Open architecture of the space operations in the prospective Russian science missions.

R. Nazirov[1] and V. Nazarov[2]
Space research institute of Russian academy of sciences (IKI RAN), Moscow, Russian Federation, 117997

Yu.Kazakevich[3] and A. Shirshakov[4]
Lavochkin Research and Production Association, Moscow, Russia, 141400

L. Elshansky[5] and V. Voron[6]
Russian Federal Space Agency (Roscosmos), Institute 42 Schepkina st., Moscow, Russia, 107996

The Russian Federal Space Program includes a lot of prospective science missions which are intended for investigations in the different branches of fundamental space researches. Analysis of availability of the respective domestic ground stations shows the necessity of developing the very busy schedule of their usage. It increases risks and decreases the possibilities of control of the spacecrafts and also constrains feasible data volume of scientific telemetry measurements. This also reduces the potential scientific effectiveness and importance of the missions. Considering these facts the new conception "Open architecture of the space operations" is studied now. This approach provides abilities for involving in the operation segment not only specialized dedicated ground tracking stations but non specialized ground stations as well. For example, it may be antenna systems which are generally used for the science radio observations, ground stations that are used for the other missions, etc. According to this conception not only domestic but also international organizations (primarily science institutions) can participate in such space operations. It's quite evident that realization of this conception requires a number of technical and methodical solutions. The current status of this approach as well as technical and methodical solutions for this conception are discussed in the article.

I. Intruduction.

The Russian Federal Space Program covers dozens of science projects [1]. Briefly it may be divided on three groups: Exploration expedition, Astronomical missions and near-earth space investigations.

Exploration of the bodies of the Solar system includes: a series of the Moon projects (such as Luna-Glob, Luna-Resource and so on), missions which will continue investigations of Mars and its moons, Venera-D project for research the Venus, Laplace mission for joint investigation the Jupiter and its moons and so on. From the information point of view of each of these missions is unique and has its own operational plan.

The list of prospective astronomical and astrophysical missions includes such projects as Spectrum-RG (for observations in Roentgen and gamma rays), Spectrum-UV(ultraviolet observations) , Millimerton (space observatory operating in millimeter, sub-millimeter and infrared wavelength ranges) and some other missions. These missions are characterized by relatively large regular communication sessions.

Most near-Earth projects intended for investigation of the Sun, space plasma, Solar-Terrestrial processes. Such missions as Resonance, ROI and many others involved in this group. The peculiarity of these projects is due to a small period of their orbits. This leads to a series of relatively short communication sessions (in the case of a single ground station).

[1] Deputy Director, Profsoyuznaya St. 84/32 Moscow, Russia.
[2] Chief of laboratory, Laboratory of data processing systems, Profsoyuznaya St. 84/32 Moscow, Russia.
[3] Director of Center, Mission operation center, Leningradskay 24, Chimki, Moscow Oblast, Russia.
[4] Deputy Chief Designer, Leningradskay 24, Chimki, Moscow Oblast, Russia
[5] Specialist, Office of Technology Policy and Quality, Roscosmos, Institute 42 Schepkina st., Moscow, Russia.
[6] Assistant of head, Roscosmos, Institute 42 Schepkina st., Moscow, Russia.

These missions are on different stages of course. Some of them are manufacturing now, some are on the design phase and some are on a feasibility stage. But the tendency increasing the number of Russian research space missions is obvious. And it requires very intensive ground space operations for successful implementation of the projects.

Making of specialized dedicated ground segments for it looks as ineffective and unreasonable expensive solution. And as contrasted with it alternative approach which allows to share available ground resources for space operations and flexible extend it is studied. Obviously that existence of such mechanism will reduce the risks and cost of the operations, increases science efficiency of investigations. It should be noted that most powerful effect would be reached if the concerned approach will cover all levels of the operations including providing of radio-channel, data processing, planning and problem-solving. Meanwhile, the openness of this approach provides availability of using domestic and foreign resources as well as facilities of different agencies, academies and universities.

II. Open architecture of joint operations.

General model of described approach is bases on results of a successful attempt to share operation resources which was made in frame of the Russian scientific space projects recently[]. The model is based on Service Oriented Architecture concept. It provides reuse and sharing of components for the provision of services. Mission operation segment and Science ground segment were joined in mentioned experience. And this approach is still working well in Specter-R and Chibis-M missions.

A. Aggregation of tracking stations in joint network.

At the time of the Soviet Union in joint space projects (in frame of Intercosmos) antenna systems were involved of various socialist countries. Tracking stations located not only in the Soviet Union, and Czechoslovakia, Poland, DDR. At that time, the standardization process within CCSDS was in the early stages, and taking into account the factor of the "iron curtain" is clear that the unique standards and protocols used for these plants in the ground segment. A total of 6 academic (three Soviet and three foreign) ground stations operated by the scientific space projects (within the framework of Intrercosmos). And this experience has demonstrated that the additional academic ground stations are an important addition to the dedicated ground segment.

After a long break in the national space researches involving foreign stations attempt has been made within the framework of the Phobos-Grunt mission. Despite the failure of the project as a whole this attempt should be considered a success. Then, in collaboration with the Russian segment of the ground control points were included the European Space Agency. The great work on the compatibility of domestic and European equipment for radio-channel providing was made. A positive result was obtained after the radio-channel has been partially refined on the basis of recommendations of CCSDS. During this experiment, the external tracking stations (relative to the dedicated domestic ground segment) tracking stations were involved in three ways:

- on the basis of long-term interagency agreements,
- based on agreements between research (academic) organizations,
- on a commercial basis.

All three ways have demonstrated their justifiability. And their composition has shown flexibility in reconfiguring the network of ground stations. The same approach we plan to use for future missions.

In the mission Chibis-M science downlink channel was developed in CCSDS formats initially. And it was much easier to integrate the foreign ground stations in operations. At present the receiving of scientific telemetry information is carried in the Czech Republic and Hungary (in addition to domestic stations in Tarusa and Kaluga).

The learned lesson led us that all prospective scientific space missions should use international standards. However, this line of work should not be seen one-sided. In our view, the use of international standards cannot be reduced just to copying the established formats, but also involves the development of their creative and adapt to the needs of our prospective projects.

The problem of aggregating the tracking station has the both organizational and technical components. Involvement of new stations in the ground segment is actually an extension of a network of ground stations. This may be interpreted as a multi-level network. And in those cases where low-level integration is impossible or too effort-consuming we may use service level integration.

B. Aggregation the services.

A ground segment contains a few different elements not tracking stations only. With a sufficient level of abstraction, in the total complex of all ground facilities involved in the science space mission, we can distinguish two centers of competence (see Fig.1):

- one of them determines the long-term operational and scientific objectives (Science Ground Segment),
- another one ensures the viability of the spacecrafts (Mission operation center).

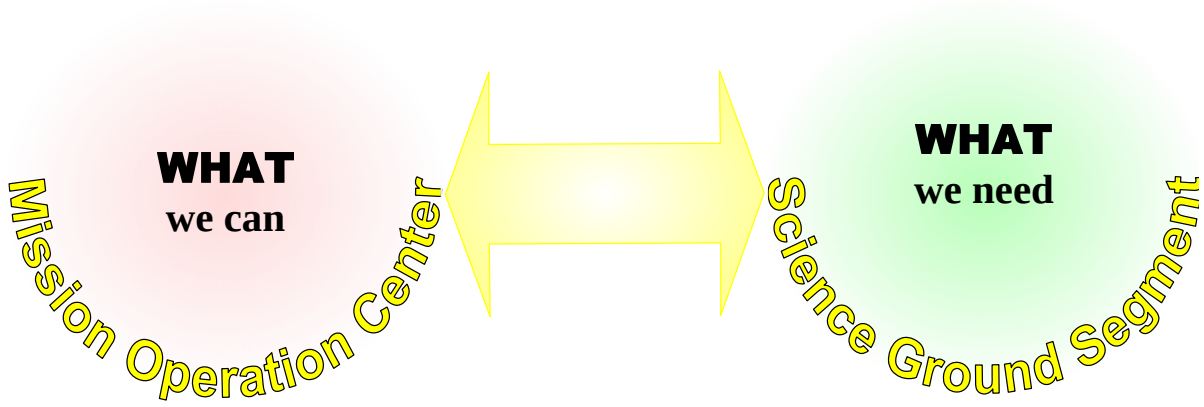

Figure 1 Two centers of competence

Interaction between these centers is very important for any science space mission. As was show in [] the most effective way for it based on service sharing. And on the basis of the positive results of this experience we suggest to extend this ideology to interagency collaboration in the mission (see Fig.2).

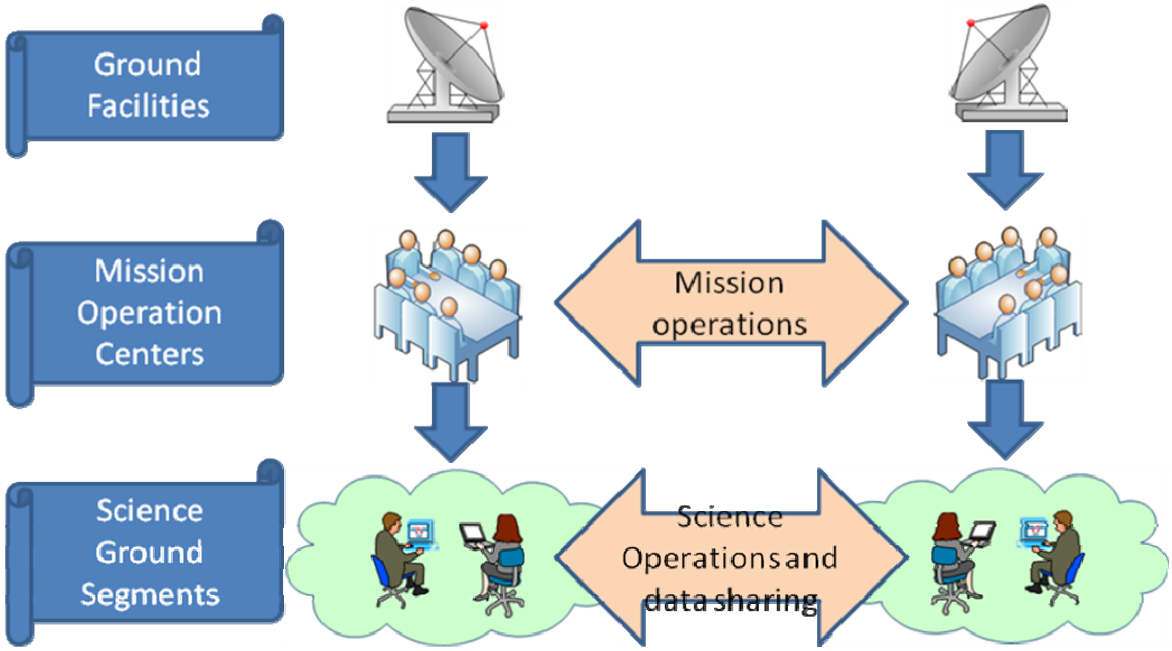

Figure 2 Interagency collaboration.

By this approach the centers of competitions mainly used by different agencies may complement each other. This ideology is studied now for joint ESA-RosCosmos mission ExoMars. And from our point of view this joint infrastructure has a lot of benefits. The mutual verification of ballistic centers, e-collaborative planning and problem-solving is just reduced list of them. Using unified service infrastructure will improve the reliability of operations, making them more effective and comfortable.

III. Conclusion

From our point of view the described concept provides serious facilitation for missions of all types. Especially for complicated difficult-implemented and respectively costly mission this approach would be one of a key factor of mission realizability, further to mentioned reducing risks and loading. And for low budget mission will help to save their mail property – low budget.

The described approach not finalized yet, the respective work and research is ongoing. Formulation of the problem implies the need for a broad discussion of the international community involved in international scientific space projects. And this article is the first step on this path.

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