Julius-Maximilians-
UNIVERSITÄT WÜRZBURG

Innocube - Going Wireless in Space

in partnership with TU berlin, ILR Institut für Luft- und Raumfahrt

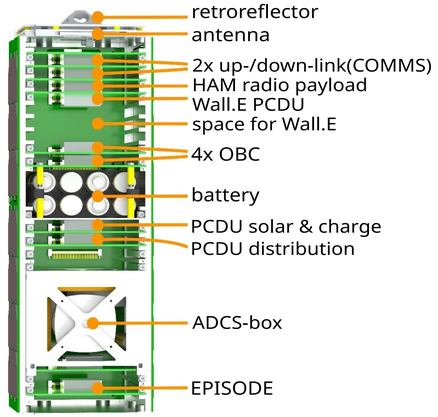
The Mission

Time frame

- Launch: Q3 2023

- Mission duration: 12 months

- De-orbiting: within the next 25 years



Innocube structure

Payloads & Experiments

The main objective of InnoCube is to show the feasibility of the following three novel systems:

- **EPISODE**: SDR-GNSS for CubeSats (antenna, FPGA, SKITH pcb & software)

- **SKITH**: wireless satellite bus & protocol

- **WALL#E**: battery as supporting structure

Possible show stoppers

Questions we adressed almost too late

1) Legal prerequisites:
Do we need permission? Which agency is responsible?
-- ISM bands are free to use on earth, ... but what about space?
-- Space is international, but we are German
=> Bundesnetzagentur

2) How do we make sure SKITH does not interfere with other scientists' measurements (e.g., radio astronomers') ?
=> Calculate worst case SKITH radio emissions
=> Use minimal possible transmission power

SKITH - Skip The Harness

SKITH aims to reduce the amount of cabling inside spacecraft by replacing traditional data harness with wireless technology. The InnoCube CubeSat mission will be based on a fully-wireless data bus.

Advantages using a **fully wireless data bus**:

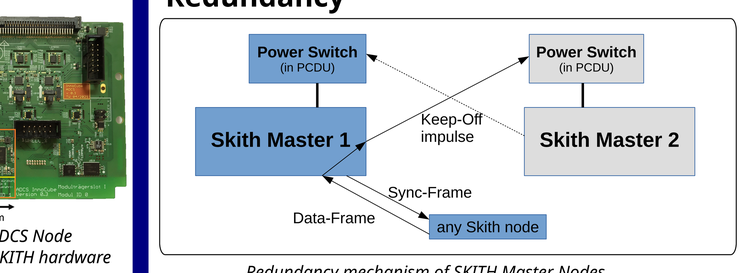
- Reduction of harness **mass**
- High **modularity** and extendibility
- Easy external **monitoring** and **testing**
- **Standardized** interface possible

Field	Type	Description	
Length	uint16_t	Length of the whole frame	
Frametype	uint8_t	1=Sync-Frame, 0=Data-Frame, 3=Sync-Frame+1PPS	
Sync-Frame only: timeUTC	uint64_t	UTC-Time of the Master(valid in 1PPS frames only)	
Sync-Frame only: slotTimes[n]	uint16_t[]	Beginn of slot n, relative to the start of the Sync-Frame, in 10microseconds	
PayloadLength	uin16_t	length of the following RODOS-MW-Frame, 0=no more MW-Frames	Repeat until slot is full
Payload[]	uin8_t[]	RODOS-MW-Frame	

SKITH Frame Header

SKITH Protocol

- Based on a Time-Division Multiple Access Protocol
- Each cycle begins with **master transmitting sync frame**
- Master node takes care of collision avoidance by publishing **dedicated slots for each node** in times relative to the Sync-Frame
- There are two master nodes for redundancy, but only one must be active at a time.
- **Latency and bandwidth** for each node is **guaranteed** and known beforehand
- Messages smaller than one slot can be grouped together to avoid wasting bandwidth
- For simplicity: **no fragmentation** of messages, largest message must fit in slot
- Onboard UTC-Time sync between all nodes
- The radio hardware takes care of channel encoding, framing and CRC



SKITH Cycle

Data Flow between SKITH Nodes

RODOS Middleware

We divide all different tasks of the software into separate "apps". Our real-time operating system "RODOS" has an integrated middelware that uses the **publisher/subscriber model** for communication between apps. Data is published to "**Topics**", to which all interested apps can subscribe.

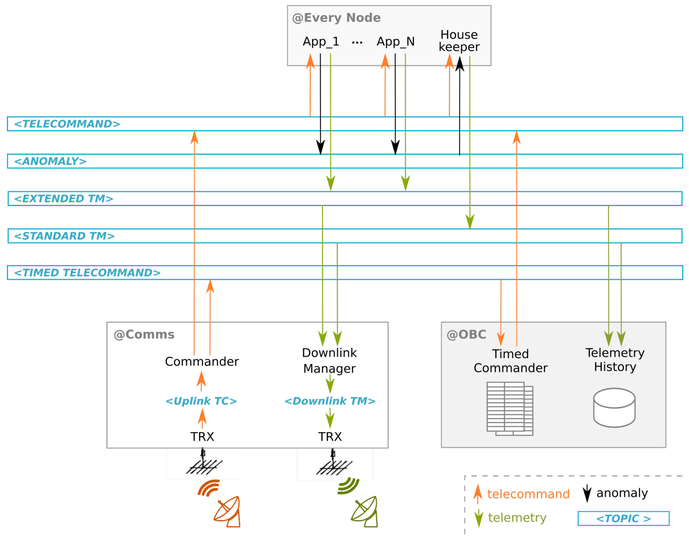
These Topics are **distributed transparently between nodes** over the SKITH radio link. So apps can be moved between nodes easily.

Main logical Topology

The Comms node connected to the transceiver uses "Telecommand" middle-ware topic to distribute telecommands to all SKITH nodes and subscribes to the telemetry topics to down-link all telemetry.

Every node has a housekeeper that collects STD-TM regularly. Extended-TM is published by each app directly.

“Timed Commander” and “Telemetry History” are the only apps that run on the OBC node, everything else is distributed.



Communication via RODOS middleware

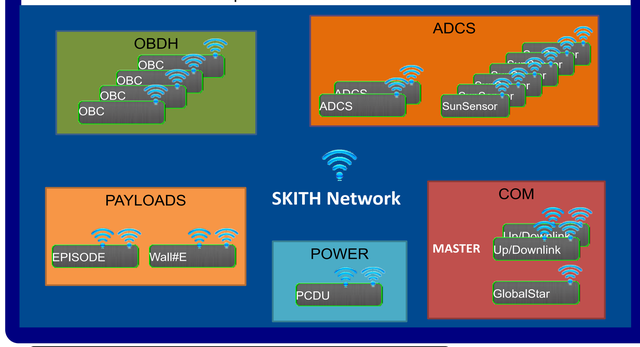
Hardware

The SKITH hardware, with its minimal footprint shown in the orange box, is integrated into the PCB of each InnoCube subsystem.

SKITH is based on a Silicon Labs Gecko SOC(EFR32FG12) featuring:
- 40 MHz ARM Cortex-M4
- 1 MB Flash / 256 KB SRAM
- low-power 2.4 GHz transceiver

ADCS Node with SKITH hardware

The entirety of SKITH nodes comprising InnoCube is depicted below. Each wireless network icon represents a SKITH instance.



Redundancy

Redundancy mechanism of SKITH Master Nodes

How it works

There are **two redundant SKITH master nodes**. To guarantee there is only one master node active at every time, and that any failure leads to a master node change, we use a **redundancy system independent of the radio protocol**. This keeps the protocol simple, too.

The **active master node ensures the proper functionality of the radio system** by verifying that it receives messages from other nodes. In that case it **keeps the power switch of the other master node in off-state** by triggering **periodic electrical impulses**. In case of any failure, these impulses stop and the other master nodes turns on. and can take over

On power up, both masters will turn on. To ensure a selection of one initially active one, they have a random time delay before triggering the keep-off pulse to the other node.

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DLR

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