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Knowledge driven operations for science space missions.

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Abstract

Usually, to carry out operations in a scientific space missions is to provide the work loop of three planning cycles (strategic, tactical and operative) as well as multi-level processing of downloaded data. And this approach is quite good, it has been worked out quite well during the era of space investigations and still brings good results, especially when conducting fundamentally new breakthrough measurements.

At the same time, during the space age, as new space experiments and research were conducted, our knowledge of the universe expanded significantly. Moreover, the use of this extended knowledge for planning of experiments in particular and carrying out operations in scientific space missions as a whole appears to be quite important and effective.

In the current space projects (even in prospective projects that currently are still being planned for future implementation), the use of this new knowledge is ensured by involving various experts in the project. In other words, traditionally, the involvement of advanced knowledge is going manually, which has neither operativeness nor efficiency. However, the proposed approach implies to create an automated information system and a technological base for its implementation.

Keywords: Data Systems, Science Ground Segments, Data Management, Knowledge Management

1. Introduction

Planning and performing of science space experiments, both for projects under implementation and for future prospective projects, is impossible without taking into account previously obtained results. Moreover, for such areas as lunar exploration, which are in the field of interest of most space agencies, it is especially important to rely on all available experience, i.e. obtained not only by respective domestic missions, but also on the results obtained by the whole world community.

As assistment for management of science space projects, as well as for principal investigators of particular experiments and specialists in space operations, to facilitate and improve the efficiency of their work, a joint Russian-Chinese initiative to create a "Joint Luna Data Center" (hereinafter - JLDC) was born. This initiative was supported by the Roscosmos State Corporation (hereinafter – Roscosmos) and the Chinese National Space Administration (hereinafter - CNSA) and the JLDC is currently being created.

JLDC is an information platform that, among other things, allows rational and efficient use of previously obtained data and knowledge for planning and operations in the preparation and implementation of scientific space missions.

2. JLDC overview

The main Goals of JLDC include:

- To achieve the maximum possible scientific return on the background of the minimization of budget and technical risks.
- Deployment of multipurpose IT platform for joint science researches and operations.
- Preparation of a new generation of scientists and engineers for future projects.

In accordance with the agreement between Roscosmos and CNSA, JLDC consists of two main nodes, Russian and Chinese. The corresponding designated entities can connect to the national main node, which consolidate the Russian and Chinese segments of JLDC.

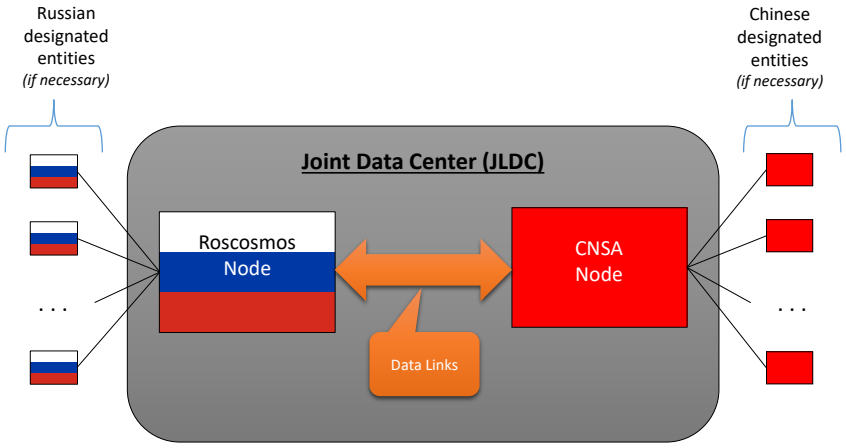

Fig. 1. JLDC structure.

At the same time, the Russian segment of JLDC has now significantly expanded the coverage of various areas of space research. And currently it covers not only lunar exploration, storage and processing of results on this topic, but also such thematics (see Fig 2) as:

- Solar System, near-Earth and interplanetary outer space.
- Moon (although the Moon is part of the Solar System, the results of lunar research are assigned to a separate thematic section).
- High-Energy Astronomy.
- Radio-astronomy.
- UV astronomy.
- Cosmic Rays.

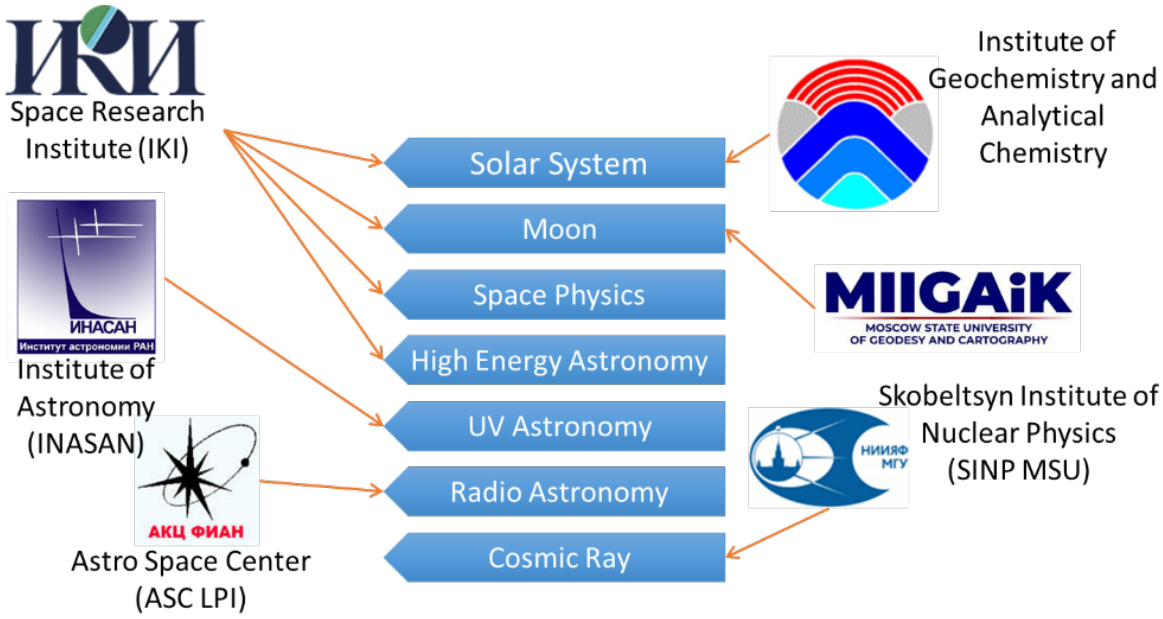

Fig. 2. Russian segment of the JLDC - Multidisciplinary Data Center for Space Researches and Operations.

In addition to the thematic sections, there will be general purpose sections in the data centre:

- Navigation.
- Cartographic.
- Interdisciplinary Analysis.
- Analytical Reporting

And some others (see Fig 3).

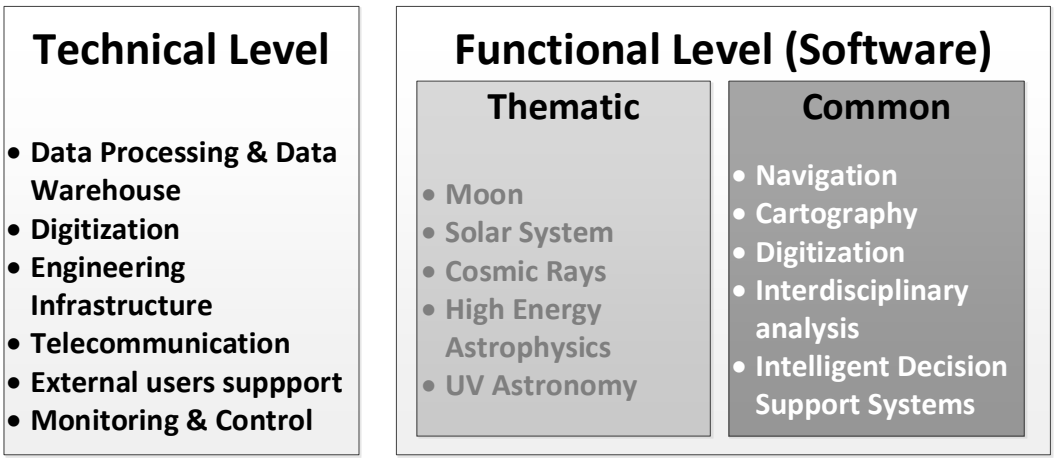

Fig. 3. Technical and Functional levels of the JLDC.

Thus, the Russian segment of JLDC is an information system that allows for joint processing and analysis of the results obtained in a wide variety of space experiments (SE). Moreover, using these results to plan current or prospective missions.

3. What is knowledge for

If you ask what is space research for? Then one of the most obvious answers would be - to gain new results or knowledge.

And if you ask yourself: how do you get new knowledge? Then, within the framework of the generally accepted space research paradigm, the obvious answer would be to measure something.

But this is not always the case. Often, in order to gain new knowledge, it is not necessary to launch a new space experiment at all, but it may be possible to jointly process the data already obtained in different space experiments (SE).

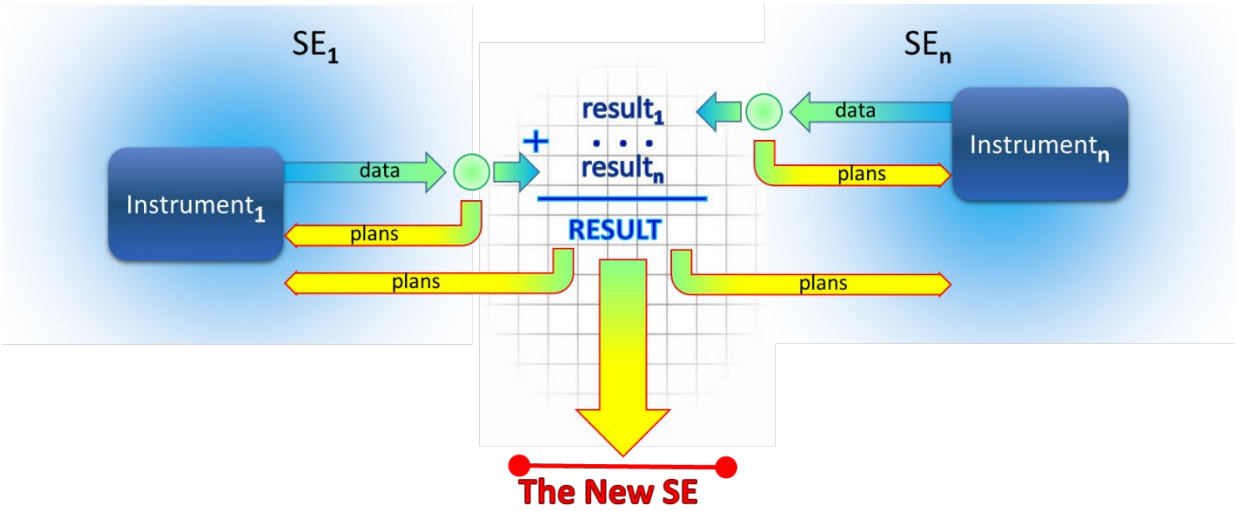

Fig. 4. The synergetic effect of using knowledge

At the same time, such a data sharing mechanism allows (see figure 4):

- to make the preparation of work plans for Instrument$_1$ and SE$_1$ as a whole more efficient;
- to make the preparation of work plans for Instrument$_n$ and SE$_n$ as a whole more efficient;
- to obtain a new result through the synergetic use of results "one" and "n";
- to plan a new space experiment.

4. Historical knowledge

But it's not that simple if we're talking about so-called historical knowledge. This is not the knowledge that was obtained as a result of a space experiment, as if directly. Rather, it is the experience gained during the preparation and execution of a space experiment. And if in the first case, when we use the measurement results to obtain an additional synergistic effect, this is quite a difficult task.

As in the first case, for automated work with knowledge, it is necessary to strictly describe, classify and annotate it. In the second case, when we use historical experience, although it is possible to do this, it is much more difficult than in the first case.

Therefore, here, first of all, we use the succession approach of employees and experts. As noted earlier, JLDC uses a layered architecture (see figure 5). It consists of three levels:

- Technical level, which provides base technical facilities for data processing, storage and communications.
- Functional level, which provides functional needed for science space operations (in other words - the software)
- Expert level, which creates new knowledge based on research results and forms exploration plans (in other words – people in experts group).

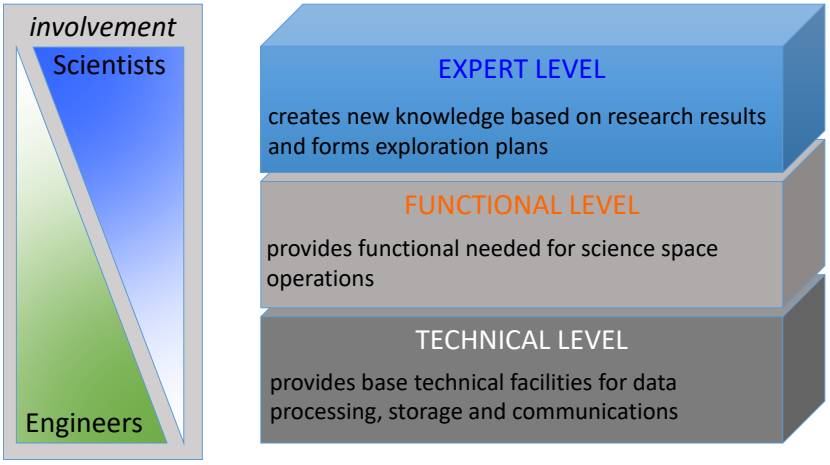

Fig. 5. The JLDC architecture.

Note, that as it shown on the Fig 5 the involvement of engineers is more widespread at the lower levels, and researchers on the reverse. So, in order to preserve historical knowledge, not only the creation, but also the use of JLDC is carried out in stages. Each of the stages is built according to the same scheme. At the beginning, the JLDC has been upgraded for about a 1,5 year on the results of the previous stage. And then, for about a year, the modified version of JLDC is being tested and adjusted. At this stage, not only new data is obtained, but also new requirements are formulated to finalize the JLDC at a new stage of upgrading. Thus, senior students can start working on JLDC under the guidance of more experienced experts. And such a cycle of 2.5-3 years allows them to complete their higher education and to get PhD. Of course, not all of them will remain in the project, but continuity will remain with this approach. Of course, we should not abandon the automatic processing of historical knowledge, despite all the problems that we discussed above. But this approach reduces the risk of losing them.

5. Conclusion

JLDC is currently in its first cycle of creation and the project is developing just now. The first results look encouraging. The joint use of data from various fields of research, obtained both from domestic spacecraft and from open sources, has already brought interesting results.

It should be noted that this approach – use knowledge for operations has always been used, but it was carried out as in a "manual" mode. For example, when forming work plans, the Scientific Committee of the mission was guided not only by the results obtained at the moment, but also by its expert knowledge and experience [3,4].

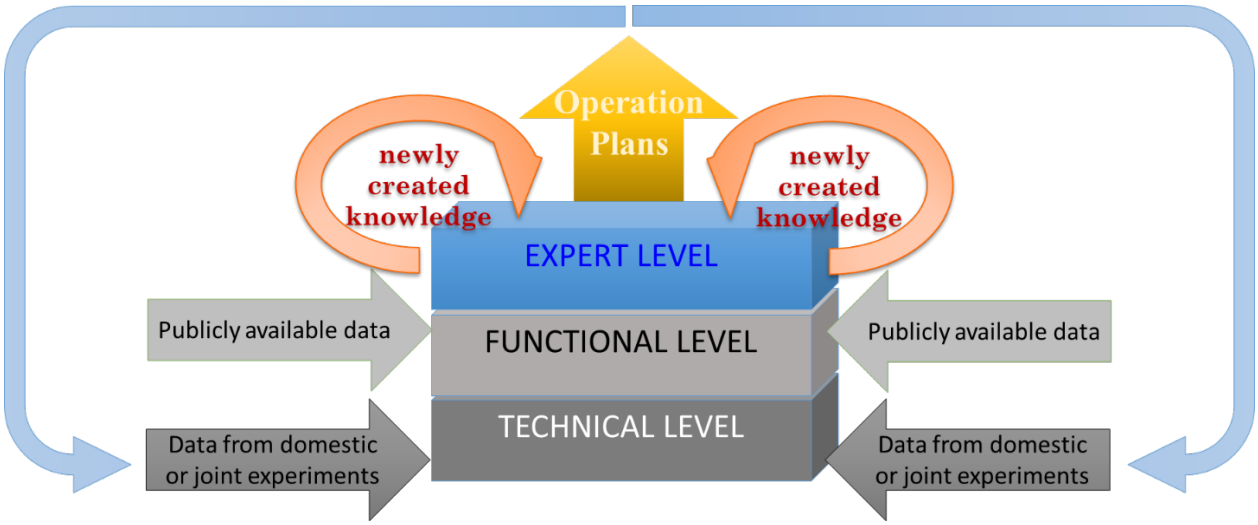

Fig. 5. JLDC inputs, internal loops and output

But using a specialized system based on modern computing technology and using the latest technologies in the field of intelligent methods and "big data" will be much more effective.

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