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SPACE SCIENCES

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Abstract: Panel "Space Sciences" was attended by moderator and 4 speakers who represented all segments covered by the conference: Academia, Industry and Societies. Various topics were discussed, such as: Space Science in Serbia and in the region, Experiences in international projects and examples of cooperation, Connection between science, industry and society and the future of Space Sciences in Serbia.

Keywords: space exploration, space law and policies, remote sensing, earth observation, mechanics and engineering, satellite applications

1. INTRODUCTION

During the first day of the conference, a Space Sciences panel was held. The panel was attended by moderator and 4 speakers (the authors of this report) who represented all segments covered by the conference: Academia, Industry and Societies. The main idea of this panel was to acquaint the conference participants with the current state of Space Sciences in mentioned segments in Serbia, as well as opportunities for cooperation, developed projects, experiences and more. This report will be divided into several sections according to the questions answered and discussed by the panel participants.

2. AVAILABILITY OF SPACE RELATED ACTIVITIES IN SERBIA

Majority of people here in Serbia, but also in other space developing countries, consider space science and space related activities as something that is unreachable to an everyday man. Lot of people think about this is all connected to Moon missions, Mars missions, rocket science and other very expensive endeavours, but today it is not just that, it is much more. Today the emphasis has changed from these large-scale missions to smaller missions and Near-Earth Objects (NEO) utilization. Pre-condition tool to understand space segment today is that today everything "revolves" about satellites and usage of satellite data for various purposes. In this light, we all are slowly starting to get acquainted with benefits of this programme especially of some of them that are free for use such as Copernicus or UN Charter programme and all the benefits we can get from them. Today, at the NGO sector, academic institution, and small and medium enterprises we are witnessing introduction and utilization of such programmes. In other words, this is our own battle we need to fight and research and develop different tools for using and exploiting the data that today is mostly easily accessible on internet and free for use.

3. EXPERIENCES REGARDING THE IMPLEMENTATION OF INTERNATIONAL PROJECTS IN SERBIA IN THE AREA OF SPACE R&D

Space Sciences, as they are defined, cover extremely wide field of science and there are many reasons why people come to it or are motivated by it. We can list just a few examples for space research and development (R&D). First one, simply, curiosity driven research like: why is the Universe the way it is, what are the laws or fate of it, how do planetary systems form, what are the conditions for life etc. This is mostly covered by sciences like physics, astronomy, and astrophysics. The second motivation can be exploration, since there are always people who are driven by the wish to explore new frontiers in space. So, we have manned space mission, and now maybe even more then before unmanned space missions and additionally very long unmanned space voyages, where there must be incorporated many different areas of science like artificial intelligence, engineering etc. Third reason could be monitoring Earth's environment, for example space telescopes could be focused outside or inwards and in the case of the latter we can research and look at the things like radiation belts, ionosphere, ozone layer, understanding climate change etc. Then, the fourth one could be something completely different like the direct economic benefit that can be very interesting to certain people and/or organizations. Today we are quite aware of satellite and communication evolution, we know how important global positioning systems are and in very near future we will have mining of various materials from space objects. Then there are the long-term technological challenges like solar sails, ion drives, space elevators and limited terraforming, depending how far you are looking to the future. These kinds

of challenges can spur similar effect, that, for example, we had going to the Moon fifty years ago. The next reason that we want to mention here as motivation for space R&D is managing existential risks. That means as first step classifying existential risks and the next one would be classifying the responses that civilization can take to mitigate those risks. In addition, one could mention a few more important areas of research, such as modifying terrestrial life for extra-terrestrial conditions, search for extra-terrestrial life, and various military applications.

When we look at Space Science, we should look at it through at least these 8 prisms. If we try to visualize this approach, we could arrange them on a graph where these motivations for space R&D are on x-axis and time is on y-axis in the sense of how far that is in the future for countries like Serbia and others in the region. First layer would be to use the things that have already been implemented in these countries and this means that we can "start small". Curiosity driven research, monitoring Earth's environment and even managing existential risks are among those that have already been developed here in Serbia, but certainly need to be expanded upon in the future. Next layer are the areas where we could contribute but still, we are not part of them. They are of importance for our country, and similarly for some other countries in our region, because there is dichotomy between research and industry and this layer could be very important in bringing these two sides together. For example, here we can talk about long term challenges. Huge projects such as solar sails or space elevators can incorporate small partners and slowly bring in commercial sector in those countries. We have necessary expertise and now we have to create multidisciplinary teams, and hopefully cross-border teams in our region, for tackling this problem in certain ways. The next layer are the projects where organization or company or country need to be partners in very large collaborations in order to contribute and for that more mature hi-tech sectors are needed, and motivations for space R&D of that type are, for example, exploration and direct economic benefits. The fourth and last layer is something that could be used in defence or military applications. Taken through these x and y axes we can look at various types of problems or ideas for research. First type, such as those curiosity driven problems, or more theoretical research, or analysis of data that is available, have already been introduced in Serbia and we are already participating in this kind of R&D. Things like measuring the ionosphere, looking at the changes in the ozone layer and in the radiation belt and better understanding of climate changes are among those that are being researched at on the Institute of Physics in Belgrade, while astrophysics and cosmology and some other of the curiosity driven research are developed at the Astronomical Observatory in Belgrade. In all these things we are making the first steps, but there are some problems like for instance that Serbia is not a member of European Space Agency (ESA) and currently we are working on solving this problem. For now, we are partners in many Horizon projects, and we are sure that membership in ESA will significantly raise the number of successful space segment projects in Serbia. Next step is that we start thinking about technological challenges and to bring researchers, engineers and financial experts involved around certain well-defined

and very ambitions international technological challenges. In this way we can substantially increase the number of international projects and collaborations in the field of Space Science.

4. THE FUTURE OF SCIENCE IN THE SPACE SEGMENT IN SERBIA AND IN THE REGION

To better understand the situation we are currently in, we can add another dimension or the third axis to the previously mentioned two-axes visualization of Space Science. The third axis could be dubbed created value. We know that different items, ideas, or projects on different timescales have different capacity for creating values. When we talk about space in general, and Space Science and technology, we need to think about all the relevant scales: temporal scales, spatial scales, and the resource scale, and we need to see how any activity can scale up to larger amount of space and further in time. In that sense, we fully endorse the mentioned key topic which is networking. Big "space" projects are not supported by single country, but it is always some sort of collaboration on different levels, both in terms of vision and investment. This happens in the space segment, as well as in other fields of human endeavour in general, including economics, quality of life, ecology, etc. Among other ideas, we need to think about local and regional integration into wider networks, first on European level and then at the global level as well. Many of those motivations and incentives that were mentioned previously are something which is, by definition, of global character. For example, investigating and possibly mitigating climate change is a priori global problem which cannot be resolved locally. Additionally, this problem can be extended by the lack of public understanding and deepened further by the lack of understanding of the problem in circles of people who are decision makers, fundraisers, and those who do not have sufficient knowledge and understanding of the problems involved. Therefore, we encounter many difficulties, like simply correctly measuring and reporting concentration of anthropogenic greenhouse gases. Networking and integrating in wider networks, in both organizational and commercial ways, is a necessary way to go.

We don't need to emphasize too much how the international collaboration is crucial for science itself, but also for engaging in projects which go well beyond the science; and not just into industry, but toward some sort of very big problems that are transgenerational. We should not discount problems, like climate change, in a way that it will be resolved by future generations, instead we need to work together to challenge and change this atmosphere of endless delays. This means a more future oriented view in research, in education and in public outreach is needed. This will immediately lead to understanding how the future of all humanity, lies in *space*. As Tsiolkovsky said: "The Earth is the cradle of mind, but one cannot live in a cradle forever." So, when we scale up all these problems, but also opportunities and benefits, to truly cosmic scales, we can expect to create maximum value which is obviously our goal in both cognitive and ethical terms.

As soon as we understand the nature of the problems and the nature of opportunities, we are on the way of helping global and transgenerational enterprise which is building sustainable human future. This in general is in space, but it does not necessarily mean beyond Earth. Quite to the contrary, probably the only way to build ecologically sustainable Earth environment is to transfer some of the Earth's industry, and problems which we created, into space by utilizing cosmic resources. In a long term, meaning 10 generations from now, that people will be completely puzzled and surprised that we could ever not think that space is our priority.

5. EXAMPLES OF INTERNATIONAL COOPERATION WHICH OFFER THE GREATEST BENEFITS AND PERSPECTIVES IN SERBIA AND SEE REGION

When we talk about the examples, we can single out those that have the most practical applications in space technologies, such as utilization of space monitoring, Earth observation programs like Copernicus, and global positioning systems like Galileo. These applications are essentially becoming part of everyday life of all citizens, whether they are aware or not, as space technologies are used for agriculture, smart transportation systems, weather forecast, meteorology, and so on. Global cooperation in the field of exchange of data from weather stations and global network of meteorological satellites and combining them with Earth observation, produces huge savings in purely financial terms just by having more accurate weather forecast.

The first and the simplest way to work on space applications is to raise to a next level what we currently have. We need to have region wide partnerships for building a critical mass related to monitoring Earth's environment. For now, each country, or in some cases institutions, in our region has ongoing efforts to do this, so we need to follow examples of other European regions and build partnerships in order to bring better quality of research and economic benefits for our region. The second level of examples of international cooperation should be connected to the potential responses to existential threats. A lot has been done at the level of strategies on what should be done and identifying the risks, so the next step that is completely feasible in our region is to start looking into the roadmaps on how to mitigate these potential threats. We need to work on and make these roadmaps together and that would be a fantastic contribution to a problem that certainly is transgenerational. Directed evolution is one of the most promising ideas on how to deal with future threats of that kind and this means to create or modify existing microorganisms for use in environments outside the Earth. This includes huge series of multidisciplinary questions including ethical issues. Our region has already shown competence at global level in working toward those ideas. We have witnessed a computer revolution a few decades ago, but the new genomic revolution is not necessarily going to happen in large institutions but instead in small collectives in various places, and we have already seen a lot of success done in our region, mostly from some companies in Slovenia. When we talk about space

elevators, mentioned before in the text, we are talking about a great technological challenge that led to lot of scientific and technological discoveries, and it has wonderful results in motivating young people to turn to science, which is something we lack in our country, but we are confident that we and everyone else will overcome this problem. Finally, we can talk about things like long term travel, where probably the best way to do this is to build unmanned probes with incorporated artificial intelligence that would have proper decision making in order to work in space in prolonged time, even when there is no, or little, contact with Earth. The region we are in is competent in development of artificial intelligence in comparison to global arena, and Space Science offers great opportunities in connecting people from different disciplines to further develop some new concepts that will ultimately lead to some technological breakthrough like long term space travel. Things like this have some components where our region can make immediate contribution, which will be good for the global effort and beneficial for our region for building self-confidence, cooperation, and growth of the high-tech sector.

When we talk about projects of this magnitude, like space travel, we have to think about a few very challenging issues, which are the human resources and infrastructure that exists here or somewhere else. We need good scenarios how to connect people from different areas of interest and how to properly and effectively use the infrastructure together. The great results cannot be achieved in one leap, but the first step is to make good approach to this problem, assemble good team and define goals that need to be done. There are already good role-models and examples of such attempts in the European Union from which we can learn much. It is important to stress that we have human resources and necessary infrastructure so the next goal should be integrating larger number of institutions and different infrastructures to pursue the same goal. That's why we need to emphasize, one more time, the importance of networking, team building and collaborations in order to achieve this.

There is another perspective from which we should look at the mentioned ideas about at least some of the big technological breakthroughs and that is space law. If we take as an example asteroid mining and legal status of excavating materials from outer space, international community agrees that this is in the so-called gray zone, and that there are lot of things that need to be done. To add another argument to this there are already several nations who have issued national legislation which allows them to have full ownership rights on anything "they excavate outside of Earth". So, in this light we can probably expect the all the nations will join the next space race at least in the space law perspective. The international community is currently working on the changes and modifications of the Outer Space Treaty, which entered into force in 1967. The new changes should reflect on the new technologies we have today and those that will be available in near future, like private space missions, asteroid mining, modifications of other planets and natural satellites in Solar system etc.