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50 YEARS OF SPACE FLIGHT: PROSPECTS FOR MANNED PROGRAMMES

Expanding Technology Horizons

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Manned space programmes are increasingly coming under criticism. It costs a lot of money to send astronauts into Earth's orbit, while there are few challenging tasks for them to perform. Unmanned space exploration is clearly more promising and has already provided much more information today than the manned space programmes, which Yuri Gagarin laid the foundation for with his space flight fifty years ago.

Moderator:

Joe Pappalardo, Senior Editor, Popular Mechanics

Panelists:

Georgy Grechko, Pilot-Cosmonaut, two-time Hero of the Soviet Union

Akira Kosaka, Deputy Manager, Japan Aerospace Exploration Agency (JAXA)

Vitaly Lopota, General Director, RSC Energia

Joel Montalbano, Director of Human Space Flight Russia, NASA

Vladimir Popovkin, Head, Russian Federal Space Agency

Gennady Raikunov, General Director, Central Scientific and Research Engineering Institute

Thomas Reiter, Director of Human Spaceflight and Operations, European Space Agency

Front row participants:

Louis R. Chenevert, Chairman and Chief Executive Officer, United Technologies Corporation

Sergei Krikalev, Pilot-Cosmonaut, Hero of the Soviet Union

J. Pappalardo:

I would like to start off by thanking everyone for coming to this very distinguished panel today. My remarks are very short because, I want to hear the answers from the panel more than, or as much as, anyone else here.

I just want to start by putting a little context to our discussion today, just by noting that space flight history is at a very critical juncture right now. It is a very exciting time to be a reporter like myself, or to be involved in this industry.

There are a lot of great opportunities and challenges, as is the case anytime there's a pivotal time in history. Right now, space touches the daily lives of billions of people on the planet, from navigation to communication. Military departments around the world consider it a pivotal area of concentration. Space telescopes and space probes are discovering things that reveal the future and the past of our entire species.

There are new spaceports, new space flight centres, being planned, and being built. Private space flight is opening up lower Earth orbit to new players, new people. But there are questions that need to be answered. Questions including, clean-up of orbital debris, the appropriate role of the private sector, how to manage that. The appropriate role of robotics: are they tools to help humanity get into space? Or are they the mechanism by which we explore how to get the return on investment from space from an economic and also a scientific standpoint?

So the men on stage here are some of the people who are helping answer those questions. And we have a lot of exciting details and some presentations. And there will be an opportunity for the audience to vote on some questions at the end. And hopefully, if there is time, ask some.

So to start off, I would very much like to invite a presentation from Mr Popovkin. Vladimir Popovkin is the head of Russian human space flight. And he has a presentation he would like to fill us in on, and I would like to invite him to please begin.

V. Popovkin:

Thank you for giving me the floor. Ladies and gentlemen, when talking about the prospects and programmes for manned spaceflight, I would like to begin by reminding you that the Soviet Union was the founder of manned spaceflight, and that in 50 years we have progressed significantly, from a single orbit to missions lasting many days. In fact Cosmonaut Polyakov spent over a year in orbit. Speaking of both today and the future, there are quite tangible near-term prospects, such as the use of the International Space Station, and as you know, the final launch of the Space Shuttle will take place in June this year. After that point, full responsibility for running the Station will fall on Russia, and this, to a large extent, defines the immediate prospects. The International Space Station will continue to operate until 2020. There are experimental programmes, and maintenance and development programmes, including for the Russian Segment of the Station. Mr Lopota will tell us about that in more detail. Just now, it is more important to look to the future. What about after 2020? In summing up 50 years of the Space Station, and of manned spaceflight, we must recognize and say that yes, we have conquered near space, the low-Earth orbit. We know how to work there for a year; we know that it is possible; we know what experiments are possible, and the pluses and minuses of space stations. What next?

Today at the Russian Federal Space Agency, we are working on our own kind of roadmap, and addressing the issue of what steps Russia should take. To speak more frankly, if we are to set ambitious tasks, then we need to think about the steps to be taken, not only by Russia, but by the international community, which is today involved in space activities in one or way another.

We see two such routes, two general directions: the first is conquering the Moon; the second is attempting to know and understand more about the origins of our solar system. Naturally, this would involve flights to Mars and its satellites. In my opinion, the science of manned space exploration must be developed in that direction in future. Of course, in order to achieve these goals, we need a period of preparation. Russia in particular, among other countries, is now beginning to study the planet Mars and its satellites more intensively. You are no doubt aware that this year, we should be launching spacecraft to one of the satellites to take a soil sample. Regarding missions to the Moon, strategically speaking, we need to understand what they are for. Man has already walked on the Moon. There does not seem to be any point in a second test flight to the Moon. Neither today, nor in the near future, will Earth need to build some kind of inhabitable bases there, or try to talk about useful mineral deposits of some sort, as we did before. When there is no need for it, it is, of course, difficult to demonstrate the value of such things.

Mars is another matter. Yes, it is a new challenge, and it is new, breakthrough technology. In my opinion, this is the more promising direction. Yes, perhaps, the Moon could be it, but I believe we need to focus on Mars.

Such discussions are taking place at the moment, but by the end of the year, we must decide, because we cannot have this sort of uncertainty in future. We do not have much time left; 2020 is just around the corner. We need to work out the direction for manned spaceflight science today. However, I will repeat here that, aside from Russia's will and desire, our negotiations with the international community are crucial, because these projects require many billions in expenditures. So here, naturally, we need international cooperation. Well, that is all I wanted to say to begin with.

J. Pappalardo:

Thank you very much. It's a good way to begin the discussion. I certainly think there will be a chance to ask questions after everyone has a chance to make their presentations. I have a few, and maybe we can open up to the audience as well. I'd like to invite Mr Lopota to make his remarks as well at this point. Mr

Lopota is the General Director of RSC Energia. Please, if you would, make your remarks.

V. Lopota:

Thank you very much. And welcome to all guests and delegates to this Economic Forum.

Let me remind you that the concept of astronautics, the concept of flights into space, was first conceived in 1687. These ideas were first expressed by Isaac Newton, in a lecture. It is true that he was really thinking about a cannon, a barrel, but he was already considering the speed that would need to be reached. He had already estimated orbital velocity and was attempting to solve this problem. It took another 287 years for the brilliant minds of the German and Russian schools of engineering to be able to solve this problem in 1957 and to think up the comprehensive space hardware and rockets that could work not only as weapons, but already as a useful and constructive endeavour for human and technological progress. Yet we needed another four years, until April 12, 1961, which is now 50 years ago, for the first, Soviet, Russian, human spaceflight. During that time much had been created, including space launch pads. At first, there were military rockets, then simply rockets that were not dangerous at all, and then a decision was taken to put a person in these rockets. At the same time a whole range of space equipment to serve human life was being designed and, in the end, astronautics was developed and human spaceflight was born.

Today, we have a clear example of excellent, unique international cooperation that is free of politics: the dynamic and constructive work of the world space powers in orbit.

Now I would like to return to something that is dear to each of us. As children, we all raised our heads and looked up at the stars. Humanity, in all its history, across many thousands of years, has already counted over three billion stars. A little later on, they were joined together into some 70,000 galaxies. The big question is whether to continue searching, continue spending. Here, on this slide, you can see the galaxies in our night sky. You can see the cosmic rays, shown here by the orange-yellow pointers, that are reaching Earth. This curve here is what prevents the rays from entering. On Earth, we can only measure the radio waves that reach us, and the small, narrow spectrum of optical waves, the infrared optical range.

Yet in order to discover what the Earth is, what the cosmic bodies are, their history and the future for earthlings, we need to rise to greater heights—remember this—to over 200 km. And once a person had done it, when over the past 15 years, with the help of manned spaceflight, incredible telescopes have been built and launched—the last 15-20 years have been particularly revolutionary with regards to knowledge of the Universe thanks to the Hubble Telescope that was launched into space—many new planets began to be discovered, beginning in 1998. We saw a completely new occurrence: mists in the Universe that are the result of an explosion of a system similar to our solar system. So that you can understand the proportions. It is written here: one light year. Light takes a year to cross these characteristic distances. We need to understand what is happening, and what prospects there are for our solar system. We know very well that the Galaxy, the one we are in, is the Milky Way Galaxy that was born seven to eight billion years ago. Note that it is supernova stars that give birth to stars such as the Sun. This is an example of a galaxy, a typical galaxy, where we all live. In recent years, we have gained completely new knowledge. Black holes, where everything simply ceases to be, have been observed. In fact, in recent years a model of the Milky Way Galaxy has emerged. There is so much turbulence that everything is spinning and the Galaxy itself is flat. It is found, for example, in the centre of our sky. All of us, when we look at the sky, are seeing the Milky Way. We are on the edge of our galaxy, which is lucky for us: we have the right level of gravity and the right conditions in which we all live. Look how we have been dragged here, alongside the appropriate space.

What are the tasks for astronautics, what are the goals? Today, humanity has been united by manned spaceflight. Our main goals are security, technological development, and prosperity. Humanity has solved a huge number of the problems of space, and is now reaping the benefits. The space services market is worth around USD 300 billion. Who is important in this market? This is just the blue segment, the budgetary allocation of the United States, which is over USD 60 billion per year. That is three times more than all of the other countries combined. This is the scale of the market. The science of manned spaceflight has already been brought together by the International Space Station. Humanity has spent over USD 120 billion on it. USD 120 billion over ten to twelve years is, perhaps, not that much. It is after all, the only single international project where humanity cannot work out what is where and where is whose, yet recognizes that we are all in the same boat; we are all doing the same thing. As for the Russian Segment, frankly speaking, the economic crisis and restructuring of our budget have really affected us, and only in 2015-2016 will we really have a fully-fledged Russian Segment. Yet despite that, a reasonable number of experiments are already being carried out on the Segment today. Forty leading Russian research organizations are holding experiments, and there will be 197 experiments this year. There is research in different areas, and work stations have been organized on both internal and external surfaces of the International Space Station. These are general experiments, and we can change the equipment there. One more small research module has been launched, which also has work stations inside. Of course, the main laboratory that Russia will put into space by the end of 2012 will be a multi-purpose laboratory module. It will have 13 work stations outside and 20 inside. This laboratory is unique in both scale and facilities, and will be the most powerful. With a view to flight opportunities, Vladimir Popovkin was exactly right: it is not clear what we are doing up until 2020. Here at the bottom is the Russian programme, and above are the proposed American and European programmes. Above, on the American line, are the private spacecraft that private companies are currently trying to develop. It is interesting to note, nonetheless, that if we look at where humanity is going in manned spaceflight, we can see two paths: capsule craft or winged craft. Today there are discussions about which is more promising. For now, as of today, I can say that consistent engineering thought, which was led by the Soviet Russian school, showed the viability of the capsule type from a security point of view. Allow me to clarify: when travelling at a speed of 8 km per second, and breaking out of the earth's gravity and returning at that speed, the body of a spacecraft reaches temperatures of up to 2,500 °C. We travel at that temperature for 7-8 minutes. That is a temperature which is 200 °C above the boiling point of steel. There are not very many materials of this kind—it's a special technology—so the flight schemes are a big gamble. That we have lost one shuttle on re-entry into the atmosphere due to a flaw in its surface is not completely unexpected. And we earthlings must really, truly understand the dangers that await us in space. Space is hostile, and humans are vulnerable. That is what we must truly understand: space does not allow for even one mistake. We are working on new spacecraft, an evolution of the capsule type, and developing different versions of hull transformations and re-entry into the atmosphere. Nonetheless, the technology is advancing, and we must know where to go next. Vladimir Popovkin was correct: we currently have a limit line. It is Mars. We cannot send manned missions beyond Mars. We need energy; we need to explore the Solar System for resources, to develop technology, to seek prospects for human life. This is a worthy challenge that must be tackled. We need to develop orbital and interorbital security infrastructures. These are already in place on Earth in the form of chemical technologies. If this can be done by humanity, then it will be through international collaboration. For human spaceflight, we need unbelievable amounts of energy. We cannot fly beyond Mars using the energy of the Sun. I would like to bring your attention to the lowest figure: 24 MW. This is how much energy we would need to send a manned mission to Mars. To service vital human functions we need 0.5 MW, and that is all we can determine on Earth. Therefore, the Russian programme has a primarily evolutionary approach to development. This is modular construction, by which everything that has been done at the previous stage has been used in the following stage without loss or a revolution in approach.

What can we do, and how can we do it? According to space research—and Mr Pappalardo has mentioned this today—it is important that we clean up orbital debris. A high level of man-made waste has been produced in geostationary orbit. In geostationary orbit, 36,000 km above the Earth's surface, there are 600-700 non-operational satellites floating. And remember, we all have a connection to this. Remember that every third bit of information goes via orbit. And we must not leave a polluted orbit for future generations. The decision not to leave debris, to remove it from each piece of equipment, was taken very late. Today, as I've already said, there is between one and six tonnes of floating metal in orbit. How we remove it is a huge problem that must be addressed. Those developments are progressing. Work is on-going in space research.

Naturally, we are currently thinking about using nuclear energy, but let us not forget about solar energy. In Germany, for example, the technology has already emerged. We have heard that solar cells with an energy efficiency factor of 40% have already been created; this is an example of incredible international cooperation. Or we may have to turn to nuclear energy. Reconnaissance work is underway to check for hazardous asteroids and comets, which the Earth is currently naturally protected from by Jupiter, as Jupiter takes the danger on itself. Using cosmic nuclear energy, we can obtain extra terrestrial power: safe, compact reactors. Earthlings at remote northern latitudes could use it.

A wide range of industry partners in Europe, America, Russia, and Japan have already worked out the details of where it is possible to go. It seems to me, Mr Popovkin, that we should have this type of international programme. Russia announced this programme back in 2009. Industry partners are currently working on this, and discussions between space agencies are underway. Yet it seems to me that Russia’s current position and current level of knowledge and training gives it the right to come forward as the initiator of such a bold programme. That is why I believe that we are alive at a truly unique time, when everyone understands that we share something all around the Earth. That is the resources and the market on Earth. Once we go beyond the Earth’s orbit, we share nothing. So we invite you to come on this great journey with us. Thank you.

J. Pappalardo:

Well, as much as I love to look at space hardware and spacecraft, I am glad that you started with pictures of the galactic disc and where we are in the galactic arm; it just reminds us how far that we've come and how much there still is to be learned. Thank you very much for that.

Next up is Joel Montalbano of NASA – he is the head of Human Space Flight Russia – to give an update on where NASA is and where it plans on going as well. Joel.

J. Montalbano:

Well, good afternoon. You know, it’s a pretty special time to be working in the space industry with the 50 years of human space flight. We, just recently, with my Russian colleagues, have launched the 28th increment to the Space Station, and so I'm here today to tell you a little bit about what NASA's plans are.

So let us see, as far as a vision, and then goals, for NASA. You know, NASA's plan is to discover. Our job—we need to go figure out and understand the unknown, take that information and apply it to humankind. And how are we going to do that?

We have identified six goals to make that work, and the first goal is to continue human space flight. We all agree to fly the International Space Station to 2020, possibly beyond. But then after that, we need to move out of low Earth orbit and we need to move out and go further, and we want to do that with humans. That is something that we want to do, and hopefully, we will be doing that with our partners.

The second goal: expand understanding of the Earth and the universe. And that has always been a goal of NASA and that will continue to be a goal of NASA.

Number three: talk about new technologies. You know, in order to get out of low Earth orbit, there is some work that we need to do, and those technologies need to be developed. We need to work together and develop those technologies so that we can leave low Earth orbit.

Advanced aeronautical research: again, this is another thing that NASA has always been proud of, something we have always done, and something we will continue.

And then number five: enable the program and institutional capabilities to support NASA's programs.

And then number six—and this is pretty important—we need to share NASA with the educators, with the teachers, with the students. We need to inspire people. If we are not going to take the space program and make people proud of it, make people happy with it, they will not participate. The people who we need to develop those new technologies and this new information so we can explore: they need to be proud of what they are doing, and we need to educate them.

We talked a little bit about the Space Station. You know, where we have been twelve years, seven months and counting. And so, 1998 you see on the top right, we first launched the Russian module followed by the U.S. module, and you see where we have come, through time.

Again, you ask people, how long we have been up there and people are surprised to hear you know, twelve years, seven months. And so, how do we do that?

Well, we do that with five partner agencies: the Canadian Space Agency, the European Space Agency, the Japanese Space Agency, the Russian Space Agency, and NASA. But it is much bigger than that.

You know, through the year 2010, we have had over 59 countries participate in the International Space Station. Fifty-nine countries and counting. And the goal is to continue providing opportunities so these countries and people can participate, so that they can fly experiments onboard the Space Station, and we can learn and then take that interest, take that learning, and apply it. So how do we do that?

Most people hear about launches in Baikonur or launches at Kennedy Space Center or French Guiana or in Japan, but we do this with control centres all over the world.

We have a mission control centre outside Montreal that the Canadian Space Agency uses. We have two main control centres in the United States, Johnson Space Center in Houston, Texas, and the centre in Huntsville, Alabama, for payloads.

We have the Russian Mission Control Centre, the Toulouse Mission Control Centre that controls the ATV; the control centre for the European Space Agency in Oberpfaffenhofen in Germany; we also have the Japanese.

The bottom line is: we do this across the world, we do this across time zones, we do this across cultures, we do this across competing national priorities and we make this work. We work together, and together, we make this the most successful international project.

So how have we done? Mr Lopota talked about some of the investigations and, you know, to date, on the first 24 expeditions, we have done over 1,100 investigations.

We have involved more than 1,600 scientists all over the world, and to date, we have published—and this is important—we have published over 300 publications. And I will tell you, that is a conservative number. And this is all while we were building the Space Station.

So now that the Space Station is mostly built, now it's time to focus on utilization and make utilization a priority, and all these numbers are going to increase. And that tells you where we are today, and it is going to get better.

So what is the next step? What do we do? What does NASA think we ought to do? And basically, we are saying space exploration begins with ISS. We need to use the Space Station as a test bed to understand how humans work in space, continue to understand the space environment, and then move on. If there are things we can do on the Space Station, bring down risk so we can go further, that is what we need to be using the Space Station for.

As far as a destination is concerned: as an agency, we are not going to pick a destination right now. What we are asking our people to do, is, we are going to develop the technologies to go to places, whether it is back to the moon, whether it is to Mars, whether it’s to a near-Earth asteroid, or to the Lagrange points. We are just going to look at the technologies to get there, get ready, and get us postured to go do that.

The main thing is to develop technology that can be shared among any of those destinations. We do not want to zero in on one destination and then have to start all over for the next destination. We need to look at the technology that buys us the flexibility to go to one of these places.

As far as human space guidelines go, we want to continue going and continue exploring and have regular missions throughout the solar system. That ought to be a long-term goal, and we are going to do this with a combination of humans and robotics. Each human brings a certain point or certain flexibility to space operations, and robotics also brings a needed flexibility to operations.

We need to inspire, and I talked about that earlier. It's so important that we have the younger generations understand what we're doing and want to work with us, because those are the people that we're going to depend on for the future of our operations.

The last item here talks about best practices. Something that NASA has stepped up on is that we go to industries that do similar things that NASA does and we talk on it. And we understand how they do that, and then we look at how NASA does it.

And what you find out is different people are doing things a little differently, and if we go to two or three or four or five different places, we take all of those best practices and bring that back to NASA. That's going to make us a better agency, a better space exploration team. And it is something that we can go ahead and share with our partners.

As far as human exploration and kind of our overview, we are really looking at three sections. The first section is to develop a heavy lift vehicle and then a multipurpose crew vehicle. These are vehicles that are going to take us out of low Earth orbit.

Part two is that we are going to be turning to commercial providers to provide both cargo and crew transportation to low Earth orbit.

And then the third one, to continue human research; there are a lot of things we're learning about the human body onboard the Space Station, and we need to continue that, because there's still a lot to learn as we go ahead and explore: new technologies, life support systems.

We still have work to do, if we are going to leave low Earth orbit, in our life support systems, in our EVAs or extra-vehicular activities, and we need to focus on that and make that a priority.

So, where are we today? We call this our family photo. This is a photo taken by the last Soyuz crew that left the International Space Station, and it shows a picture of all the contributions of all the partners and what we have in space right now.

We also need to remember the crew that is on board. Right now, the 28th expedition is on board. We have three Russians, two Americans, and a Japanese astronaut, and these are the people who are taking the experiments we worked on. They are taking the work from Mission Control Centres and are taking these results, these requests from our scientists, providing the information and allowing our scientists across the world to understand better how we live and operate in space.

Lastly, it has been mentioned about the Space Shuttle. This year is 30 years from the first launch of the U.S. Space Shuttle. On July 8, Space Shuttle Atlantis will launch from Kennedy Space Center. It will be the last time Space Shuttle Atlantis flies, and the last time the Space Shuttle programme flies. And so this is just the photo of the crewmembers who will be on that mission.

Thank you very much for your time.

J. Pappalardo:

I definitely enjoyed looking at your slide with the accomplishments of the Space Station. I often think it is the least-understood and least-appreciated wonder of the world and a new way to communicate to people what is up there, what its purpose is, and what it is doing. I think that there is an opportunity to sell that to the public as a worthwhile investment, so it was nice to see that as well.

Next up is Gennady Raikunov, the General Director of the Central Scientific and Research Engineering Institute; if you would, please?

G. Raikunov:

I would like to thank you for the opportunity to speak at such a distinguished Forum. I would like to say that this year is the 50th anniversary of Yuri Gagarin’s flight, and that over these 50 years, the disagreements have continued, despite the many clear achievements in astronautics. There have been disagreements about the role and place of, and investment in, manned spaceflight, and about the overall challenges that astronautics faces. In actual fact, this is not as trivial as it may seem at first glance. These issues are quite complex, and I would therefore like to mention the practical results, including the fundamental ones, that we have achieved today in regard to the presence of humans in space, and attempt to define their role in general research.

The extension of the working lifespan of the International Space Station (ISS) to 2020 has given new momentum to the research that all parties are carrying out today, including Russia. In fact, a scientific and technical council has been organized at the Russian Federal Space Agency, Roscosmos, to create a long-term programme. We approached the issue in a new way, inviting 150 organizations in addition to those that consistently worked on ISS research and experiments. And this research was given a new impetus. Seventy proposals were put forward and developed into a long-term programme of space experiments on the ISS. Today, there are over 203 space experiments, 59 of which have already begun, and approximately 102 experiments are at the preparation stage. In the near future, a number of these will begin. Today I would like to talk about some fascinating experiments like those that are linked to the fundamental question of how life appeared, including life on Earth.

Both America and Russia have held a range of experiments that aimed to answer this question. For example, could life, as one theory states, have been brought to Earth from Mars? There were many sceptics who said that long-term life could not be found in deep space, and that, surely, over those millions of years, the object that reached Earth, in the form of a meteorite, for example, or in some other form, would have died. However, the experiments conducted showed that, simply put, that was not so. The experiments carried out by Russia on objects like seeds, spores such as green algae, various eggs, and maggots such as those of the African mosquito, showed that these objects could exist and survive in space over an eighteen-month period.

Then disagreements began over the fact that during take-off, these objects experience unusual temperatures, pressure, and g-force, and that they would surely die. Yet the experiments conducted in Russia, and at the Russian Academy of Science Institute for Biomedical Problems in particular, showed that

that was not the case. In this case, at certain depths under the surface of the space ‘vehicle’, life continues to survive. Moreover, the maggots and eggs produced the same mosquitoes as those that had not left Earth, except that they were more robust, and that for some reason—and this is a matter for research—they had lost their reproductive functions. So it turns out that a range of fundamental questions that are linked to other fundamental questions that humankind has been asking for hundreds or thousands of years have found some kind of answer in the experiments held on the Space Station. Fundamental research is also taking place, like that on plasma crystal being conducted by academician Vladimir Fortov in conjunction with the European Space Agency. We are working very successfully on this with the Germans. It is an attempt to create ordered structures, major systems, in plasma that can be obtained due to the high-frequency gas discharge of the microgravity environment on the Station, with consideration of the vacuum that exists outside the Station. The basic results obtained are very interesting, as recognized today by the international community.

We obtained very curious results from research into the Earth’s atmosphere, near-Earth space, and in particular the plasma component in near-Earth space. The research looked at the impact of both natural and man-made factors on these substances. Preconceived notions about local effects on the atmosphere, particularly the ionosphere, turned out to be false. The majority of these processes were not just regional, but in fact global in nature. Moreover, it is very curious that the ISS, as a very large object that revolves around Earth affecting the plasma structures of near-Earth space and causing perturbation, is also affecting different force fields – both electric and magnetic. It turned out that in many cases the perturbation is such that a number of devices simply fail. I am not talking about the entire range of issues linked to Earth remote sensing for fishing, agriculture, or prospecting for deposits of various sorts (ores, hydrocarbons, and others), that are also being addressed, although to a lesser extent, because the orbit is not synchronized with the sun. Nevertheless, some results have been obtained. Moreover, there have been multiple results for materials science on the crystallization process – particularly of non-conductives, semiconductors, and a range of other materials that have enabled the creation of new structures – research on whether crystallization occurs at the biochemical level, defining the atomic structure of large crystalline biochemical systems, and so forth.

However, I would like to say one more thing, with regard to the tasks that Vladimir Popovkin mentioned, on exploring Mars and the Moon. Of course, extending the lifetime of the Space Station allows us to develop and create the whole range of technology that will be needed for those flights. Previously, these types of experiments had taken place on Earth, such as the Mars500. Yet taking account of the extension to 2020, we will likely be able to complete some of the most complex control systems with the help of the International Space Station. For example, if we installed a rover and penetrators on Earth, and from the United States of America, or from Japan or Russia, via a communications satellite and relay (to obtain the desired time delay), we tried to hand over control to the International Space Station so that the astronauts would imitate a station on the Moon, or Mars, and control the rover, penetrator or other on-planet objects, then we could check all the functionality, the mission programme and its effectiveness, and so on. The entire range of experiments that could be conducted on the International Space Station could lay the groundwork for prospective future programmes to open up other planets. Yet at the same time, our research shows that a very significant number of experiments that our researchers would like to conduct cannot be conducted on the Station. This is due to many factors: the disturbances to the Station caused by human movement, turning on equipment, and adjusting engines during docking and equipment separation; the formation of gas and dust; the internal atmosphere that emerges from adsorption and desorption processes with incoming flows (albeit tenuous, but nonetheless, that atmosphere exists). There are fairly limited energy resources, particularly for growing crystals and many other experiments. I will not list all the reasons, especially those linked to the configuration of the Station and the impossibility of installing a sufficient amount of equipment for astrophysics research and so on. All of this brings us to consider that, despite the fact that today there is over one tonne of equipment and apparatus on the Russian Segment, we cannot, in any case, conduct a great number of the experiments that we would like to. In this regard it seems that, after 2020, we need to transfer to some other structure of an open nature with changeable modules that would enable different research to take place while in operation. This would include changes in orbit. For example, remote sensing, as I have already said, needs a sun-synchronous orbit. It would require changes in inclination, because from our station, we, sadly, cannot see a great part of the territory of Russia or even key arctic regions, and so on. Moreover, in the long term at least, it would be interesting to view the Moon, from a research point of view, not as an artificial satellite, but as a natural satellite that has dramatically different dimensions, different conditions, and where there would be no need for fuel to correct the orbit or orientation, or to stabilize the Station, and for a whole range of other advantages that I will not mention just now, but that I will discuss if there are questions about this. I would like to say that programmes like those, to go to the Moon, Mars, asteroids, and Lagrangian points, are so expensive that they require significant efforts and international cooperation. Insofar as it seems to me, not even the most developed country in the world would be able to manage that, and even if it could, it is not rational to conduct these experiments and research in one country, since knowledge is universal. We see (and Vladimir Popovkin has talked about this a lot today), that humanity is confronted by new, key challenges and that in fact a range of automatons—and I emphasize automatons, not people—such as Hubble, Keppler, Spitzer and so on, enabled us to overturn the worldview of how our Universe, our galaxy and galaxy clusters, and even our solar system were formed. Naturally this needs huge investment, huge efforts and international cooperation. In this respect, of course, the International Space Station gave us the necessary momentum when we realized that we could be effective and work well together.

Today, we have a huge range of examples of this type of fruitful international cooperation in science, for example, the joint Konus/WIND experiment with America to investigate gamma rays and x-rays, and the involvement of our equipment in the American scientific research programme on the Moon and Mars, the Mars Odyssey LRO, where Russian equipment such as LEND and HEND allows us to map regions with high water content for subsequent landings. And promising work is continuing in the USA on a new piece of Russian equipment that will map and study the frozen subsoil of these planets. At the same time, America has worked very successfully on our Foton craft programme, particularly with the second and third versions. We are working fairly successfully on space equipment and equipment launches with the European Space Agency, especially on the exploration of Mars and Venus. We are working on the Mars Express and Venus Express, which should also yield interesting results. There is very promising cooperation with India on lunar exploration. There are very interesting results from the fundamental research connected with our Russian Resurs DK space equipment, on which RIM Pamela is installed. In conjunction with the Europeans, and the Italians in particular, who are doing tests to determine the presence of dark matter in near-Earth space and in space, including searching for black holes. There is quite successful collaboration on the Integral Astrophysics Research Programme, among others. So the examples suggest that this kind of successful scientific research and effective cooperation is a reality, and is already taking place. This allows us to take an optimistic view of the future of large-scale international programmes to explore the Universe, the Galaxy, and primarily our system, including the Moon. This is especially true of petrological and geological research that will allow us to answer the questions around how the Moon was formed, and to focus on Mars, and so on; very interesting research into the presence of life and structures on Europa, Io, and Ganymede, and so on and so forth. This is why I would like to call for us all to join forces in order to answer the questions that we have today. Speaking in practicalities now: if today there is no direct return that is much greater than the investment, this could, naturally, lead to comparison with other areas. For example, the Collider, which is very expensive, does not offer direct returns either. Yet it nonetheless enables us to answer—of course, there is no absolute guarantee, but it is possible—the fundamental questions about the existence of mesons and muons, and perhaps to answer the questions currently posed by Hawking and other astrophysicists about the fact that in the microcosm, we have hit the limits for these elementary particles, and that nothing smaller exists. This is radically opposed to other theories that state that there could be progress in the micro- and macrocosms. However, once again, these questions can only be answered through international cooperation, only by combining forces: financial, intellectual, scientific, and more. I hope that this will take place within our lifetimes, and that we will see the new results. Thank you very much.

J. Pappalardo:

I think one thing that might help in that regard is a better understanding of the scientific process: that big discoveries come in very small steps, and small experiments can lead to big breakthroughs.

When people ask me what the value of space flight and space experiments are, it is nice to be able to point to specific things like discovering the origin of life on Earth or the development of new materials as ways to have returns on those investments. I think those are good points.

I would like to introduce our next speaker, Thomas Reiter, who is the European Space Agency's Director of Human Spaceflight and Operations.

T. Reiter:

Thank you very much. Good afternoon, ladies and gentlemen. Fifty years after Yuri Gagarin's first flight, I think space flight has not lost its fascination at all. I think it has become much more a part of our daily life than we are aware of. This is certainly true for the areas of Earth observation, of navigation, and of telecommunications.

But it is definitely the case that space flight has an influence on what we do every day. I am especially grateful that on an occasion like this, the International Economic Forum, we are including space flight in the discussions, because it definitely influences economies. It influences political processes quite a bit.

After 50 years of space flight, it has not lost its attractiveness for science. We have heard a lot of examples of that, and definitely, space flight has not lost its attractiveness and its fascination for the general public. I think, specifically, that human space flight evokes this fascination: the combination of science, of technology, and fascination for the general public.

Now in these years, in this past half-decade, we have seen an evolution from an era of competition into an era of cooperation. That is what I would like to expand on a little bit – the era of cooperation – where ESA has quite a visible role together with our partners from Russia, from NASA, from JAXA, and all the other member countries on the International Space Station.

But this did not happen in just one step. It had a history. There was participation in the Intercosmos Programme a couple of years ago, in the last decade, where various European members were flying to the Salyut Station, to the Mir Station. Myself, I had the chance to fly with my Russian colleagues to the Mir Station in those days. We welcomed our colleagues from NASA in those days – in 1995 – to the station, and that was really the start of fantastic international cooperation.

Today, the International Space Station is in orbit. We have already heard quite a lot about it, about the work up there. Six people are up there permanently and doing a lot of scientific research. ESA, the European Space Agency, has made quite a contribution with the Columbus research module, which is there to conduct a variety of scientific research. I will get to a few more examples in that field.

They are also making contributions in the area of logistics. Currently, there is a European supply vehicle, the ATV, docked to the station. In just a few days, it will undock from the ISS and then burn up in the atmosphere. In this way, I think it shows that Europe has found a very solid part in this international cooperation. This is something that can be built upon in future endeavours in exploration. But I will come to that in a moment.

Let us now expand a little bit on the use of the ISS for scientific research. We have already heard a lot of examples, also, from the European side. There have been a lot of experiments conducted since the ISS has been in orbit. More than 300. They are processed, of course. Not each experiment directly leads to a publication. We need to repeat the experiments before we have enough data to publish. But it is a huge source of interest in the scientific world. Apart from enlarging our knowledge, expanding the range of our knowledge about physical properties—about a lot of things—of course it has very concrete applications in vast areas. I would like to give you some explanations or some examples of that.

With the help of the research we are doing up there in the field of material sciences, we intend to improve casting processes, which are of huge relevance, for example, to the car industry. It is important to have a better understanding, for example, of the viscosity of melts in order to model the casting processes and to improve these processes on Earth.

Now if we can go to microgravity, it is important, or it is possible, to determine specific physical parameters which are much higher-precision, and viscosity is one of them. So in the upcoming years, we will continue using the ISS for exactly this point of research. This is not only important for pure science, but it is important for applying this science here on Earth to concrete applications with a certain economic impact for industry.

A second example, and it has been already mentioned, is in the area of plasma physics. We have conducted very interesting experiments with our Russian partners. I see Sergei Krikalev here, who actually started this experiment in orbit a couple of years ago. I, myself, had the chance to do it, and this leaves a lot of range for fundamental physics. But also there, we could derive a very interesting application for the area of medicine. With this plasma, it has been found that you can significantly diminish the time needed to disinfect your hands, for example, for medical doctors when they are going to do an operation. Usually this process takes some minutes to really disinfect their hands before they do an operation. Now, with this plasma, this can be done within a few seconds, and it is very small and very easy without any impact on the skin. So this is a very excellent example of how fundamental research can lead to concrete applications.

Let me give you a last example from the area of human physiology, where we did a lot of experiments and they are still on-going. For example, for the immune system of our human body, to understand the processes: how the immune system actually works, to fight all those diseases which are still around and that need to be fought.

Another area, osteoporosis, a very widespread disease, where the origin, the mechanisms are not yet very well understood. Coming into weightlessness gives a fantastic opportunity to understand the processes and the real cause of these kinds of diseases, to find countermeasures.

Now you might believe me that I can go on for quite some time in giving you these examples. I think this is already a good example of how we are using the ISS and how we are intending to continue to use it. In this context, I would like to stress the fact that in March, the ESA Council supported the continuation of the ISS until at least 2020.

I think this gives us an excellent basis for continuing our research in this wide range of scientific fields that I have mentioned. At the same time, I would like now to come to the area of exploration, which has been touched on today.

Very clearly, there are a lot of destinations that are reachable for human beings in the next couple of decades, and Joe has indicated that. There is the moon. There is Mars. There are the moons of Mars; there are Lagrange points. However, I think our next step is to boil down this wide variety of possible destinations, and it would be my personal wish that we make a choice in the not-too-distant future because, of course, we need to develop the technologies. It is very important to agree upon a destination.

I can personally tell you, if I look up into the evening sky, the next destination is very visible to me. It is our moon, and I really do not believe that going back to the moon is just a repetition. Maybe, if you just look at the event itself, it might be a repetition. But technology-wise, I do not believe it is really a repetition. Because even though we do not need to start from scratch to develop the technologies, today we would have made huge steps in that area more than 40 years after the first human beings went to the moon. So I think this is a very, very interesting destination.

It remains to be seen if this will be the choice of the international community. Scientifically, it is of high interest, just as Mars is of high interest. In this context, I have to say that for the European Space Agency, the combination of human and robotic exploration is not a contradiction; it goes together very well. It is complementary. There can be a lot of symmetries in both areas, and that is what we are going to pursue with two programmes. Actually, one of them is ExoMars, and the other programme, which is currently being studied, is the Lunar Lander programme, and I would be very happy if we could expand the international cooperation in this field as well.

Now, coming back to the International Space Station, which still is and will be the human outpost in space for the next decade and, I hope, beyond 2020, will be, apart from the scientific objectives that we have been talking about, without any doubt, the ISS will be a platform to further develop technologies that can be used for further exploration activities.

As my predecessors have already indicated, the European Space Agency will also use the ISS as a test bed for the development of further technologies, for example, in the area of regenerative life support systems, radiation, and so on.

We will do that, of course, in close coordination with our partners, because we would like to prevent any replication of activities. It should go together very well, and I believe that if we want to achieve these very interesting goals of continuing human exploration in this decade, it should start, and definitely in the next decade it should be a very well-coordinated endeavour amongst all the members.

Here are my last words about some more commercial initiatives in this respect. Now, I think there are four main reasons why space flight is so important and so interesting for a wide area of other industrial branches. First of all, the need for extremely lightweight construction. Secondly, the systems need to be built extremely reliably, because it is not easy to do maintenance on satellites. We can do maintenance on the International Space Station because we have humans up there. We have astronauts up there. We have a line of logistics. But still, these systems need to be extremely reliable, and reliability is a very important design factor for a lot of other systems here on Earth.

The third point is that we need to deal with very efficient systems, because it is not very easy to refuel satellites yet. It is possible to refuel the Space Station, but we have limited resources in orbit. So we need to build the systems that are extremely efficient, and efficiency is, of course, a very important topic now in other areas as well.

The last reason space flight in general is so interesting to other industries is just the environment where it takes place – very extreme conditions – and the fact of weightlessness. All these conditions have the high relevance for applications here on Earth.

That is why this kind of technology, why space flight has a wide range of applications here on Earth beyond the area of fascination. I am very happy that in the future we are looking into interesting destinations to work toward and that I have been able to be here with my colleagues. Thank you very much for your attention.

J. Pappalardo:
Thank you. It is always nice to hear an impassioned plea to go back to the moon. The goal is not just to go and put your feet on it, but to understand it as a celestial body. If you look at some of the studies that are just coming out now on what they are still learning from those missions in the 70s, you understand that we do not know that much about the moon. There is a lot to be learned. So I think that is a point well taken that I always appreciate hearing.

I am very honoured to introduce Cosmonaut Georgy Grechko, not just a one-time hero of the Soviet Union, but twice over, and he has a presentation. I would invite him to speak. Thank you.

G. Grechko:
Firstly, I would like to congratulate everyone on the 50th anniversary of human spaceflight. So much has been done in those 50 years. Almost 500 people have already worked in space, 12 of them on the Moon. Over 2,000 unmanned craft have been launched, and at different distances, from near-Earth to the edge of the Solar System. True, there is even more debris in space as a result, and that is a problem. Nonetheless, the human race can be proud of what has been done in space in those 50 years.

Although, in my opinion, we can only be especially proud of the first ten, fifteen twenty years, because at that time the USA and the USSR were rivals, and a great number of missions were launched as a result: Gagarin, Leonov's first spacewalk, the American Moon landing, and of course the incredible Hubble, the first docking craft, and the emergence of space stations. In this way, the rivalry led to much innovation—mostly new missions. After that, what happened in the remaining, let us say, 30 of those 50 years? Let us take a look at the two most dangerous, difficult, and yet shortest, stages of spaceflight: take-off and landing. At the moment, we basically travel in single-use rockets. As a consequence, a launch using a single-use rocket never meets the desired criteria: 2,000 kg, and a payload of USD 2,000 per kg. Because the first stage breaks away, the criteria are never met. The Americans attempted to reduce the cost of launching the shuttle to the desired level by reusing it, but the shuttle is a very expensive machine; it has very high running costs, and the goal of reducing launch costs at the pad was not achieved. When the single-use rockets were flying year after year, decade after decade, I remember Khrushchev saying that we were churning out rockets like sausages. I think that eating even your favourite German sausage for 30 years would give you indigestion. That is to say that we need to do something new.

Attempts to make the shuttle and Buran, have, unfortunately, not lowered the costs of space exploration. In my time, there have been examples of completely different launch pads in different countries. Perhaps we can recall that even in 1932 there was Zenger's project, the MAKS project in Russia, and HOTOL in Great Britain, in which the spaceship would set off from the side of a very large plane, and not from Earth. There was even an interesting project recently, Marengo, by which the spacecraft would launch from a ground effect vehicle. These are all very different types of flight, and they could bring us to the magic number of USD 2,000 per kg. However, until now, these projects have been left to history, and never implemented. It is clear that humanity has lost the motivation for making progress in space with more complex apparatus. So something strange occurs: during the Cold War and all that rivalry there were lots of new launches, but we, cosmonauts and engineers, dreamt then, not of competition, but of cooperation. Cooperation began, and a lot of money was allocated to space. We began to repeat things with small modernizations. This is what happened with take-off.

Now for landings. We launch capsules with parachutes, then winged landing equipment, then again return to wings and then from wings to capsules. We are simply going from A to B and back again. But there have been some very interesting projects. Here is why. Capsules travel well through the dense layers of the atmosphere, but they cannot land on a pre-prepared pad or at an aerodrome, whereas winged craft do not travel well through the dense layers of the atmosphere, and it is very hard to protect the wings. These spacecraft are very heavy and do not handle well. And yet a design has already been proposed that takes the positives of both capsules and winged craft and removes the negatives. In the 1930s, Stern had already proposed that the dense layers of the atmosphere were first passed without wings, and then the wings would come out: the so-called 'Lapotok' made by Tsybin or Syromiatnikov, in which the wings were folded up and shaded from the plasma flow. When the wings were uncovered, they were at the edge of the plasma flow. And there is an even greater delight to this type of flight: if, while passing through the dense layers of the atmosphere, the wings below are deployed at a certain speed, and the cruising engine is turned on, then you can complete the landing at the nearest aerodrome. Let us take a look, though, at how a cosmonaut is currently met after a mission. There are aircraft, helicopters, all-terrain vehicles, search groups, emergency services, communications, the command post... And, if you land at an airport, your wife can simply meet you with a bouquet of flowers and that is it. Much cheaper.

Now for the main question that has been posed: do we even need manned missions? Unmanned equipment is even cheaper, there is more of it, and it has far more functions. For instance, unmanned equipment provides us directly with connections and television broadcasts and is used for navigation, meteorology, prospecting for minerals, and even charting the migration of rare animals. Nevertheless, people often say to me, "Well, what's this space of yours for, who needs it? I live without space, and I am fine." That is why I would like to take advantage of the presence, here today, of the important people who take decisions about spaceflight and to make a proposition: we need to agree on one day on which we turn off everything that is working in space. Then people will understand why we need space. One person will not be able to listen to a concert; another will not be able to watch football. In a worst-case scenario, the craft would begin to collide, and then the public would no longer be asking why we need space, but would want all the space equipment to be turned back on quickly, and never turned off again. So what about manned craft? Of course, we cannot solve medical and biological problems without a human presence. Yet, after all, they only account for individual scientific experiments, and not direct systematic work.

At this point, liquid crystal is frequently mentioned. The OST gave us new data on the solar corona and the stellar photometer gave us the fine structure of the atmosphere. A pilot can take very good, targeted photos, and of course, undertake installation and maintenance work. In this way, a comparison of manned and unmanned equipment shows the greater efficiency of unmanned equipment for its comparatively low cost. So perhaps we could cancel expensive manned flights and economize on equipment with a small loss of scientific information? Just one Hubble has done more for science than all the orbital stations put together, has it not?

So we do not need manned spaceflight, since it is expensive and inefficient. But let us now recall that the multibillion-dollar Hubble was inoperable when launched into orbit. Billions were simply thrown out into space. It is unbelievable, but the Hubble's lenses did not take sharp images. What could be done? Take Hubble out of orbit, bring it back to Earth, redo it, relaunch it… Very expensive. Yet, the Hubble was very cleverly designed. It was designed so that astronauts could repair it. And this was done. The astronauts arrived, connected to the Hubble, spacewalked and were anchored. They put the Hubble's 'glasses' on and the telescope began to see clearly, and this was done several times. So a very expensive, unmanned piece of equipment has worked for over 15 years, thanks to manned spaceflight. In that time, it has made startling discoveries. Then they remembered that this type of work could be entrusted to robots. There was a case on the last flight the astronauts took to the Hubble. The craft had become obsolete and a shuttlecraft was supposed to reach orbit and the Hubble. It was a big gamble. A company decided to do the specialized work to fix the Hubble. But then, the company abandoned the specialized work, because a human being is better than even the most complex, multipurpose robot.

One more example. We had a solar telescope on the Fortune, and I was able to put it into operation with the help of some medical equipment. I listened to the telescope as it worked with a phonendoscope, found the cause, and got it up and running. I do not think that there is any robot that would come up with that method.

Let us now return to the main question: what is most important, most needed – manned or unmanned spaceflight? There can be no right answer to this question, because the question itself is not right, and either response would be incorrect. In fact, the question should be asked as follows: what is the optimal ratio of manned to unmanned flights? In the Hubble example, we saw that the unmanned equipment should nominally operate 24 hours a day without food or sleep and so on. However, once it came out of service, humans were needed to service it, to repair it, to reconstruct and update it. I think that that is the ratio of manned to unmanned flights needed in space.

Or some other means of maintenance. In his time, Feoktistov proposed that we create a cloud: one single, central station with all the automated equipment, like Hubble, around it. While the equipment is working, the cosmonauts carry out medical research, and when something breaks, the equipment notifies them and it is undocked, corrected, adjusted, and then put back to work again. Still, experience has shown that complex equipment can be initially perfected on a manned flight, and then should be sent unmanned, which is far more efficient.

In this way, I believe that on board the orbital stations we do not need to be doing experiments every minute, every day, every hour with breaks for eating and sleeping. We need to ensure that the automated systems are working. That is to say, that we do not need people on the ISS to work with scientific equipment, but to adjust and ensure automated system operations.

And finally, travel to Mars. First, it is interesting that experience shows that preparing astronauts on Earth, in training centres, for manned orbital flights is perfectly adequate. Good flights, good results. But preparing for a flight to Mars on Earth alone would, I think, be a mistake. This is much more difficult work, because an orbital station would perhaps have to be transformed into an offshoot of the training centre. This is to say that those who will go further into space should be trained onboard a space station. Before travelling to Mars, they should go to asteroids, because there are asteroids that we could reach in six months, rather than the 18-24 months it would take to get to Mars. And whoever travels to the asteroid best can be sent to Mars. So why go to Mars at all? What will we gain from a flight to Mars? Almost nothing. Astronaut Buzz Aldrin says that we should travel to Mars one-way and colonize it, like the Europeans colonized America. They did not sail from Europe to America and then back to Europe; they colonized it straight away. But still, what do we want with Mars? We, the Russians, are satisfied that we have the first satellite and the first person in space; the Americans are satisfied with their wonderful flight to the Moon. Why are these stargazers dreaming of Mars when, in practical terms, the money could be far better spent on Earth than on Mars?

I want to end with the fact that if we had listened to the pragmatists instead of the dreamers, we would never have gone into space; it is a very expensive and foolhardy undertaking. But then, no one would ever have flown from continent to continent, because planes fall out of the sky. And people would not have sailed the oceans because boats sink. Or swum across a river because there is a crocodile. We would never have come out of our caves, because there was a sabre-toothed tiger. That is to say, that if we had always been pragmatic and never followed the dreamers, then we would still be living in caves. I would say that even if travelling to Mars is banned, humans will travel to Mars anyway. And the last thing I will say is that if Korolev were alive, we would already have been to Mars a long time ago. Thank you.

J. Pappalardo:

You know you have an interesting panel when it includes a call to extort the world into more space funding by shutting off satellites and all space systems. So thank you for your comments.

One of the exciting things about recent space flight history is the inclusion of more countries and the increasing number of those countries. So we are very happy to have Akira Kosaka who is the Deputy Manager of the Japan Aerospace Exploration Agency. He will be our last speaker today.

A. Kosaka:

Thank you very much. I am Akira Kosaka. I am the Director of JAXA, Moscow Office. We, JAXA, opened our representative office in Russia this April, so it is my great pleasure and great honour to be here and to attend this panel with the top management of the Russian organizations and representatives from the United States and Europe, and also with human heroes from space.

OK. I would like to move on to human space activities in Japan. So Japan has been conducting its human space activities mainly through the International Space Station programme. Japan's contribution to the International Space Station is mainly three things.

The first one is a large, high-quality laboratory named Kibo. The second thing is the cargo transportation service by our HTV. We transport many things to the Space Station on a once-per-year basis. The third one is our Japanese astronauts and cosmonauts.

Japanese astronauts work very seriously like Japanese *sarariman*, so we believe that their contribution to the Space Station is tremendous. So far, we have four Japanese astronauts who fly Space Station assembly missions and three astronauts who stay for a long time as part of expedition crews.

We, Japan, have been able to participate in the Space Station programme mainly due to two things. The first thing is, of course, that Japan has obtained the technologies and system engineering capabilities which are necessary for running large-scale human space systems.

The second one is more important, I believe, and that is the international human network.

Through the interchange with engineers of the space-leading countries, including the United States and Russia, a large number of Japanese engineers have been rising to the level at which they can be involved in the planning of future space activities. That is a benefit Japan has gained through joining the International Space Station programme.

For the world, for humanity, the International Space Station is also very significant. This project is incomparable in scale: a science and technology project exclusively for a peaceful purpose. This is without precedence in history.

So far, we have faced many challenges, many difficulties: technical difficulties and also financial difficulties, including the Space Shuttle accident and some Russian financial difficulties. Every time, our international partners have worked very hard and cooperatively to find us a way to overcome the challenges.

Now, we are very proud to be on the Space Station in orbit.

So for the future, we believe that our achievement and experience of continuous joint activities in the Space Station programme for more than 25 years will become the basis for human space missions beyond the Space Station programme.

Also, we believe that it is very important to share the common vision that future human space planetary exploration can be foreseen as an extension of participation in the ISS programme.

This vision to continue our activity beyond the Space Station would encourage our generation and also the next, younger, generations.

There is no doubt that human space activities cost an enormous amount of money. Therefore, it is not realistic or affordable for Japan to do everything by ourselves. For us, the realistic path is international cooperation.

So far, right now, any international consensus about the goal and about the destination of future human space exploration has not been established. But a respectable destination, a human space transportation system, will be the fundamental system for future space activities.

Japan does not have this system now. But Japan will start basic research and development of key elemental technologies so that we can have a starting prospect of the realization of such a system by 2020.

As one of the efforts, we, JAXA, are considering using our HTV vehicle to demonstrate the entry technology to upgrade the HTV with return capabilities. We expect we would obtain the technologies necessary for future human space systems while contributing to the demand for return capabilities from ISS after the retirement of the space shuttle.

Lastly, JAXA will do our best to contribute to the Space Station programme also for future human space missions so that we can enjoy the present as a reliable and attractive partner. Thank you very much.

J. Pappalardo:

In a time when everyone is worried about the economy, budget, doing things in an effective and as-cheap-as-possible way, highlighting some of the win-wins of international cooperation is probably more relevant now than it ever has been.

One of the things we are doing here today is we are having an interactive poll of the audience. So everyone make sure you turn your little green button on so you can participate and your vote will be registered.

It is interesting that, sitting here today and thinking about the history of space flight since Yuri Gagarin, the Space Age really began in a time when international competition and national prestige was a huge motivator.

So the first question would be, and you choose one, two, or three as your answer, exploration of outer space, primarily, is motivated by: 1) national prestige, 2) economic benefit, or 3) the expansion of knowledge in science.

So the "pure science" is up. The "prestige" is still up there. Pretty high. I do not know how long it takes to register everybody.

Well, "pure science" is pulling ahead. Interesting. I think, on the panel today, a lot of the open questions about space and the far-ranging answers show that we can get all manner of information, and not just from space exploration, but how it would benefit us down here on planet Earth, maybe had something to do with that one. OK.

We have three questions. The second one is about the exploration of planets and what will enable the exploration of the solar system most effectively: the efforts of one country, a small coalition of two or three countries, or a large global international cooperation regime?

I guess at an international economic forum, it is polite, if nothing else, to pick number 3, but I think the more people involved, probably the bigger the benefits get. Excellent.

And the third question would be: where do we want to go? Which non-terrestrial object should be the major interest for exploration for a manned expedition? Would it be the moon, Mars, asteroids, or remote solar system planets? How ambitious are we feeling?

It is like watching election results in the United States.

Maybe my vote for the moon will push it over one way or the other. There you go. I tied it! Oh. Anyhow. So the closer is obviously better.

So one thing that I wanted to ask the panel myself that we have not touched on very much is—there's a very heavy government presence here on the stage, but there is a lot of private sector involved in space, and it is growing—and I wanted to open this up to the panel and ask: what is the appropriate role of the private sector, and how can the involvement of more companies help international cooperation? And it sort of speaks to that first question of involvement. How can we leverage the private sector into greater involvement on international cooperation in space exploration and missions?

I would invite anyone to jump in first or I can just pick one of you, which I will do if no one volunteers shortly. Mr Popovkin, how can private sector cooperation be used to foster international collaboration in space issues?

V. Popovkin:

Well, that is a very interesting and complex question. It is clear that today we use the results of our activities in space in communications and for taking pictures of the Earth, which require some 90% of the resources spent on space if you take the market as a whole. Of course, without the private sector or public-private partnerships, that would not be so. There are a number of examples.

Around the world, including in Russia, more private organizations are being brought in that are doing just that.

As for fundamental scientific research, without state support it would not be possible, because it is by definition unprofitable. In a generation or so, when it has become more profitable and commercial interests have emerged, then the private sector will come in. But to begin with, it is not possible without investment.

The same goes for manned programmes. Yes, at one point, Russia, like a few other countries, was carting tourists up into orbit, and in hard times, when there was a lack of resources, that helped to preserve and develop the industry, including the manned flight sector. Now, however, we need to attract private industry. America, as far as I am aware, is going down that road. In Russia, as I see it, we also understand this.

I would like to focus again on one factor: international cooperation. We should remember that our Forum, taking place here in St. Petersburg, is an economic forum. Russia has, it seems, a large space sector. It conducts 40% of all launches and the preparation of, say, 20% of all space equipment in the world, including manned flight. Unfortunately, it turns out that, despite all this, Russia's current share in the space market (which, as we can see, over a year turns over around USD 600 billion), is somehow unjustly low: no more than 3%. As the first nation in space, this is, naturally, not satisfactory. Today, the conditions to get others to move aside a little have been created, firstly in the field of telecommunications, and secondly, in direct television broadcasts and mobile internet. Today, we have everything required for the industry in those areas. And the first steps have already been taken. We will make comparable units for telecommunications: a satellite information system in Krasnoyarsk. We have made great advances in Earth remote sensing. This year, we will most likely roll out and approve the GLONASS system once it is fully complete. Once it has been approved, it will be available for use by the global community. We are also prepared to cooperate with all countries, but in equal partnerships, based on the understanding that a contribution from a given country, and intellectual potential and production capacity, are all properly recognized.

So the intellectual and industrial potential of the space industry is one of the few of those that are competitive in our country. I think there are few for whom it would bring on negative emotions. Our task, I repeat, is to take our rightful place on the international commercial space market. In our opinion, the Russian market is around 10-12% by volume, which is perfectly adequate for development and quite respectable. Thank you.

J. Pappalardo:

Thank you very much. Mr Reiter has it so, you are off the hook.

Speaker 1:

Thank you very much.

J. Pappalardo:

Off you go. Thank you very much for participating.

Speaker 2:

It's not only rockets that launch second…

V. Lopota:

You asked about the private sector. The private sector will be wherever there is profit to be made. It all depends on the capital structure of the market that is there. Today, the development of capital in America and Europe, for example, enables segmentation. The private sector makes up two thirds of the market, while the state sector comprises one third. In Russia, it is currently the other way round. The private sector comprises one third, while the state sector makes up two thirds. This is the structure of private capital in Russia, which is different than in America and Europe. Therefore, if there will be profit, a segment that generates profit, there will be private capital in any area, from manned flight to near or deep space.

V. Popovkin:

Allow me here, as always, to respond to Mr Lopota. Any business—private or state—cannot be unprofitable. Naturally, in the charter of any corporation that is not an open state unitary enterprise, the most important thing is to turn a profit. The point of the private sector in space, as I understand it, is private investment in space activities. It is no secret that if we take any industry today, including the American space industry, over two thirds of the investment in both manned and automated programmes comes from the state, while only one third comes from the private sector, private investment. We must not confuse the issue here. Another issue is what we need to do to make our industry more attractive in terms of organizing industry production and construction. We are already restructuring, consolidating, streamlining, and optimizing within these groups, and we are relinquishing non-core assets and parts of large groups. Our end goal is to hold an IPO to raise funds for development. But I will say it once more: we must not confuse company structures, state or private, with the structure for investing in space industry companies. Unfortunately, today, as I have already said, two thirds of investment in any country is state investment, while one third is private investment, which is, naturally, focused on the most profitable areas. Once again, this is telecommunications, using the results of space endeavours for photos, navigational devices, and navigational charts of the Earth. And today that is in the private sector. We must not confuse one thing with another.

J. Pappalardo:

I could stay here for hours and certainly ask you, but I think they are going to kick us off the stage. I do not think I'll have an opportunity to sit with such august company anytime soon, so I just want to thank each and every one of you for appearing at the Forum and sharing your thoughts. Thank you all very much. It was a great pleasure and honour to be here with you.