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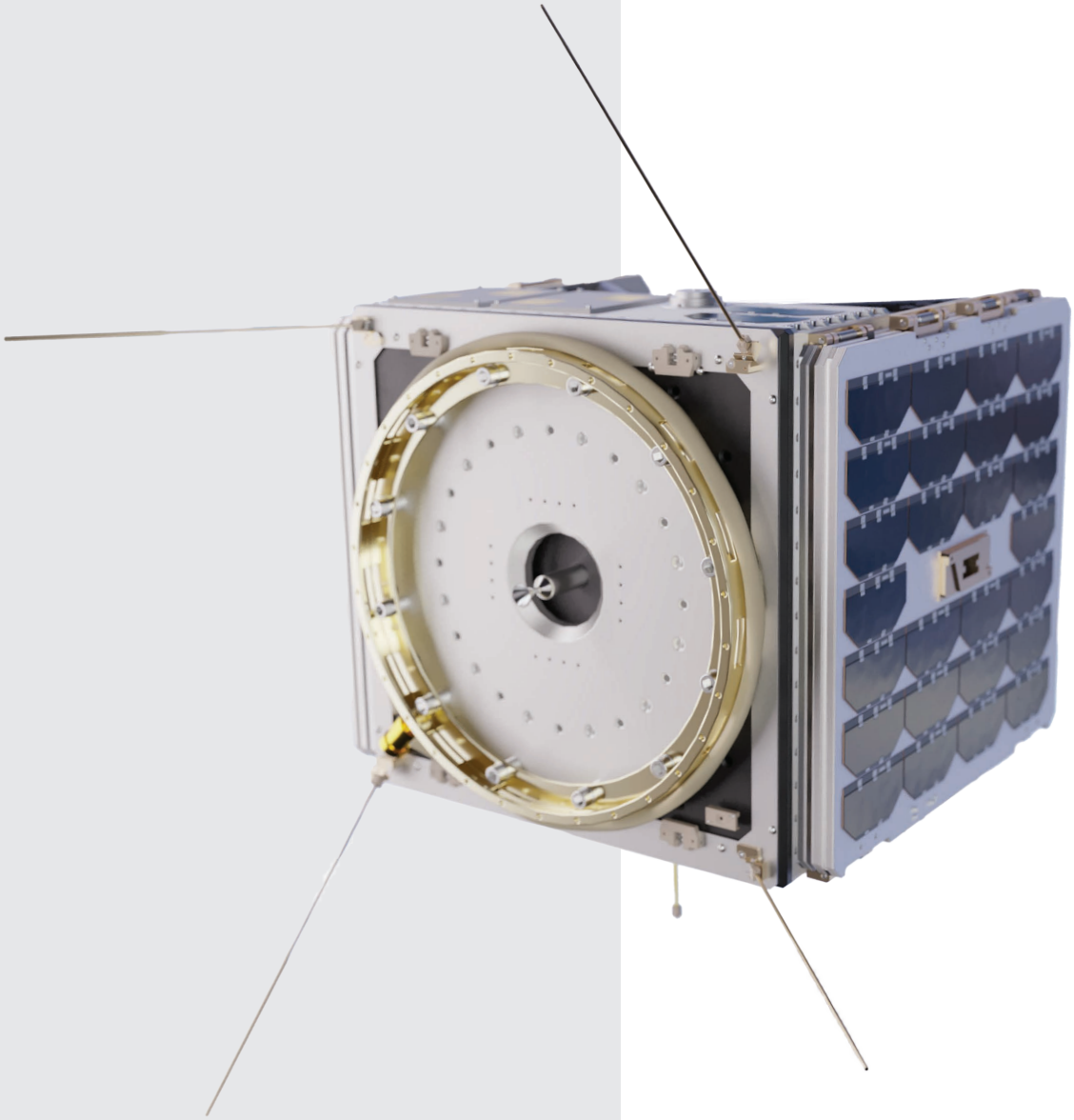

MP42

High-Performance Microsatellite Bus (up to 115 kg)

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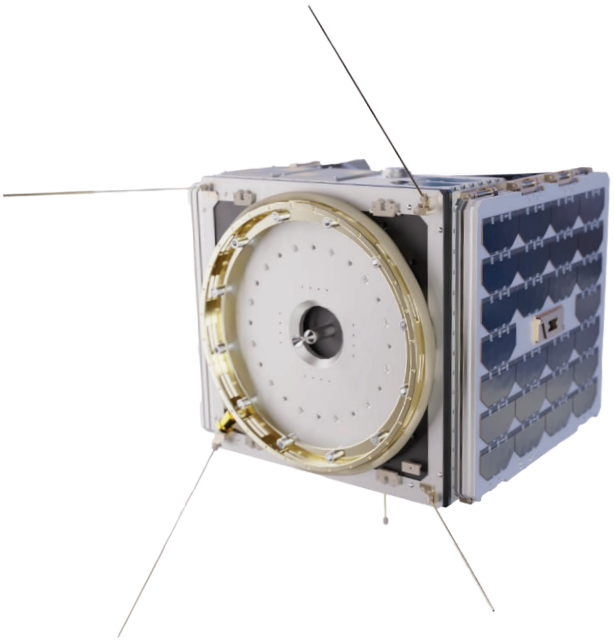
Heritage Microsatellite Buses Serving Highly Demanding Satellite Missions

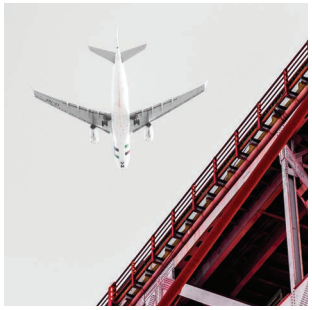


MODULAR ARCHITECTURE

Hardware and software of NanoAvionics satellite buses, as well as mission operations infrastructure are established on baseline architecture and mission-specific "building blocks" for flexible, time & cost efficient integration, resulting in wide applicability, reliability, repeatability and manufacturability.

MULTI-PURPOSE

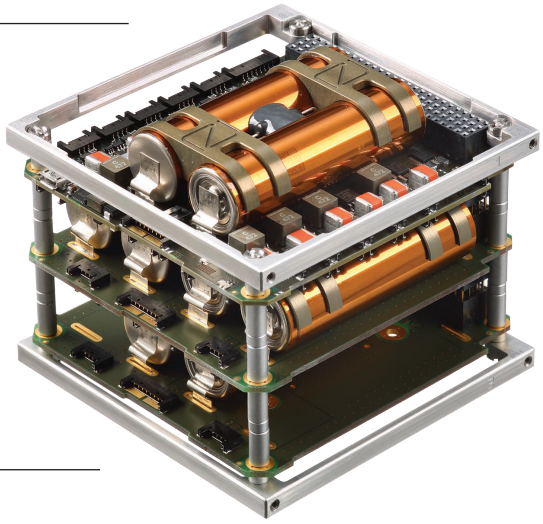
MP42 buses are highly versatile – their performance capabilities are optimized for remote sensing, high data throughput & complex communications missions, emergency communications, and fundamental research missions. All requiring minimal reconfiguration.



POWERFUL AND RELIABLE HARDWARE

All of the MP42 subsystems have been flight-proven during commercial, scientific and technology demonstration missions.

Latest technological developments have been implemented to ensure the practical reliability of the platform. Critical systems such as the Flight Computer, Payload Controller, Electric Power System and all others are 20krad radiation-tolerant and have an expected lifetime of at least 5 years in LEO.



HIGH PAYLOAD DATA DOWNLINK SPEED

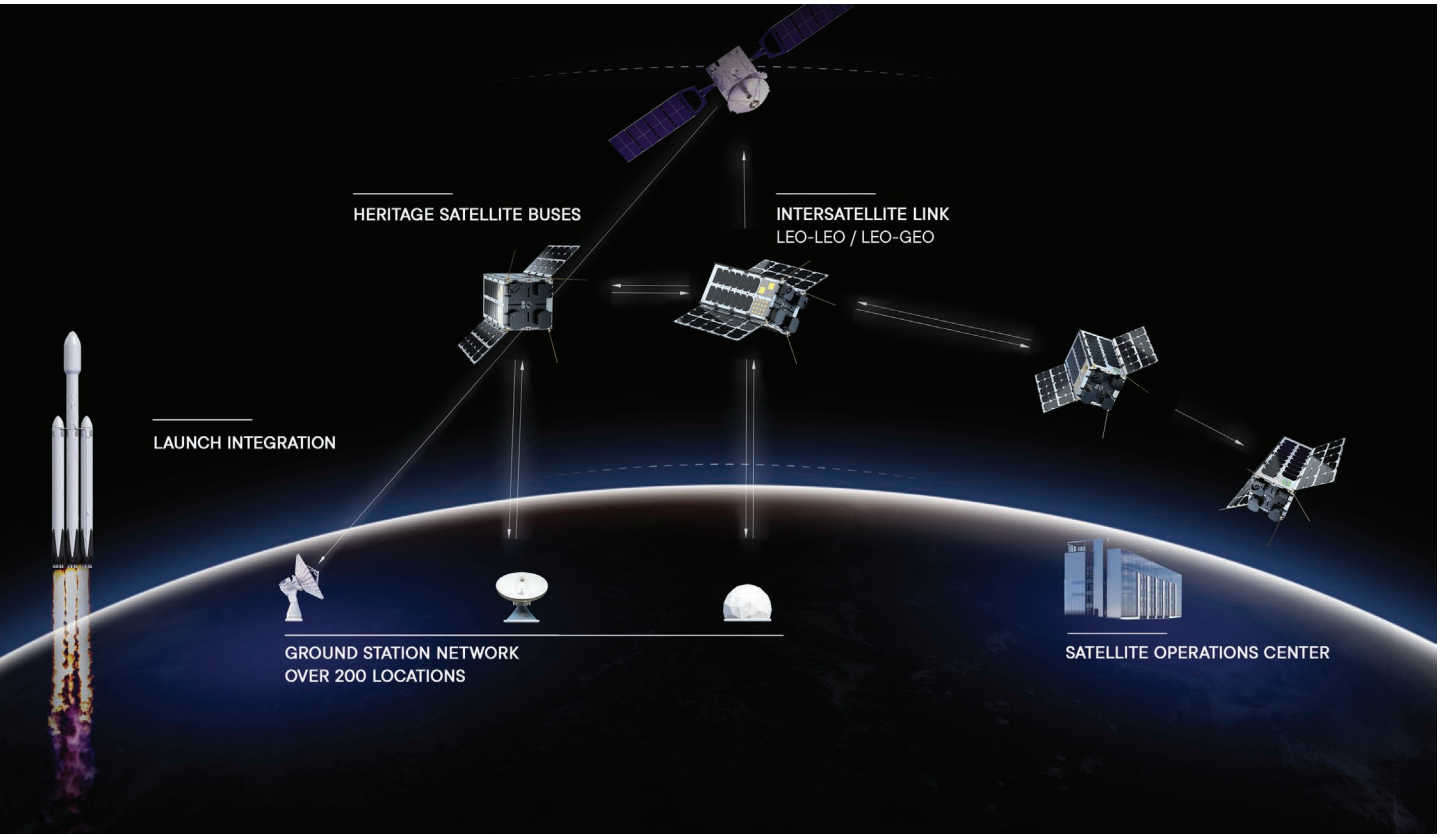
Up to 1 Gbps downlink on the X-Band.

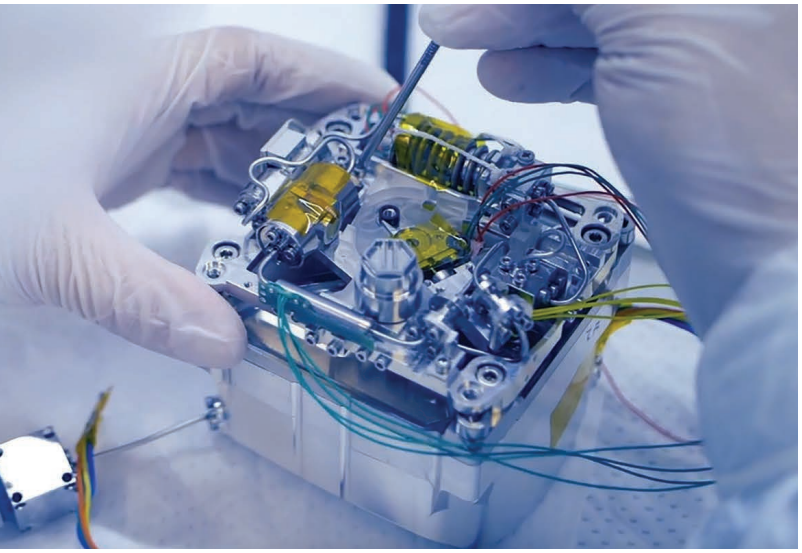
INTERSATELLITE LINK

Ensures uninterrupted real time communications (LEO-LEO and LEO-GEO options available).

FULL MISSION SERVICES AND RELIABLE INFRASTRUCTURE

NanoAvionics provides constellation oriented end-to-end mission infrastructure, covering all aspects of small satellite missions: high performance and reliable spacecraft; payload integration, launch-related logistics, documentation and mission operations. By outsourcing their space segment to NanoAvionics, organizations can benefit from massive cost savings and deploy their constellations with much quicker momentum compared to any other solution.





PROPELLED BY GREEN CHEMICAL PROPULSION SYSTEM (EPSS)

The EPSS enables satellites to perform high-impulse maneuvers including orbit maintenance, precision flight in formations, orbit synchronization, atmospheric drag compensation and even orbital deployment in certain cases, resulting in an extended satellite orbital lifetime. This translates to new opportunities for unique customers' missions and allows significant savings on constellation maintenance costs. The propulsion unit also provides satellites with a decommissioning utility at the end of the mission, meeting space debris mitigation requirements of ESA and NASA.

NanoAvionics. Engineering the Future of Commercial Space

COMPANY'S EXPERTISE

- NanoAvionics is a globally operating small satellite prime, providing End-to-End Space Infrastructure and enabling a wide range of satellite missions and applications through its economically viable technology.
- NanoAvionics' consists of more than 100 driven and skillful employees with over 85 satellite missions and commercial projects successfully completed to date.
- The company has 5 hubs globally with sophisticated facilities in North America, Europe and the United Kingdom to support day-to-day design, engineering, and manufacturing activities: ISO 7 class certified cleanroom with ISO 5 clean areas, Thermal-Vacuum chambers, modern design, analysis and manufacturing tools, as well as assembly and testing procedures following ESA's and NASA's standards. All of this allows to serve the needs of company's most ambitious customers.
- NanoAvionics is ISO 9001 certified, following very high standard quality management procedures.
- Highly streamlined production capacity under certified and controlled industrial environments.
- Technological partnership clusters established with reliable suppliers, manufacturers, test facilities and launch providers worldwide.

MP42 Bus Specifications

Subsystem	MP42 Bus Specifications
General Features	• Total empty bus mass: from 30 kg • Payload volume: 48 x 48 x 32* cm (*payload height is highly adjustable to customers payload requirements) • MP42 bus is pre-integrated (mechanically, electrically and functionally tested) and pre-qualified to be ready for instant payload integration. Therefore, final flight acceptance and flight readiness procedures are minimized for the Customer • Default operation of the MP42 Bus during satellite mission is implemented at command level by execution of uploaded scripts • A sophisticated mission code can be prepared by the NanoAvionics team according to separately agreed terms and conditions
Payload Controller (PC 2.0)	• Dual ARM A9 CPU running Linux • 1 GB DDR3L or 512 MB DDR3L ECC protected volatile memory • 4 x microSD 32GB to 128 GB Software Interfaces, Main Electrical Interfaces and 1Gbps Ethernet ports: • I2C/SPI/CAN/RS422/LVDS
Payload Communication	Satlab S-Band Full-duplex Transceiver SRS-4 (Default) • Receive frequency range: 2025-2110 MHz • Transmit frequency range: 2200-2290 MHz • Data rate TX: up to 10 Mbps • Data rate RX: 128 kbps • Transmit & Receive Modulation: BPSK, QPSK, 8PSK (only transmit) • Transmit power: adjustable 20-33 dB Satlab S-Band Full-duplex Transceiver SRS-3 (Optional) • Receiver frequency range: 2025-2110 MHz • Transmitter frequency range: 2200-2290 MHz • Data rate TX: 500 kbps (without FEC) • Data rate RX: 128 kbps • Modulation: GMSK • Output Power: up to 30 dBm X-Band Transmitter (Optional) • Carrier frequency (factory settable): 8100 - 8500 MHz • Output power: 8 W (max T, EOL) • Modulation: QPSK, 8PSK, 16APSK, 32APSK • Symbol rate (customizable): 200 Msymb/s • Throughput: up to 1Gbps Large bus's housekeeping data packets can be requested also as well as other highspeed S-band and X-band radio equipment options.
Command, Control and Telemetry NanoAvionics "SatCOM UHF"	• ARM 32-bit Cortex™ M4 CPU with clock speed up to 72 MHz (configurable) • External interfaces: 3xUART, CAN, GPIO • Modulations: GFSK2 • RX sensitivity: -122 dBm • RF Architecture: half duplex • RF output power: up to 3W

Subsystem	MP42 Bus Specifications
Solar Panels (GaAs)	• Triple junction GaInP/GaInAs/Ge epitaxial structure Solar Cells • 30 % efficiency • NASA-qualified low out gassing Solar Cell adhesive • Magnetically clean circuit design without current loops to avoid spontaneous satellite spin up due to parasitic magnetic dipole effects
Flight Computer (Including ADCS functionality) NanoAvionics “SatBus 3C2”	• ARM 32-bit Cortex™ M7 CPU with clock speed up to 400 MHz (configurable) • In-orbit Firmware Update • User-friendly console ADCS sensors: • High precision Inertial Measurement Unit (IMU) • Magnetic Sensors System • Albedo-free Fine Sun Sensors • Star Tracker Actuators: • Reaction Wheels System • Integrated Magnetorquers Attitude control type: 3-axis stabilization Attitude pointing accuracy: 0.05° Attitude pointing knowledge: 0.01° Attitude maneuver ability (Slew rate): Up to 5°/s Operational modes: • Sun pointing mode • Nadir pointing mode • Velocity pointing mode • Ground geodetic coordinate pointing mode • Client defined pointing mode
Reaction Wheels, Magnetorquer and GPS Systems	Reaction Wheel System Specifications: • Momentum: 0.04 Nms • Torque: ±100 mNm Magnetorquer Specifications: • Nominal magnetic dipole strength of X, Y and Z axis magnetorquer coils @ 5 V: 1 Am^2 GPS System Receiver Specifications: • Position accuracy: ± 2.5 m • Velocity accuracy: ± 0.1 m/s • Time Accuracy: ± 10 ns (if pulse-per-second signal is used)
NanoAvionics Electrical Power Supply “EPS 2.0“	• Input, Output Converters efficiency: up to 97 % Battery Cells Balancing Fail-Safe Design Outputs: • 20 output channels in default, up to 80 output channels in extended output version (configurable voltage rail) • Nominal Max Power Per Rail - 50 W (80 W for 24 V) • High Output Power: up to 15 A Batteries: • 16 V Design; 28 to 56 cells; 280 Wh to 560 Wh • 28 V Design; 58 to 112 cells; 560 Wh to 1.1 kWh
Propulsion System NanoAvionics “EPSS C3”	• Thrust per Thruster: 1N BOL to 0,25N EOL • Maximum Total Impulse (N-sec): > 4000 • Average Specific Impulse: 220 s • Propellant mass: 1,9 kg
Umbilical connector	Contains the following interfaces through 16-pin connector: • Main Satellite CAN Bus • Battery charging • EPS Kill Switch Reset • EPS Kill Switch Override

MP42 Bus Power Configurations

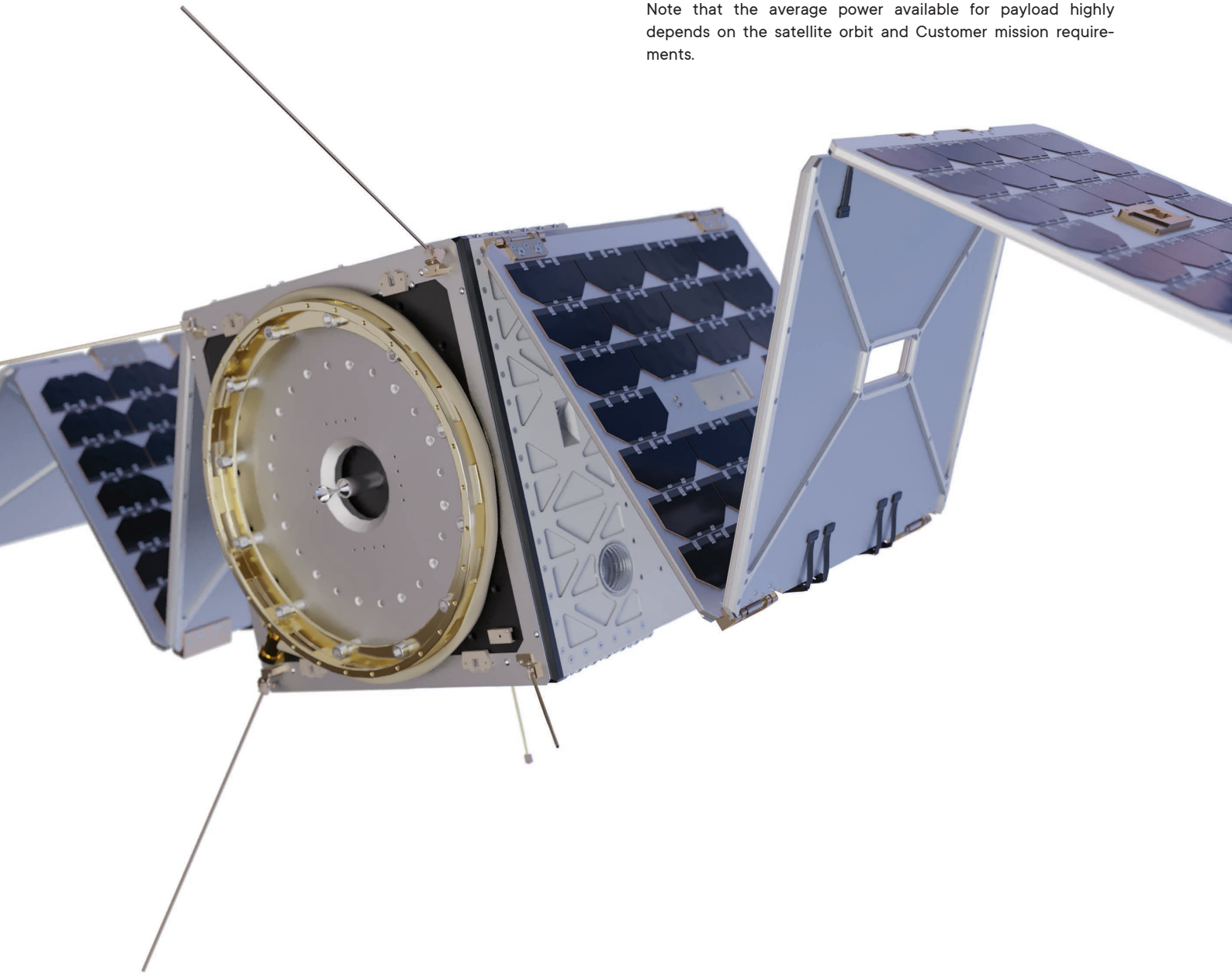
The configuration of solar panels is fully dependent on mission requirements. Therefore, for the configuration estimation the Customer shall provide NanoAvionics with inputs such as:

1. Desired orbit parameters
2. Payload specifications (power and duty cycle)
3. Payload thermal requirements
4. Preliminary information on ground/orbital objects pointing (if any)
5. Other critical data which could have an impact on power and thermal configuration

Example power options available to practically handle thermal loads through excess heat dissipation are within the following ranges:

- Default: No Deployable Panels Configuration giving up to 55 W OAP in SSO with Continuous Sun Tracking
- High Power Single Deployable Panel Configuration giving up to 160 W OAP in SSO with Continuous Sun Tracking
- High Power Double Deployable Panel Configuration Giving up to 260 W OAP in SSO with Continuous Sun Tracking
- High Power Triple Deployable Panel Configuration Giving up to 360 W OAP in SSO with Continuous Sun Tracking

Note that the average power available for payload highly depends on the satellite orbit and Customer mission requirements.



MP42 Payload Installation

The MP42 bus allows easy and fast integration of the payload through baseline electrical, data, software, mechanical and thermal interfaces as well as extensive documentation and professional Customer support. NanoAvionics engineers can also perform the Payload integration in order to ensure smooth and reliable operation throughout the entire mission's lifetime.

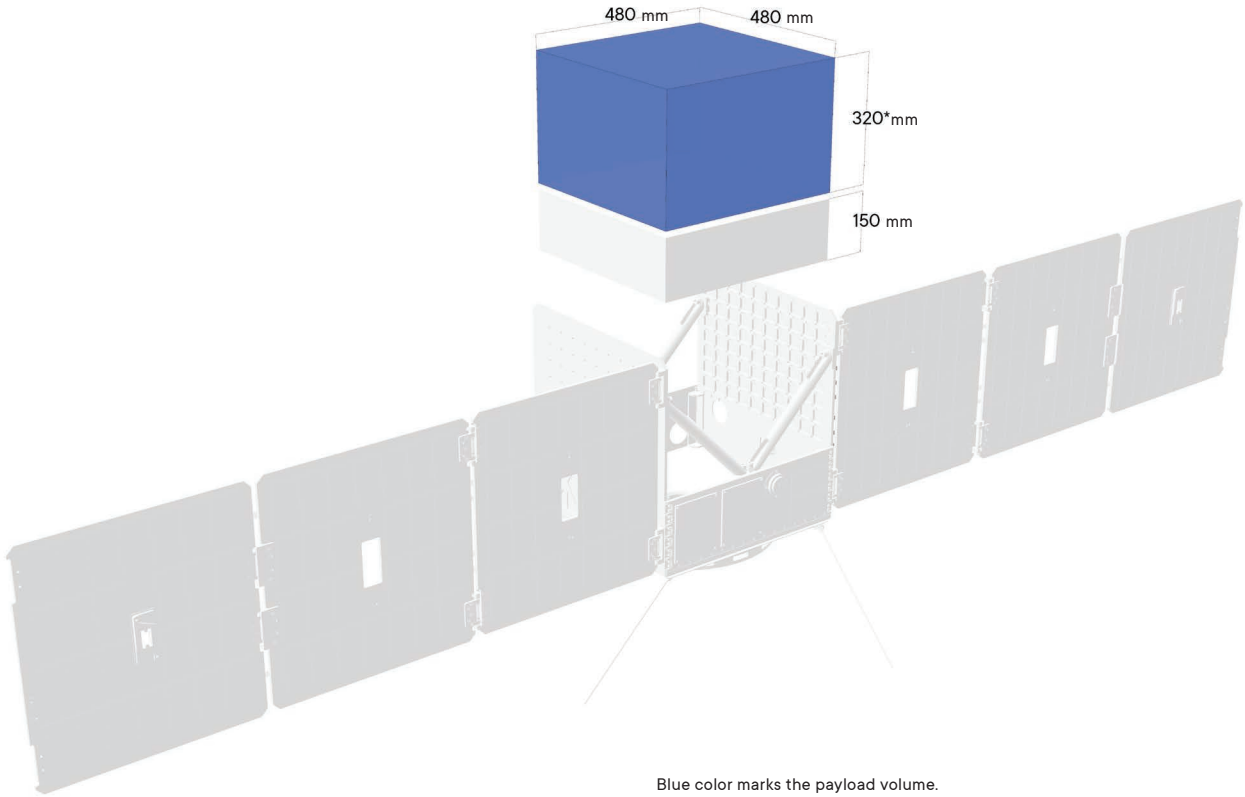
The mechanical brackets and harness needed to accommodate the payload instruments are provided by NanoAvionics to ensure mechanical rigidity and stability of the payload allocation. Thermal control, power and data interfaces are connected under the guidance or recommendations of the NanoAvionics team.

Additional qualification, EM compatibility or functional testing might be performed if required by the Customer or launch provider for safety or flight acceptance reasons.

Payload Interfaces – Mechanical Layout

NanoAvionics microsatellite buses offer flexible envelopes for the Customer's payload, thus significantly reducing mechanical constraints for payload integration. The bus package also includes all required harnesses (wires and connectors) to connect the payload and prepare the flight software through programming, debugging and umbilical interfaces which allows software upload and charging of the satellite when fully integrated.

NanoAvionics provides extensive documentation and excellent Customer support, allowing smooth and quick payload integration. If needed, Customer can request the Payload integration to be performed by NanoAvionics.



Blue color marks the payload volume.
*Adjustable according to customer's payload requirements

Payload Interfaces - Data

All signals and power channels are available on Molex Pico-Lock type connectors.

Default	Optional
• I2C x2 • SPI x2 • CAN x2 • RS-422 x4 • LVDS (22 pairs) • Ethernet (1 Gbps) x2	• 4 UART interfaces • 44 GPIO pins • 24 LVDS pairs (48 GPIO pins) available on expansion board • PCIE x2, SATA, USB 3.0, SpaceWire interfaces available on the expansion board

Launch & Logistics

NanoAvionics offers a piggyback-launch opportunity to Low Earth Orbit (LEO) with all commercially available launch vehicles. NanoAvoinics services includes a complete launch package taking care of all aspects related to launch, logistics of the satellite, and satellite-deployer-launch vehicle integration. More specifically, the company offers:

- Securing a launch opportunity on one of the suitable upcoming launches, with the possibility to switch the launch time 6 months before agreed time with no additional charges;
- Technical interface control – arrangement and coordination of technical interfaces, equipment, and documentation required for the launch acceptance;
- Logistical coordination and support – coordination of Satellite and Ground Support Equipment logistics to the launch site, facilitating travel of personnel and equipment re-export if needed;
- Launch vehicle integration – final satellite flight preparation campaign and, if required, satellite fueling operations. Final checkout of the satellite and integration with the launch vehicle at the launch site;
- Provision of the satellite orbit and altitude data at ejection and commissioning support.

Mission Operations

NanoAvionics has extensive experience in operating satellites in an optimal manner, taking into account data and power constraints, while using payload instruments on-board the satellite. The company's satellite operations centre offers cost-effective support for satellite operations, while ensuring the highest standards of data security. To meet demanding customers' missions' requirements, NanoAvionics have developed powerful mission control software which is capable of handling multiple satellite missions.

The company provides global coverage using its extensive ground stations network, which includes NanoAvionics owned ground stations in Denmark, Lithuania and the USA, as well as commercial partners' ground stations in over 200 locations around the globe (KSAT, LeafSpace, AWS and others).

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