



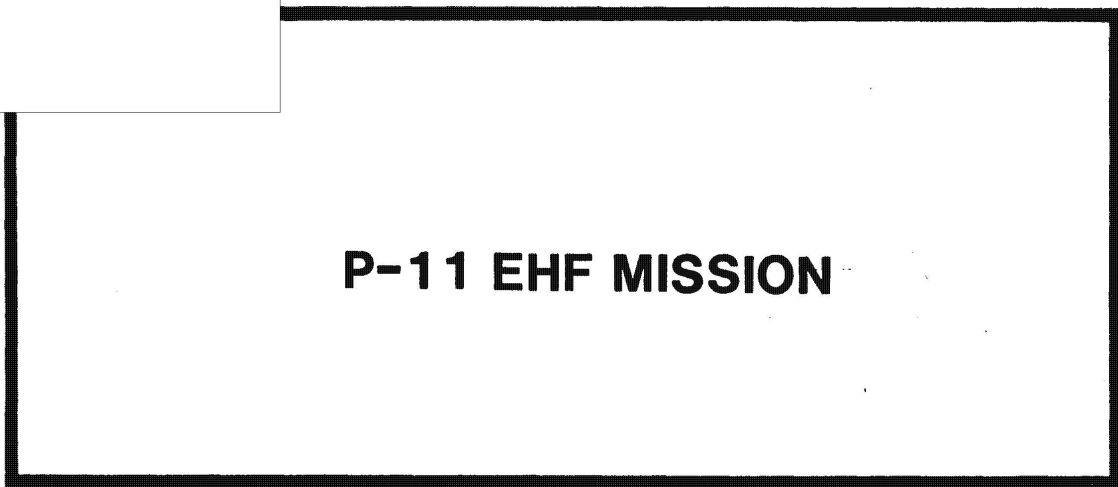
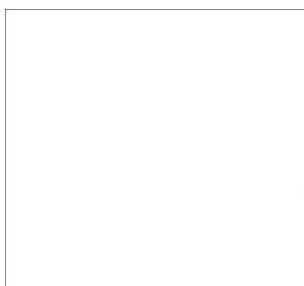
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24 September 1986

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APR 9 1987



P-11 EHF MISSION

CLASSIFIED BY: BYE-1
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EHF COLLECTION CHALLENGES

- **NARROWER BEAMWIDTH**

- **LESS SIDELobe ENERGY**

- **LESS SENSITIVE COLLECTION EQUIPMENT**

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PROBLEM WITH TRADITIONAL SIDELobe COLLECTION

CANNOT GENERALLY COLLECT

>10 PULSES WITH NO CANDY STRIPING

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OBJECTIVE

DEMONSTRATE THAT A SPINNING PENCIL BEAM COLLECTOR CAN MEET ALL KEY EHF COLLECTION REQUIREMENTS AT 35 GHz:

>10 PULSES COLLECTED

>10⁶ nmi²/20 MINUTES

>20 nmi LOCATION UNCERTAINTY

} SEMI-TI

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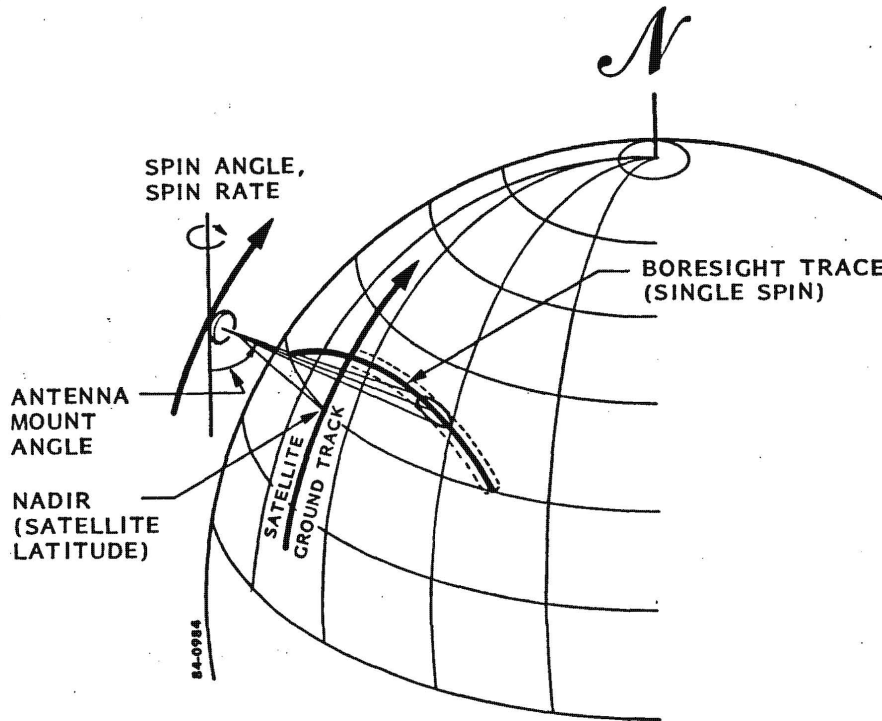
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SPINNING PENCIL BEAM GEOMETRY



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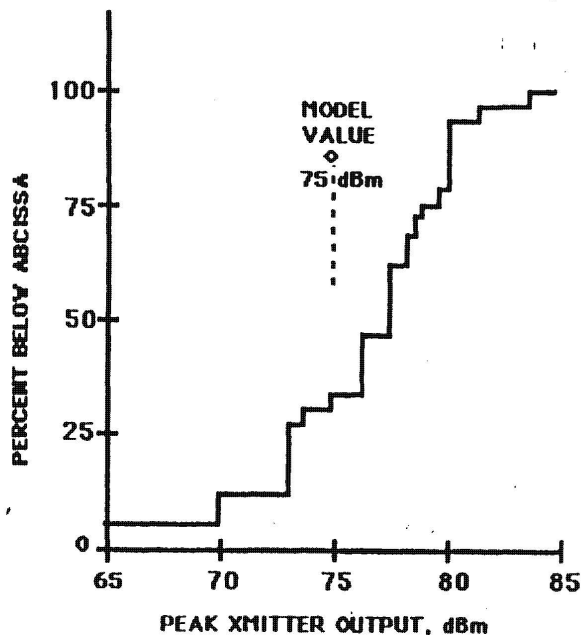
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HISTOGRAMS OF KA BAND EMITTER POWERS

KA BAND - RED AND BLUE EMITTERS
REF: MMW EMITTERS 1985 - 1995

STATISTICS

MEDIAN RED = 74 dBm
MEDIAN RED + BLUE = 76.5 dBm
SELECTED MODEL VALUE = 75 dBm



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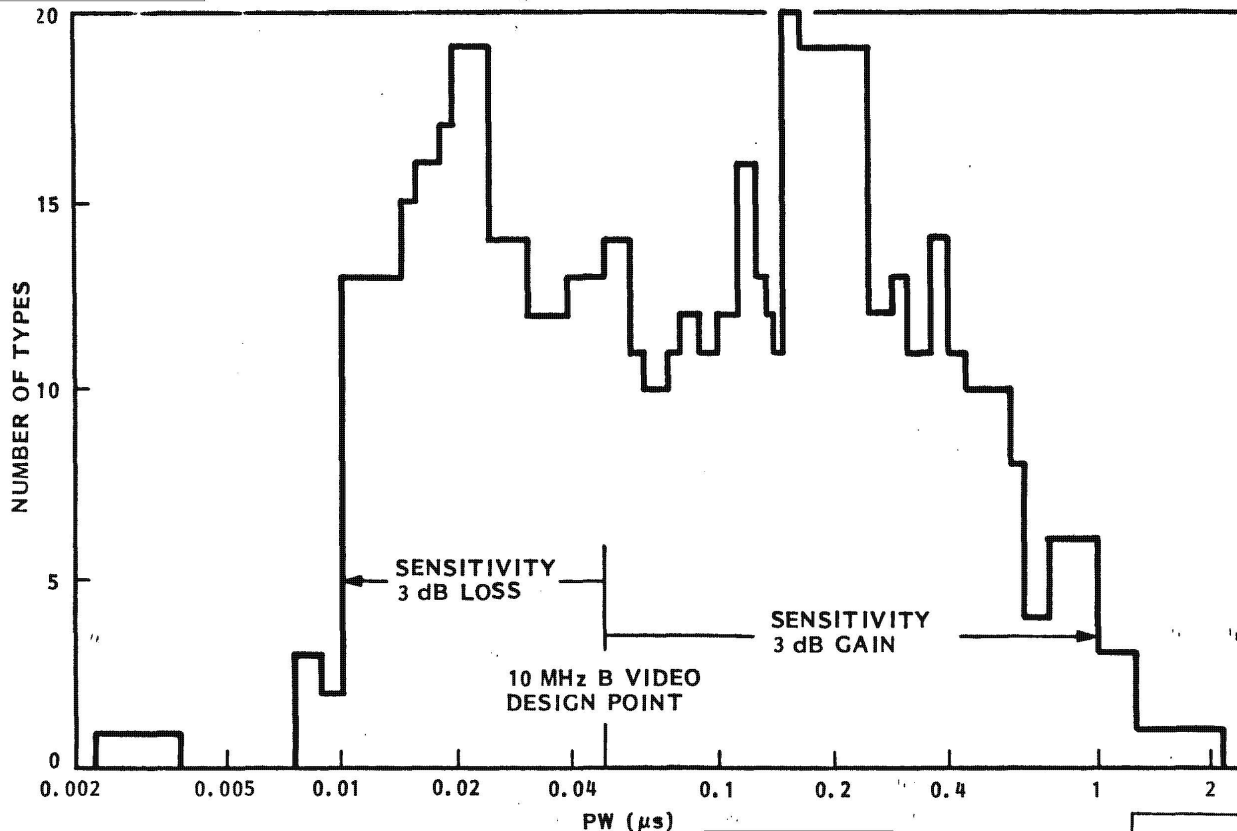
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PULSEWIDTH DISTRIBUTION OF EHF SIGNALS



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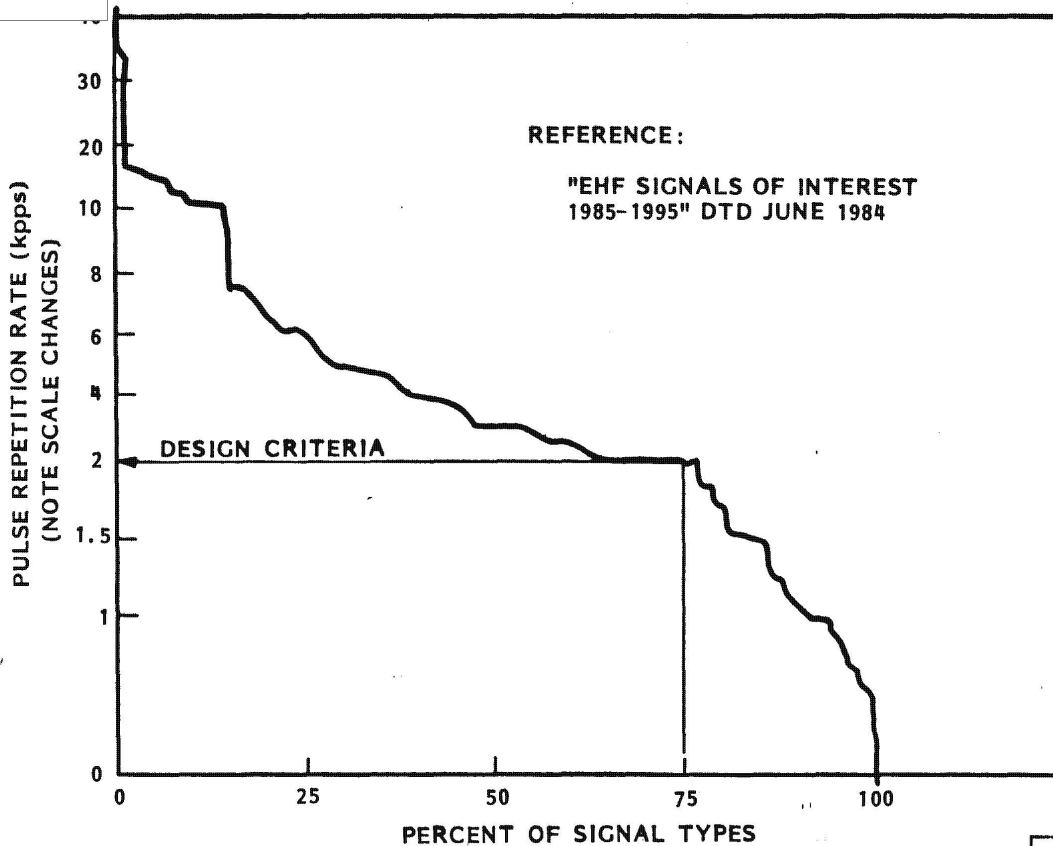
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EHF PULSE REPETITION RATE DISTRIBUTION



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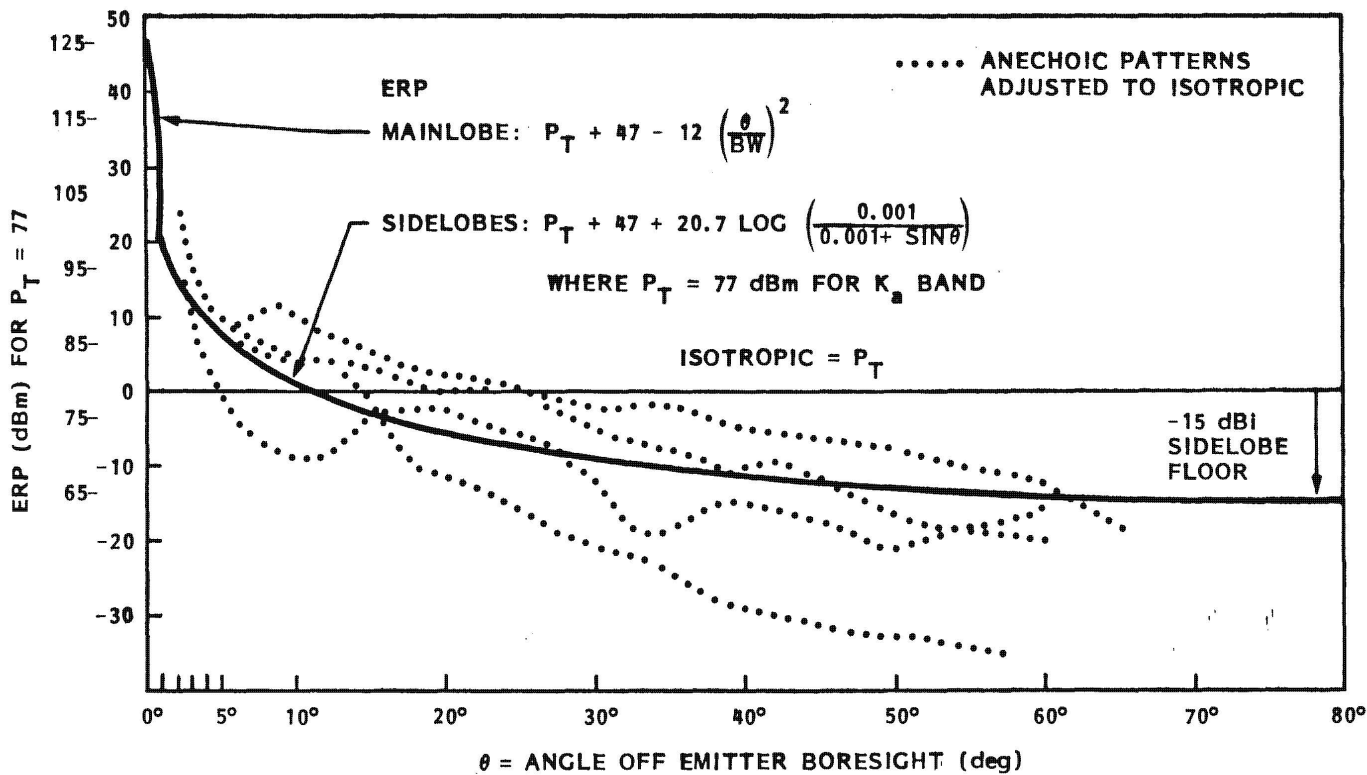
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EHF EMITTER MODEL



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EMITTER TYPE DISTRIBUTION

REF: "EHF SIGNALS OF INTEREST, 1985-1995" DATED JUNE 1984

	TILT-UP BEAMS (%)	HORIZONTAL BEAMS (%)	TILT-DOWN BEAMS (%)	TOTAL (%)
HORIZON SCANNERS	9	24	8	41
SECTOR SCANNERS	15	11	7	33
FIXED AZIMUTH	4	4	18	26 ⁽¹⁾
	28	39	33 ⁽²⁾	100

- (1) PROBABILITY OF INTERCEPT NOT A FUNCTION OF DWELL TIME
- (2) NOT COLLECTIBLE BY MAINBEAM COLLECTORS

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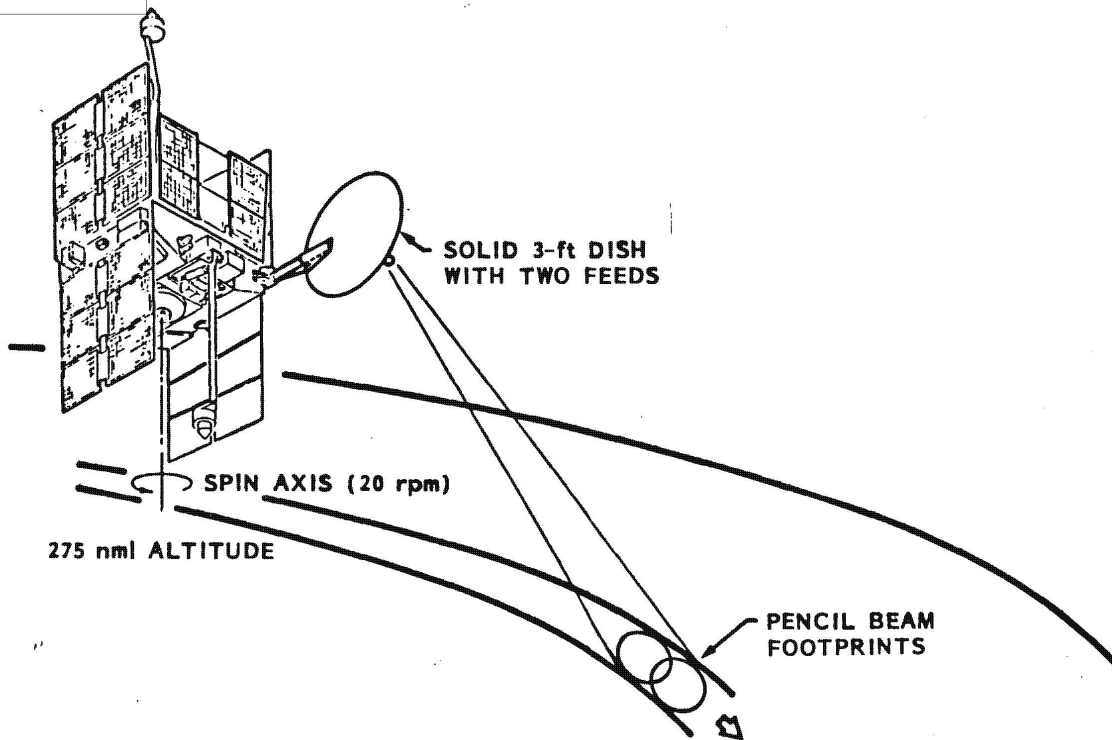
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P-11 EHF MISSION CONFIGURATION



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ASSUMPTIONS/VARIABLES

- -79.6 dBm RECEIVER SENSITIVITY
- 2 FEEDS USED IN SPIN DIRECTION TO DOUBLE DWELL TIME
- OTHER VARIABLES AFFECTING PERFORMANCE:
 - ALTITUDE
 - DISH DIAMETER
 - SPIN RATE
 - ANTENNA MOUNT ANGLE

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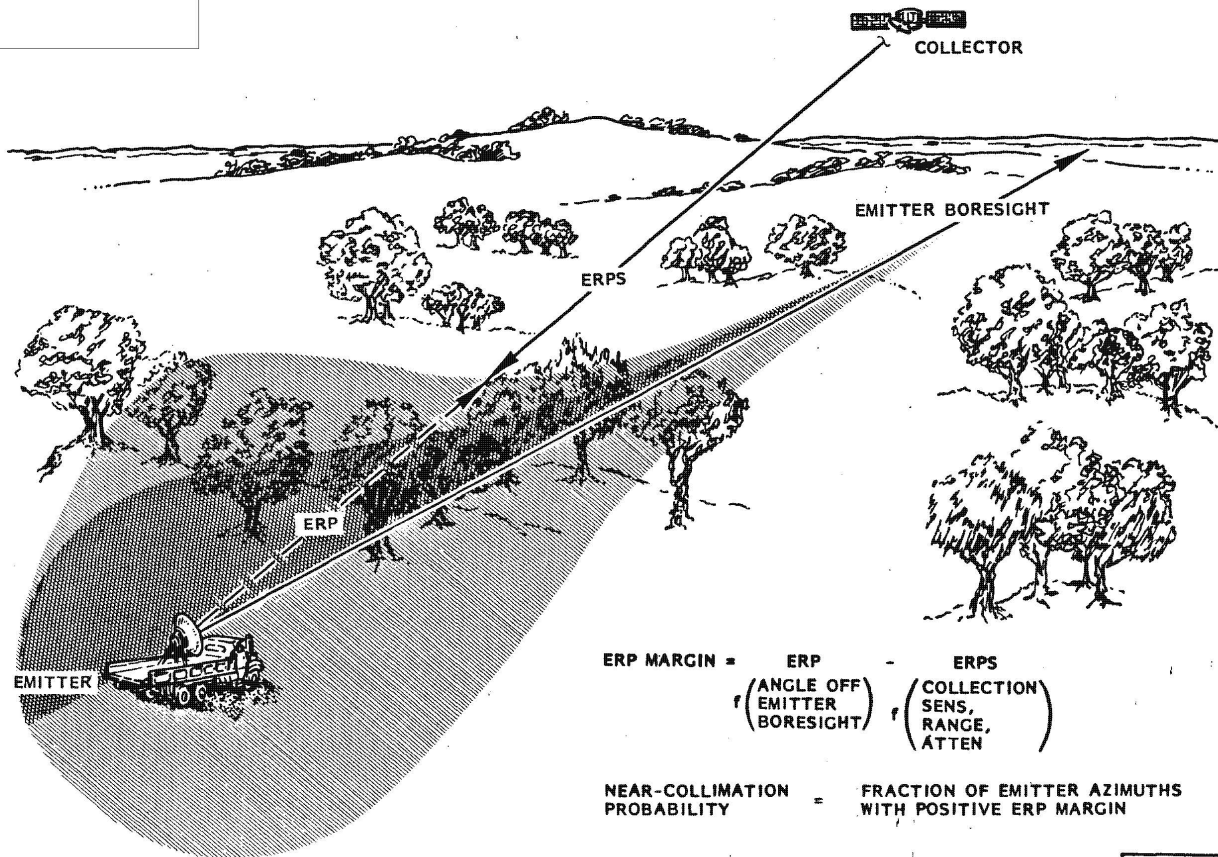
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ERP MARGIN



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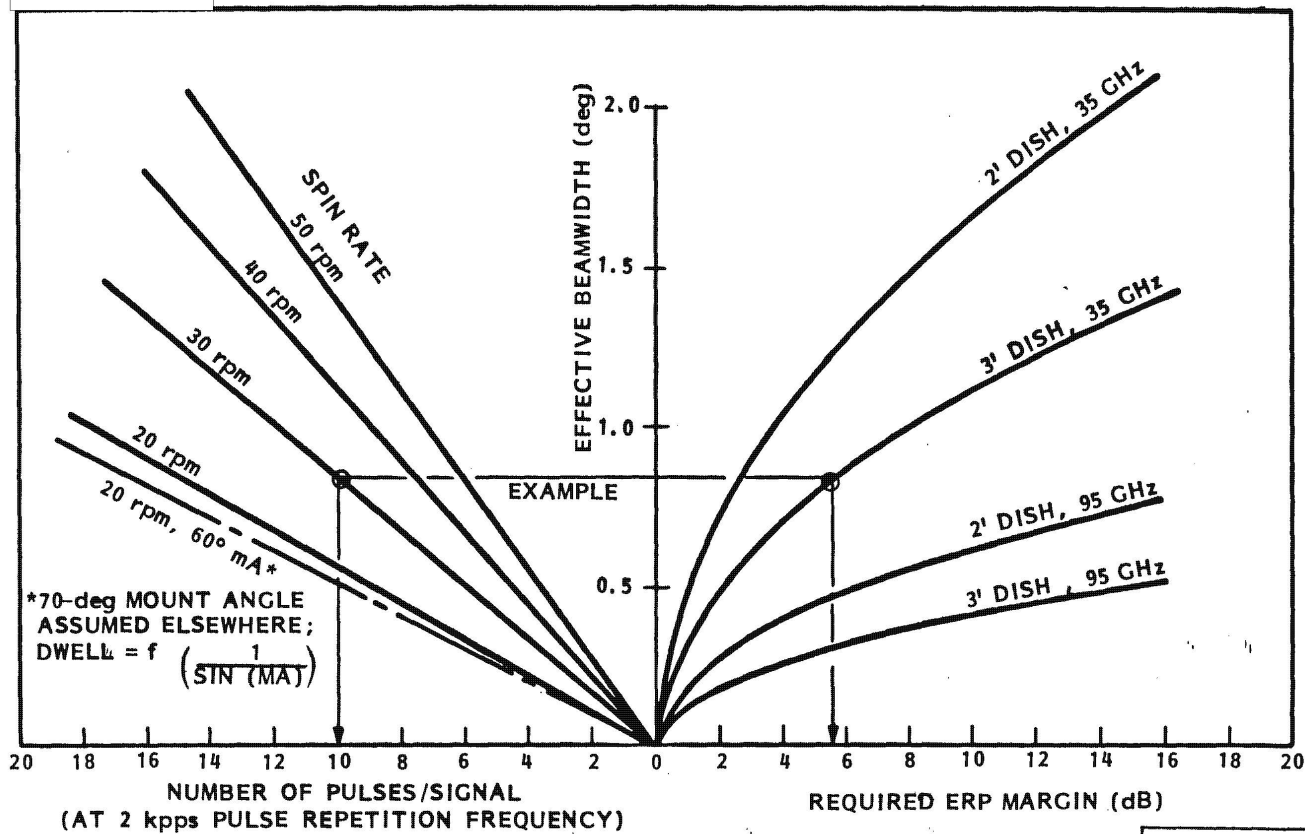
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VARIABLES AFFECTING PULSE COLLECTION



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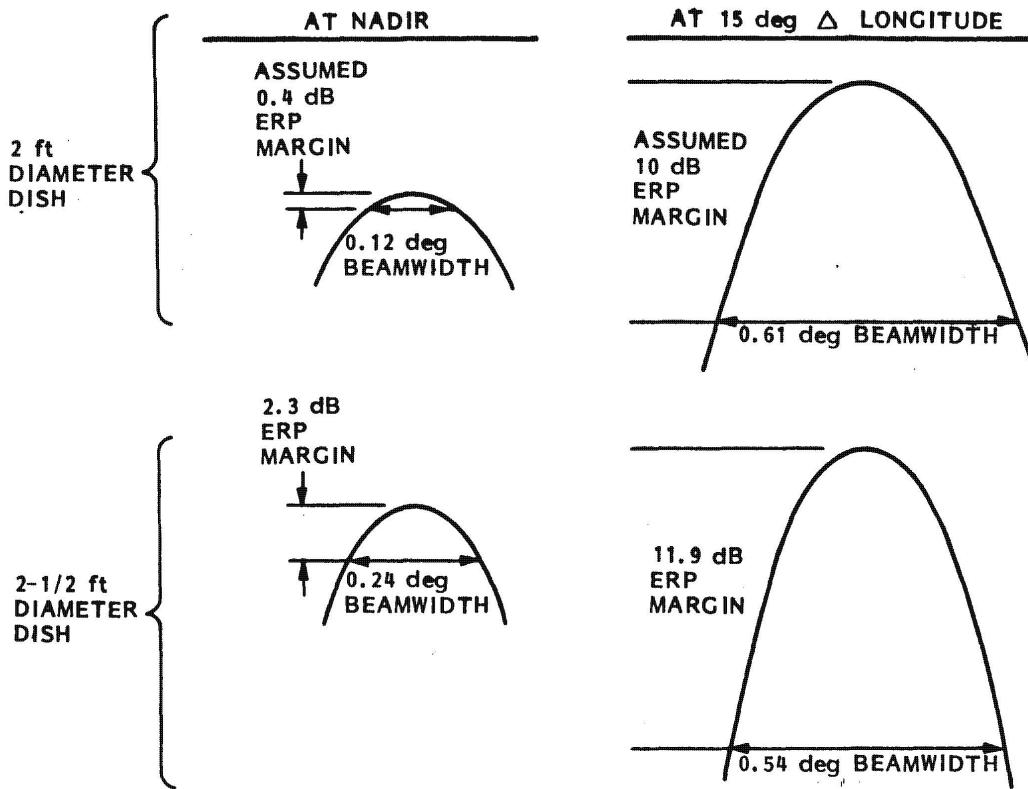
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DISH DIAMETER INFLUENCE ON EFFECTIVE BEAMWIDTH

95-GHz FREQUENCY



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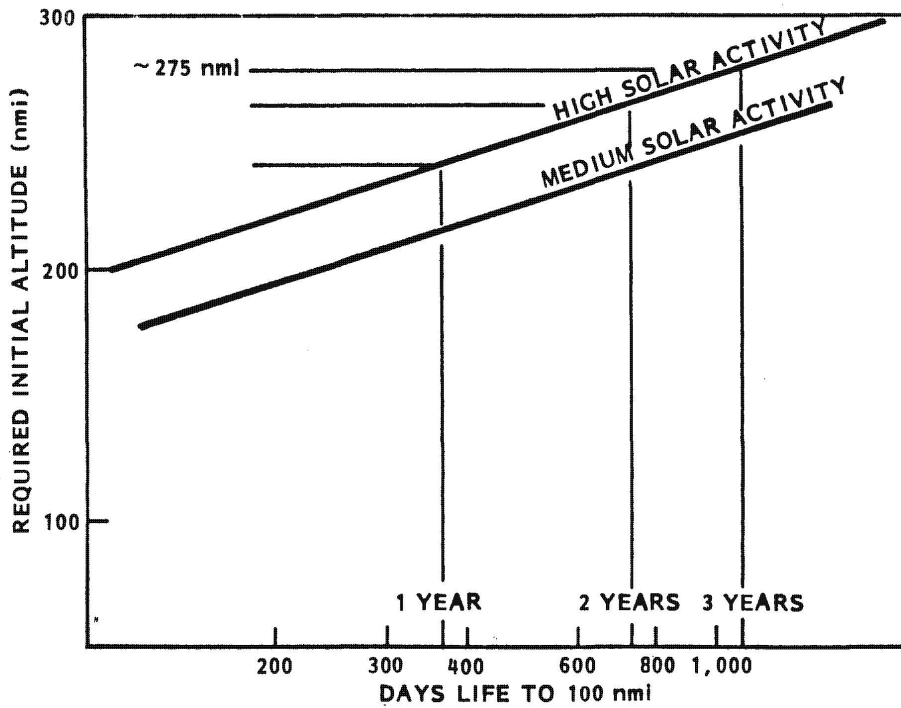
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ALTITUDE EFFECT ON LIFETIME



275 nmi CHOSEN
 3-YEAR ORBIT LIFE IN EARLY
 MID-1990s MATCHES P-11
 VEHICLE LIFE

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COMPARATIVE ANALYSES OF EHF COLLECTORS

PARAMETER	B-003 P-11 PROPOSAL	CANAAN P-11 ANALYSIS	CANAAN ^{3/} FINAL REPORT
ALTITUDE (Nm)	275	275	430 (-2.3 to -4.3) dB DIFF
INCLINATION (deg)	90	90	82
SPIN RATE (RPM)	20	20	17
ANT GAIN (dB)	47.5	47.5	50.3 (+2.8)
MOUNT ANGLE (deg)	60	60	80
NO. OF BEAMS	2	2	1
LATITUDE (Deg N)	50	50	30
EMITTER ANT PATTERN			
AT 10° OFF BS (dBi)	0	0	0
AT 90° OFF BS (dBi)	-15	-15	-15
EMITTER TUBE POWER			
35 GHz (dBm)	77	75	75
COLLECTOR SENSITIVITY			
35 GHz (dBm)	-79.6	-81 ^{2/}	-78 ^{1/} (-3.0)

1/ BASED ON L-1 MEASURED SENSITIVITY (-75) PLUS IMPROVED N.F. (OLD 10 ⇒ 5 + 2)

2/ BASED ON ABOVE PLUS IMPROVED CHANNELIZED FILTER (250 MHz ⇒ 64 MHz)

3/ THIS SYSTEM HAD 2.7 dB LESS ERP SENS AND DID NOT CLOSE TO ISOTROPIC BACKLOBE MODEL

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METHOD OF SATISFYING REQUIREMENTS

- SATISFY REQUIREMENTS WITH COLLECTION OF NEAR-IN LOBES

- SIDELOBE COLLECTION IS ADDITIONAL BENEFIT

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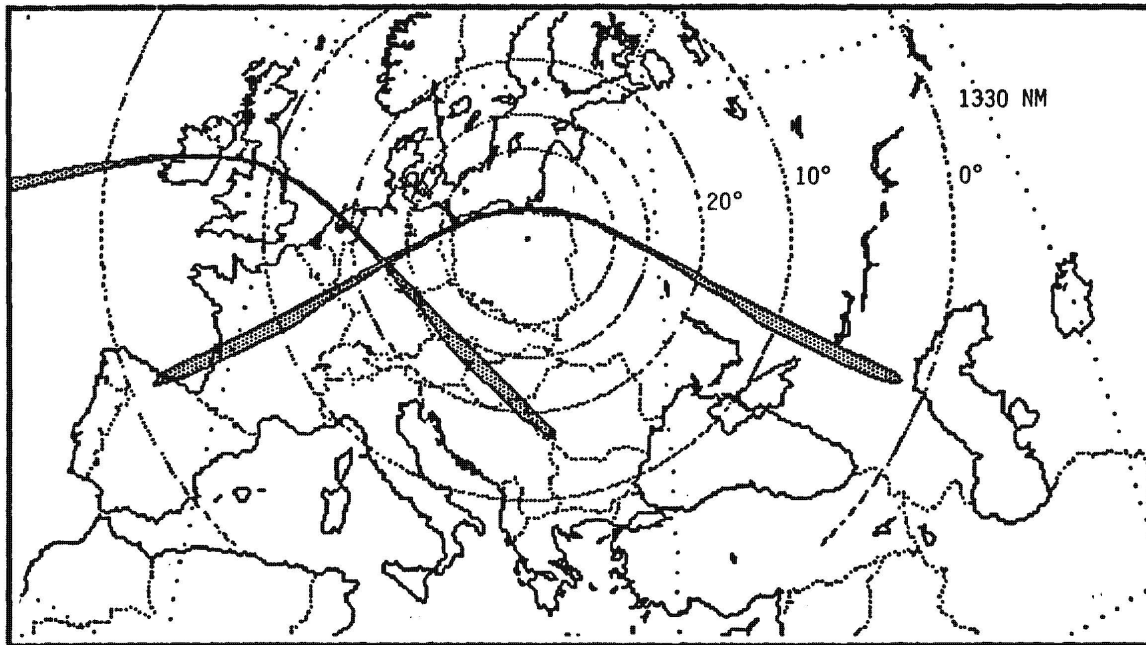
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ERP CONTOUR FOR P-11 COLLECTOR

MAINLOBE Emitter MODEL



H = 275 NM, INC = 90°, LAT = 50°, ANT = 3' DISH, F = 35 GHz
 SENS = -81 dBm, TX EL STEERING = 10°, POL LOSS = 3 dB

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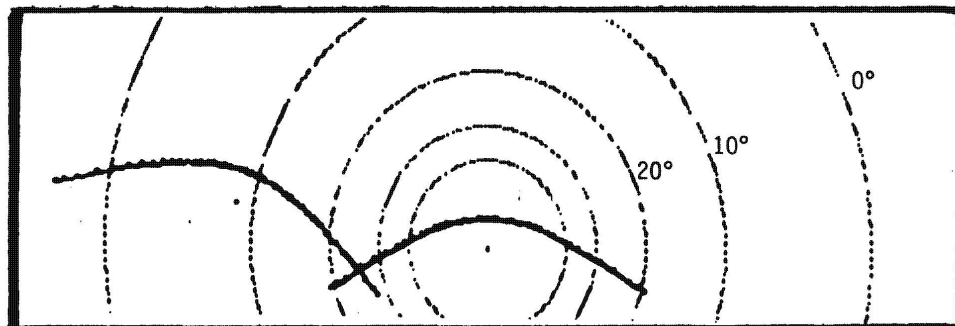
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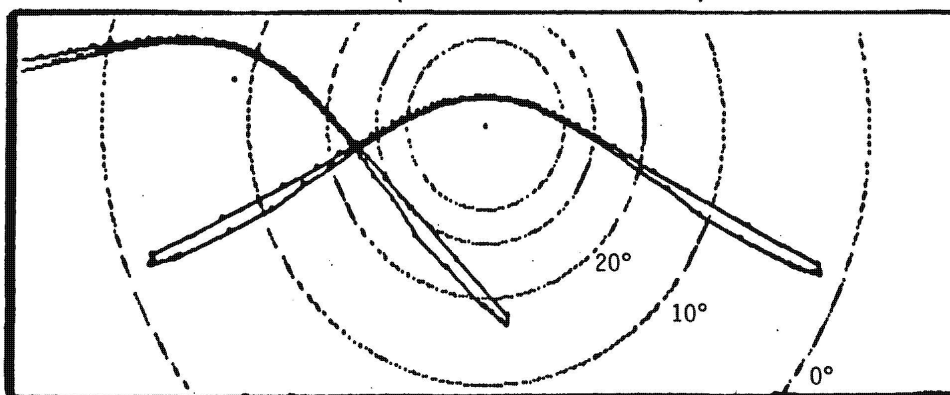
COMPARISON OF MAINLOBE AND BACKLOBE MODELS

ISOTROPIC BACKLOBE MODEL (ERP = 60 dBm)



ERP CONTOUR
AREA =
6,600 NM²

SPINNING MAINLOBE MODEL (TX ELEV STEERING = 10°)



ERP CONTOUR
AREA =
69,300 NM²

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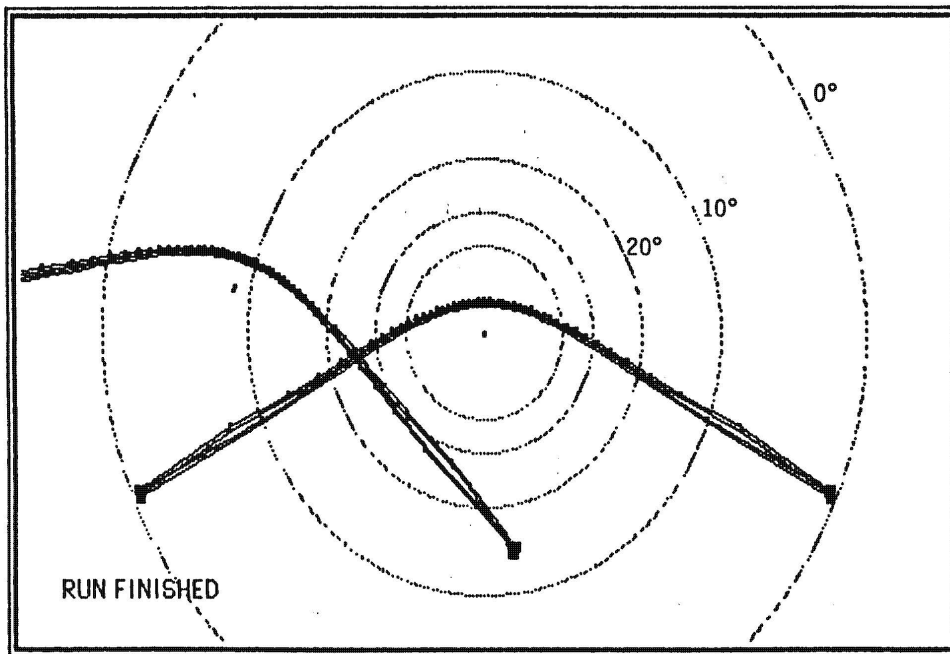
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ERP CONTOUR FOR TX ELEV STEERING - 0°

TWO SUCCESSIVE SPINS



EACH ERP CONTOUR AREA = 46,500 NM²

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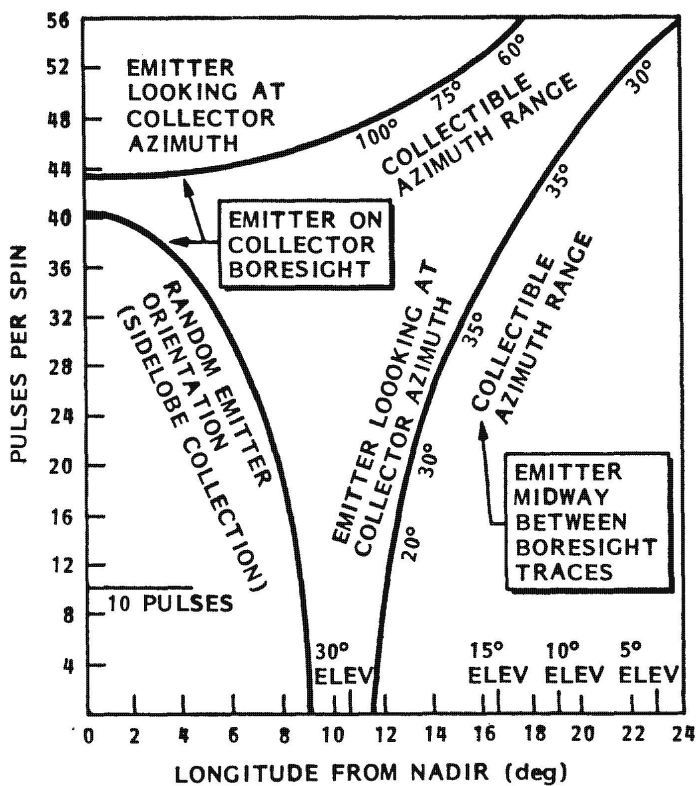
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35 GHZ PULSE COLLECTION WITH 2 FOOT DISH

50 deg N. LATITUDE



275 nmi ALTITUDE
 20 rpm
 2 FEEDS IN SPIN DIRECTION
 60° ANTENNA MOUNT ANGLE

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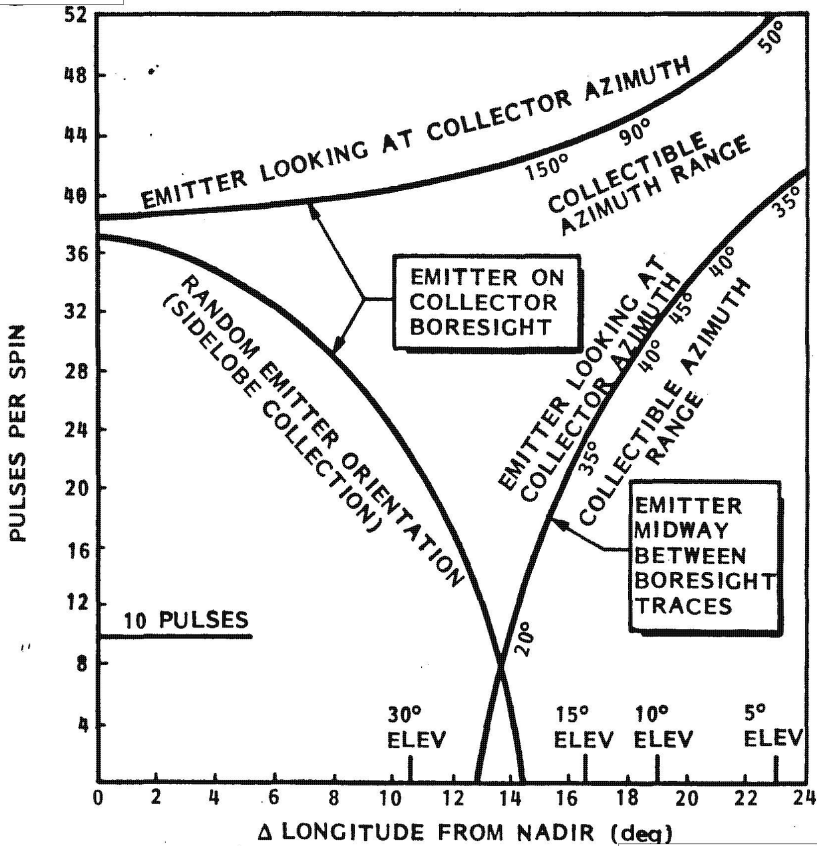
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35 GHz PULSE COLLECTION WITH 3-foot DISH

50 deg N. LATITUDE



275 nmi ALTITUDE
 20 rpm
 2 FEEDS IN SPIN DIRECTION
 60 deg ANTENNA MOUNT ANGLE

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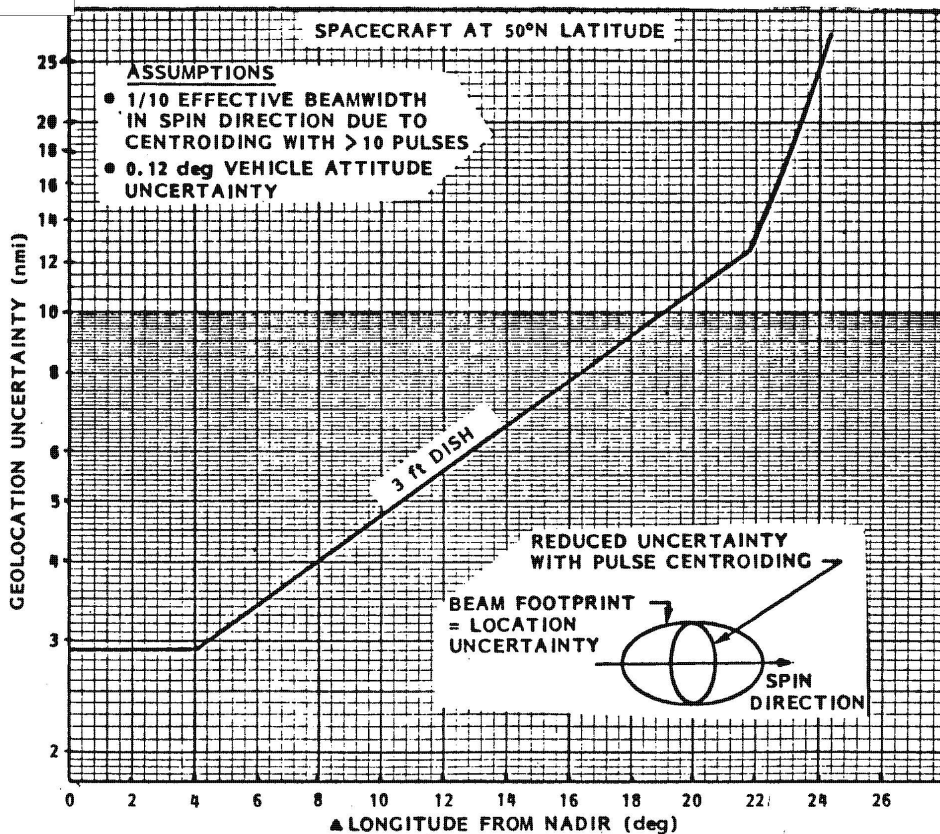
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GEOLOCATION UNCERTAINTY



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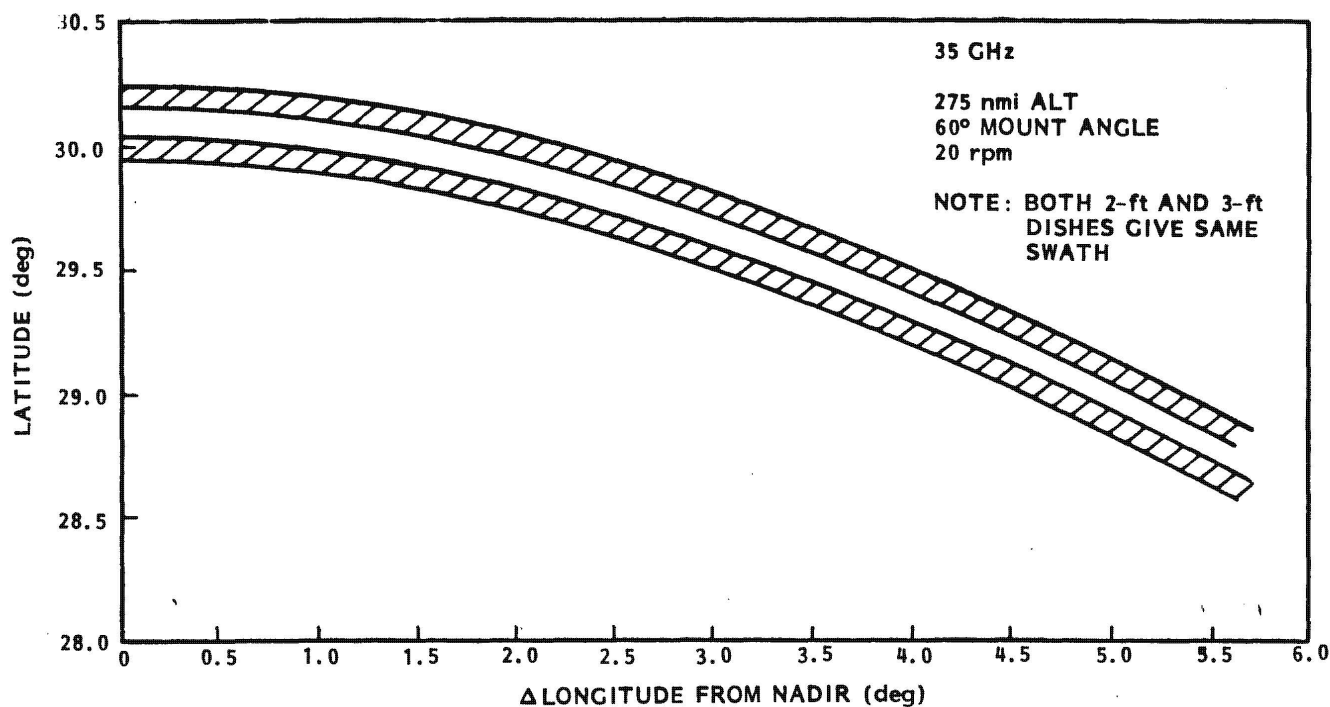
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SWATH OF SIDELobe SENSITIVITY NEAR NADIR

62-dBm SIDELOBES ASSUMED (ISOTROPIC - 15 dB)



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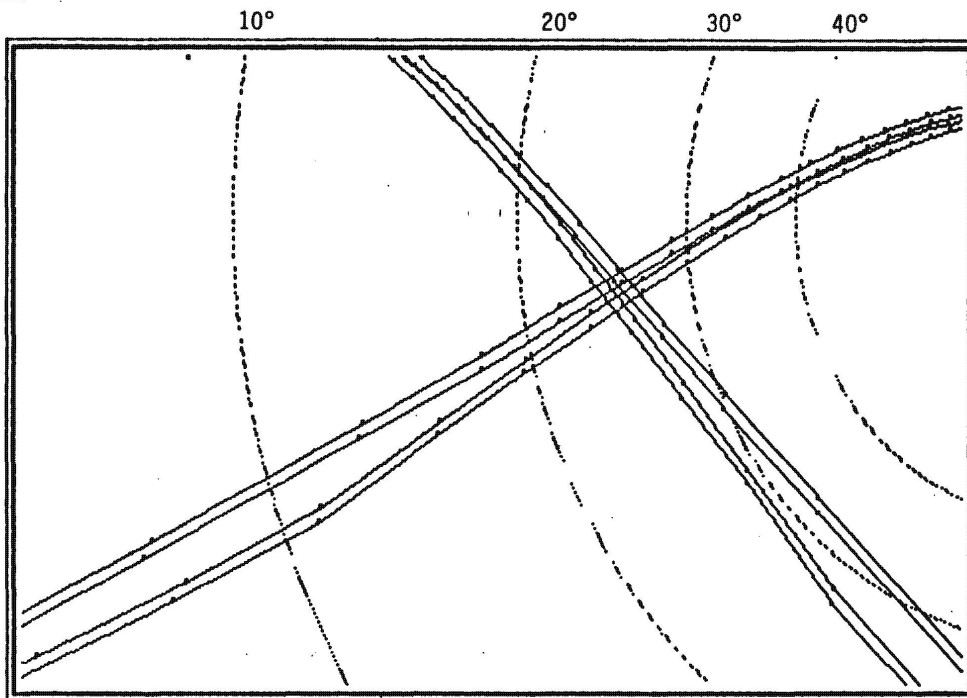
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BLOWUP OF OVERLAP/UNDERLAP REGION



- o SPATIAL CANDYSTRIPING 40° TO 80° ELEV
- o TIME CANDYSTRIPING (SCAN ON SCAN) 0° TO 20° ELEV
- o MIXED TIME AND SPACE 20° TO 40° ELEV

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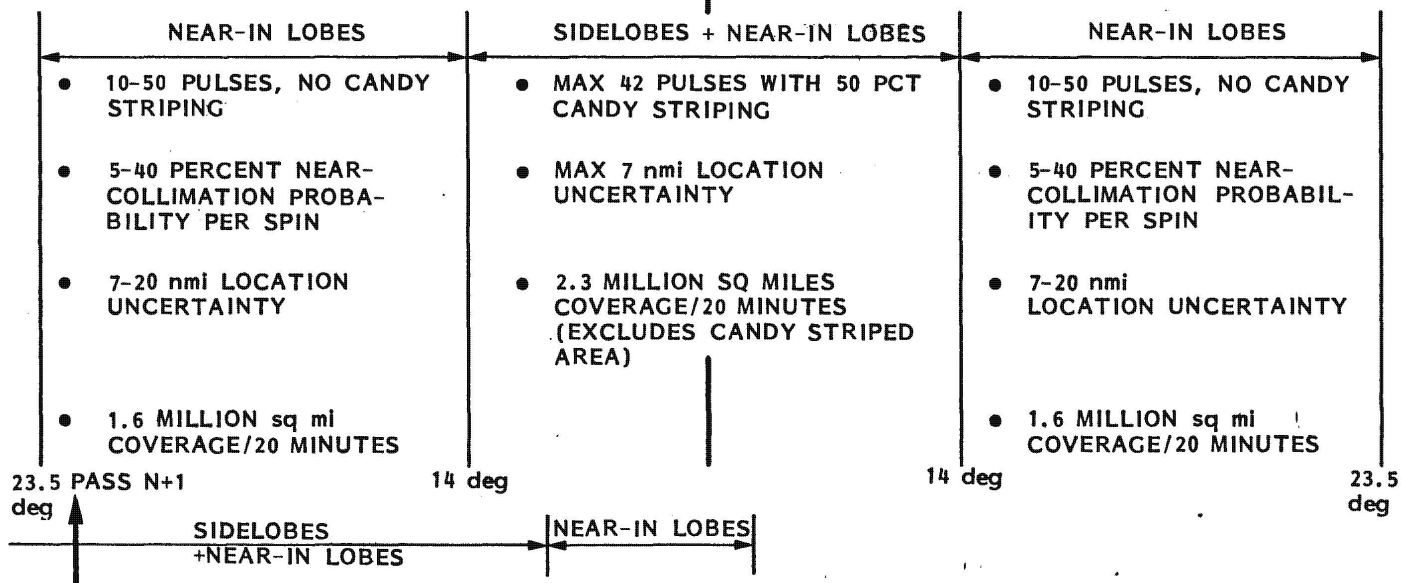
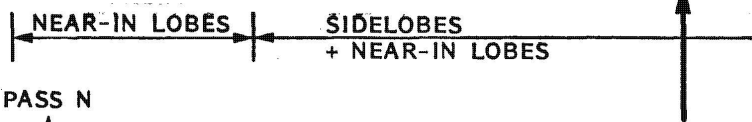
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35 GHz COLLECTION SUMMARY

3 ft DISH, 275 nmi ALTITUDE

PASS N-1



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ANALYSIS OF P-11 EHF COLLECTOR

OBJECTIVE:

- **ANALYZE POI PERFORMANCE USING CANAAN COMPUTER MODELS**
 - MAINLOBE EMITTER MODEL
 - BACKLOBE EMITTER MODEL
 - SCAN ON SCAN
- **COMPARE WITH EARLIER ANALYSIS**

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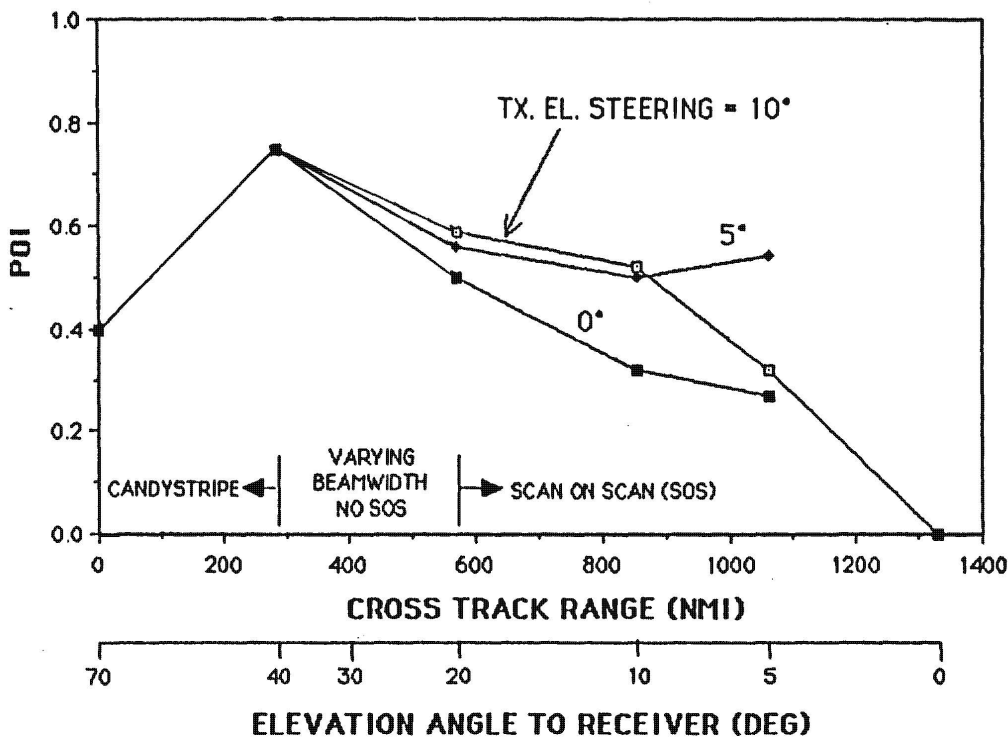
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PROBABILITY OF 10 PULSE INTERCEPT



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CONCLUSION

A SPINNING PENCIL BEAM COLLECTION PLATFORM CAN BE DESIGNED TO MEET ALL KEY EHF COLLECTION REQUIREMENTS AT 35 GHz.

REQUIREMENT	CAPABILITY
> 10 PULSES	10-50 PULSES
> 10^6 NMI ² /20 MINUTES	5.5×10^6 NMI ²
< 20 NMI LOCATION UNCERTAINTY	3 NMI NEAR NADIR 20 NMI AT 4 DEG. EMITTER ELEVATION

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UNQUANTIFIED OPPORTUNITIES
WITH SIDELOBE COLLECTOR

- DOWN-LOOKING RADARS
- SENSITIVITY WITH RAIN

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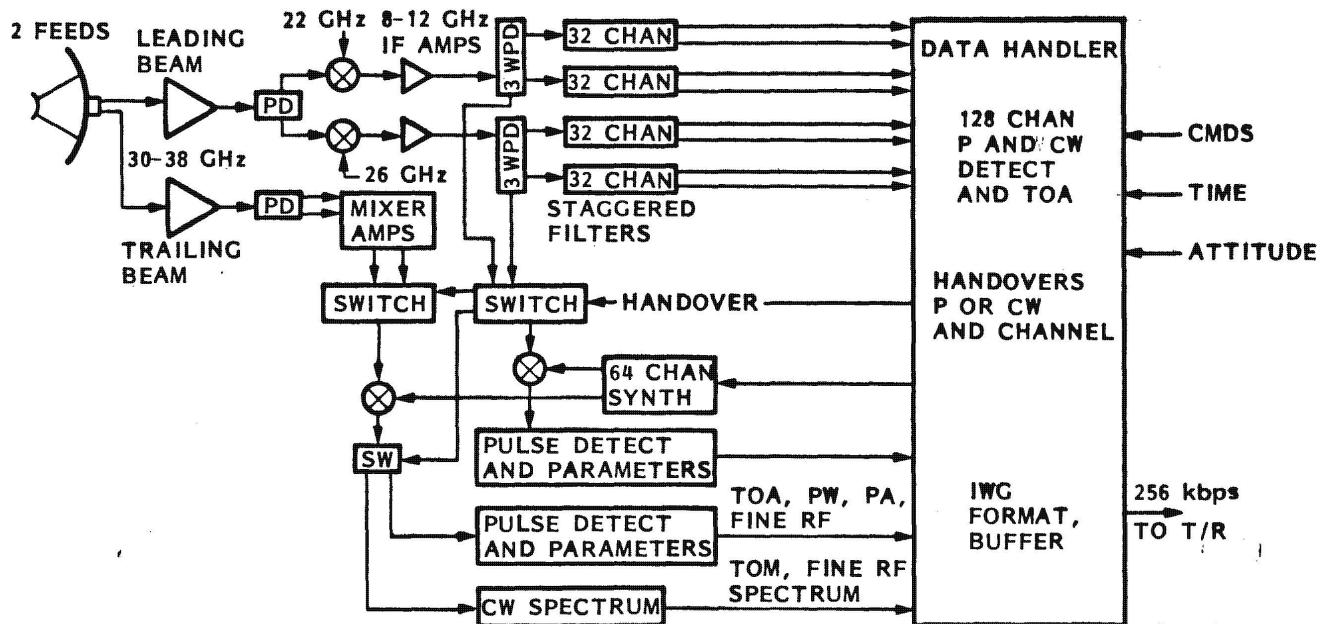
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P-11 EHF MISSION BLOCK DIAGRAM



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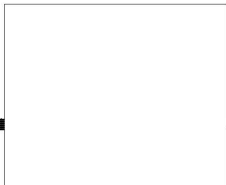
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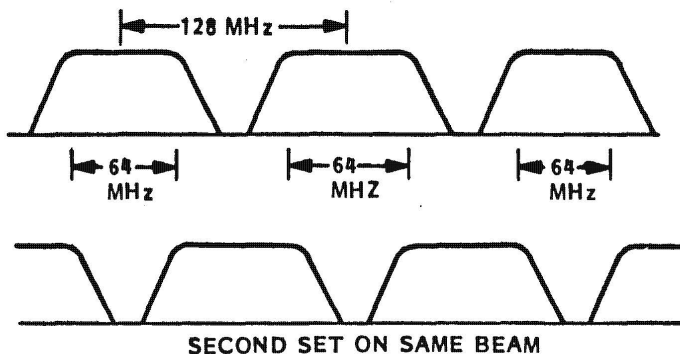
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PAYLOAD ARCHITECTURE FEATURES



- 8 GHz INSTANTANEOUS BANDWIDTH
- LEADING BEAM HAS A PAIR OF 4 GHz STAGGERED FILTER BANKS COVERING EACH 4 GHz TO PREVENT 3 dB CROSSOVER LOSSES



- VIDEO FILTERS
 - 10 MHz FOR PULSE DETECTION AND TOA
 - 0.5 kHz FOR CW DETECTION; REPEAT EACH msec AFTER DETECTION
- SET-ON MEASUREMENT RECEIVERS
 - PULSE RECEIVER IN DETECTION BEAM AND TRAILING BEAM MEASURES TOA, PW, PA, FINE RF, BANDWIDTH AFTER FIRST PULSE
 - CW 128 CHANNEL x0.5 MHz RADIOMETRIC SPECTRUM ANALYSIS IN TRAILING BEAM

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PAYLOAD WEIGHT AND POWER

ELEMENT	lb	W
3-FOOT ANTENNA	30	-
FEEDS, MIXERS, PREAMPS	4	6
TRG, TSG, LOs	4	5
DUAL 4 GHz 64 CHANNELIZER	60	21
SET-ON RECEIVERS	45	60
DATA HANDLER	17	23
HARNESS, BRACKETS, etc.	6	-
TOTALS	163	115
ANTENNAS	1	
FEEDS	2	
PULSE SET-ONS	2	
CW SET-ONS	1	
FREQ ACCESS (GHz)	8	

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P-11 WEIGHT SUMMARY



STRUCTURE/BRACKETRY	58.2
THERMAL CONTROL	9.9
PYRO RELAY BOX/SQUIBS/ARM PLUG	4.6
ORBIT ADJUST MOTORS (2)	110.9
SPIN ROCKETS (4)	1.9
6 AH BATTERIES (3)	55.1
CHARGE CONTROL UNIT (3)	1.2
POWER CONTROL ASSY	9.8
POWER DISTRIB AND CONTROL	7.0
SOLAR ARRAY/DEPLOY MECHANISMS	77.7
WIRE HARNESS	15.5
COMMAND RECEIVER/DEMOD (2)	5.2
TELEMETRY COMMAND UNIT	18.5
TIMER/ADDRESS PLUG	6.8
COMMAND ANTENNAS (2)	11.6
DUPLEXER AND SWITCH	5.8
TYPE 40 TAPE RECORDERS (2)	46.0
NARROWBAND TRANSMITTER (2)	4.6
KC 46 ENCRYPTORS (2)	6.0
MULTICOUPLER	1.1
SPIN AXIS CONTROL	5.2
SPIN RATE CONTROL	9.1
WOBBLE DAMPER	1.2
NUTATION DAMPER	2.2
HORIZON SENSOR	1.6
SOLAR ASPECT SENSOR	3.0
DATA CONTROL UNIT (MODIFIED)	11.0
PAYLOAD	133.0
3 ft SOLID PARABOLIC ANTENNA	30.0

491 lb BUS WITH ATTITUDE CONTROL AND PAYLOAD SUPPORT

163.0 lb PAYLOAD AND ANTENNA

654.0 lb
66.0 lb 10 PERCENT CONTINGENCY
720.0 lb TOTAL WEIGHT

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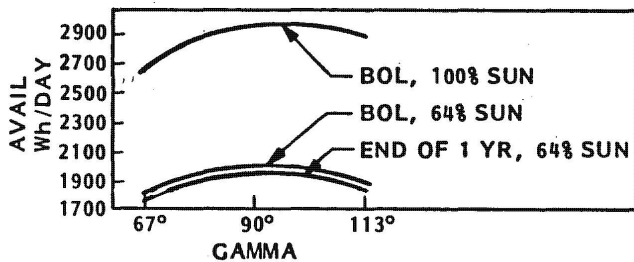
POWER SUBSYSTEM SIZING

	CONTINUOUS	READIN (4:1 MODE)	READOUT (1:1 MODE)								
TASKING	N/A	9 PASSES/DAY AT 20 MINUTES/PASS = 3 h/DAY	9 PASSES/DAY AT 5 min/PASS READOUT +2 1/2 min BEFORE AND AFTER								
POWER CONSUMPTION	10 W x 24 h = 240 Wh/DAY	115 W PAYLOAD 28 W TYPE 40 T/R 10 W DCU <hr/> 153 W x $\frac{20}{60}$ x 9 = 459 Wh/DAY	<table style="width: 100%; border: none;"> <tr> <td style="text-align: center;"><u>WATTS</u></td> <td style="text-align: center;"><u>Wh/DAY</u></td> </tr> <tr> <td>RO: $143 \times \frac{5}{60} \times 9 =$</td> <td>107</td> </tr> <tr> <td>B&A: $120 \times \frac{2.5}{60} \times 9 =$</td> <td>45</td> </tr> <tr> <td style="text-align: center;"><u>MAX 143 W</u></td> <td style="text-align: center;"><u>152 Wh/DAY</u></td> </tr> </table>	<u>WATTS</u>	<u>Wh/DAY</u>	RO: $143 \times \frac{5}{60} \times 9 =$	107	B&A: $120 \times \frac{2.5}{60} \times 9 =$	45	<u>MAX 143 W</u>	<u>152 Wh/DAY</u>
<u>WATTS</u>	<u>Wh/DAY</u>										
RO: $143 \times \frac{5}{60} \times 9 =$	107										
B&A: $120 \times \frac{2.5}{60} \times 9 =$	45										
<u>MAX 143 W</u>	<u>152 Wh/DAY</u>										

SOLAR ARRAY SIZING:

240 Wh/DAY CONTINUOUS
459 Wh/DAY READIN
152 Wh/DAY READOUT

$851 \text{ Wh/DAY} + 0.8 \text{ EFF} = 1,064 \text{ Wh/DAY REQMT}$



BATTERY SIZING (NO SUN):

CAPACITY ≥ 2 (PEAKLOAD) = $2 \left(\frac{163 \text{ W}}{26 \text{ V}} \right) = 12.5 \text{ Ah}$

CAPACITY ≥ 4 (SINGLE DISCHARGE)

= $4 \left(\frac{163 \text{ W}}{26 \text{ V}} \right) \left(\frac{20}{60} \text{ h} \right) = 8.4 \text{ Ah}$

3 BATTS AT 6 Ah = 18 Ah CAPACITY

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