Open Space architecture

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The subject of inquiry in this work is near-earth space stations whose development history is more than 40 years. The questions of construction architecture and correlation between architectural decisions and overall efficiency of these stations utilization are examined in this work more carefully. Space stations are mainly very expensive objects and its customers along with developers aim to increase its service life as much as possible. Though when service life is very long, various problems in the area of physical ageing of material parts and consumer qualities loss appear. Namely, the element base, the actuality of solving tasks and developer generations are changing. As a result, the traditional decisions lead to the following. At the beginning the life time of station modules is set to be long as much as possible. In so doing, the cost and period of these modules creation are getting more. As a result, the orbital object does not answer the current requirements and it has out-of- date element base with limited capabilities in reconfiguration. Not to mention that large amount of works necessary for servicing and repair of this construction. To deal with such a problem can be possible by use of new design approach for space stations creation.

The proposed new concept of manned space missions in the LEO domain is based on the following main points.

1. LEO is a well-studied and enough familiar region of space (including direct participation of humans) within the Earth's latitude up to 51,7 degrees. Of certain scientific interest continue to be latitudes more than 51,7 degrees and the polar regions of Earth, where a number of new studies with short time direct involvement of humans might be justified. In general, currently there is no need for permanent human presence in LEO with regard to scientific research.

2. The LEO region as a manned space mission domain is of interest primarily for periodic manned spaceflights connected with development of space exploration and interplanetary mission technologies as well as for specific experiments for which conditions of space flight - vacuum, microgravity and radiation environment – are essential.

3. There is a need for manned space facilities able to support human LEO activities with minimal operational costs.

4. It is necessary to provide flexibility of the created LEO infrastructure with respect to its adaptation to new LEO tasks.

5. International cooperation capabilities with regard to the LEO region should be combined so that technological advantages of any partner country would be utilized in joint projects in the best way.

6. Flexibility, cost effectiveness, adaptability and technological excellence of manned LEO missions could be achieved by implementing a series of joint international projects consolidated with common conceptual approaches and unified architectural options.

7. The ISS is one of early low-orbit infrastructure projects but it should not replace the letter due to high operational costs, architecture features and oversize.

New design options could be revealed, among other things, as optimal combination of approaches to dedication (specialization) and versatility of orbital facilities, namely, development of a series of dedicated orbital vehicles and their operations within orbital clusters of "open" architecture, i.e. that one enabling to replace (or just remove, dispose) any of them.

The term "open system" means that a system is initially designed not as a complete self-contained object (or a set of objects) with a certain scope of tasks to solve but as a facility to solve top priority, most urgent tasks of the nearest period with possibility of reconfiguring into facilities with an additional or alternative specialization in a more distant future. The lifetime of an open system theoretically could be unlimited (by virtue of any of its element replacement). With that, such a system can split into several independent systems (if new tasks are incompatible with the original ones) or be disposed after the first mission (if the work order is single).

Since the "open" system term is introduced, so obviously one should define the notion of a "closed" system. "Closed" (in contrast to "open") system is an object completed from the viewpoint of design ("platform", "base") aimed at solving tasks for some (limited with "base") period of time. A list of these tasks could be rigid or correctable in the course of operations but among the elements of the system which enable solving these tasks there are certainly critical ones without which the declared goals cannot be reached. Excluding these elements from the nomenclature (in particular, their loss as a result of failure) leads to loss of the system. In fact, this limits the life span of a closed system.

Such programs as the "Mir" orbital complex, ISS, unexecuted "Mir-2" are examples of a closed system. All these facilities have elements critical for performance functions of a manned space station ("Mir" or "Mir-2" core modules, RS ISS Service Module) absence of which would have deprived a station of ability to perform its mission. Of course, the same is applicable to space stations "Salyut" and "Skylab" where the "core" element, in fact, implies the entire system.

It is easily to see that the concept of an "open" system differs from that of "universal" one. In particular, these differences lie in the fact that an "open" architecture space vehicle at every instant of its existence is not universal, as it has to perform a quite separate and specific task. However, due to the reconfiguration in time and replacement of specialized elements the ensemble of the tasks to be solved could be not only greatly expanded but – theoretically – infinite.

Specialized orbital facilities – station modules - being developed should when possible cover the ensemble of future manned space missions (each in its own set of specialization). It is natural that the assortment of specialized orbital facilities should be minimal, as far as possible, and unified within a separate set of tasks taking into account possible gradations of the main design capabilities from expected work orders. This can lead to a case that a part of the service requirements associated with crew life support can refer to the transport vehicle since it is an integral part of manned space missions, and the duration of the latter depending on the tasks can be relatively small (for example, during replacement of the scientific equipment on the autonomous platform. In the whole the redundancy of service functions on the station, if required for concrete missions is achieved by special purpose modules (power or logistics modules) and by a resupply spacecraft (transportation technical vehicles).

As an illustration of new approaches Figure 1 shows a version of a new space station based on the Russian Segment of the ISS and its transformation depending on changes in tasks and priorities of the space program. An open system could be built to reach goals of the current Long-term Program of Science and Applications Research (SAR) as an initial task. With the advent of manned new generation transport spacecraft (NGTS), new laboratory and service-power modules the station will be ready to perform a wider range of SAR which are currently under discussion. With maturing of one of these new areas of research one could build inflatable habitable modules that provide significant amount of internal pressurized space for comfort onboard stay of the crew. Accordingly, the station could be transformed from a laboratory station into a hotel station. This will be an important aspect of gaining a new quality – ensuring safety and possibility of staying onboard the station much larger number of people than can be achieved today. New people will bring new ideas, generate new space goals, build new tools for exploration ...

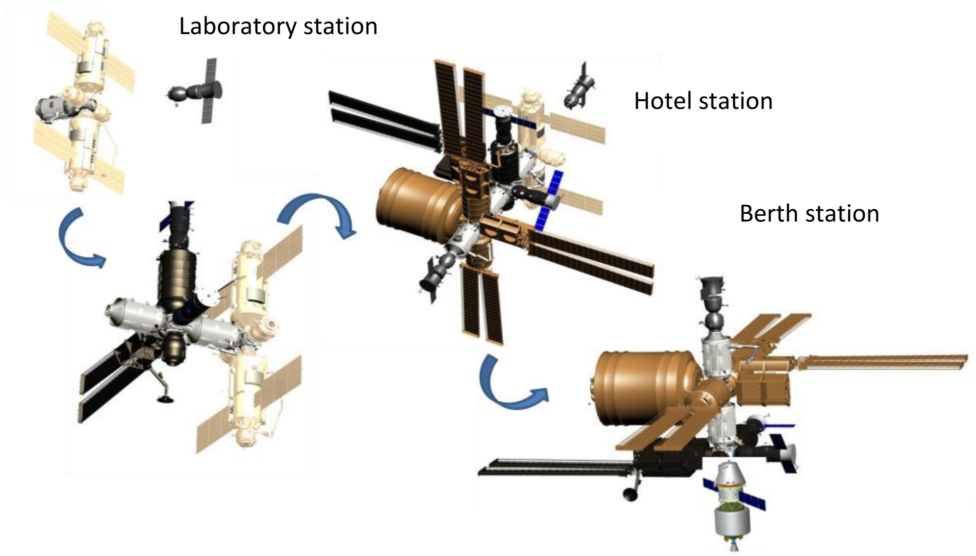

Fig. 1: Building a new generation space station (NGSS) and its transition depending on tasks to solve