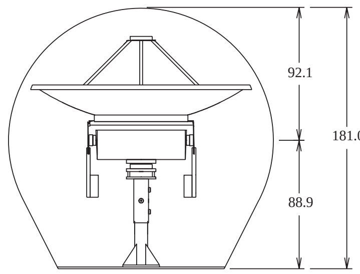
Specifications for SMART Station™ **HRPT Professional (170R)**

The SMART Solution™

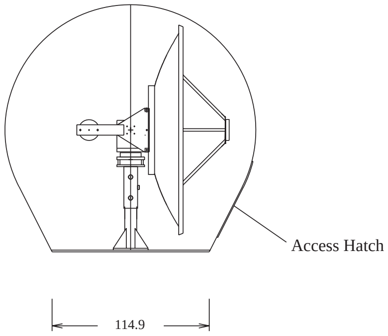
Workstation:
Choose a high performance Pentium-based Workstation running Microsoft Windows NT, or a DEC AlphaStation 400 UNIX Workstation running DEC OSF/1. See the SMART Station CPU Specifications for details.

SMARTrack™ :
Running under MS Windows NT™ ,or DEC OSF/1, provides satellite tracking, antenna control, HRPT data acquisition, scheduling unattended operations, processing HRPT data to NOAA Level 1-B and ERDAS file formats, SGP4-based orbital modeling, visible and infrared calibration, automated update of orbital elements via SMART Link™.

ERDAS Imagine® & SMARTech's HRPT Module:
Running under Windows NT™, or DEC OSF/1, provides image display, zoom, palette selection, rectification to multiple map projections, production of standard and user-defined data products such as sea surface temperature and vegetation indices, image enhancement and filtering, map composition and annotation, and overlay vector data such as coastlines and political boundaries.



Dimensions in cm



SMARTech

SMART Antenna™ System: Professional Model 170R

Antenna Type:	Solid Parabolic Aluminum
Antenna Diameter:	1.5 meters (5.0 feet)
Gain:	26.7 dBi at 1700 MHz
Beamwidth:	8.2 degrees typical
Finish:	Low reflectance (8-10%) white powdercoat
Acquisition Elevation (10^{-6} BER)	1.0 degrees
Azimuth Range:	720 degrees
Elevation Range:	180 degrees
Azimuth & Elevation Peak Torque:	170 Nm (125 ft.-lbs.)
Backlash (both axes):	0.15 degrees
Overall Positioning Accuracy:	0.3 degrees
Azimuth & Elevation Speed:	15 degrees/second
Protection:	Az/El Limit Switches
Stowing:	Automatic to vertical position
Antenna/Positioner Weight:	113 kg (250 lbs.)
Winds (Survival & Operational)	200 km/hour (125 mph)
Tracking Control:	Internal microprocessor running SGP4 model
Antenna Interface:	RS-422
Radome:	Rigid, 2-piece, fiberglass construction

Integrated Feed / LNA / Downconverter: IFD 1700

RF Input Frequency:	1690 - 1710 MHz
RF Input Bandwidth:	35 MHz (3 pole filter)
Image Rejection:	60 dB typical
Downconverter Gain:	45 dB typical
Downconverter Noise Figure:	0.8 dB (60K) typical
IF Output Frequency:	125.0 - 145.0 MHz
Power Requirements:	+12 to +16 VDC @ 500 mA max
Polarization:	RHCP (Dual RHCP / LHCP optional)
Frequency Stability:	+ / - 2 KHz typical
IF Output Connector:	type 'N' female
Environmental:	-30 to +60 degrees C
IF Cable Length:	Up to 100 meters

HRPT Receiver: BPSK 1700

IF Input Frequency:	120 - 170 MHz
IF Input Connector:	BNC Female
Bit Rate:	DC to 2.5 Mbps
Loop Bandwidth:	0.003% to 3.0% of center frequency
Capture Range:	3 X loop bandwidth
Image Rejection:	60 dB typical
IF Rejection:	60 dB typical
Adjacent Carrier Rejection:	1 dB maximum BER degradation
Parasitic Interference Rejection:	60 dB typical
Input Level:	-10 to -30 dBm (70mV to 7 mV @ 50 ohms)
Input Impedance:	50 ohms
Implementation Loss:	$\leq$ 1 dB
Demodulator Type:	PSK & BPSK-PLL Demodulators
Output:	Clock and Data RS-422 (NRZ & Manchester)

Combined Bit / Frame Synchronizer: IBFS 1700

Input	Serial, TTL, RS-422: NRZ or Manchester
Bit Rates:	5 bps to 2.5 Mbps
Clock Recovery:	DPLL with real time correlator
Insertion of Decryption / Recorder:	Via 5-channel SMART Decryption Interface
Data Path Selection:	Automatic via SMARTrack through Bus
Automatic Tracking Range	$\pm$ 12% of specified bit rate
Loop Bandwidth:	1.0% standard
Bit Error Rate:	$\pm$ 1.5 dB of theoretical
Threshold:	SNR $\geq$ 6 dB
Jitter:	> 1 dB for jitter amplitudes < 1.0% of bit rate
Output:	8 to 64-bit words to Workstation Bus
BUS Interface:	64-bit PCI Bus

The SMART Solution

RF Link Budget for Professional Model 170R HRPT SMART Station

SMARTech

Providing Tomorrow's Solutions Today

This RF Link Budget is valid for the Professional Model 170 HRPT SMART Station integrating:

- A **Professional Model 170** SMART Antenna;
- An **IFD 1700** Integrated Feed / LNA / Downconverter;
- A **BPSK 1700** Dual BPSK / PSK Demodulator;
- An **IBFS 1700** Integrated Bit/ Frame Synchronizer.

A Link Budget is a measure of the performance of a satellite earth station. The Link Budget is an analysis of the ability of the system to receive data from a satellite under certain conditions. Normally, these conditions include:

- A particular elevation above the horizon (5° being most common);
- A satellite transmitter power which represents the worst-case scenario;
- A gain for the receiving antenna which is calculated from the size of the antenna and the frequency of the received signal;
- Certain atmospheric conditions (usually worst-case-scenario).

Parameter	Units	5 deg.
Effective EIRP (from satellite)	dBm	40.00
Free Space Loss	dB	-166.60
Absorption	dB	-0.40
Rain Attenuation Loss	dB	-0.20
Polarization Loss	dB	-0.20
Antenna Pointing Loss	dB	-0.10
Feed Insertion Loss	dB	-0.20
Total Path Losses	**dB**	**-167.70**
Ground Station Antenna Gain (3 dB)	dB	26.70
Total Received Signal Power	**dBw**	**-101.00**
Noise Calculations		
Ground Antenna Noise Temperature	Kelvin	34.00
LNA Noise Temperature	Kelvin	65.00
Total System Noise Temperature	Kelvin	99.00
	dB	19.96
System G/T	**dB - K**	**6.74**
Link Calculations		
Loss for Modulation Index	dB	-0.70
Total Data Power	dBm	-101.70
Data Bandwidth (660 Kbps)	dB / Hz	61.20
Eb/No for B.E.R. = 10E-6	dB	10.70
Estimated Technical Losses	dB	1.00
Boltzman's Constant	dBm s/deg.	-198.60
System Noise Figure	dB	19.96
Noise Power Density	dBm / Hz	-178.64
Necessary Data Power	dBm	-105.74
Margin for Data Reception	**dB**	**+4.04**

The link budget indicates that this configuration will maintain a 10^{-6} bit error rate at a satellite elevation angle as low as 1.0° above the horizon. The Link Budget takes into account factors for transmitting power, gains, losses and noise figures, including the factors listed below.

1. The Effective Isotropic Radiating Power (EIRP) of the is satellite determined from:
- The satellite transmitter power;
- The gain of the satellite transmitting antenna;
- The radiating pattern of the satellite antenna.

The EIRP is the amount of power (measured in dBm) being transmitted from the satellite in a particular direction. The EIRP value is different for different directions because the radiating pattern of the transmitting antenna is not a simple curve. The direction used in the calculation is determined by the link budget elevation.

2. The total path loss is calculated by summing losses from the following factors.
- The Free Space Loss (this is a function of the distance between the satellite and the receiving antenna: the greater the distance, the greater the loss);
- Absorption of the RF signal by the atmosphere (maximum);
- Loss due to attenuation of the signal by heavy rain (4 inches per hour);
- Loss due to the polarization of the transmission signal (constant);
- Loss due to errors in the pointing of the antenna (maximum);
- Loss due to blockage of the signal by the feed horn (constant).

3. The ground station receiving antenna gain is calculated from the size of the antenna, the frequency of the transmission, and the antenna efficiency at that frequency. These efficiencies are provided by the antenna manufacturer, and are determined by range tests.

4. The total power received at the feed horn (in dBw) is then calculated by adding the EIRP, the Total Path Losses and the Ground Station Antenna Gain.

5. The system noise temperature (in Kelvin) is then calculated from:
- The Ground Antenna Noise Temperature;
- The noise temperature inherent in the feed horn, low noise amplifier and downconverter (a combined figure for the IFD in a SMART Station).

The antenna noise figure is the amount of background noise impinging on the antenna from RF sources in the sky and from the earth. The larger the dish antenna, the smaller the beamwidth, and the lower the noise temperature. The closer to the horizon the antenna is pointing, the greater the noise figure due to noise from the earth. The antenna noise temperature is also frequency dependent and is determined from a set of standard tables.

The LNA noise temperature is inherent in the particular LNA / downconverter used. Manufacturers of these components measure the noise levels in their laboratories and provide these to their customers.

6. The total system noise temperature in Kelvin is converted to dB, and then subtracted from the antenna gain to provide the System G/T. The G/T is a measure of the satellite earth station's signal to noise ratio.

7. The final step is to calculate the Link Margin in the following manner.
- A loss due to the modulation index is subtracted from the Total Received Power to provide a Figure for the Total Data Power.
- The power required to support the satellite transmission data rate is calculated, and is termed the Data Bandwidth (the higher the data rate, the more power required).
- The power necessary to achieve the required bit error rate is then calculated (for a B.E.R. of 10^{-6} 10.7 dB are required). The lower the B.E.R. the more power required.
- Maximum additional losses due to hardware configurations are included. This loss is estimated, but is based on past experiences with identical configurations. Every satellite earth station is a little bit different form every other one, and SMARTech includes an additional 1.0 dB hardware loss as an additional safety factor. In reality, this type of loss is approximately 0.1 dB.
- The system Noise Power Density is derived by adding the system noise figure to Boltzman's Constant (-198.6 dBm s/deg.).
- The necessary data power is the sum of the Data Bandwidth, the B.E.R requirement, Estimated Technical Losses and the Noise Power Density.
- The Link Margin (in dB) is the difference between the Total Data Power and the Necessary Data Power. If the Link Margin is a negative number, the satellite earth station will not support the required B.E.R. under the particular conditions. If the Link Margin is a positive number, the satellite earth station will support the required B.E.R. under the particular conditions, and provides a "safety margin" against additional losses or noise equal to the Link Margin. Further calculations indicate that this configuration will maintain a 10^{-6} bit error rate at a satellite elevation angle of 0.5°.

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