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Ground test bench for Attitude Determination and Control Systems

The purpose of using the test bench is experimental testing and research of the operation of the orientation, stabilization and navigation algorithms of the spacecraft in terrestrial conditions.

Functional purpose of the Test bench:

- testing and optimization of ADCS software
- development of operating modes of the spacecraft
    - angular velocity damping mode
    - modes of rough and accurate triaxial orientation
- experimental determination of the inertia tensor components and determination of the main axes of inertia
- risk reduction
- simulation and emergency response
- verification of algorithms and models of ADCS after computer simulation, taking into account:
    - inaccuracies in the installation of sensors and actuators
    - real errors and sensor noise.

Software functionality:

● Spacecraft trajectory calculation according to SGP4 model, based on TLE files, the ability to select start time and duration of the simulation

● Formation of a magnetic field vector along the flight path of the spacecraft in accordance with IGRF13 model in a topocentric or orbital coordinate system

● The ability to compensate the Earth natural magnetic field

● Ability to manually control magnetic field in three axes, the maximum amplitude of a magnetic field vector is 150,000 nT

● Measurement of the attitude quaternion of the platform with test object in the orbital coordinate system

● Measurement of the angular velocity of test object.

Composition:

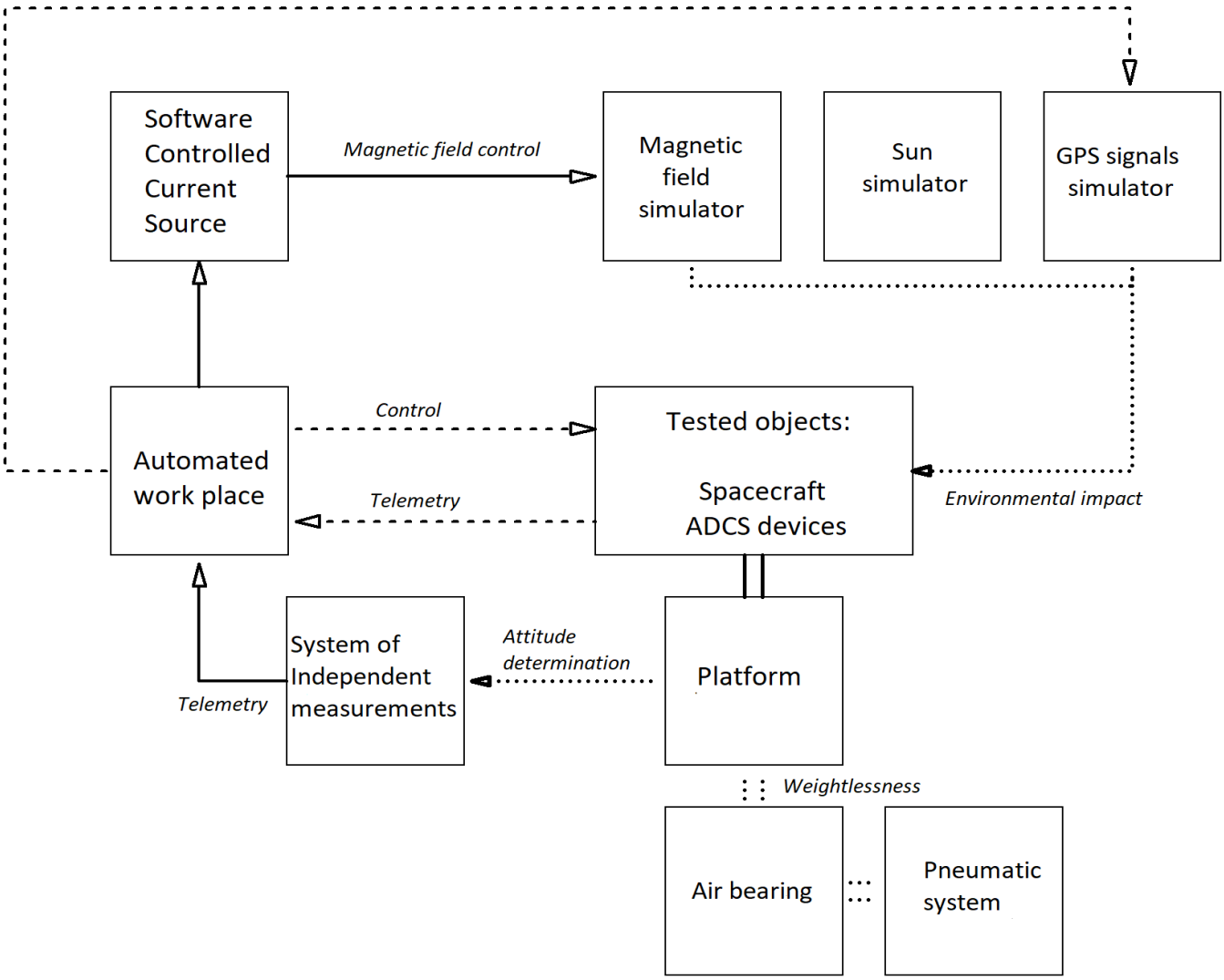
1. Magnetic field simulator
2. Air bearing
3. Platform for installation of the test object
4. System of independent measurements
5. Sun simulator
6. GPS simulator
7. Automated work place

Depending on the test object, various modifications of the stand devices are offered:

- Magnetic field simulator: big (cage 2x2x2 m), small (cage 1.3x1.3x1.3 m).
- Air bearing: load capacity up to 15, 35, 65, 160 kg.
- Platform for installation of the test object: for CubeSat 3U, for microsatellite type TabletSat, for the installation of ADCS devices. It is possible to develop a platform for a specific project.
- System of independent measurements: standard and high accuracy.

Software for modeling ballistics and calculating the orbital magnetic field, the position of the Sun is supplied with the stand.

Structural scheme



Systems and principles of work

- Magnetic field simulator

  The main structural element of the Earth's magnetic field simulation complex is a magnetic cage in the form of three pairs of mutually orthogonal Helmholtz coils. By controlling the current in the coils, it is possible to change the magnetic field in the uniformity zone in the center of the magnetic system. The magnetic field is controlled by a power source, a software-controlled current source. Magnetic field simulator is equipped with a magnetometer.

Properties (big cage 2x2x2 m)

Range of reproduction of a constant magnetic field without taking into account the magnetic field of the Earth	±150 mcTl
Angular orientation of the magnetic field vector	From 0 to 4π steradian
The rate of change of the magnetic field	Up to 100 mcTl/min
Relative error of reproducible magnetic field	Not worse than 10%
The unevenness of the magnetic field in the work zone inside the magnetic system in magnitude	Not worse than 5%
The unevenness of the magnetic field in the work zone inside the magnetic system in the direction	Not worse than 5%
Work zone	Sphere Ø400 mm
Three-component magnetic field monitoring device	Included
Range of measured values of electromagnetic induction	From 0 to ±200 mcTl
Magnetometer sensitivity	Not worse than 0,02 mcTl
Software controlled current source supply voltage	220 V

- Air bearing

In the center of the magnetic system, an air bearing is installed. The basic structure carries an air support, consisting of a gas-dynamic bearing (rotor) and a cup (stator) with special nozzles. Air from the compressor through pipelines, a gas pressure, flow control system, and an air purification and dehydration device come out of the nozzles, and allows to create a thin air layer between the bearing and the cup, which provides rotation with minimal friction in three rotational degrees of freedom. The system is equipped with a locking device with a micro-lift, which allows to fix the platform with the test object in the idle position, as well as smoothly put it down without damaging the air bearing.

Properties:

The ability to rotate the platform about a vertical axis	360°
The ability to rotate the platform relative to the horizontal axes	30º
The moment of friction in the air bearing	Not more than $1*10^{-5}$
Microlift stroke	50 mm
Compressor performance	1,8 l/s

- Platform for installation of the test object

The platform with rotor part of air bearing fixed on it is designed to install the test object. During the experiments, the object must be installed on air bearing inside the zone of uniformity of the magnetic field. Platform is equipped with system of balancing weights.

- System of independent measurements

The system of independent measurements is designed to verify the operation of spacecraft ADCS. The system determines the orientation and angular velocity independently by analyzing the video information about the orientation of special markers installed on the platform. The system includes at least 4 cameras and at least 16 different markers that are evenly distributed on the platform with the test object.

Properties (for high-precision system):

Orientation accuracy	Not worse than 0.3°
Angular velocity accuracy	Not worse than 0.2°/s
Telemetry rate	10 Hz

- Sun simulator

It is a fixed light source - a spotlight with a halogen lamp having a narrow beam angle. Installed motionless, it illuminates the test object, simulating solar radiation in the optical frequency range.

Sun simulator beam angle	8-20º
Illumination at a distance of 1.5m	90000 lux
Radiation flux	1400 W/m2
The diameter of the light spot at a distance of 1.5m	600 mm
Power supply voltage	220 V

- GPS Signals simulator

The simulator of global navigation satellite systems is designed to generate radio frequency navigation signals of the GPS navigation satellite system. Based on SDR (Software-Defined Radio) technology.

Generated signals	GPS: L1
Number of channels	16
The number of simulated satellites	32