EUROPEAN WORKSHOP ON ON-BOARD DATA PROCESSING (OBDP2021)
14-17 JUNE 2021

Brain in Space

Making AI in space accessible to all

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Agenda

1. About Spire
2. Spire Space Services
3. The ‘Brain in Space’ project
   1. The story behind ‘Brain in Space’
   2. Objectives of the project
   3. Approach
4. Chip selection
5. Testbed assembly
6. Software development

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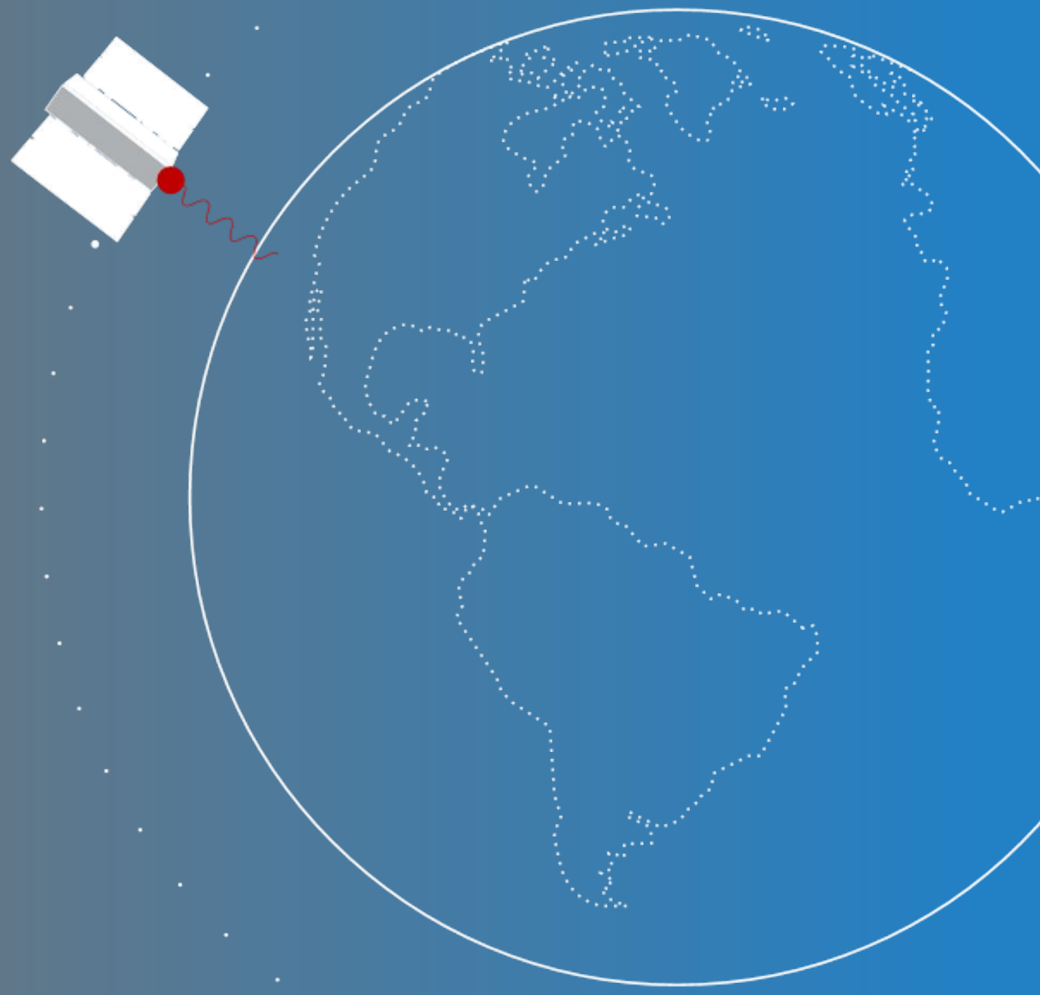
About Spire

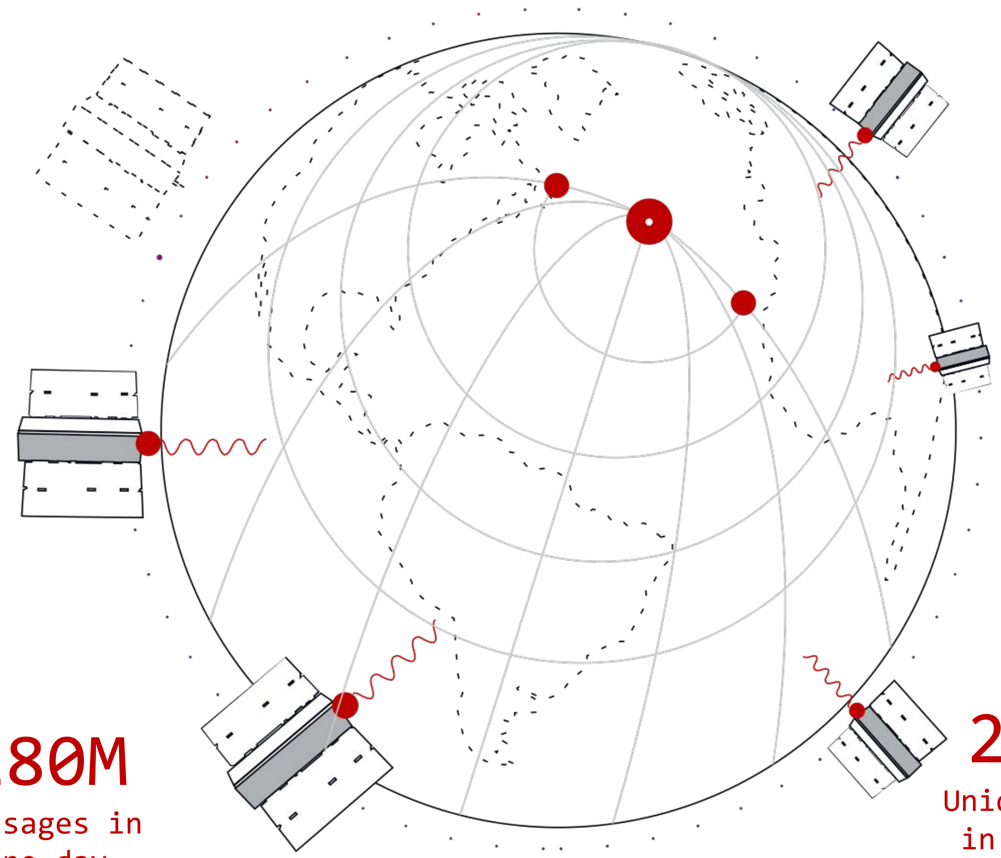


The Spire constellation

One of the largest private constellations in the world.

- The Low Earth Multi-Use Receiver (LEMUR) is Spire’s 3U CubeSat platform used to track maritime, aviation, and weather activity from space
- We operate the world’s largest RF sensing fleet and are the largest producer of radio occultation and space weather data
- Our data provides a global view with coverage in remote regions like oceans and poles; all data can be refreshed within 15 minute cycles
- We are continuously launching improved sensors and upgrading them in-orbit
- We turn ideas into live feed from space in as little as 6-12 months

100+
Satellites in Operation



30M
Satellite Messages in one day

180M
Messages in one day

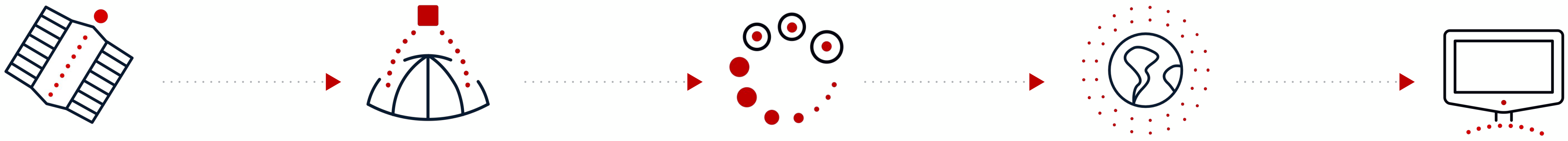
270K
Unique MMSIs in one day

29
Ground Stations

Our satellites

Covering the Earth 24/7

Data services provider that owns its own satellite infrastructure	One of the largest private satellite constellations in the world



Satellite Build and Launch

Data Collection

Data Processing

Data Fusion and Modelling

Productization & Business Improvements

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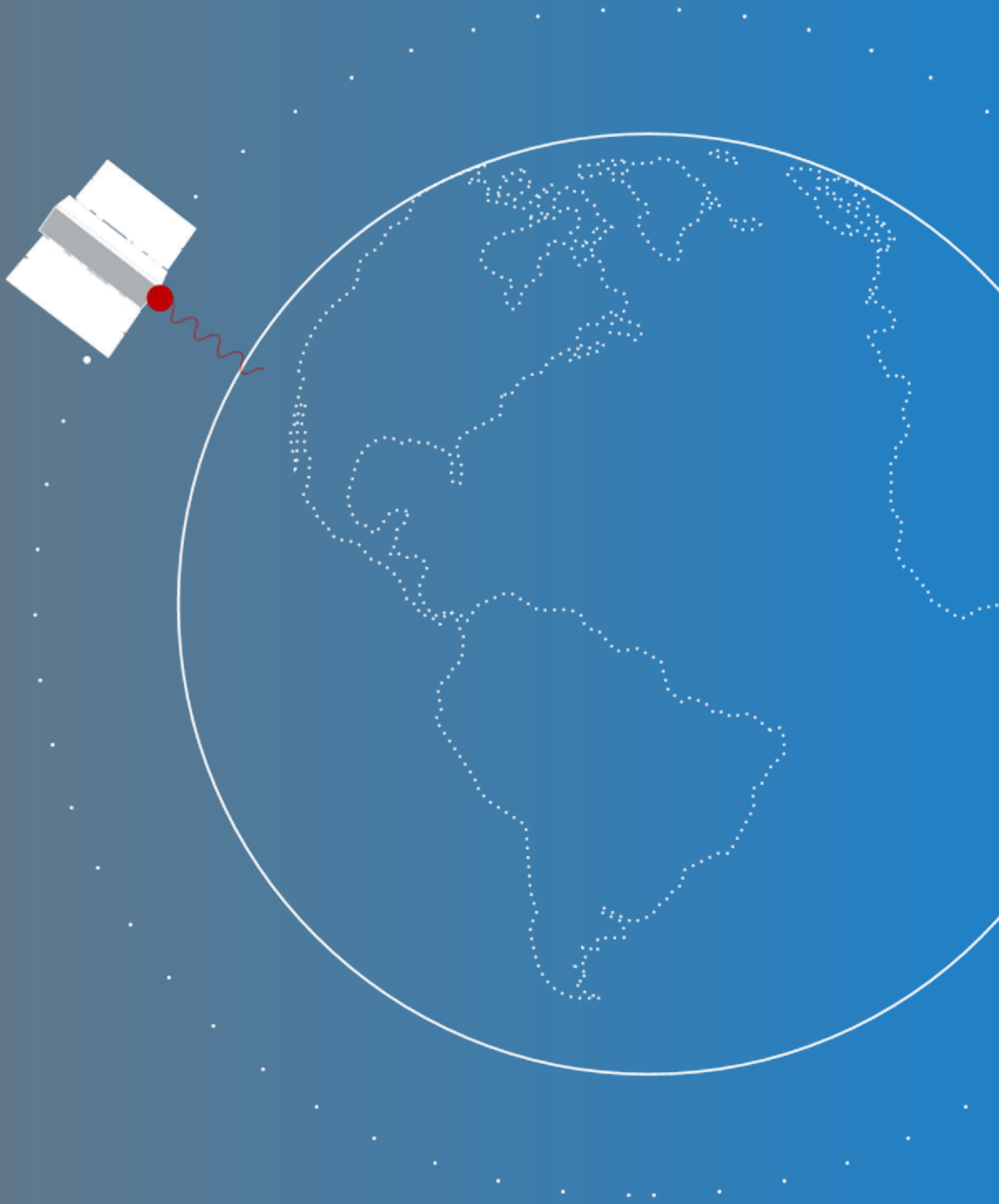
Spire Space Services



Spire Space Services: The idea

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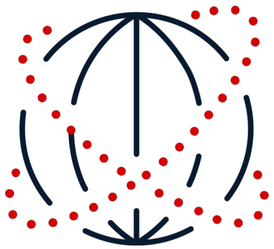

Customer applications, ideas, and innovations

Spire's proven space + ground + web platform

Rapid + scalable deployment of distributed applications

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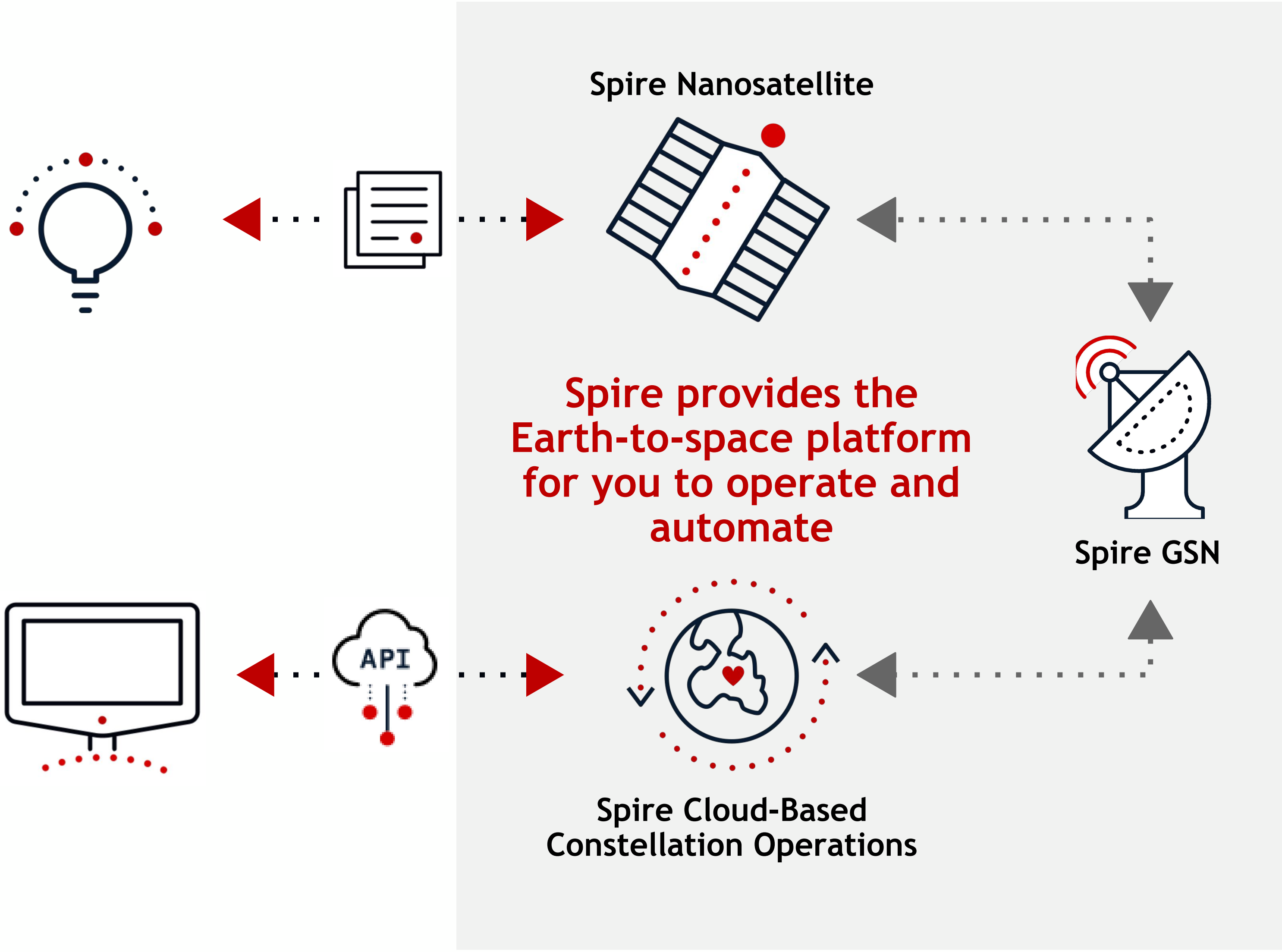
Spire Space Services: How it works

You design an application

Your hardware and/or software is hosted on a Spire platform in LEO

You control your application

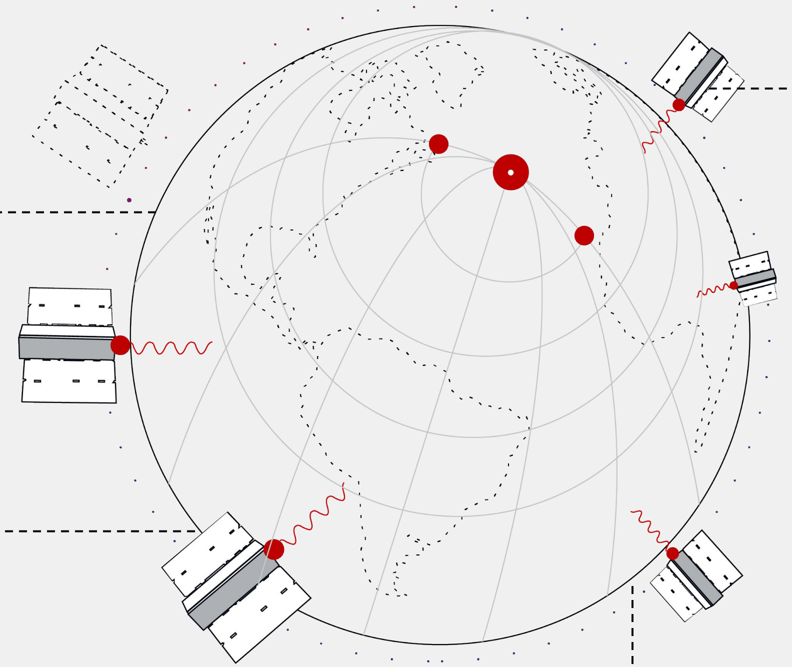
Using web APIs, you schedule operations, perform upgrades, and retrieve your data



End-to-end Space Services offering

Solutions in Space

Build your application on top of our global space platform, using one of the world's largest networks of sensors, software-defined radios and high performance computers.



Software in Space

Deploy your software to existing satellites, using Software Defined Radios (SDR) in space to test and scale your application without the need to launch a dedicated spacecraft

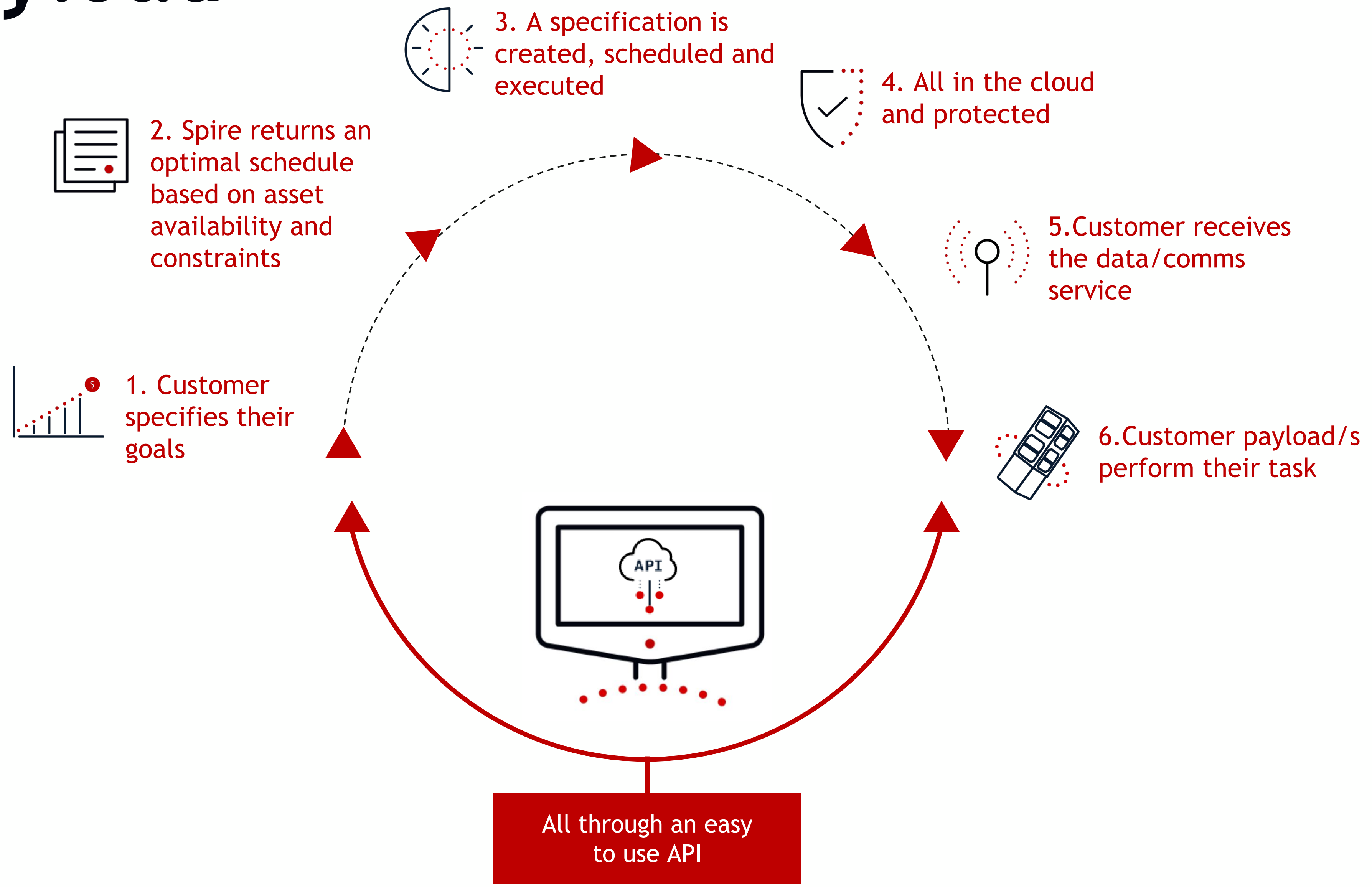
Payloads in Space

Host your payload on a trusted, fully-integrated platform and benefit from flexible and consistent launch schedule to get into on-orbit operations faster than with any other provider.

Constellation at your service

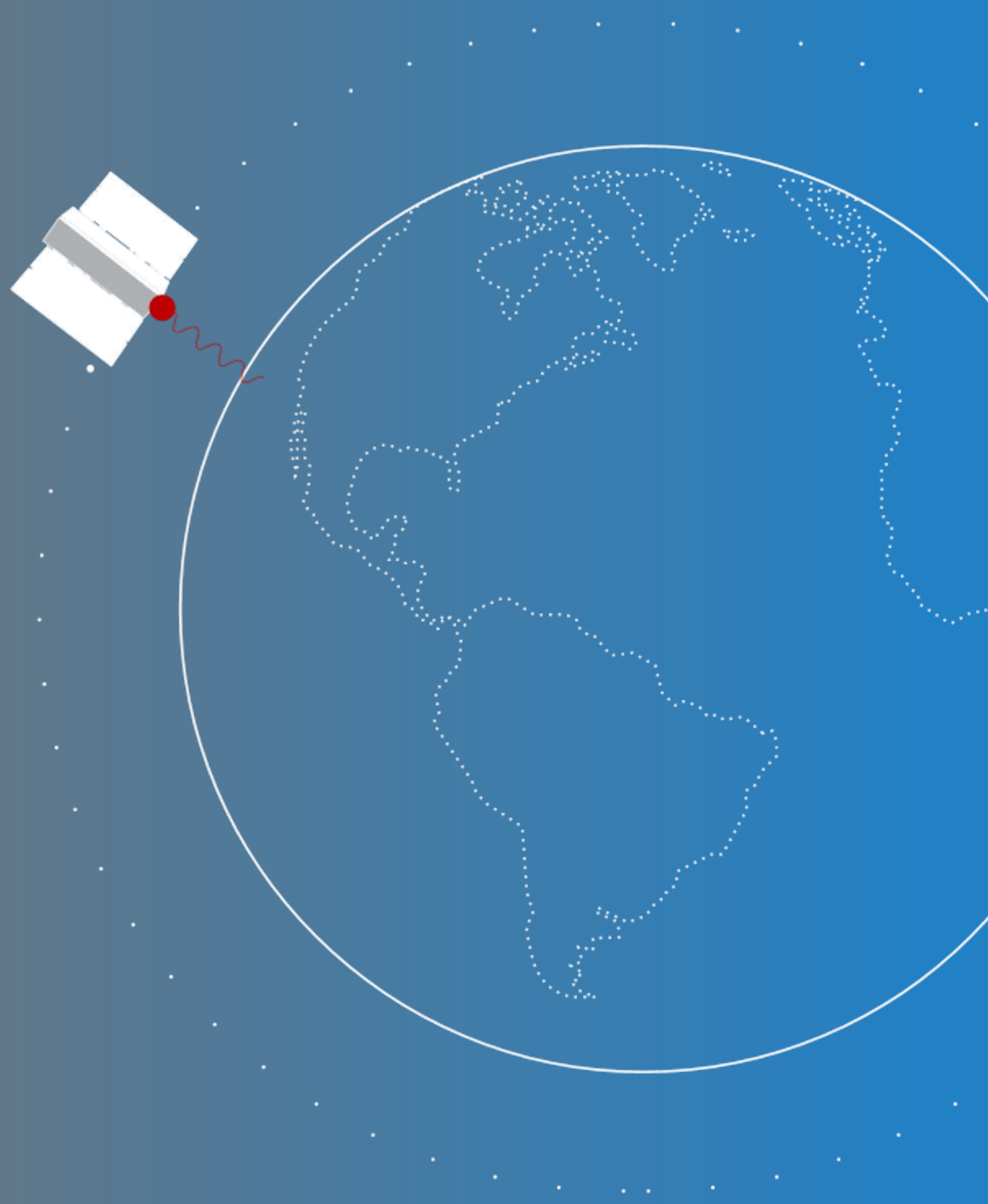
Over 300 years of Spire space heritage - 110+ LEMUR satellites launched - global network of ground stations: end - to - end space service to rapidly grow your mission at constellation scale

Optimal payload access and control



Global Insights

The
‘*Brain in Space*’
project



The story behind ‘Brain in Space’

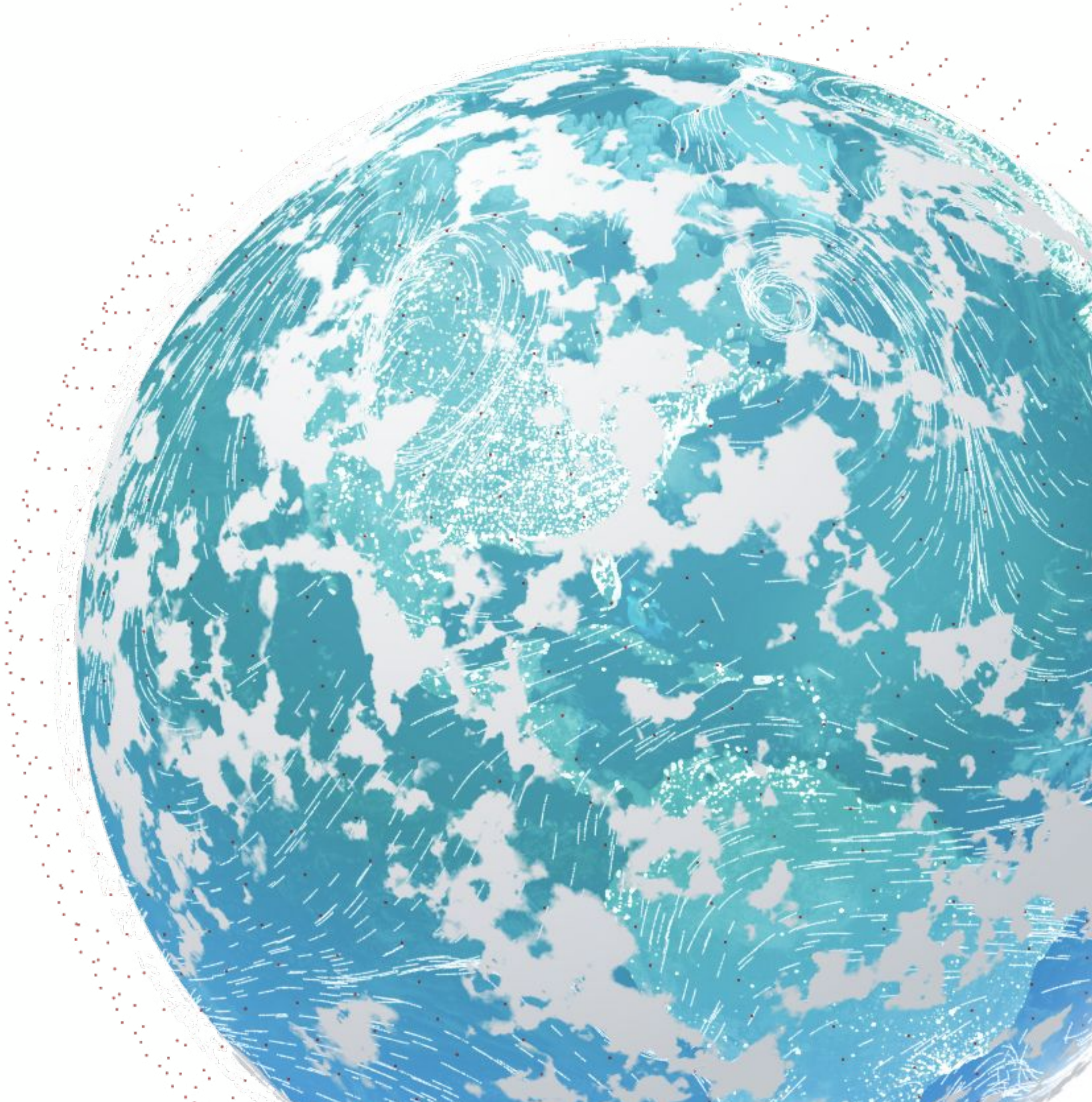
Exponential growth in launch of small satellites

Massive rise of space-generated data

Shift from *(“Can I get this data?”)*

to a more complex data-triage problem

(“Can I get the right data to the right people at the right time with minimal use of additional resources?”)



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The story behind ‘Brain in Space’

Technological developments in chipmaking made processing of an increasing part of data analytics possible directly at the satellite level, resulting in:

- Reduced ground infrastructure need
- Improved constellation efficiency
- Decreased latency for critical information
- Prioritization of data made possible
- Autonomous decision making for time critical decisions

‘Brain in Space’ objectives & approach

Nanosatellite testbed with embedded AI/ML chips for users to test AI applications and frameworks.

The purpose of this testbed is to create a simulated operating environment on the ground that allows to test the ability of a chip to enable the running of AI algorithms, to perform :

- time-critical missions
- reduction of download bandwidth requirements
- autonomous decision-making

Approach

Chip selection ☑ → **Hardware & Software set up** ☑ → **Operations**: Enabling actual testing of the retained chip's capabilities by end users ☑

Chip selection

Main Requirements:

- SWaP constraints from the platform
- Space environment

Tradeoff analysis :

- Power consumption
- Processing capacity
- ~~Performance benchmark~~ *(highly dependent on setup)*

Chip architectures considered :

- Graphical Processing Units (GPUs)
- Tensor Processing Units (TPUs)
- Vision Processing Units (VPUs)
- Field-Programmable Gate Arrays (FPGAs)

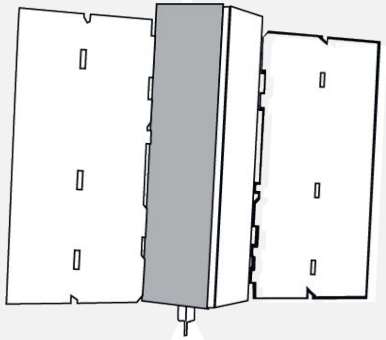
Framework compatibility

- Many frameworks on the market
- Open source or Hardware licence
- Choice of framework driven by various parameters
- Frameworks compatibility

Selected chips available on the testbed

Carried on Spire satellites

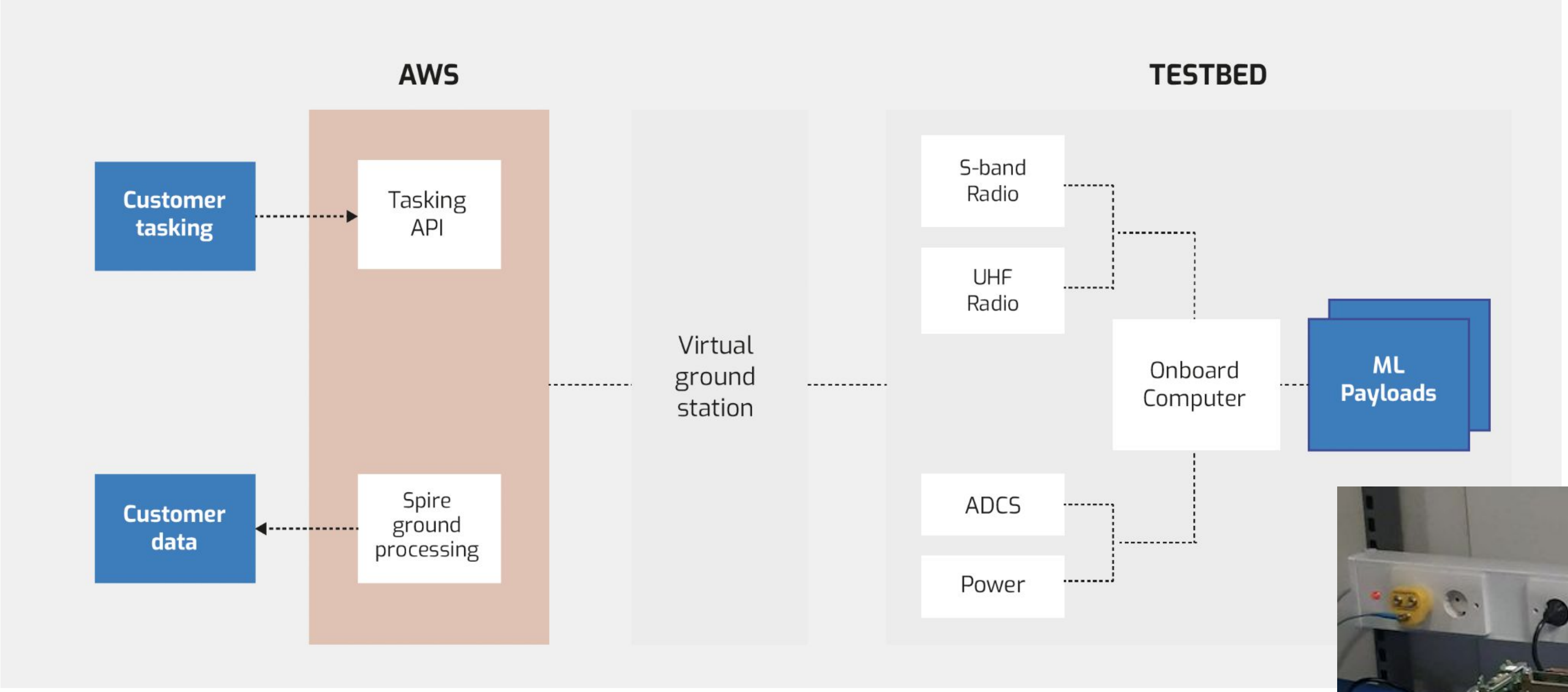
- Xilinx Zynq Ultrascale+
  - FPGA
  - Xilink engines for running AI algorithms on the chip
- Nvidia Jetson TX2i
  - GPU
  - Toolkits for on-board processing
- Xilinx Zynq 7000 Series
  - Not directly available to end users
  - Part of the satellite BUS components

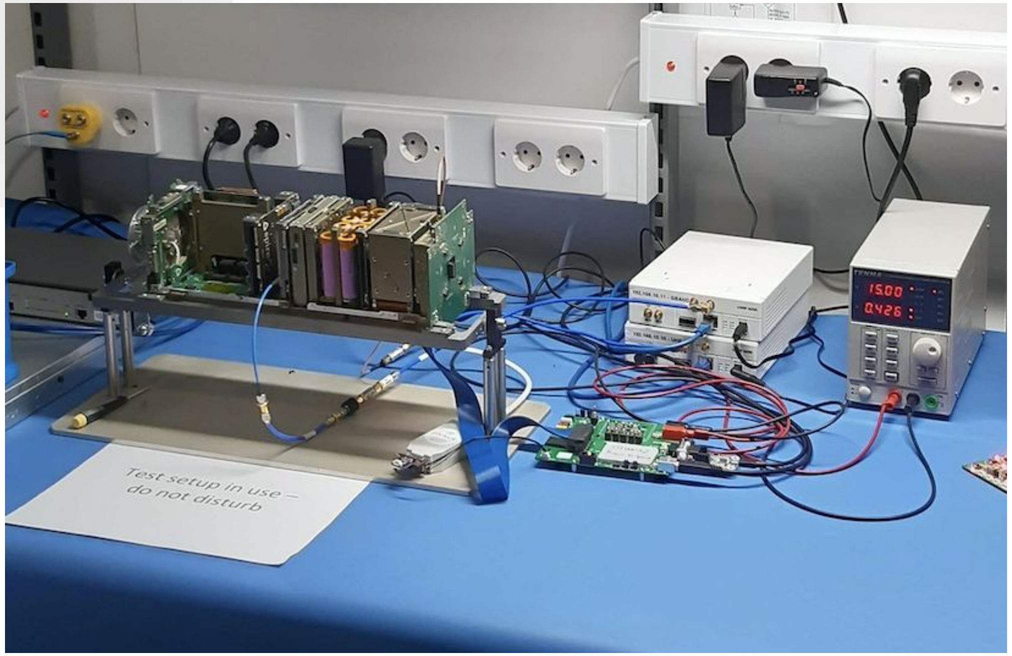


'Brain in Space' testbed only

- Google Coral
  - TPU
  - TensorFlow Live runs natively
- Nvidia Jetson Nano
  - GPU
  - Lower processing power but also lower power consumption than other GPUs
- Intel Myriad X
  - VPU
  - Optimized for deep learning and rapid prototyping
  - Compatible with both the TensorFlow and Caffe frameworks

‘Brain in Space’ testbed overview



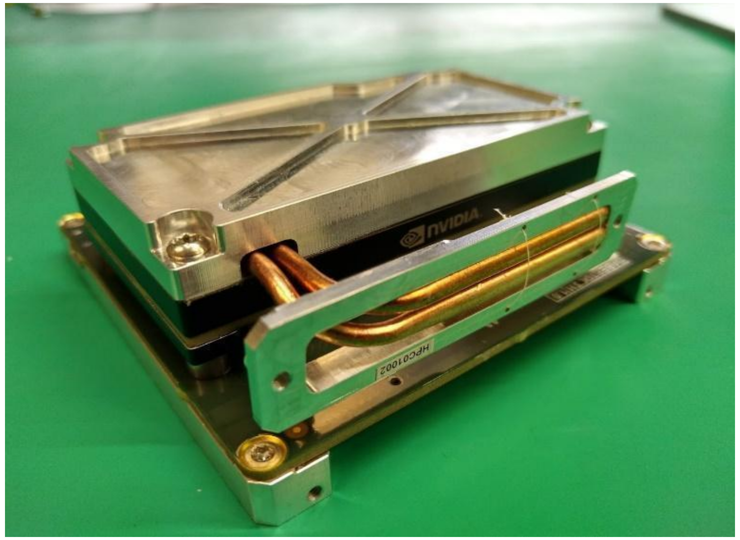


Example application

AIS payload testing with the computing module, based on Nvidia TX2i.

Objective :

- show how to use the ‘Brain in Space’ API for end-to-end processing, representative of how it is performed on orbit



Test procedure :

- Upload needed data files with Tasking API
- Wait until upload has completed using the /tasking/uploads API endpoint.
- Schedule a payload processing window with the Tasking API
- Once the payload processing window has completed, wait for the output to become available in the associated data bucket and download it.
- Compare that received message content and metadata with reference data.

Thank you!

Appendix

Additional Assets