DOCUMENT

document title/ titre du document

ESA TRACKING STATIONS (ESTRACK) FACILITIES MANUAL (EFM)

prepared by/*préparé par* Peter Müller

reference/*réference* DOPS-ESTR-OPS-MAN-1001-OPS-ONN
issue/*édition* 1
revision/*révision* 1
date of issue/*date d'édition* 19/09/2008
status/*état* Approved/Applicable
Document type/*type de document* SSM
Distribution/*distribution* see next page

European Space Agency
Agence spatiale européenne

ESOC
European Space Operations Centre - Robert-Bosch-Strasse 5, 64293 Darmstadt - Germany
Tel. (49) 615190-0 - Fax (49) 615190 495 www.esa.int

6 ESTRACK CORE NETWORK STATIONS

6.1 Cebreros (CEB) Station

Figure 3 shows the Cebreros Aerial View.

Figure 3: Cebreros Aerial View

6.1.1 GENERAL INFORMATION

The Cebreros site is made available to ESA, based on an international agreement between ESA and the Government of Spain.

6.1.1.1 Location

The Cebreros site is located near the village of Cebreros, province of Avila, Spain, about 85 km west of Madrid, on km 8 on the road AV-562, see Figure 4.

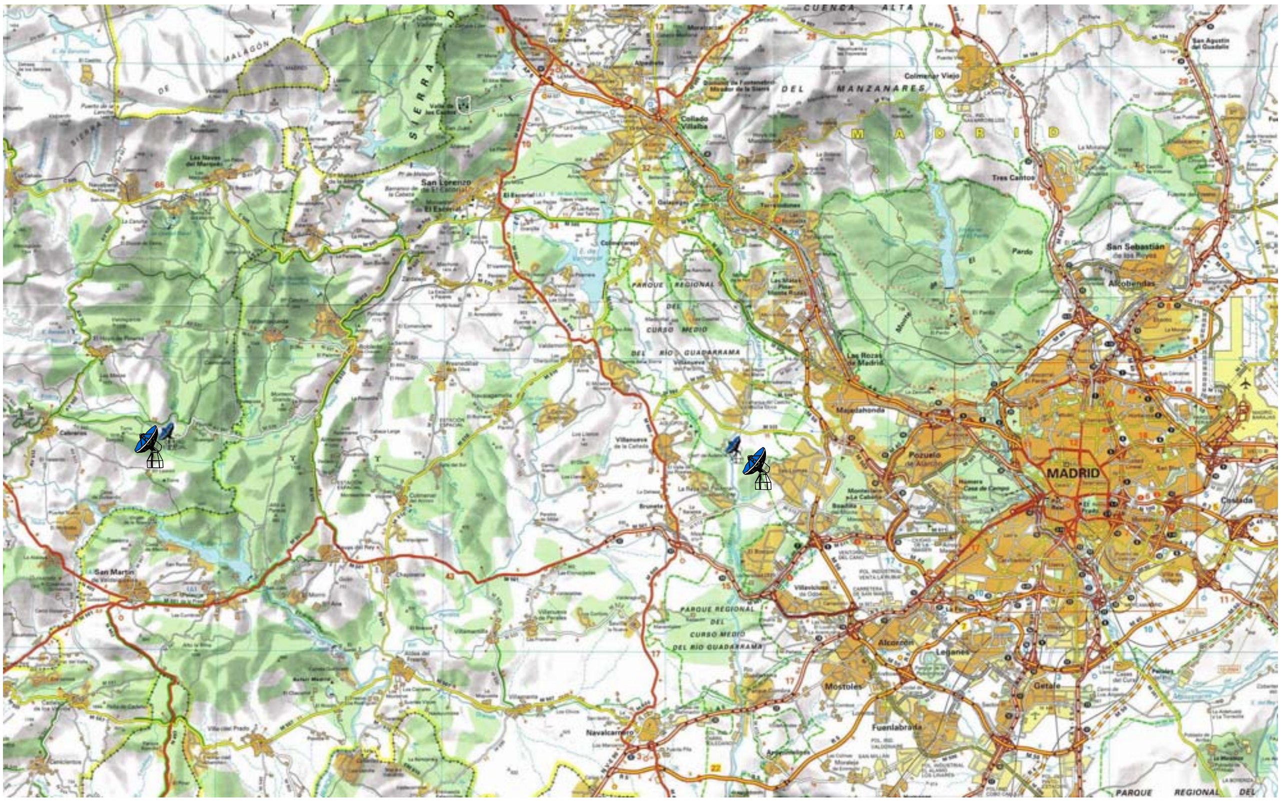

Figure 4: Cebreros Area Map

The site was formerly the “Cebreros” Deep Space Station 62 of the National Aeronautics and Space Administration (NASA).

6.1.1.2 Access

Site visits require a confirmed Station Intervention form sheet.
The Cebreros site is accessible only by road, it is not served by public transport.
Following the northern road, Cebreros station is approximately 93 Km from Barajas Airport.
At the Airport exit, take the A10 in the direction “M40 Norte, A1 Burgos, A6” for approximately 7 Km. Exit at junction 3 direction “M40 Zaragoza, R2” to join the M40 motorway ring. Continue on the ring for 18 km in direction of A6. Exit the M40 at Junction 46 (Km 48) and Join the A6 in the direction of “A Loruña”. Continue the A6 for approximately 7 Km until junction 18 to join the M505 in direction of Las Rozas, El Escorial. Continue the M505 motorway heading west in direction of El Escorial during 27 Km. Arriving in the first round-about, take on the left the M600 heading south in direction of “Valdemorillo / Avila” to avoid El Escorial. After 600 m in the second roundabout, turn on the right to join again the M505 in direction of Avila. Continue the M505 for a approximately 8 Km until you reach the “Puerto de la Cruz Verde” and continue straight to take the M512 in direction of “Robledo de Chavala”. Follow the M512 for 10 Km to pass Robledo and continue for 3,5 Km until the intersection with the M539 (Cebreros). At the intersection, turn right on the M539 in direction of Cebreros. After 6 Km you enter in the province

of Avila and the M539 change to AV562. Continue for 4 Km until the ESA sign is shown (Km 10). Turn left to follow the sign and continue for 1,1 Km to the Station entrance.
Accommodation can be arranged through the station manager.

6.1.1.3 Entry Requirements

The entry requirements to Spain are as for the European Union. Spain is in addition part of the EU “Schengen” Agreement.

6.1.1.4 Climate

Outside temperature may differ from –10° C in winter to + 40° C in summer.
A summary of the weather characteristics for Cebreros area is given below:

Warmest month:	July/August
Average daily maximum temperature for July/August:	34 °C
Maximum recorded temperature in July/August:	37 °C
Lowest recorded temperature in July/August:	19 °C
Coldest month:	February
Average daily minimum temperature for February:	-5.5 °C
Maximum recorded temperature in February:	tbd °C
Minimum recorded temperature in February:	-7 °C
Average annual rainfall:	476 mm

6.1.1.5 Management

The ESA on-site representative is the Cebreros TT&C and Site Manager.
The Maintenance and Operations (M&O) of the site is provided by Ingenieria y Servicios Aerospaciales S.A (INSA).

6.1.1.6 Local Contact

The local ESA contact point for Cebreros is:

ESA Cebreros TT&C and Site Manager
Mr Lionel Hernandez
email: Lionel.Hernandez@esa.int
Tel +34-91 89638-45
Fax +34-91 89638-13

The Postal address of the station (mail, letters) is:

European Space Agency (ESA)/Agencia Europea del Espacio
Cebreros Satellite Tracking Station
P.O. Box - Apartado 32 A
E- 05260 Cebreros (Avíla)
Spain

The Delivery address of the station is:

European Space Agency (ESA)/Agencia Europea del Espacio
Cebreros Satellite Tracking Station
Road/Carretera AV-562 , Km 10
E-05260 CEBREROS (Avila)
Spain

6.1.1.7 Logistics

Address for packages transported via airfreight

European Space Agency (ESA)/Agencia Europea del Espacio
Cebreros Satellite Tracking Station
c/o Agente de Aduanas / Customs Agent VALTAIR S.L
Terminal de Carga - Oficina 161
Madrid-Barajas Airport
E-28043 Madrid,
Spain

Custom Clearance Agent:

VALTAIR S.L.
Customs Agent Code Núm. 23.820
Postal Address:
Alcarria, 5-7 Oficina 6,
E-28820 Coslada, Madrid, España
Tel.: +34.91.669.03.02
Fax: +34.91.669.66.01
Person of Contact:
Mr. Julio Puerro / Mrs. Conchita Franco

6.1.2 STATION SERVICES

Figure 5 shows the site plan of Cebreros.

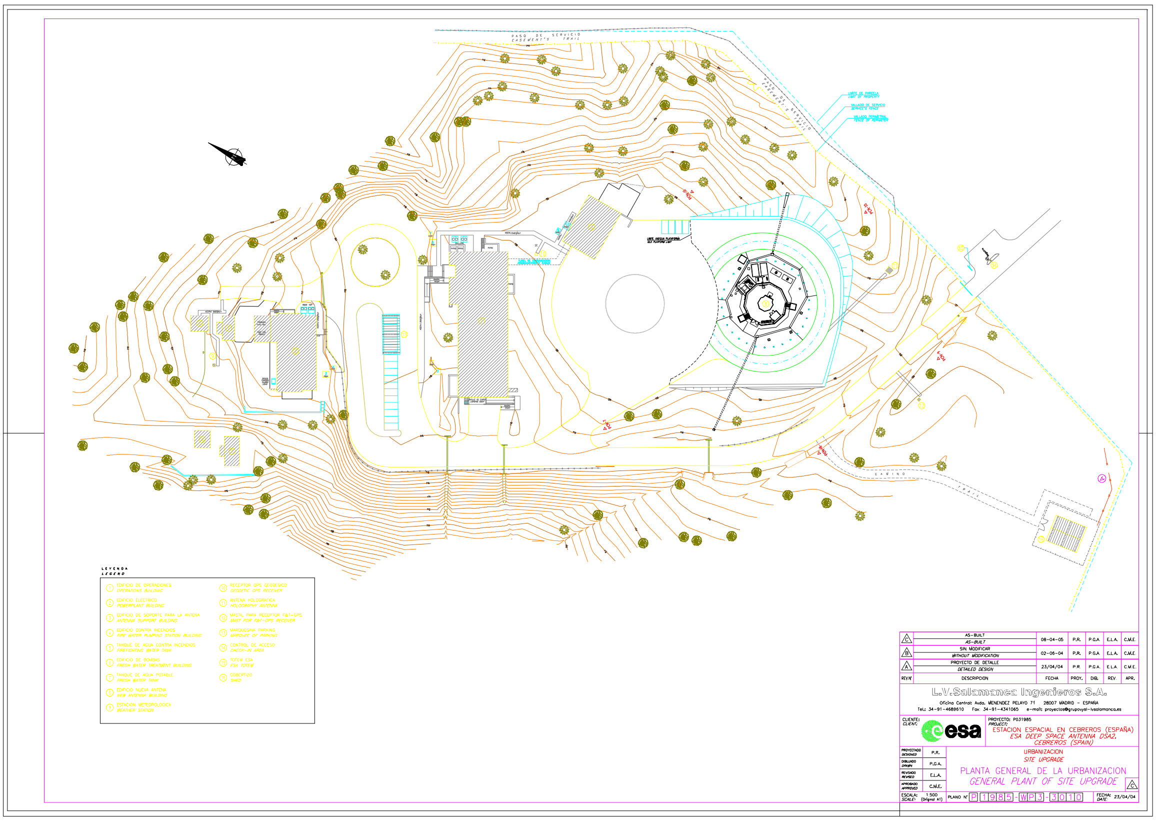

Figure 5: Cebreros Site Plan

6.1.2.1 Security

The site is fenced and guarded 24/7. An access control and surveillance system is installed.

6.1.2.2 Power

The power plant is designed to furnish a reliable electricity supply to all power consumers. It provides a short-break (SB) power supply using Diesel Generators, and a no-break dirty (NB-dirty) and a no-break clean (NB-clean) power supply using Static Converters and Batteries. Via low voltage switches the electricity (3x 400V, 50 Hz) is distributed to the consumer groups.
Public power into the power plant is rendered by two diversely routed 15 kV medium voltage line and two transformers of 1000 kVA.
Two Diesel Generators supply each 500 kVA within 15 seconds after public power failure. Two Static Converters supply each 80 kVA. The Battery capacity allows for a maximum bridging time of 6 minutes.

6.1.2.3 Air Conditioning

The station air conditioning system supplies air to the main building equipment rooms at a temperature of 24° C + 10%, with a controlled humidity of 50% - 70% Relative Humidity.

6.1.2.4 Communications

The Cebreros station is connected via the ESA Operations Network (OPSNET) in a triangular setup (Cebreros, Villafranca, ESOC) using 2 Mbps international private leased circuits (IPLCs). The connectivity into the Cebreros site is diversely routed through a fibre optic link and a microwave link.
All non-operational and Internet traffic is routed via the ESA Administrative Network (ESACOM).

6.1.3 CEBREROS-1 (CEB-1) TERMINAL

Figure 6 shows shows the Cebreros-1 (CEB-1) antenna, which provides X-band transmit, as well as X- and Ka-band receive capability (X/XKa).

Figure 6: Cebreros-1 (CEB-1) Antenna

6.1.3.1 Services and Performance

The Cebreros-1 (CEB-1) terminal provides the following services:

- Tracking
- Telemetry
- Telecommand
- Radiometric Measurements (Ranging, Doppler, Meteo, Delta-DOR)
- Radio Science

Table 2 details the Cebreros-1 (CEB-1) Performance Characteristics. For the definition of individual characteristics see 5.6.

1	Rev. 2.4		41	DOWNLINK	
2	18-Sep-2008	CEBREROS-1 (X / X Ka)	42	L-band RX band [MHz]	N/A
3	TERMINAL	CEB-1	43	L-band Polarization	N/A
4	Longitude	04 deg 22' 03.18" W	44	L-band G/T [dB/K]	N/A
5	Latitude	40 deg 27' 09.68" N	45	S-band RX band (MHz)	N/A
6	Altitude [m]	794.095	46	S-band Polarization	N/A
7	Antenna Diameter [m]	35	47	S-band G/T [dB/K]	N/A
8	S-band Beamwidth [deg]	N/A	48	X-band RX band [MHz]	8400 - 8500
9	X-band Beamwidth [deg]	Rx: 0.064 Tx: 0.074	49	X-band Polarization	RHC, LHC
10	Ka-band Beamwidth [deg]	Rx: 0.017	50	X-band G/T [dB/K]	50.8 (at 10 deg El.)
11	Antenna Speed [deg/s]	Az: 1.0 deg/s El: 1.0 deg/s	51	Ka-band RX band [MHz]	31800 - 32300
12	Azimuth Range [deg]	0 - 540	52	Ka-band Polarization	RHC, LHC
12	Elevation Range [deg]	0 to 90	53	Ka-band G/T [dB/K]	55.8 (at 10 deg El.)
14	Search / Acquisition Aid	NO	54	Modulation Schemes	IFMS compliant
15	Tilt Facility	NO	55	Carrier Freq Search Range	+/- 1.5 MHz
16	Tracking Mode	Program	56	Subcarrier Frequency	2 kHz to 1.2 MHz
17	Angular Data Accuracy (autotrack+pointing error)	N/A	57	Data Rates	IFMS compliant: - 1.2 Mbps (RCD) - 8 Mbps (SCD HS)
18	FUNCTIONALITIES		58	Data Coding Scheme	R-S, Convolutional and Concatenated
19	TM/TC Standards	PCM, CCSDS	59	INTERFACES	
20	TM/TC Redundancy	YES	60	TM/TC Connectivity	TCP/IP SLE (TMTCS)
21	Comms Redundancy	YES	61	Rng/Dop Connectivity	FTP (IFMS)
22	Ranging	IFMS compliant	62	Meteo Connectivity	FTP (IFMS)
23	Doppler	YES	63	Angles Connectivity	N/A
24	Meteo	YES	64	Pointing Format	STDM
25	Autotrack Antenna Angles	NO	65	Tracking Interface (ESOC)	FDS
26	Delta-DOR	YES			
27	Radio-Science	YES			
28	Frequency & Timing	MASER			
29	UPLINK				
30	S-band TX band [MHz]	N/A			
31	S-band Polarization	N/A			
32	S-band EIRP [dBm]	N/A			
33	X-band TX band [MHz]	7145 - 7235			
34	X-band Polarization	RHC, LHC			
35	X-band EIRP [dBm]	138 (XHPA), 128 (XLPA), 122 (XSSA)			
36	Ka-band TX band (MHz)	N/A			
37	Ka-band Polarization	N/A			
38	Ka-band EIRP [dBm]	N/A			
39	Modulation Schemes	IFMS compliant			
40	Subcarrier Freq. [kHz]	8 or 16 kHz			

Table 2: Cebreros-1 (CEB-1) Performance Characteristics

6.1.3.2 Antenna Horizon

Figure 7 shows the Cebreros-1 (CEB-1) Antenna Horizon Mask.

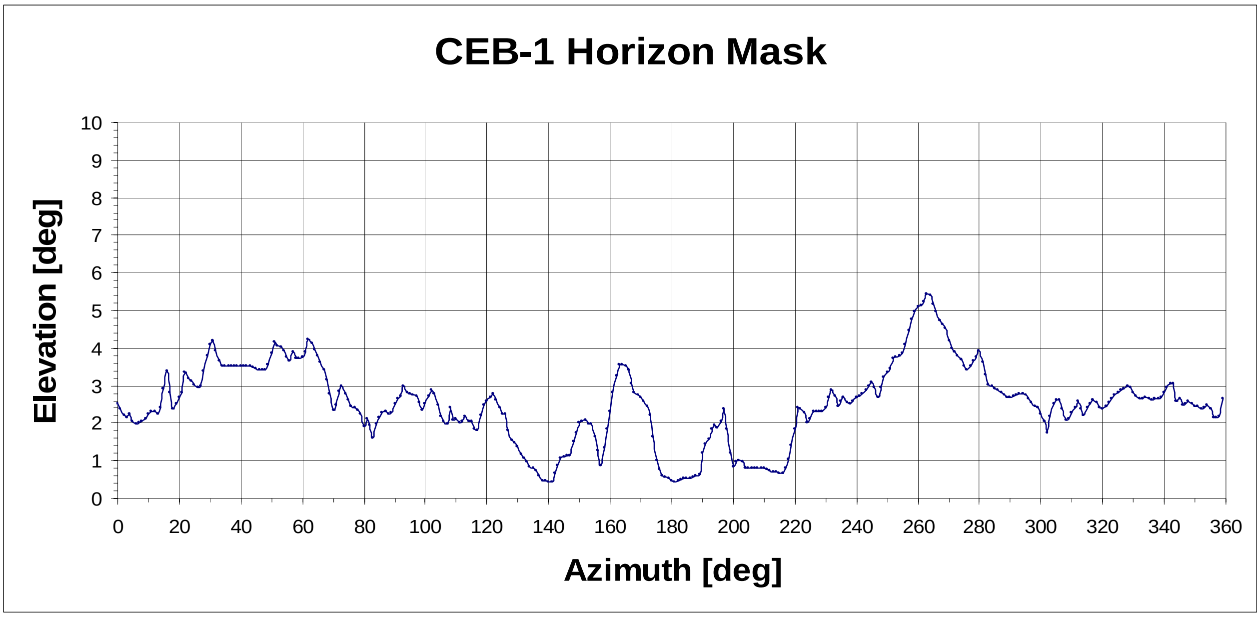

Figure 7: Cebreros-1 (CEB-1) Antenna Horizon Mask

6.1.3.3 Functional Description

Figure 8 shows the Cebreros-1 (CEB-1) Block Diagram, which is used for the functional description.

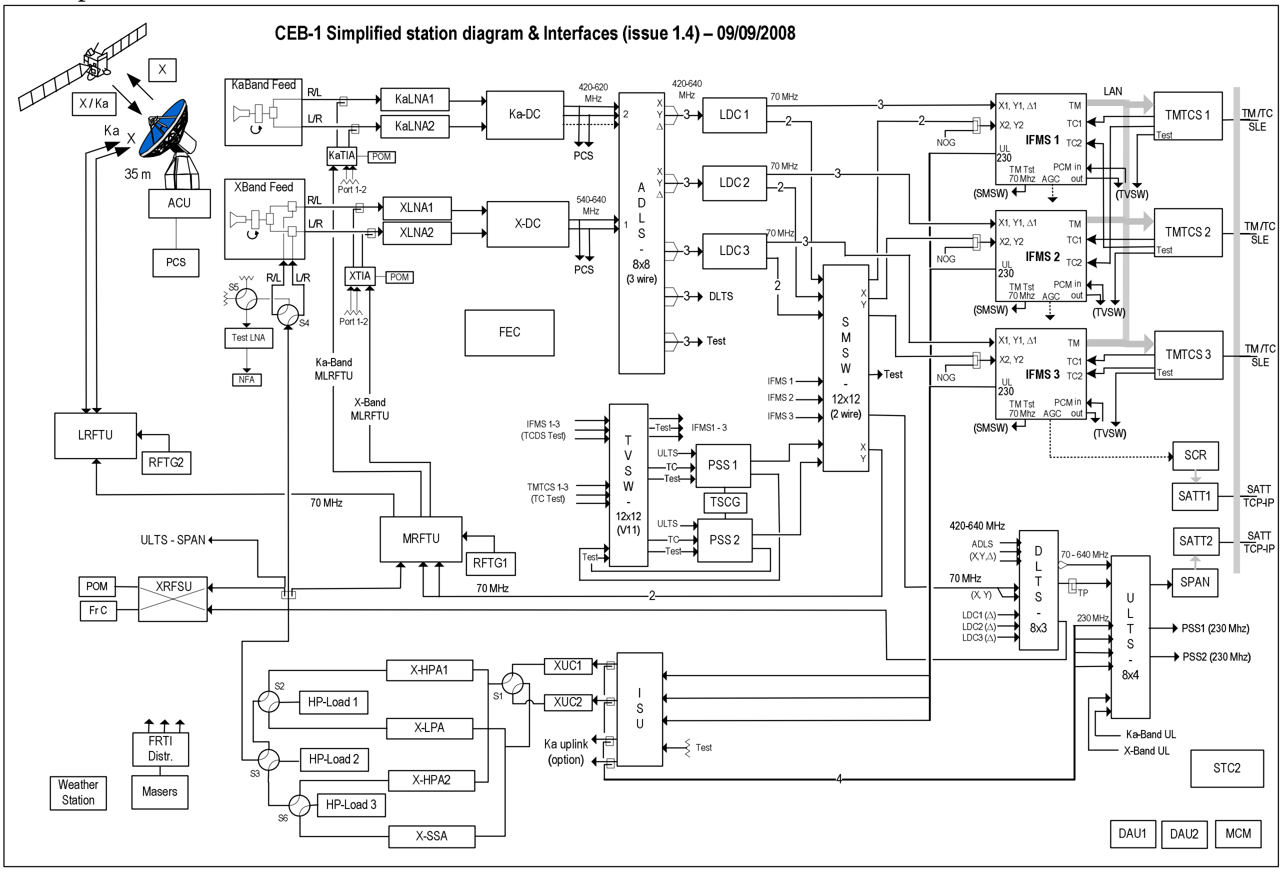

Figure 8: Cebreros-1 (CEB-1) Block Diagram

6.1.3.3.1 Antenna

The X-band transmit and X- and Ka-band receive (X/XKa) Cassegrain Beam Wave Guide antenna is fitted with a shaped 35m parabolic main reflector and a shaped hyperbolic subreflector in an elevation over azimuth mount. Auto-tracking of X- and Ka-band signals is not possible. An S- and X-band probe with reflective converter allows for signal delay calibration. An air-conditioning system outside the antenna tower provides cooling of the antenna tower.
The antenna pointing is performed by the Antenna Control Unit (ACU), which affects both axes using drive amplifiers, motors and gearboxes. Optical position encoders deliver the azimuth and elevation positions to the ACU.
The incoming electromagnetic wave is conveyed via the reflector, subreflector and beam waveguide system to a frequency sensitive dichroic mirror, that splits the X-Band and the Ka-Band

signals, to the respective feeds, which together with their polarizer matches the free space field electromagnetic configuration to the waveguide modes.
The coexisting X-band receive and transmit signals for each polarisation are separated by Diplexer filters. The receive waveguide branches (X-band and Ka-band receive) are fed to cryogenically cooled Low Noise Amplifiers (LNAs), which amplify the Right-Hand-Circular (RHC) and Left-Hand-Circular (LHC) signals, which subsequently can be phase adjusted by Phase Shifters.
The X-band signals [8400-8500 MHz] are down-converted to L-band [620-420 MHz]. The Ka-band signals [31,800-32,300 MHz] are down-converted to L-band [640-540 MHz]. The downlink signals are then transferred for telemetry processing.
The uplink signal coming from telecommand processing at 230 MHz is delivered to X-band transmission. It is routed to the X-band Up-Converter (XUC) for conversion to [7145 - 7235 MHZ] and via a switch to the X-band High Power Amplifier (XHPA) or X-band Low Power Amplifier (XLPA).
A transmit waveguide assembly routes the RF signal to the X-band feed. The transmitted polarisation is selected with the polarization switch, which routes the RF signal to the uplink arm of one of the two Diplexers, one for each polarisation. To avoid radiating the RF power to the antenna, the RF signal can also be routed via a set of switches to one of the two high power dummy loads.
The X-Band Feed (including polarizer) matches the incoming waveguide electromagnetic mode with the free space field configuration. It circularly polarises the uplink signal coming from one of the two Diplexers. The Beam Wave Guide (BWG) system conveys the high power RF flux from the X-Band feed to the antenna sub-reflector and main reflector where it is forwarded to free space.

6.1.3.3.2 Tracking

The tracking of spacecraft is possible by pointing the antenna in program track mode based on orbital predictions.
For program track the antenna Azimuth and Elevation pointing angles are derived from predicted Spacecraft Trajectory Data Messages (STDM's) or State Vectors in the Front End Controller (FEC).

6.1.3.3.3 Telemetry

The downlink L-band signals are fed via the Antenna Downlink Switch (ADLS) into tuneable L-band down-converters for conversion to 70 MHz intermediate frequency (IF) and further signal routing through the 70 MHz switch (SMSW).
The 70 MHz signals are combined and demodulated in the Intermediate Frequency Modem System (IFMS), which provides remnant and suppressed carrier demodulation. Doppler predictions coming from Spacecraft Trajectory Data Messages (STDM) information improve the signal acquisition process. The Telemetry Channel Decoding System (TCDS) hosted inside the IFMS performs frame synchronisation, time tagging, Viterbi and Reed-Solomon decoding. The output data is transferred to the Telemetry and Telecommand System (TMTCS) for data structure processing according to Space Link Extension (SLE), which ultimately delivers the telemetry data via OPSNET to the Spacecraft Control Systems.
All three telemetry chains are redundant and the various switches allow flexible signal routing.

6.1.3.3.4 Telecommand

The Telemetry and Telecommand System (TMTCS) receives SLE conformant Telecommand data via OPSNET from the Spacecraft Control Systems. It provides telecommand data and clock to the Intermediate Frequency Modem System (IFMS) Uplink Modulator (ULM), which provides the Phase Shift Key (PSK) modulation of the telecommand bit stream onto a sub-carrier, which is then used to phase modulate the uplink carrier at 230 MHz. Via the Antenna Uplink Switch (AULS) the uplink signal is routed to the X- band antenna uplink.
The telecommand chains are redundant and the various switches allow flexible signal routing.

6.1.3.3.5 Radiometric

The radiometric measurements comprise Doppler, Ranging, Meteorological, Delta Differential One-way Range (Delta-DOR) and Radio Science measurements.
The station design is such that any of the three downlink chains can be used for Telemetry reception and for radiometric measurement including Delta-DOR and Radio Science Investigation (RSI).
The Intermediate Frequency Modem System (IFMS) Ranging and Telemetry Demodulators deliver integrated Doppler measurements of the received carrier phase, known as Doppler-1 and Doppler-2.
The IFMS Uplink Modulator generates the ranging tone, which is Phase-Shift-Key (PSK) modulated by a sequence of codes. This ranging tone is phase modulated on the uplink carrier and can be transmitted simultaneously with the telecommand subcarrier. The IFMS Ranging Demodulator pre-steers the expected downlink carrier in case of coherent transponding of the spacecraft based on Spacecraft Trajectory Data Messages (STDMs), demodulates the received tone and compares the received codes with codes replica to derive the two-way propagation delay.
The IFMS meteorological unit gathers outside air temperature, pressure, humidity, wind force and direction information.
All radiometric measurement data are delivered through OPSNET to Flight Dynamics for processing.
For (Delta-DOR) the IFMS records spectra for further processing in a correlator to derive the phase of the received satellite electromagnetic wave with respect to the same reception at a another location on earth. Angular calibration of the signal is achieved by measuring known radio sources, e.g. quasars, before and after the satellite measurement. Due to the amount of data collected, the DDOR samples are stored in the External Storage Units (ESU). Two redundant ESU are available, allowing DDOR to be performed from any two of the three redundant downlink chains.
For Radio Science Investigations the IFMS records spectra and doppler measurements of the received X- and Ka-band downlinks. In addition dual frequency ranging can be performed, i.e. one uplink X-band signal containing the ranging code is coherently transponded on-board to an X-band and Ka-band downlink signal, which are received simultaneously by two IFMS Ranging Demodulators, which both use the same codes replica. The frequency dependent downlink propagation delay can be measured in this way.
All Radio Science measurements are delivered through OPSNET to the Science Community for processing.

6.1.3.3.6 Monitoring and Control

The monitoring and control (M&C) system allows full local and remote control over the terminal. It is based on a hierarchy of M&C systems: the Station Computer (STC), the Front End Controller (FEC), the Monitoring and Control Module (MCM) and Local Man Machine Interfaces (MMI) on the various devices.
The Station Computer (STC) is composed of a local server, a local workstation and a remote workstation housed in the ESTRACK Control Centre (ECC). Mission specific terminal configurations are normally affected through pre-validated macro-procedures, also individual equipment configurations are possible. The STC interacts through a set of subsystem controllers, either in separate units or implemented in complex devices (e.g. IFMS/TMTCS), with all the terminal equipment. Remote spectrum visualisation is supported.
The Front End Controller (FEC) is the subsystem controller for all the antenna front end devices and responsible for antenna steering.
The Monitoring and Control Module (MCM) is the subsystem controller for all simple back end devices, e.g. switches.
In case of failure of the monitoring and control system, the terminal can be locally operated from the individual equipment Local Man Machine Interfaces.

6.1.3.3.7 Frequency and Timing

The frequency reference generation is based on a Hydrogen Maser with very high long term frequency stability. The frequency distribution system coherently derives 5, 10 and 100 MHz signals and amplifies them for distribution to the devices.
The time reference is based on Universal Time Coordinated (UTC), and synchronised with the Global Positioning System (GPS) delivered time. The time is distributed without the calendar year via IRIG-B 5 MHz, 1 kHz and 1 pulse per second (pps) signals. The calendar year is configured separately on the devices.

6.1.3.3.8 Test and Calibration

The objective of the test and calibration function is to validate the telemetry and telecommand functions, and to calibrate the Ranging and Doppler function before the operational satellite pass.
The telemetry function is tested with simulated spacecraft telemetry, which is generated in the Portable Satellite Simulator (PSS), frequency converted to the appropriate downlink frequency and injected into the antenna via a test antenna, so called Telemetry Test Long Loop (TTLL) configuration. The telemetry is then delivered in a Data Flow Test (DFT) to the spacecraft control system for verification.
The telecommand function is tested by demodulating and decoding of the 230 MHz uplink signal and comparing it to known telecommand formats. Based on the telecommand received in the PSS the simulated telemetry generation can be altered. The test telecommands originate from the spacecraft control system.
The ranging and doppler function is calibrated by conducting a ranging and doppler measurement in an antenna loopback configuration, in which the uplink frequency is transponded to the downlink frequency. The emulated transponding involves reception of the uplink frequency by the test antenna and conversion to the downlink frequency in the Reflective Converter (RFLC) with

subsequent transmission via the test antenna back into the main antenna. This calibration measures the station internal signal delay and any frequency offset.
For phase calibration of the tracking channels, a remote controllable calibration tower is available.
Test tools for integration and performance validation activities are not described.

6.1.4 ADDITIONAL FACILITIES

6.1.4.1 GPS-TDAF

A Global Positioning System (GPS) dual-frequency receiver system with geodetic accuracy is installed on the site, which delivers continuous measurements to the ESOC Navigation Facility.

6.1.5 PLANNED DEVELOPMENTS

It is planned to upgrade the CEB-1 terminal with Ka-band transmit and Ka-band autotrack capability for support of the Bepi-Colombo mission.

6.5 New Norcia (NNO) Station

Figure 31 shows the New Norcia (NNO) Arial View.

Figure 31: New Norcia (NNO) Aerial View

6.5.1 GENERAL INFORMATION

The New Norcia site is owned by ESA.

6.5.1.1 Location

The New Norcia site is located 140 kilometres north of Perth in Western Australia, see Figure 32.. It occupies an area of 170 m x 190 m.

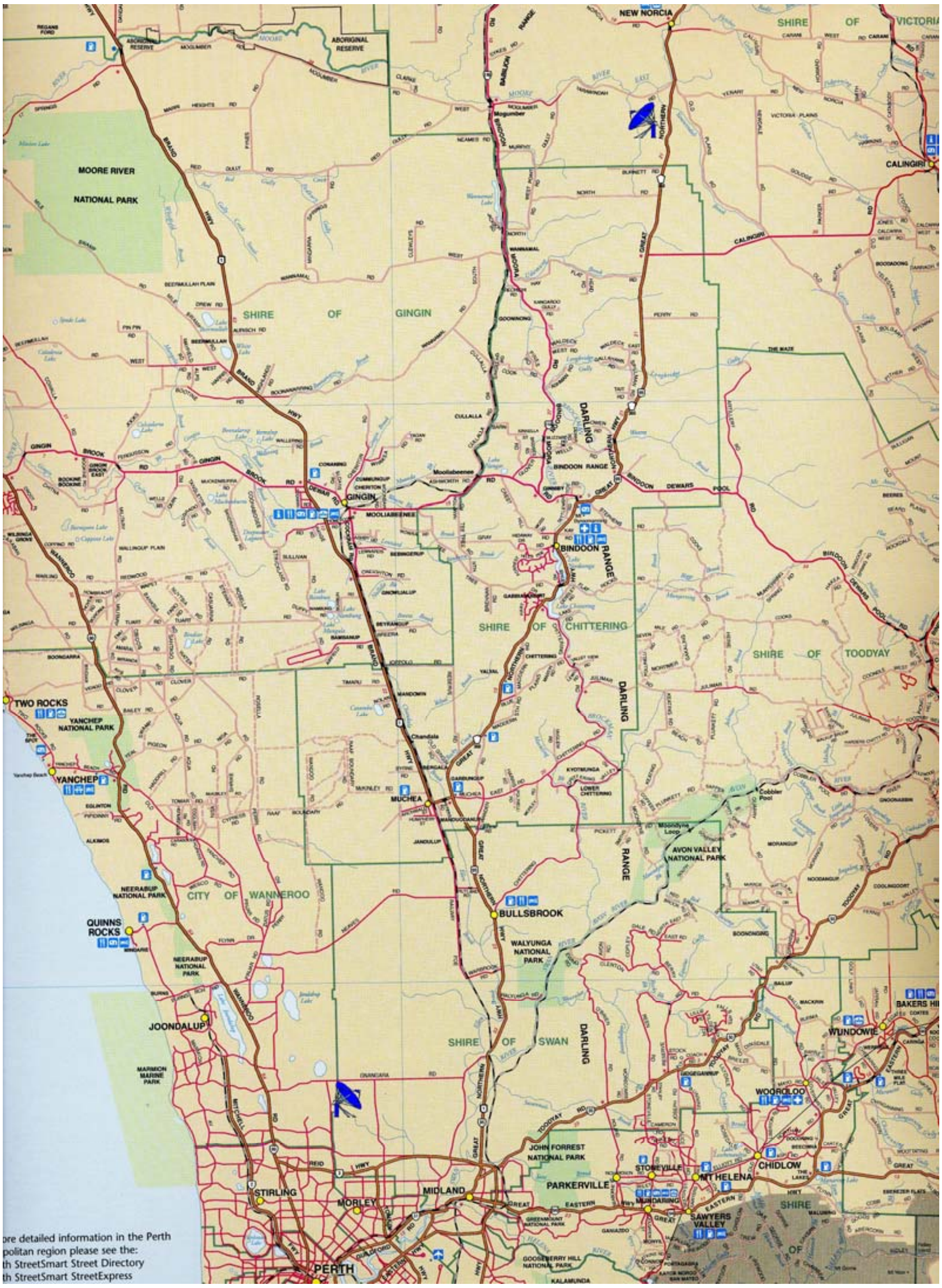

Figure 32: New Norcia (NNO) Area Map

6.5.1.2 Access

Site visits require a confirmed Station Intervention form sheet.
Perth has an international airport. The New Norcia site is located on the Great Northern Highway. The exit to the access road of the site is signposted.
Accommodation can be arranged through the station manager.

6.5.1.3 Entry Requirements

Visitors from overseas require a current passport and an entry visa for Australia.

6.5.1.4 Climate

A summary of the weather characteristics for the New Norcia area is given below:

Warmest month	February
Average maximum daily temperature in February	29.9° C
Highest recorded temperature in February	44.6° C
Lowest recorded temperature in February	8.7° C
Coldest month	July
Average minimum daily temperature for July	9.0° C
Highest recorded temperature in July	24.7° C
Lowest recorded temperature in July	1.2° C
Average annual rainfall	893 mm

6.5.1.5 Management

There is no ESA on-site representative at the New Norcia site.
The Maintenance and Operations (M&O) of the site is provided by Stratos.

6.5.1.6 Local Contact

The local point of contact for the New Norcia station is:

New Norcia Station Manager
Mr. John Holt
email: John.Holt@stratosglobal.com
Tel +61-8-93020-400
Fax +61-8-9321 5526

6.5.1.7 Logistics

Postal delivery is via Xantic at the Perth International Telecommunications Centre. The postal address is:

Xantic BV
Perth International Telecommunications Centre
PO Box 1115
Wangara
W.A. 6065
Australia

Delivery is via Xantic at the Perth International Telecommunications Centre. The delivery address is:

Xantic BV
Perth International Telecommunications Centre
ESA Operations New Norcia
620 Gnangara Road
Wangara
W.A. 6065
Australia

The postal address of the Customs Manager is:

Global Transport Logistics
Attn Mr Peter Thornett
73 North Lake Road
Myaree 6154
Western Australia
Phone +61 8 9333 5000
Fax +61 8 9333 5050
email: peter@globaltransport.com.au

6.5.2 STATION SERVICES

Figure 33 shows the New Norcia (NNO) Site Plan.

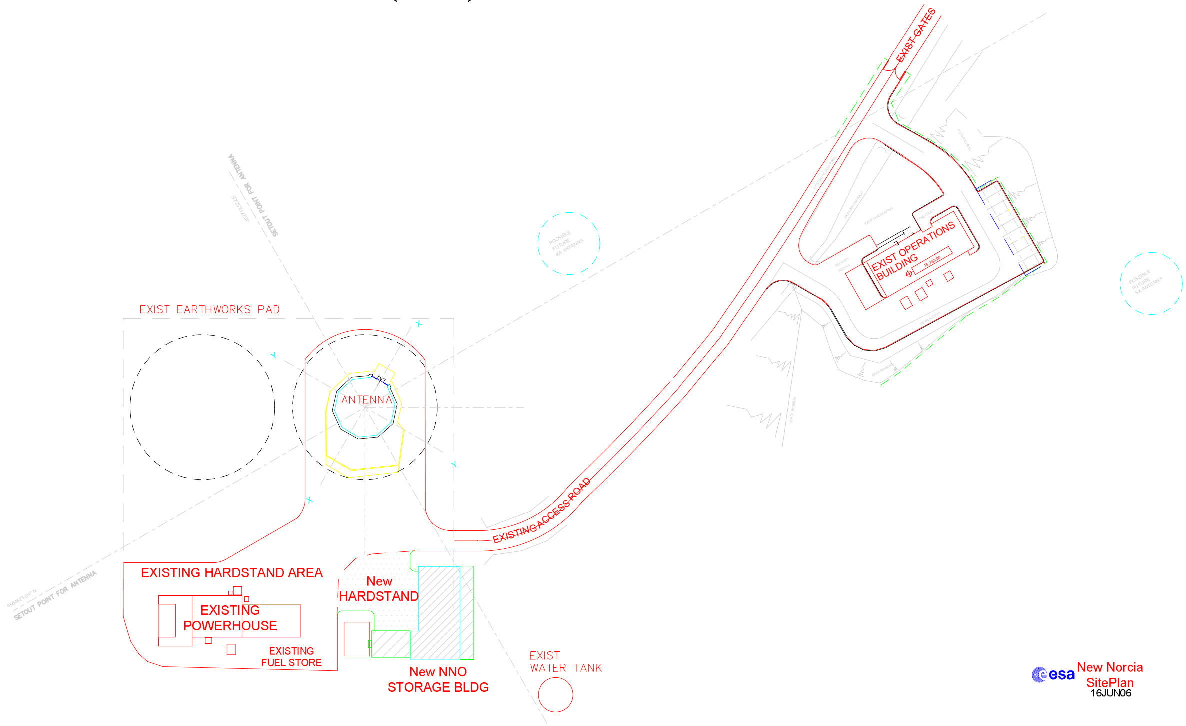

Figure 33: New Norcia (NNO) Site Plan

6.5.2.1 Security

The site is fenced and guarded 24/7. An access control and surveillance system is installed.

6.5.2.2 Power

The power plant is designed to furnish a reliable electricity supply to all power consumers. It provides a short-break (SB) power supply using Diesel Generators, and a no-break (NB) power supply using Static Converters and Batteries. Via low voltage switches the electricity (3x 400V, 50 Hz) is distributed to the consumer groups.
Public power into the power plant is rendered by one 33 kV medium voltage line and two transformers of 500 kVA.
Two Diesel Generators supply each 400 kVA within 1-2 minutes after public power failure. Two Static Converters supply each 300 kVA. The Battery capacity allows for a maximum bridging time of 6 minutes.

6.5.2.3 Air Conditioning

The station air conditioning system supplies air to the main building equipment rooms at a temperature of 24°C + 10%, with a controlled humidity of 50% - 70% relative humidity.

6.5.2.4 Communications

The New Norcia station is connected via the ESA Operations Network (OPSNET) in a triangular setup (New Norcia, Perth, ESOC) using 2 Mbps international private leased circuits (IPLCs). The connectivity into the New Norcia site is diversely routed through two fibre optic links.
All non-operational and Internet traffic is routed via the Xantic Administrative Network.

6.5.3 NEW NORCIA-1 (NNO-1) TERMINAL

Figure 34 shows the New Norcia-1 (NNO-1) antenna, which provides S- and X-band transmit, as well as S- and X-band receive capability (SX/SX).

Figure 34: New Norcia-1 (NNO-1) Antenna

6.5.3.1 Services and Performance

The New Norcia-1 (NNO-1) terminal provides the following services:

- Tracking
- Telemetry
- Telecommand
- Radiometric Measurements (Ranging, Doppler, Meteo, Delta-DOR)
- Radio Science

Table 8 details the New Norcia-1 (NNO-1) Performance Characteristics. For the definition of individual characteristics see 5.6

1	Rev. 2.4		41	DOWNLINK	
2	18-Sep-2008	NEW NORCIA-1 (S X / S X)	42	L-band RX band [MHz]	N/A
3	TERMINAL	NNO-1	43	L-band Polarization	N/A
4	Longitude	116 deg 11' 29.40" E	44	L-band G/T [dB/K]	N/A
5	Latitude	31 deg 02' 53.61" S	45	S-band RX band (MHz)	2200-2300
6	Altitude [m]	252.2558	46	S-band Polarization	RHC, LHC
7	Antenna Diameter [m]	35	47	S-band G/T [dB/K]	37.5
8	S-band Beamwidth [deg]	Rx: 0.28 Tx: 0.30	48	X-band RX band [MHz]	8400 - 8500
9	X-band Beamwidth [deg]	Rx: 0.064 Tx: 0.074	49	X-band Polarization	RHC, LHC
10	Ka-band Beamwidth [deg]	N/A	50	X-band G/T [dB/K]	50.1
11	Antenna Speed [deg/s]	Az: 0.4 deg/s El: 0.4 deg/s	51	Ka-band RX band [MHz]	N/A
12	Azimuth Range [deg]	0 to 480	52	Ka-band Polarization	N/A
12	Elevation Range [deg]	0 to 90	53	Ka-band G/T [dB/K]	N/A
14	Search / Acquisition Aid	Perth Steering	54	Modulation Schemes	IFMS compliant
15	Tilt Facility	NO	55	Carrier Freq Search Range	+/- 1.5 MHz
16	Tracking Mode	Program / Slave	56	Subcarrier Frequency	2 kHz to 1.2 MHz
17	Angular Data Accuracy (autotrack+pointing error)	N/A	57	Data Rates	IFMS compliant: - 1.2 Mbps (RCD) - 2 Mbps (SCD LS)
18	FUNCTIONALITIES		58	Data Coding Scheme	R-S, Convolutional and Concatenated
19	TM/TC Standards	PCM, CCSDS	59	INTERFACES	
20	TM/TC Redundancy	YES	60	TM/TC Connectivity	TCP/IP SLE (TMTCS)
21	Comms Redundancy	YES	61	Rng/Dop Connectivity	FTP (IFMS)
22	Ranging	IFMS compliant	62	Meteo Connectivity	FTP (IFMS)
23	Doppler	YES	63	Angles Connectivity	N/A
24	Meteo	YES	64	Pointing Format	STDM
25	Autotrack Antenna Angles	NO	65	Tracking Interface (ESOC)	FDS
26	Delta-DOR	YES			
27	Radio-Science	YES			
28	Frequency & Timing	MASER			
29	UPLINK				
30	S-band TX band [MHz]	2025-2120			
31	S-band Polarization	RHC, LHC			
32	S-band EIRP [dBm]	127 (SHPA) 117 (SLPA)			
33	X-band TX band [MHz]	7145 - 7235			
34	X-band Polarization	RHC, LHC			
35	X-band EIRP [dBm]	137 (XHPA) 127 (XLPA)			
36	Ka-band TX band (MHz)	N/A			
37	Ka-band Polarization	N/A			
38	Ka-band EIRP [dBm]	N/A			

39	Modulation Schemes	IFMS compliant			
40	Subcarrier Freq. [kHz]	8 or 16 kHz			

Table 8: New Norcia-1 (NNO-1) Performance Characteristics

6.5.3.2 Antenna Horizon

Figure 35 shows the New Norcia-1 (NNO-1) Antenna Horizon Mask.

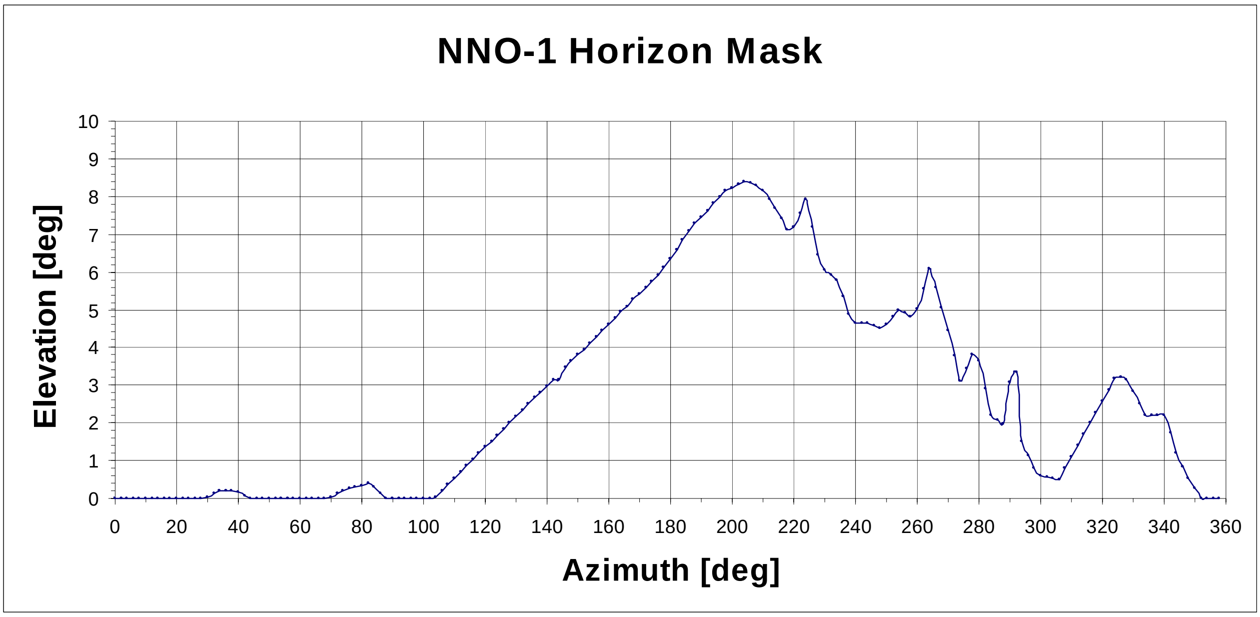

Figure 35: New Norcia-1 (NNO-1) Antenna Horizon Mask

6.5.3.3 Functional Description

Figure 36 shows the New Norcia-1 (NNO-1) Block Diagram, which is used for the functional description.

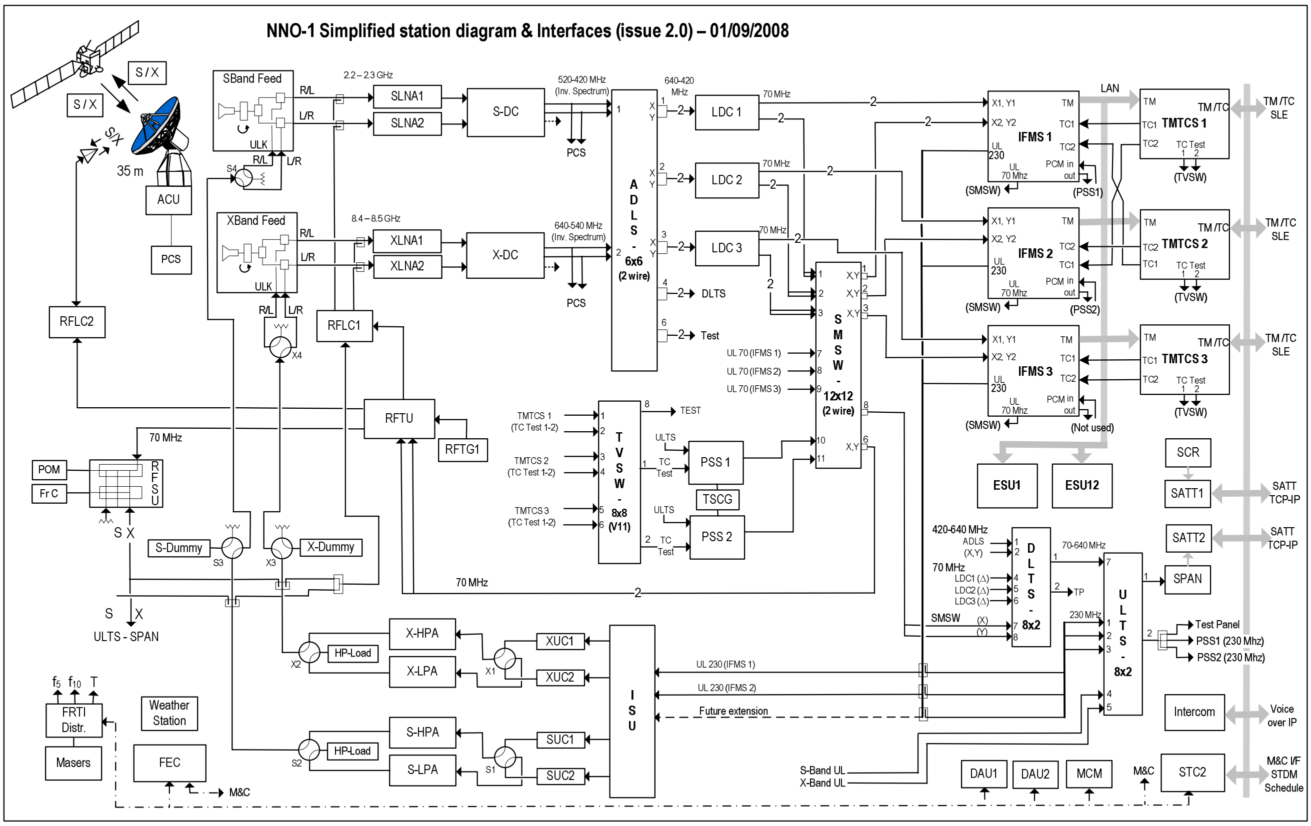

Figure 36: New Norcia-1 (NNO-1) Block Diagram

6.5.3.3.1 Antenna

The S- and X-band transmit and S- and X-band receive (SX/SX) Cassegrain Beam Wave Guide antenna is fitted with a shaped 35m parabolic main reflector and a shaped hyperbolic subreflector in an elevation over azimuth mount. Auto-tracking of S- and X-band signals is not possible. An S- and X-band test antenna with reflective converter allows for signal delay calibration. An air-conditioning system outside the antenna tower provides cooling of the antenna tower.
The antenna pointing is performed by the Antenna Control Unit (ACU), which affects both axes using drive amplifiers, motors and gearboxes. Optical position encoders deliver the azimuth and elevation positions to the ACU.
The incoming electromagnetic wave is conveyed via the reflector, subreflector and beam waveguide system to a frequency sensitive dichroic mirror, that splits the S-Band and the X-Band signals, to the respective feeds, which together with their polarizer matches the free space field electromagnetic configuration to the waveguide modes.
The coexisting receive and transmit signals for each polarisation inside each feed are separated by Diplexer filters. The receive waveguide branches are fed to cryogenically cooled Low Noise Amplifiers (LNAs), which amplify the Right-Hand-Circular (RHC) and Left-Hand-Circular (LHC) signals, which subsequently can be phase adjusted by Phase Shifters.

The S-band signals [2200-2300 MHz] are down-converted to L-band [520-420 MHz]. The X-band signals [8400-8500 MHz] are down-converted to L-band [640-540 MHz]. The downlink signals are then transferred for telemetry processing.
The uplink signal coming from telecommand processing at 230 MHz is delivered to S-band or X-band transmission. It is routed either to the S-band Up-Converter (SUC) for conversion to [2025 - 2120 MHZ] and via a switch to the S-band High Power Amplifier (SHPA) or S-band Low Power Amplifier (SLPA); or to the X-band Up-Converter (XUC) for conversion to [7145 - 7235 MHZ] and via a switch to the X-band High Power Amplifier (XHPA) or X-band Low Power Amplifier (XLPA)
A transmit waveguide assembly routes the RF signal to the X-band feed or S-band. The transmitted polarisation is selected with the polarization switch, which routes the RF signal to the uplink arm of one of the two Diplexers, one for each polarisation and frequency band. To avoid radiating the RF power to the antenna, the RF signal can also be routed via a set of switches to one of the two high power dummy loads.
The X-Band Feed or S-band Feed (including polarizer) matches the incoming waveguide electromagnetic mode with the free space field configuration. It circularly polarises the uplink signal coming from one of the two Diplexers. The Beam Wave Guide (BWG) system conveys the high power RF flux from the X-Band and S-Band feeds to the antenna sub-reflector and Main reflector where it is forwarded to free space.
Concurrent radiation in X-band and S-band is possible.

6.5.3.3.2 Tracking

The tracking of spacecraft is possible by pointing the antenna in program track mode based on orbital predictions or slaving the antenna to PER-1 in autotrack mode using the same received signal.
For program track the antenna Azimuth and Elevation pointing angles are derived from predicted Spacecraft Trajectory Data Messages (STDM's) or State Vectors in the Front End Controller (FEC). Autotrack is achieved by slaving the antenna to the PER-1 antenna.

6.5.3.3.3 Telemetry

The downlink L-band signals are fed via the Antenna Downlink Switch (ADLS) into tuneable L-band down-converters for conversion to 70 MHz intermediate frequency (IF) and further signal routing through the 70 MHz switch (SMSW).
The 70 MHz signals are combined and demodulated in the Intermediate Frequency Modem System (IFMS), which provides remnant and suppressed carrier demodulation. Doppler predictions coming from Spacecraft Trajectory Data Messages (STDM) information improve the signal acquisition process. The Telemetry Channel Decoding System (TCDS) hosted inside the IFMS performs frame synchronisation, time tagging, Viterbi and Reed-Solomon decoding. The output data is transferred to the Telemetry and Telecommand System (TMTCS) for data structure processing according to Space Link Extension (SLE), which ultimately delivers the telemetry data via OPSNET to the Spacecraft Control Systems.
All three telemetry chains are redundant and the various switches allow flexible signal routing.

6.5.3.3.4 Telecommand

The Telemetry and Telecommand System (TMTCS) receives SLE conformant Telecommand data via OPSNET from the Spacecraft Control Systems. It provides telecommand data and clock to the Intermediate Frequency Modem System (IFMS) Uplink Modulator (ULM), which provides the Phase Shift Key (PSK) modulation of the telecommand bit stream onto a sub-carrier, which is then used to phase modulate the uplink carrier at 230 MHz. Via the Antenna Uplink Switch (AULS) the uplink signal is routed either to the S band or X-band antenna uplink.
The telecommand chains are redundant and the various switches allow flexible signal routing.

6.5.3.3.5 Radiometric

The radiometric measurements comprise Doppler, Ranging, Meteorological, Delta Differential One-way Range (Delta-DOR) and Radio Science measurements.
The station design is such that any of the three downlink chains can be used for Telemetry reception and for radiometric measurement including Delta-DOR and Radio Science Investigation (RSI).
The Intermediate Frequency Modem System (IFMS) Ranging and Telemetry Demodulators deliver integrated Doppler measurement of the received carrier phase, known as Doppler-1 and Doppler-2.
The IFMS Uplink Modulator generates the ranging tone, which is Phase-Shift-Key (PSK) modulated by a sequence of codes. This ranging tone is phase modulated on the uplink carrier and can be transmitted simultaneously with the telecommand subcarrier. The IFMS Ranging Demodulator pre-steers the expected downlink carrier in case of coherent transponding of the spacecraft based on Spacecraft Trajectory Data Messages (STDMs), demodulates the received tone and compares the received codes with codes replica to derive the two-way propagation delay.
The IFMS meteorological unit gathers outside air temperature, pressure, humidity, wind force and direction information.
All radiometric measurement data are delivered through OPSNET to Flight Dynamics for processing.
For Delta-DOR, the IFMS records spectra for further processing in a correlator to derive the phase of the received satellite electromagnetic wave with respect to the same reception at a another location on earth. Angular calibration of the signal is achieved by measuring known radio sources, e.g. quasars, before and after the satellite measurement. Due to the amount of data collected, the DDOR samples are stored in the External Storage Units (ESU). Two redundant ESU are available, allowing DDOR to be performed from any two of the three redundant downlink chains.
For Radio Science Investigations the IFMS records spectra, doppler and AGC measurements of the received S- and X-band downlinks. In addition dual frequency ranging can be performed, i.e. one uplink X-band signal containing the ranging code is coherently transponded on-board to an X-band and S-band downlink signal, which are received simultaneously by two IFMS Ranging Demodulators, which both use the same codes replica. The frequency dependent downlink propagation delay can be measured in this way.
All Radio Science measurements are delivered through OPSNET to the Science Community for processing.

6.5.3.3.6 Monitoring and Control

The monitoring and control (M&C) system allows full local and remote control over the terminal. It is based on a hierarchy of M&C systems: the Station Computer (STC), the Front End Controller (FEC), the Monitoring and Control Module (MCM) and Local Man Machine Interfaces (MMI) on the various devices.
The Station Computer (STC) is composed of a local server, a local workstation and a remote workstation housed in the Ground Facilities Control Centre (GFCC). Mission specific terminal configurations are normally affected through pre-validated macro-procedures, also individual equipment configurations are possible. The STC interacts through a set of subsystem controllers, either in separate units or implemented in complex devices (e.g. IFMS/TMTCS), with all the terminal equipment. Remote spectrum visualisation is supported.
The Front End Controller (FEC) is the subsystem controller for all the antenna front end devices and responsible for antenna steering.
The Monitoring and Control Module (MCM) is the subsystem controller for all simple back end devices, e.g. switches.
In case of failure of the monitoring and control system, the terminal can be locally operated from the individual equipment Local Man Machine Interfaces.

6.5.3.3.7 Frequency and Timing

The frequency reference generation is based on a Hydrogen Maser with very long term frequency stability. The frequency distribution system coherently derives 5, 10 and 100 MHz signals and amplifies them for distribution to the devices.
The time reference is based on Universal Time Coordinated (UTC), and synchronised with the Global Positioning System (GPS) delivered time. The time is distributed without the calendar year via IRIG-B 5 MHz, 1 kHz and 1 pulse per second (pps) signals. The calendar year is configured separately on the devices.

6.5.3.3.8 Test and Calibration

The objective of the test and calibration function is to validate the telemetry and telecommand functions, and to calibrate the Ranging and Doppler function before the operational satellite pass.
The telemetry function is tested with simulated spacecraft telemetry, which is generated in the Portable Satellite Simulator (PSS), frequency converted to the appropriate downlink frequency and injected into the antenna via a test antenna, so called Telemetry Test Long Loop (TTLL) configuration. The telemetry is then delivered in a Data Flow Test (DFT) to the spacecraft control system for verification.
The telecommand function is tested by demodulating and decoding of the 230 MHz uplink signal and comparing it to known telecommand formats. Based on the telecommand received in the PSS the simulated telemetry generation can be altered. The test telecommands originate from the spacecraft control system.
The ranging and doppler function is calibrated by conducting a ranging and doppler measurement in an antenna loopback configuration, in which the uplink frequency is transponded to the downlink frequency. The emulated transponding involves reception of the uplink frequency by the test antenna and conversion to the downlink frequency in the Reflective Converter (RFLC) with

subsequent transmission via the test antenna back into the main antenna. This calibration measures the station internal signal delay and any frequency offset.
For alignment of the antenna mechanical axis, an optical target is available.
Test tools for integration and performance validation activities are not described.

6.5.4 ADDITIONAL FACILITIES

6.5.4.1 GPS-TDAF

A Global Positioning System (GPS) dual-frequency receiver system with geodetic accuracy is installed on the site, which delivers continuous measurements to the ESOC Navigation Facility.

6.5.4.2 GESS

A Galileo Experimental Sensor Station with geodetic accuracy is installed on the site, which delivers continuous measurements to the ESOC Navigation Facility.

6.5.5 PLANNED DEVELOPMENTS

It is planned to upgrade the NNO-1 terminal with Ka-band receive capability for support of the Bepi-Colombo mission.