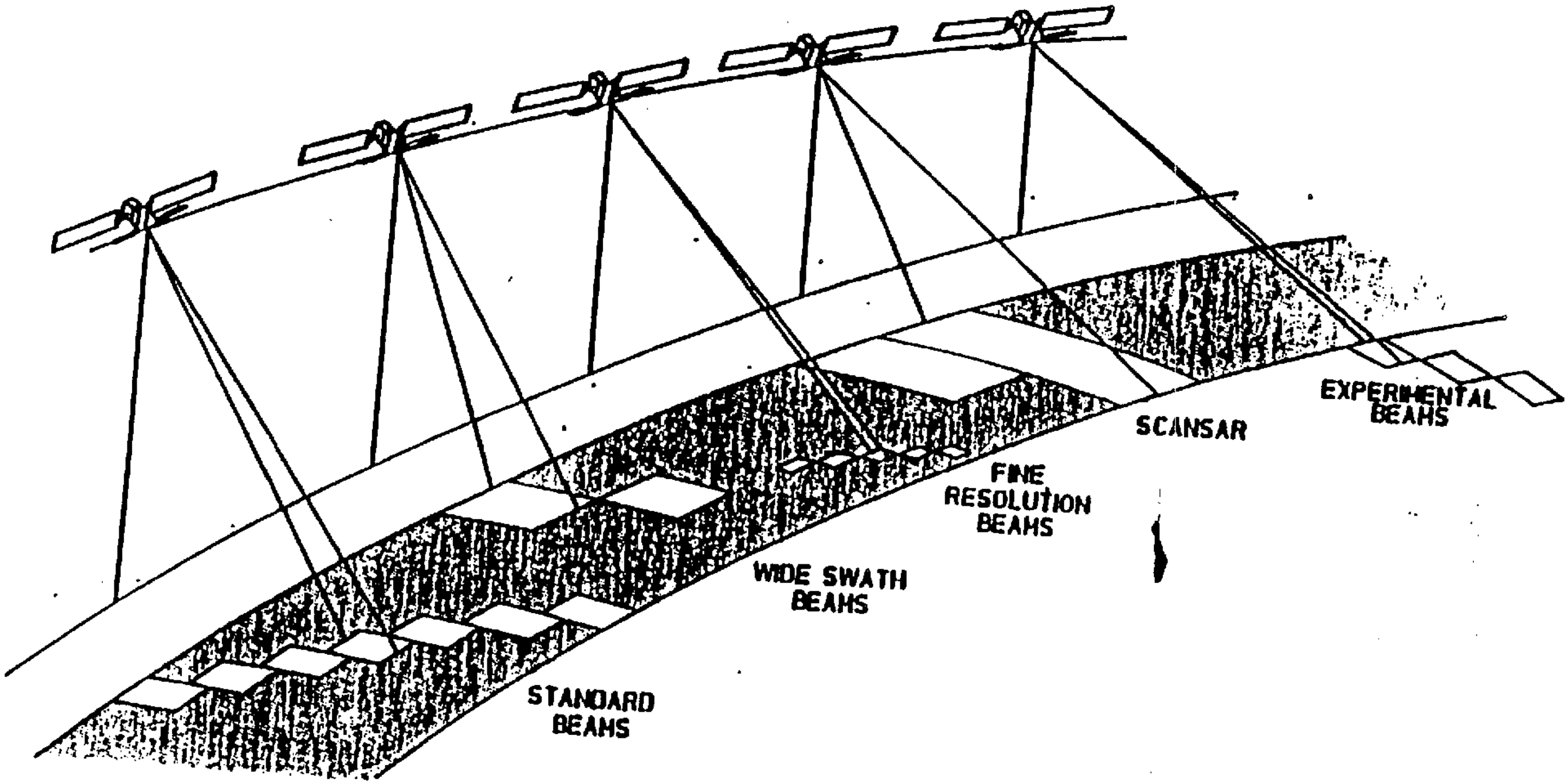
MISSION CONCEPT FOR SPAR

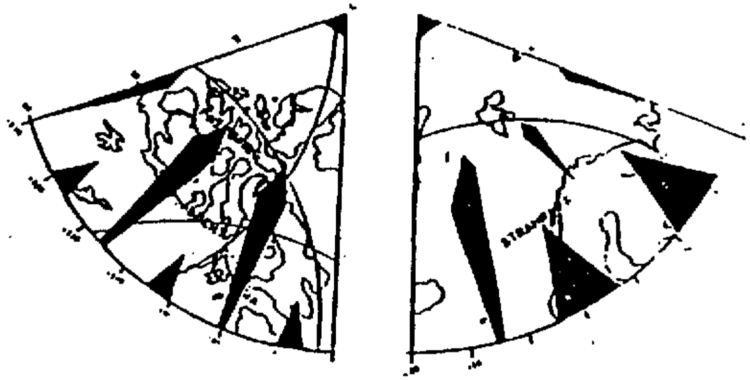


MISSION CONCEPT

SATELLITE PERFORMANCE

- RADAR PERFORMANCE UNCHANGED
  - ALL MODES STILL AVAILABLE
  - IMAGE QUALITY UNCHANGED
  - BETTER POWER SYSTEM CAPABILITY IN DAWN-DUSK ORBIT PROVIDES POTENTIAL FOR MORE OPERATION
- ADDITIONAL CAPABILITY INTRODUCED
  - NORMAL - RADAR RIGHT LOOKING COVERS ARCTIC
  - SPECIAL - PLANNED FOR 2 TWO-WEEK PERIODS
    - RADAR LEFT LOOKING
    - COVERS ANTARCTIC
- ORBIT ALTITUDE UNCHANGED
  - COVERAGE THEREFORE UNCHANGED


EXPERIMENTAL
BEAMS
SCANSAR
FINE
RESOLUTION
BEAMS
WIDE SWATH
BEAMS
STANDARD
BEAMS



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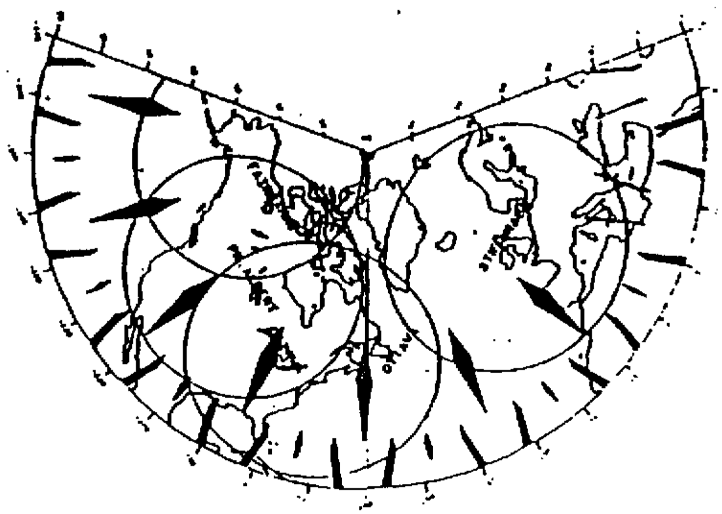

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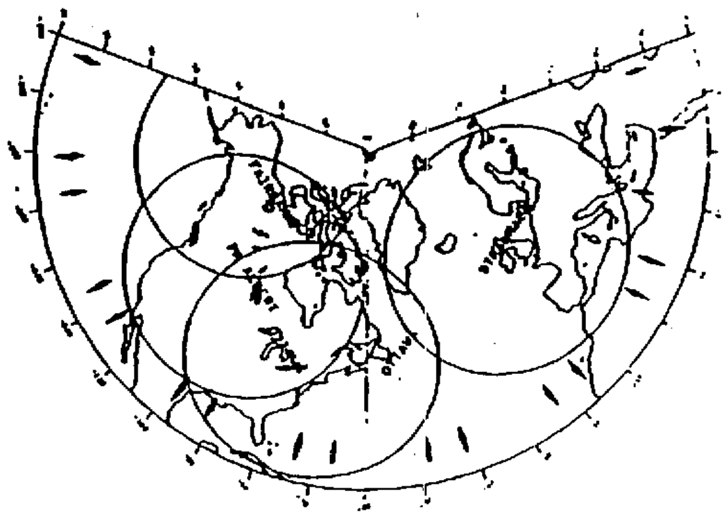

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PROGRAM OBJECTIVES

- TO LAUNCH IN MID 1994
- A REMOTE SENSING SATELLITE
- TO OPERATE FOR IN EXCESS OF FIVE YEARS
- TO COLLECT DATA FOR:

ICE	BOTH POLES
OCEANS	
RESOURCES	RENEWABLE AND NON-RENEWABLE

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USER REQUIREMENTS

- ICE MONITORING
  - COASTAL AND POLAR
  - MEASURE ICE TYPES AND EXTENT

RESPONSE

- HIGH SENSITIVITY
- NARROW BRAM CAPABLE OF STEERING TO FOLLOW SELECTED TRACKS
- RAPID COVERAGE OF ARCTIC (1 TO 3 DAYS) FROM POLAR ORBIT
- LEFT LOOKING MODE FOR ANTARCTICA
- SCANSAR (500 KM/100M STRIPMAP)

USER REQUIREMENTS

o **SHIP MONITORING**

- COASTAL NAVIGATION
- NAVIGATION THROUGH ICE
- SUPPORTS NATURAL RESOURCE EXTRACTION

RESPONSE

- WIDE COVERAGE CAPABILITY (WIDE BEAMS AND SCANSAR)
- DESIGNED TO SEE ALL BUT SMALLEST VESSELS IN HEAVY SEAS
- HIGH RESOLUTION AND INCIDENCE ANGLE $>40^{\circ}$

USER REQUIREMENTS

- **RENEWABLE RESOURCES**
  - AGRICULTURE, FORESTRY, HYDROLOGY

  RESPONSE

  - CROP DISCRIMINATION BY RADAR RETURN (CALIBRATED SAR)
  - SOIL MOISTURE CONTENT (C-BAND, 20^{o} INC)
  - CANOPY OR GROUND COVER (30^{o} -45^{o} INCIDENCE)
  - ABILITY TO MAP RESERVOIRS

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- **USERS REQUIREMENTS**

  o **NON-RENEWABLE RESOURCES**

  - GEOLOGY

  - RESOURCES

  RESPONSE

  - VARIABLE LOOK ANGLE BUILDS QUASI-STEREO MAP

  - WORLD WIDE COVERAGE BY ORBIT SELECTION AND ON BOARD RECORDING

  - ORBIT STABILITY/SAR PHASE STABILITY FOR INTERFEROMETRY

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USER REQUIREMENTS

- o SCIENTIFIC
  - GLOBAL CLIMATE MODEL
  - EXPERIMENTAL USE OF SAR

RESPONSE

- CALIBRATION
- EXPERIMENTAL BEAMS

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TECHNICAL RE-EVALUATION

- o CONFIGURATION DEVELOPED TO FIT DELTA LAUNCH VEHICLE (SMALLER SIZE LED TO NEW CONFIGURATION)

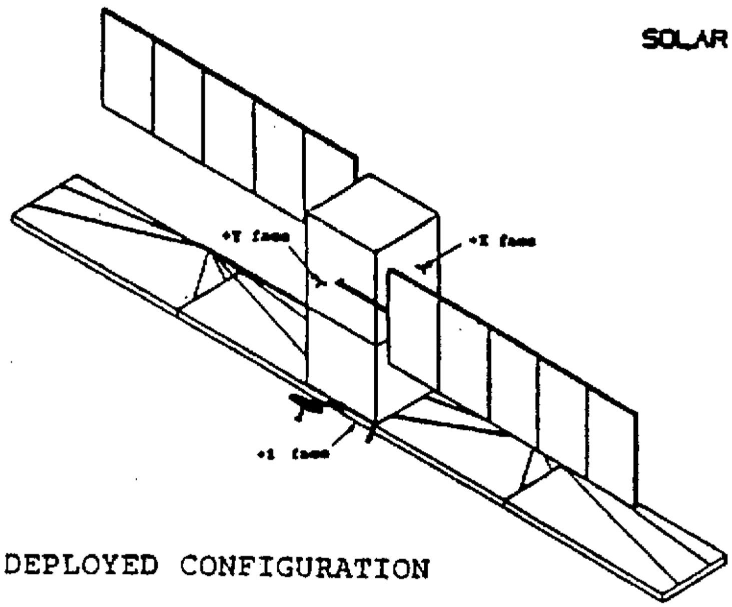
- o AVAILABILITY OF SUITABLE BUS FROM US

  RFQ ISSUED TO 8 POTENTIAL SUPPLIERS

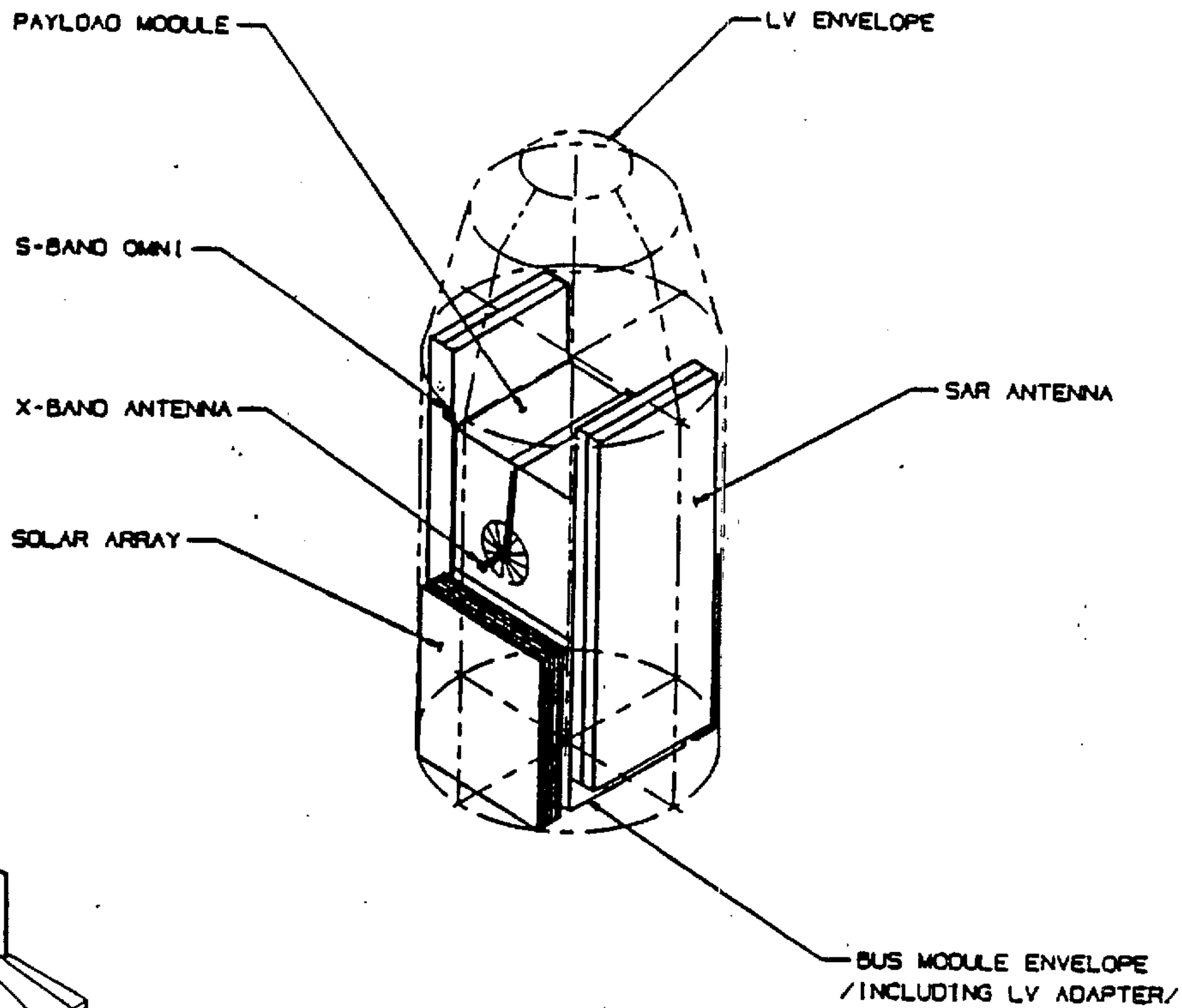
  - ONLY ONE COMPLETE NO BID
  - ONE FURTHER NO BID FOR CONTRACTUAL REASONS
  - ONE TO CONSIDER LATER
  - ONE STILL TO COME
  - FOUR BIDS RECEIVED
  - TECHNICAL DATA ON 3 INDICATE STRONG POTENTIAL TO SUPPORT MISSION

- o RPO LOOKING AT OTHER COMPLEMENTARY OPTIONS

SPACECRAFT CONCEPT



DEPLOYED CONFIGURATION



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PROPOSED CHANGES TO ACCOMODATE BUS PURCHASE:

<u>IMPLEMENTATION PHASE</u>

- o COMMERCIAL APPROACH TO PRIME ACTIVITIES PROGRAM MANAGEMENT, SYSTEMS, PRODUCT ASSURANCE AND INTEGRATION AND TEST (LOWER COST DESPITE INCREASED RESPONSIBILITIES)
- o FLIGHT PROVEN HARDWARE DELETED FROM DEVELOPMENT PROGRAM. NEW ITEMS REQUIRING DEVELOPMENT MAINTAINED
- o SHORTER TEST PROGRAM - 3 MONTHS DELETED FROM PROGRAM
- o SERIES PROGRAM - LESS TEST EQUIPMENT REQUIRED
- o IDENTIFIED FLIGHT PROVEN TAPE RECORDERS

PROGRAM SCHEDULE

- LAUNCH MUST BE MID 1994 TO AVOID CONFLICT WITH POLAR PLATFORMS
- 60 MONTH BUILD PROGRAM REQUIRES SPRING 89 CONTRACT
- 6 MONTH PRESTART TO SELECT MAJOR SUPPLIERS AND MAKE VITAL SYSTEMS PREPARATIONS
- THEREFORE NEED TO START WORK IN SEPTEMBER 1988
- NEED CANADIAN GOVERNMENT COMMITMENTS SOON

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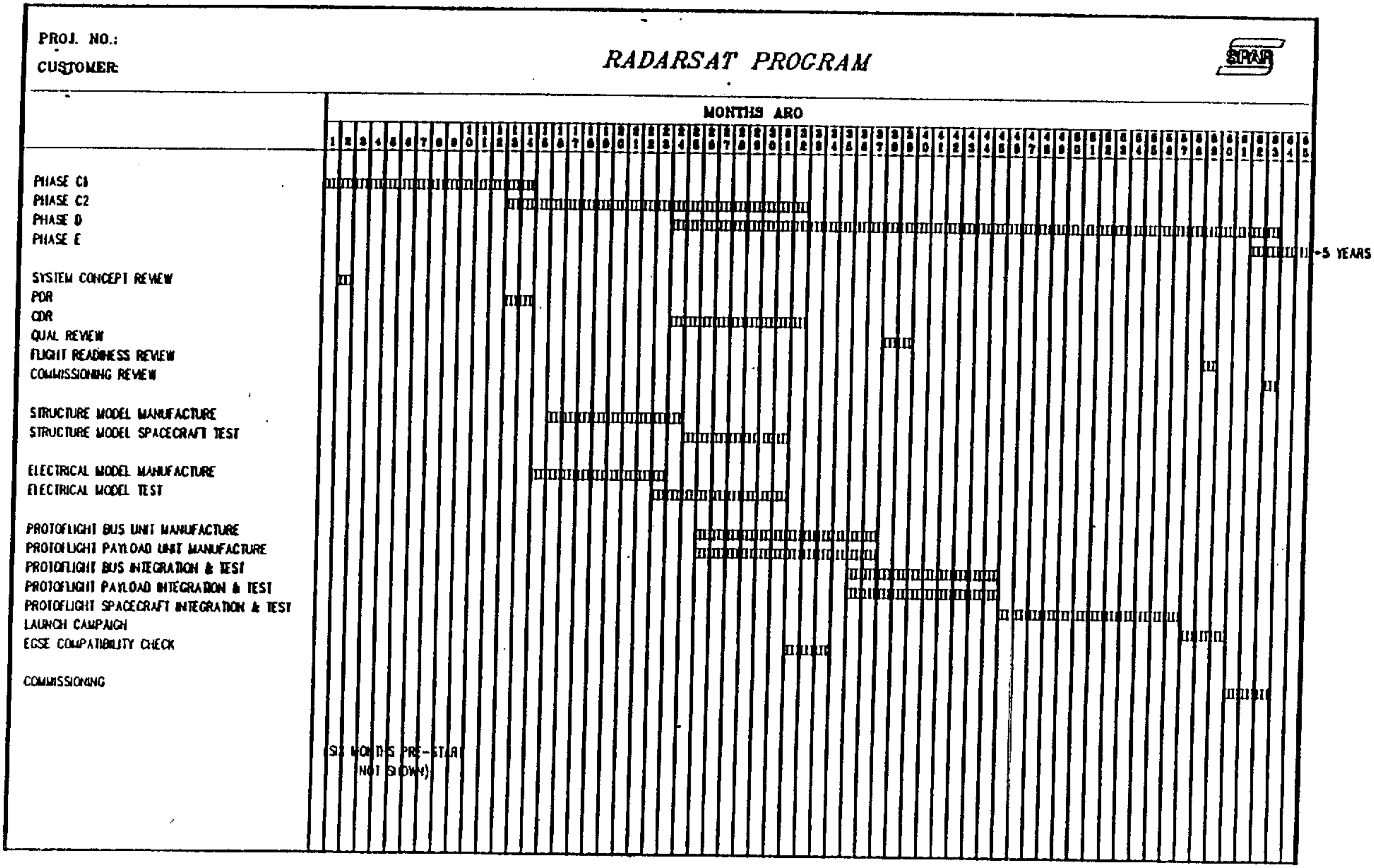
LAUNCH VEHICLE DATA REQUIREMENTS

- MUST SELECT BUS DURING PRESTART
- FFP BIDS REQUIRE BEST POSSIBLE DATA BASE
- NEED TO CONFIRM BY SEPTEMBER AT LEAST:

	SPAR ASSUMPTION
MINIMUM SHROUD SIZE	ROSAT
MINIMUM LIFT CAPABILITY	3200 KG
LAUNCH LOADS	DELTA II
ACCOUSTIC ENVIRONMENT	DELTA II
THERMAL ENVIRONMENT	DELTA II
LAUNCH PROFILE	DELTA II
AVAILABILITY OF LV ADAPTORS	PER BUS SUPPLIER

- MLV RFP MAY HELP IDENTIFY DESIGN DRIVERS


PROJ. NO.:
CUSTOMER:
RADARSAT PROGRAM
SPAR
MONTHS ARO
PHASE C1
PHASE C2
PHASE D
PHASE E
←5 YEARS
SYSTEM CONCEPT REVIEW
PDR
CDR
QUAL REVIEW
FLIGHT READINESS REVIEW
COMMISSIONING REVIEW
STRUCTURE MODEL MANUFACTURE
STRUCTURE MODEL SPACECRAFT TEST
ELECTRICAL MODEL MANUFACTURE
ELECTRICAL MODEL TEST
PROTOFLIGHT BUS UNIT MANUFACTURE
PROTOFLIGHT PAYLOAD UNIT MANUFACTURE
PROTOFLIGHT BUS INTEGRATION & TEST
PROTOFLIGHT PAYLOAD INTEGRATION & TEST
PROTOFLIGHT SPACECRAFT INTEGRATION & TEST
LAUNCH CAMPAIGN
EGSE COMPATIBILITY CHECK
COMMISSIONING
(SIX MONTHS PRE-START
NOT SHOWN)

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SUMMARY

- A RESTRUCTURED PROGRAM HAS BEEN SUCCESSFULLY DEFINED
- BASIC SATELLITE PERFORMANCE MAINTAINED
- RADAR PERFORMANCE MAINTAINED
- ANTARCTIC COVERAGE MODE CONFIRMED
- INDUSTRY (SPAR AND RADARSAT INTERNATIONAL) SHARING THE RISK
- DECISIONS ARE NEEDED SOON

SAR SYSTEM PERFORMANCE

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SAR PERFORMANCE

BASIC SET OF BEAMS
WIDE SWATH, FINE RESOLUTION & EXPERIMENTAL BEAMS
SCANSAR

COVERAGE
SPATIAL RESOLUTION
RADIOMETRIC PERFORMANCE

CALIBRATION
VERIFICATION
PROCESSOR FUNCTIONS

BASIC SAR IMAGING REQUIREMENTS (FROM 1984)

COVERAGE:

ACCESSIBILITY SWATH WIDTH	≥500 KM
INCIDENCE ANGLES	20° - 49° +
INDIVIDUAL SWATH WIDTHS	≥100 KM
OVERLAPS	10%

RESOLUTION:

AZIMUTH (4 LOOKS)	28 M
GROUND RANGE	25 M

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BASIC BEAMS

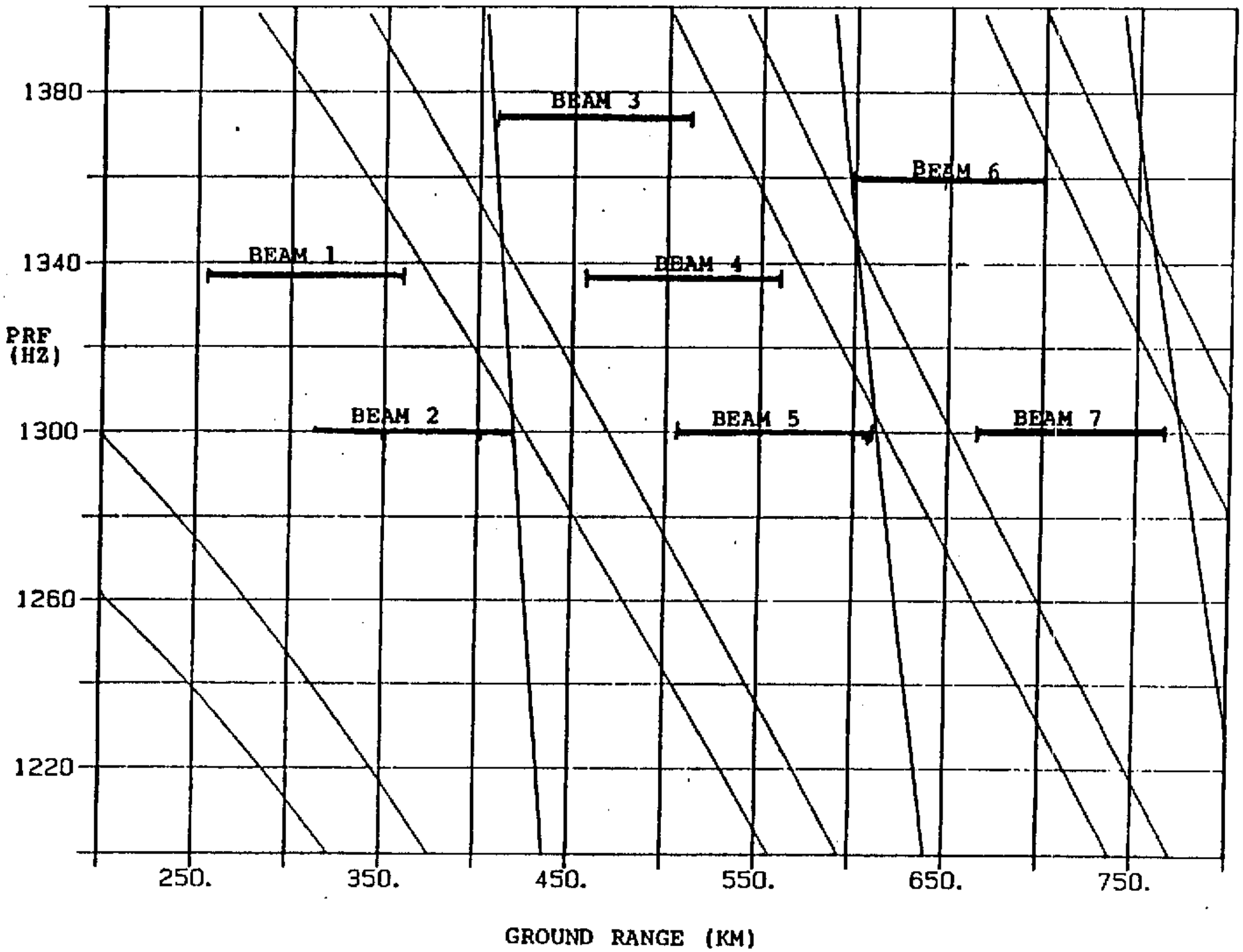
A SET OF SEVEN BEAMS DESIGNED TO SATISFY THE BASIC IMAGING REQUIREMENTS

THE BEAMS ARE DEFINED

- TO COVER 100-105 KM SWATH WIDTH
- TO AVOID AMBIGUITY FROM THE NADIR REGION WITH APPROPRIATE PRF
- TO HAVE LARGE OVERLAPS WHERE POSSIBLE (>10%).

TWO PULSE BANDWIDTHS AND SAMPLING RATES ARE AVAILABLE TO KEEP GROUND RANGE RESOLUTION AND DATA RATE REASONABLY UNIFORM ACROSS THE SET OF BEAMS

BASIC BEAM COVERAGE (1)



PRF'S AND COVERAGE ARE FOR NOMINAL ALTITUDE OF 792 KM

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BASIC BEAM COVERAGE (2)

BEAM	INCIDENCE ANGLES	GROUND RANGE	WIDTH	RESOLUTION (4 LOOKS)
1	20.0-27.4°	254-360 KM	106 KM	28 X 28 M
2	24.2-31.1°	313-418 KM	105 KM	28 X 24 M
3	30.4-36.8°	405-512 KM	107 KM	28 X 29 M
4	33.5-39.5°	456-561 KM	105 KM	28 X 27 M
5	36.4-42.1°	505-610 KM	105 KM	28 X 25 M
6	41.3-46.4°	595-700 KM	105 KM	28 X 23 M
7	44.7-49.2°	665-765 KM	100 KM	28 X 22 M

ALL FIGURES ARE GIVEN FOR NOMINAL ALTITUDE 792 KM

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WIDE SWATH BEAMS

TWO BEAMS DESIGNED TO GIVE COVERAGE OF A WIDER SWATH WITHOUT SIGNIFICANT DEGRADATION IN IMAGE QUALITY.

THE BEAMS ARE DEFINED

- TO COVER SWATH WIDTHS OF OVER 150 KM
- TO BE USED WITH THE LOWER BANDWIDTH PULSE
- TO AVOID NADIR AMBIGUITIES

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FINE RESOLUTION BEAMS

A SET OF FIVE BEAMS DESIGNED TO OPTIMIZE THE SENSITIVITY FOR FINE RESOLUTION IMAGING OF THE NARROWER SWATH DICTATED BY DATA RATE CONSTRAINTS

A THIRD WIDE BANDWIDTH PULSE (NOMINALLY 30 MHZ) IS PROVIDED TO ALLOW A GROUND RANGE RESOLUTION FINER THAN 10 M TO BE ACHIEVED OVER A SIGNIFICANT SEGMENT OF THE ACCESSIBILITY SWATH

SINGLE-LOOK PROCESSING WILL PROVIDE A COMPARABLE RESOLUTION IN AZIMUTH

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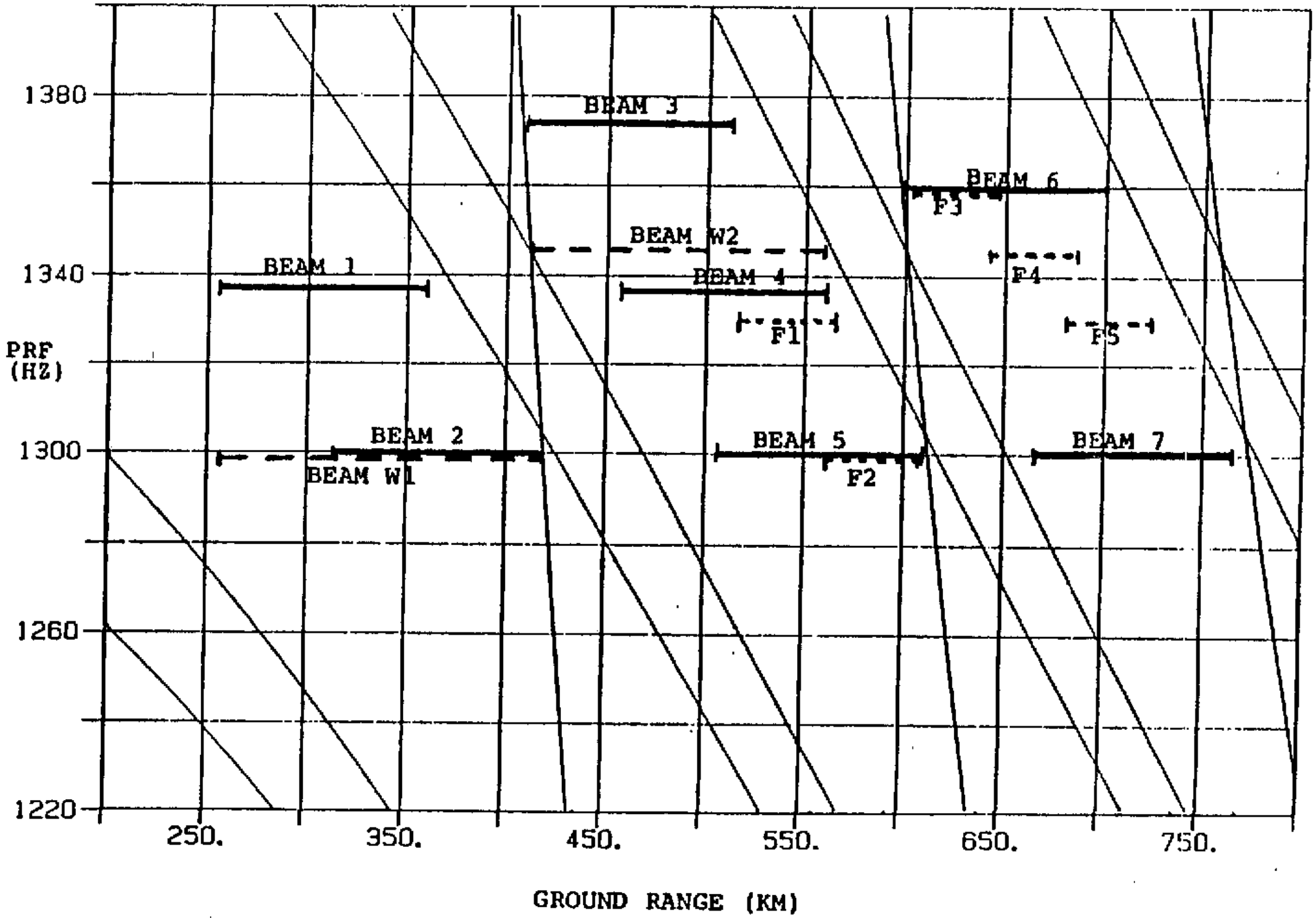
WIDE SWATH AND FINE RESOLUTION BEAM COVERAGE (1)



PRF'S AND COVERAGE ARE FOR NOMINAL ALTITUDE OF 792 KM

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WIDE SWATH AND FINE RESOLUTION BEAM COVERAGE (2)

BEAM	INCIDENCE ANGLES	GROUND RANGE	WIDTH	RESOLUTION
W1	20.0-31.1°	254-418 KM	164 KM	28 X 40(4 LOOKS)
W2	30.7-39.4°	411-559 KM	148 KM	28 X 29
F1	37.0-39.7°	516-566 KM	50 KM	8 X 10.1(1 LOOK)
F2	39.4-42.0°	560-608 KM	48 KM	8 X 9.7
F3	41.7-43.9°	602-646 KM	44 KM	8 X 9.3
F4	43.6-45.7°	642-685 KM	43 KM	8 X 8.9
F5	45.4-47.4°	680-723 KM	43 KM	8 X 8.6

EXPERIMENTAL BEAMS

- THE SAR IS NOT LIMITED IN ITS OPERATIONS TO THE DEFINED BEAMS. ALTERNATIVE BEAMS CAN BE FORMED IF THE APPROPRIATE PHASE COEFFICIENTS FOR THE ELEVATION BEAM FORMING NETWORK ARE TRANSMITTED TO THE SATELLITE

- SPECIFICALLY, THE SAR IS REQUIRED TO OPERATE EXPERIMENTALLY WITH BEAMS POINTING BEYOND THE FAR EDGE OF THE NORMAL ACCESSIBILITY SWATH:

  - SIX BEAMS HAVE PROVISIONALLY BEEN DEFINED TO COVER THE REGION OUT TO ABOUT 59° INCIDENCE ANGLE.

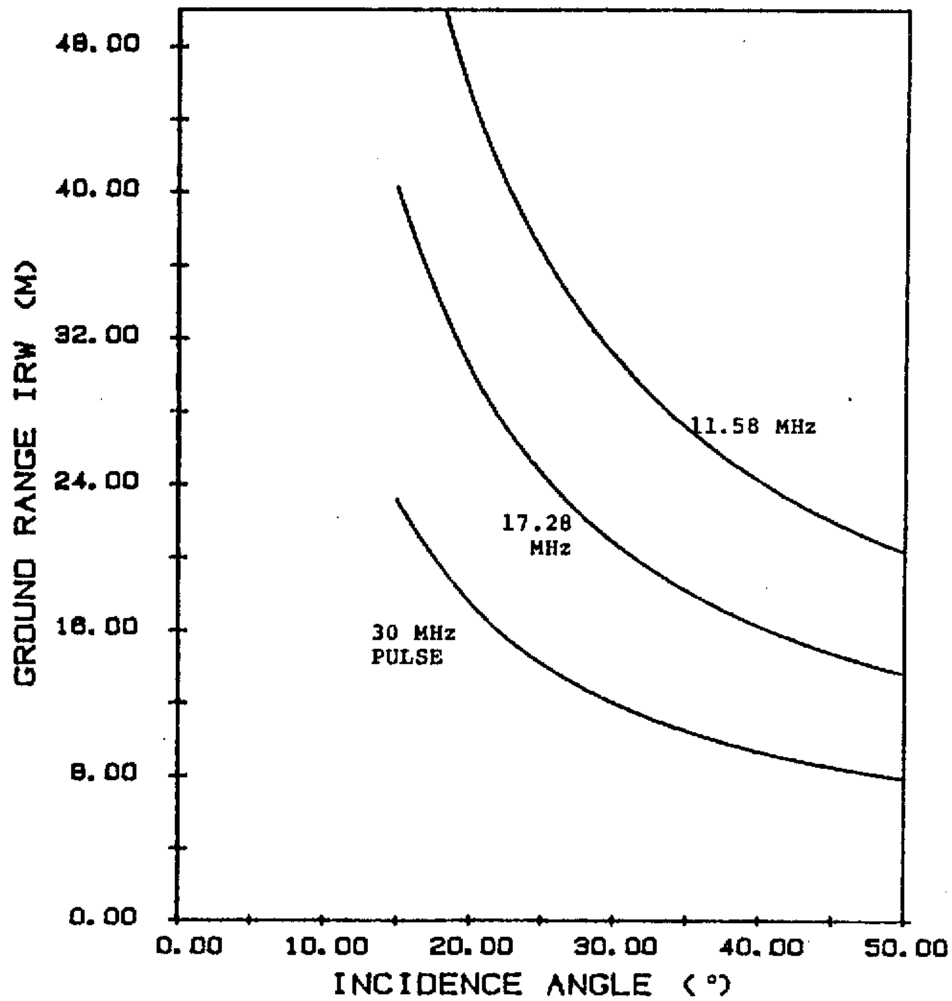
  - SWATH WIDTHS ARE NOMINALLY 70-80 KM, BUT IT IS RECOGNIZED THAT RANGE AMBIGUITY LEVELS MAY RISE VERY SHARPLY AT THE EDGES.

MULTIPLE PULSE BANDWIDTHS

PULSE 1 = 11.58 MHz   PULSE 2 = 17.28 MHz   PULSE 3 = 30 MHz (TBC)

BEAM	PULSE	GROUND RANGE RESOLUTION	DATA RATE
1	2	32 - 24 M	79 MBPS
2	2	27 - 21 M	85 MBPS
3	1	32 - 27 M	74 MBPS
4	1	29 - 25 M	76 MBPS
5	1	27 - 24 M	78 MBPS
6	1	25 - 22 M	89 MBPS
7	1	23 - 21 M	86 MBPS
W1	1	48 - 31 M	79 MBPS
W2	1	32 - 26 M	97 MBPS
F1	3	10.4 - 9.8 M	100 MBPS
F2	3	9.9 - 9.4 M	100 MBPS
F3	3	9.4 - 9.1 M	100 MBPS
F4	3	9.1 - 8.7 M	100 MBPS
F5	3	8.8 - 8.5 M	100 MBPS

GROUND RANGE RESOLUTION



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ASSESSMENT OF SPATIAL RESOLUTION PERFORMANCE

THE 3 dB IMPULSE RESPONSE WIDTH (I.R.W.) ASSESSMENT INCLUDES:

- THE BROADENING DUE TO THE WEIGHTING FUNCTION
- THE EFFECTS OF PHASE & AMPLITUDE ERRORS IN THE COHERENT INTEGRATION
- THE EFFECT OF PHASE ERRORS ON MULTI-LOOK REGISTRATION (ALL EFFECTS ARE ASSESSED BY SIMULATION).
- THE BROADENING INTRODUCED BY THE PROCESSOR (RELATIVE TO IDEAL)

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SCANSAR

IN SCANSAR IMAGING, THE OPERATIONAL TIME IS SHARED BETWEEN TWO OR MORE BEAMS WITH CONTIGUOUS SWATHS TO GIVE VERY WIDE COVERAGE IN A SINGLE PASS.

THE RADARSAT ANTENNA DESIGN WAS INHERENTLY CAPABLE OF VERY RAPID SWITCHING. THE ONLY MODIFICATION REQUIRED TO PROVIDE THE SCANSAR CAPABILITY WAS THE ADDITION OF REGISTERS TO STORE PHASE COEFFICIENTS FOR FOUR BEAMS.

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SCANSAR COVERAGE (1)

TWO STANDARD COMBINATIONS OF BEAMS HAVE BEEN DEFINED:

2-BEAM SCANSAR COMBINING WIDE SWATH BEAMS 1 AND 2

4-BEAM SCANSAR, AS FOR 2-BEAM, BUT WITH BASIC BEAM 7 AND AN ADDITIONAL BEAM TO COVER THE INTERMEDIATE REGION

(AN ALTERNATIVE 4-BEAM SCANSAR, AVOIDING NADIR AMBIGUITIES, COMBINES WIDE SWATH BEAMS 1 & 2 AND BASIC BEAMS 5 & 6)

OPTION	INCIDENCE ANGLES	GROUND RANGE	WIDTH
2-BEAM	20 - 39°	254 - 559 KM	305 KM
4-BEAM A	20 - 49°	254 - 765 KM	511 KM
B	20 - 46°	254 - 700 KM	446 KM

DATA RATES IN ALL CASES REMAIN BELOW 100 MBPS

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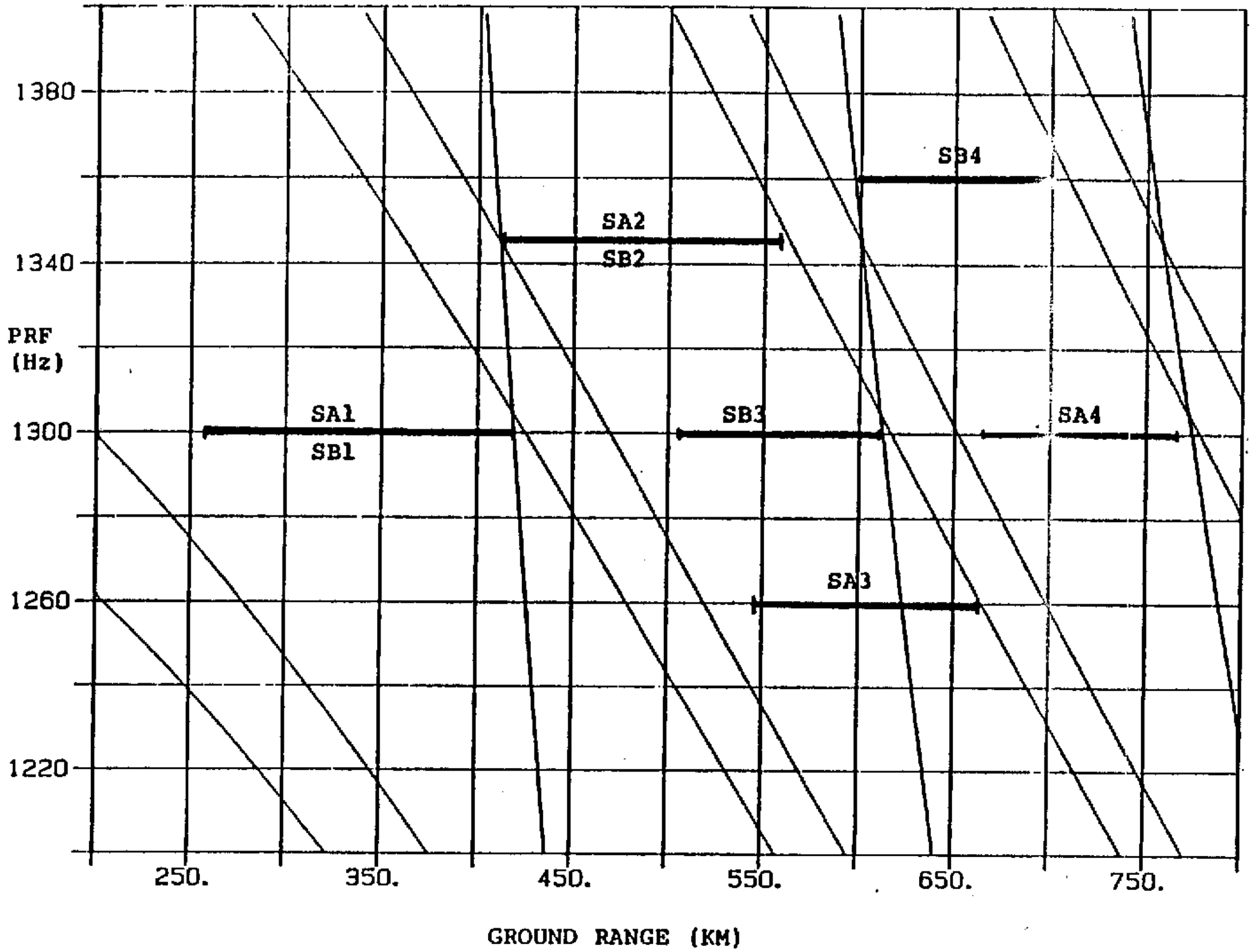
SCANSAR COVERAGE (2)



PRF'S AND COVERAGE ARE FOR THE NOMINAL ALTITUDE OF 792 KM

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SCANSAR BEAM SWITCHING (1)

A SERIES OF PULSES ARE TRANSMITTED AND RECEIVED WITH ONE BEAM TO ALLOW AN IMAGE TO BE FORMED OF A SECTION OF THE CORRESPONDING SUBSWATH. OPERATIONS SWITCH TO ANOTHER BEAM FOR A SERIES OF PULSES, THEN ON TO ANOTHER ... BEFORE RETURNING TO THE FIRST.

EACH SERIES OF PULSES MUST BE LONG ENOUGH TO GIVE THE REQUIRED AZIMUTH RESOLUTION.

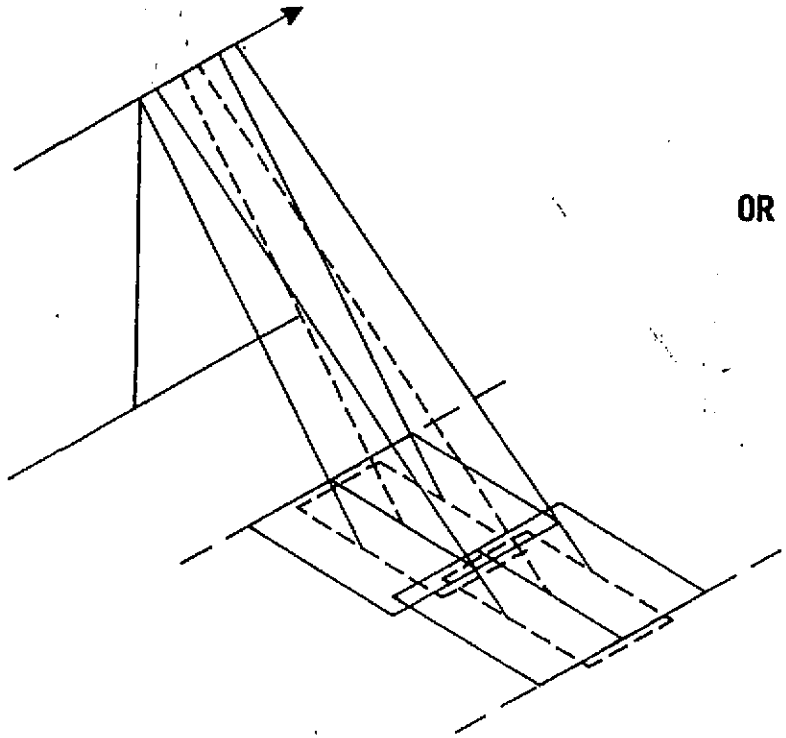
THE FULL CYCLE AROUND ALL THE BEAMS MUST BE SHORT ENOUGH TO GIVE CONTINUOUS ALONG TRACK COVERAGE.

MORE THAN ONE PRF MUST BE USED IF WIDE COVERAGE IS TO BE OBTAINED WITHOUT BREAKS BETWEEN SUBSWATHS.

SCANSAR BEAM SWITCHING (2)

THE ONLY RESTRICTION PLACED ON THE LENGTHS OF OPERATION FOR EACH BEAM ARE THAT THEY COMPRISE EQUAL NUMBERS OF PULSES.

VARIOUS SINGLE AND MULTIPLE LOOK OPTIONS ARE AVAILABLE. E.G. FOR 2-LOOK IMAGING:



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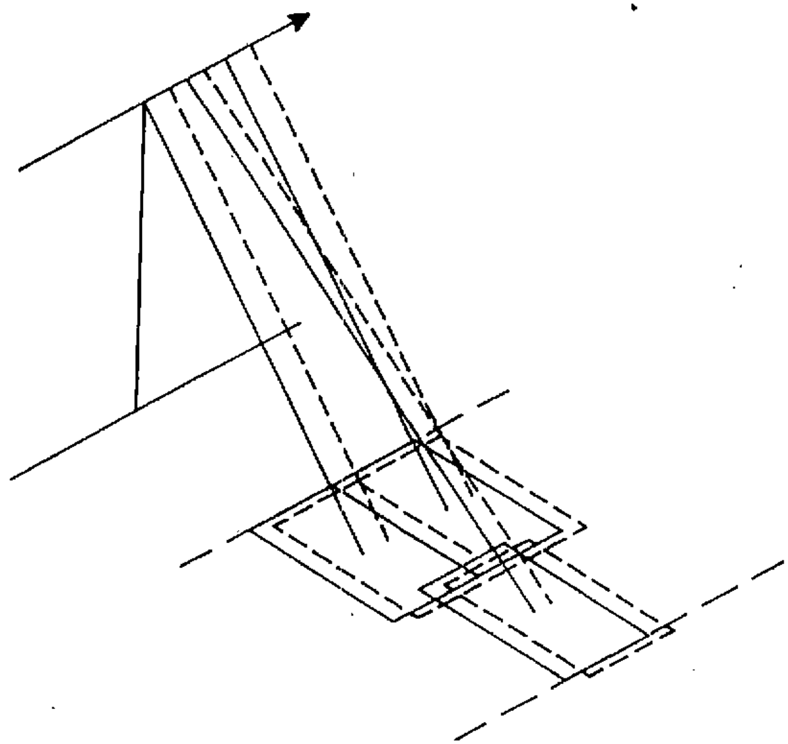

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RESOLUTION IN SCANSAR IMAGES

Beam	Azimuth Resolution (m) 2-Beam 1-Look	2-Beam 2-Look	4-Beam 1-Look	4-Beam 2-Look	Ground Range Res. (m)
1	26-28	45-49	45-49	88-96	45-30
2	28-31	49-54	49-54	96-105	30-24
3			54-58	104-112	25-22
4			58-62	112-120	22-20

FOR STANDARD PRODUCTS OF ABOUT 100M RESOLUTION

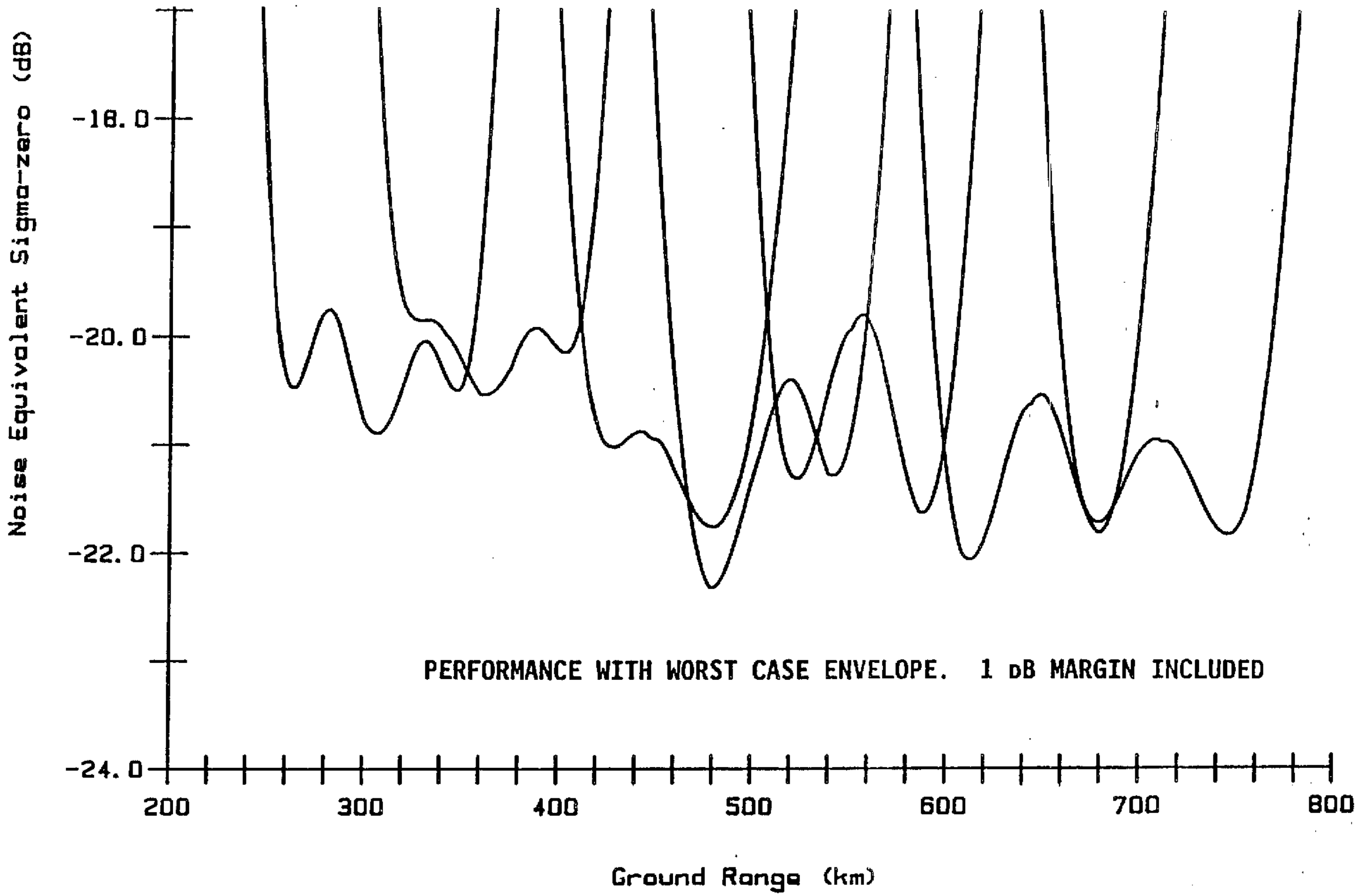
2 - BEAM OPERATIONS PROVIDE 4 X 4 INDEPENDENT LOOKS
4 - BEAM OPERATIONS PROVIDE 2 X 4 INDEPENDENT LOOKS

NOISE EQUIVALENT σ_0 ASSESSMENT

PERFORMANCE FIGURES ARE BASED ON THE FOLLOWING:

- REFERENCE NOISE TEMPERATURE	UP TO 320 K
- RECEIVER NOISE FIGURE	3.1 dB
- RF LOSSES (EXC. ANTENNA) + LOSSES IN PROCESSING	4.4 dB
- MEAN TRANSMITTER POWER AT OUTPUT OF HPMC	220 W
- ONE-WAY ANTENNA GAIN (INC. ANTENNA LOSSES) AT PEAK OF AZIMUTH PATTERN	38 - 41 dB

SENSITIVITY/NOISE-EQUIVALENT σ_0



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RANGE AMBIGUITY RATIO

ELEVATION BEAM PATTERNS ARE DESIGNED TO PROVIDE A RANGE AMBIGUITY RATIO OF BETTER THAN -22 DB AT ALL POSITIONS ACROSS THE SWATH. (CALCULATIONS INCORPORATE σ_0 AS A SIMPLE FUNCTION OF INCIDENCE ANGLE.)

PERFORMANCE WILL BE DEGRADED IN PRACTICE DUE TO PHASE ERRORS IN THE BEAM FORMATION. THE EFFECT OF THESE ERRORS WILL BE MINIMIZED BY:

- COMPENSATION FOR TEMPERATURE VARIATION
- USE OF COMPLEMENTARY PATTERNS ON TRANSMIT AND RECEIVE TO REDUCE PEAK SIDELOBES IN COMPOSITE PATTERN

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AZIMUTH AMBIGUITY RATIO

THE SAR IS DESIGNED TO OPERATE WITH PRF'S FROM 1200 TO 1400 HZ. THE NOMINAL PRF'S FOR ALL DEFINED BEAMS ARE AT LEAST 1270 HZ.

WITH A 15 M ANTENNA, THIS PROVIDES SUFFICIENT OVERSAMPLING OF THE DOPPLER BANDWIDTH TO ALLOW SOME SHAPING OF THE AZIMUTH BEAM.

A 1 DB TAPER IN THE WEIGHTING SIGNIFICANTLY REDUCES THE SIDELOBE CONTRIBUTION TO THE AMBIGUITY RATIO WITHOUT CAUSING ENERGY FROM THE EDGE OF THE MAINLOBE TO FALL INTO THE AMBIGUITY REGIONS.

AUTOMATIC GAIN CONTROL

SIGNAL LEVELS IN THE RECEIVER ARE CONTROLLED TO MATCH THE DYNAMIC RANGE OF THE A/D CONVERTER.

THE BLOCK FLOATING POINT SETTING IS ADJUSTED ACCORDING TO THE LEVELS IN THE DIGITIZED SIGNAL AS ASSESSED BY A COUNT OF THE OCCURRENCE OF THE MOST SIGNIFICANT BIT WITHIN A PULSE RETURN.

VARIATIONS IN THE MEAN LEVEL SHOULD BE TRACKED BY THE AUTOMATIC CONTROL ENABLING QUANTIZATION NOISE TO BE RESTRICTED TO NEAR THE THEORETICAL MINIMUM OF ABOUT -19 dB FOR 4-BIT DIGITIZATION.

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SAR PERFORMANCE SUMMARY

BEAM/MODE	SWATH WIDTH (KM)	RESOLUTION (M)		NO. OF LOOKS	NOISE EQUIV. σ_0 (dB)
		RANGE	AZIMUTH		
BASIC BEAMS					
1	106	24 - 32	28	4	-21
2	105	21 - 27	28	4	-21
3	105	27 - 32	28	4	-21
4	105	25 - 29	28	4	-21
5	105	24 - 27	28	4	-21
6	105	22 - 25	28	4	-21
7	100	21 - 23	28	4	-21
WIDE SWATH BEAMS					
W1	164	31 - 48	28	4	-18
W2	148	26 - 32	28	4	-18
FINE RES. BEAMS					
F1	50	10	8	1	-21
F2	49	9 - 10	8	1	-21
F3	44	9	8	1	-21
F4	43	9	8	1	-21
F5	43	8 - 9	8	1	-21
SCANSAR					
2 - BEAM	305	24 - 45	31 - 26	1	-18
4 - BEAM	511	20 - 45	62 - 45	1	-18 - -21

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CONSTRAINTS IMPOSED BY TAPE RECORDER RATE

WITH THE 85 MBPS DATA RATE LIMIT ON THE TAPE RECORDER, THE REDUCTIONS IN SWATH WIDTH ARE AS FOLLOWS:

BASIC BEAMS 1 - 7		NO REDUCTION
WIDE SWATH	BEAM 1	NO REDUCTION
	BEAM 2	FROM 148 KM TO 133 KM
FINE RESOLUTION BEAMS		FROM 43 - 50 KM TO 34 - 40 KM
SCANSAR	2 - BEAM	FROM 305 KM TO 295 KM
	4 - BEAM	FROM 511 KM TO 446 KM

OTHER IMAGE QUALITY PERFORMANCE PARAMETERS

PARAMETER	PERFORMANCE FOR BASIC BEAMS	
PEAK SIDELOBE RATIO	20.0dB	
SIGNAL DEPENDENT NOISE RATIO	-9.2dB	
RANGE AMBIGUITY RATIO	-21 dB(DESIGN)	-18 dB(SPEC) EXC. NADIR
AZIMUTH AMBIGUITY RATIO	-22.0dB	
NOISE EQUIVALENT SIGMA-ZERO	-21.0dB(DESIGN) -20 dB	-18.5 dB(SPEC) (EXPECTED)
GLOBAL DYNAMIC RANGE	30.0dB	
RADIOMETRIC STABILITY - LIFE	3.0dB*	
ORBIT SUBCYCLE (3 DAYS)	2.0dB*	
ORBIT	1.5dB*	
100KM X 100KM AREA	1.0dB*	
ABSOLUTE LOCATION ACCURACY	1.5KM (TBC)	
GEOMETRIC DISTORTION - AZIMUTH	40M	
.GROUND RANGE	40M	

* INDICATES DESIGN GOAL

SPAR

RADIOMETRIC CALIBRATION SCHEME

RADIOMETRIC CALIBRATION COMBINES MEASUREMENTS OVER TIME SCALES.

1. PRE-FLIGHT MEASUREMENTS (WITH INFREQUENT UPDATES)

   BEAMS, CALIBRATION SIGNAL LEVELS.

2. EXTERNAL CALIBRATION (EVERY 1 - 3 DAYS)

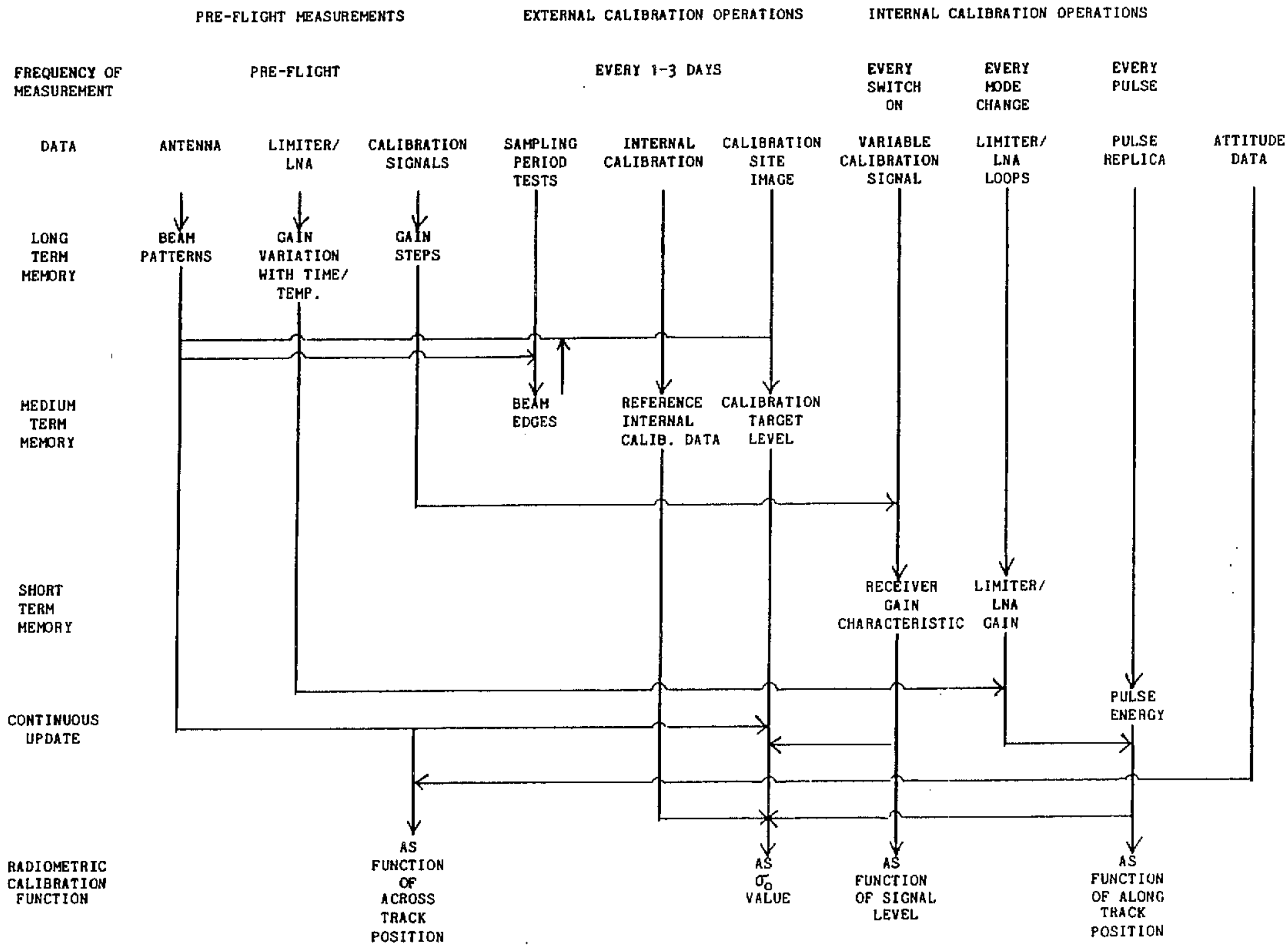
   MEASUREMENTS OVER CALIBRATION SITE

3. INTERNAL CALIBRATION (EVERY IMAGING PERIOD)

   INC. PULSE DATA, LIMITER/LNA, ATTITUDE AND RECEIVER GAIN CHARACTERISTIC

SPAR

RADIOMETRIC CALIBRATION FLOW CHART



TARGET FIGURES FOR RADIOMETRIC CONSISTENCY

THE FOLLOWING ARE RELATIVE RADIOMETRIC ACCURACY GOALS FOR STANDARD RADARSAT BEAMS:

100 KM SQUARE AREA	1 DB
ORBIT TO ORBIT	1.5 DB
ORBIT SUBCYCLE (3 DAYS)	2 DB
LIFETIME	3 DB

REQUIREMENTS FOR OTHER BEAMS ARE SLIGHTLY RELAXED

SPAR

GROUND PROCESSOR RADIOMETRIC CALIBRATION OPERATIONS

PROCESSOR INCLUDES:

1. STORED GAIN PATTERNS AND RELATIVE GAINS FOR ALL BEAMS
2. ANALYSIS OF SIGNAL RETURN TO LOCATE BEAM EDGES AND REFINE POINTING DATA
3. CALCULATION OF PULSE ENERGY FROM INTERNAL CALIBRATION DATA
4. ANALYSIS OF IMAGES OF CALIBRATION SITE
5. LOGGING OF MEAN SIGNAL LEVELS TO ENSURE LONG TERM CONSISTENCY

SPAR

VERIFICATION OF SAR PERFORMANCE

THE IN-FLIGHT VERIFICATION OF THE SAR PERFORMANCE WILL CONSIST OF A COMBINATION OF:

DIRECT MEASUREMENT FROM IMAGES OF SPECIFIC AREAS AND TARGETS	(E.G. RESOLUTION)
ANALYSIS BASED ON MEASUREMENTS FROM IMAGES	(E.G. LOCATION ACCURACY)
ANALYSIS OF RAW SIGNALS AND CALIBRATION DATA	(E.G. DYNAMIC RANGE)
ANALYSIS USING DATA FROM RECEIVERS ON THE GROUND	(E.G. AMBIGUITY RATIO)
SIMULATION BASED ON INTERNAL SIGNAL MEASUREMENTS	(E.G. IMPULSE RESPONSE SIDELOBES)

SPAR

PROCESSOR PERFORMANCE

ALL PERFORMANCE SPECIFICATIONS FOR THE FULL SYSTEM ARE DEPENDENT ON A PROCESSOR WHICH SATISFIES THE FOLLOWING FOR THE BASIC BEAMS:

RANGE IRW BROADENING	10%	
AZIMUTH IRW BROADENING	10%	
IMPULSE RESPONSE FUNCTION SIDELOBES	-25 DB	PEAK
ISLR DEGRADATION	2.8%	OF MAINLOBE ENERGY
RADIOMETRIC ERRORS	0.1 DB	VARIATION
RADIOMETRIC LINEARITY	0.97	CORRELATION COEFF.
ABSOLUTE LOCATION ACCURACY	40 M	
GEOMETRIC DISTORTION	30 M	EACH DIRECTION WITHIN 100 KM SQUARE AREA

ALL PROCESSOR DEGRADATIONS ARE RELATIVE TO THE IDEAL.

SPAR

SCANSAR PROCESSING

A MODIFIED FORM OF ALGORITHM IS REQUIRED FOR AZIMUTH PROCESSING OF SCANSAR DATA BECAUSE OF ITS DIVISION INTO DISCRETE BLOCKS.

THE 'SPECAN' ALGORITHM DEVELOPED BY MDA CONSISTING OF A FREQUENCY 'DERAMP' FOLLOWED BY AN FFT IS WELL-SUITED TO THIS FORM OF DATA.

SOME SIMULATIONS PERFORMED ON SUBSECTIONS OF A PASS OF SEASAT DATA DEMONSTRATE THAT THE USE OF SPECAN IS APPROPRIATE.

OTHER MODIFICATIONS ARE REQUIRED IN THE PROCESSOR FOR DOPPLER TRACKING, RADIOMETRIC CORRECTION AND MERGING OF IMAGE SEGMENTS AND SUBSWATHS.

SPAR

OTHER PROCESSOR FUNCTIONS

IN ADDITION TO ITS BASIC PROCESSING TASKS, THE PROCESSOR IS REQUIRED TO PERFORM THE FOLLOWING:

DOPPLER CENTRE FREQUENCY AND AMBIGUITY TRACKING
RADIOMETRIC AND PULSE CALIBRATION OPERATIONS
ROUTINE MONITORING OF IMAGE QUALITY
PERIODIC IMAGE QUALITY VERIFICATION
LOGGING OF ESSENTIAL SIGNAL AND IMAGE PARAMETERS

SPAR

SAR PERFORMANCE SUMMARY

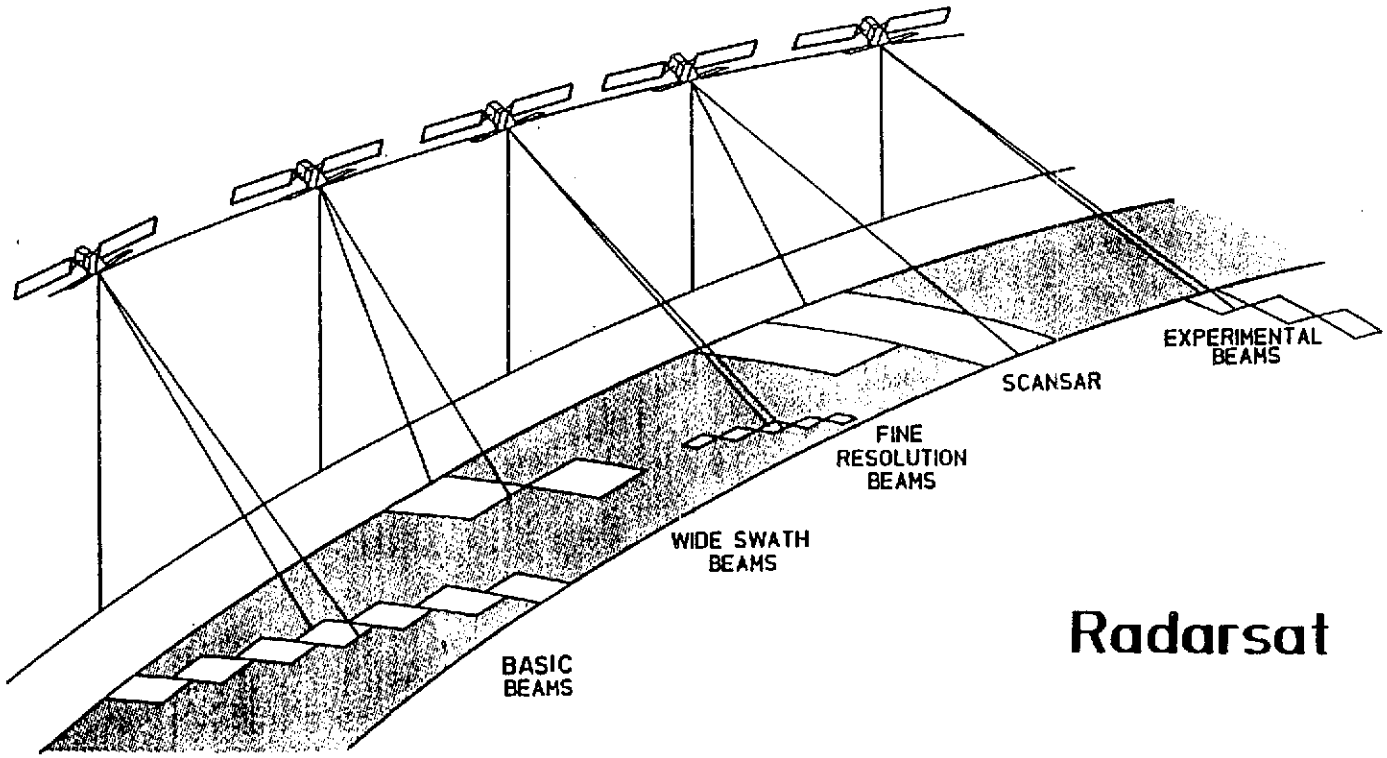
THE CONCEPTUAL DESIGN OF THE SAR IS NOW WELL ESTABLISHED AND THE DETAILED INSTRUMENT DESIGN IS WELL ADVANCED.

THE INSTRUMENT IS DESIGNED TO BE HIGHLY FLEXIBLE IN CHOICE OF IMAGING OPTIONS SO AS TO SATISFY A WIDE RANGE OF USER REQUIREMENTS:

- INCIDENCE ANGLES FROM 20° - 49° (59° EXPERIMENTALLY)
- SWATH WIDTHS UP TO ABOUT 500 KM
- RESOLUTION AS FINE AS 8M IN EACH DIMENSION

PERFORMANCE HAS NOT HAD TO BE COMPROMISED EITHER BY THE RESCOPING WITHIN THE LAST FEW MONTHS OR BY THE REQUIREMENT FOR ANTARCTIC COVERAGE.

SPAR



Radarsat

ANTARCTIC COVERAGE

SPAR

UNDERSTANDING OF REQUIREMENTS

SPATIAL REQUIREMENTS

o COVERAGE OF ANTARCTICA WITH MEDIUM SWATH WIDTH AND CONSTANT INCIDENCE ANGLE

- BEAM 7, SWATH WIDTH OF 100 KM, INCIDENCE ANGLE OF 45° - 49°

TEMPORAL REQUIREMENTS

o IMAGERY DURING MINIMUM AND MAXIMUM ICE COVERAGE

- ASSUMED TO BE FEBRUARY AND OCTOBER

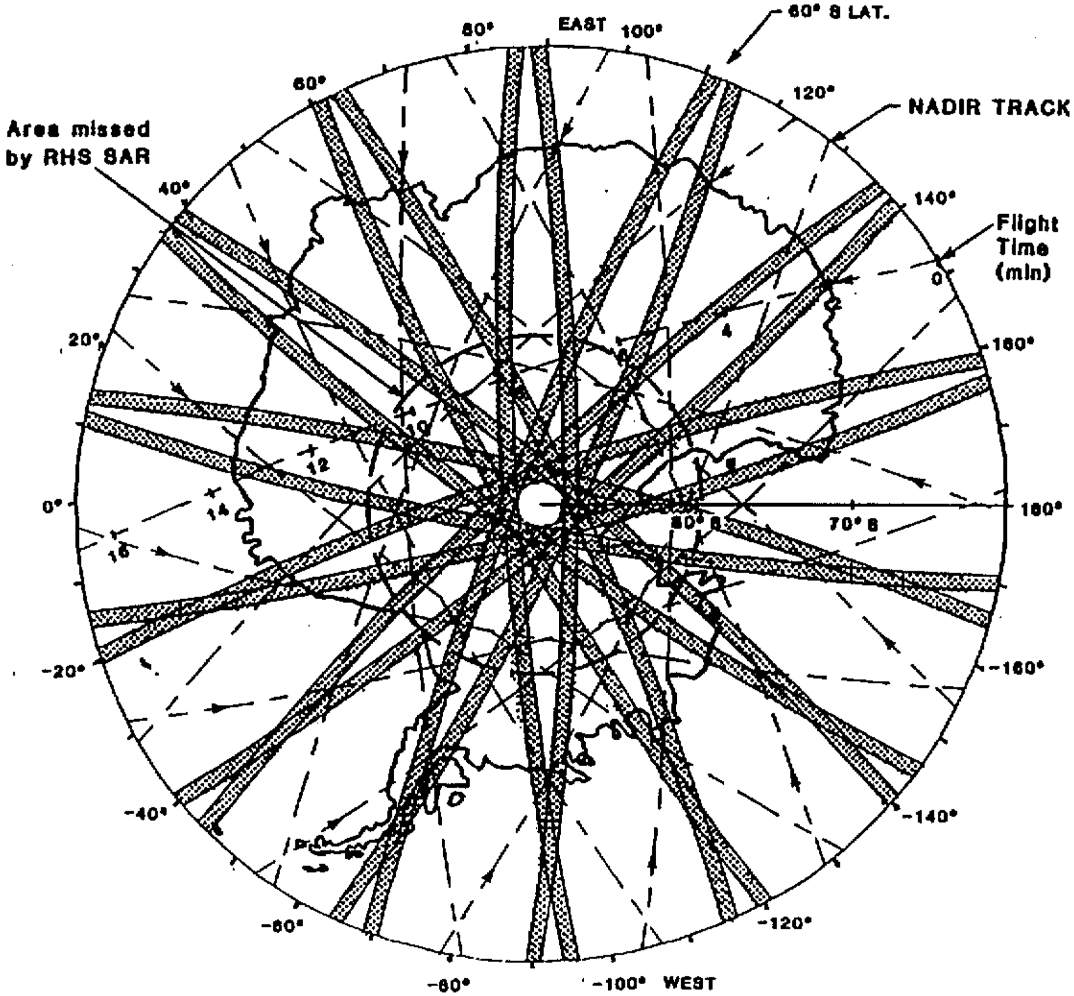
- TEN DAYS AT EACH OPPORTUNITY IS ADEQUATE

SPAR

Antarctica

1 DAY
LHS

100km Swath
792km Alt

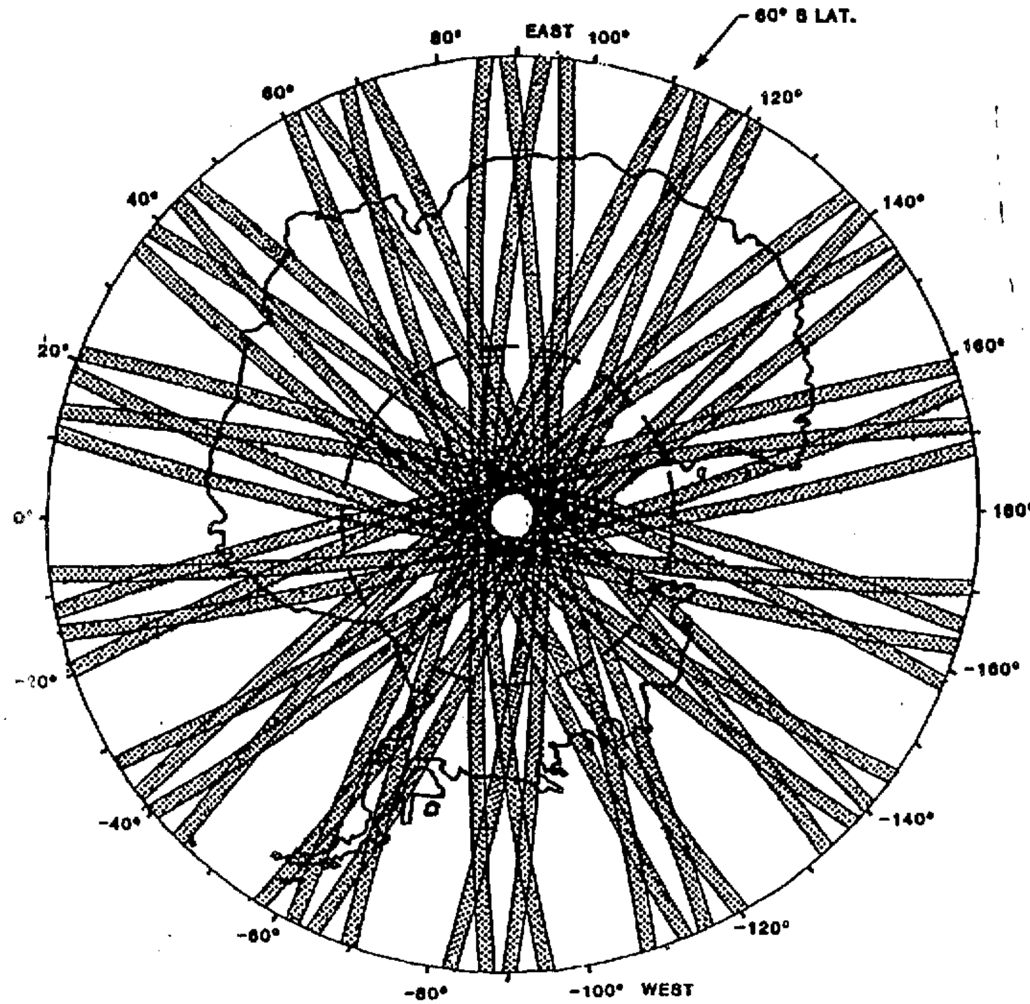


SPAR

Antarctica

2 DAYS
LHS

100km Swath
792km Alt

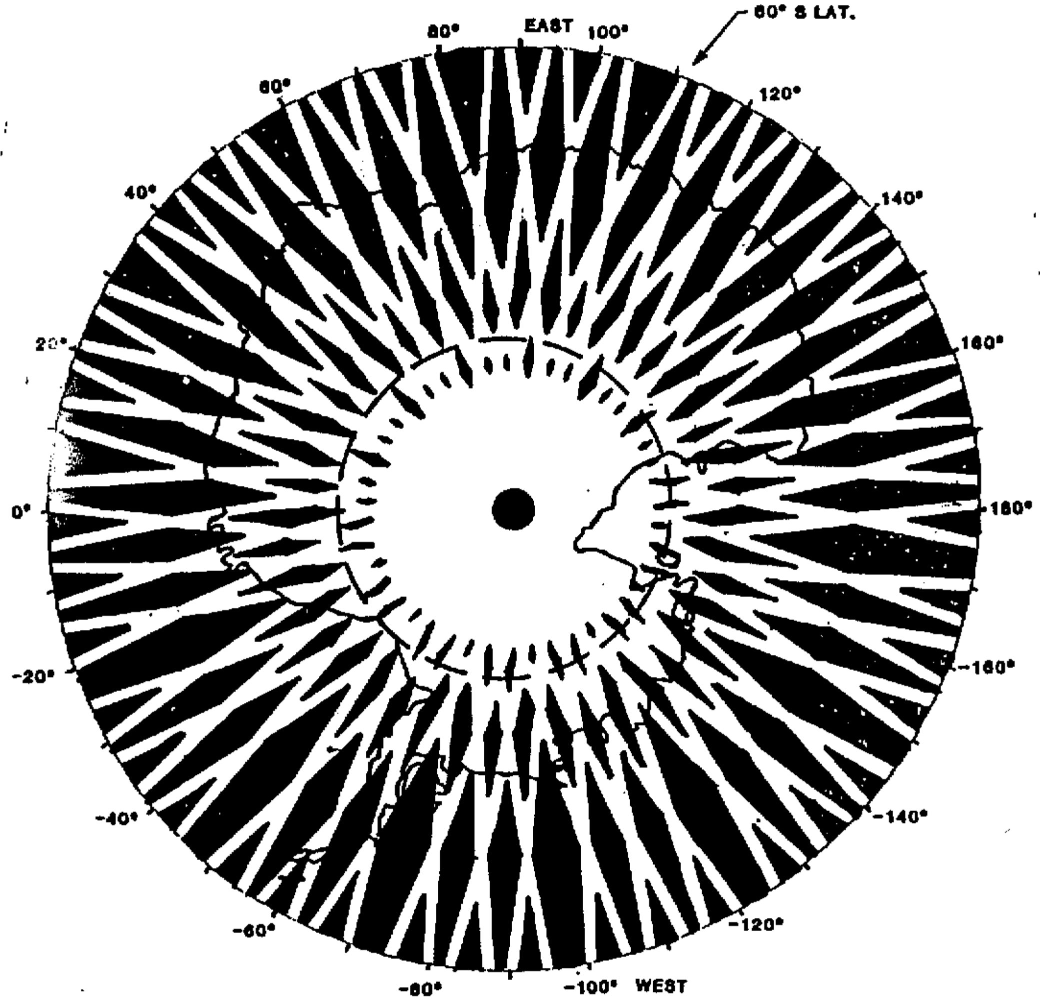


SPAR

Antarctica

3 DAYS
LHS
GAPS ONLY

100km Swath
792km Alt

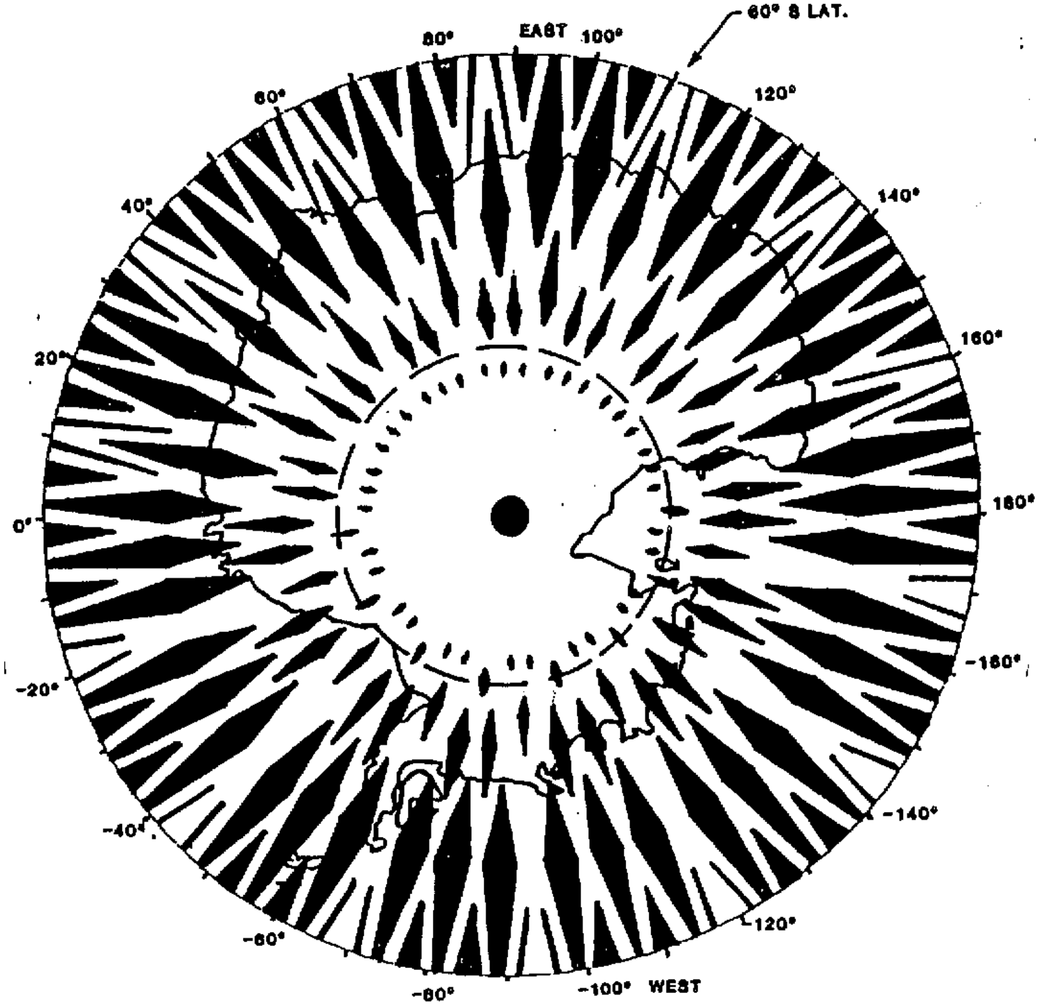


SPAR

Antarctica

4 DAYS
LHS
GAPS ONLY

100km Swath
792km Alt

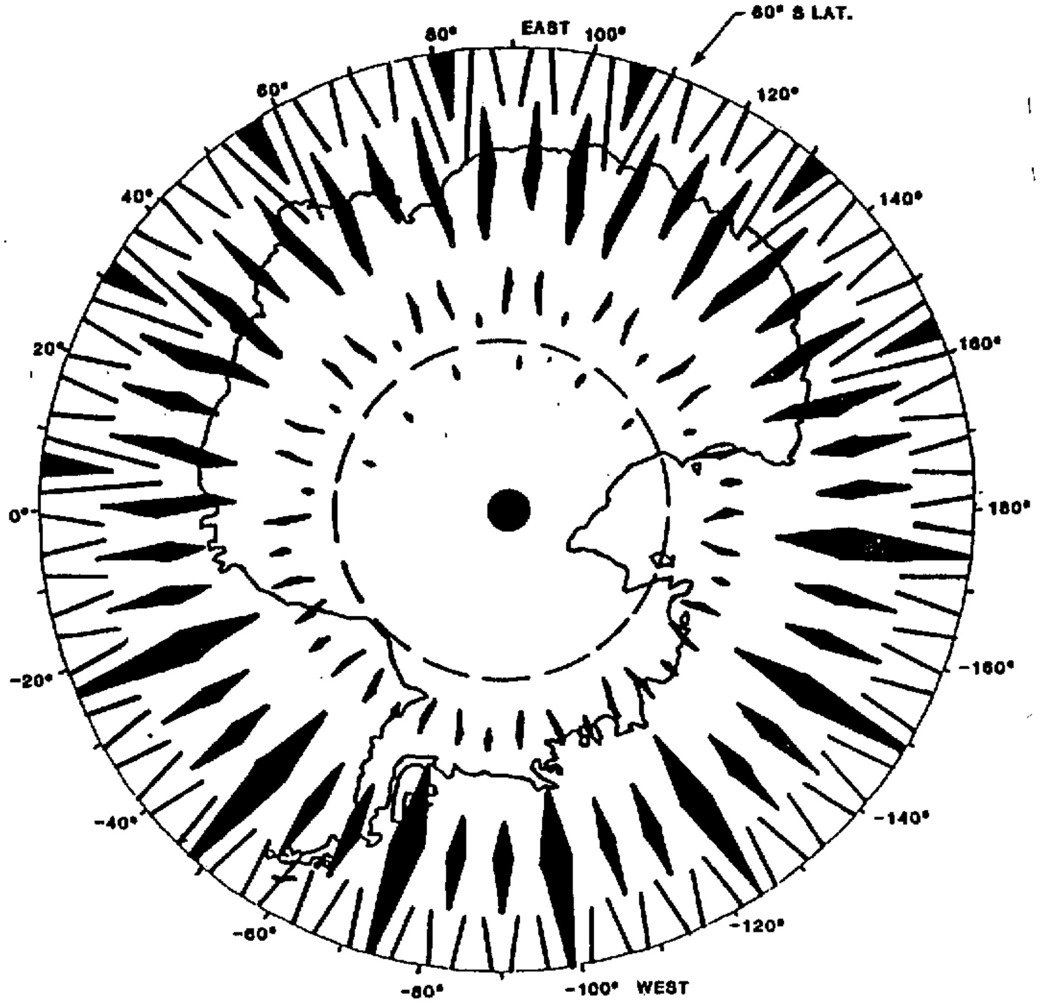


SPAR

Antarctica

6 DAYS
LHS
GAPS ONLY

100km Swath
792km Alt

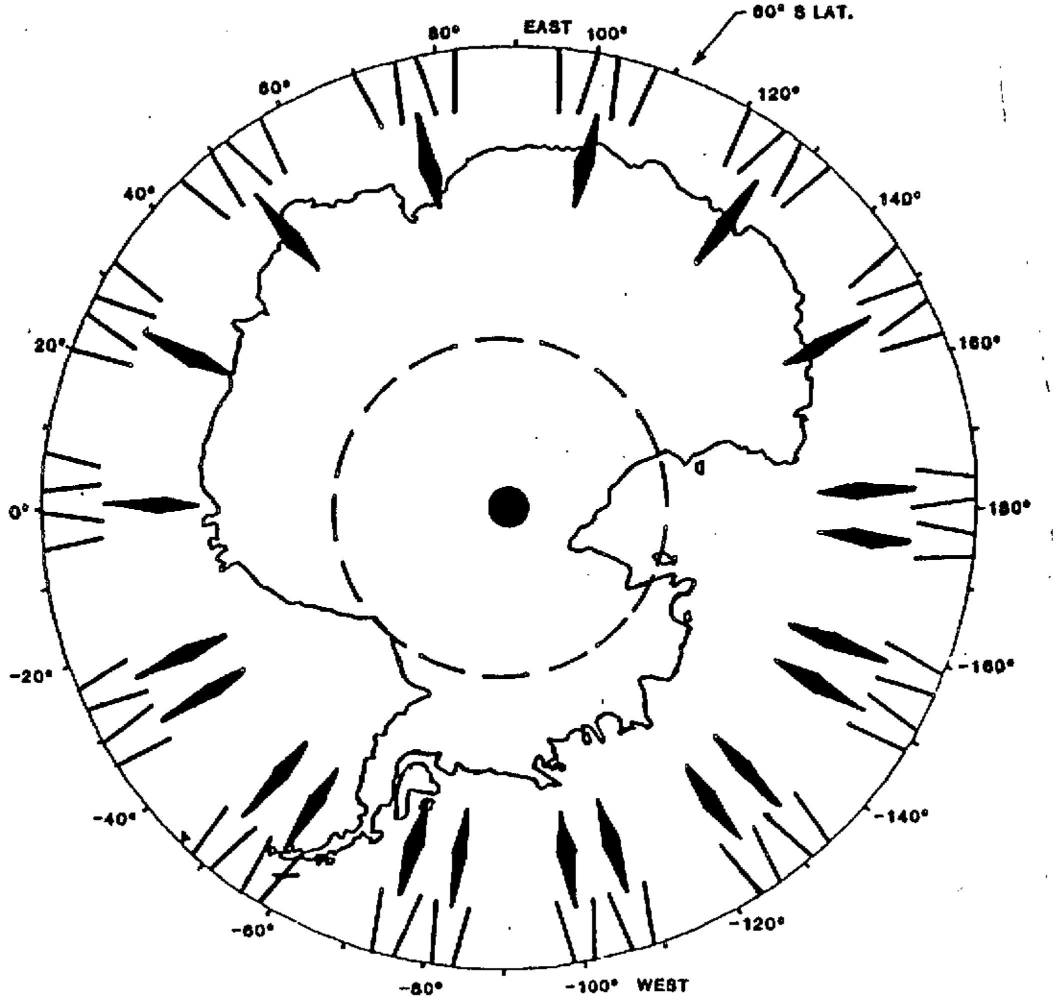


SPAR

Antarctica

8 DAYS
LHS
GAPS ONLY

100km Swath
792km Alt

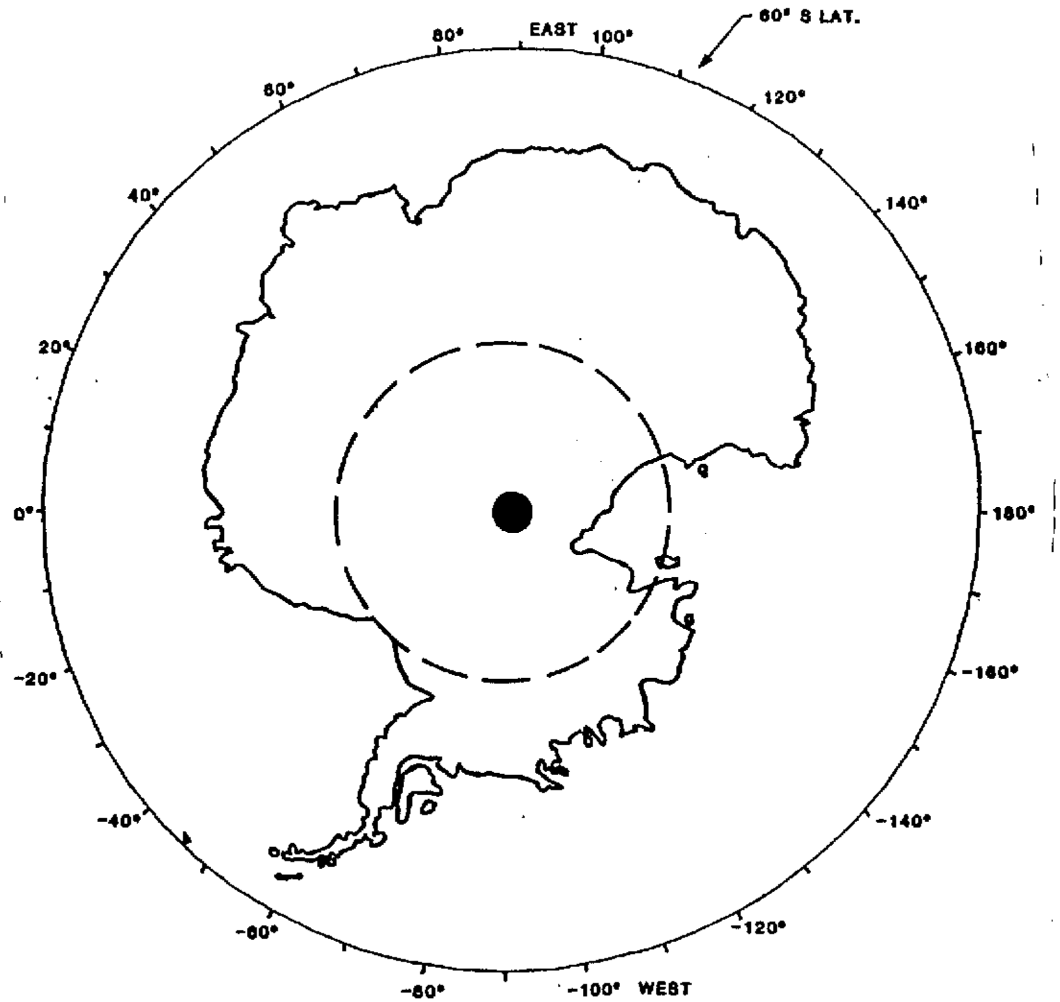


SPAR

Antarctica

10 DAYS
LHS
GAPS ONLY

100km Swath
792km Alt

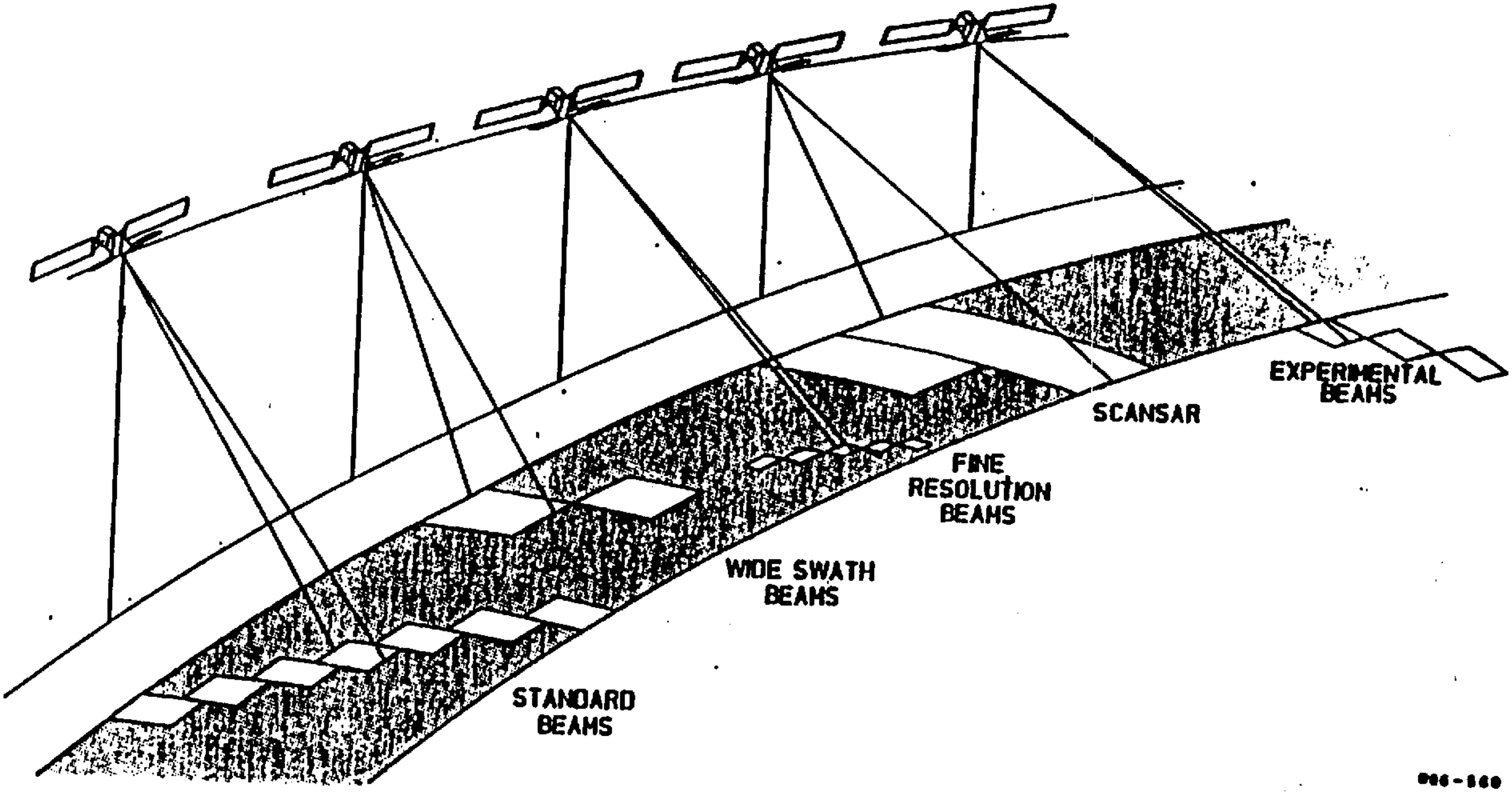


SPAR

CONSTRAINTS

- NO DIRECT DOWN LINK STATION IS CURRENTLY ENVISIONED.
  - TAPE RECORDERS MUST BE USED, MINIMUM AVAILABLE CAPACITY EQUIVALENT TO 15 MINS OF IMAGING
  - TAPE RECORDERS TO BE DUMPED IN THE CURRENT PASS OR SUBSEQUENT PASS (FAIRBANKS AND OTTAWA AND PRINCE ALBERT).
- SAR WILL NOT BE OPERATED IN ECLIPSE
  - ECLIPSE SEASON BETWEEN LATE MAY AND EARLY AUGUST, OVER ANTARCTICA BUT AWAY FROM PERIOD OF MAXIMUM AND MINIMUM ICE

SPAR



AVAILABLE BEAMS (BASELINE DESIGN)

SPAR

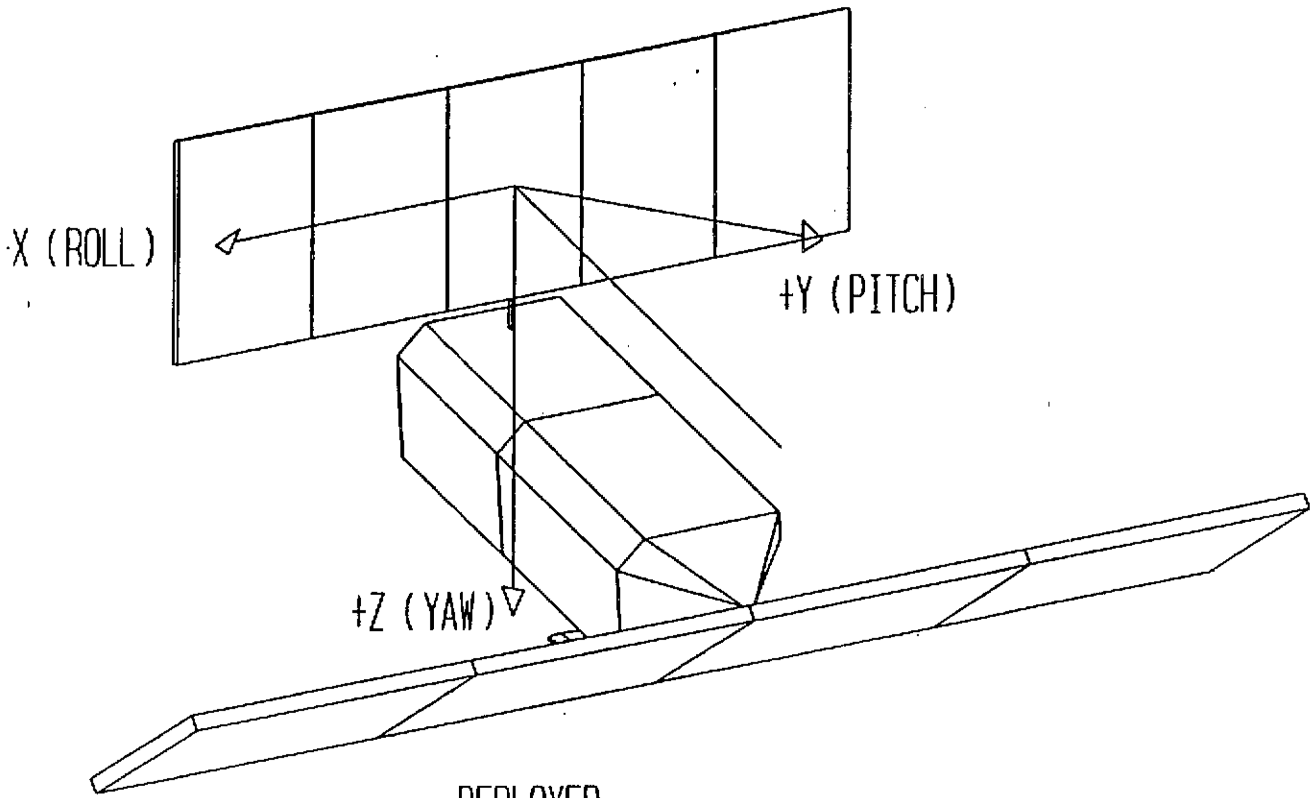
IMPLEMENTATION

- o SAR IS NOMINALLY RIGHT LOOKING
  - REQUIRES TO BE LEFT LOOKING FOR POLAR (ANTARCTIC) COVERAGE
- o TWO OPTIONS AVAILABLE FOR RE-ORIENTING THE SAR TO THE LEFT
  - ROTATING THE SPACECRAFT ABOUT THE NADIR THROUGH 180^o
  - ROTATING THE SPACECRAFT ABOUT THE ROLL AXIS BY 60^o
- o SPACECRAFT WILL STAY IN THE CHOSEN ORIENTATION FOR THE TEN DAYS REQUIRED TO GIVE COMPLETE COVERAGE
- o SAR PERFORMANCE WILL BE ESSENTIALLY THE SAME AS FOR THE RIGHT LOOKING CASE
  - MINOR DEGRADATION MAY BE CAUSED BY A SMALL DISTORTION OF THE ANTENNA BECAUSE OF DIFFERENT THERMAL ENVIRONMENT

SPAR

IMPLEMENTATION
(CONT'D)

- o BEAMFORMING CAPABILITIES
  - IN THE YAW CASE BEAMS WILL BE FORMED AS IN THE NOMINAL RIGHT LOOKING MODE
  - IN THE ROLL CASE THE SAME BEAMS WILL BE GENERATED BY COMMANDING NEW PHASE COEFFICIENTS TO THE ANTENNA



DEPLOYED
CONFIGURATION

SPAR

IMPACTS

- ATTITUDE CONTROL MUST BE DESIGNED TO ACCOMMODATE THE REQUIRED MANEUVER
- SPACECRAFT MUST BE DESIGNED THERMALLY TO ACCOMODATE THE NEW ATTITUDE
- TAPE RECORDER USE WILL BE SIGNIFICANTLY INCREASED DURING ANTARCTIC COVERAGE
- NORMAL USER ACCESS TO IMAGERY WILL BE MODIFIED DURING ANTARCTIC COVERAGE
  - TAPE RECORDERS WILL BE MONOPOLIZED BY ANTARCTIC IMAGING
  - NORMAL COVERAGE WILL BE INTERRUPTED OR AT DIFFERENT INCIDENCE ANGLES DUE TO DIFFERENT SAR GEOMETRY
- FOR THE YAW MANOEUVER IS 15 MINS/ORBIT OF SAR OPERATION IS AVAILABLE DUE TO THERMAL CONSIDERATIONS.
- FOR THE ROLL MANEUVER THE OPERATING TIME PER ORBIT WILL REMAIN AT 28 MINS.
- DEPENDING ON GROUND STATION VISIBILITY IT MAY REQUIRE TWO PASSES TO DUMP THE DATA WITH LIMITATIONS ON RECORDING OF DATA ON THE SECOND ORBIT

SPAR

ACHIEVABILITY

- THE REQUIRED ANTARCTIC COVERAGE IS ACHIEVABLE WITH SIGNIFICANT BUT REALISTIC MODIFICATIONS TO THE RADARSAT CONCEPT
- THE COMPLEXITY OF THE SPACECRAFT IS INCREASED WITH OBVIOUS COST IMPACTS.
- DURING THE PERIOD OF ANTARCTIC OPERATION, THERE WILL BE SIGNIFICANT IMPACT ON SERVICES TO ALL OTHER USERS.

SAR IMPLEMENTATION

GENERAL HARDWARE REQUIREMENTS

- MULTI BEAM OPERATION
  - SELECTABLE SINGLE BEAM
  - RAPID SWITCHING BETWEEN BEAMS FOR SCANSAR
- THREE PULSE BANDWIDTHS
- VARIABLE PRF
- 28 MINUTES OF OPERATION PER ORBIT
- AUTONOMOUS OPERATION FOR PERIODS WHEN OUT OF GROUND CONTACT
- GOOD PULSE-TO-PULSE STABILITY
- 5.3 GHZ CENTER FREQUENCY

SPAR

SAR DERIVED PARAMETERS

- TRANSMITTED PULSE WIDTH: 42 US NOMINAL
- 36 DBW (3981W) PEAK RF POWER AVAILABLE AT HIGH POWER MICROWAVE OUTPUT
- PRF SELECTABLE IN 2HZ STEPS BETWEEN 1200 HZ AND 1400 HZ TO COVER COMPLETE RANGE OF VALUES REQUIRED BY SYSTEM DESIGN
- BANDWIDTH OF LINEAR FM PULSE SELECTABLE FROM: 30 MHZ, 17.28 MHZ OR 11.58 MHZ

SPAR

SPACECRAFT DESIGN CHARACTERISTICS

- TOTAL MASS: 729.2 KG

- DC POWER:

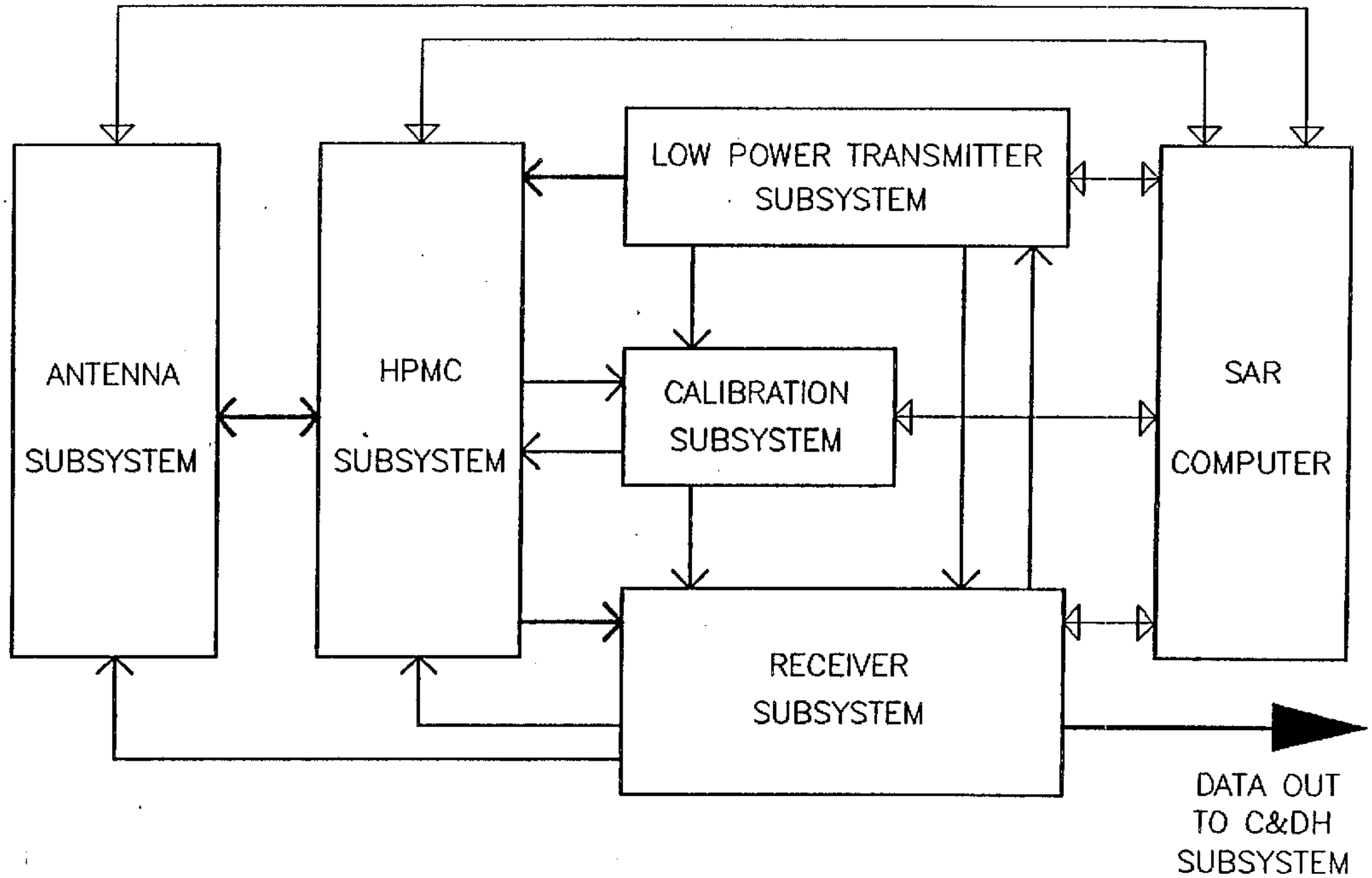
INITIALIZE	25W
IDLE	145W
READY	265W
IMAGE	1440W

- THE INSTRUMENT WILL NORMALLY BE IN IDLE MODE BETWEEN IMAGE PERIODS

- DATA RATE: LESS THAN 100 MBS^{-1} FOR REAL TIME DATA AND LESS THAN 85 MBS^{-1} FOR RECORDED DATA

- MAXIMUM ANTENNA DIMENSIONS: 15M X 1.5M

SPAR



RADARSAT SAR BLOCK DIAGRAM

LOW POWER TRANSMITTER

- DIGITAL CHIRP GENERATOR WITH STORED PULSE CODES FOR THREE BANDWIDTHS
- FACILITY IS INCLUDED TO PROGRAM ONE ADDITIONAL CHIRP PULSE IN-FLIGHT
- THE LPT PROVIDES FIXED FREQUENCY TONE BURSTS FOR CALIBRATION PURPOSES
- THE LPT INCLUDES THE STABLE MASTER OSCILLATOR FROM WHICH ALL RF AND TIMING SIGNALS ARE GENERATED
- LO FREQUENCY IS GENERATED IN THE LPT BY MULTIPLYING SMO. BOTH ARE OUTPUT TO THE RECEIVER FOR SIGNAL DOWNCONVERSION
- DUAL CHANNEL REDUNDANCY

LOW POWER TRANSMITTER OUTPUTS

- RF OUTPUT (TO HPMC)

  POWER LEVEL COMMANDABLE FROM 23 TO 30 DBM IN 1 DB STEPS
  NOMINAL CENTER FREQUENCY: 5.3 GHZ
  MODULATION LINEAR FM (DOWN-CHIRP)
  RESOLUTION BANDWIDTHS AT IF:

PULSE 1	30.002 MHZ (TBC)
PULSE 2	17.282 MHZ
PULSE 3	11.582 MHZ

  PULSE WIDTH: 42 US

- DIGITAL CHIRP GENERATORS ARE AVAILABLE FOR TERRESTRIAL APPLICATIONS.

HIGH POWER MICROWAVE CIRCUIT (HPMC)

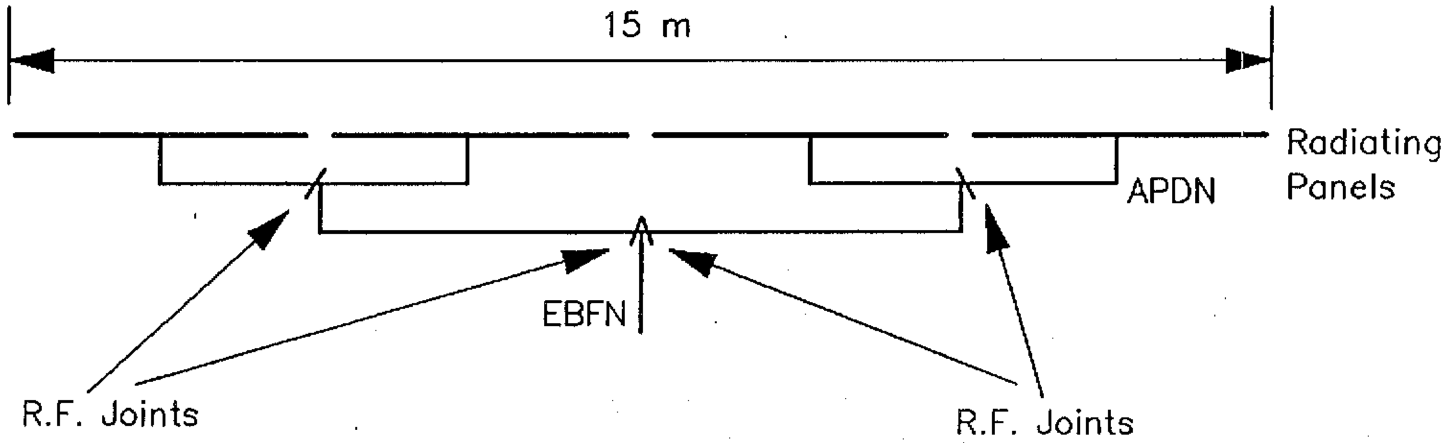
- AMPLIFIES RF PULSE FROM LPT
- OUTPUT LEVEL 36 DBW PEAK
- ERS-1 HPA DESIGN IS BEING USED
- TRANSMIT/RECEIVE SIGNAL PATHS PROVIDED BY THE TRANSMIT RECIEVE MICROWAVE CIRCUIT (TRMC)
- THE TRMC INCLUDES INTERFACES FOR PROVIDING REPLICA PULSE OUTPUT AND INJECTION OF CALIBRATION SIGNALS
- OPERATIONAL TIME IN IMAGE MODE IS LIMITED BY THERMAL CONDITIONS.
- REDUNDANT HPA'S INCLUDED. TRMC IS NOT REDUNDANT, BUT DOES INCLUDE SWITCHING FOR REDUNDANT INTERFACES TO OTHER SUBSYSTEMS

SPAR

ANTENNA SUBSYSTEM

- THE ANTENNA IS A SLOTTED WAVEGUIDE ARRAY WITH AN APERTURE OF 15 X 1.5M
- THE AMPLITUDE DISTRIBUTION OVER THE RADIATING SURFACE IS FIXED
- BEAM SHAPING AND POINTING IS CONTROLLED BY ADJUSTING THE PHASE DISTRIBUTION OVER THE ELEVATION (SMALL DIMENSION) OF THE ANTENNA. THIS IS ACCOMPLISHED WITH 32 VARIABLE PHASE SHIFTERS
- EACH PHASE SHIFTER CAN BE LOADED WITH UP TO 4 PHASE COEFFICIENTS, WHICH PROVIDES THE CAPABILITY OF SWITCHING BETWEEN BEAMS FOR SCANSAR IMAGING
- PHASE SHIFTER CONTROL IS PROVIDED BY THE SAR COMPUTER, WHICH UPDATES THE PHASE COEFFICIENTS ACCORDING TO THE IMAGE REQUIREMENTS AND TEMPERATURE OF EACH DEVICE. TEMPERATURE COMPENSATION IS CONTINUOUS DURING AN IMAGE PERIOD

SAR ANTENNA CONFIGURATION



SPAR

RECEIVER SUBSYSTEM

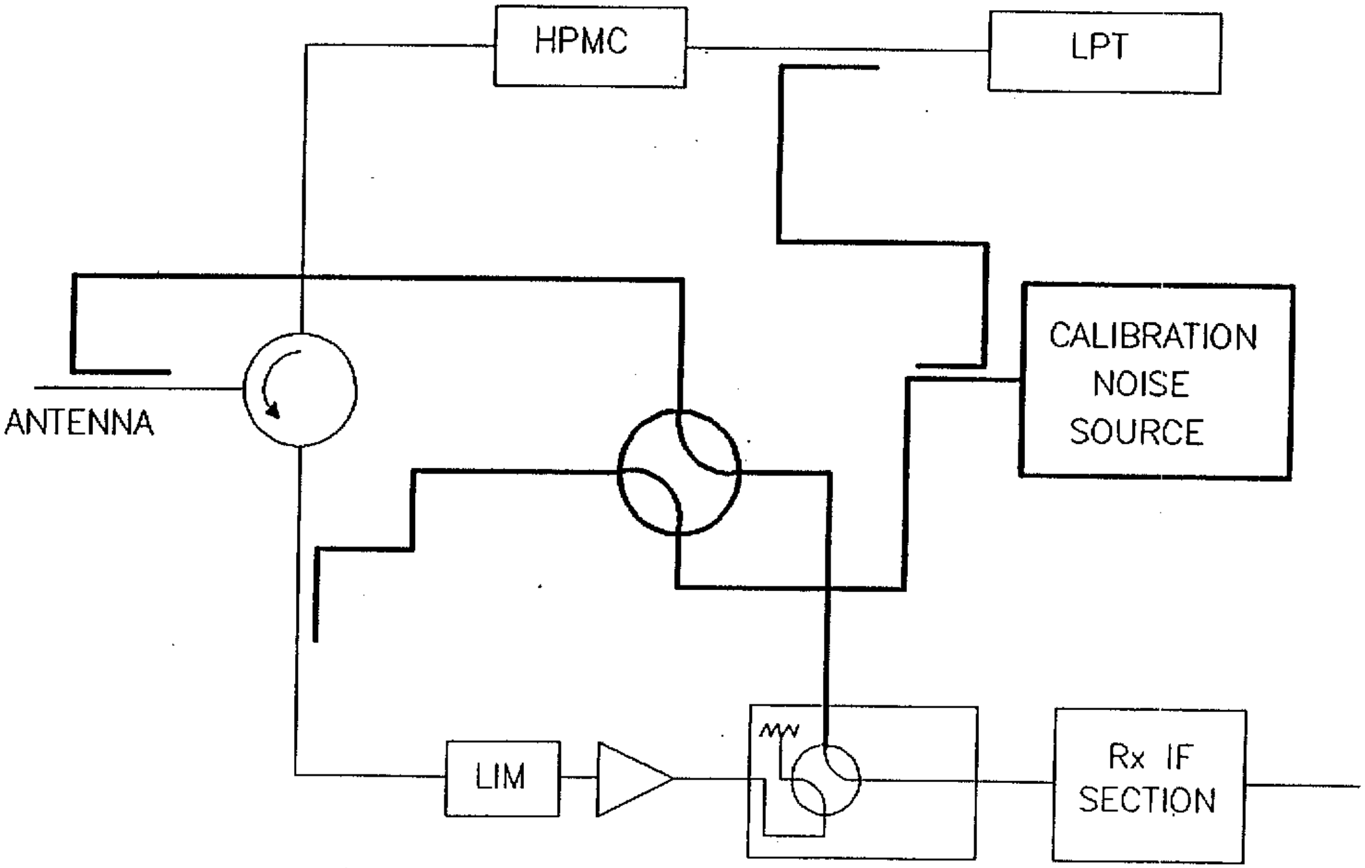
- LOW NOISE MICROWAVE RECEIVER THAT DETECTS THE RADAR RETURN
- PROTECTION FOR THE LNA DURING THE TRANSMIT PERIOD IS PROVIDED BY A LIMITER
- RECEIVER OUTPUT CONSISTS OF TWO 4-BIT DATA WORDS, REPRESENTING THE IN-PHASE (I) AND QUADRATURE PHASE (Q) OF THE DETECTED SIGNAL
- NOISE BANDWIDTH IS DEFINED BY SELECTABLE SAW FILTERS IN THE IF SECTION
- AN AUTOMATIC GAIN CONTROL IS INCLUDED TO MAKE BEST USE OF THE RECEIVER DYNAMIC RANGE
- MEAN DATA IS MAINTAINED BELOW 100 MBS^{-1}.
- THE RECEIVER CONTAINS THE RADAR TIMING UNIT WHICH GENERATES ALL TIMING SIGNALS REQUIRED TO SYNCHRONIZE THE RADAR OPERATION. THESE ARE DERIVED FROM THE SMO LOCATED IN THE LPT.
- BREADBOARD MODELS OF THE RF AND ANALOGUE TO DIGITAL CONVERTER UNITS HAVE BEEN BUILT.

SPAR

CALIBRATION SUBSYSTEM

- PROVIDES REFERENCE NOISE SIGNAL (WITH VARIABLE LEVEL) THAT CAN BE INJECTED INTO THE RECEIVER EITHER VIA THE HPMC OR DIRECTLY AFTER THE LNA
- THE CALIBRATION SUBSYSTEM IS PRIMARILY A SWITCHING NETWORK THAT ALLOWS A VARIETY OF SIGNALS TO BE INJECTED INTO THE RECEIVE PATH

CALIBRATION SUBSYSTEM
(CONT'D)



SAR COMPUTER

- THE COMPUTER CONTROLS ALL ASPECTS OF SAR OPERATION (MODE CHANGES, OPERATING PARAMETERS, ETC.)
- IT GENERATES SUBSYSTEM COMMANDS AND OPERATING PARAMETERS FROM AN IMAGE DEFINITION TABLE RECEIVED FROM THE MISSION CONTROL CENTER
- A TEMPERATURE COMPENSATION ALGORITHM IS INCLUDED TO CORRECT THE PHASE SETTINGS OF THE ANTENNA PHASE SHIFTERS. THIS FUNCTION IS ASYNCHRONOUS TO THE RADAR OPERATION
- HEALTH AND STATUS MONITORING OF SAR SUBSYSTEMS IS A CONTINUOUS FUNCTION OF THE SAR COMPUTER. DETECTION OF UNSAFE CONDITIONS WILL RESULT IN EQUIPMENT POWER OFF
- AUXILIARY DATA REQUIRED BY THE GROUND PROCESSOR IS GENERATED BY THE COMPUTER AND PASSED TO THE C&DH

SAR COMPUTER HARDWARE

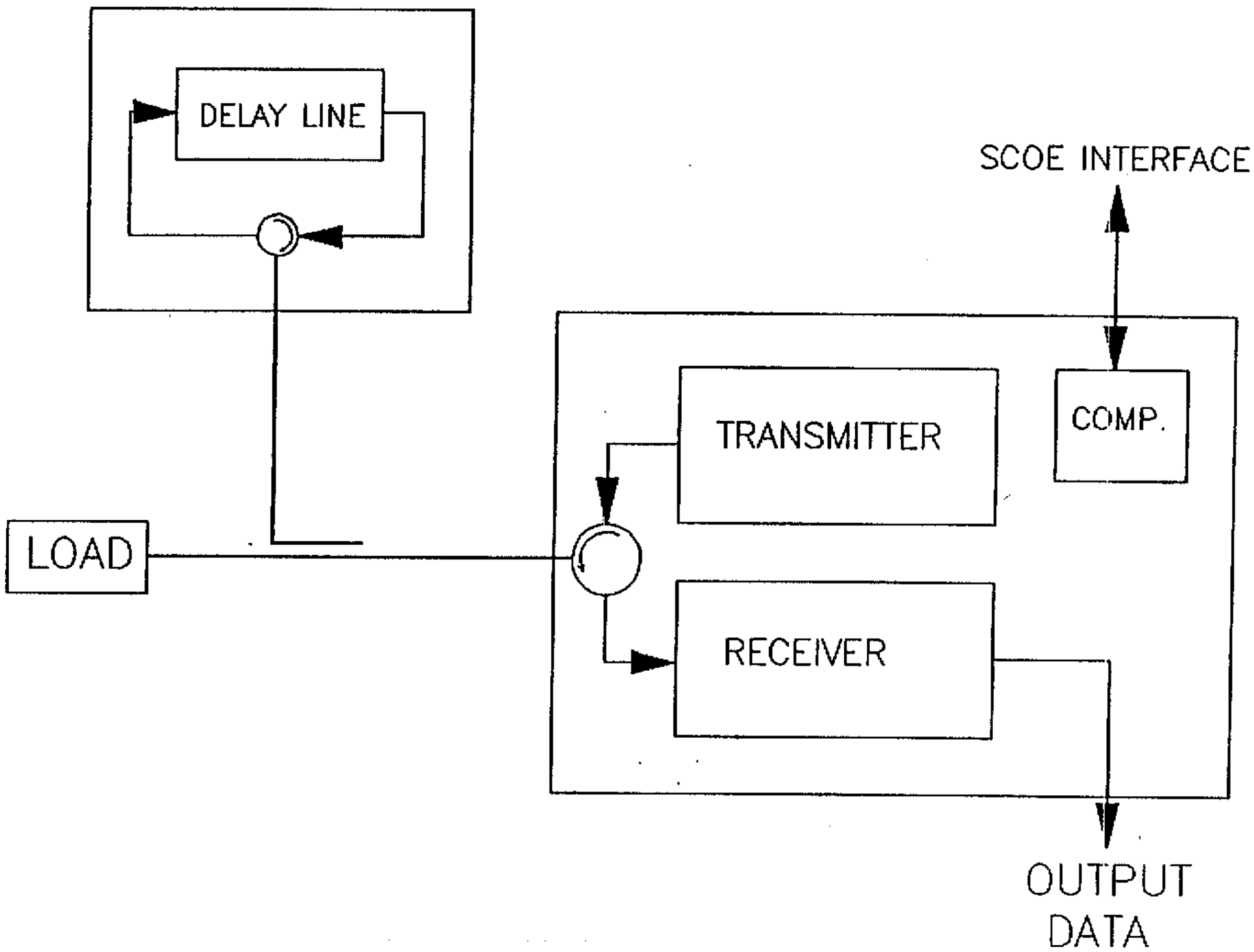
- 64K BYTES MEMORY (32K 16-BIT WORDS)
- MODULAR DESIGN ALLOWING ANY COMBINATION OF I/O CARDS, ROM BOARDS, ETC.
- TI SBP9989 RAD HARDENED MICROPROCESSOR
- ROM USED FOR BASIC OPERATING SYSTEM AND SAR CONTROL PROGRAMS
- BASED ON THE SOMM WHICH IS UNDER DEVELOPMENT AT SPAR. BREADBOARD EVALUATION IS NOW IN PROGRESS.

SPAR

GROUND VERIFICATION

- THE SAR INSTRUMENT WILL BE TESTED BY RE-INJECTING A DELAYED VERSION OF THE TRANSMITTED PULSE
- FULL PERFORMANCE VERIFICATION WILL BE DONE BY ANALYSIS USING A SOFTWARE MODEL TO CONVERT MEASURED TEST DATA INTO IMAGE QUALITY PARAMETERS

GROUND VERIFICATION TEST METHOD



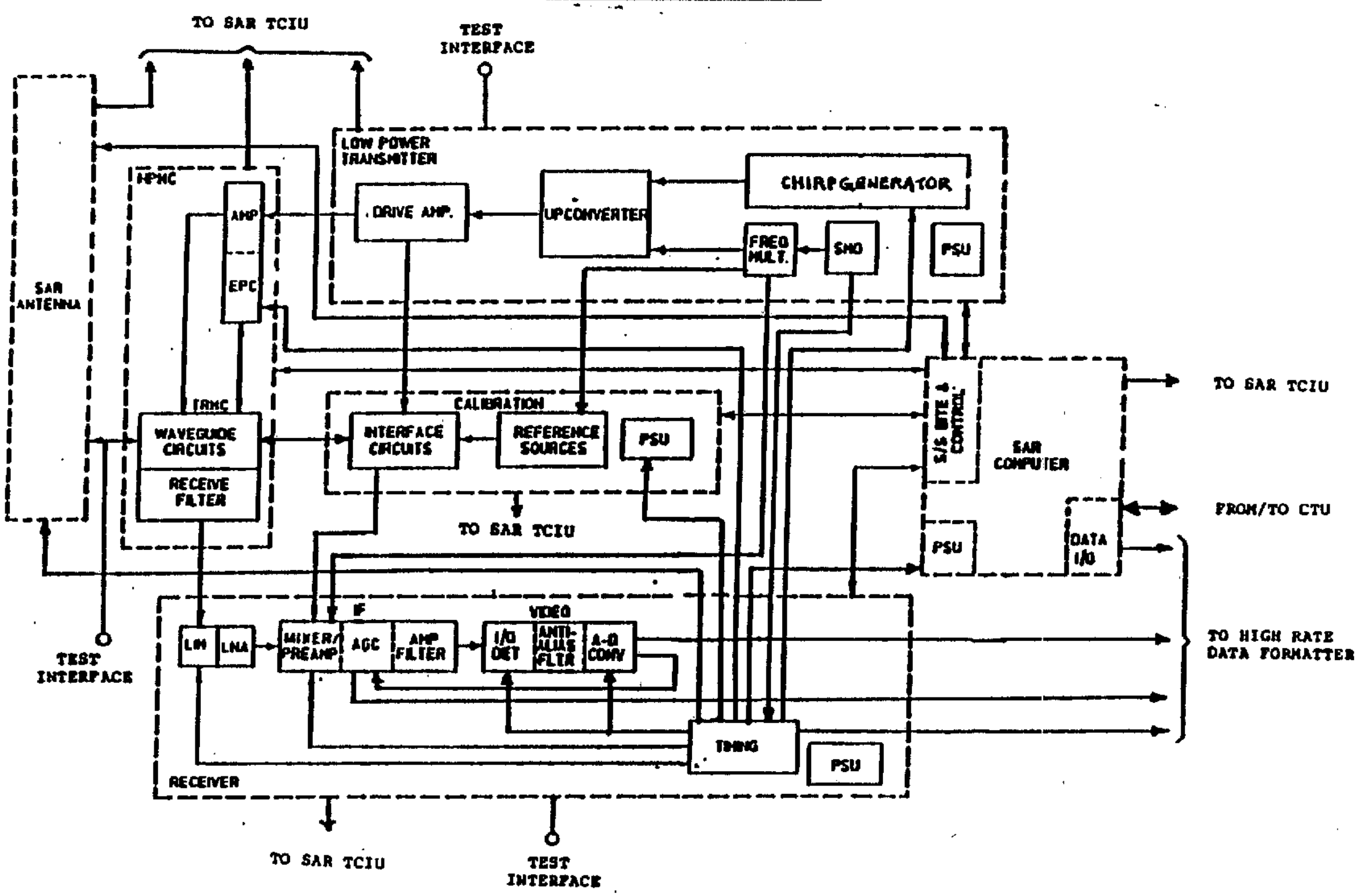
SPAR

SAR INSTRUMENT HARDWARE STATUS

SUBSYSTEM	STATUS
LOW POWER TRANSMITTER	GROUND BASED DESIGNS HAVE BEEN IMPLEMENTED
HPMC	SMALL MODIFICATION TO ERS-1 DESIGN. THIS IS CURRENTLY AT ENGINEERING MODEL BUILD.
ANTENNA	A BREADBOARD MODEL HAS BEEN BUILT AND TESTED.
RECEIVER	SOME BREADBOARD UNITS HAVE BEEN BUILT AND TESTED.
CALIBRATION SUBSYSTEM	STANDARD TRANSMISSION LINE AND SWITCHES. NOISE SOURCES ARE AVAILABLE.
COMPUTER	SOMM BREADBOARD EXISTS. DEVELOPMENT ONGOING.

SPAR

SAR BLOCK DIAGRAM



N.B. Redundancy Not Shown

MASS BUDGET

SUBSYSTEM	MASS
LPT	12 KG
HPMC	136.7KG
ANTENNA	520 KG
RECEIVER	10.5 KG
CALIBRATION	7.5 KG
COMPUTER	25.0 KG
HARNESS	17.5 KG
TOTAL	729.2KG

SPAR

DC POWER BUDGET

	INITIALIZE	IDLE	READY	IMAGE
LPT	0	15	45	45
HPMC	0	50	75	1250
ANTENNA	0	25	70	70
RECEIVER	0	20	40	40
CALIBRATION	0	10	10 (22.5)	10 (22.5)
COMPUTER	25	25	25	25
TOTAL	25	145	265 (277.5)	1440 (1452.5)

SPAR

RF LOSS BUDGET

COMPONENT	LOSS
HPMC - ANT W/G LOSS	0.25 DB
MISMATCH LOSS	0.20 DB
TRANSMIT PATH LOSS	0.45 DB
HPMC RX PATH LOSS	1.35 DB
ANT - HPMC W/G LOSS	0.25 DB
MISMATCH LOSS	0.30 DB
HPMC - RX W/G LOSS	0.10 DB
RECEIVE PATH LOSS	2.00 DB
TOTAL LOSS	2.45 DB

SPAR

SAR INSTRUMENT PHASE/AMPLITUDE ERRORS

AMPLITUDE ERRORS (DB)

	LIN	QUAD	HIGHER
IN-PULSE	0.82	0.82	0.52
PULSE-TO-PULSE	0.4	0.4	0.3
AZIMUTH SYNTHESIS	0.4	0.4	0.3

PHASE ERRORS (DEG)

	LIN	QUAD	HIGHER
IN-PULSE	201	62	8
PULSE-TO-PULSE	85	23	3
AZIMUTH SYNTHESIS	85	23	3

SPAR

AMPLITUDE ERROR BUDGET (DB)

		IN-PULSE			PULSE-TO-PULSE			APERTURE SYNTHESIS		
SUBSYSTEM		LIN	QUAD	HIGH	LIN	QUAD	HIGH	LIN	QUAD	HIGH
LPT		0.4	0.4	0.2	0.18	0.18	0.10	0.18	0.18	0.10
HPMC		0.6	0.6	0.4	0.3	0.3	0.2	0.3	0.3	0.2
ANTENNA		0.2	0.2	0.12	0.1	0.1	0.06	0.1	0.1	0.06
RCVR	IF	0.3	0.3	0.2	0.11	0.09	0.08	0.11	0.09	0.08
	LIM/ LNA	0.11	0.09	0.09	0.11	0.09	0.09	0.11	0.09	0.09
CALIBRATION		0.1	0.08	0.06	0.1	0.08	0.06	0.1	0.08	0.06
RSS TOTAL		0.79	0.76	0.49	0.39	0.38	0.26	0.39	0.38	0.26
SYS REQ		0.82	0.82	0.52	0.4	0.4	0.3	0.4	0.4	0.3

SPAR

PHASE ERROR BUDGET (DEG)

		IN-PULSE			PULSE-TO-PULSE			APERTURE SYNTHESIS		
SUBSYSTEM		LIN	QUAD	HIGH	LIN	QUAD	HIGH	LIN	QUAD	HIGH
LPT		80	20	2	40	8	0.8	40	8	0.8
HPMC		130	50	7	14	14	2.3	14	14	2.2
ANTENNA		50	18	1.8	25	9	0.9	25	9	0.9
RCVR	IF	80	16	2	40	8	0.8	40	8	0.8
	LIM/ LNA	80	16	2	40	8	0.8	40	8	0.8
CALIBRATION		40	8	0.8	40	8	0.8	40	8	0.8
RSS TOTAL		200.5	61.64	8.05	85	23	2.9	85	23	2.9
SYS REQ		201	62	8	85	23	3	85	23	3

SPAR

RELIABILITY BUDGET

SUBSYSTEM	RELIABILITY
LPT	0.9990
HPMC	0.9767
ANTENNA	0.9700
RECEIVER	0.9970
CALIBRATION	0.9990
COMPUTER	0.9940
TOTAL	0.9387
SPACECRAFT REQ	0.8730

SPAR

SAR ANTENNA IMPLEMENTATION

- BRIEF DESCRIPTION
- PERFORMANCE: PREDICTED AND MEASURED
- DEVELOPMENT PLAN

BY: LUIS MARTINS-CAMELO

SPAR

BRIEF DESCRIPTION (1)

MAIN CHARACTERISTICS

- SLOTTED WAVEGUIDE PLANAR ARRAY
- 1.5M X 15M NOMINAL
- 4 PANELS ALONG AZIMUTH, 1.5 X 3.75M EACH (NOMINAL)
- DEPLOYABLE, ONE EXTENDIBLE SUPPORT STRUCTURE (ESS) FOR EACH HALF (I.E., FOR EACH 2 PANELS)
- 32 15M-LONG SLOTTED WAVEGUIDE ROWS ACROSS ELEVATION (1.5M) DIMENSION
- EACH ROW IS INDEPENDENTLY EXCITED BY THE ELEVATION BEAM FORMING NETWORK (EBFN)
- EBFN HAS CONSTANT AMPLITUDE AND FULLY FLEXIBLE PHASE AT EACH ROW, TO PROVIDE ELEVATION BEAMSHAPE CONTROL
- 32 ELECTRONICALLY CONTROLLED 6-8 BIT VARIABLE FERRITE PHASE SHIFTERS (VPS)

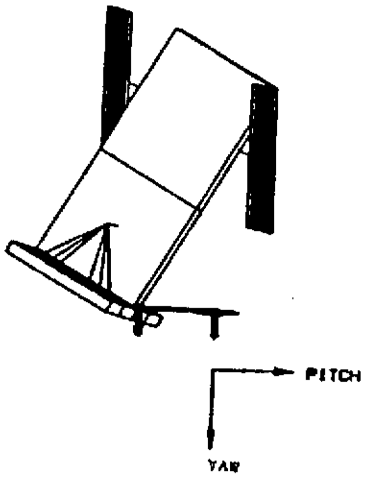
SPAR

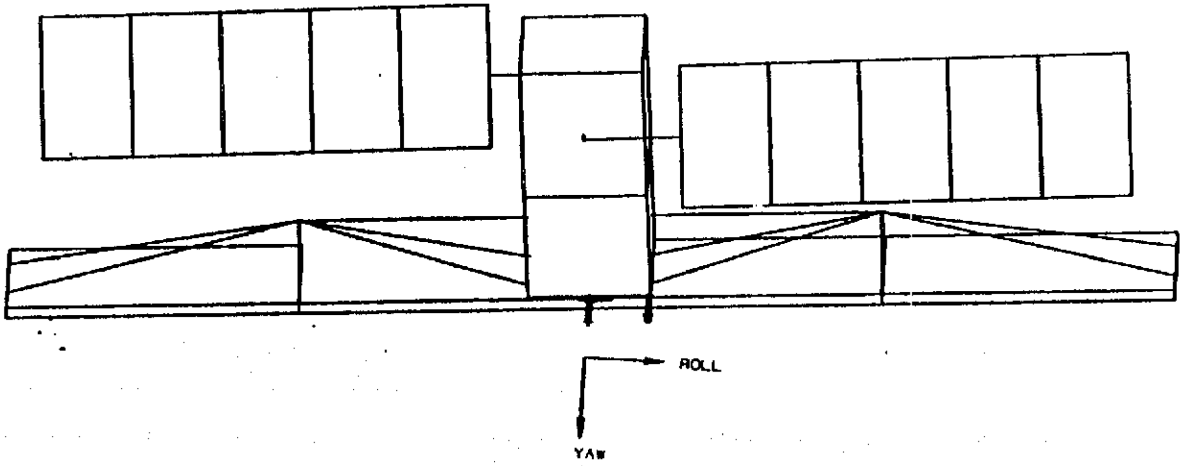
BRIEF DESCRIPTION (2)

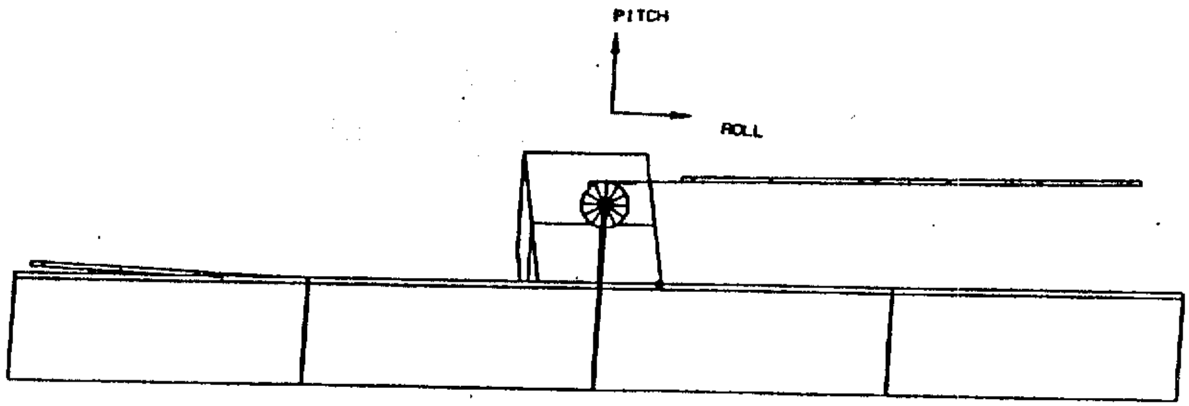
DESIGN DETAILS

- INCLINED RADIATING SLOTS ON THE NARROW WAVEGUIDE WALL
- TRAVELLING - WAVE EXCITATION MODE. THIS REQUIRES:
  - TERMINATING LOADS IN EACH WAVEGUIDE RUN
  - RADIATED BEAM IS SQUINTED IN AZIMUTH (5^{o})
- IN THE ELEVATION PLANE, MECHANICAL BORESIGHT OF PLANAR ARRAY POINTS AT 29.8^{o} FROM NADIR, I.E. IT POINTS APPROXIMATELY TO THE CENTER OF THE COVERED SWATHWIDTH.

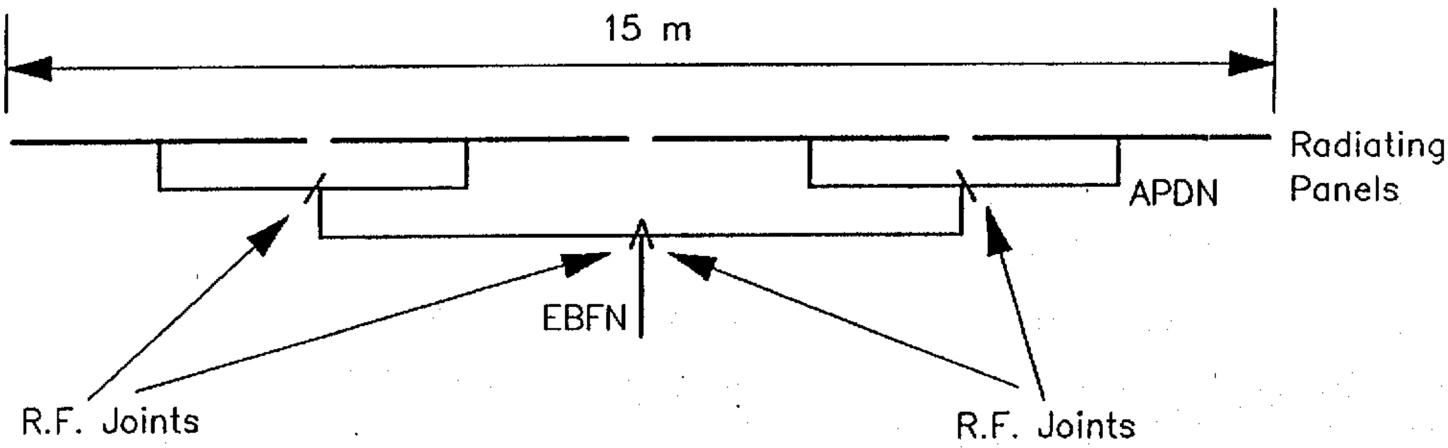
BRIEF DESCRIPTION (3)







SAR ANTENNA CONFIGURATION



SPAR

PERFORMANCE (1)

o SOFTWARE	ANALYSIS	PLANAR ARRAY
	SYNTHESIS	ELEVATION BEAMSHAPES SLOT PARAMETERS

- o BREADBOARD PHASE, 1986/1987
  - COMPUTED PREDICTIONS
  - MEASURED RESULTS

  VERY GOOD AGREEMENT

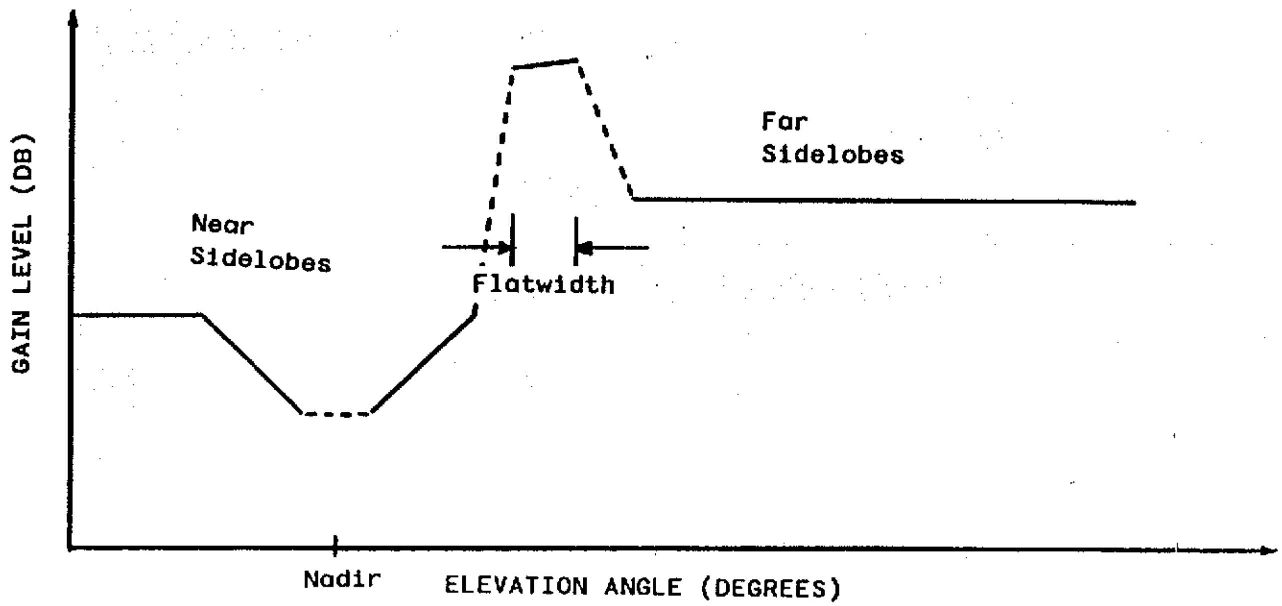
- o FLIGHT DESIGN: COMPUTED PREDICTIONS

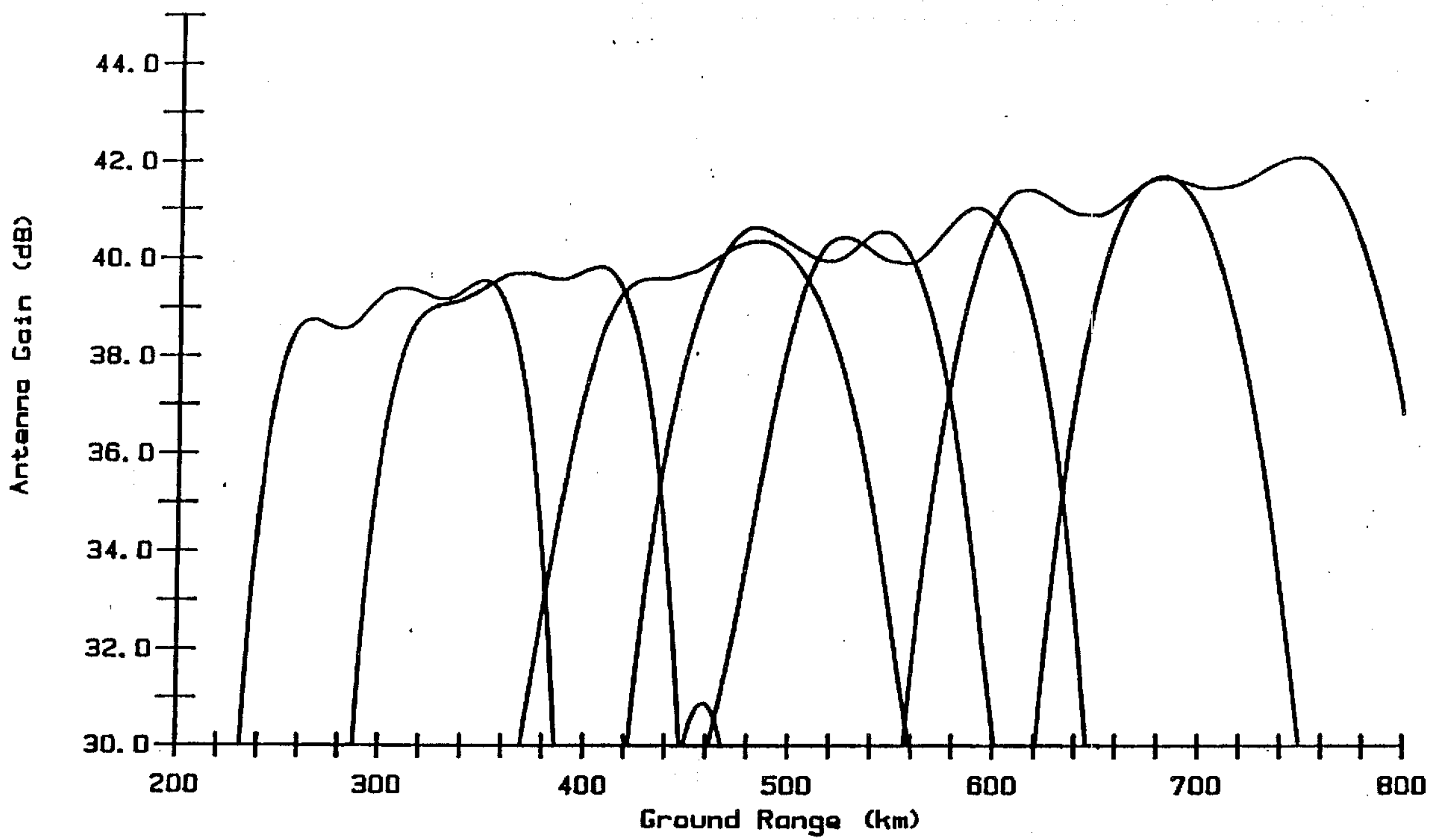
SPAR

PERFORMANCE (2)

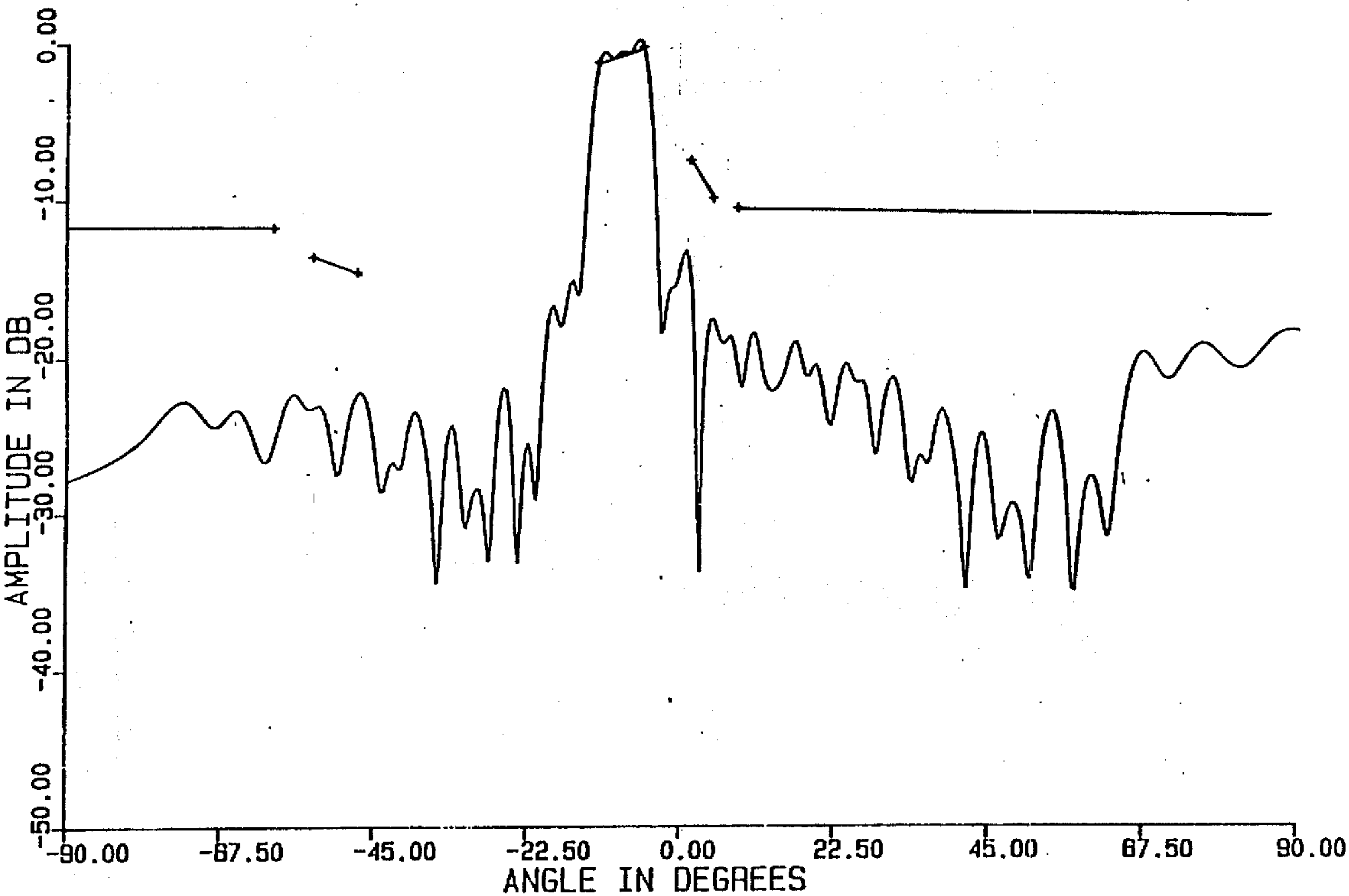
MAJOR SPECIFICATIONS

- o GAIN AT MIDDLE OF FLATWIDTH
- o RIPPLE OVER THE FLATWIDTH
- o ELEVATION BEAMSHAPE MASKS
- o ELEVATION AND AZIMUTH AMBIGUITY RATIOS

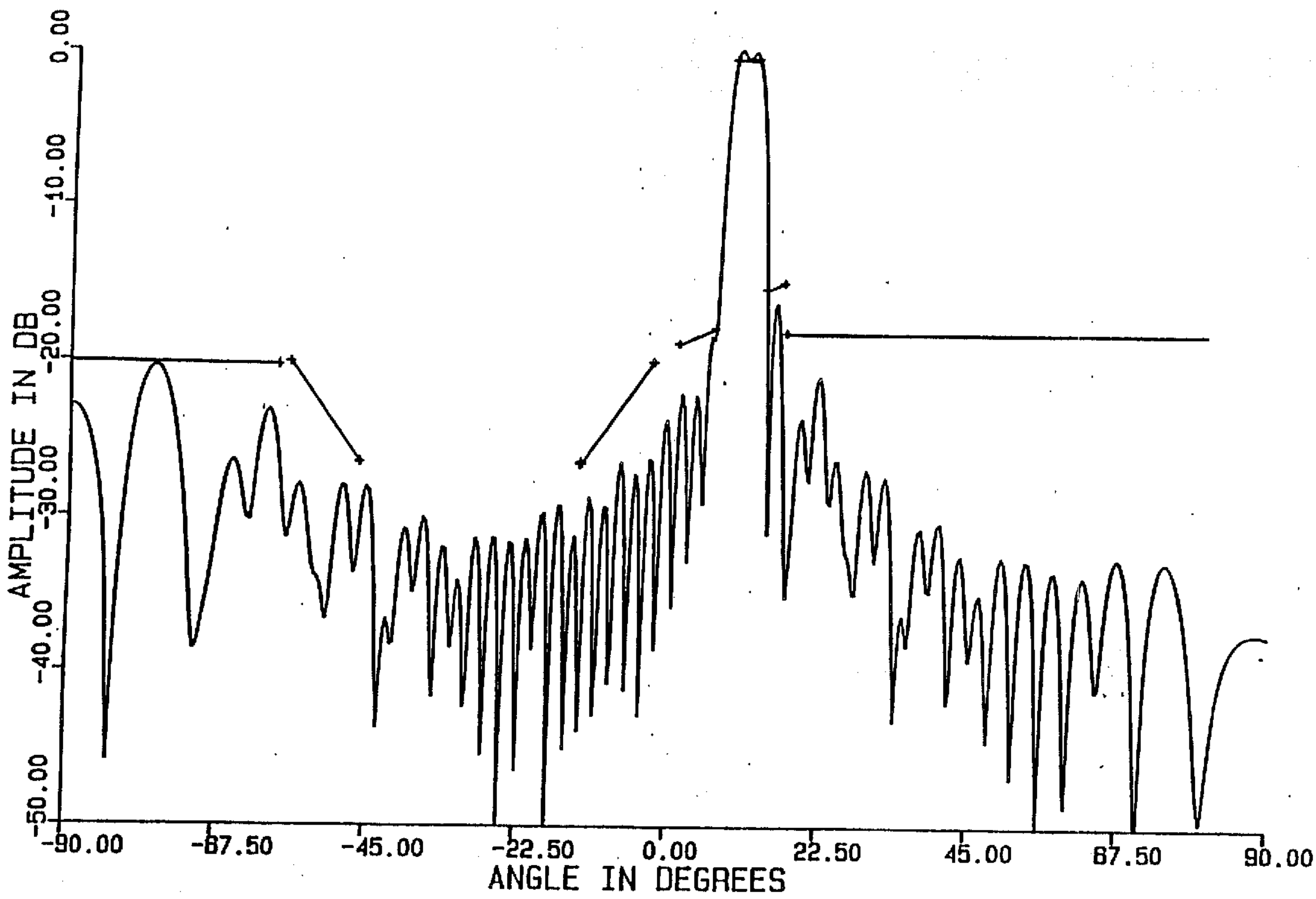



44.0
42.0
40.0
38.0
36.0
34.0
32.0
30.0
Antenna Gain (dB)
200
300
400
500
600
700
800
Ground Range (km)

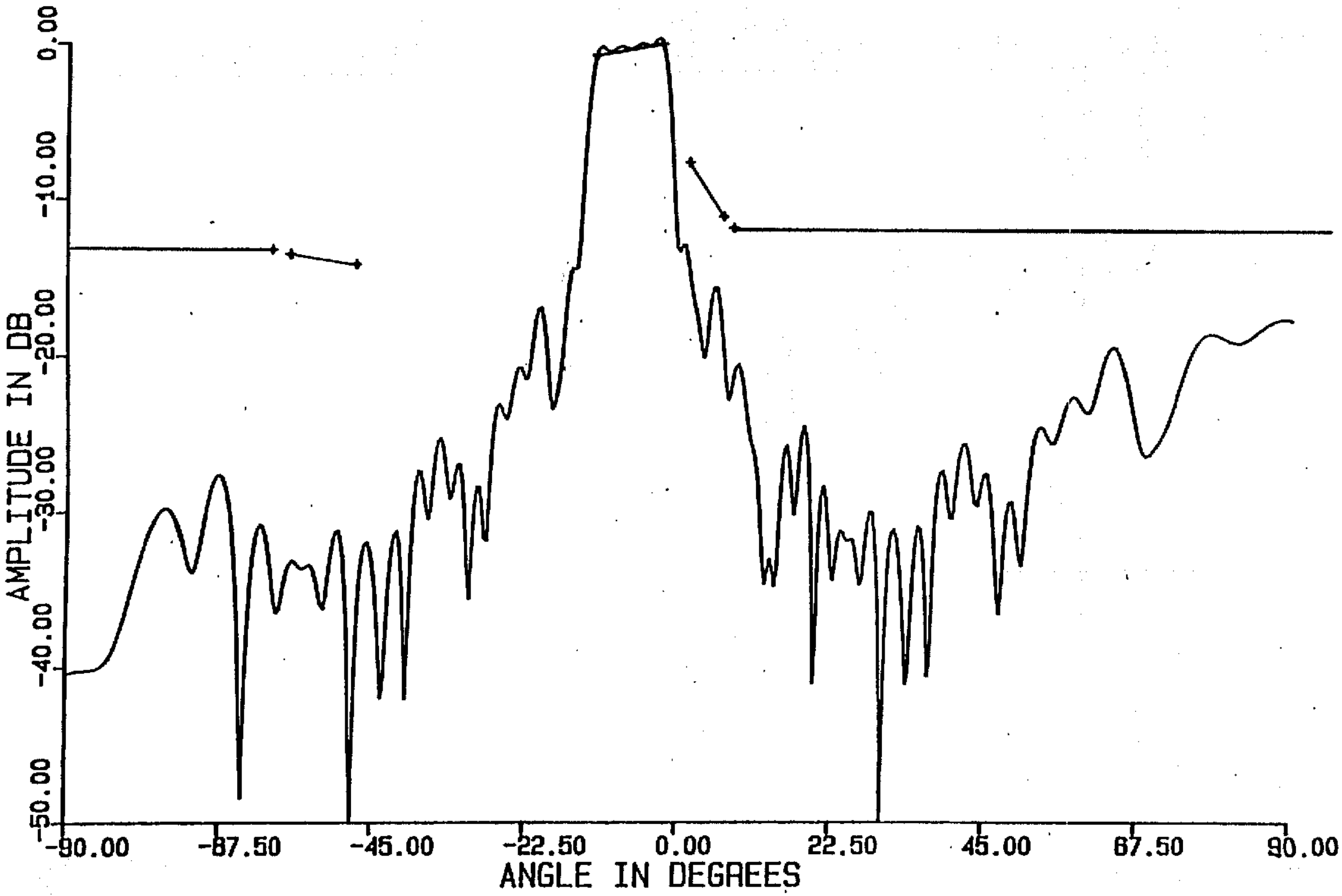
SPAR



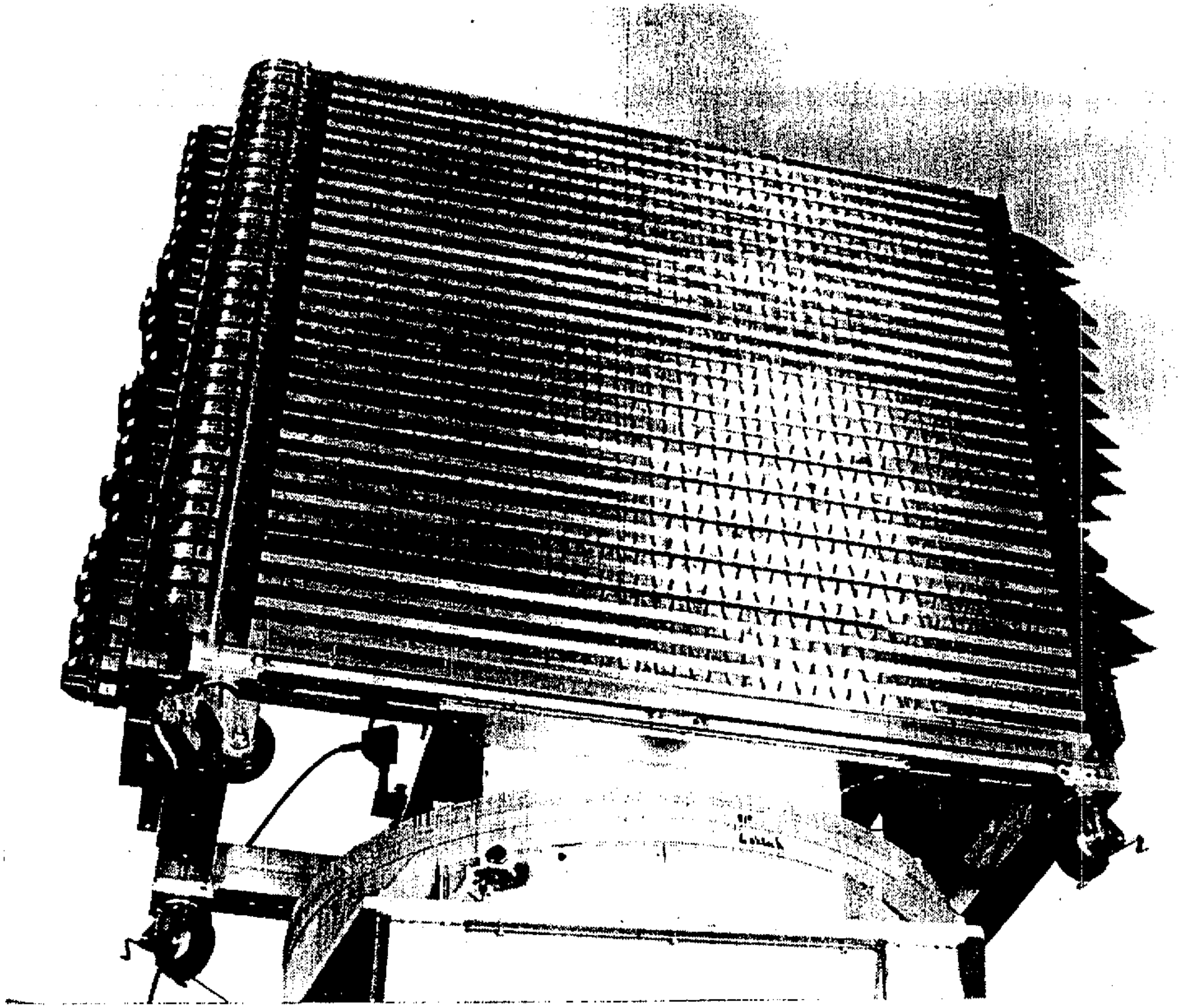
ELEVATION BEAMSHAPE FOR BEAM #1



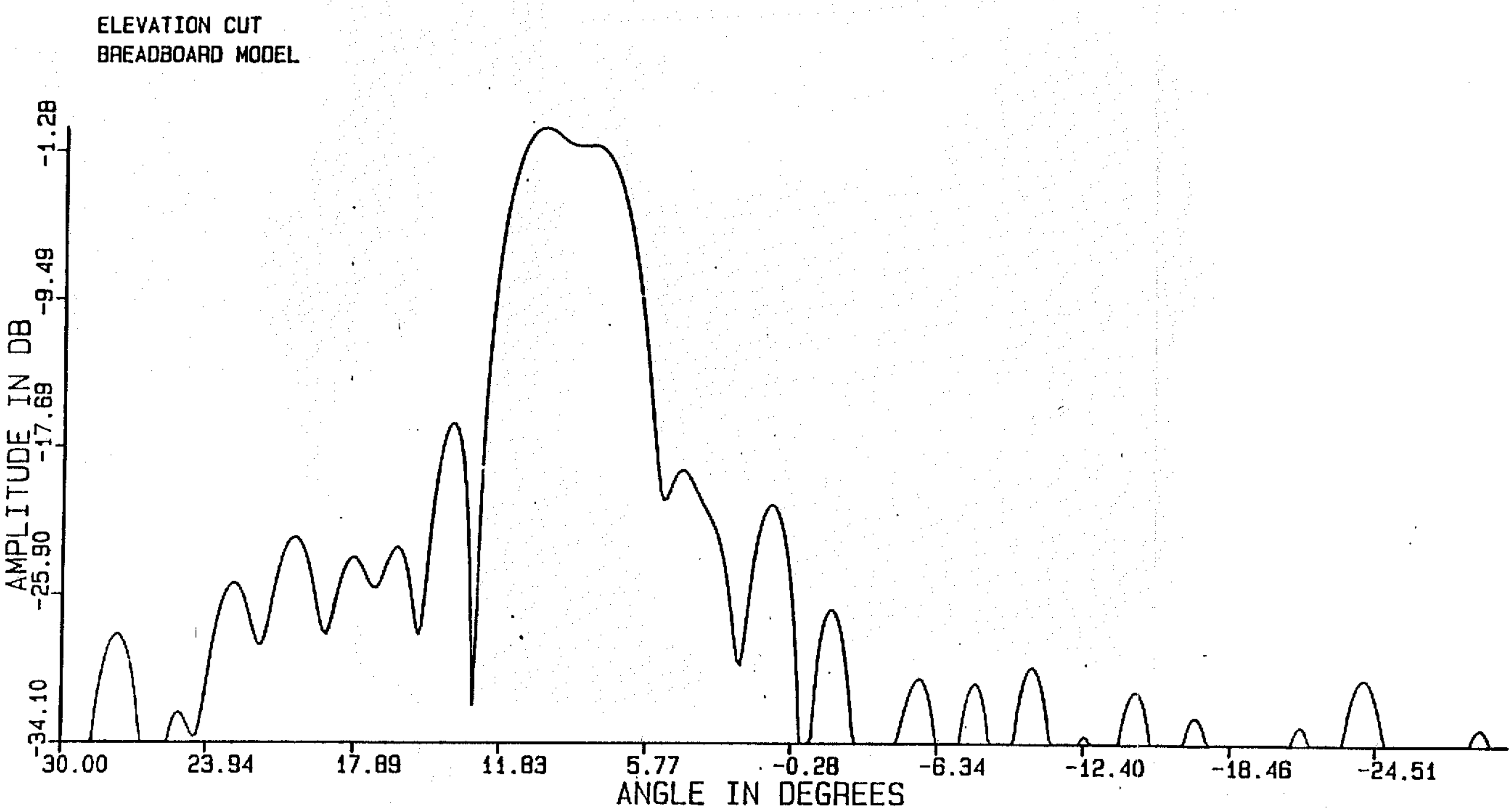
ELEVATION BEAMSHAPE FOR BEAM #7



ELEVATION BEAMSHAPE FOR BEAM #W1

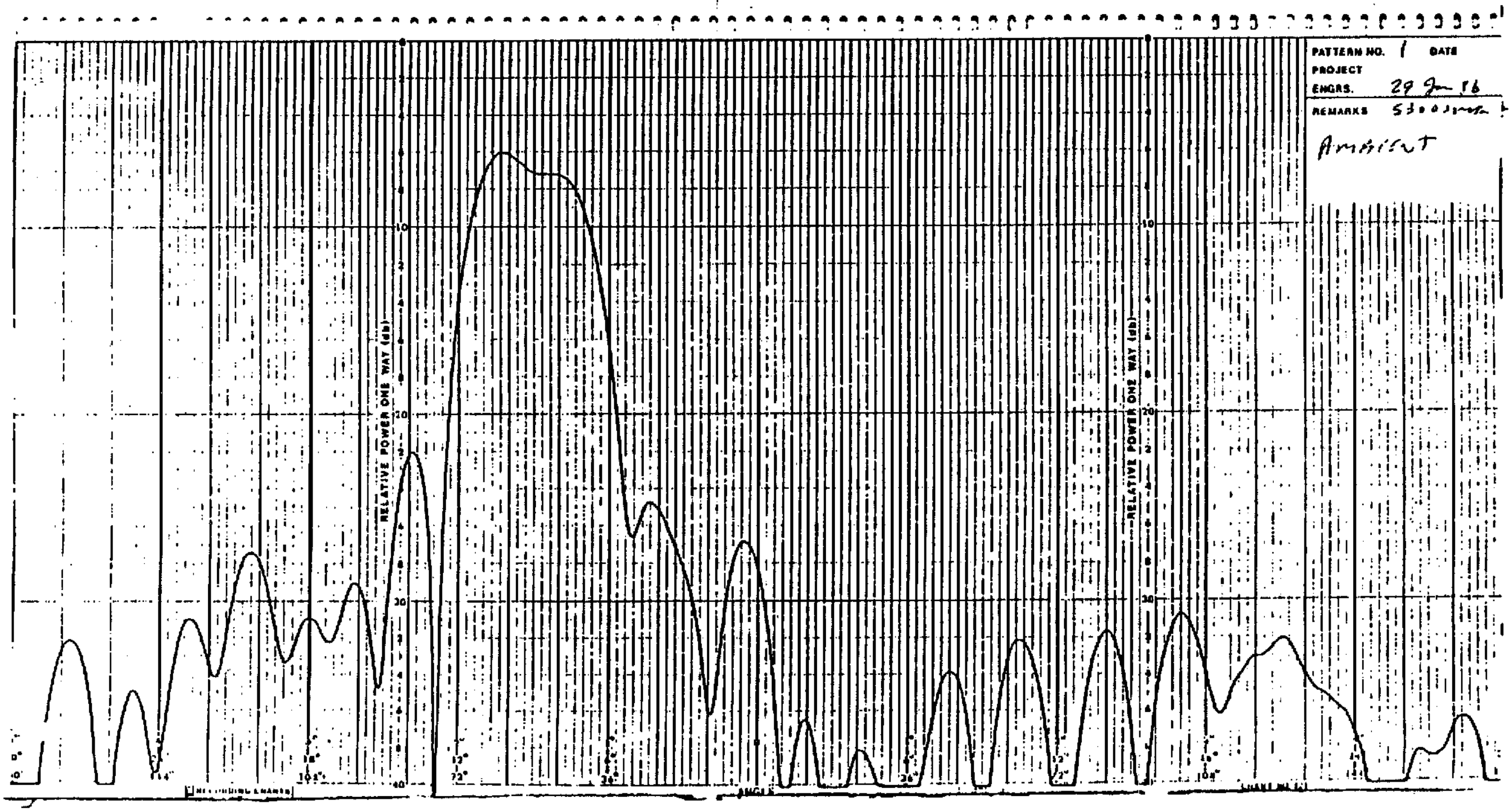


BREADBOARD



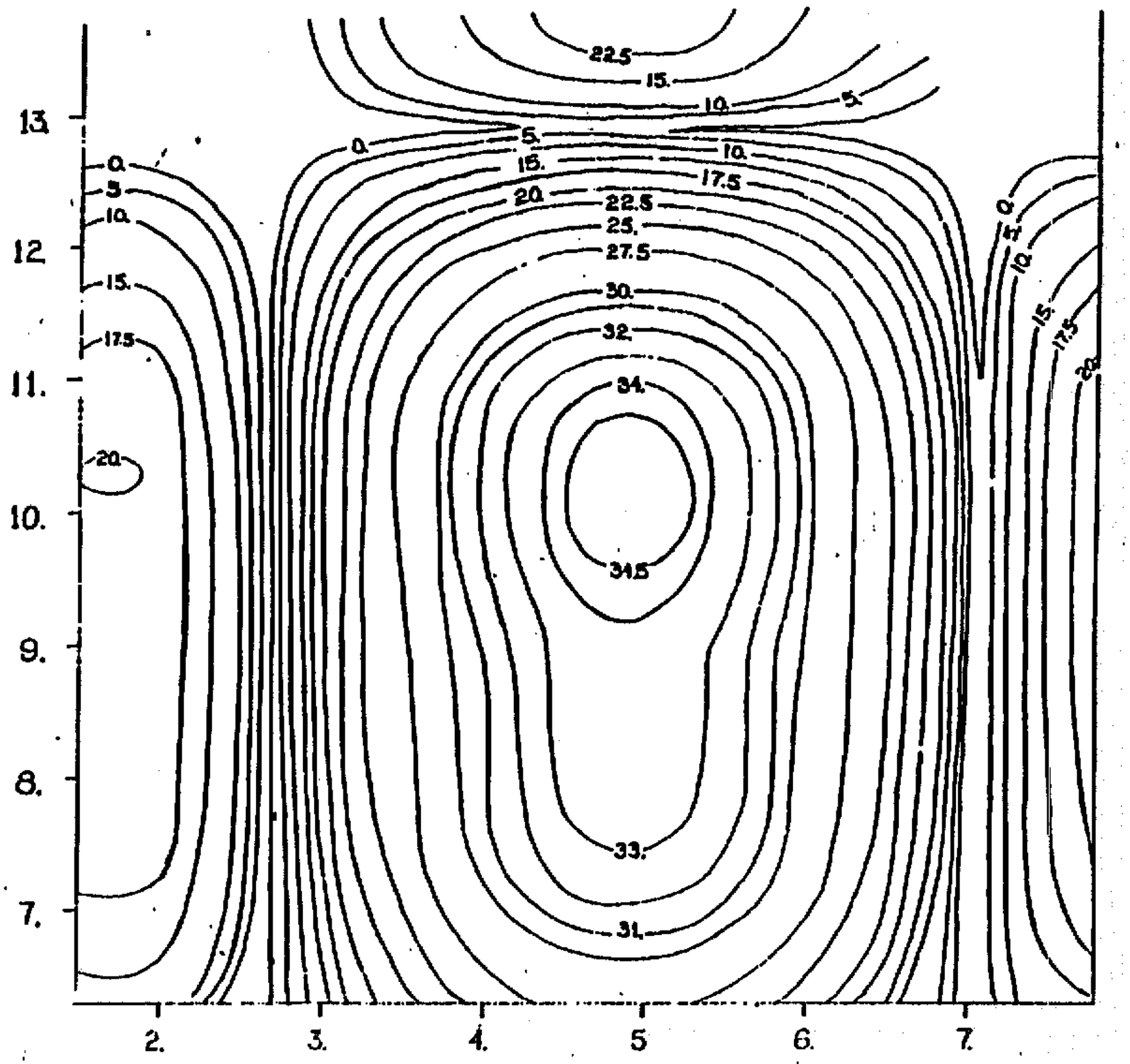
COMPUTED ELEVATION PATTERN

SPAR



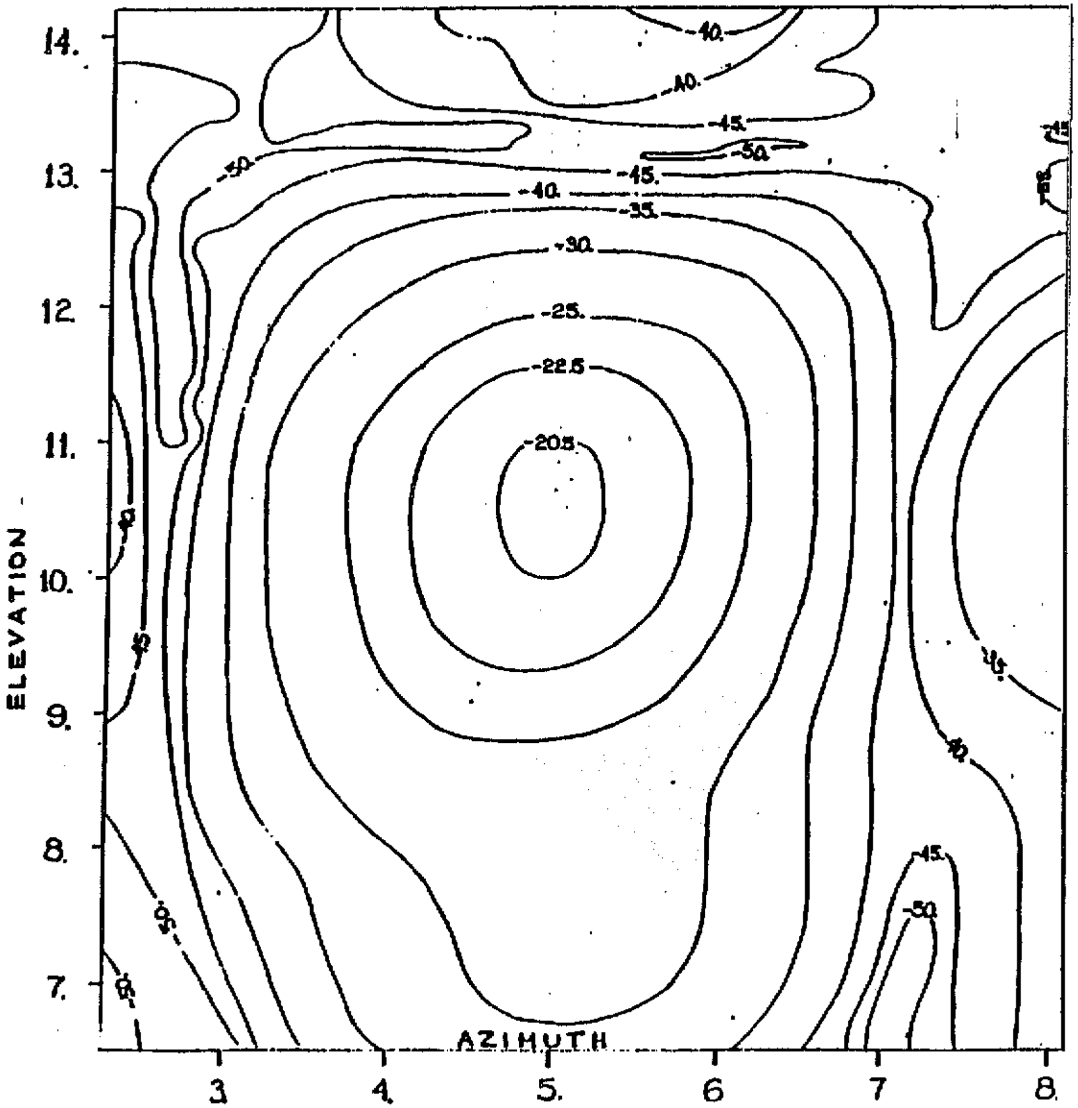
BREADBOARD MEASURED ELEVATION PATTERN

SPAR



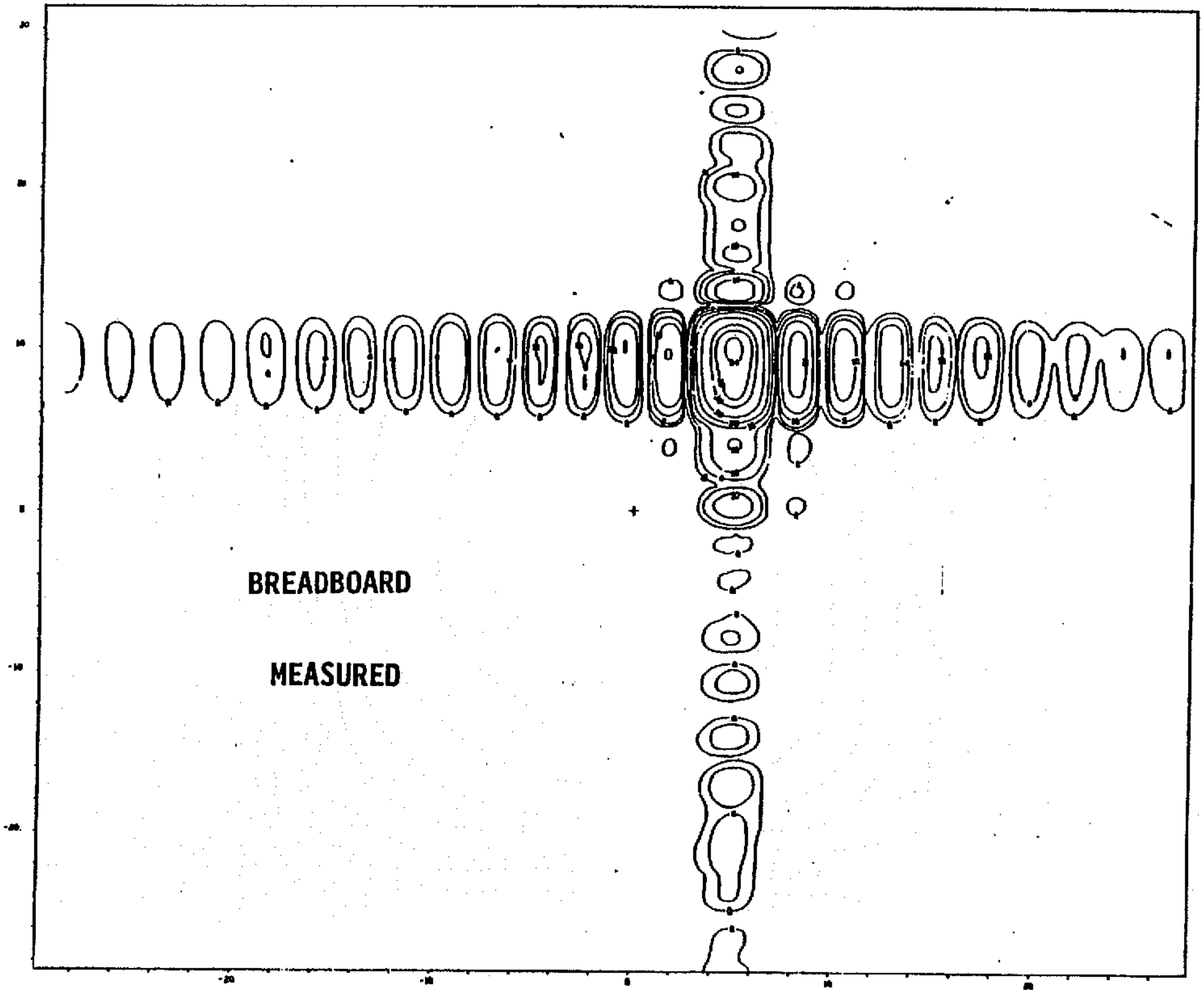
MEASURED BREADBOARD

COPOLARIZED CONTOUR PLOT, FINE RESOLUTION



MEASURED BREADBOARD

CROSS POLARIZED CONTOUR PLOT, FINE RESOLUTION



COPOLARIZED CONTOUR PLOT +/-30 DEG IN BOTH AZIMUTH AND ELEVATION

SPAR

DEVELOPMENT PLAN (1)

- o BREADBOARDING OF COMPONENTS
  - SLOTTED WAVEGUIDE RUNS
  - CHOKE FLANGE ASSEMBLIES
  - REDUCED-SIZE PANEL
  - COUPLERS FOR APDN
  - WAVEGUIDE LOADS
  - EBFN COMPONENTS
  - VPS AND ESS AS NEEDED

- o ELECTRICAL MODEL: 2 FULL SIZE PANELS + APDN + CHOKE FLANGES
  EBFN WITH 32 VPS

SPAR

DEVELOPMENT PLAN (2)

- o DEPLOYMENT/STRUCTURAL MODEL:
  - ELECTRICAL MODEL PANELS
    1/2 ESS ENGINEERING MODEL
    SPACECRAFT PANEL SIMULATOR JIG
  - EBFN
  - VPS ENGINEERING MODEL
- o THERMAL MODEL: ANALYTICAL SIMULATION
- o PROTOFLIGHT MODEL

SPAR

LAUNCH VEHICLE INTERFACES

SPAR

LAUNCH VEHICLE:

- o MLV COMPATABILITY REQUIRED
- o DELTA II (7920) WITH 10' FAIRING ASSUMED
- o ACTUAL LV MUST HAVE AT LEAST THE PERFORMANCE OF THE DELTA II (7920)

ENVELOPE:

- o 2794 MM (110") DIAMETER
- o 4135 MM CYCLINDRICAL LENGTH + NOSE CONE
- o ENVELOPE INCLUDES LV ADAPTOR

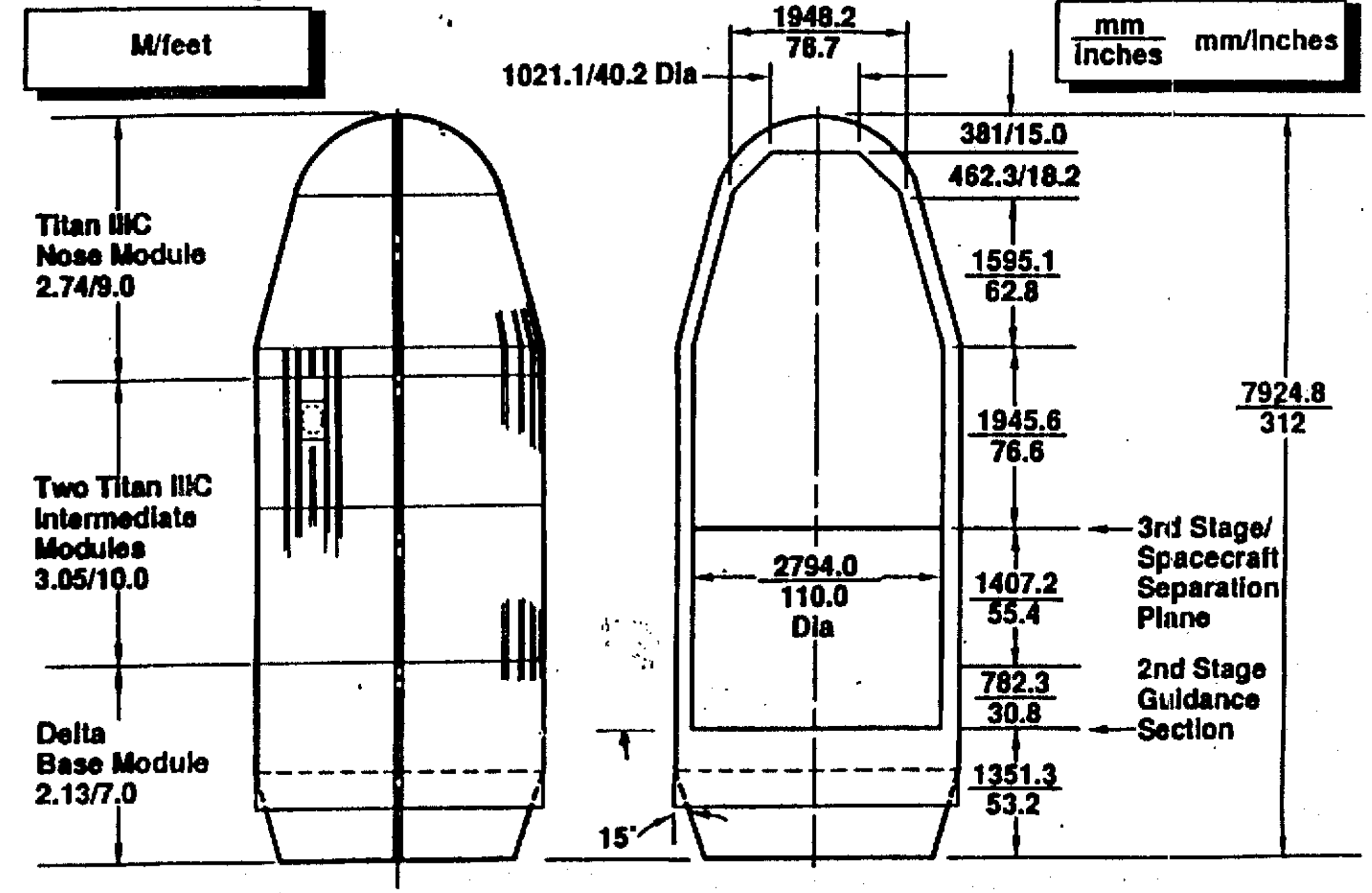
INJECTION CAPABILITY:

- o 3800 KG INTO 185 KM TRANSFER ORBIT
- o 3152 KG INTO 800 KM SUN-SYNCHRONOUS
- o DIRECT INJECTION ASSUMED

SPAR

10 FT DIAMETER FAIRING

DELTA II
McDonnell Douglas



SPAR

LV ADAPTOR:

- ASSUMED TO BE INCLUDED WITH THE LV
- MUST BE INCLUDED IN ENVELOPE AND LAUNCH MASS
- SHOULD HAVE A CAPABILITY OF 3200 KG ABOVE SEPARATION PLANE 1600 MM
- ROSAT ADAPTOR RING:

  - 152.4 MM (6 IN) HEIGHT
  - 54.5 KG MASS
  - 3200 KG AT 1567 MM CAPABILITY

- RME FOUR POINT ADAPTOR

  - 406.4 MM (16 IN) HEIGHT
  - 68.0 KG MASS
  - 2500 KG AT 1580 MM FOR RME/LACE
  - 3200 KG CAPABILITY EXPECTED

SPAR

LV ADAPTOR: (CONT'D)

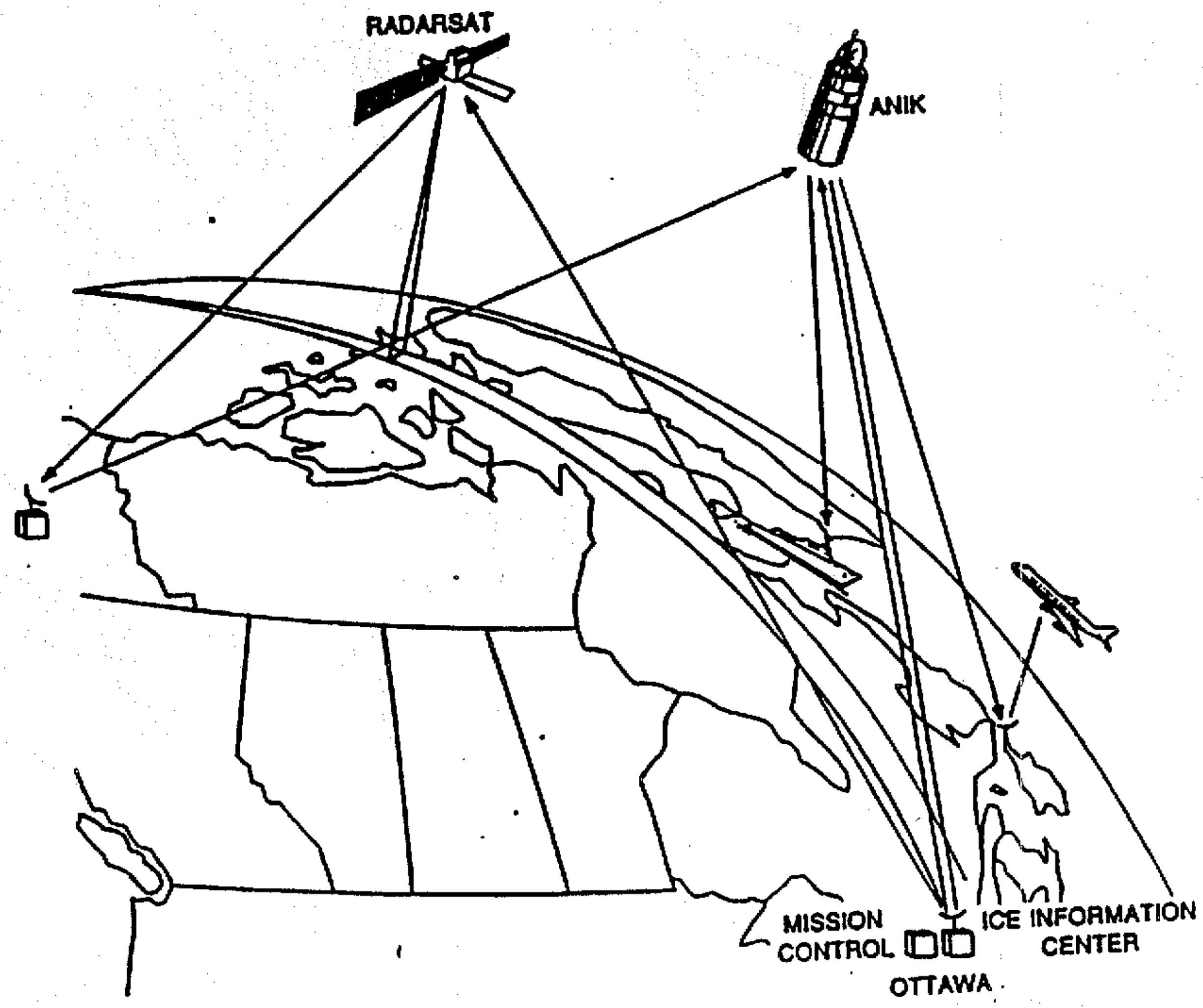
- o 6019 THREE POINT ADAPTOR
  - 483 MM (19 IN) HEIGHT
  - 57 KG MASS
  - 2177 KG AT 2083 MM CAPABILITY
  - MODIFICATIONS MIGHT BE REQUIRED IF USED

DELTA II (7920) AVAILABILITY:

- o DELTA II (7920) SCHEDULED FOR 1991
- o CURRENT WTR FACILITY REQUIRES MODIFICATION
- o SUCH MODIFICATION WHICH MAY BE REQUIRED ARE ASSUMED TO BE INCLUDED WITH THE LAUNCH

SYSTEM ARCHITECTURE

SPAR

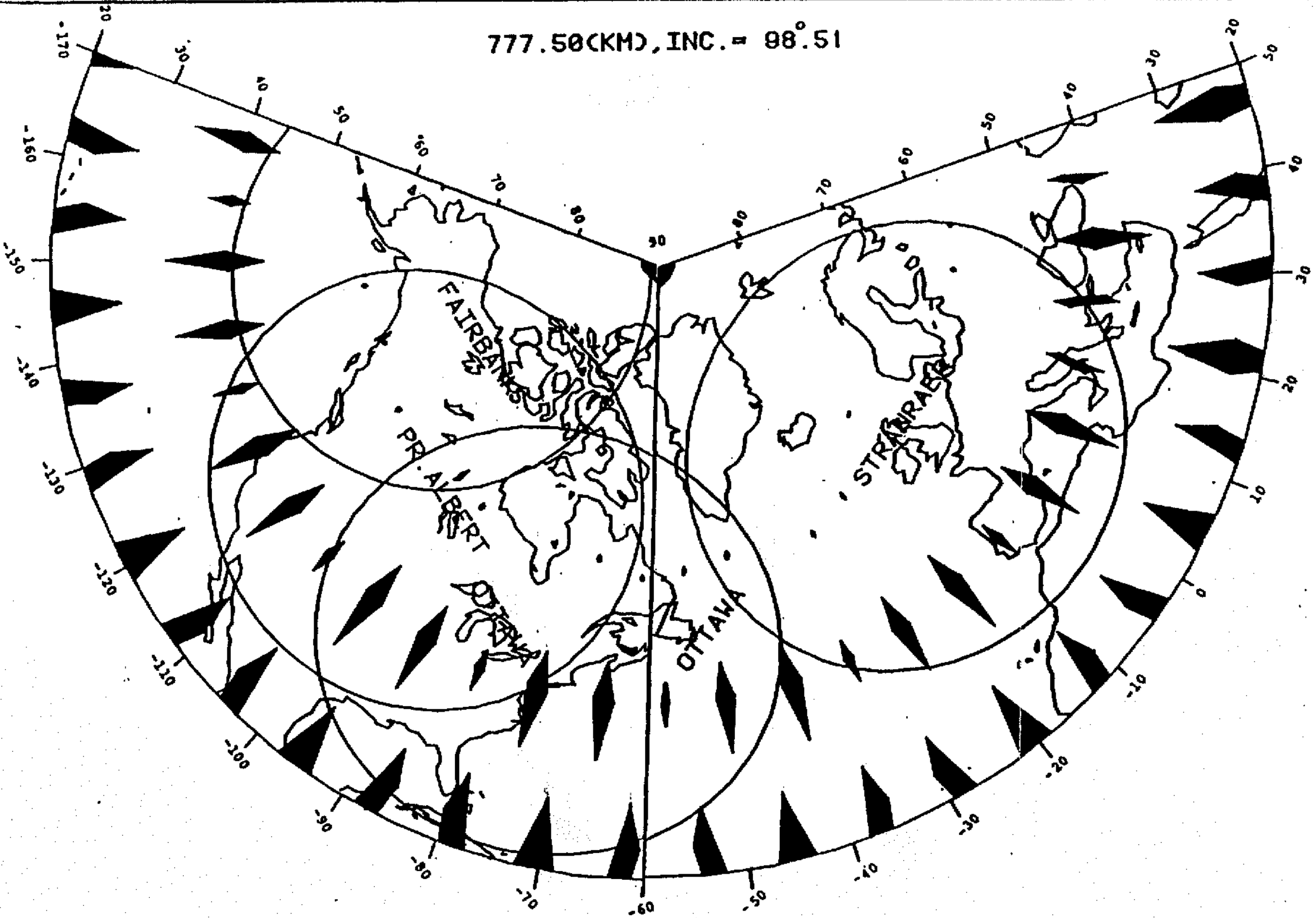


MISSION CONCEPT
FOR SPAR

A85-806

SYSTEM OUTLINE

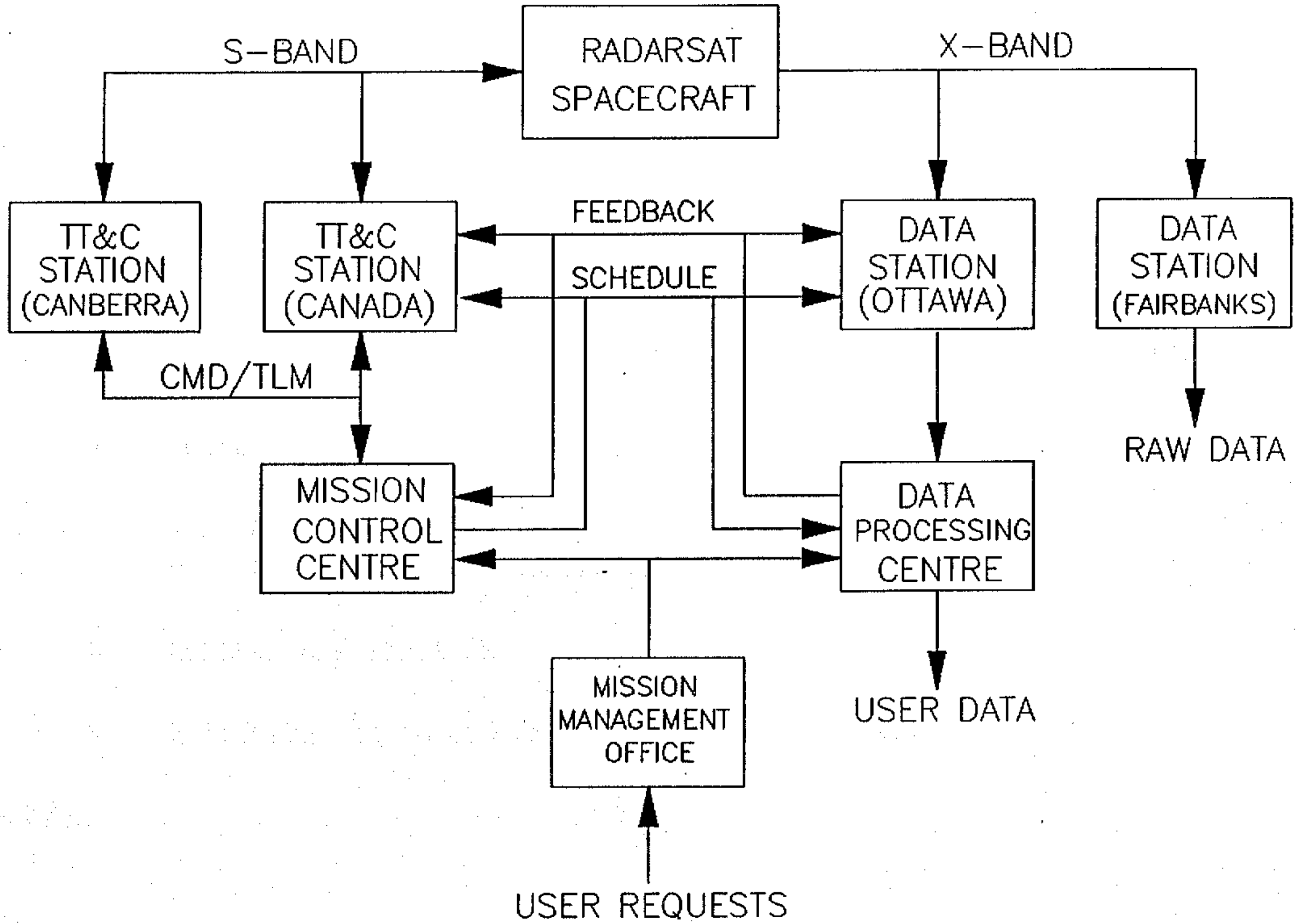
SPAR



ORBIT 244/17: COVERAGE GAPS AFTER THREE DAY SUBCYCLE

SPAR

RADARSAT SYSTEM ARCHITECTURE



SPACECRAFT

- o SPACECRAFT IN AN 800 KM, SUN SYNCHRONOUS ORBIT
- o MODULAR CONSTRUCTION
  - PLATFORM MODULE (PROPULSION, POWER, AOCS ETC.)
  - PAYLOAD MODULE (SAR, COMMAND & DATA HANDLING)
- o MODES
  - NOMINAL MODE: RIGHT LOOKING SAR (28 MINS/ORBIT OPERATION)
    OR
  - ANTARCTIC MODE: LEFT LOOKING SAR (15 - 28 MINS/ORBIT OPERATION)

SPAR

SPACECRAFT (CONT'D)

- o SPACECRAFT OPERATION

  - IT IS ONLY PROPOSED TO OPERATE THE SAR DURING SUNLIT PORTIONS OF ORBIT (ECLIPSE SEASON IS MAY TO AUGUST AND ONLY OVER SOUTH POLE).

  - 28 MINS OF SAR OPERATION / ORBIT
    CAN BE ANYWHERE IN THE ORBIT
    UP TO SIX DIFFERENT IMAGING SESSIONS/ORBIT CAN BE REQUESTED

SATELLITE CONTROL AND MONITORING

- INTERFACE TO SPACECRAFT AT S-BAND
- TT&C STATION LOCATED IN CANADA
- CONTROL IS PERFORMED BY A MISSION CONTROL SYSTEM (=POCC) LOCATED IN THE OTTAWA AREA
  - REAL TIME MONITORING AND CONTROL OF RADARSAT
  - FLIGHT CONTROL (ORBIT MAINTAINANCE, DETERMINATION, EPHEMERIS DISTRIBUTION)
  - PRODUCTION OF DETAILED OPERATION SCHEDULES
  - CONTINGUENCY PLANNING AND EXECUTION
- EXECUTIVE CONTROL PERFORMED BY A MISSION MANAGEMENT OFFICE IN CONJUNCTION WITH THE INTERNATIONAL STEERING COMMITTEE.
  - RECEIVES USER REQUESTS AND SETS PRIORITIES
  - PROVIDES INPUT TO MCC SCHEDULING
  - PROVIDE THE PRIMARY MANAGEMENT INTERFACE TO THE USERS

SPAR

DATA ACQUISITION AND PROCESSING

- o DATA DOWNLINKED AT X-BAND
- o DATA RECORDED AT DATA ACQUISITION STATION
- o BACKHAULED TO PROCESSING FACILITY AT LOWER RATE
- o DATA PROCESSING THROUGHPUT RATES
  - 1500 (100 KM X 100 KM) SCENES PER DAY (MAXIMUM)
  - 600 SCENES/DAY (TYPICAL
  - ZERO BACKLOG PROCESSING (I.E. 1/4 REAL TIME RATE)
  - 4 HOUR END-TO-END PRODUCT DELIVERY

DATA ACQUISITION AND PROCESSING (CONT'D)

o PROCESSED PRODUCTS

- GEOREFERENCED PRODUCTS : SYSTEMATIC GEOMETRIC CORRECTION
  LOCATION BASED ON SATELLITE DATA
- GEOCODED PRODUCTS : STANDARD MAP PROJECTION
  ROTATED AND RESAMPLED
  LOCATION WITH GCP'S
  CORRECTION FOR TERRAIN (IF DTM AVAILABLE)
- SPECIAL PRODUCTS : E.G. RAW DATA, SINGLE-LOOK,
  COMPLEX-VALUED DATA

SPAR

ADDITIONAL FACILITIES

- OTHER DATA ACQUISITION STATIONS WILL BE ABLE TO ACCESS RADARSAT DATA (E.G. FAIRBANKS FOR ANTARCTIC DATA).

- THE TT&C STATION WILL PROBABLY REQUIRE SUPPORT DURING LAUNCH AND EARLY ORBIT PHASE (E.G. CANBERRA).

MISSION PLANNING

SPAR

OPERATIONAL ORBIT PARAMETERS

ALTITUDE

- NOMINALLY 800 KM
- IN THE RANGE 750 - 810 KM
- ONE OF THE ALTITUDES OF PARTICULAR INTEREST
  - 777 KM GIVES 3 DAY SUB-CYCLE AND 17 DAY REPEAT
- FINAL CHOICE YET TO BE MADE BUT SPACECRAFT INSENSITIVE TO CHOICE

SPAR

OPERATIONAL ORBIT PARAMETERS
(CONT'D)

OTHER PARAMETERS

- o INCLINATION
  - SUN-SYNCHRONOUS (NOMINALLY 98.6°) DEPENDENT ON ALTITUDE
- o ASCENDING NODE TIME
  - 18.00 HRS (±15 MINS), DAWN/DUSK OR TWILIGHT ORBIT
- o ECCENTRICITY
  - <0.001
- o ORBITAL PERIOD
  - NOMINALLY 101 MINS

SPAR

LAUNCH AND ORBIT ACQUISITION

LAUNCH

o LAUNCH FROM WTR IN MID 1994

ORBIT ACQUISITION STRATEGY

o TWO OPTIONS

- DIRECT INJECTION TO 800 KM
- INJECTION TO 185 KM AND ORBIT RAISING TO 800 KM
- 800 KM OPTION PREFERRED

SPAR

LAUNCH AND ORBIT ACQUISITION
(CONT'D)

DEPLOYMENTS & AOCS CALIBRATION

- o DEPLOYMENTS
  - SOLAR ARRAY, SAR ANTENNA, C&DH ANTENNA (IF REQUIRED)
- o GYRO CALIBRATION
- o PREFERRED TO BE CARRIED OUT WITHIN VISIBILITY OF A GROUND STATION (OTTAWA, CANBERRA, GOLDSTONE, MADRID)

OPERATIONAL ORBIT ACQUISITION

- o CORRECTION OF LAUNCH VEHICLE DISPERSION ERRORS
  - 18.5 KM ALTITUDE AND 0.05 DEGREES

SPAR

LAUNCH AND ORBIT ACQUISITION
(CONT'D)

COMMISSIONING

- CHECKOUT OF ALL SPACECRAFT SYSTEMS
- VERIFICATION INSTRUMENT PERFORMANCE
- EXPECTED DURATION 3 MONTHS

SPAR

ORBIT MAINTENANCE

PARAMETERS CONTROLLED

- ALTITUDE CONTROLLED TO <5 KM
- ASCENDING NODE TIME CONTROLLED TO ±15 MINS

DRAG EFFECTS

- SPACECRAFT GEOMETRY GIVES LOW DRAG
- ESTIMATED AT LESS THAN 500M/MONTH IN ALTITUDE

ORBIT MAINTENANCE

- WILL BE PERFORMED EVERY 5-10 MONTHS
- STRATEGY
  - PLANNED OUTAGE

C&DH SYSTEM

SPAR

FUNCTIONAL REQUIREMENTS

- o TO INTERFACE BETWEEN PLATFORM TT&C SYSTEM AND SAR INSTRUMENT FOR TRANSFER OF COMMAND AND TELEMETRY DATA
  - TWO TELECOMMAND INTERFACE UNITS (TCIU'S)
- o TO COLLECT HIGH RATE DATA FROM THE SAR AND FORMAT THIS FOR DOWNLINKING.
  - HIGH FORMATTER PROVIDED
  - HIGH RATE DOWNLINK CHANNEL OPERATING AT 100 MBPS
- o TO PROVIDE STORAGE FOR SAR DATA BETWEEN GROUND STATION PASSES
  - TAPE RECORDERS PROVIDED TO STORE 15 MINS OF SAR DATA
  - SECOND HIGH RATE DOWNLINK CHANNEL OPERATING AT 85 MBPS.
- o DOWNLINK REALTIME AND STORED DATA SIMULTANEOUSLY
  - BOTH X-BAND CHANNELS OPERATING.

SPAR

C&DH HARDWARE STATUS

- o DOWNLINK TRANSMITTER
  - IDENTICAL TO THAT BUILT AND QUALIFIED BY SPAR FOR ERS-1
- o DOWNLINK ANTENNA
  - REPEAT OF ERS-1 ANTENNA DESIGNED AND MANUFACTURED BY SPAR
- o TAPE RECORDERS
  - DEVELOPED BY ODETICS FOR THE LANDSAT PROGRAM
- o FORMATTERS
  - RADARSAT SPECIFIC DESIGN
- o TCIU'S
  - RADARSAT SPECIFIC DESIGN

SPACECRAFT

SPACECRAFT CONFIGURATION

CONSTRAINTS

o	LV ENVELOPE:	2.794M DIAMETER
		4.135 M CYLINDRICAL LENGTH
o	SAR ANTENNA	15.0 M X 1.5 M
		LOOKS RIGHT 30° TO NADIR
		SQUINTED 5° IN AZIMUTH PLANE
		4 MECHANICAL PANELS
o	P/L HIGH POWER EQUIPMENT:	2.7M^2 AREA COLD VIEW FOR THERMAL DISSIPATION.
o	P/L LOW POWER EQUIPMENT:	4M^2 TOTAL MOUNTING AREA COLD VIEW NOT REQUIRED.
o	C&DH ANTENNA:	NADIR LOOKING

SPAR

SPACECRAFT CONFIGURATION (CONT'D)

- o **MODULARITY**
  - SEPARATE BUS AND PAYLOAD MODULES
  - MODULES THERMALLY ISOLATED
- o LV FAIRING RESTRICTION COMPROMISES
  - SAR ANTENNA TIEDOWNS ON BUS MODULE (2) & PAYLOAD MODULE (4)
  - EARTH SENSORS AND S-BAND ANTENNA ON PAYLOAD MODULE

SPACECRAFT CONFIGURATION (CONT'D)

CONFIGURATIONS

- o TWO CANDIDATE CONFIGURATIONS HAVE BEEN IDENTIFIED
  - THE TRIANGULAR CONFIGURATION

    AND
  - THE RECTANGULAR CONFIGURATION
- o FINAL CHOICE OF CONFIGURATION MAY DEPEND ON PLATFORM DIMENSIONS AND CONFIGURATION AND HENCE SELECTED BUS CONTRACTOR.

SPACECRAFT CONFIGURATION (CONT'D)

- **TRIANGULAR CONFIGURATION**

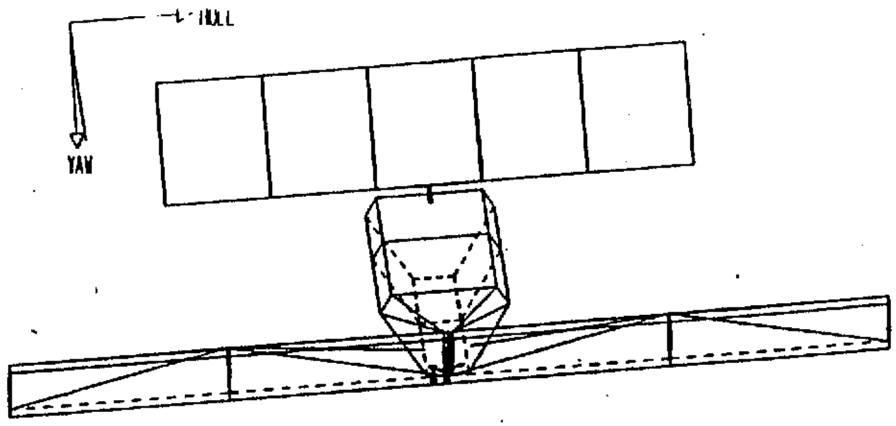
  - SAR ANTENNA STOWES ALONG LV AXIS ON ± X FACES

  - SAR ANTENNA DEPLOYMENT NOT PLANAR
    (REQUIRES 3 D OFF LOADER FOR GROUND DEPLOYMENT).

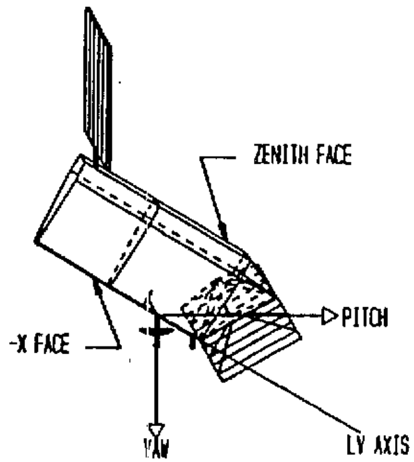
  - HIGH POWER EQUIPMENT ON -Z (ZENITH) FACE
    WHICH IS CANTED 30 AWAY FROM SUN WITH MINIMAL SOLAR HEAT INPUT

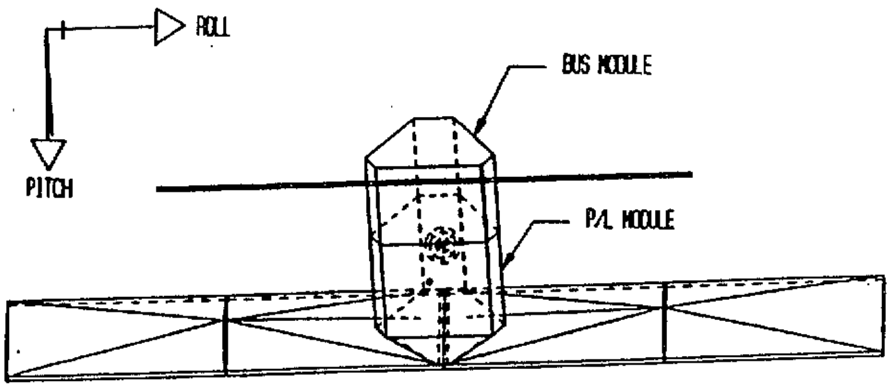
  - 60° ROLL OR 180° YAW OPTIONS AVAILABLE FOR ANTARCTIC COVERAGE (BOTH REQUIRE SOME ARTICULATION BY SOLAR ARRAYS AND ROLL REQUIRES ARTICULATION BY C&DH ANTENNA).

TRIANGULAR CONFIGURATION



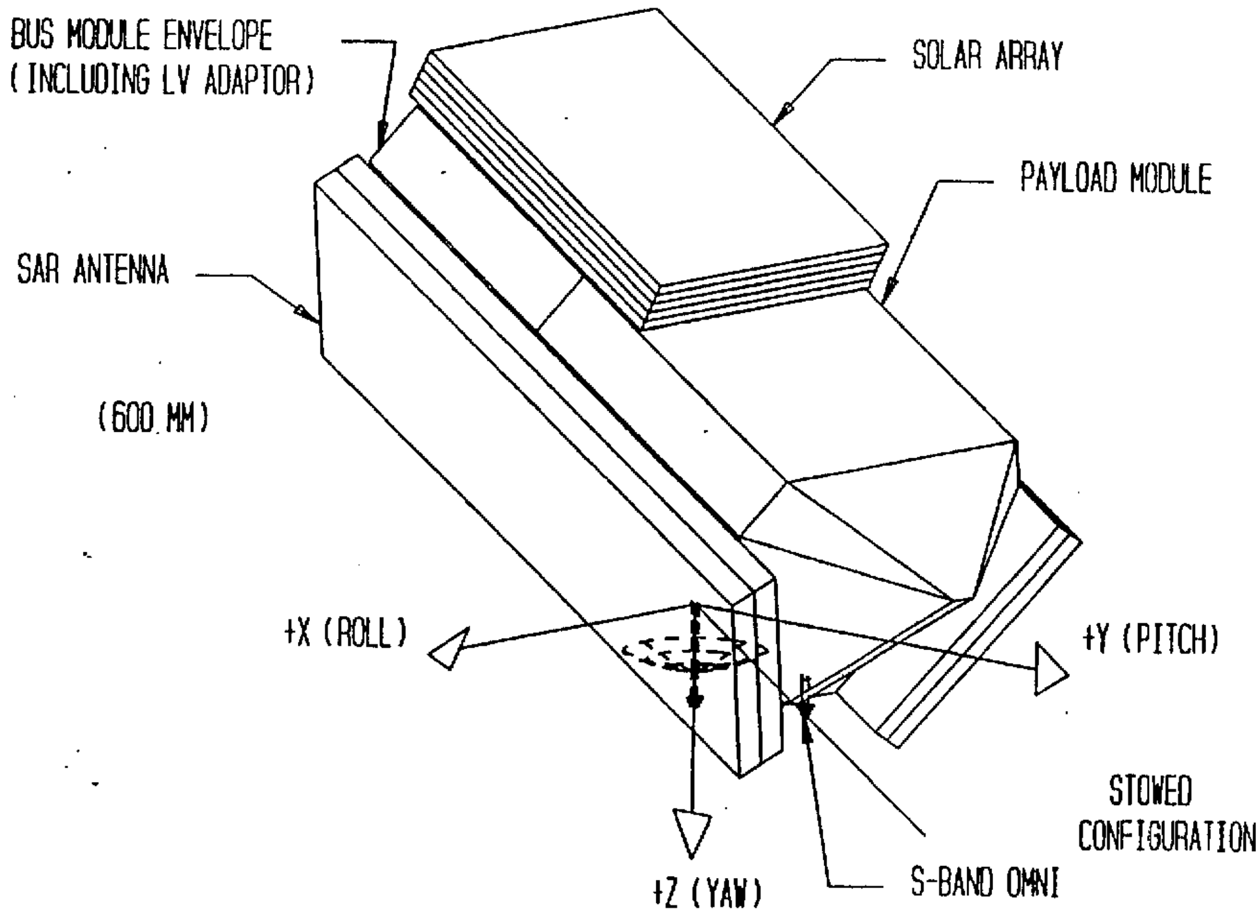
DEPLOYED
CONFIGURATION





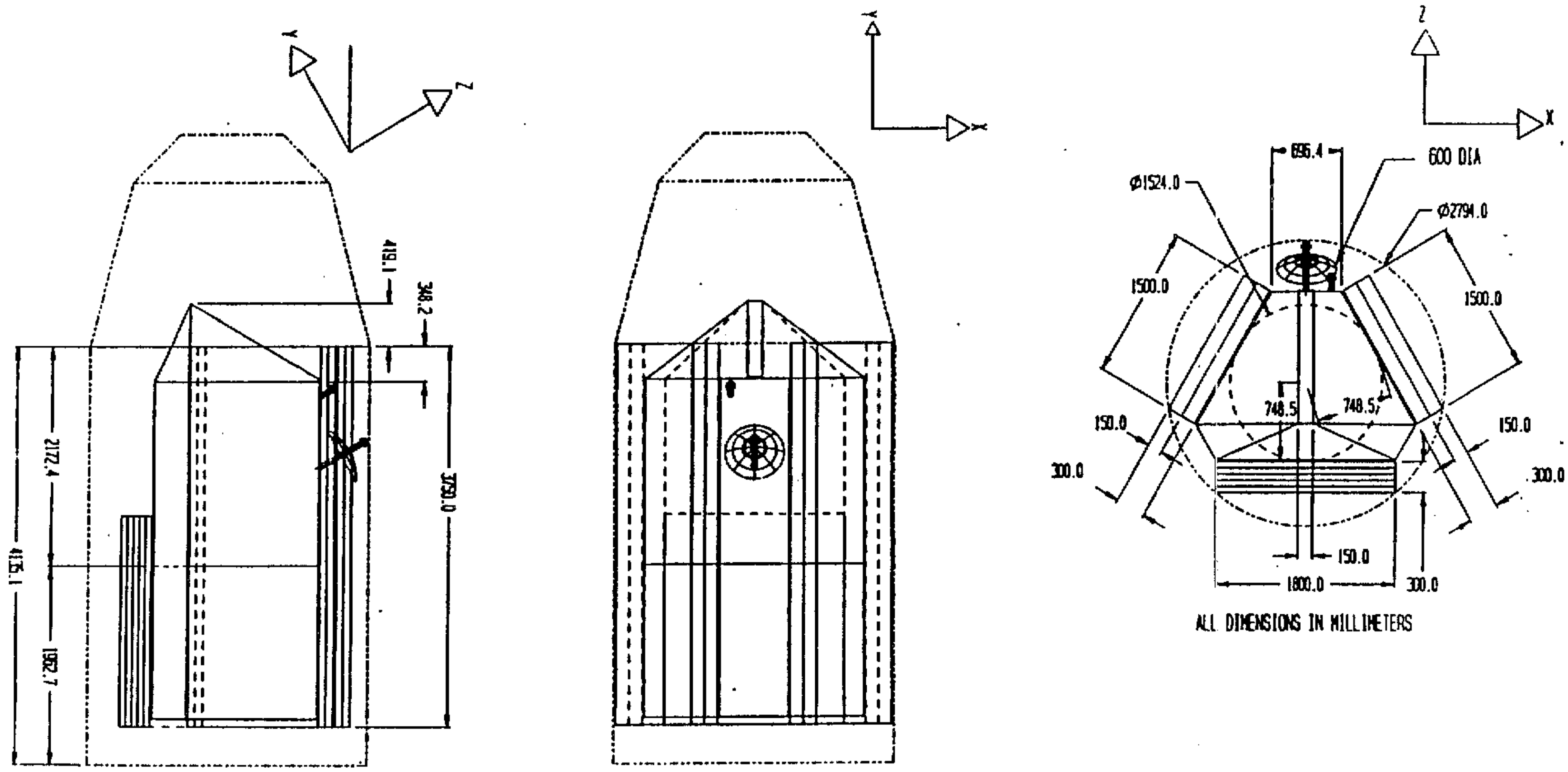
DEPLOYED
CONFIGURATION

TRIANGULAR CONFIGURATION



SPAR

TRIANGULAR CONFIGURATION

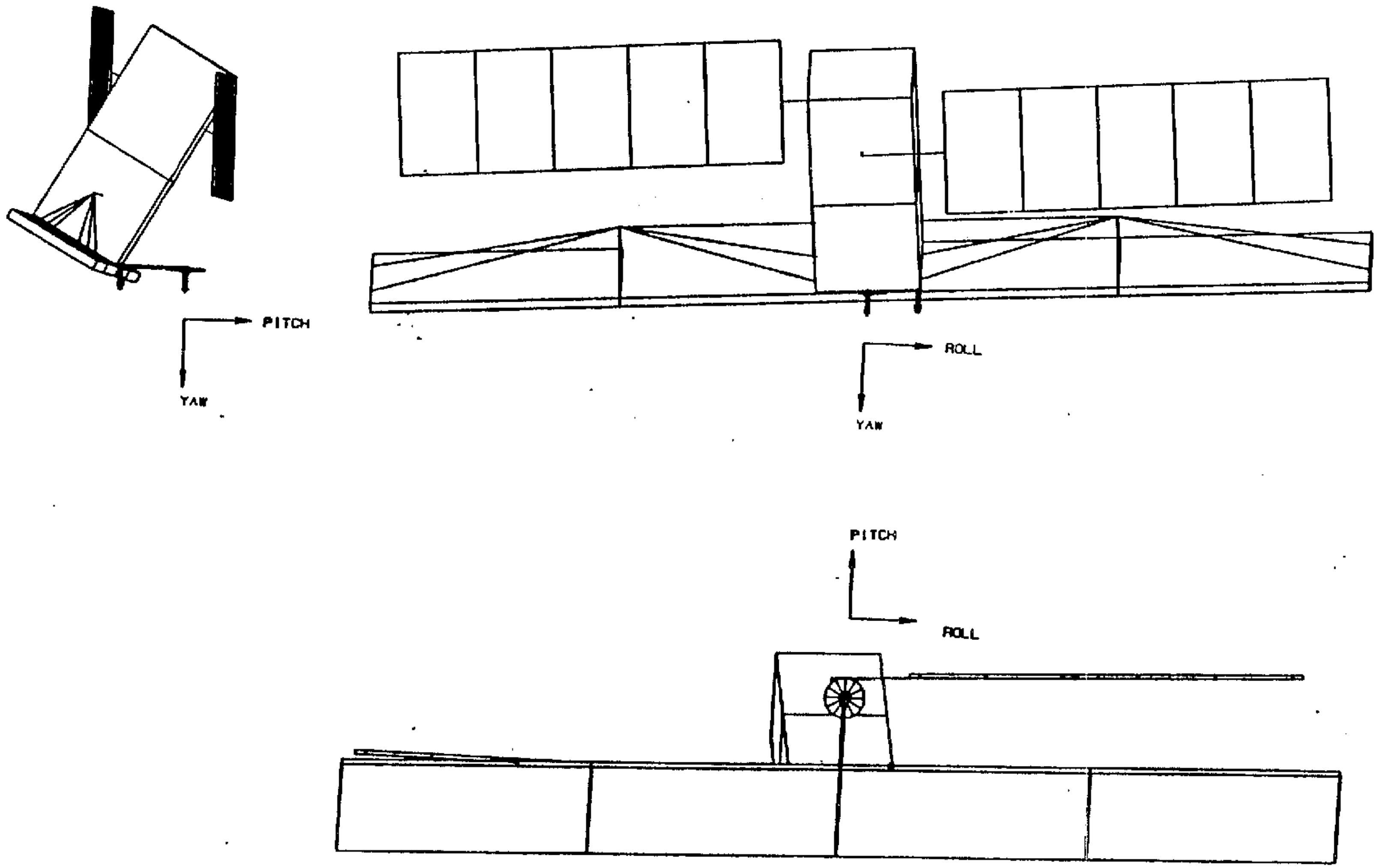


SPAR

SPACECRAFT CONFIGURATION (CONT'D)

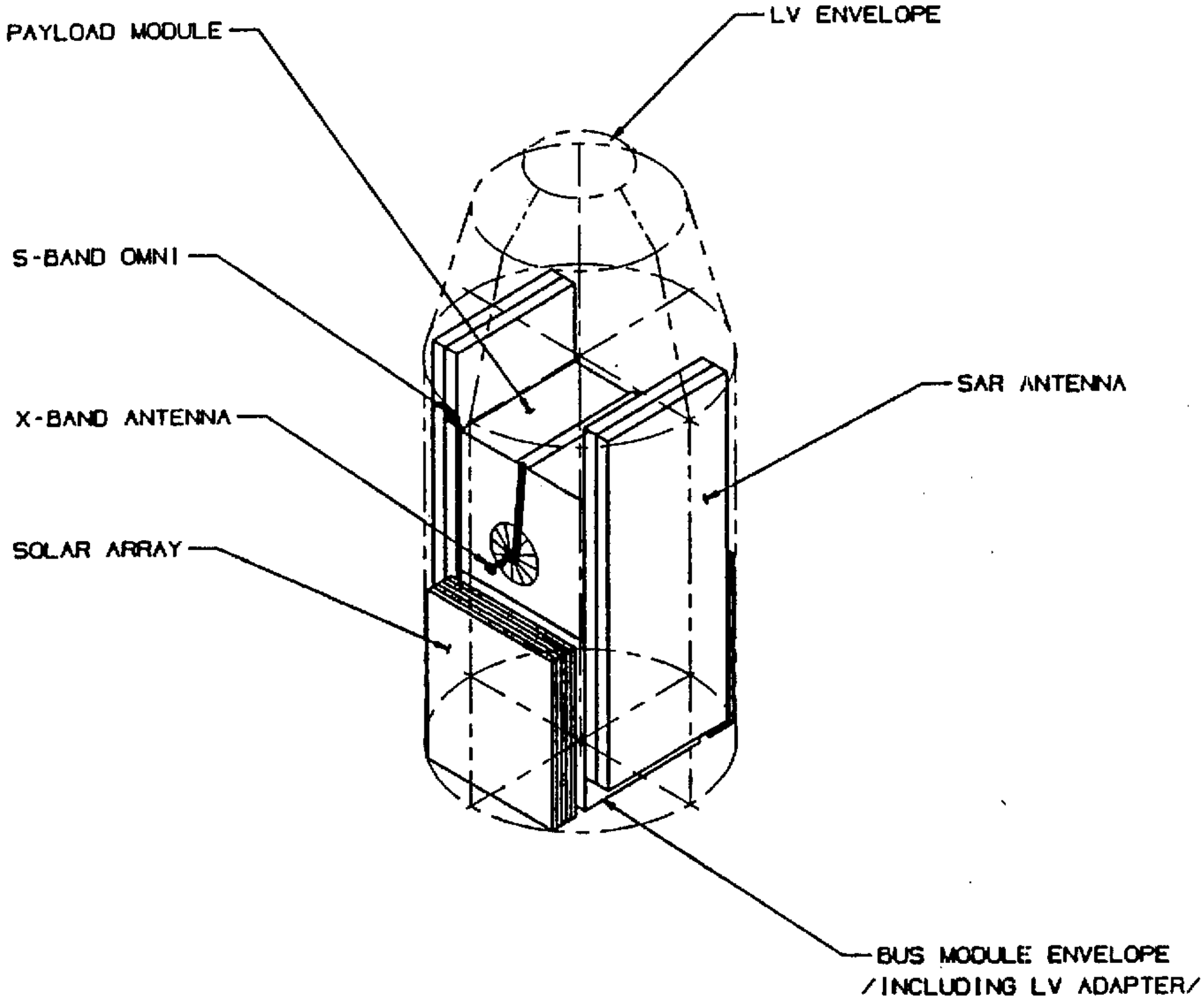
- RECTANGULAR CONFIGURATION
  - SAR ANTENNA STOWES ALONG LV AXIS ON ± X FACES
  - SAR ANTENNA DEPLOYMENT PLANAR
  - HIGH POWER EQUIPMENT ON -Y (COLD) FACE WICH IS CANTED 30 TOWARDS THE EARTH.
  - 60^{o} ROLL OPTION ONLY FOR ANTARCTIC COVERAGE (YAW OPTION IS NOT THERMALLY VIABLE)
  - C&DH ANTENNA MUST BE GIMBALLED TO MAINTAIN NADIR POINTING

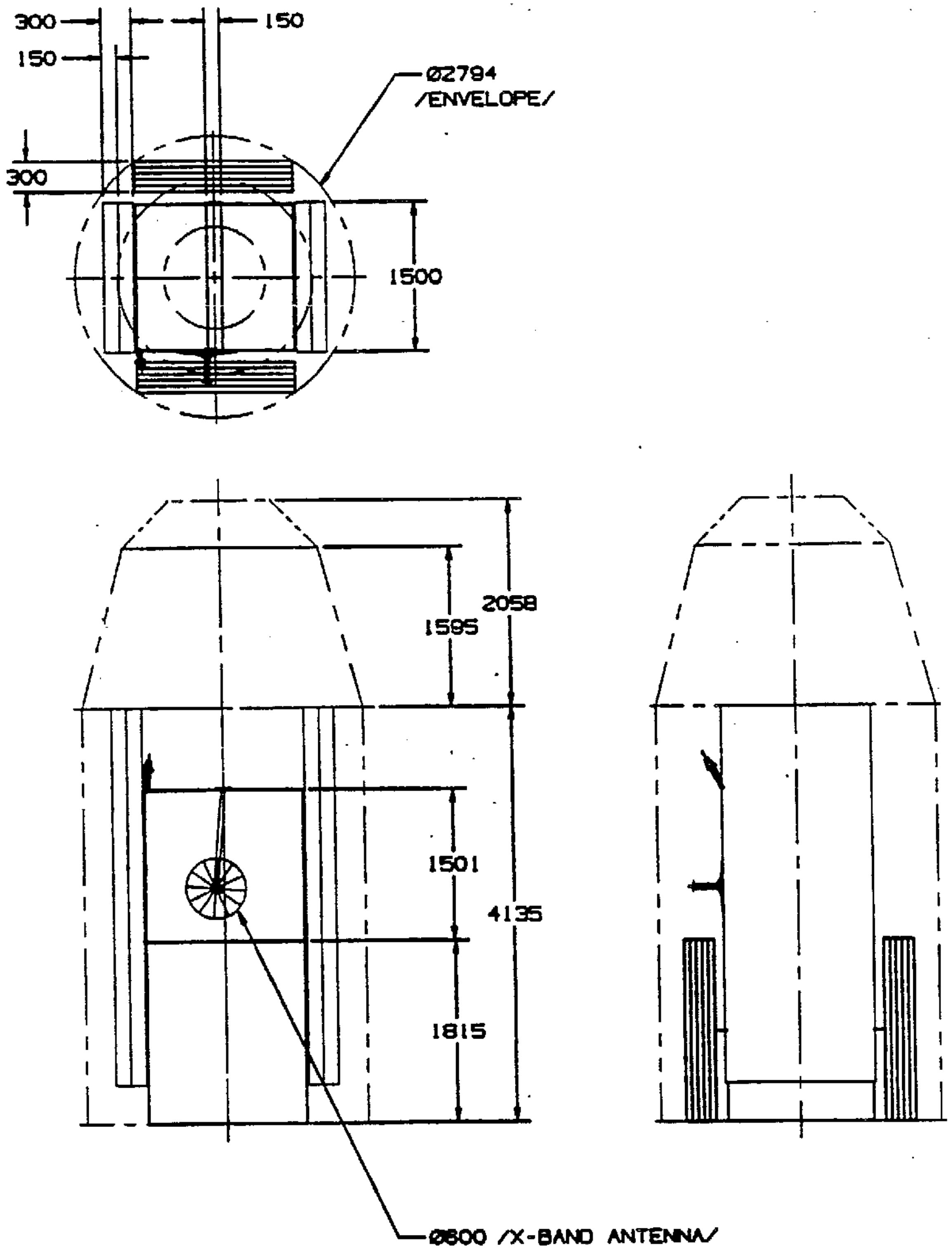
RECTANGULAR CONFIGURATION



SPAR

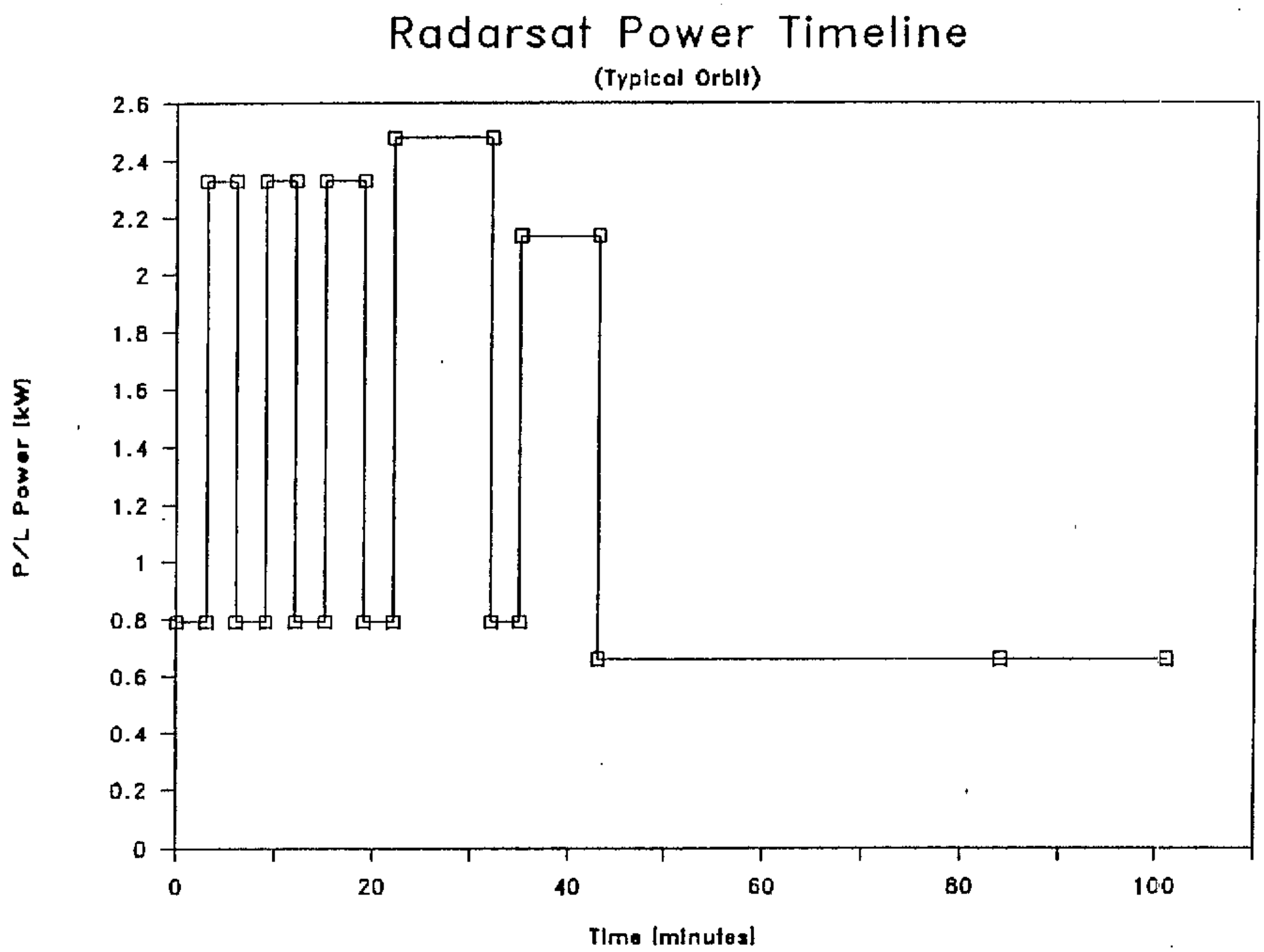
RECTANGULAR CONFIGURATION





ALL DIMENSIONS ARE IN MILLIMETERS

RECTANGULAR CONFIGURATION


Radarsat Power Timeline
(Typical Orbit)
P/L Power (kW)
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
Time (minutes)

PAYLOAD POWER BUDGET

	ECLIPSE	SUNLIGHT
MAX	660 W	2500 W
AVERAGE	660 W	1200 W
DURATION	17 MIN	101 MIN
SEASON	<80 DAYS	

DEVELOPMENT PLAN

SPAR PROPOSED MODEL PHILOSOPHY

- STRUCTURE MODEL (SM)
- ELECTRICAL MODEL PAYLOAD (EM)
- PROTO-FLIGHT SPACECRAFT (P F S/C)
- QUALIFICATION MODELS AT UNIT LEVEL
- SUBSYSTEM QUALIFICATION AT P F S/C LEVEL

STRUCTURE MODEL

- o IT IS ANTICIPATED THAT THE MASS OF THE PAYLOAD WILL NECESSITATE STRENGTHENING OF THE BUS PRIMARY STRUCTURE.

- o PROPOSED CONFIGURATION REQUIRES THE CURRENT FOUR SAR ANTENNA PANELS TO BE TIED DOWN EACH SIDE OF THE SPACECRAFT TO BOTH THE PAYLOAD AND BUS MODULE STRUCTURES.

- o PROPOSED TO RETAIN SPACECRAFT SM.

SPAR

THERMAL TESTING

- o DAWN/DUSK ORBIT IS A RELATIVELY STABLE THERMAL ENVIRONMENT.
- o ECLIPSE PERIOD JUNE/JULY OVER ANTARCTICA, MAXIMUM DURATION 17 MINUTES.
- o NO IMAGING PLANNED OVER THIS AREA DURING THIS PERIOD.
- o ASSUMPTION MADE THAT U.S. BUS WILL HAVE BEEN THERMALLY VERIFIED AND THEREFORE THE THERMAL INTERFACE TO THE PAYLOAD WILL BE WELL DEFINED.
- o ON THE PAYLOAD THE HPMC SUBSYSTEM HAS BEEN IDENTIFIED AS REQUIRING A THERMAL MODEL SUBSYSTEM TEST. THE TEST WILL BE PERFORMED BY THE HPMC CONTRACTOR
- o THE RESULTS OF THE HPMC AND PAYLOAD UNIT THERMAL TESTS WILL BE INPUTTED TO THE PAYLOAD MATH MODEL.
- o THERE IS SUFFICIENT CONFIDENCE IN THE THERMAL MATH MODELLING TO DELETE THE REQUIREMENTS FOR A THERMAL MODEL SPACECRAFT OR PAYLOAD.

SPAR

EM BUILD AND TEST PROGRAM

- o UNITS WILL BE NON-REDUNDANT AND MANUFACTURED TO ENGINEERING MODEL STANDARDS.
- o PRIOR TO ASSEMBLY INTO EM, EACH UNIT WILL BE ELECTICALLY TESTED (PERFORMANCE, FUNCTION AND INTERFACE) AT AMBIENT TEMPERATURE AND PRESSURE.
- o EMC TESTS WILL ALSO BE PERFORMED AT UNIT LEVEL.

ELECTRICAL MODEL

C&DH ELECTRONICS

- TELEMETRY & COMMAND INTERFACE UNIT (TCIU)
- FORMATTER
- QPSK MODULATOR
- INTERCONNECTING HARNESS

SAR ELECTRONICS

- LOW POWER TRANSMITTING SYSTEM
- CALIBRATION SUBSYSTEM
- COMPUTER SUBSYSTEM
- RECEIVER SUBSYSTEM
- HIGH POWER MICROWAVE CIRCUIT (HPA REPLACED BY A REPRESENTATIVE FILTER)
- TCIU
- INTERCONNECTING HARNESS

SPAR

ELECTRICAL MODEL (CONT'D)

SAR ANTENNA

- o TWO RADIATING PANELS
- o ELEVATION BEAM FORMING NETWORK (EBFN)
- o 32 VARIABLE PHASE SHIFTERS
- o INTERFACE ELECTRONICS

<u>THE EM TEST PROGRAM WILL ACHIEVE THE FOLLOWING OBJECTIVES:</u>

- DEMONSTRATION OF FUNCTIONALITY/PERFORMANCE OF NEW DESIGNS.
- TEST OF INTERFACE CAPABILITY
- TEST OF COMPATIBILITY WITH THE CHECKOUT EQUIPMENT
- COMPLIANCE WITH THE EMC REQUIREMENTS

QUALIFICATION

UNITS

- ANY UNIT THAT HAS NOT BEEN PREVIOUSLY QUALIFIED, OR CANNOT BE QUALIFIED BY SIMILARITY, WILL BE SUBJECTED TO A QUALIFICATION TEST PROGRAM. (IN ACCORDANCE WITH ENVIRONMENTAL DESIGN AND TEST SPECIFICATION).

- AFTER COMPLETION OF QUAL PROGRAM UNIT MAY BE REFURBISHED FOR FLIGHT SPARE USE.

SUBSYSTEMS

- AT SUBSYSTEM LEVEL QUALIFICATION WILL BE ACHIEVED BY PROTO-FLIGHT LEVEL TESTING AT SPACECRAFT LEVEL.

SPAR

PROTOFLIGHT SPACECRAFT

- BUS PROCURED FROM U.S. CONTRACTOR AND DELIVERED TO SPAR FULLY INTEGRATED AND TESTED.

- INTEGRATION AND TEST PERSONNEL FROM SPAR WILL SUPPORT BUS ACTIVITIES, ELECTRICAL, MECHANICAL CHECKOUT EQUIPMENT AND SOFTWARE AT BUS CONTRACTORS PLANT.

- PAYLOAD WILL BE INTEGRATED AND TESTED AT SPAR (STE-ANNE-DE-BELLEVUE) INCLUDING INTEGRATION OF THE SAR ANTENNA EBFN.

- THE PAYLOAD AND SAR ANTENNA RADIATING PANELS, IN A SEPARATE CONTAINER, WILL BE SHIPPED TO SPAR (DFL).

SPAR

INTEGRATION AND TEST OF P/F SPACECRAFT

- o THE I & T PROGRAM IS DEVISED TO VERIFY THAT THE RADARSAT SPACECRAFT:
  - MEETS OR EXCEEDS THE SPECIFIED DESIGN AND PERFORMANCE REQUIREMENTS AT THE TIME OF DELIVERY.
  - IS FREE OF LATENT MATERIAL AND WORKMANSHIP DEFECTS.
  - WILL SURVIVE THE LAUNCH ENVIRONMENT
- o WILL MEET OR EXCEED THE SPECIFIED PERFORMANCE REQUIREMENTS THROUGHOUT THE MISSION LIFE.
- o HAS SUFFICIENT TEST DATA TO ENSURE EFFECTIVE SPACECRAFT OPERATION IN ORBIT.
- o THE TEST FLOW INDICATES A PERIOD OF 52 WEEKS FOR SPACECRAFT I & T ACTIVITIES.

LAUNCH CAMPAIGN

THREE MAJOR PHASES OF ACTIVITY:

- SPACECRAFT TRANSPORTATION AND FINAL PREPARATIONS
- HAZARDOUS OPERATIONS
- LAUNCH PAD OPERATIONS