# iBLOCK –
# iBOSS Building Block

# iBLOCK

## iBLOCK concept

One key element of the iBOSS approach is the catalogue of standardized and pre-qualified building blocks – the iBLOCKs – allowing the assembly of modular space systems. Each iBLOCK carries different subsystem components.

## Structural design

Space structures need to withstand the launch loads, must protect the integrated components against the hazardous space environment and offer thermomechanical stability in a wide temperature range. Thus, the iBLOCK concept uses a CFRP (Carbon Fiber Reinforced Plastics) frame-stiffened shear web. The polygonal beam elements are joined in the cube's corners by aluminum node elements, providing the load paths into a load-carrying central structure. The side panels made of a CFRP sandwich material support the subsystem components.

Fig. 1: Outer structure of an iBLOCK

## Thermomechanics

The used CFRP increases thermal conductivity and minimizes thermal deformation of the primary structure, which guarantees its mechanical stability. This satisfies the on-orbit requirements for assembling modular space systems consisting of iBLOCKs.

## Dimensions

The outer dimensions of the baseline iBLOCK are 40 x 40 x 40 $cm^3$, which can be extended to multiples of the baseline shape for systems like tanks, dedicated payloads, etc. required for special functionalities. For the integration of a functional subsystem component inside an iBLOCK a volume of 25 x 25 x 25 $cm^3$ is provided. The mass of an iBLOCK (without subsystem component) is approximately 17 kg.

Fig. 2: Inner structure of an iBLOCK (e.g. with reaction wheel subcomponent)

## Applications and redundancy concept

The connected modules shall provide the standard tasks of a satellite bus. Consequently, each individual module has to fulfil the following common tasks and requirements:

- Providing infrastructure for payloads and satellite components
- Failure detection and handling
- Controlling all standard components of a module (interfaces, power unit, sensors)

If one of the components fails, redundant components in neighboring iBLOCKs will take over the task. Failure of one component in the global data bus chain can be handled by rerouting the data path via another iSSI of the affected iBLOCK. Further an Optical CAN Interface (OCI), which is connected to the local data bus can be used to command components in a neighboring iBLOCK. Therefore, very high reliability can be achieved without the need to carry multiples of components.

| | Mass [kg] | Number # | Total [kg] |
|---|---|---|---|
| Structure | 4,98 | - | 4,98 |
| iSSI | 2,53 | 4 | 10,12 |
| Electronics | 0,85 | - | 0,85 |
| Others | 0,5 | - | 0,5 |
| Total | | | 16,45 |

Fig. 3: Mass properties of an iBLOCK with 4 iSSIs (Standard Interfaces)

## On-Board Data Handling and Software-Framework

The software framework offers the possibility to distribute a program, executed on the satellite among the individual iBLOCKs. Therefore, every cube provides a ROS node to handle the setup of the distributed framework. This distribution concept allows to balance the thermal conditions, power consumptions and processing loads of each iBLOCK and enables to dynamically select the best suitable iBLOCK for the execution of certain tasks. For larger calculation tasks, the system can distribute threads over the entire iSAT to calculate in parallel. Hereby, the computation time can be kept low and the processor load is shared over the iSAT which leads to less power consumption in summary. For the distribution of threads or full tasks, data has to

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be shared with the executing unit. This data handling and saving of task state is also done by the distributed computation system. Furthermore, the software framework is capable of detecting the sensor and actor configurations of each iBLOCK. If changes occur in network configuration it can automatically detect these, and compute new optimal routes throughout the network.

In addition to the power and thermal balancing, this concept guarantees data and calculation redundancy. This will be ensured through a controlling schema within the distributing system. The system is able to recognize e.g. the malfunction of an iBLOCK which is calculating a task. The task can then be switched to another iBLOCK and the malfunction can be fixed.
The hardware for data handling consists of an array of combined switches/On-Board Computers (OBCs, see below), which handle communication through several ports and detect the configuration of the satellite through Rapid Spanning Tree Protocol (RSTP). This is also used to do loop handling in the network.

Typical subsystems of the space segment like Attitude and Orbital Control System (AOCS), Thermal Control System (TCS), Electrical Power System (EPS) and Attitude Determination System (ADS) are built as agent-nodes on top of the ROS operating system and run in every module simultaneously while master-nodes (like Pilot, TT&C) always run on just a single module. Master nodes can be moved around by the distributed operating system freely to make optimal use of processing time.

## On-Board Computer (OBC)

The On-Board Computer (OBC) connects neighboring modules using an integrated network switch, based on Time-Triggered Ethernet. It provides an operating system that automatically distributes control tasks among the modules, resulting in a distributed operating system which is scalable and grants a very high redundancy.

## Power Control Unit (PCU)

The goal for power consumption of an individual building block is to reach about less than 5W in running state without payloads. The Power Control Unit (PCU) is controlled by the OBC and acts as a decentralized regulator for the satellite-wide power bus.

## Communication concept

The data handling subsystem is divided into two parts: (1) The local data bus connecting the different components within each module (iSSI, PCU, OBC) and providing control programs with a bus based on CAN to control devices. (2) The global data bus connecting the modules of a satellite with a high degree of flexibility using network switches. Due to readily available components, it is the perfect choice to build a highly interconnected network topology.

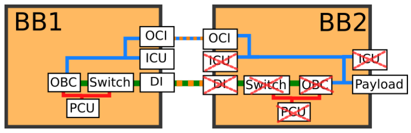


Fig. 4: iBLOCK redundancy concept using optical CAN interface

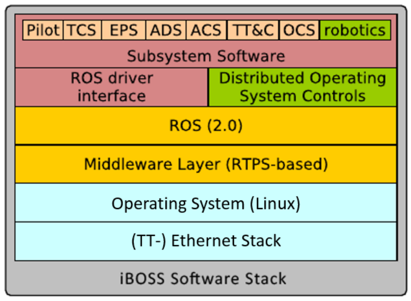


Fig. 5: iBOSS software stack

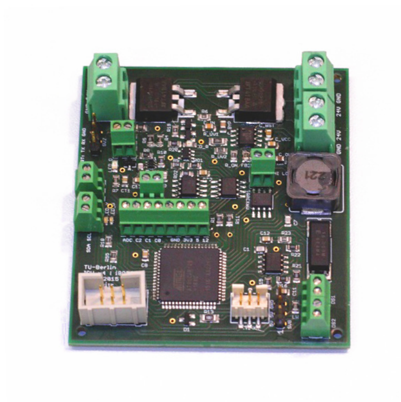

Fig. 6: Interface Control Unit (ICU)

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