SAFIR

A Small-Satellite Program for Two-Way Environmental Data Collection and Distribution

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ABSTRACT

A new approach in space technology arises in various areas utilizing small satellites, also called μSATs. Implementing modern equipment especially in the field of electronics and computers, leads to powerful systems which are able to cover wide areas of application. In addition, new launch capabilities, such as secondary payloads and piggy-backs on CIS launchers enables a "low cost" approach for satellite based applications. In this context OHB-System developes the small satellite system called SAFIR (SAtellite For Information Relay) with unique communication capabilities. The major operation is aimed to two-way data collection and distribution of environmental "in-situ" measurements. Moreover, the implemented features are also usable in a variety of other applications where simple communications are desired. The pilot project SAFIR is partly funded by the German Space Agency (DARA).

1. INTRODUCTION

In various national and international programmes (e.g. BLMP in Germany, JMP and CORINE on European level) first systematic measurements and data analyses of individual in-situ measurements were performed or planned in order to improve the understanding for the impact of pollution on the global ecological system (Fig. 1). In the near future further European enhancement on these activities is foreseen under the co-ordination of the new European Environmental Agency (EEA).

In this context, user requests have shown increasing needs for appropriate dedicated two-way, low cost communication systems. The SAFIR system, consisting of a network of 6 satellites at altitude of 640 to 800 km with inclinations between 62°-98°, control station in Bremen, and small portable terminals (Macro- and Micro Station), will cover this niche. For this purpose, in advance a communication link test phase is established with the following selected users

- anchored buoys (Univ. of Bremen)
- diving buoys (Univ. of Kiel)
- tracking of forest impacting game (Austria)
- migrating birds (White Stork) (Max Planck Inst./Fed. Research Center for nature conservation and landscape ecology, FRG, and the Soc. for the protection of nature in Israel)
- meteorological antarctic stations, Alfred-Wegener Institute, FRG

2. PROGRAMME BACKGROUND

For monitoring of the global ecological status two complementary methods were established:

- remote sensing from flying platforms like aircrafts and satellites
- in-situ measurements from ships, buoys and ground based autonomous, remotely controlled measurement stations

Remote sensing implies that the sensor systems are accommodated aboard the satellite. Typical Instruments are RADAR and passive SPECTROMETERS, which provide a quantity of averaged information about specific ground patterns. This sensing technology always generates planes with informations e.g. images in different spectral ranges. Already existing satellite systems designed for this purpose are SPOT and LANDSAT. A new generation of dedicated remote sensing satellites was born with the launch of ERS-1, the European Remote Sensing Satellite, in 1991. A lot of high sophisticated data analysis methods for pre-processing the raw data generated by the on-board instruments are already proven and established in specific European and international centers to serve potential users with necessary information.

In-situ measurements are originally point measurements and often simple but with more capabilities in data quality and parameter diversity. The coverage of a specific area is achieved by deploying of in-situ measurement stations or buoys. An example for a diving buoy for ocean research and monitoring is shown in Figure 2. A number of dedicated programmes on local level have been established concerning ecological, biological, and in some cases pollution observation. This activities will be enhanced in the very near future in states, European level and worldwide.

For improved "in-situ" measurement methods two important requirements are mandatory:

- the measurement systems shall be remotely controlled and operate with minimum power consumption for at least one year,
- the user shall have direct access to his measurement systems several times a day for data collection and system control.

Further requirement of many user are the position determination and tracking capabilities. These can be achieved by GPS receivers installed in the ground terminals or using the Doppler-shift measurement on the satellite. Both methods will be supported by SAFIR.

3. SAFIR COMMUNICATION CONCEPT

The proposed SAFIR concept is designed as a complement to traditional satellite based information services and comparable with the electronic mail service on earth with enhanced capabilities.

The user data management (collection & distribution of data) is implemented on the SAFIR on-board computer. The data management software contains a table of currently valid users, their passwords and locations on the globe, so that an exact timing of the individual link time is possible. In addition, the link time for each terminal will be calculated in advance, which allows a precise communication planning.

The communication concept is based on the time-sharing principle using selective call technique. All links are initiated by SAFIR. The link to a ground terminal will be established by a first call that addresses a specific ground terminal by the associated password. After response of the addressed ground terminal the two-way information exchange will be performed within a individual and limited time slice, whereby the next link times will be remotely programmed into the ground terminal. The ground terminal can now switch to a sleep mode for reducing power consumption until the next programmed link time. After completion of the link the next terminal listed in the table on-board will be addressed. The table itself will be updated if necessary by the service operation manager at the satellite control station.

A solid state mass-memory device (2*5 M Byte) is used to store the data for later transfer and/or multi-user access (store and forward). The amount of used memory depends on the number of users, the length of the individual messages, and the delay between the exchanges.

4. SAFIR GROUND SEGMENTS

The SAFIR ground segment consists of three types of ground terminals:

- Hubstation,
- Macro Stations.
- Micro Station.

The Hubstation equipped with three RF bands (20cm, 70cm, and 200cm) is located at Bremen and is used to control the satellite and update the data management.

The Macro Stations are the SAFIR ground terminals for the various user applications. They can be used as stand-alone data collection platforms or interfaced to user specific measurement equipment and to users personal computers (see Fig. 3). Significant for the Macro Stations are its simple handling with standard interfaces, small size, low power consumption, and multipurpose use.

The realized terminals are based on a combination of a fixed programmed micro-controller with a given RAM to provide the capabilities of a mailbox system (see Fig. 4). Due to the universality of modern microcontrollers it is possible to compress the information before transmitting and decompressing after receiving by optional software. Further cryptography is possible. The microcontroller is interfaced via a dedicated modulation/ demodulation (MODEM) to the HF-Transmitter/ Receiver (Tx/Rx).

The technical parameters of the Macro Station are as follows:

- Processor unit with Microcontroller and 256 kByte SRAM,
- 8-channel 10Bit A/D converter
- RS-232 Interface
- 8 digital I/O control ports
- CPU Power consumption 5μA (at 5V) in sleep mode, 50mA during operation
- RF-Unit with FSK modulation at 2.4 (4.8) kbps, 5W RF TX power
- Tx/Rx at 70cm/2m

In the standard version the electronics are accommodated on two boards with EUROCARD size (160x100mm). with approx.. weight of 500 g.

The standard Micro-Station consist of a microcontroller and 70 cm RF unit with approx. weight of 80 g in the first version. This unit will operate with a baud rate of 300 bps and RF TX power of 0.5 - 1W. Optionally an RS 232 standard interface is implemented.

5. SAFIR ORBIT

The SAFIR satellites can be launched into LEO near polar orbits, using ARIANE or CIS launchers.

The SAFIR system will run in two phases, in phase A (links and frequencies tests) SAFIR-R will be launched on CIS Remote Sensing Satellite RESOURCE-03 in March 1993 into a sun synchronous orbit with the following parameter:

- Apog. 696 km
- Perigee. 678 km
- Inclination 98.04°
- Period 98 min
- appr. mission life 3 years.

This orbit allows a global coverage with 3-14 contacts per day depending on the geographical latitude of the user stations. Figure 5 depicts the orbit and the satellite visibility from Bremen.

In phase B, "operational phase" additionally SAFIR-1 will be launch in June 1994 on RESOURCE 04, After RESOURCE-04 has reached its final orbit SAFIR 1 will be ejected, using an ejection mechanism which is based on a special spring system and pyrotechnics.

6. SAFIR CONFIGURATION

SAFIR belongs to the low-cost Micro-Satellite class. The subsystem design of the satellite is based on existing technology from BREM-SAT, a small scientific satellite. The structure of SAFIR consists of two modular compartments, which provides sufficient stiffness. A bottom plate carries the launcher interface, and the three communication units. This allows a close accommodation to the antenna system. A middle plate carries the battery packs, the power supply unit, the onboard computer, and the boom interface.

Figure 6 depicts an impression of all SAFIR subsystems and the flight configuration. The simple attitude control and stabilization subsystem consists of a gradient gravity boom and magnetic torquer as actuators. As sensing devices magnetometer, sun and star sensors are implemented. Numeric simulation runs have shown that a nadir pointing accuracy of ±5° can be achieved.

A silicon cells solar generator mounted on four sides of the satellites outer shell produces up to 28 W which is distributed by the power control electronics. During eclipse and peak consumption electrical power is provided by a 7Ah NiCd battery pack. The power bus provides unregulated 24V, regulated ±15 and 5V.

A modified BREM-SAT on-board computer is used for satellite control and user data management. It is based on the INMOS T800 Transputer and equipped with 2*5 Mbyte mass-memory. The memory includes an error detection and correction unit and additionally latch-up protection. The interfacing to the satellite subsystems is performed by a dedicated system interface board, Fig.7.

The SAFIR communications system provides tracking, telemetry and control (TT&C) for the satellite, and communication and position determination capabilities for the user stations. The user stations are supports by a single-frequency, half-duplex up/down link at 401 MHz. The link operates with 300 bps up to 9600 bps FSK. Doppler measurement can be performed on the up-link signal by frequency counting. The TT&C functions are realized via the 2m-Band subsystem.

The computer aboard SAFIR is able to handle TT&C and user communication links simultaneously achieving an optimal usage of the link time. The Table below summarizes the most important parameters of SAFIR:

- Size	450 x 450 x450 mm
- Mass	appr. 50 kg
- Power	25W aver. 50W peak
- Stabilization	Gravity Gradient
- Pointing acc.	±5°
- Communication	70cm, 2m, opt. L-Band
- Data rate	300 bps - 9600 bps
- Up-link	401 MHz, 148 MHz
- Down-link	137 MHZ, 401 MHz

7. CONCLUSIONS

Increasing demands on earth monitoring also requires improved world wide "in-situ" measurement capabilities. Such a network needs appropriate communication infrastructure which is not yet provided by existing communication satellites. Recent evaluations have shown, that small satellites could be a real low-cost alternative solution to fill this gap. Moreover, the short development phase for satellites like SAFIR allows fast response on actual problems and needs in environmental and pollution monitoring.

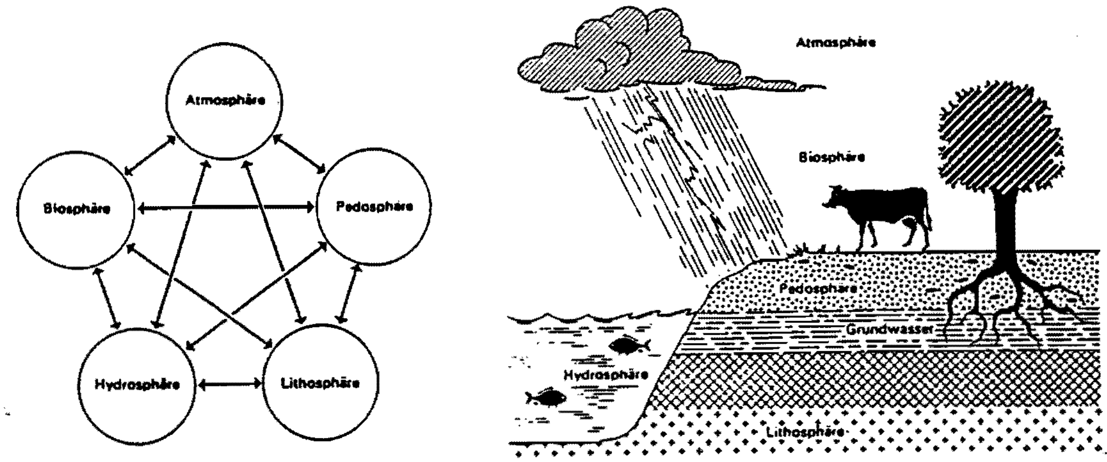

Figure 1: Scheme of the basic ecological areas

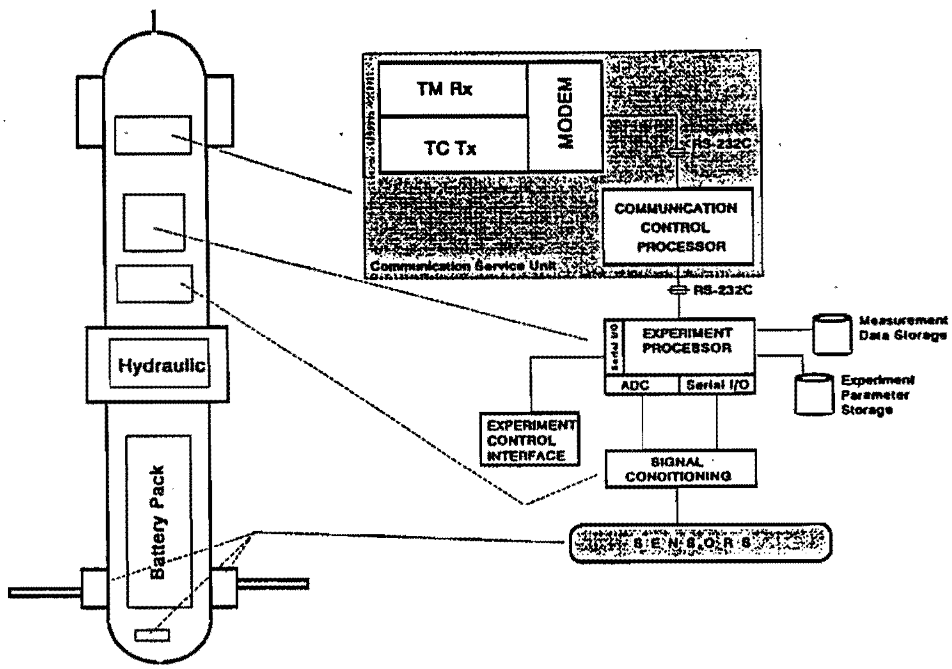

Figure 2: Diving bouy for ocean research (University of Kiel)

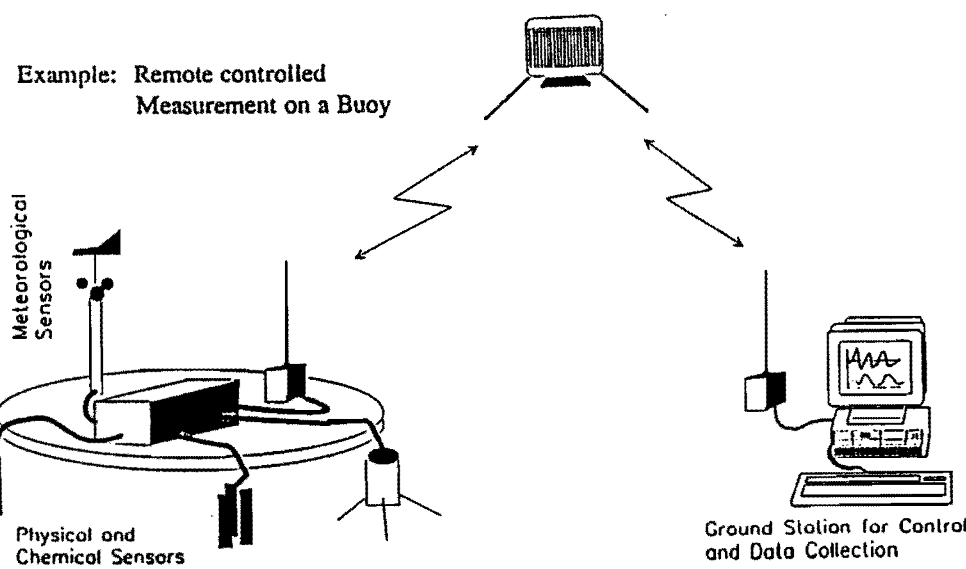

Figure 3: Remote controlled measurement equipment on a bouy

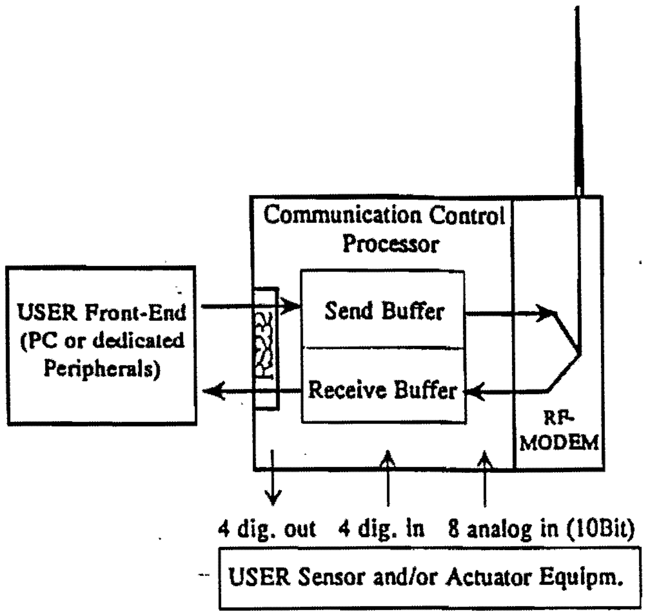

Figure 4: Principle of the SAFIR Macro Station

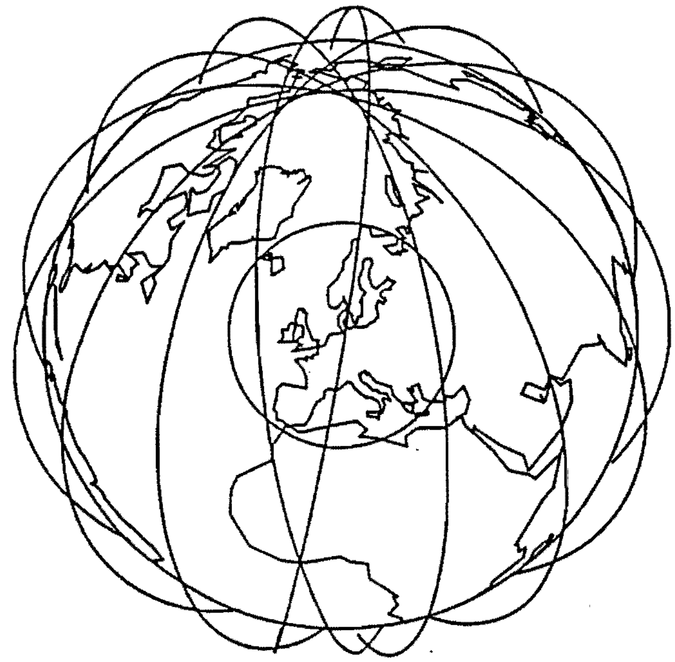

Figure 5: SAFIR orbit and visibility from Bremen

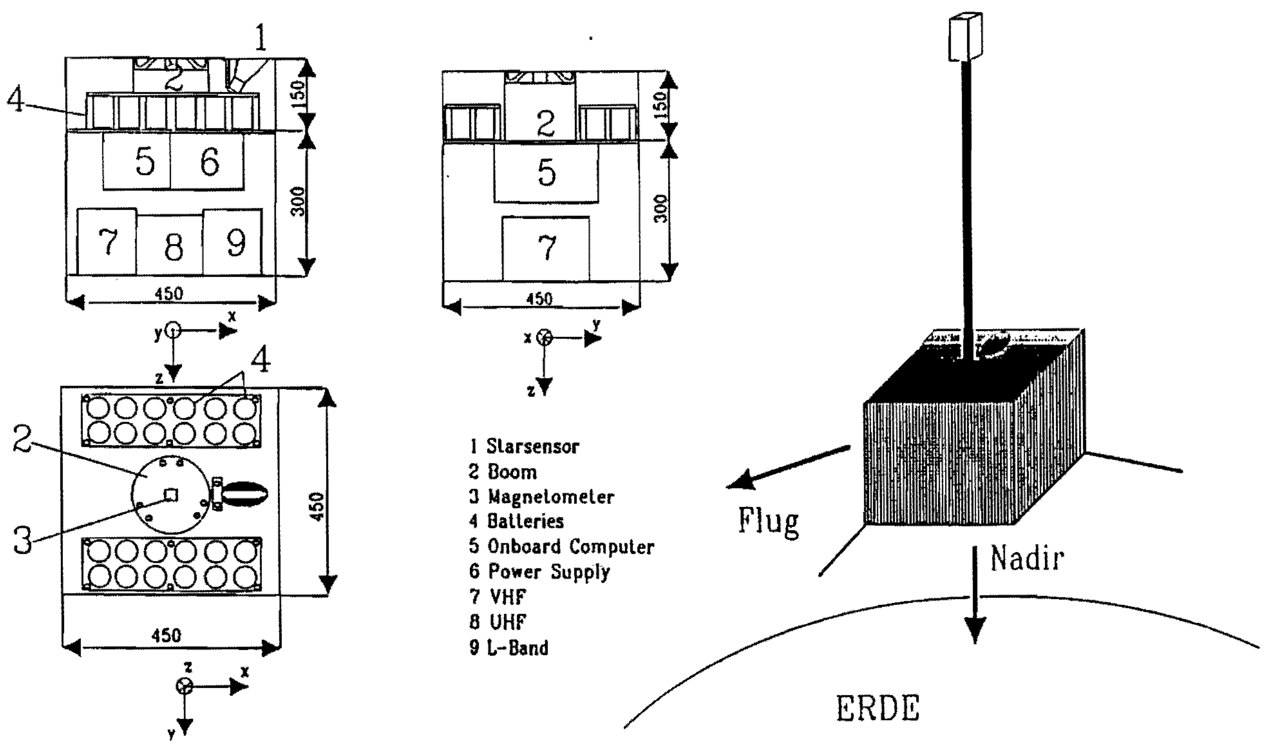

Figure 6: SAFIR subsystems and flight configuration

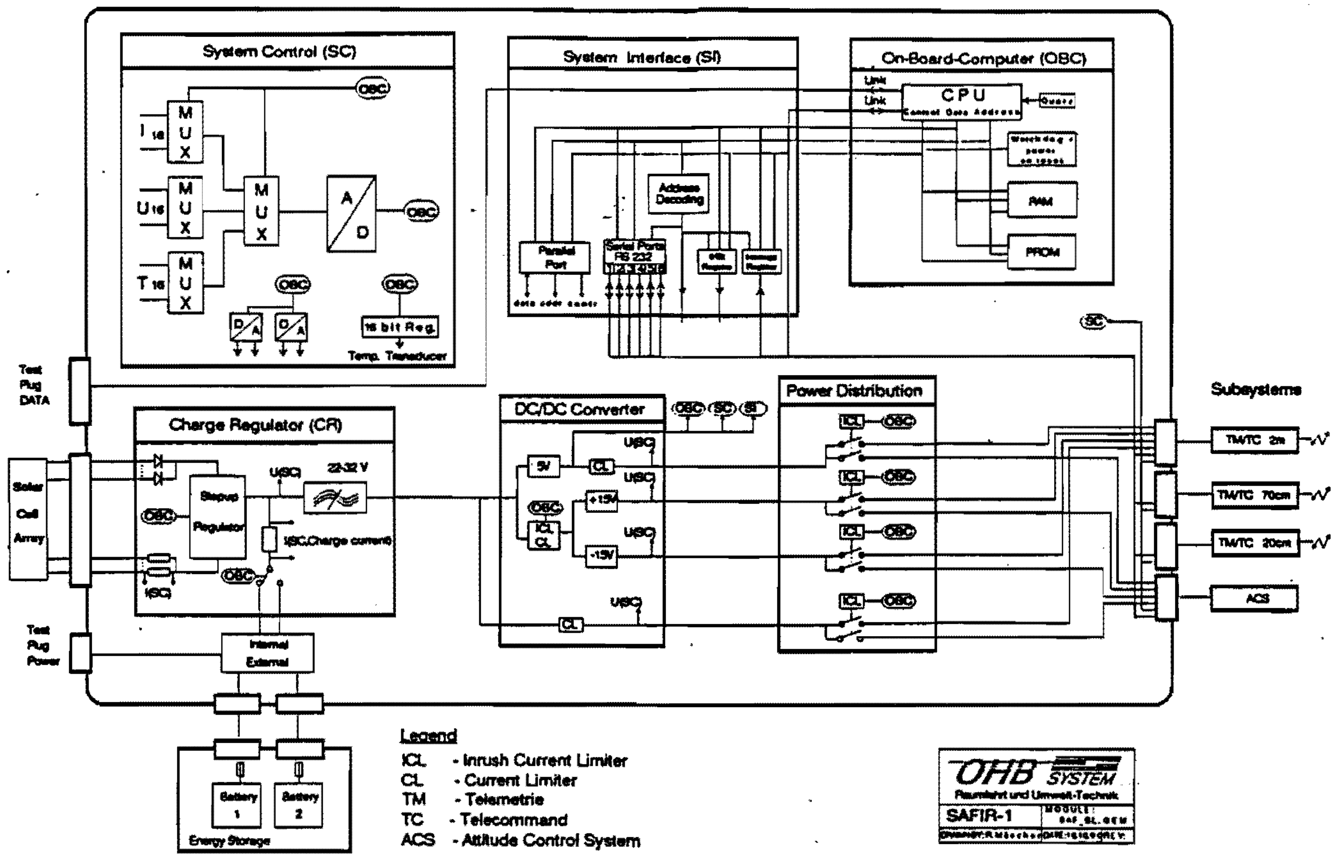

Figure 7: OBDH and power subsystems of SAFIR