Concepts of the Rubin Testbed for In-Orbit Verification of MNT

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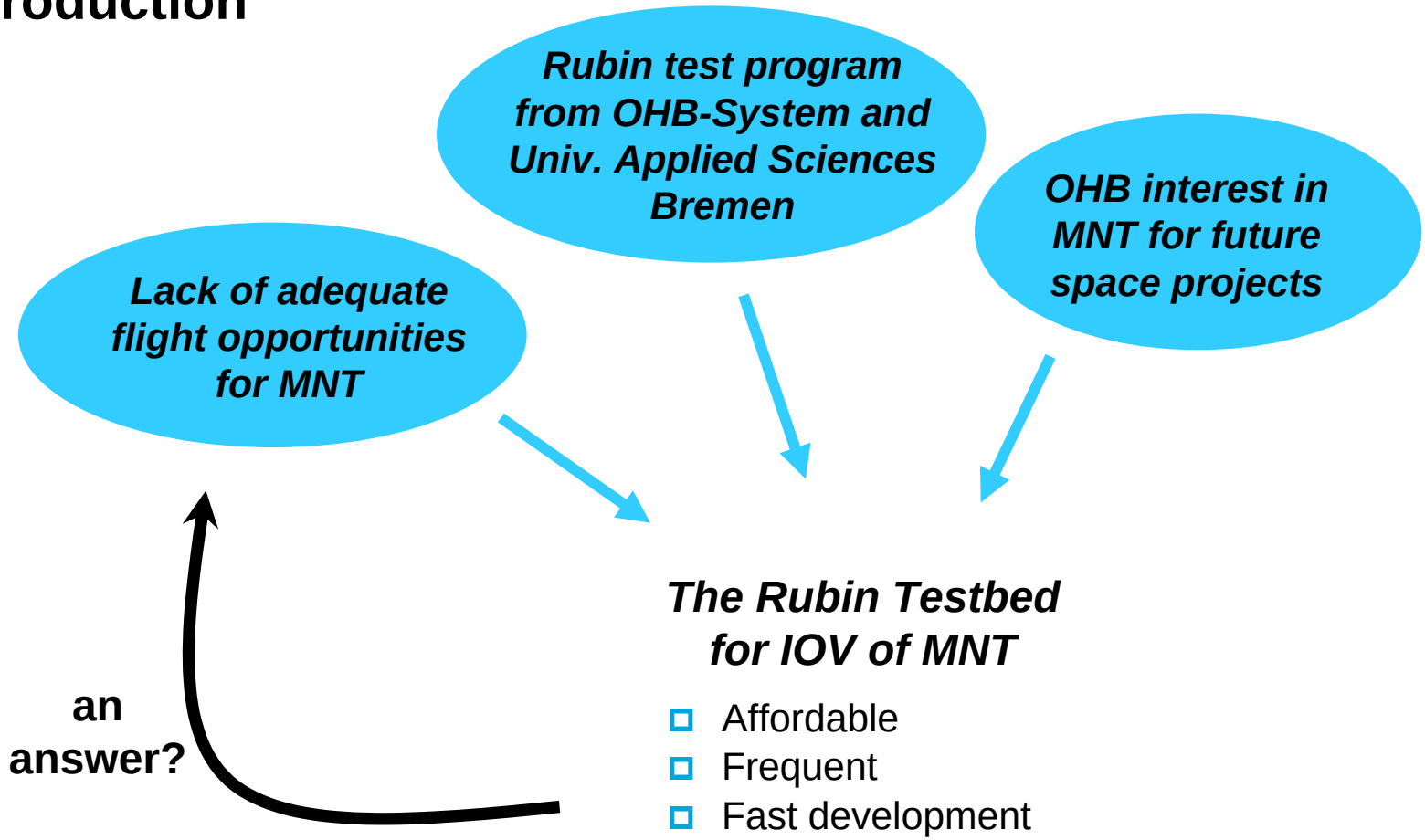
Presentation Overview

- Introduction
- Rubin Background
- Rubin Concept:
  - Orbcomm Communication
  - Architectures
  - Key Technologies
- Summary

Introduction



Rubin Missions (1/2)

6 Rubins developed, launched and operated since 2000

- BIRD Rubin (2000). Attached payload with CHAMP and MITA. First payload to communicate via Orbcomm
- Rubin-2 (2002) Free flyer launched on Dnepr. Command and control via Orbcomm
- Rubin-3 (2002) and Rubin-4 (2003). Cosmos LV telemetry via Orbcomm

Rubin-2 on Dnepr adapter ring

Rubin Missions (2/2)

- Rubin-5 (2005) launched on Cosmos and still operational today 24 months after launch. Payload consists of:
  - Debris detector
  - Advanced Solar Antenna (ASOLANT)
  - DLR GPS Receiver
  - S-band beacon transmitter
  - 3D magnetometer
  - Camera
- Rubin AGILE launched on April 23rd 2007. Objective to function as backup for scientific data transmission from the satellite
- Rubin ready for launch this year with GPS receiver and AIS experimental payload
- Rubin MNT mission foreseen for 1st half of 2008 with AAC components:
  - Remote Terminal Units
  - Mass memory
  - Magnetic ACS module (M-ACS)

Debris detector plate and TMTC unit

Horizon snapshot by Rubin 5 camera

Communication via Orbcomm

Experiment attached to the upper stage of the Launcher in a < 700 km Orbit

- **Scientific Data from Experiment**
- **House-Keeping Data**
- **Commands to Experiment**

ORBCOMM Space System Constellation of 29 satellites in LEO (~ 750 km orbit)

Two-way communication with global coverage

- **Direct Mode. No max length specified**
- **Store-and-forward Mode. Max length 182 bytes**

esa

Scientists/ Customer

OHB System

Internet

Communication via Orbcomm (2/2)

Orbcomm System

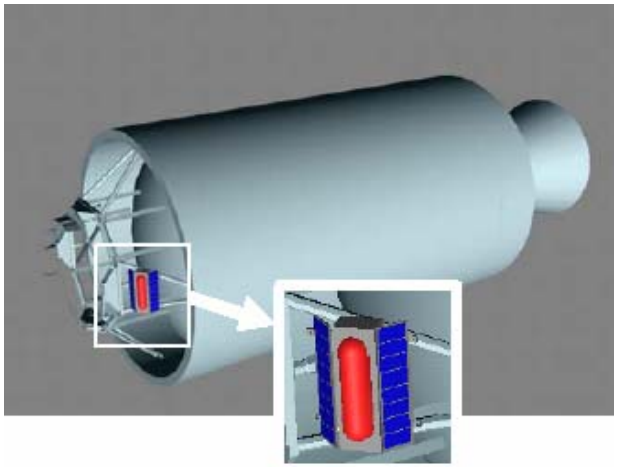
- Satellite based, global, two-way message based communication system
- Segments
  - Space Segment: 29 operational satellites in LEO
  - Ground Segment
    - 13 Gateway Earth Stations (GES) communicating with the satellites
    - 5 Gateway Control Centres processing messages and forwarding these through GES to satellites or terrestrial communication networks
    - 1 Single Main Network Control Centre monitoring and managing the system
  - Subscriber or User Segment
- Orbcomm transmission modes:
  - Direct Mode – direct link between user and GES via Orbcomm satellite. No max length specified
  - Store-and-forward Mode – message uploaded to satellite and stored until communication with user or GES can be established. Max length 182 characters per message but can be combined for large file transfer

Rubin Concept

A case-by-case design so far. No standardised platform

Features:

- Low cost approach utilising COTS components
- Launched into typical LEO orbits as piggy-back passenger
- Short development schedule
- Typical in-orbit lifetime of 1 year
- Benign thermal environment thanks to upper stage thermal capacity
- Global communication access via Orbcomm and emails to your own computer, i.e. no dedicated ground infrastructure or frequency allocations necessary
- Approximately 1 launch per year so far



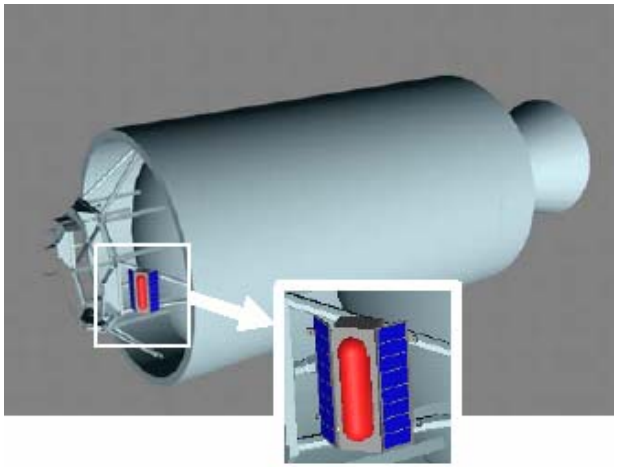
Rubin as attached payload on LV upper stage

Rubin Concept

A case-by-case design so far. No standardised platform

Features:

- Attached to upper stage or free-orbiting
- Data rates (based on Rubin 5)
  - Max: ~13 kbyte/day
  - Mean: ~3 kbyte/day
- Data interfaces: Serial (RS232), CAN, (SpaceWire)
- Power
  - Generated (typical): ~10 W
  - Payload (typical average): ~5 W
  - Modem turns off when power too low
- Mass storage: ~2 Mb

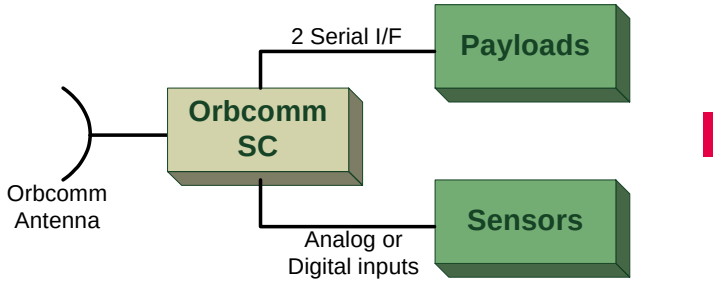


Rubin as attached payload on LV upper stage

Rubin Architectures (1/2)

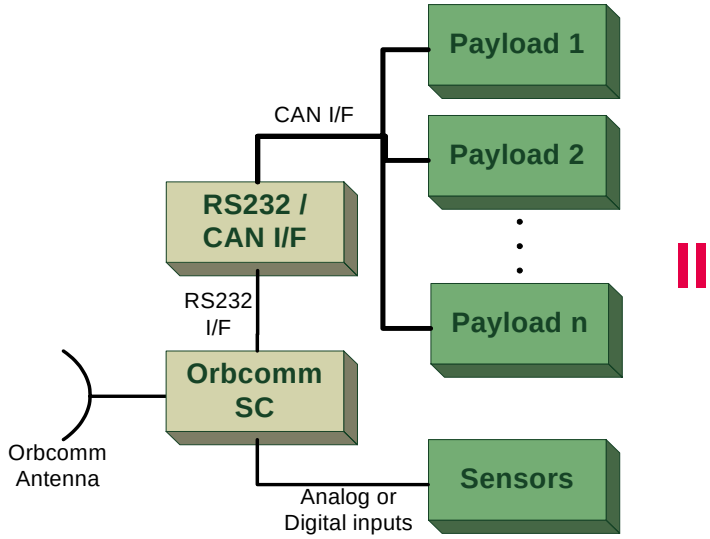
Architecture I:

- Orbcomm Modem used for communication with ground and controlling payloads
- 2 serial I/Fs used for payloads. Direct sampling of auxiliary sensors
- Used on most Rubins so far. Dual configuration on Rubin 5



Architecture II:

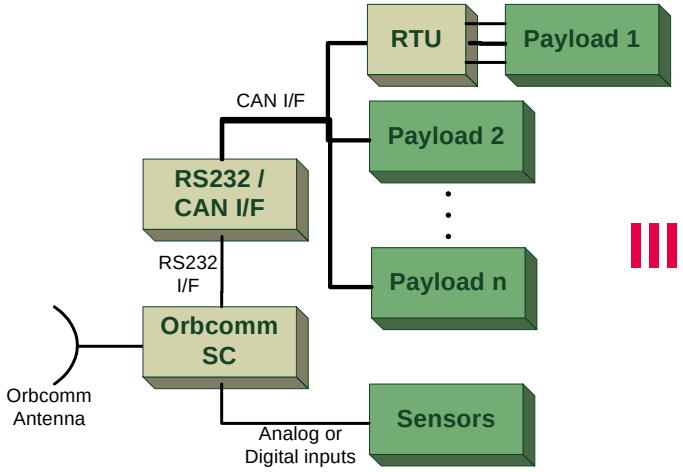
- Dedicated bus interface can be inserted to communicate with more payloads.
- Interface module connected to serial I/F on Orbcomm modem
- Architecture developed but not flown yet



Rubin Architectures (2/2)

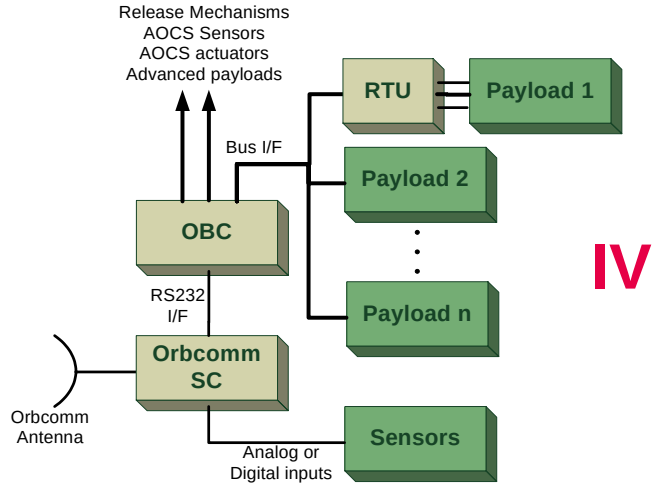
Architecture III:

- For payload with different interfaces (not CAN) or requiring advanced payload handling beyond the performance of the Orbcomm Modem Remote Terminal Units (RTUs) with flexible interfaces, user programmable functionality etc. can be inserted.
- Facilitates development of Rubin missions by letting payload suppliers program the RTU towards a specified I/F to Rubin



Architecture IV:

- Future concept for e.g. a 3-axis stabilised Rubin or with very advanced data handling will require the utilisation of a dedicated onboard computer for payload data handling, avionics, mechanisms, etc.



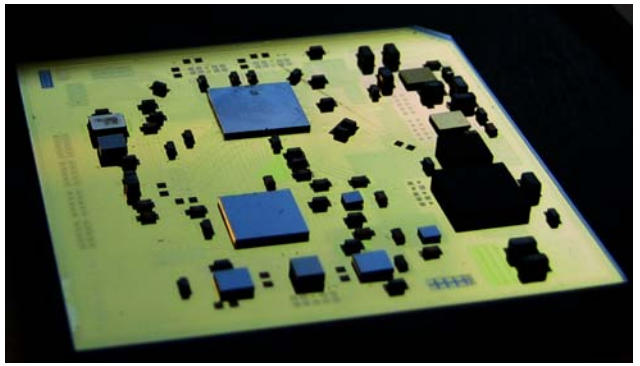
Orbcomm Subscriber Communicator

- Orbcomm Modem used for Rubin missions is the QuakeGlobal Q2000 Compact Orbcomm GPS Modem.
- Q2000 not space qualified but is vibration tolerant and has a large temperature range
- Features:
  - VHF Communication via Orbcomm
  - 4 Analog Input
  - 8 Digital Output
  - Real Time Clock
  - 2 RS232 Serial Ports / RS485 Port
  - Windows configurable and/or C programmable
  - CPU for execution of user written software
  - 2 Mb memory data storage
  - Samplig rate of 100 Hz of user equipment

Quakeglobal 2000 (www.quakeglobal.com)

Remote Terminal Unit

- Miniaturised Remote Terminal Units (RTUs) under development at Angstrom Aerospace Corporation (AAC)
- First (current) generation based on FPGAs and microcontrollers. Second generation on a fully qualified ESA ASIC
- Dimensions: 33 x 33 x 2.5 mm^3
- Mass: 4g
- Features (first generation)
  - Redundant CAN 2.0b and Spacewire
  - User programmable functionality
  - Optional Plug ‘n Play (PnP) over CAN
  - 6x14 bit A/D, 4x12 bit D/A
  - SPI, UART
  - 60 User I/O connected to FPGA (for integration of I2C or other functions).
  - 48 bit distributed spacecraft elapsed time
  - Latch-up protection



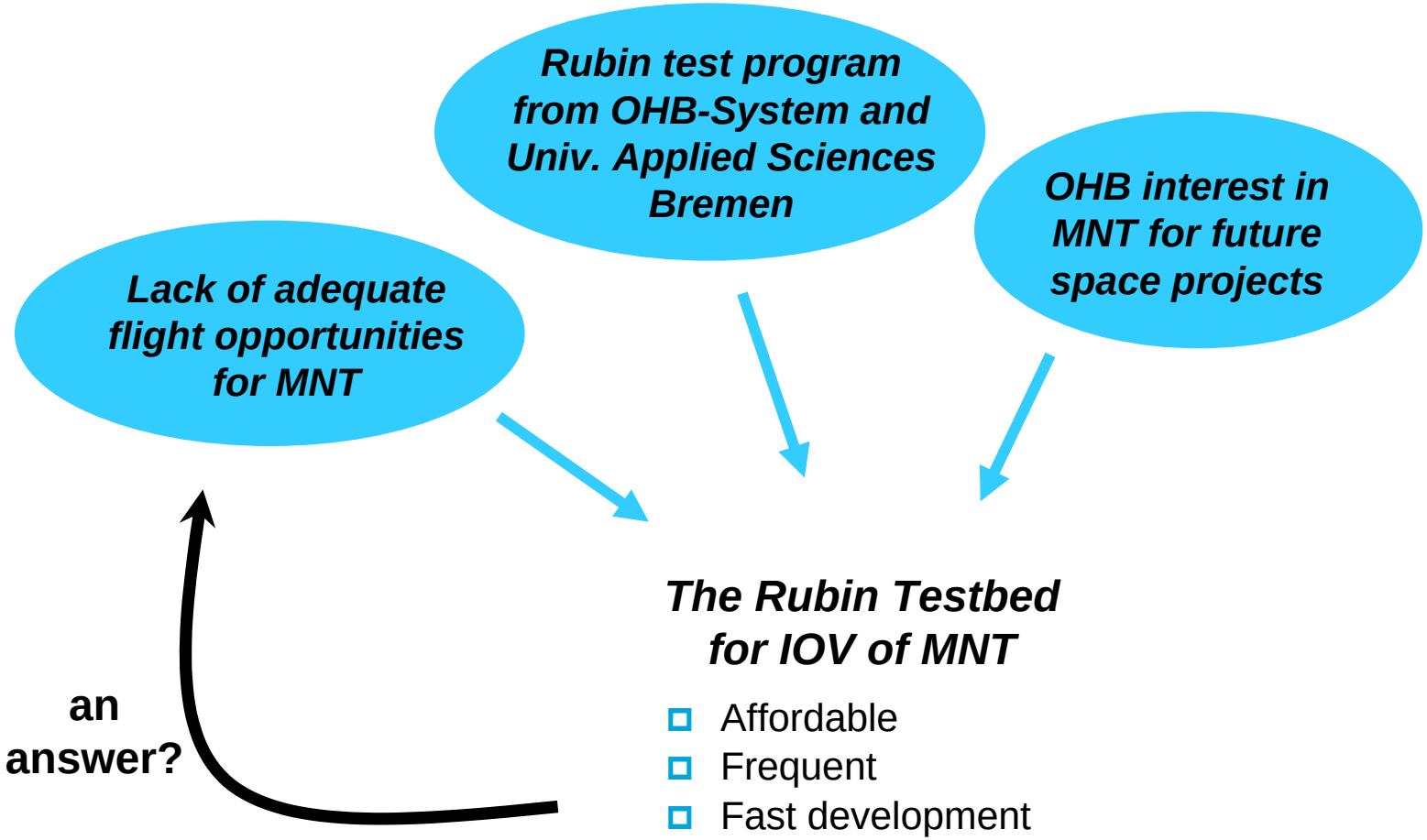
Photograph of a Angstrom Aerospace 3D-SiP RTU module, with only flip-chipped components on a 525 mm silicon substrate with hermitically sealed metallic Through Silicon Vias (TSV)

- **Flight targeted for first half of 2008**

Summary

- The Rubin program for in-orbit verification of new technologies is examined for applicability for testing Micro- and Nanotechnologies
- ~1 Rubin flight/year since 2000 and the program is continuing using close ties between OHB and relevant launch providers
- Communication via Orbcomm provides global access to the Rubin spacecraft for TMTC and payload data downlink – all controllable via a standard computer with Internet connection.
- Different architectures are being investigated to enable an increasing performance and flexibility of Rubin to various mission and payloads
- Flight of Candidate technologies for inclusion for future missions and foreseen for launch in 1st half of 2008

Rubin Testbed for IOV of MNT



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