BITS AND BYTES IN MICROGRAVITY: INSIGHTS INTO THE HARDWARE AND SOFTWARE OF SOUNDING ROCKETS

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German Aerospace Center
Space Operations and Astronaut Training
Oberpfaffenhofen, Germany

German Aerospace Center (DLR)

Approx. 10,000 employees

across 58 institutes and facilities

at 30 sites.

International offices in Brussels, Paris, Tokyo and Washington D.C.

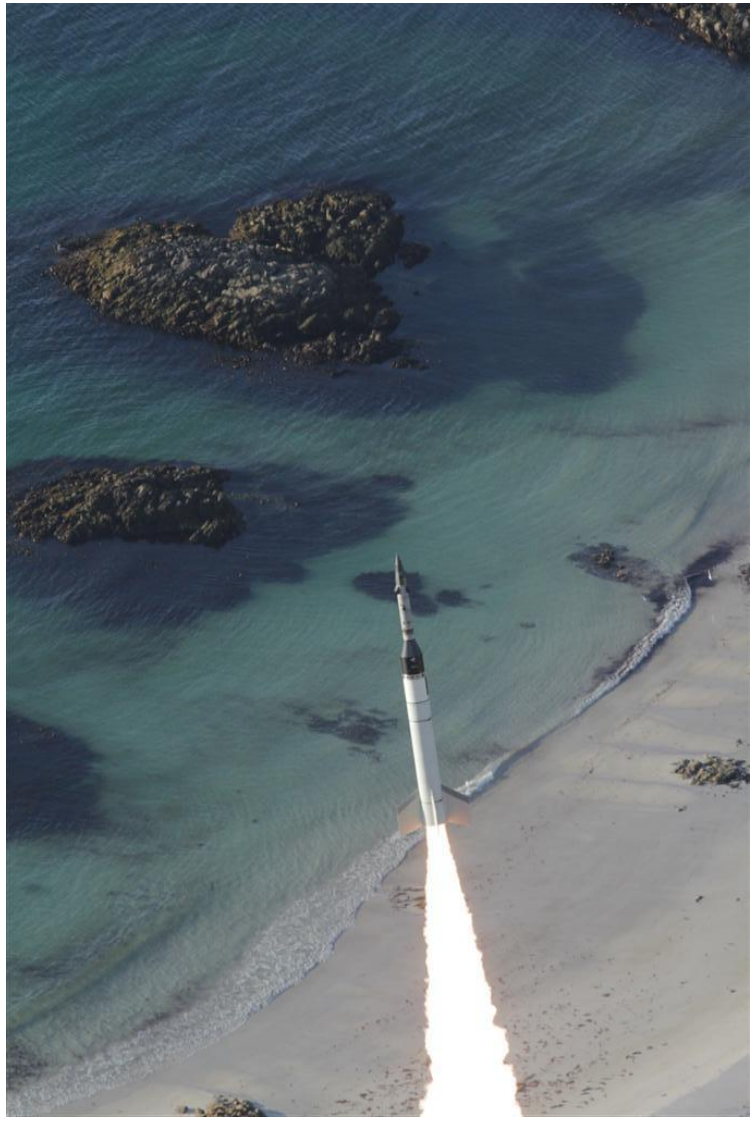
MORABA
MOBILE RAKETENBASIS

„We develop build and fly customized sounding rockets“

MORABA
MOBILE RAKETENBASIS

DLR

SHEFEX II



MORABA
MOBILE RAKETENBASIS

550+
Launches
in more than 55 years

20
Launch Sites
in 14 countries on 5 continents
(America, Antarctica, Asia, Australia, Europe)

30
Launch Vehicles
have been used, developed, adapted and/or operated for the scientific community

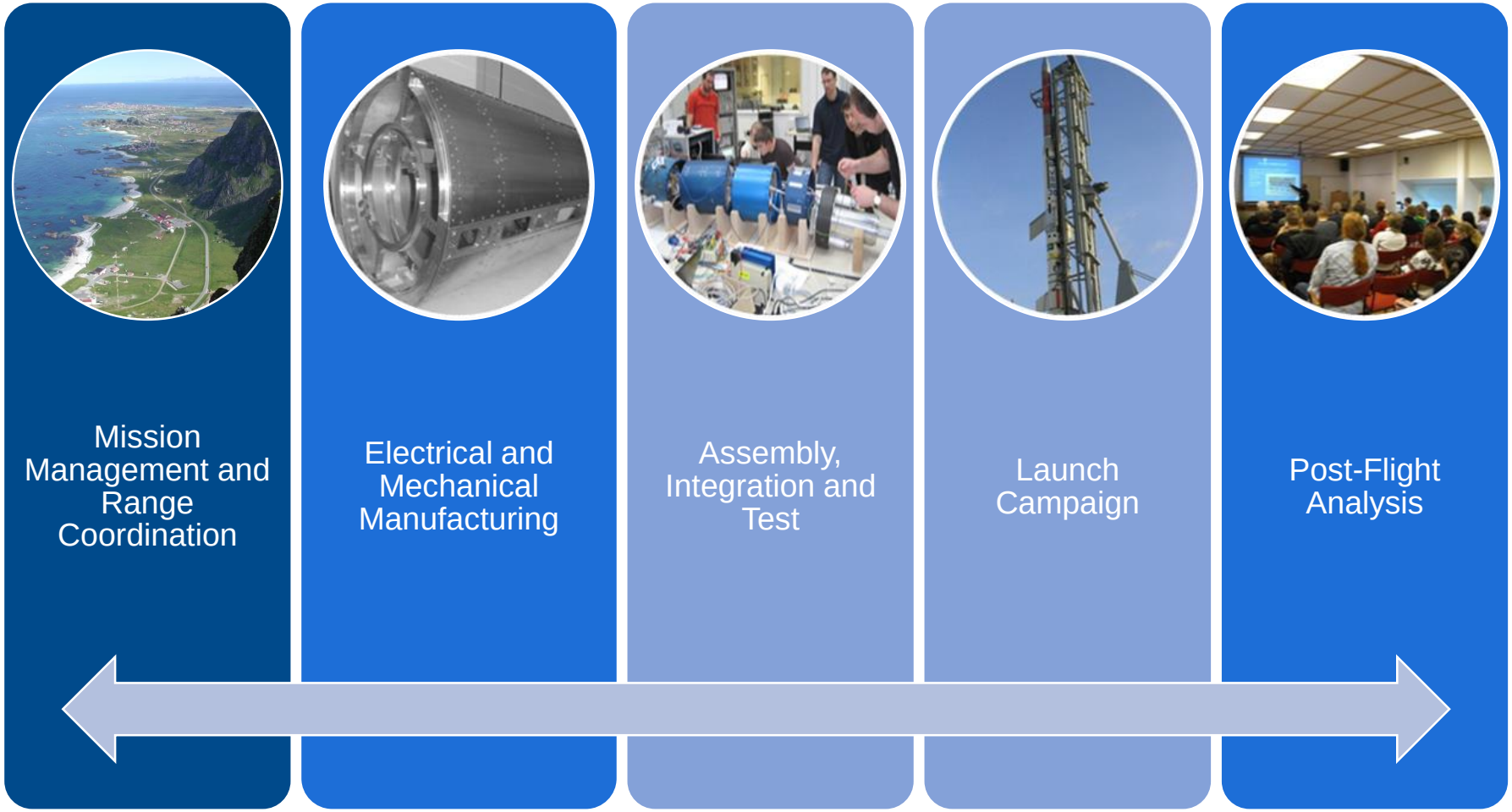
7
Research fields
Aeronomy, Astronomy, Microgravity, Hypersonics, Student Education, Technology demonstration and Security/Defence related research

7.058 kg
Lift-Off Mass
was the heaviest rocket launched under MORABA responsibility to date (SHEFEX 2)

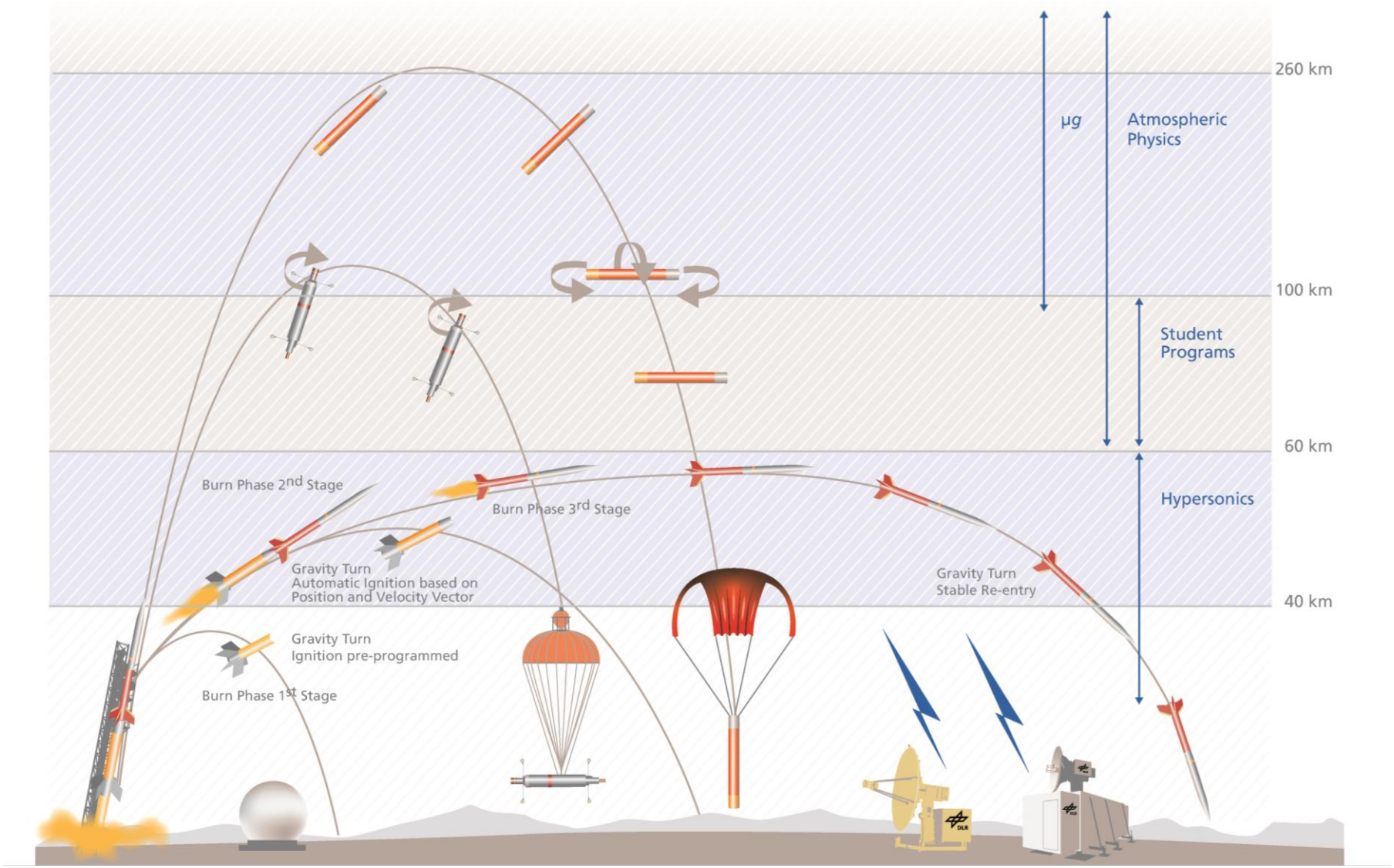
~65
Employees

Esrange Space Center, Schweden

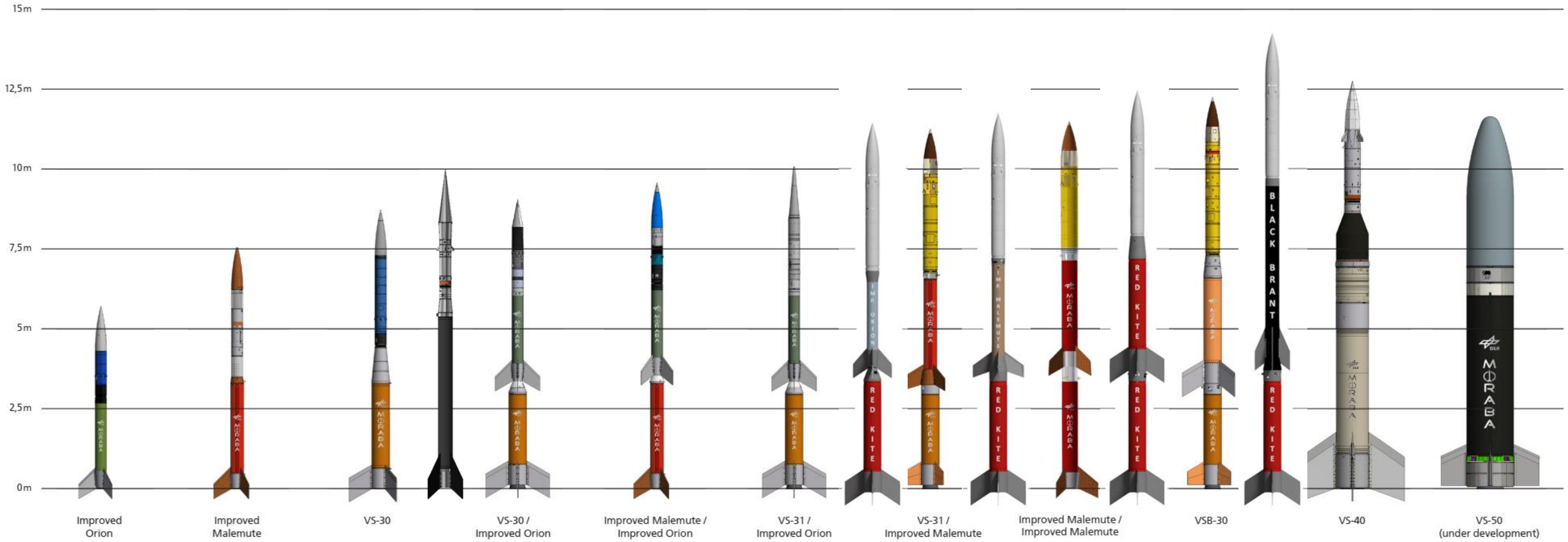
What is required to fly a sounding rocket?



Mission Flight Profiles



Vehicle Selection



Sites Utilized by MORABA

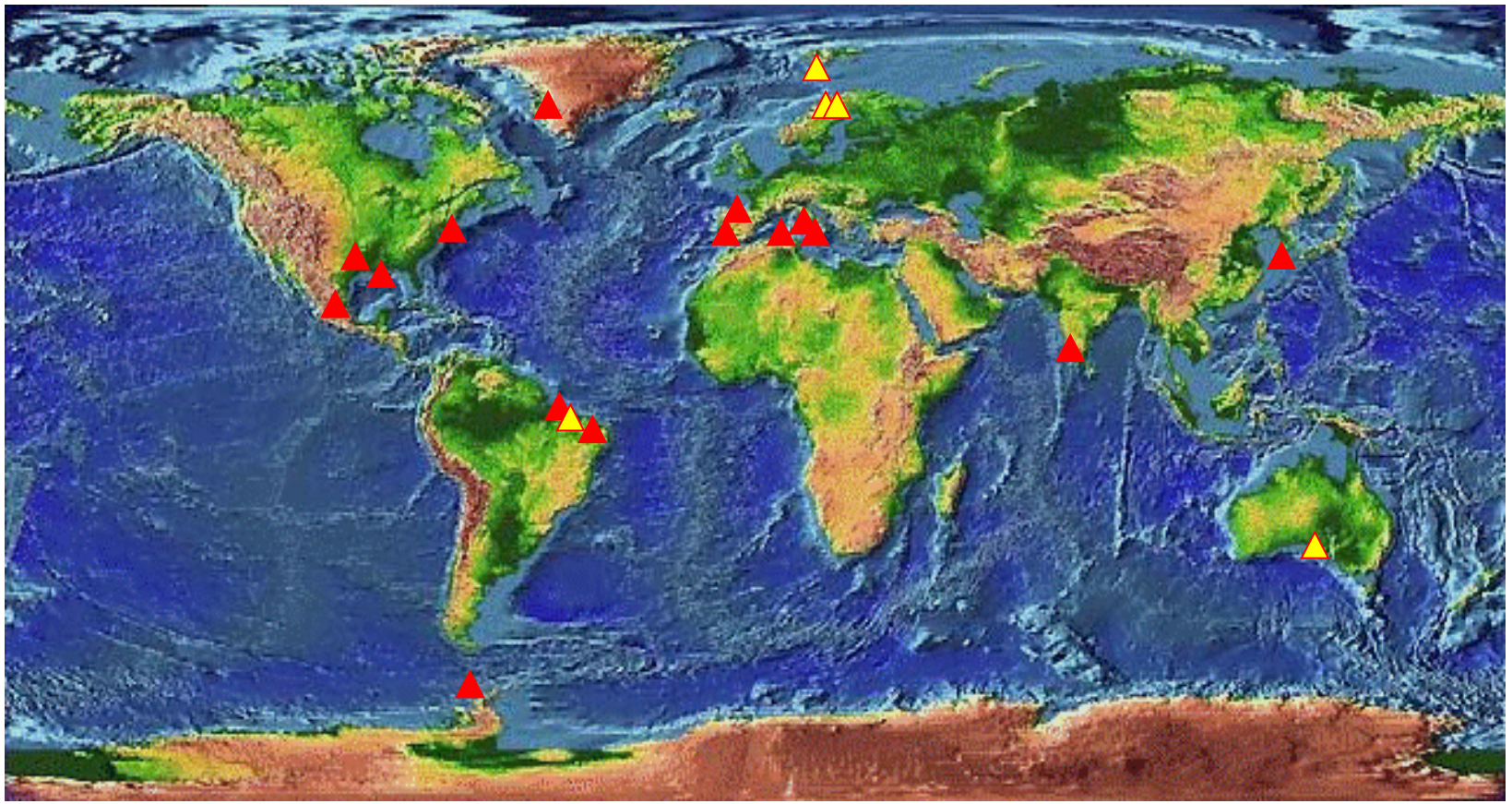
Huelva, Spain
Biscarosse, France
Perdas de Fogu, Sardinia
Karystos, Greece
Kreta, Greece

Spitzbergen, Norway
Andenes, Norway
Kiruna, Sweden

Greenland

Wallops Island, USA
Matagorda, USA
White Sands, USA
Palestine, USA

Kourou, French Guyana
Alcântara, Brazil
Natal, Brazil



Kagoshima, Japan

Woomera, Australia
Coober Pedy, Australia
Koonibba, Australia

Adelaide Island, Antarctica

Thumba, India

How to build a rocket

Mobile Rocket Base

Launch Services

- Aerodynamics
- Trajectory Prediction
- Dispersion Analysis
- Wind Weighting
- Mobile Launcher
- Ignition Systems
- Rockets AIT & Launch
- Flight Safety
- Post-flight Analysis

Mechanical Flight Systems

- Structural Analysis
- Thermal Analysis
- Staging Systems
- Fin Assemblies
- De-spin Systems
- Separation Systems
- Recovery Systems
- Instrument Integration & Payload AIT
- Post Flight Analysis

Data Handling

- Service Systems
- Multi-channel TV transmission Systems
- RF Systems
- EGSE
- Experiment AIT
- Environmental Tests
- Data Analysis

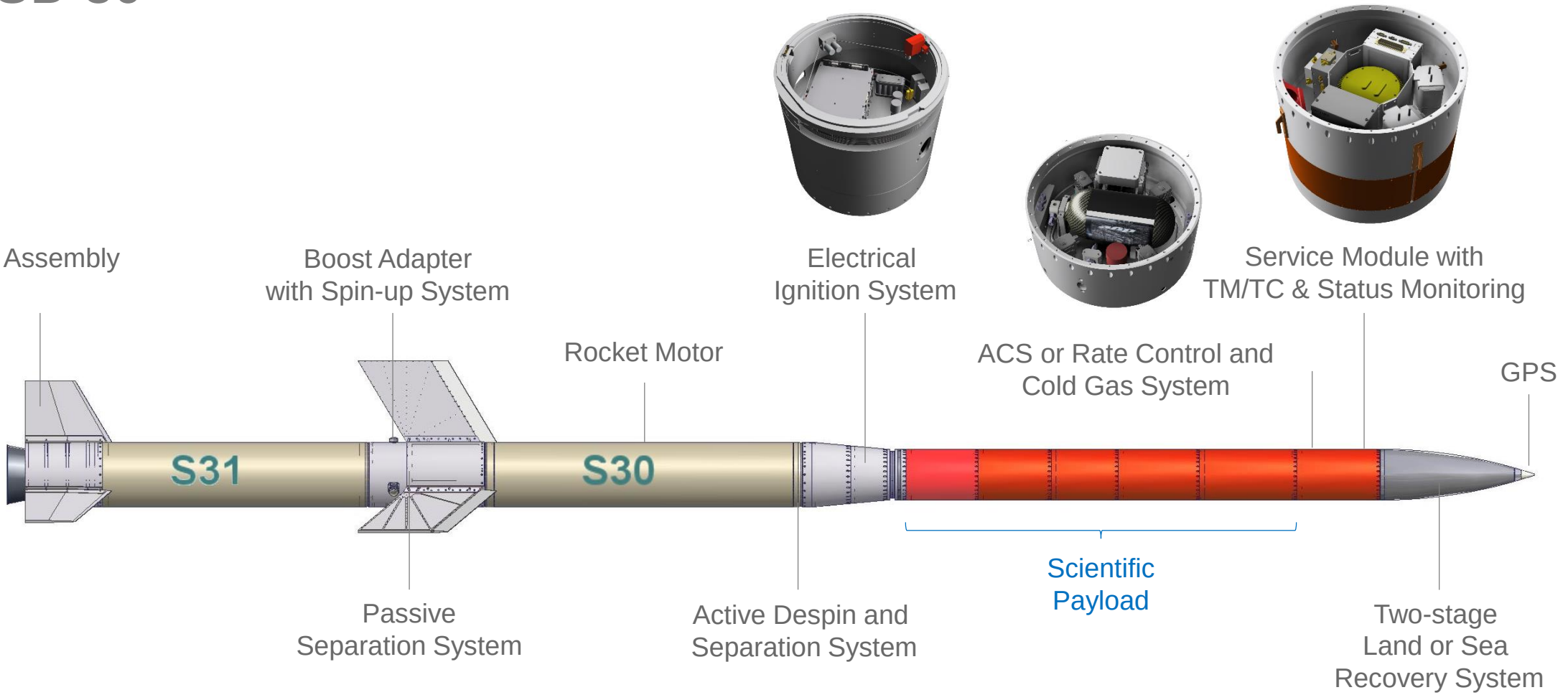
Control and Instrumentation

- Control Systems for Flight Control, Attitude Control and Rates
- Navigation
- Sensors
- EGSE
- Experiment AIT
- Environmental Tests
- Data Analysis

Telemetry, Tracking & Command

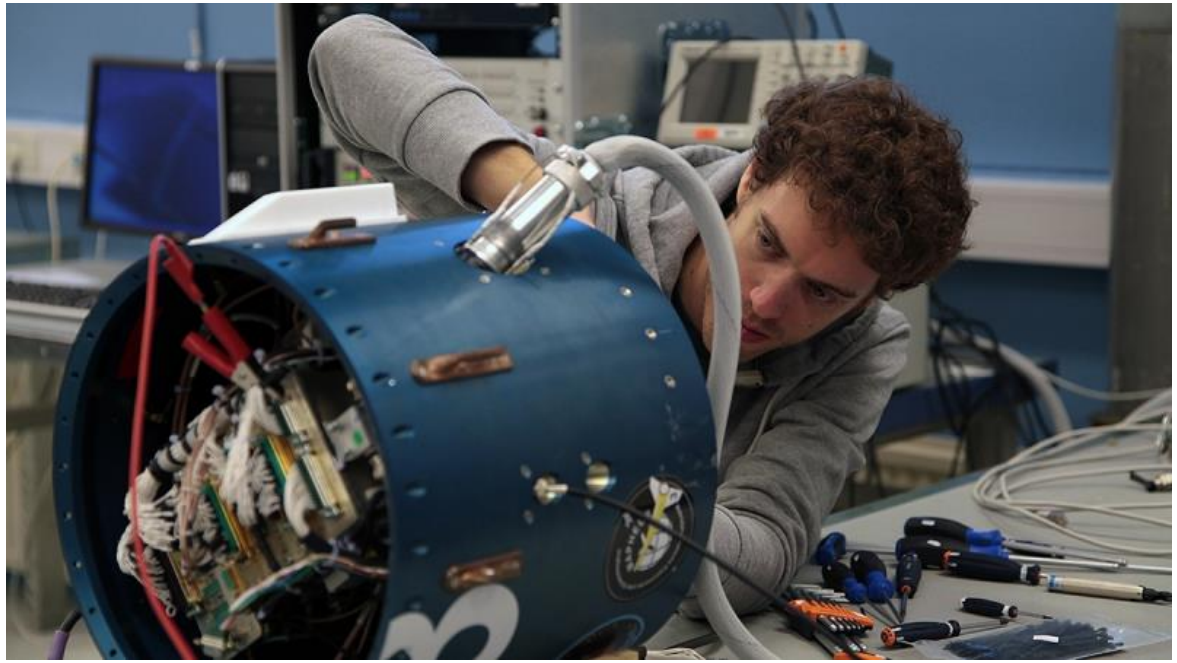
- Mobile Ground Stations
  - Telemetry
  - Tele-command
  - Instrumentation Radar
- IIP-Prediction
- Quick-Look
- Data Recording
- Data Distribution

Rocket Motor and Payload Support Systems
VSB-30



Payload Support Systems
Modular Service Module

- Modular selection and assembly of required performance and service
- Standard „normal world“ interfaces for ease of testing from lab to flight
- Scalable
- „Normal“ TM Bitrate of 4x10MBit/s



Payload Support Systems
Modular Service Module

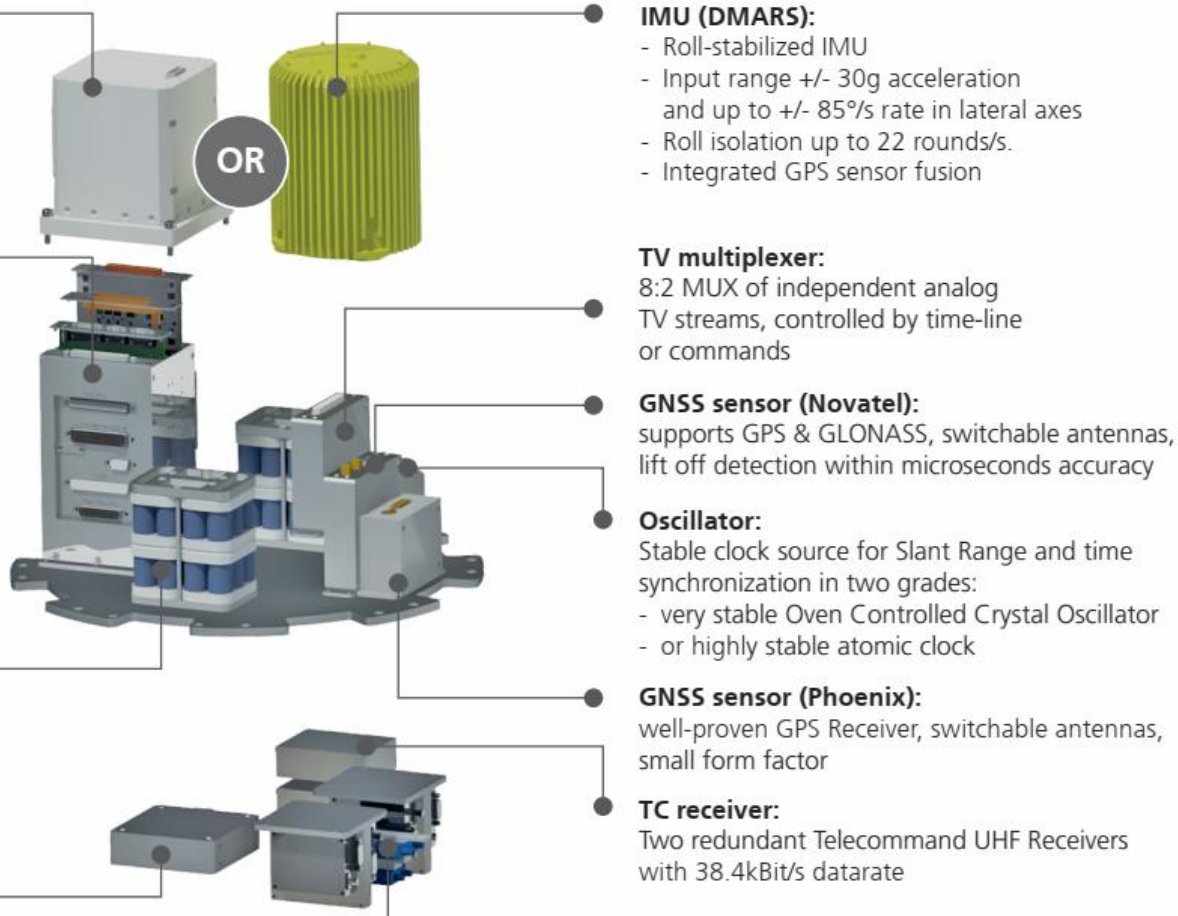
IMU (SensorCube):
Quartz flexure accelerometers
- Input range of ± 30 G down to ± 0,1 µG (all axes)

Fiber optic gyroscopes
- Input range ± 1470 deg/s in roll and ± 980 deg/s in lateral axes

Ebox:
- Fast Ethernet Interface
- 12 RS422/UART serial ports with flags
- 2 CAN Hosts
- Up to 32 Mbit/s downlink incl. framing & protection using multiple transmitters
- Uplink incl. framing & protection up to: 38.4 kBit/s in flight and 1 Mbit/s on ground
- 15 switchable power channels
- 12 PT1000 temperature sensor interfaces
- Processing power for attitude determination & control and other calculations

Batteries:
Two stacks of 4 packs of 6 NiMH cells with a total capacity of 75 Wh incl. redundancy provide power for the whole payload with max 3A per experiment and a voltage between 24V and 36V.

Ethernet switch:
- 5 Ports
- Fast Ethernet (100MBit/s)
- Quality of Service
- Virtual LANs.



IMU (DMARS):
- Roll-stabilized IMU
- Input range +/- 30g acceleration and up to +/- 85°/s rate in lateral axes
- Roll isolation up to 22 rounds/s.
- Integrated GPS sensor fusion

TV multiplexer:
8:2 MUX of independent analog TV streams, controlled by time-line or commands

GNSS sensor (Novatel):
supports GPS & GLONASS, switchable antennas, lift off detection within microseconds accuracy

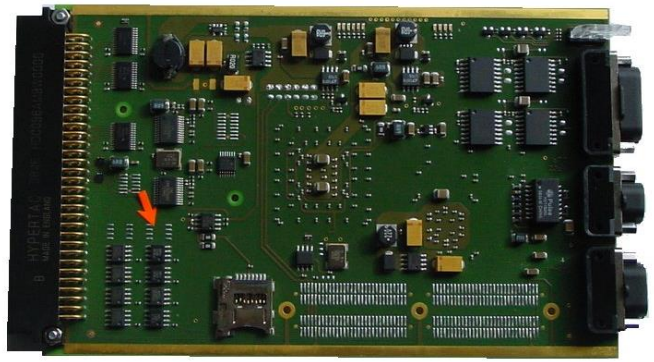
Oscillator:
Stable clock source for Slant Range and time synchronization in two grades:
- very stable Oven Controlled Crystal Oscillator
- or highly stable atomic clock

GNSS sensor (Phoenix):
well-proven GPS Receiver, switchable antennas, small form factor

TC receiver:
Two redundant Telecommand UHF Receivers with 38.4kBit/s datarate

TM/TV transmitter:
Up to four 10W S-Band transmitters with up to 10 MBit/s data rate each OR TV Transmitters for analog video transmission alternatively including Antenna Coupler Network

Payload Support Systems
Multifunction-Card 2nd Generation (MFC 2G)



Input / Output

- 16 RS422 HD @ 35 Mbit/s
- 8 ISO RS422 HD @ 35 Mbit/s
- 8 LVDS HD @ 100 Mbit/s (shared with RS422)
- 2 CAN (shared with RS422)
- Ethernet 10/100 Base-T
- 38 Digital I/O in 5 Banks @ 3.3 or 5V
- 2 GMSK Modems @ 38.4 kBit/s
- 8 Low side switches, 50V, 0.5A
- 4 User programmable LEDs
- Housekeeping circuits

Calculation & Storage

- Dual Core Blackfin 561 running at 500 MHz as CPU and data pre-processor
- Cyclone 3 (EP3C120 or EP2C80) used as periphery controller, communication and data co-processor
- 64 MB SDRAM
- 2 MB SRAM
- 64 MB NOR-Flash
- µSD-card socket for mass storage (currently available > 4GB)

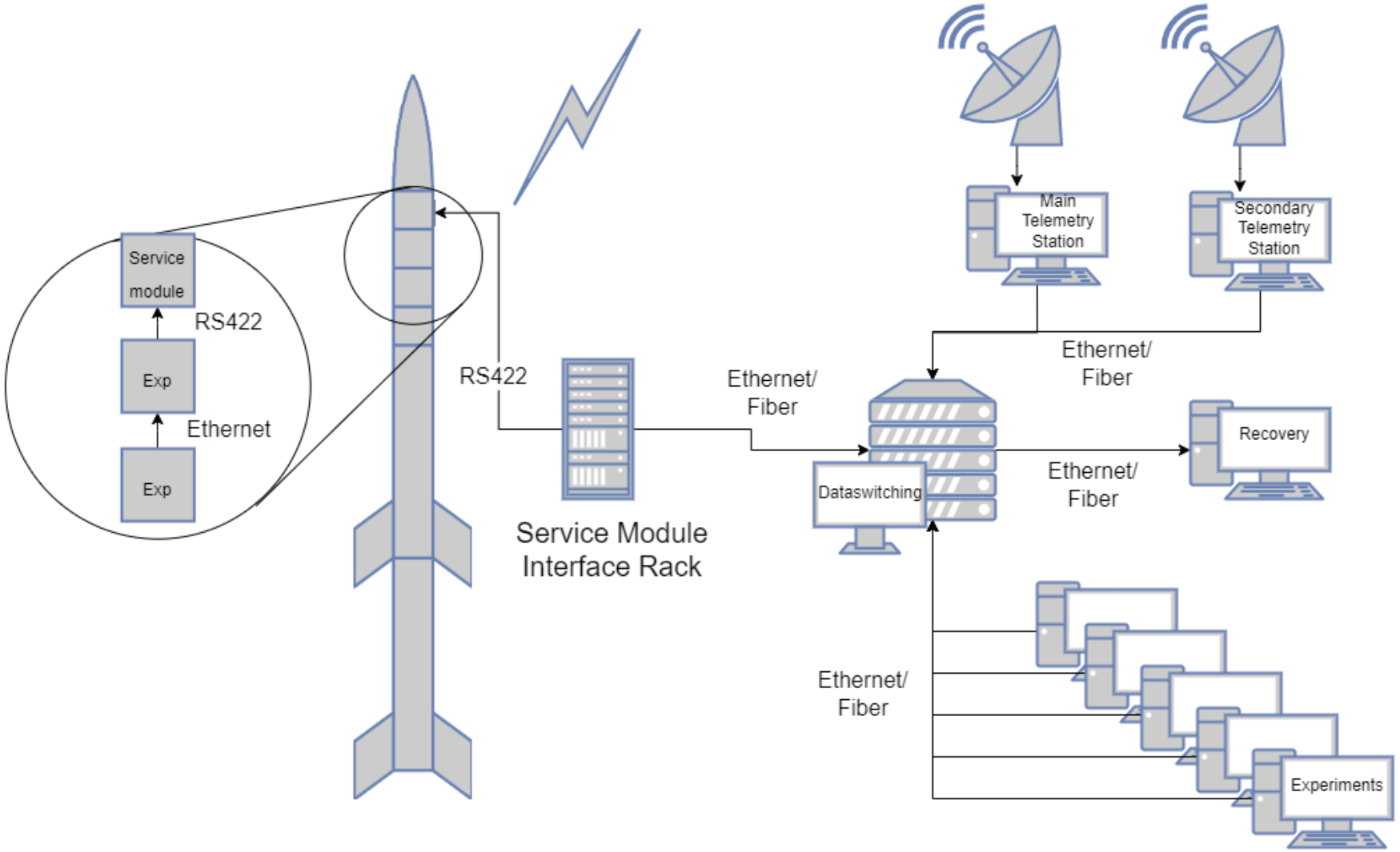
Functional and Environmental Testing

Functional and Environmental Testing

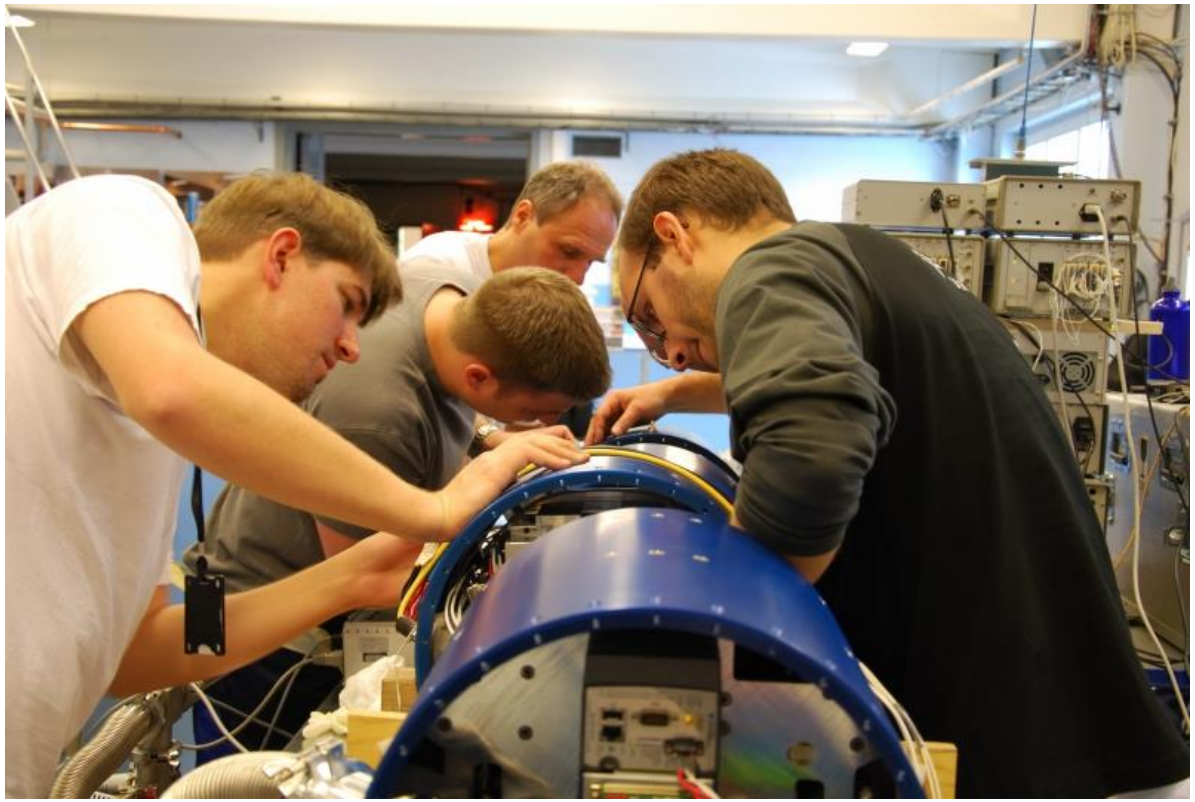
Assembled Payload with Rocket Motor Systems

Deploying of the Mobile Infrastructure

Electrical Ground Support Equipment (EGSE) Hardware

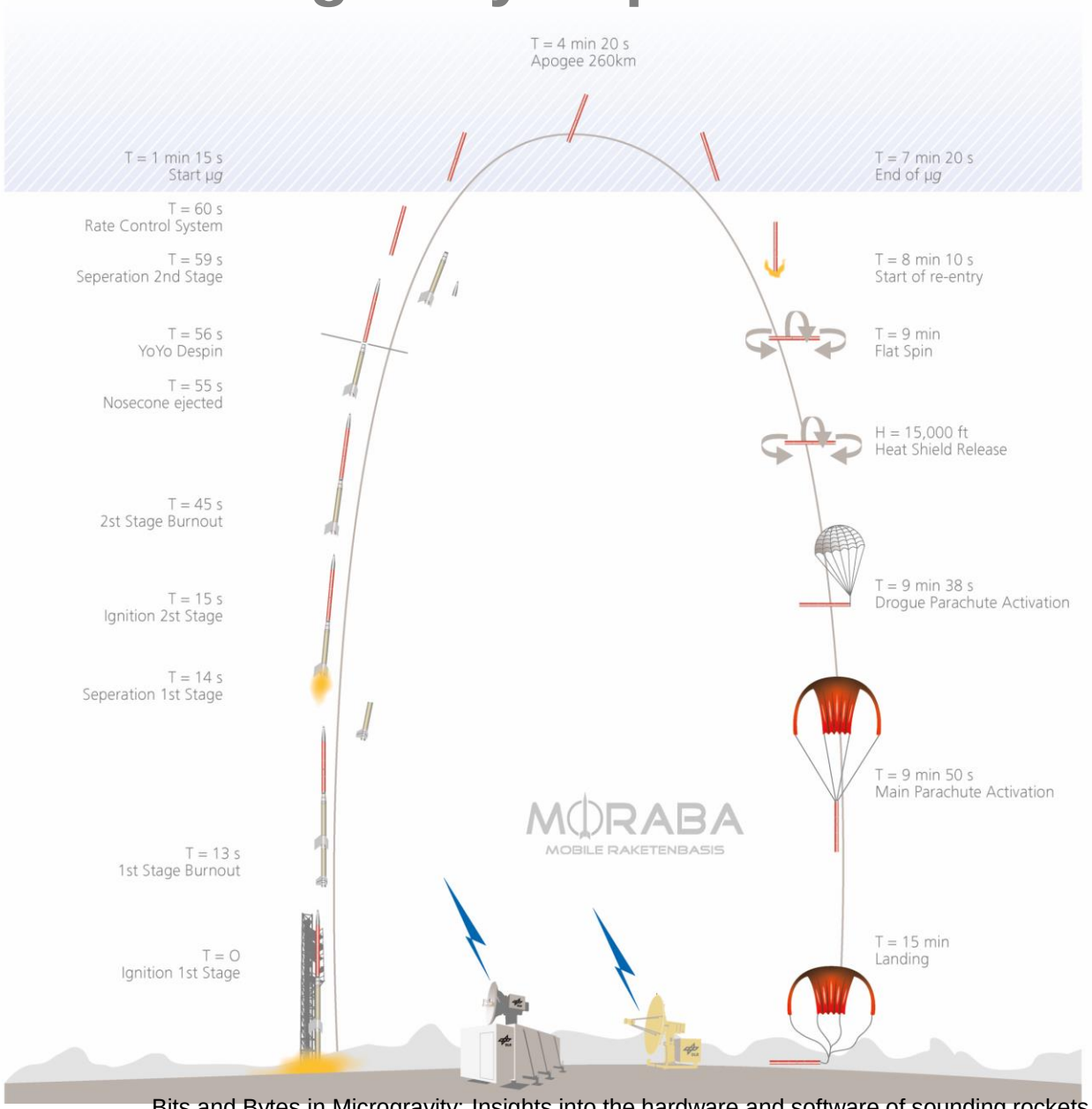


Tests and Launch Preparation

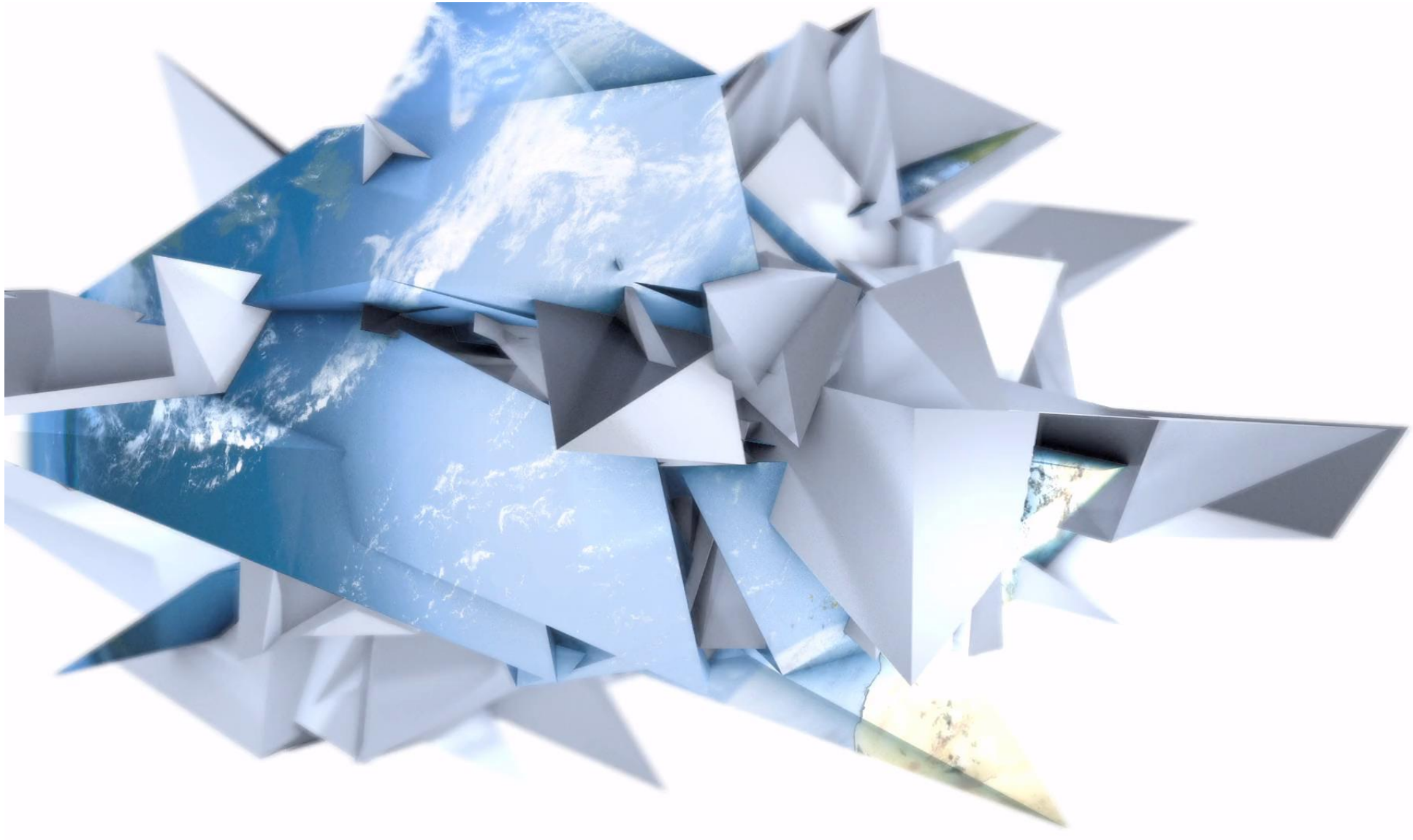


Launch Preparation and Launch

Flight Profile for Microgravity Experiments



Launch of the Mapheus 5 Sounding Rocket



Recovery and Data Analysis

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