Space Operations and Astronaut Training

Communications and Ground Stations

General Description of Ground Segment

DLR

6 Weilheim

6.1 Site

6.1.1 Location

The Ground Station Complex Weilheim is located about 60 km southwest of Munich and about 30 km south of Oberpfaffenhofen (see Figure 4-1: Location of GSOC Oberpfaffenhofen).

The figure 6-1 shows the Weilheim premises indicating the buildings and antennas.

6.1.2 Access and access requirements

Site visits require a formal invitation, a valid passport or ID card and a confirmed site access form sheet. For longer stays the visitor is registered on a list at the gate.

Public Transportation: none

By car:
From Munich take the state road B2 to Weilheim. In Weilheim turn right in direction to Landsberg and follow the road for approx. 5 km. Then follow the DLR signs for approx. 4 km.

By train:
There is an hourly connection by train between Munich central station and Weilheim (for details see http://reiseauskunft.bahn.de). Travel time is 40 minutes. From Weilheim city to the DLR ground station premises taxis are available.

6.1.3 Point of Contact

The PoC for the Ground Station Weilheim is the Station Manager:

DLR
Zentrale deutsche Bodenstation
Weilheim/Lichtenau
Mr. Martin Häusler
Reichenbergstrasse 8
82362 Weilheim/Lichtenau
Tel.: +49 8809 14 248
Fax: +49 8809 14 1095
Mail: Martin.Haeusler@dlr.de

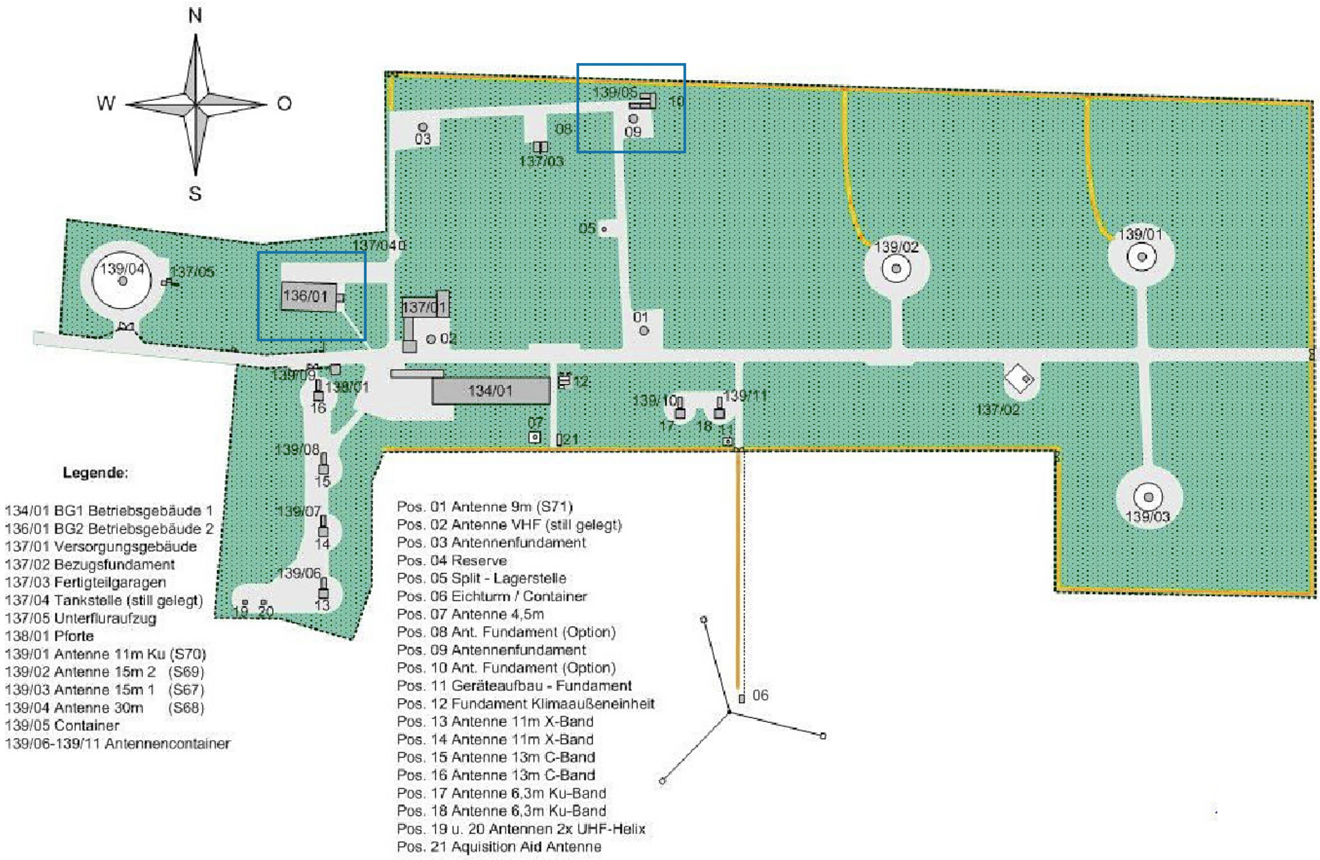
6.1.4 Logistics

Weilheim logistics is handled via GSOC. For details see chapter 5.1.4.

6.1.5 Site security

The Ground Station security guard at the main gate is in attendance 24h/7d. The site perimeter is secured with a 2,8m fence.

Figure 6-1:
Site plan of Weilheim Ground Station; Buildings BG2 and 139/05 indicated



6.1.6 Climate

The pre-alpine area of South-Bavaria experiences considerable precipitation with varying snow falls in winter and variable rainfall levels throughout the year. Winds are usually low and do not exceed 100 km per hour. Gusts do not exceed 160 km/h.

A summary of the weather characteristics for the Weilheim area is given in table 6-1.

6.1.7 Environmental conditions

Table 6-2 lists the environmental conditions which affect the operations of the installations.

Table 6-1 (left): Weilheim weather characteristics

Weilheim weather characteristics	
Warmest month:	July
Average daily medium temperature for July:	17°C
Highest recorded temperature in July:	37°C
Lowest recorded temperature in July:	2°C
Coldest month:	January
Average daily medium temperature for January:	-2°C
Highest recorded temperature in January:	10°C
Lowest recorded temperature in January:	-25°C
Average annual rainfall:	1040 mm

Table 6-2 (bottom): Weilheim Ground Station Environmental conditions

	Operational Conditions	Survival Conditions
Outside temperature	-30°C – 50°C	-35°C – 60°C
Inside equipment	0°C – 40°C	N/A
Wind degraded performance	≤ 75 km/h (gusts < 100 km/h) ≤ 120 km/h	≤ 200 km/h (antenna in survival position) < 150 km/h (antenna in operational position) N/A
Rain	100 mm/h	N/A
Snow	≤ 30 mm/h (heating system required)	≤ 100 mm/h; max 300 mm at 90 km/h wind
Ice (on not heated surfaces)	≤ 5 mm	≤ 30 mm at 90 km/h wind
Humidity	≤ 100%	N/A
Solar radiation	1 kW/m2	N/A
Seismic	N/A	0,3 g horizontal 0,1 g vertical

6.2 Antennas

The Weilheim Station complex provides communications with earth orbiting, geostationary spacecrafts, and deep space probes. The antennas supporting Multi-Mission purposes are listed in the table 6-3.

The 13m Ka-Band antenna will be installed in 2012. The 30m antenna is currently not connected to the Switch Matrix (see chapter 6.5.1 for details).

There are additional 9 Antennas on the site operated by DLR on behalf of external customers.

6.2.1 Antenna overview

An overview of the antennas in Weilheim which are used for Multi-Mission operations is provided in the table 6-3.

Table 6-3: Weilheim Antennas for Multi-Mission operations (status January 2012)

	Antenna					
Designation	13m Ka	30m	15m I	15m II	11m	9m
GDS Name	S73	S68	S67	S69	S70	S71
Band (1)	Ka	Multi-Band (3)	S	S	Ku	S
Frequency [GHz] (Receive)	18,1 – 21,2 25,5 – 27,5	N/A	2,2 – 2,3	2,2 – 2,3	10,70 – 12,75	2,2 – 2,3
Frequency [GHz] (Transmit)	22,55 – 23,15 27,5 – 31,0	N/A	2,025 – 2,12	2,025 – 2,12	13,75 – 14,50	2,025 – 2,12
3dB Beam width (transmit) [deg]	0,056	0,35 (S-Band)	0,66	0,66	0,15	1,03
Gain [dBi] @ [GHz]	65,5 @ 20	54 @ 2,295	47,8 @ 2,25	48,3 @ 2,25	60,8 @ 12,75	43,1 @ 2,25
G/T [dB/K] @ elevation [°]	42 @ 10	35 @ 5 (S-Band)	26,7 @ 5	27,8 @ 5	36,3 @ 10	≤21,5 @ 25
Pointing Accuracy [deg]	±0,001	±0,001	±0,03	±0,03	±0,01	±0,1
EIRP [dBW] @ [GHz]	90 @ 30	N/A	58..78 @ 2,075	59..79 @ 2,075	≤ 95 @ 14,25	≤ 60 @ 2,3
Polarization	RHC/LHC H/V	RHC	RHC/LHC	RHC/LHC	RHC/LHC H/V	RHC/LHC
Telemetry in Band	Ka	N/A	S	S	Ku	S
Command in Band	Ka	N/A	S	S	Ku	S
Tracking in Band	Ka	N/A	S	S	Ku	S
Tracking Speed [°/s] AZ EL	15 6	1,5 1,0	15 6	15 6	2 2	≤ 6 ≤ 6
Category (2)	A	A, B	A	A	A	A

(1) Designation according to IEEE classification
(2) A: near earth network; B: deep space network; see definitions in §3.1
(3) Because of easy access to the feed the band can be changed easily. Possible bands: L, S, C, X

6.2.2 Horizon Mask

Each antenna has a unique horizon mask. A typical mask for the Weilheim location is shown in the figure 6-2.

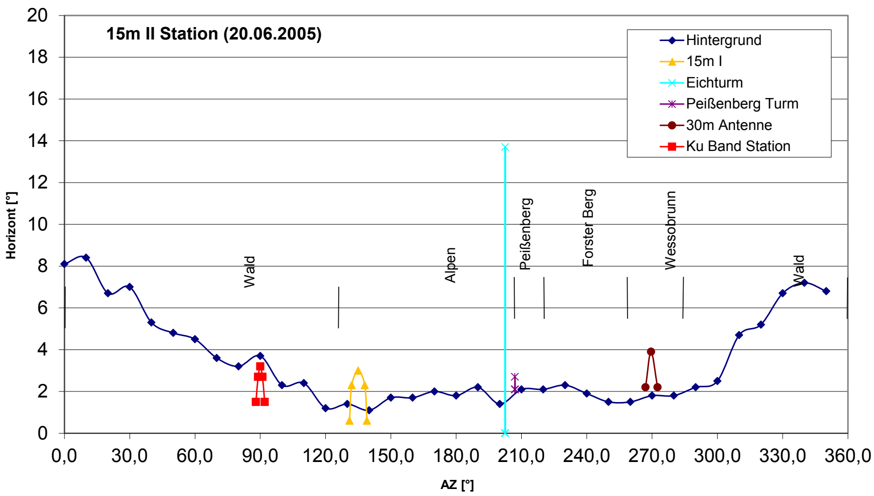


Figure 6-2:
Horizon Mask of the 15m Antenna S69 (0°=North)

6.2.3 Visibility

The geostationary visibility above 10° elevation is between –50° and +70° longitude (compare figure 6-3).

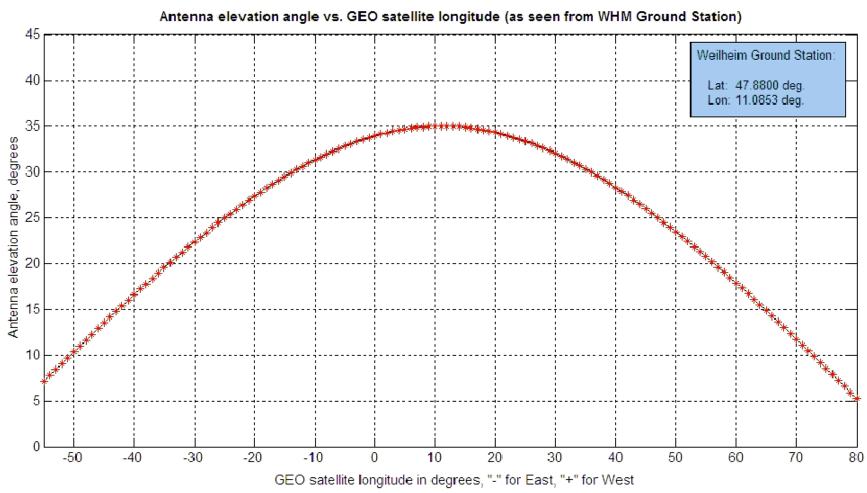


Figure 6-3:
Visibility for GEO satellites from Weilheim Ground Station

6.3 Buildings

The Ground Station Weilheim comprises several buildings. The buildings 136/01 (BG2) and 139/05 accommodate control rooms and related infrastructure (see Figure 6-1: Site plan of Weilheim Ground Station). The Building BG2 houses the Multi-Mission antenna control room, the building 139/05 will house the Weilheim Backup Control Centre (BUCC).

The BUCC is planned to be an "emergency" control room wherein the capabilities for monitoring and commanding of satellites are installed. In case the Control Centres at GSOC-OP become inoperable, the BUCC assume this function for a limited timeframe and maintain the health of the spacecrafts. The BUCC will be outfitted for the following satellites:

- GRACE-1 and GRACE-2
- TerraSAR-X
- Tandem-X

The BUCC will be operable for telemetry and command in summer 2012; connections (ISDN) to other LEOP ground stations will be implemented later.

6.3.1 Security

There is no additional access control in building BG2; building 139/05 is secured by keys.

6.3.2 Uninterrupted Power supply

All the power supply comes from the mains power grid. The mains electricity goes through UPS (Uninterrupted Power Supply) block before being connected to equipment. The UPS is to avoid short-time power supply interruption that could lead later to troubles in equipment functionality.

In case of long-term power break, there will be no problem to get enough electrical power inside of the station. A powerful diesel generator can produce at least 1.2 MW within 10 seconds, which is sufficient to drive every antenna in operational mode.

A summary of the electrical characteristics of Weilheim ground station are given in table 6-4.

After installation of the new 13-meter Ka-band antenna the UPS capability will be at its limit and therefore will be upgraded.

The BUCC is also connected to the UPS.

6.3.3 Air conditioning

Air conditioning is provided in BG2 for the control room (106), the server room (105) and the test room (108); in building 139/05 for the rooms 101, 102 and 104 (compare Figure 6-5 and Figure 6-7). The limits are set at 50-70% for humidity and temperature of 20-22° Celsius.

6.3.4 Frequency and Timing System

The ground station is equipped with an automatic redundancy switching frequency and timing system comprising the following components:

- GPS controlled BVA standards
- GPS Station Clocks and Time Code Readers
- Frequency and Time Distribution Unit

The ground station time standards are synchronized to Universal Time Coordinated (UTC). Synchronization is accomplished via GPS receivers.
A caesium beam frequency standard with long-term stability of five parts in 10-12 /day is the primary source for time and time interval measurements at the station complex. A GPS referenced rubidium standard is used as backup. The station complex can provide both serial time, for use with recorded data, and parallel time, for use with automatic data processing facilities. For this purpose two NTP servers provide time sync to the computer network with the standards as described in Table 6-6.

6.3.5 Computer Network

All servers and network elements are interconnected by a structured twisted pair cable system (CAT 6) to a switched 10/100 Mbit Ethernet based Local Area Network (LAN). There are two physically separate LANs (Office LAN and OPS LAN).

Identical unmanaged switches are used for these interconnections. A third one is installed for redundancy.

The equipment installed inside the antenna basements of each Station is connected via fiber links to the LAN. This means, that all subsystems of the antennas are accessible from the station computers to perform necessary Monitoring & Control functions.

Protocols used at the Weilheim Ground Station LAN are:

- TCP/IP
- NETBEUI (not for operations).

6.3.6 WSP-C (Weilheim SLE Provider)

WSP-C supports SLE RAF and CLTU services and acts as a SLE Provider to send telemetry and receive telecommand at the Weilheim ground station.

It is connected to the antenna system and receives the telemetry after it has been digitalised, and sends it to the SSB system at GSOC. Alteratively it receives telecommands from the SSB and sends them to the Antenna system for uplink radiation.

The WSP-C can support the CORTEX and some other baseband equipment protocols

Table 6-4: Electrical characteristics of Weilheim Ground Station

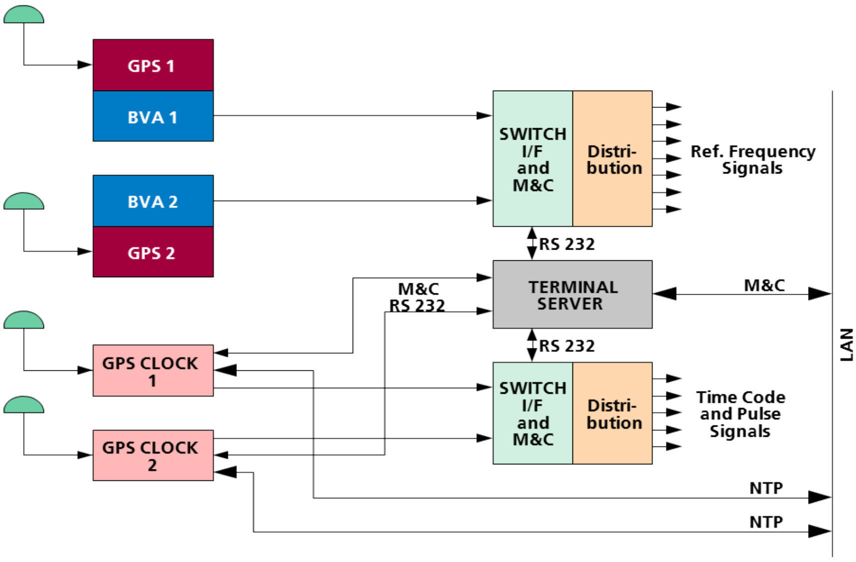
Average need in electrical power	400 kVA
UPS capability	3 x 200 kVA
Diesel generator	1,2 MW

Table 6-5: Weilheim frequency standard characteristics

Type: Dual GPS controlled BVA`s	OSCILLOQUARTZ, OSA5581, automatic redundancy switching
station reference frequency	1, 5 and 10 MHz
accuracy GPS-BVA	3 x l0-12 with or without Selective Availability (SA)
stability: GPS-BVA GPS-Rubidium Standard	 3×10^{-12}/ day 2×10^{-12}/ day

Table 6-6: Weilheim time standard characteristics

Type: GPS-Clocks	True Time, XL-DC 652 automatic redundancy switching
timing accuracy	< 40 ns rms, (150 ns peak) to UTC/USNO with Selective Availability (SA) and tracking 8 satellites
time code	NASA 36, IRIG B, NTP



BVA = Very Low Noise OCXO (GPS controlled)
NTP = Network Time Protocol

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30.01.2002

Figure 6-4: Weilheim Frequency and Timing system

6.5 Subsystems

6.5.1 Ground Station subsystems overview

The Weilheim Ground Station concept is depicted in the figure 6-9.

The station concept is to use as far as possible standard baseband equipment for the different antennas and applications. This concept has been realized by building up a pool of TT&C baseband units, which can be connected to the different antenna- and RF-systems by means of switch matrix. This solution allows flexible and cost-effective usage of equipment in conjunction with a high grade of redundancy. Furthermore, it allows the support of special requirements (e.g. multiple TM channel processing or extremely high availability requirements) by job-splitting on multiple devices.

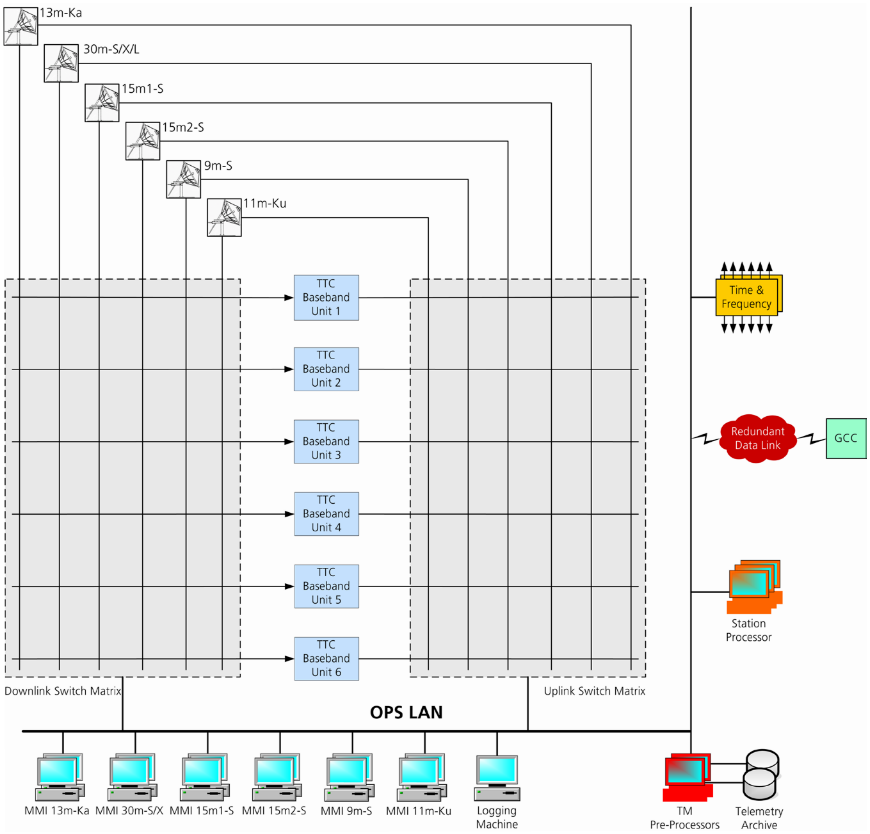

Figure 6-9: Weilheim Ground Station Concept

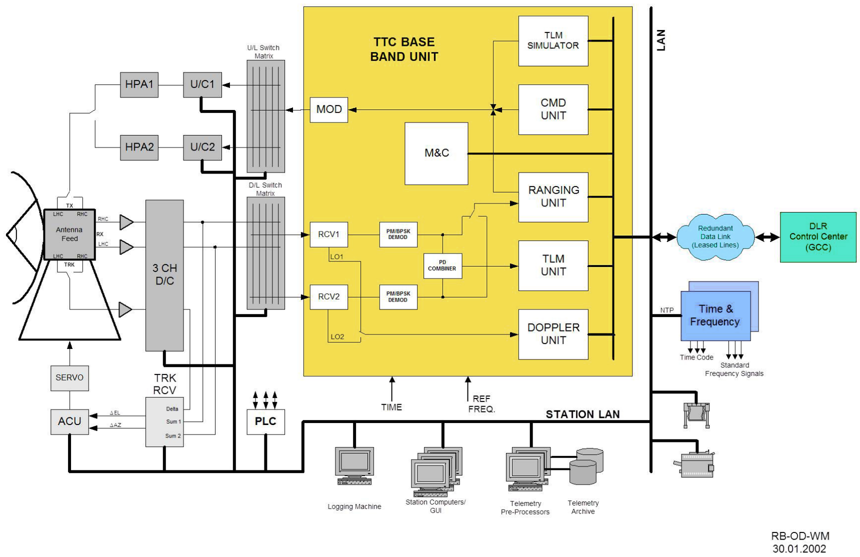

Figure 6-10: Block diagram of a ground station antenna (15m S-Band)

6.5.2 Baseband Subsystem

The overall station IF - Baseband System consists of several identical CORTEX–systems, which are cross-switched to the different station systems and configured in references to the actual satellite missions (CORTEX is a registered trademark of the former IN-SNEC Inc., now Zodiac Data Systems).

Most functions are performed digitally, either by standard microprocessors or DSPs or by means of dedicated digital components (synchronisation, coding). The following functions and signal processing performances are listed:

- IF reception
- Telemetry processing
- IF modulation / demodulatio
- Satellite ranging
- Satellite telecommanding
- Telemetry simulation
- Time code decoding and data time-tagging.
- Reference frequency
- Coding and Synchronization

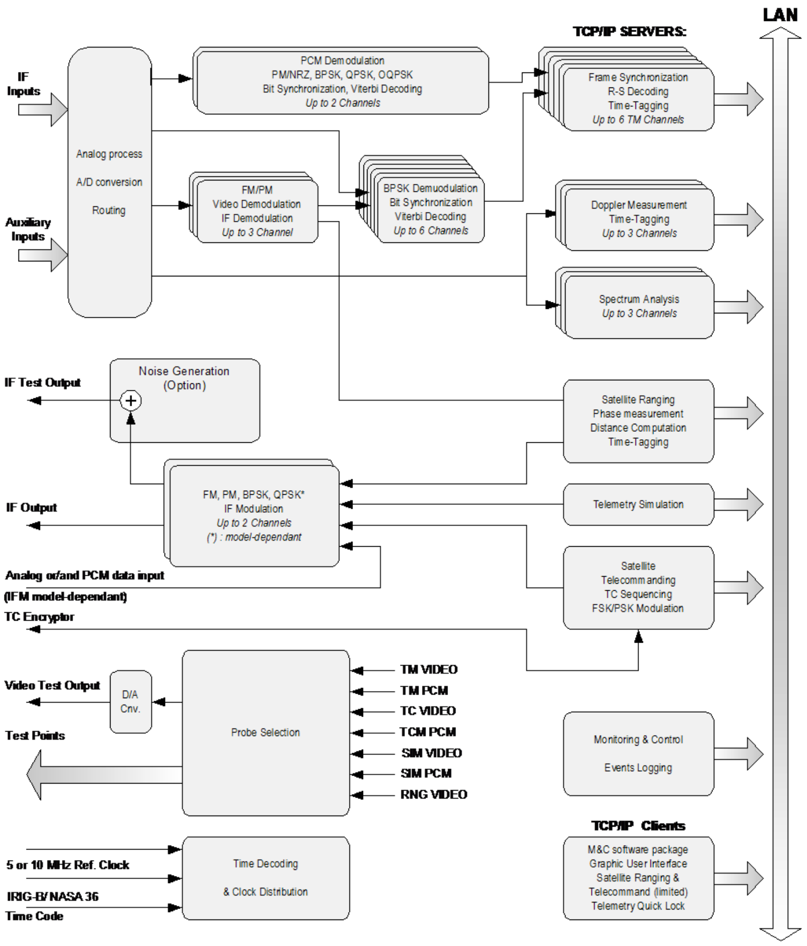

Figure 6-11:
Block diagram of the IF Baseband system

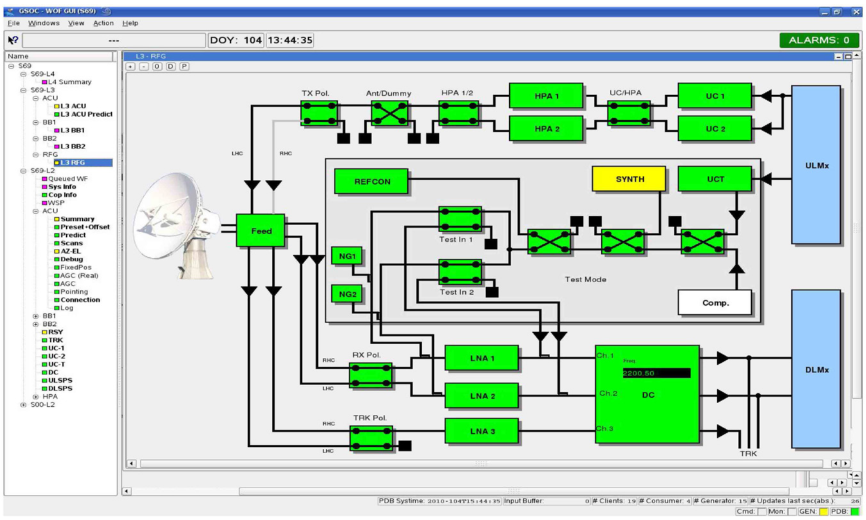

Figure 6-12:
Weilheim Monitoring and Control System GUI

7 Communications Infrastructure

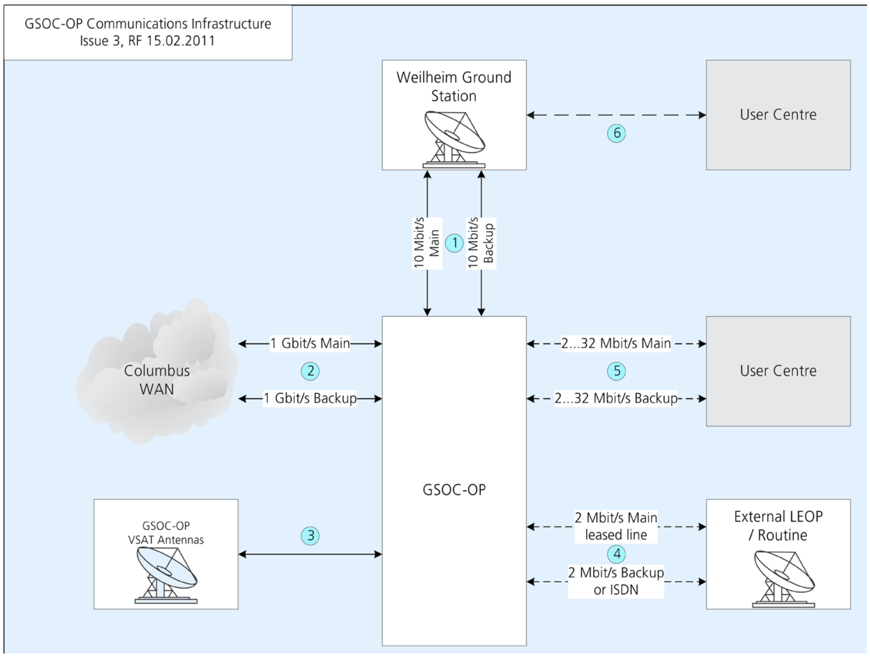

Figure 7-1: Communications System overview (simplified)

Data Link GSOC-OP ⇔ Weilheim	
Main	Leased Telekom Line 10 Mbit/s
Backup	Leased Telekom Line 10 Mbit/s (hot redundant)
Data transmission protocol	TCP/IP; SLE

Table 7-1: Data Interface GSOC-OP⇔ Weilheim

The GSOC-OP Communications Infrastructure is depicted in the figure 7-1. It shows a simplified view onto the facilities involved and the communication lines between them. To ensure maximum availability all communication lines are redundant.

The solid lines indicate permanent connections (numbered 1 to 3), the dashed lines connections which can be established on request (numbered 4 to 6).

7.1 Permanent connections

7.1.1 GSOC-OP Weilheim

The Weilheim LAN (OPS LAN) is connected via 2 CISCO Routers and 2 hot redundant data links to the Ethernet LAN at GSOC/SCC in Oberpfaffenhofen. These connections are available all year.

Internal telecommunication is handled by an internal communication network, which is interfaced to the public communication network. Further communications like data, voice and fax are transmitted to and from the Weilheim station complex also via public networks. All of the circuits are full period (24 hours per day), permanent channels, leased from T-Systems and alternately routed.

7.2 Temporary connections / connections on request

7.2.1 LEOP / Routine operations

To provide the necessary ground station coverage needed for LEOP operations it will be necessary to include additional ground stations into the ground station network. GSOC has settled agreements with other space agencies such as ESA, CNES, ISRO, SSC (Prioranet) for mutual ground station support. A typical LEOP configuration is depicted below with the GSOC combined network shown thereafter.

7.2.2 GSOC-OP ⇔User

Project specific data connections can be either from GSOC-OP to an external user (number 5 in Figure 7-1) or directly from the Ground Station to an external user (number 6 in Figure 7-1). Both alternatives have been realized in the past but the direct connection from the Ground Station to an external user usually is an exception.

Project specific data connections are built up according to customer requirements. The following features have to be specified:

- Data rates
- Redundancy
- Availability
- Security
- Protocols
- etc.

concerning data rates and redundancy Figure 7-1 shows some numbers which can be realized within short timeframe and at moderate costs.

Availability depends on several factors, i.e. redundancy concept, used hardware and selection of a suitable service provider and necessary effort and cost.

Security is applied on different levels, i.e. whether data not encrypted, encrypted or use of physically separated lines be used. The routing of TM/TC over Internet is not foreseen.

Different protocols are supported as standard and are according to CCSDS recommendations.

In order to standardize the interfaces for the transport and management of space data on ground GSOC-OP usually offers the TM/TC interface according to the SLE (Space Link Extension) services which are defined by the CCSDS.

The SLE services include two major elements:

- data transfer services that move space link data units between ground stations, control centres and end-user facilities
- management services that control the scheduling and provisioning of the transfer services

An overview of SLE services provides [RD3]. Details to RAF and CLTU services can be found in [RD5] and [RD6].