



Sergey V. Timofeev

## **DEVELOPMENT OF THE PRINCIPLES OF THE MODULAR SPACECRAFT NAVIGATION**

Master's Programme Spacecraft system design

The abstract of the Master's Thesis

Krasnoyarsk 2014

The thesis work is done at the “Applied physics and space technology” department of Federal State Autonomous Educational Institution of Higher Professional Education «Siberian Federal University».

**Supervisor:**

Head of Sector of spacecraft coordinate-metric systems Roman F. Fatkulin

**Peer Reviewer:**

Zhukov Andrey V., JSC "Academician M.F. Reshetnev" Information Satellite Systems".

The thesis defence will take place on July 8, 2014 at Siberian Federal University, venue: 12A, Kirova Street, Zheleznogorsk, 662971, Russia

**Master's Program Leader**



Victor E. Chebotarev, Professor  
Doctor in Engineering Science

## INTRODUCTION

### **The validity of dissertation.**

Nowadays satellite navigation encompasses many areas of everyday life and activities of man. Satellite radio navigation is a unique affordable means global, rapid, precise determination of all parameters of moving objects. To maintain the health system satellite navigation system requires constant updating of new spacecraft to replace the obsolete and end of their active lifetime.

One of the directions of development of space equipment is creation of spacecrafts on the basis of universal platforms of modular construction. The modularity of the spacecraft allows to project and test modules independently from each other that accelerates process of design and device creation. As the modularity allows to modernize and replace separate parts systems (modules) without mentioning the main part of the spacecraft.

Designing spacecraft usually uses a complex method of rational design based on a hierarchical procedure for analysis and synthesis of the spacecraft: the external design of the spacecraft at the space system and the internal design of the spacecraft at its constituent parts.

**Subject of research** - principles of modular design spacecraft navigation

**The purpose of dissertation:** To develop a spacecraft navigation using modularity.

### **The novelty**

1. Certain features and towards the creation of a spacecraft with a large number and variety of specifications based on modular construction.
2. Lure unified basic design with modular construction.

**Place of dissertation realization.** Inter base department of Applied Physics and Space Technology of the Federal State Autonomous Educational Institution of Higher Professional Education "Siberian Federal University"

**Place of International internship.** Institut Aeronautique et Spatial (Toulouse, France).

## CONTENTS OF DISSERTATION

**In introduction** the urgency of the topic and stated purpose of the work, noting its novelty and practical significance.

**In the first chapter** describes the general principles of satellite navigation. Satellite radio navigation is a unique affordable means global, rapid, precise determination of all parameters of moving objects. Global footprint covering the entire surface of our planet, near-airspace and outer space, under  $\neg$  adheres properties spacecraft orbits and rapid movement of the satellites in orbits around the Earth. Promptness of navigation definitions in the required time, countable hours, minutes, seconds or less, given when selecting the type and number of orbits of spacecraft in orbital grouping. Availability of reliable navigation in any weather, regardless of the time of day and year, is achieved by using high-frequency radio satel-

lite. High precision navigation definitions is achieved by selecting the navigation method, the high stability of the radio and on-board time scale, as well as due to the high prediction accuracy of the satellite position at the time of navigation measurements. Satellite navigation radio if necessary, can provide a complete definition of the vector of motion parameters such as location, direction and speed, time correction. Satellite radio navigation uses the totality of terrestrial and space vehicles, space-based navigation system and implementing active or passive method of navigation.

**In the second chapter** presents the design principles of the spacecraft.

One of the important tasks of the internal design of the spacecraft is its layout, the creation of design-layout scheme that determines the appearance of Design spacecraft.

Spacecraft design appearance is defined by its purpose and functioning of the orbit, formed by its structural and mounting as type of used devices and systems used by the launch vehicle.

Spacecraft structurally is a complex devices and assemblies mounted on a common base and connected to a constructive total cable network.

Structurally-layout scheme of the spacecraft is determined based on the following assumptions:

- Special Use basic equipment.
- Quantitative composition of equipment, its size, weight, special features.
- Parameters missiles, area size of the payload, the maximum and minimum weight displayed on the desired orbit, special parameters.
- The level of technology achieved at this point in time, given the promising developments in science and technology.
- Specific conditions of the manufacturer and the designer, are important capabilities of a particular company and the time allotted for development.

General principles for the layout of the spacecraft.

External layout of the spacecraft.

The arrangement of the spacecraft, which consists in designing the geometric shape of its conventionally divided into external and internal.

When the external arrangement solved the problem of determining design-layout scheme for transport and working position of the spacecraft.

Internal layout of the spacecraft.

Principles of the internal layout of the spacecraft depend on the chosen design-layout scheme: monobloc with sealed or leaking unit and modular instrumentation.

Selecting the type of instrument unit spacecraft: Tightness or leaks - largely depends on the capabilities of equipment operation in a vacuum.

A review of a number of space platforms unpressurized instrument performance.

Monobloc constructive layout circuits with leaking instrument unit used on spacecraft of the new generation, which target board manufacturing complex in the form of a monoblock is impractical. In this case, the parameters of structural layout scheme spacecraft are chosen from the condition of the optimal placement of equipment onboard digital complex and its antenna with the constraints of the layout in the

area of missile payload, especially when the group starts. For cased constructive layout diagrams unified functional structure of the onboard systems and their instrumental composition, while the design concept of the spacecraft can be original.

**In the third chapter** presents the principles of modular spacecraft navigation.

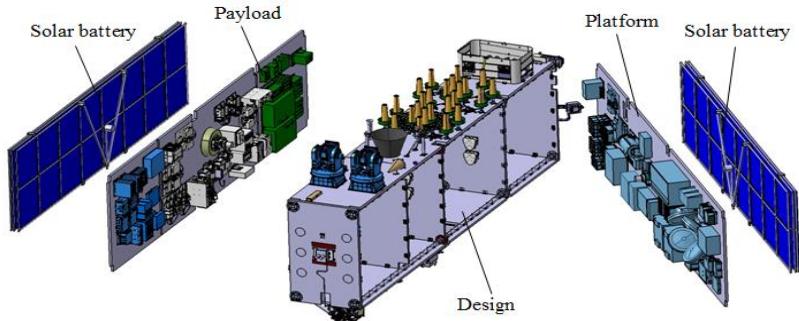


Fig. 1. Enlargement partitioning scheme spacecraft

The analysis set for spacecraft targets and discussed constructively and layout schemes was defined shape design of the spacecraft and the main characteristics, adopted the principle of modular block construction of the apparatus, as the most appropriate optimization and harmonization of requirements simultaneously.

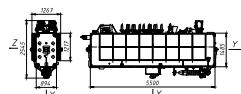


Fig. 2. Transport position of the spacecraft

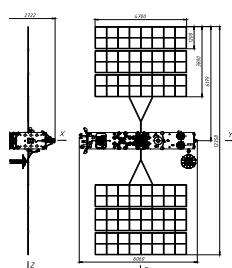


Fig. 3. Operating position of the spacecraft

This decision is based on the fact that the spacecraft, designed on this principle, has high mass-energy characteristics, and the blocks and modules that make up the unit have a considerable degree of autonomy and can be used as part of spacecraft destined for a wide range of tasks. One of the main purposes of said ideology construction - to ensure the transition from creating unique one-piece with a long cycle of development and manufacturing technology for rapid and economical production of spacecraft, containing in its composition the maximum number of unified functionally complete modules. In this case when considering unification should address issues like unification types and systems in general, and interfaces, protocols, interfaces, control algorithms, element base, manufacturing processes, quality assurance standards, methods, experimental testing, and acceptance testing. Modern office systems for spacecraft must be built based on the failover module and main principle of a unified switching environment. Also need to provide high-speed system design, ease of testing and test systems, fault tolerance to special factors, system performance, low weight, size and power consumption of the whole system.

Summary Presented composition and mass of the spacecraft in the table.

Table 1.

Nº	Name	Weight, kg
1	Onboard information - navigation system	167,0
2	Inter-satellite laser navigation - a coherent system	75,0
3	Onboard synchronizing device	127,0
4	Retroreflective optical antenna system	6,0
5	On-board control	95,0
6	Antenna-feeder devices	90,0
7	Electron system	65,0
8	Orientation and stabilization system (COC)	90,0
9	Power system	205,0
10	Thermal control system	30,0
11	Mechanical devices	85,0
12	Construction of general purpose	350,0
13	Onboard cable network	120,0
14	Loads compensating	15,0
15	Balancing loads	20,0
16	Additional payload	60,0
Total	Spacecraft navigation	1600,0

The structure and description of the main systems of navigation spacecraft, consisting of three main modules:

1. Structure
2. Platform subsystems;
3. Payload subsystems

The principles of accommodation in the area of spacecraft payload booster. Is a zone of payload launch vehicles must be capable of accommodating a spacecraft (spacecraft unit) in the starting position with the necessary security clearances.

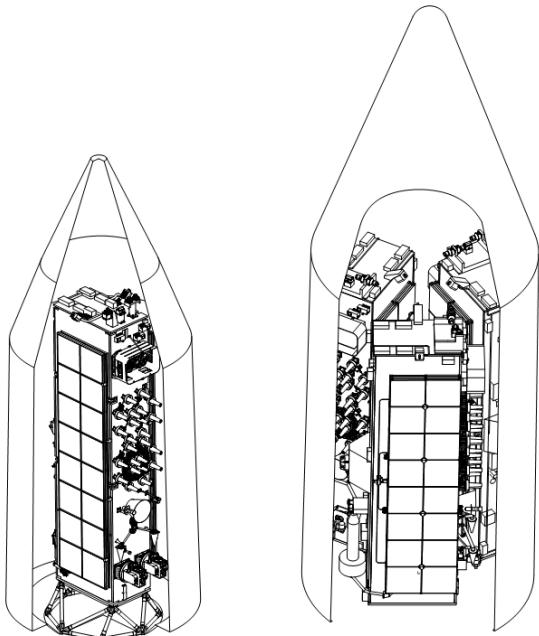


Fig. 4. Block of one-and three spacecraft under nosecone

Presented launch vehicle spacecraft. Launch vehicle intended to launch a spacecraft with the required mass - dimensional characteristics into the desired orbit, ensuring the required accuracy of the orbital parameters and taking into account possible limitations on the date, start time, duration of the ejection phase, the joint operation conditions, etc

**In conclusion** the main conclusions and results are presented.

## MAIN RESULTS AND CONCLUSIONS

In this paper defined the face of the spacecraft design, estimate the parameters of service systems, proposed a possible structure of the equipment payload was conducted thermal analysis module of the spacecraft and launch vehicle definite spacecraft into orbit operation.

Applying the principle of modular spacecraft could be used to create advanced navigation devices for satellite navigation systems.

According to the results of design study of a spacecraft can be concluded that there is a technological point, lets talk about the possibility of the creation of this spacecraft

## MAIN PROVISIONS OF DISSERTATION PUBLISHED IN THE FOLLOWING

Zvonar V, Fatkulin R, Ilin M, Timofeev S. The navigation spacecraft in a geostationary orbit // Intelligence and science: proceedings of XIII International youth scientific conference "Intelligence in Science" - Zheleznogorsk, 2013. - P. 19-20.