ORBITA.PRO

COMPLEX ITERATIVE DESIGN OF SPACE SYSTEMS

In 2016, more than 200 spacecrafts weighing less than 50 kg were sent into orbit. Google, SpaceX, OneWeb, and Iridium already develop and deploy constellations of hundreds and thousands of unified small satellites.

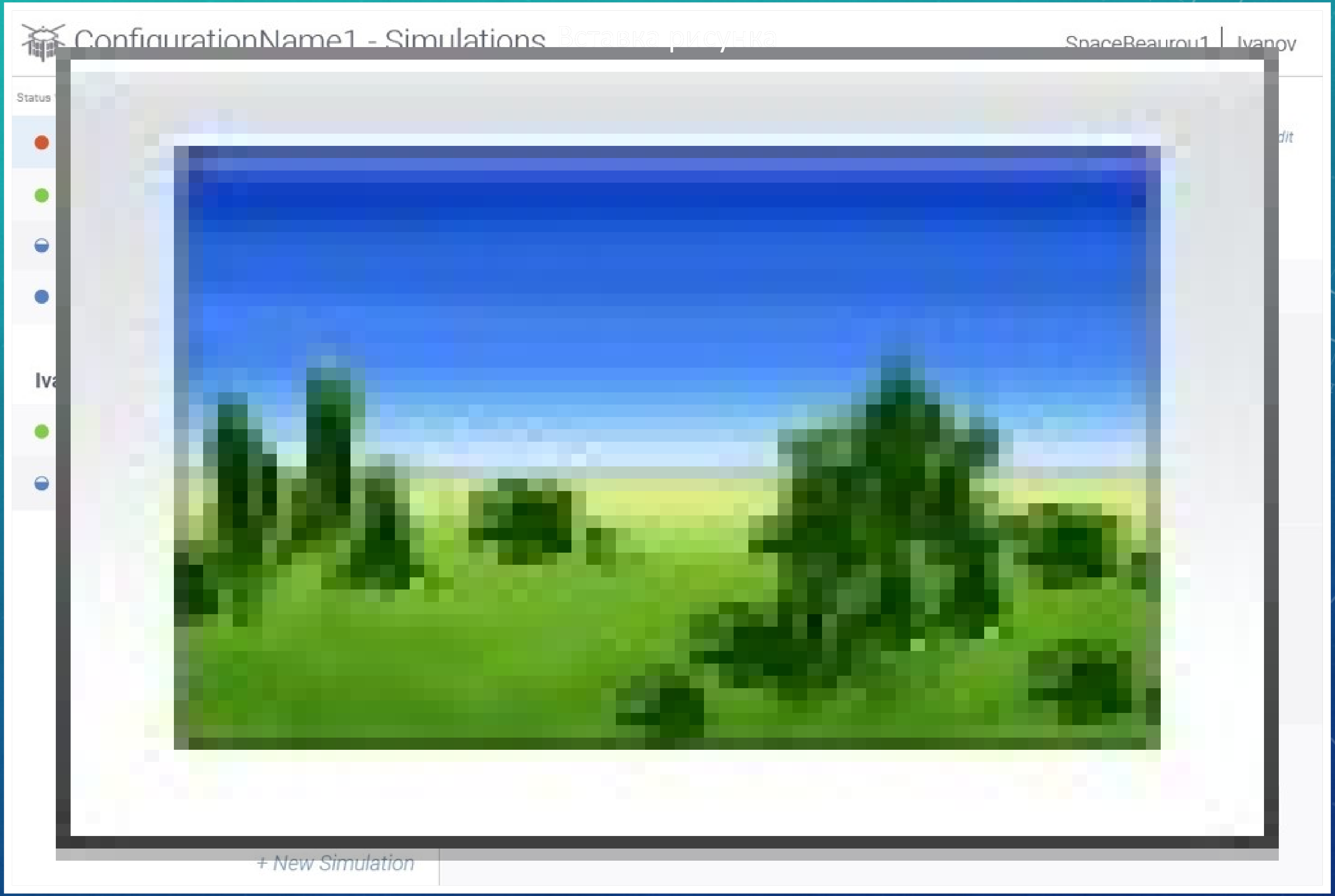
Facing these challenges, the traditional way of designing, manufacturing, testing, launching, and operating satellite constellations becomes cumbersome.

We propose the following steps for designing, manufacturing, testing, launching, and operating complex space systems with multi-satellite constellation

1. Math modelling for every step of the product life cycle, from market analysis to system operation
2. Math modelling for all components and connections from the very first step of choosing system parameters
3. Choosing between fast-and-rough estimate and precise-and-long analysis for any aspect of modelling on every step of modelling
4. The earlier results of modelling serve as basic data for the more detailed further steps
5. Combination of software/hardware systems for software/hardware design, test, and operation
6. Multivariate analysis of systems, the possibility of mathematical comparison between different versions of systems
7. Database of typical schemes of spacecraft constructions
8. Database of commercially available components

We create Orbita.Pro as a SaaS-service with computer center on the server side

Orbita.Pro
GUI prototype



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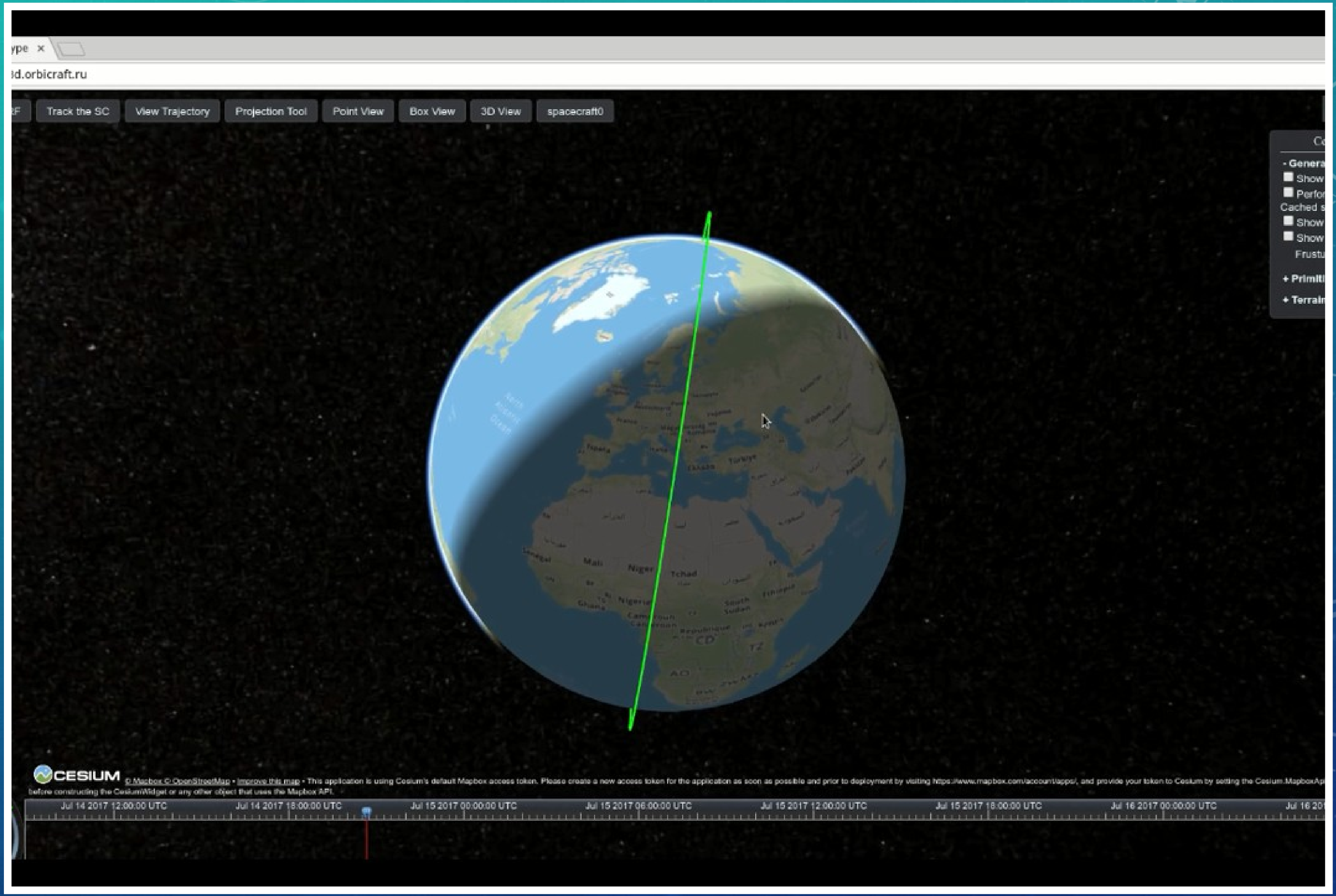
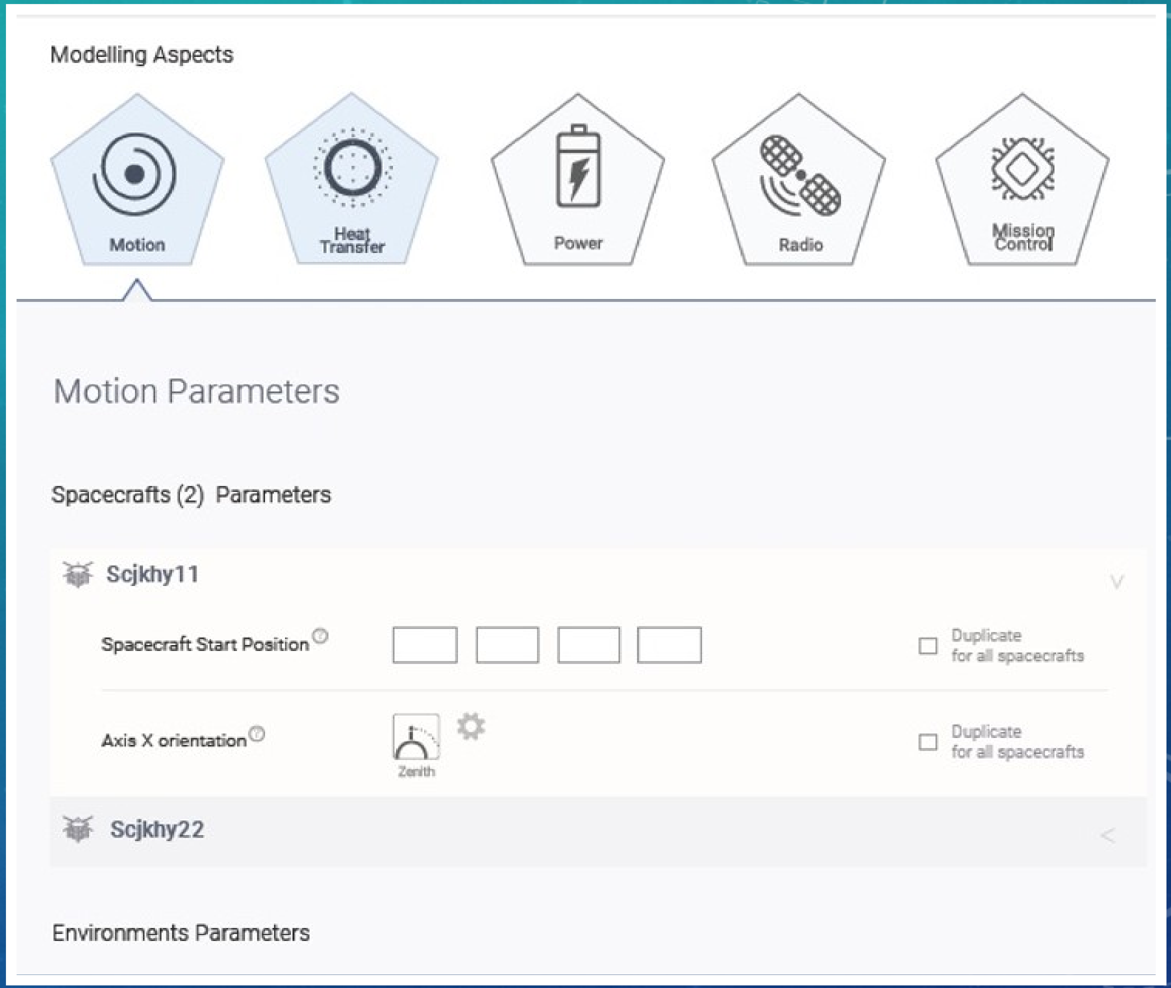
GUI prototype



The complex modelling engine supports the following aspects of space system operation:

- Orbit determination and attitude control
- Thermal control
- Electric power
- Cables and structure
- Telemetry retrieval
- Onboard processing

Balancing computational accuracy and response time for every modelling aspect allows Orbita.PRO to be a flexible and useful instrument for all stages of space system life cycle



Modelling aspects: orbit determination

Orbital flight model is designed for the Earth orbit and includes the following features:

- Complex model of Earth's gravitational field, such as the Russian PZ-90-2011
- Complex model of atmosphere
- Sunlight pressure
- Gravitational attraction of moon and sun

The numerical integration is based on:

- Euler method
- Runge–Kutta fourth-order method with constant step
- Adams–Bashforth four-step method with constant step

Modelling aspects: heat transfer analysis

Heat transfer analysis is implemented on three levels of complexity:

- **Basic level**. The spacecraft is presented as a single node with no temperature variation across the structure, only Sun radiation is taken into account.
- **Design level**. The spacecraft is presented as a set of nodes with no temperature variation across node. Nodes are linked with radiative and conductive heat transfers, the radiation of Sun and Earth is considered.
- **Detailed level**. The spacecraft is presented as a set of finite elements linked with radiative and conductive heat transfers, Sun and Earth radiation is considered. Radiation heat transfer analysis is based of Monte-Carlo method.

3 types of external radiation heat sources are available:

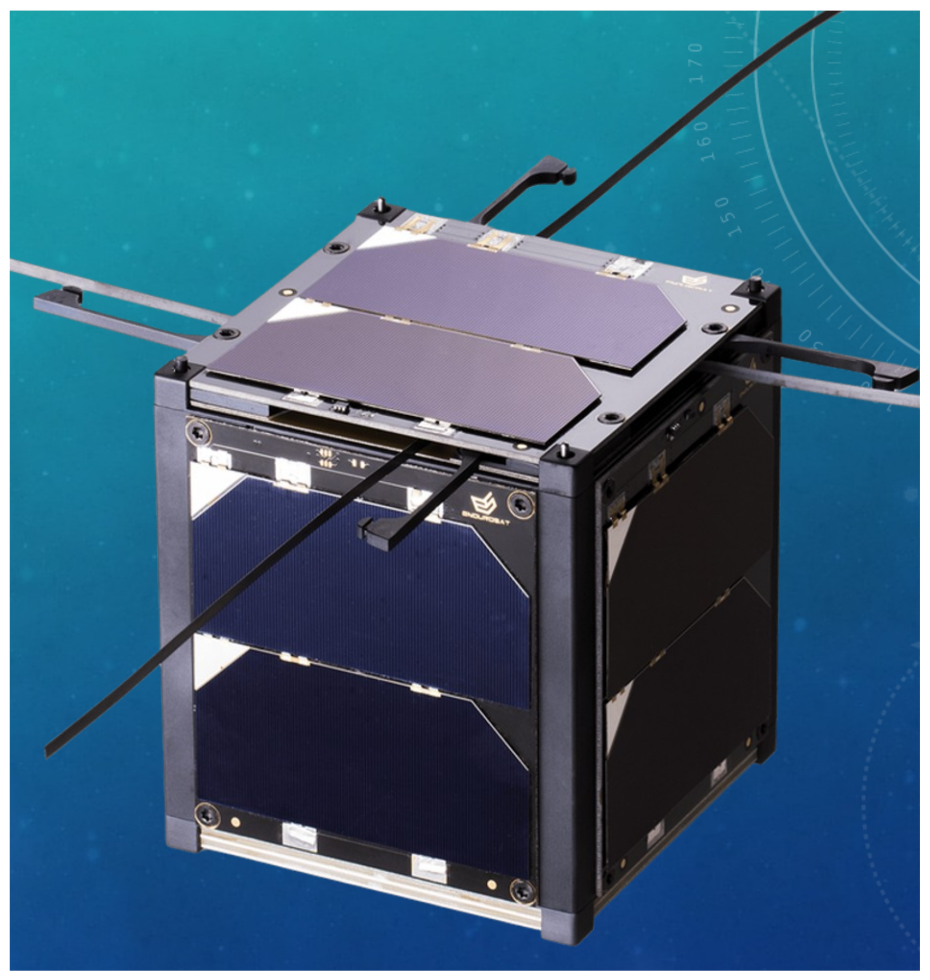
- Solar radiation
- Earth-reflected solar radiation
- Earth radiation

Case 1
1UCubesat for the University

Aim. 1U Cubesat for a university loaded with a radiation detector, orbit 500-600 km, no precise orientation is needed, results sent via UHF-transceiver.

Orbita.PRO simulator is used for:

- Procurement planning
- Analyzing power balance
- Planning flight timeline and communication sessions
- Virtual testing of the space system with spacecraft and ground segment

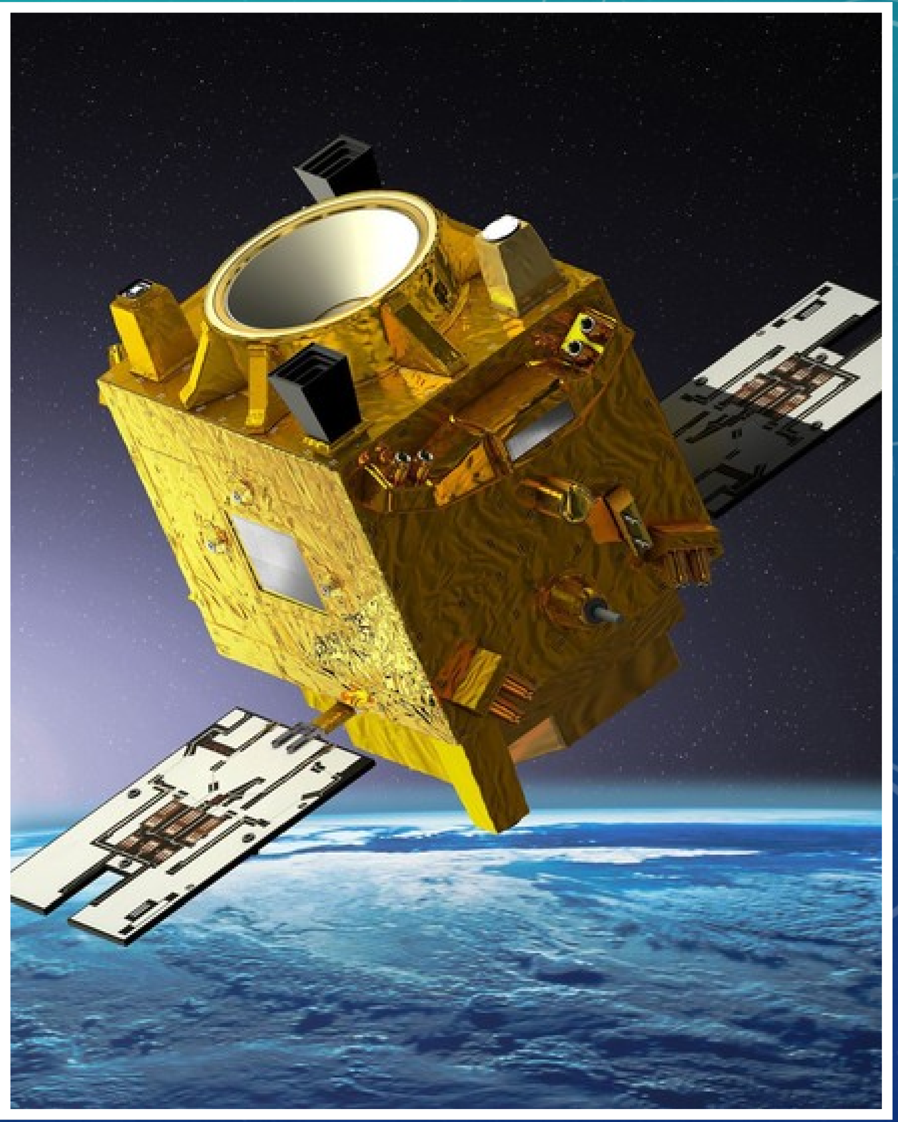


Case 2
Microsatellite for Earth observation

Aim. Microsatellite for Earth observation, loaded with 15 m resolution camera (approx. 25 kg), 500 km orbit. Involves attitude control system. The earlier experience is to be considered.

Orbita.PRO simulator is used for:

- Calculating camera requirements based on orbital environment, orientation, and cost;
- Teamwork support for every spacecraft system: power system, telemetry and telecommands, thermal control etc.;
- Planning flight timeline and communication sessions;
- Complex tests, including testing all the components and systems and regression testing;
- Testing the spacecraft for stress and vibration

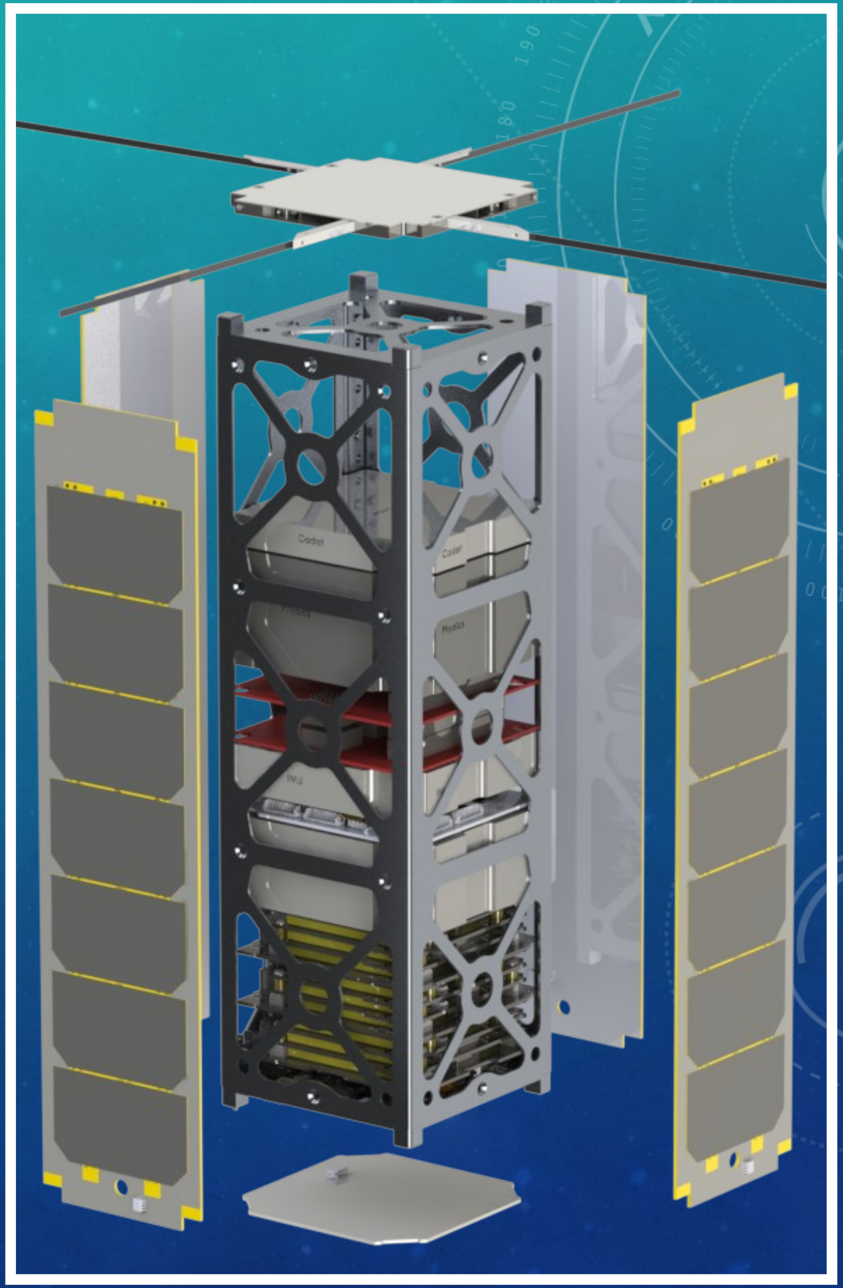


Case 3
3U Cubesat constellation for the Internet of Things

Aim. 3U Cubesat constellation for the Internet of Things. Global coverage is needed.

Orbita.PRO simulator is used for:

- Calculating the cost of a single spacecraft and of the entire system;
- Comparing system configurations with and without inter-spacecraft connection for:
  - Cost,
  - Latency,
  - Possible number of users
- Analyzing different types of connection (radio, laser, and others);
- Teamwork support for every spacecraft system: power system, telemetry, thermal control etc.;
- Planning the flight timeline and communication sessions;
- Complex tests, including testing all the components and systems and regression testing;
- Testing the spacecraft for stress and vibration



Key benefits

Compared to AGI STK, NASA Gmat, ESA SimSat and Sputnix Satellite Modeller

1. Fast development: reducing time to CDR from year to month
2. Mathematical modelling from the very first step: supporting every decision by complex analysis
3. Advanced technologies: rising up flexibility and reducing the input threshold with up-to-date mathematics, algorithms, and cloud infrastructure
4. Repeatable accuracy: securing repeated accuracy of results with detailed description of software and hardware tests
5. Open architecture: Orbita.PRO can integrate and be integrated with external systems

Possible consumers

The emerging private space companies around the world

Partners

SPUTNIX Ltd is a Russian private company providing high-tech microsatellite components, technologies and microsatellite-based services. The company operates since 2011, providing cost-effective solutions based on microsatellite technology and high-level technical support at all stages of product life cycle.

Keldysh Institute of Applied Mathematics is a research institute specializing in computational mathematics. It was established to solve computational tasks related to national programs in nuclear and thermonuclear energy, space research, and missile technologies. The main direction of activity of the institute is the use of computer technology for solving complex scientific and technical issues of practical importance.

NATIONAL TECHNOLOGY INITIATIVE is a program aimed at creation of fundamentally new markets and conditions for Russian global technological leadership by 2035.

Russian Venture Capital Association (RVCA) is Russian pioneering professional organization unifying representatives of private equity and venture capital funds. The RVCA activities are aimed at promoting Russian private equity and venture capital market formation, the innovative activity intensification, and the competitive growth of real economy sector of Russia.