

**The TET-1 Satellite Bus – A High Reliability Bus for Earth Observation, Scientific  
and Technology Verification Missions in LEO**  
**Pestana Conference Centre – Funchal, Madeira - Portugal**  
**31 May – 4 June 2010**

**S. Eckert<sup>(1)</sup>, S. Ritzmann<sup>(1)</sup>, S. Roemer<sup>(1)</sup>, W. Bärwald<sup>(2)</sup>**

<sup>(1)</sup> *Astro- und Feinwerktechnik Adlershof GmbH, Albert-Einstein-Str.12, 12489 Berlin,  
Phone: +49 30 6392 1000, Fax: +49 30 6392 1002*

*s.eckert@astrofein.com, s.ritzmann@astrofein.com, s.roemer@astrofein.com*

<sup>(2)</sup> *DLR, Optical Information Systems, Rutherfordstr.2, 12489 Berlin,  
Phone: +49 30 67055 535, Fax: +49 30 67055 532, wolfgang.baerwald@dlr.de  
Germany*

## **1. Abstract**

The TET-1 (TechnologieErprobungsTräger) satellite is the core element of the “On Orbit Verification” (OOV) program of the German Aerospace Centre (DLR). In this Astro- und Feinwerktechnik is responsible for the satellite bus. This satellite bus is now a commercial available product of Astro- und Feinwerktechnik that is offered to the micro satellite community. The paper will give an introduction into the design, opportunities and special aspects of the TET satellite bus.

## **2. Introduction**

The TET satellite bus is designed as a modular, flexible and high reliable microsatellite for LEO applications. A typical orbit for this bus has an altitude between 450 and 850 km and an inclination between 53° and SSO. The typical launch of a satellite based on the TET satellite bus is as a piggyback payload. This results in an overall envelope of 670 x 580 x 880 mm and a satellite mass of 120 kg.

The first mission for this satellite bus will be the TET-1 mission which will be launched as part of the OOV program in late 2010. Kayser-Threde is the prime contractor for this mission, Astro- und Feinwerktechnik is responsible for the satellite bus and DLR-GSOC for the ground system.

The launch will be provided by Lavoshkin with an SOYUS/FREGAT launch, together with METEOR-2.

## **3. Satellite bus**

The satellite bus technology is based on the technology of the space proven BIRD satellite bus, flown by the DLR in 2001. But it was adapted with regards to new available components with regards to a better performance, more payload volume and mass and a much higher reliability of the system (which results in more redundancies and more reliable EEE-parts).

With 70 kg satellite bus mass, including the payload support system, the satellite bus is able to provide a payload capacity of 50 kg with an envelope of (460 x 460 x 428) mm (fig. 1).

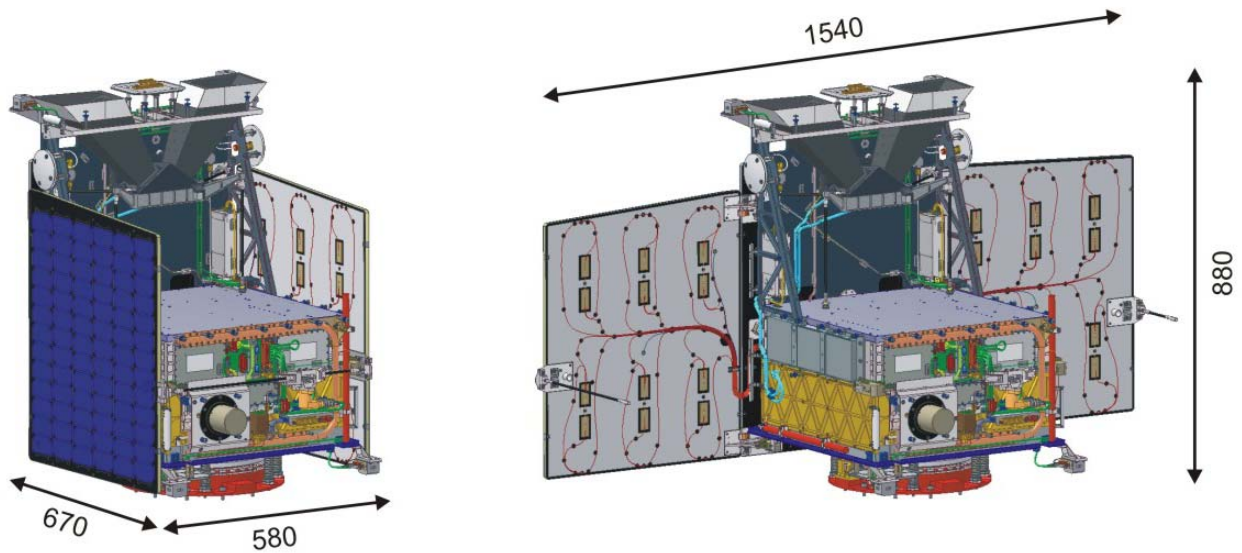


Fig. 1. TET-1 envelope

For the TET-1 mission the payload consists of 11 different payloads. Nine payloads are accommodated in the payload segment (space is seen in fig. 2). The other three are placed on the middle solar panel and the payload panel (fig. 3). More details about the payloads you will find in the TET-1 system paper [1].

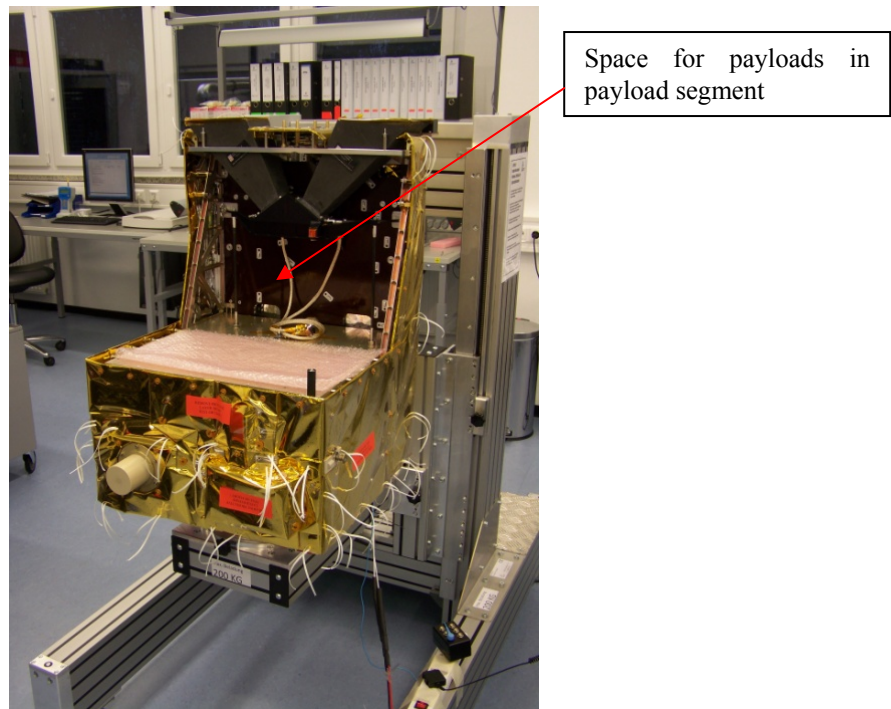


Fig. 2. Payloads Segment during MLI fitting

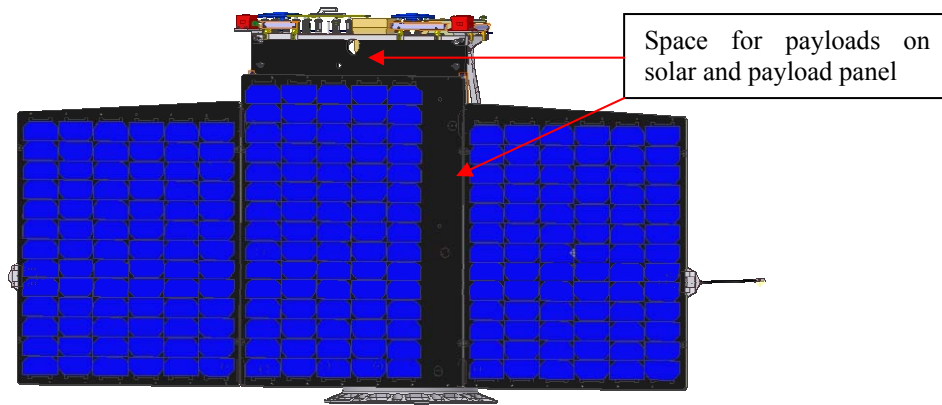


Fig. 3. Payloads on solar and payload panels

A special point in the design of the satellite bus was the interface between satellite bus and payload. To support different kind of missions the system contains the nominal satellite bus and a Payload Support System (PSS, fig.4). This payload support system is on its payload interface side adaptable to the data (Spacewire, RS422/485, CAN-Bus ....) and power interface requirements, data storage requirements and payload control requirements. In case of TET-1 this payload support system was designed and build by Kayser-Threde.

So the nominal satellite bus will be in normal cases unchanged for different missions, but of course can adapted in parts, like an upgrade to X-Band transmission if higher data rates are required. (see chapter 5). The printed circuit boards (PCBs) of the Payload Support Systems will be adapted for every new payload accommodation.

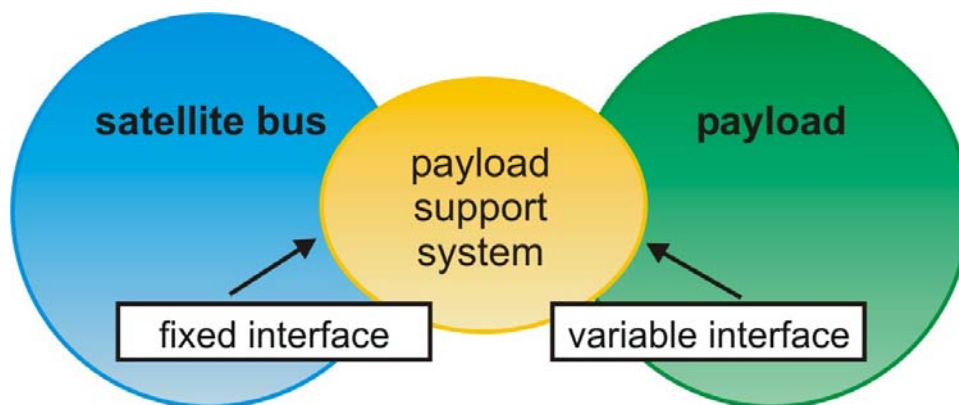


Fig. 4. Interface philosophy

The satellite bus is divided in three segments: the Service Segment, the Electronic Segment and the Payload Segment (fig. 5).

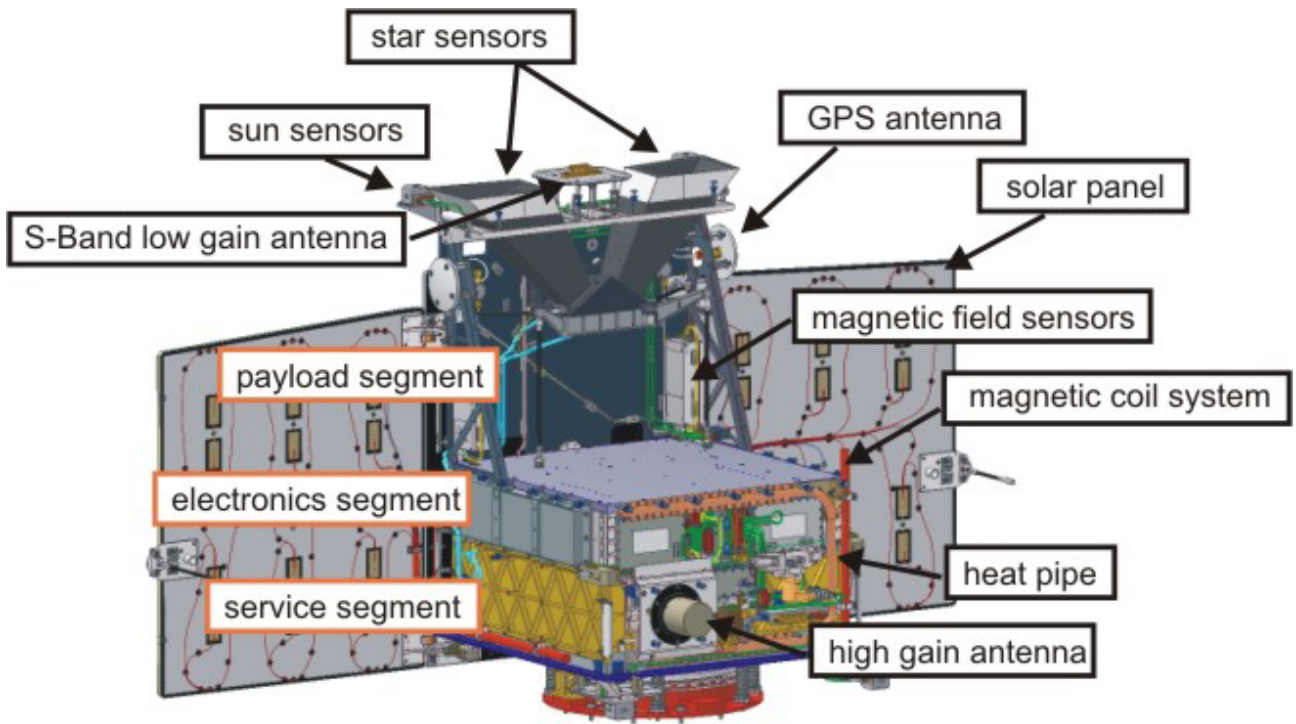


Fig. 5. Segments of satellite bus

The Service Segment contains the PCU, two IMUs, four reaction wheels and two battery stacks. In the Electronic Segment you find on the left side the Payload Support System and on the right side the Spacecraft Bus Computer, the PDU, data processing boards of the redundant sun sensor system, the redundant GPS and the driver electronic of the redundant magnetic coil system. All of these components of the Electronic Segment are designed as PCBs in Europe Card size (160 x 100 mm<sup>2</sup>, max. 15 PCBs for PSS and 15 PCBs for Satellite bus components) and are connected via two backplanes. Additional to that the complete TM/TC hardware is integrated into the Electronic segment, except the two low gain antennas (for omni directional communication).

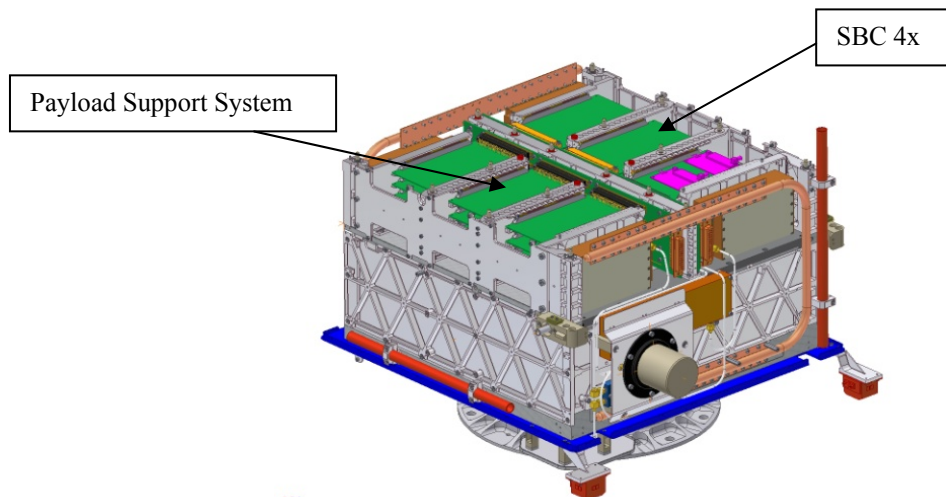


Fig. 6. Top view of Electronic Segment (with attached Service Segment)

The Payload Segment contains the payload itself, parts of the AOCS and one of the low gain antennas. Due to the design the sole mechanical and thermal interface between payload and satellite bus is the payload platform, which allows an easy and fast integration of the pre-assembled payload.

This payload platform can be designed as optical bench (like on BIRD), but in the TET-1 mission it was not required.

The power subsystem consists of a PCDU (PCU+PDU), NiH2 cell battery stacks (with 240 Wh) and a solar generator which has 3 panel (2 deployable) with 220W electrical power.

The Spacecraft Bus Computer (SBC) controls all activities of the satellite bus and consists of 4 identical SBC boards (2 in hot, 2 in cold redundancy) and watchdog circuits for failure detection and recovery. One node (worker) is controlling the satellite while the second is supervising the correct operation of the worker node.

The TMTC system is based on a S-Band system with hot redundant receivers and cold redundant transmitters with a high bit rate of 2,2 Mbit/s and a low bit rate of 137.5 kbit/s. The two receiver/transmitter pairs can be switched to the omni directional low gain antenna system or the high gain antenna.

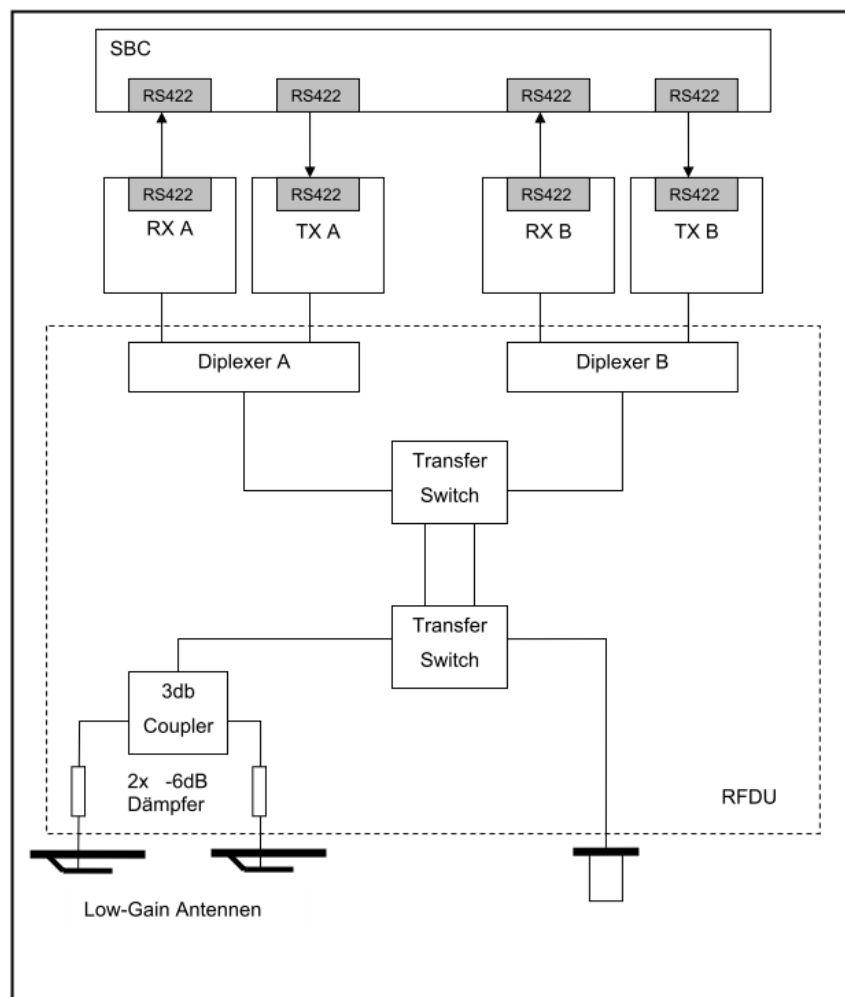


Fig. 7. TM/TC system

The AOCS of the satellite bus consists of two star sensors, two IMUs, two magnetometer, 2 sets of Course Sun sensors, 4 reaction wheels, a redundant magnetic coil systems, 2 GPS systems and an On-board-Navigation-System, which runs as software application on the SBC. The AOCS is a state based systems controlled by an application software in the SBS. More details about the AOCS you will find in paper [2].

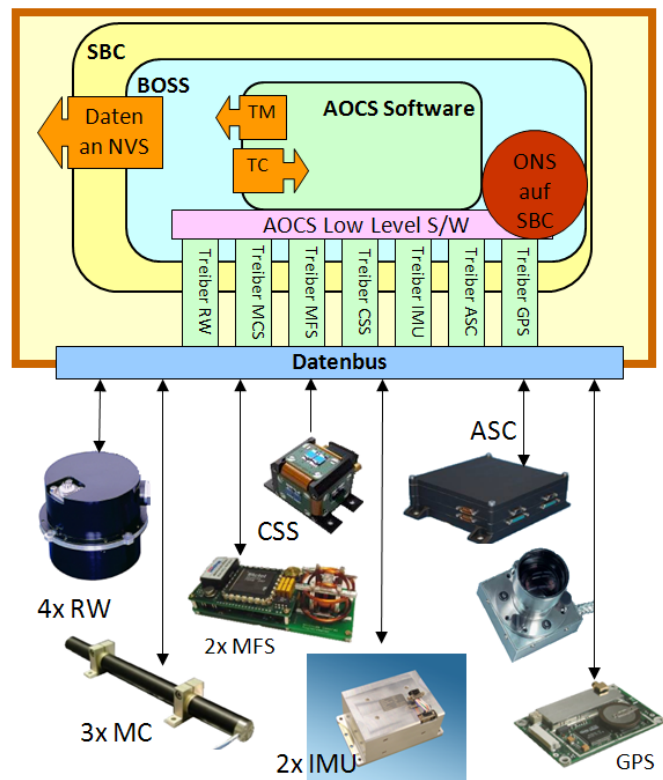


Fig. 8. AOCS hardware

An outstanding feature of the TET satellite bus is the very high reliability of 0.95 over the mission time of 14 month (including LEOP) which is secured by the use of HighRel-EEE-parts, multiple redundancies (in hardware, hot and cold redundancies, and function) and the complete ECSS compliant AIV process.

#### 4. Technical data

The following shows the basic technical data of the TET satellite bus:

TET-envelope (length x width x height)	(670 x 580 x 880) mm <sup>3</sup>
mass of TET-spacecraft bus	< 70 kg
type of stabilisation	3-axis stabilisation
accuracy of alignment	2 arcmin (5 arcmin required for TET-1)
Pointing knowledge	~ 10 arcsec
jitter	~ 12 arcsec/sec (2 arcmin/sec required for TET-1)
Position knowledge	10 m
alignment of payloads or solar arrays	sun, earth, nadir, zenith, in flight direction and deep space
power consumption (payload and payload handling system)	20 W (for TET-1, up to 80 W with adapted radiator for following missions)
payload power peak	160 W per 20 min
bus voltage/max. current	20 V DC ( min. 18 V; max. 24 V) / 8 A
data rate uplink	4 kbit/s
data rate downlink	2,2 Mbit/s
reliability (14 month mission)	0,95 (0,92 required for TET-1)

## 5. Actual Project Status

The design was frozen and the production process of the flight model was started with the CDR in January 2009. A structure and thermal model, an engineering model and an engineering AOCS model were integrated and tested during the years 2008 to 2010.



Fig. 9. STM on shaker (left), EM AOCS on test bed (right)

In the moment the AIV process of the protoflight model of TET-1 is in progress. The TRR for the satellite bus was holding on 7<sup>th</sup> May and the functional verification of the satellite bus will be completed until the end of May.

After that the integration of the payloads will be done by Kayser-Threde followed by the environmental verification with IABG. The planned FRR for the complete TET-1 satellite is in late September 2010.

## 6. Planned Upgrade

As a result of the request from the market there will be an upgrade analysis in mid 2010 to adapt the satellite bus to:

- Higher payload mass ( $\geq 70$  kg) and increased envelope
- More power for payload
- X-Band downlink
- Propulsion system (as optional piggyback system, will be part of payload mass)

## 7. Summary

The TET satellite bus, with perpetuation of the proven BIRD design concepts and technologies, was adapted to new available components with regards to a better performance and higher reliability of the system.

Herewith Astro- und Feinwerktechnik can offer now a satellite bus with outstanding reliability and high modularity for LEO applications to the community.

## 8. Funding

The R&D project, on which this report is based, is implemented on behalf of the Federal Ministry of Economics and Technology under Ref.Nr. 50RV0801.

## 9. References

- [1] S. Foeckersperger, K. Lattner, C. Kaiser, S. Eckert, S. Ritzmann, R. Axmann and M. Turk, *The On-Orbit Verification Mission TET-1 – Project Status of the Small Satellite Mission & Outlook for the One Year Mission Operation Phase* , 4S Symposium 2010, Funchal, Portugal, 2010.
- [2] Z. Yoon, T. Terzibaschian, C. Raschke and O. Maibaum , *Development of the Fault Tolerant Attitude Control System of OOV-TET Satellite* , 4S Symposium 2010, Funchal, Portugal, 2010