

# **DESIGN OF A MULTI-PURPOSE KU-BAND STATION**

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## **ABSTRACT**

Deutsche Telekom has been operating different communication satellites for several years. DLR (Deutsches Zentrum für Luft- und Raumfahrt e.V.) with its GSOC (German Space Operation Center) is responsible for German space missions. Deutsche Telekom and DLR formed a joint venture to build a Ku-Band station for back-up purposes and to provide LEOP services in the Ku-Band for Europe. The station is located at the DLR premises near Munich. The new station is operational since 1998.

The aim was to design the system in a way that the operation effort in costs aspects and human intervention is minimized. All operational tasks can be performed besides the routine work of one person at the Satellite Control Center (SCC). The station is remote controlled from different SCCs.

The SCC has one consistent Human Machine Interfaces which includes not only the Ku-Band station but also the backup S-Band stations at different locations.

This paper describes conception and operation of a LEOP Ku-Band Station with shared users at different sites.

## **KEY WORDS**

Ku-Band Antenna, LEOP; monitoring and control, OpenVMS, Human Machine Interface, network.

## INTRODUCTION

The SCC of Deutsche Telekom is located near Usingen, about 50 km north-west of Frankfurt/Main. The system has been under operation since the launch of the first flight model DFS in June 1989.

The DLR ground station is located at Weilheim, Germany. The ground station is operated by the GSOC (German Space Operation Center) which is located at Oberpfaffenhofen near Munich. The GSOC is responsible for nearly all German Scientific space missions.

The DLR was a partner in supporting Deutsche Telekom's communication satellites Symphony, TVSat and DFS. The Satellite Control Center of Deutsche Telekom was developed by DLR. In 1994 Deutsche Telekom and DLR signed a partnership agreement.

The following map shows the site locations.

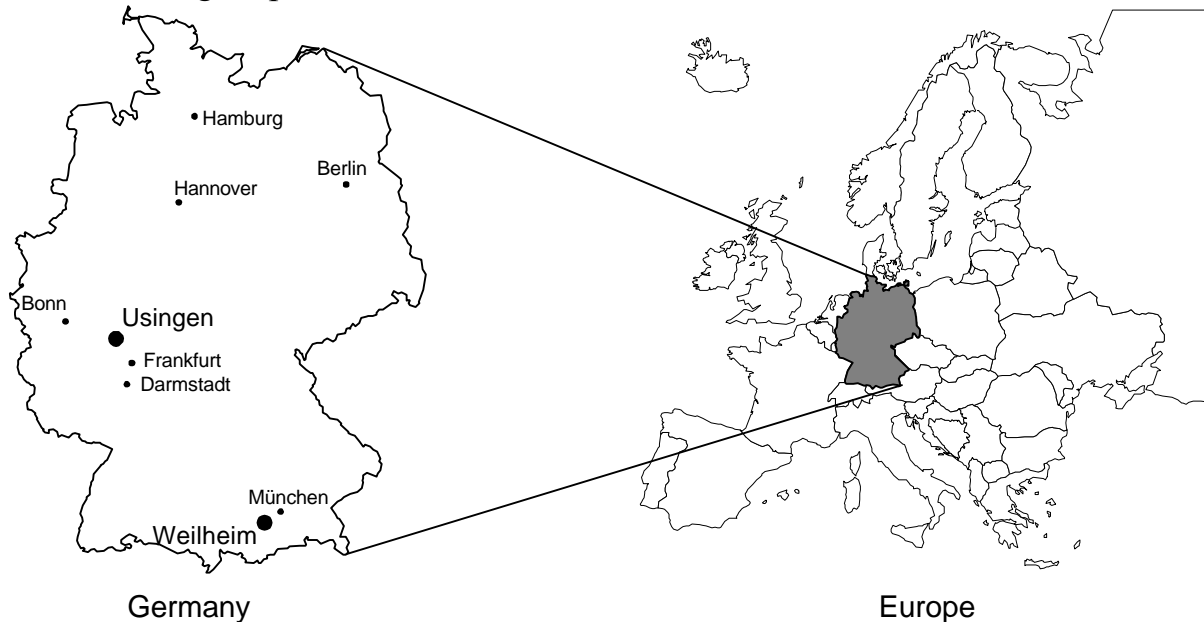


Figure 1: Site locations

This joint-venture combines the advantages of both organisations:

- Deutsche Telekom's commercial oriented cost-effective operations of spacecrafts and
- DLR's scientific reputation and orientation in space programs

## REQUIREMENTS

The new station should support the different needs of both organisations and also of external customers. The station shall support multiple missions:

- Commercial satellite support
- Scientific satellite support
- LEOP operations
- Backup support

Beside the technical requirements, a reduction of the entire operations costs and fully remote capability from different locations were main design topics.

New software and hardware to be developed shall enable the station controllers at both locations with a sophisticated and intuitive design of hardware and software.

### A KU-BAND ANTENNA, WHY?

Traditional communication satellites were positioned mainly in the S-Band. Most satellites are still using onboard omni- directional S-Band antennas for emergency purposes.

New global satellite systems are not longer using the S-Band. In Europe the S-Band is in high demand not only for space based application but also for terrestrial networks and new applications.

Further discussions and a need for a back-up ground station for Deutsche Telekom's own satellites lead to the decision not to build a another S-Band antenna but to proceed with a full motion 11m Ku-Band antenna to serve different needs of the space community.

### STATION PERFORMANCE

The following tables describes the performance specification of the Ku-Band antenna:

Main reflector	11.1 m diameter	Azimuth	$\pm 160$ degree
Min. Flux density in autotrack mode	-180 dBW/m <sup>2</sup>	Elevation	0 - 175 degree

Table 1: Mechanical specification

Receive section		Transmit section	
Receive frequency	10.7...12.75 GHz	Transmit frequency	13.75...14.5 GHz
G/T (10 deg. Elev.):	36 dB/K	EIRP	91 dBWi max.
Polarisation circular	RHC and LHC	Polarisation circular	RHC and LHC
Polarisation linear	X and Y	Polarisation linear	X and Y

Table 2: Receive and transmit specification

## NETWORKING

The antenna is located at DLR's Weilheim site in Bavaria close to the Alps. Deutsche Telekom SCC and DLR's GSOC are connected via terrestrial data lines. The following figure is an overview of the network.

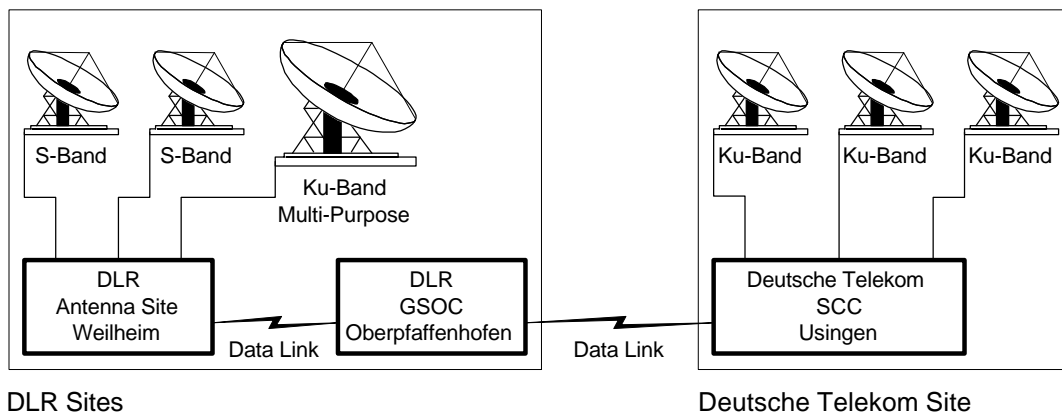


Figure 2: Network

DECNet and TCP/IP are the used network protocols between the different sites.

## RESOURCE SCHEDULER

A resource scheduler for a shared use station based on a priority scheme is mandatory. This resource manager is located at DLR's GSOC. The final decision which party can use the antenna is made here.

This decision is based on a schedule and on the priority of the not scheduled request. A spacecraft emergency has always the highest priority.

After the control is passed to one of the SCC's the entire ground station is fully remote controlled from that site. Controlling of a device or the entire antenna can only be performed from a single location. Monitoring information is available in real-time to both sites.

## **BASEBAND DESCRIPTION**

The baseband is build by the use of commercial-off-the-shelf (COTS), equipment. The TC (Telecommand), TM (Telemetry) and RNG (Ranging) functions are formed by industry standard VME bus units. All single units of the baseband are connected via a standard Ethernet interface with the TCP/IP protocol.

A redundant set of Klystrons (two kW) as power amplifiers are installed. A software controlled automatic tuning and automatic switch-over over in case of failures is implemented.

## **COMPUTER SYSTEMS - HARDWARE**

The computers are Digital Equipment's Alpha AXP running OpenVMS as operating system.

## **COMPUTER SYSTEMS - SOFTWARE**

Both SCC's are using the same software which not only reduce the development costs for supporting different platforms but each SCC can work after the necessary software set-up as a back-up SCC for the other site.

The display system is based on the X11 standards. Commercial software packages are used to create the graphical user interface.

## **HUMAN MACHINE INTERFACE**

The Human Machine Interface (HMI) for the Ku-Band station is TIGRIS. TIGRIS is formed by the tools TeleUSE and sphinx-dyna. It realises based on X11 and Motif the graphical user interface for the station. The next figure is an example of a TIGRIS display page.

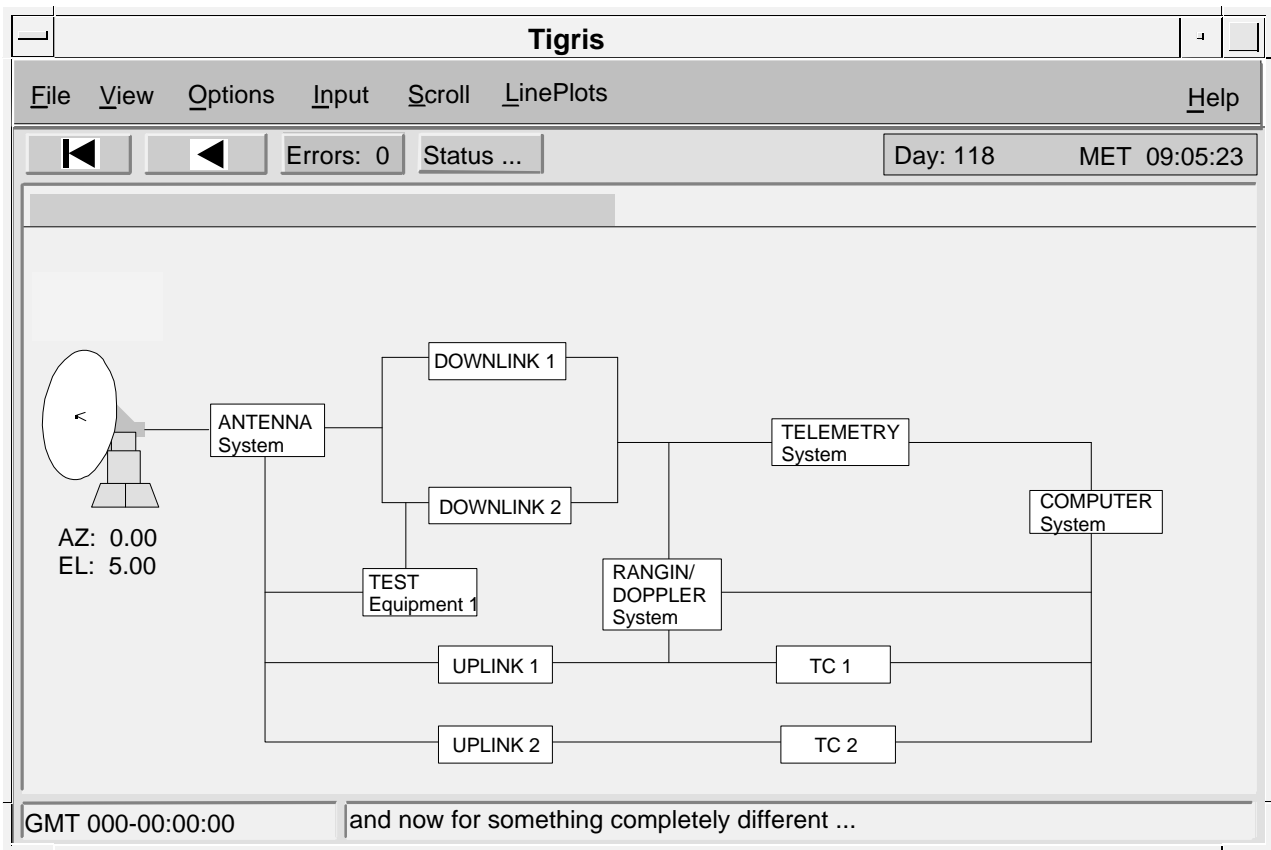


Figure 3: TIGRIS display page

## HIERARCHY

All system and subsystem display pages are designed in a hierarchical way. The following levels are defined:

- System level
- Subsystem (device) level
- Parameter level

The real system is represented by linked graphical objects on several display pages.

This top-down design allows the user a simple overview of the system status. More detailed information can be requested by a simple mouse click on the graphical object representing the real device.

## **INPUT**

The configuration of the station is possible via single parameters or pre-defined procedure (Macro) consisting several single commands. The use of pre-defined procedures simplify the operation of the station. In addition all Motif based input possibilities are available.

Based on the knowledge and privileges of the operator the procedure level or the detailed single command level is accessible.

## **ALARM**

The status of each system or subsystem is shown by the colour of the graphical object:

- green: Object within normal operation limits
- yellow: Object outside normal operation limits, but still operational
- red: Object failure, not operational

An alarm list is generated by the HMI for all parameters which are defined as alarms. An audible alarm can be enabled. Each alarm must be individual confirmed by the operator.

## **HELP**

An extensive help text is assigned to each object. The help function can be enabled which the mouse. In case of system failures the necessary recovery procedure are also described by the help function.

## **EDITOR**

A graphical editor is available for display design. Static and dynamic formats can be created like:

- Linking of parameters to graphical objects
- Colour definition of these objects
- Display hierarchy

The definition of new pages can be performed by the user expensive external software development is no longer an issue.

## **MONITORING AND CONTROL**

The Monitoring and Control (MaC) processor performs the processing of all station parameters. This includes the processing of monitoring and derived parameters and the generation of the control information for the station devices. Again TIGRIS is used as HMI.

A mission dependent set-up of the Ku-Band station parameters ensures the optimal performance for each individual mission.

## **CONCLUSIONS AND EXPERIENCES**

The following conclusions and experience can be taken from this joint venture project

- Extensive use of Commercial of the shelf equipment and software tools will reduce the development costs
- Only the use of existing standards for software development and display systems ensure the future support effective maintenance
- Ground station hardware is no longer expensive, the main cost factor is software development

The design of the HMI only together with the final end user (ground station or spacecraft operator) will guarantee the use and acceptance of the new features and software systems.

## **REFERENCE**

[1] The new GSOC Ku-Band Monitoring and Control System, DLR, Dr. Udo Haering and Martin Pilgram, Münchner Str., D-82234 Wessling, Germany

[2] TIGRIS MMI User's Guide, KMTT-MM-UG-01.1, 1995, DLR, D-82234 Wessling, Germany