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LESSONS OF LIFE FROM OUTER SPACE

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Moderator:

Sergei Nedoroslev, Chairman of the Board of Directors, Kaskol JSC

Panelists:

Georgy Grechko, Astronaut-pilot, twice Hero of the Soviet Union

Sergei Krikalev, Astronaut-pilot, Hero of the Soviet Union and Hero of Russia, world record-holder for time spent in space

S. Nedoroslev:

Good afternoon. We are glad to welcome you all here.

Many people are still on their way, it seems it is not so easy to find this entrance to the StarBar. But I think we will start anyway. Since this will be a conversation, the dialogue will be truly two-way, in addition to our guests' remarks.

S. Krikalev:

So be ready for questions too.

S. Nedoroslev:

Our guests today are people who are changing the world. They have no need of introduction, at least in front of this audience. Or worldwide, for that matter. These are our amazing cosmonauts, true heroes many times over. Georgy Grechko, we will start with you. He needs no introduction. We were just talking about how this began in 1975, with reference to your first spaceflight. Even I remember this event; I was still in school at the time. The name 'Grechko' for us was something unusual and related to our future, to what was most important. I do not know if we have any other such symbols of hope today which unite large numbers of young people. But our generation was lucky. We had you. Time marched on and new names appeared. And as adults, we all saw your courage, Sergei. Courage which continues to this day. Sergei Krikalev, too, needs no introduction. These are record-setters who are known the world over. But even that is not the most important part. These are people who have truly changed the world.

Let us start today's discussion. Mr. Grechko, we turn to you. We know how you are changing the world. But how has the world changed you? How have your space travels changed you? How did you prepare for that? And what changed after your first time in space?

G. Grechko:

In our days, space was only a dream. Even that great dreamer Tsiolkovsky said that man will only ascend into space in a hundred years' time. He said that in 1935. So if that were true, then even now, we still would not have made it into space. Filled with science fiction, I decided that instead of becoming an astronaut – living a hundred years seemed unlikely and a centenarian flying into space seemed implausible – I would set my sights on something more modest. I set out to become a rocket-builder, take part in the creation of a rocket, and have my son or grandson take one of them into space. But the genius Korolev outpaced Tsiolkovsky's predictions, which came to pass much earlier than scheduled. So I had the truly good fortune of working on the R-7 rocket and working on the testing when the rocket did not want to fly. And now it is the best rocket in the world, in terms of reliability. Suddenly it happened that three times in a row, as they say; it took off into space.

A bad speech should be short and a good one should be even shorter, so I will finish. It is wonderful to be a dreamer. We do not have them anymore. It is wonderful to be a romantic. This is the age of pragmatism, though. It is a pity.

S. Nedoroslev:

Thank you, Mr. Grechko.

Mr. Krikalev, what was happening in your life in 1975, when Mr Grechko here went into space for the first time?

S. Krikalev:

I was graduating from school, my final year. Mr. Grechko said that science fiction spurred him to decide on his direction in life. It helped to encourage me too, I think. But while he may have been pessimistic, expecting man to make it into space in a hundred years, I knew for certain that people would be travelling in space. I was born after the first satellite was launched. So I had no doubt that people would be flying into space, and would keep flying into space and that the earth was round. I knew from the very start that this is an engaging field of work, one that is very interesting to be in. Sometimes people say, you know, that they wanted to become

a cosmonaut at three or five years old. That was not the case with me. I have some sort of memory like that, but I did not have a clear enough idea of what it was exactly.

G. Grechko:

I asked a six-year-old: what will you be when you grow up? Absolutely clearly and without a second thought, he said he wants to be a banker.

S. Krikalev:

I think that shows a change in priorities. Back to 1975, when Mr. Grechko went into space, I was saying that that was the year I graduated from school, I had pretty good marks and enjoyed sport. So I resolved to do something interesting with myself, something to be proud of. I already realized that the likelihood of becoming a cosmonaut was pretty slim. In that period of 1961 through 1975, fewer than 50 people went to space. The likelihood that I of all people, from among our country's many millions, would join those small ranks was minuscule. But honestly, I was an optimist. I figured like this, as I recall: right now, dozens are going into space. In 10 or 15 years, maybe, it will be hundreds. After the year 2000 there will be thousands. And being one out of thousands means there is a chance. So I decided to work in that direction and to try to become a cosmonaut. You cannot commit yourself to the extent that if you do not reach your goal, then your whole life is ruined. Still I decided to go into something interesting. Rocket-building, space science, aviation, this seemed a worthy area to me, one deserving of my efforts. That said, the secrecy around space science and rocket-building meant a lack of information about the what, where, and how of it all. I read the guides to post-secondary institutions from cover to cover and I did not find anything in Leningrad. When I found the extended-length guides and looked at cosmonauts' biographies, I saw that some of the cosmonauts had graduated from the Moscow Aviation Institute, at Bauman Moscow State Technical University. So by the middle or end of tenth (final) grade, I had the idea to go to Moscow and apply to those places. But here I was, reading in

the newspapers about the spaceflight of Sergei Grechko. They included his biography too, as usual, and there I saw that he had graduated from the Leningrad Mechanical Institute. As they explained, the reason the institute was called just 'mechanical' in our days was to defuse the international tension. So the specialization 'Rocket-building' was named in a roundabout way too: 'Aircraft design and manufacture'. When I began to really read Sergei Grechko's biography between the lines, I realized that these were the same specializations taught at Bauman and at the Moscow Aviation Institute, And that there was no need to go far away for a good education. Until recently, Georgy and I were the only two from St. Petersburg who had gone to space, and both of us from Voyenmekh Technical University. A third Petersburg cosmonaut went into space not long ago: Andrei Borisenko. He also went to Voyenmekh. So our group of cosmonauts has a rather Voyenmekh bent to it.

S. Nedoroslev:

You see how there is a real link between generations. Not metaphorically, but directly: repeating the same path.

G. Grechko:

Since we can all ask questions here, I have one for Sergei. My generation went into spaceflight one way, and yours in another. You are helping now to select cosmonauts, so my question is: how is today's generation going into spaceflight?

S. Krikalev:

We are having a new selection round for cosmonauts. Looking at history again, I can more or less imagine what it was like during the first and second rounds, in the 1960s and 70s. I myself went through it in the 80s. We were talking with the doctors at one point and they said that based on medical criteria alone, they would weed out everybody except for one, out of hundreds. Then they examined us, and out of seven, they chose only two. Then the two of us were put together with another two,

and we all started space training together. And out of our group, which was trained to fly to space, only two actually did so. The end result of these many selection steps was that maybe one out of thousands made it.

By the time I was graduating at the institute, I knew that the people making it into manned flight were from the Korolev Design Bureau, which made the first rockets, the first satellites, the first manned spacecraft, and the people joining the ranks of the cosmonauts were those with experience in the space industry and in manned flights.

And it was literally this year they decided to start another selection round. The previous one had been semi-closed. As a military organization, the cosmonaut training centre drew on pilots from the Defence Ministry. The civilian industry drew on people working at the design bureau. This time, however, they decided to loosen this a bit. At first we wanted them to include space industry workers who may not work at the design bureau: the makers of spacesuits, rockets, communications satellites, etc., so they too could have the chance to join. But the Federal Space Agency decided to make it an open competition. There were strict requirements, of course: a higher education degree and certain work experience, say. We did not want students who were unclear on what they wanted; we wanted people who had the proven ability to work systematically in their chosen field.

The initial results of the latest recruitment round show that we were conducting a big social experiment as well. Based on the results, we can say that society and its priorities have changed. Unfortunately, the number of people wanting to work in this field and give their efforts, time, and health to it are becoming fewer and fewer. In one and a half months, the open competition drew applications from only 300-odd people. True, some of them were 'recycled': they had already passed the medical component so it was a bit easier for them to make it through the further whittling-down.

Still, why did we decide to throw the doors wide open to everyone? Our thinking was: with sub-standard pay for years in the space industry, many talented people were forced to go work at banks or as mathematicians at private companies. Maybe

now they could use their mathematical knowledge for the benefit of space science. We expected to have many people not quite aware of what they were getting into, and we had plenty of them too. One of them was asked, “Why do you want to be a cosmonaut?” His answer? “I live right by here and I have no work right now.” A mother of several children applied to be a cosmonaut because she was tired of sitting around with her children. These arguments did not seem so compelling. At one interview, we already mentioned one man who submitted all of the necessary documents to us, except for a certificate of health from a mental health centre. When they refused him for having an incomplete application, he went to the Federal Space Agency to find out how he could join without having that certificate from a mental health centre. Needless to say, that spooked the examining commission a bit.

So there are fewer and fewer people wanting to become cosmonauts. It is a problem for us. Now we are trying to spend more time and effort on what they used to call 'career guidance', trying to explain to people what it is that we do, because there are good people out there. I cannot agree with Mr. Grechko when he says that there used to be dreamers and now they do not exist. They exist. Maybe there are not as many. Maybe they work in some other sectors. Do we believe that this sector, of developing industry and spaceflight, is important for our country? Then we must bring our kids, our dreamers, into it so that they can help to carry it on after us.

S. Nedoroslev:

Thank you.

G. Grechko:

A quick response: from the design bureau alone, we had 200 applications from would-be cosmonauts.

S. Nedoroslev:

Which year was that?

G. Grechko:

In 1962.

S. Krikalev:

There were about 20,000 employees then, yes?

G. Grechko:

Right. There were 200 applicants from a single facility. Now there are only 300 from the whole of Russia. And that includes those who want to go to space to escape their kids or want to sneak in without a mental bill of health.

S. Nedoroslev:

In that case I have a question both for you, Mr. Grechko, and for you, Mr. Krikalev.

Many people today are saying that distant space has long been the realm of unmanned craft. Right now we cannot contemplate manned flights to distant space, unfortunately. Near space has been quite crowded for years, even decades. What is the outlook, in your view? We have fewer people wanting to be cosmonauts, but Russia was also the first country to put a tourist in space. So the Federal Space Agency has played a big role in the trend of space tourism. It was no easy feat, I think.

We have two lines converging, as it were: fewer people who want to be professional cosmonauts, but a jump in the number of people who are also signing up on websites – not always to run away from the kids, but to offer their due part of heroism and to go into space. There a great many of them.

When do you think unpiloted passenger flights will be possible, if they are possible at all?

G. Grechko:

Passenger flights are not unpiloted, by their very nature.

S. Nedoroslev:

There is a lot of talk about unpiloted passenger aviation.

S. Krikalev:

It still does not exist.

S. Nedoroslev:

It still does not exist. This is more of a psychological thing. So I would like to hear your opinion: how feasible is it? Mr. Grechko, just how involved was the cosmonaut in controlling the spacecraft when you flew? And what had changed, Mr. Krikalev, when you flew?

S. Krikalev:

A lot of questions at once; I'll answer them in turn.

S. Nedoroslev:

First I want to start about the pools of potential candidates. We have fewer and fewer professional pilots.

S. Krikalev:

I would like to pay our due to the banner line of today's discussion, 'Conversations to Make a Difference'. Of course, we need conversations so that a difference can be made in the world. But as I see it, that difference comes from deeds, not words. Deeds must certainly be preceded by discussions and opinions, perhaps ones formed collectively. Rather often though the deed becomes lost under a torrent of words. That might be what differentiates our generation from that of the 60s and 70s. We say the world is becoming more virtual. Instead of learning to fly on a real plane, young people can play on a computer. Virtual things begin to stand in for real

ones. That is why I think that the development of many areas, including manned spaceflight, is lagging behind.

You can look for explanations in the processes of perestroika and restructuring that created upheaval for so many years. But if we look at America circa the early 60s and 70s, growth there also was much faster than today. Coming back to these conversations, to make a difference I think that if words are capped off by deeds, then there is no difference between them. That is what we need to pay attention to. This is building on the topic that we had just touched on.

S. Nedoroslev:

Mr. Grechko, your thoughts?

G. Grechko:

When I stopped dreaming about rocket-building and started dreaming about travelling to space, of course I wanted to go to Mars. I wanted to start a revolution like in the novel *Aelita*, meet Aelita herself, and all that. And the orbital flights in 1975 were naturally of great interest. But this is now more the domain of machines. If I were younger now, I would still go to Mars, like I wanted to from the very beginning. There is no gold there, no platinum, maybe even no other minerals. But man must grow. Man must expand his horizons. In order to remain man, man must keep going.

At one point the Americans had a programme for separating the shuttle into modules and using the main module to put together spaceships to go to Mars. It was a brilliant idea, more than half of it had already been worked out! Dozens of times over. So the project would be much cheaper. I was so happy to hear about this programme. I was mad that it was American and not Russian. Then the next president cancelled the programme and went full-bore for technology-heavy methods of exploration. I am very disappointed.

We are becoming a consumer society through and through. We are losing our intellect along with everything else. I am a little afraid to make the comparison, but

when we keep consuming and consuming and consuming, you know, we start to look like a little piggy. The piggy is there consuming and consuming, and at some point it wants to look at the stars. But it cannot lift its head up anymore. Its neck cannot support looking at the stars. I think our civilization needs to look up from the trough. Or else we will keep looking down at it and we will never be able to see the stars.

S. Krikalev:

It is funny you should say that. The moment before we came in here for the discussion, we talked with people who are holding astronomy olympiads in St. Petersburg. There are still people who want to look at the stars and pass this knowledge on to the next generation. But in our time, we also had astronomy lessons and the opportunity to learn how the world is made and to learn by looking at the stars. Alas, these lessons are no longer part of the usual school curriculum. We cannot say that people have turned bad, however. There are people who want to look starward. There are people helping to do this. Our task is to help the people who want to go forward and visit these distant worlds.

S. Nedoroslev:

Thank you.

Many people today want to visit space. They are called private researchers or tourists. Some have already gone, thanks to our rocket, our R-7 so renowned for its reliability. There are several major projects for this kind of tourism worldwide. Mr. Krikalev, you spent a long time in space over the course of many flights. You are part of the cosmonaut elite. What problems can tourists encounter physically or psychologically when preparing to stay in a confined space?

S. Krikalev:

Who are the people with the problems, those wanting to be passengers or those wanting to fly the thing?

S. Nedoroslev:

The passengers.

S. Krikalev:

A brief historical digression. I am not sure how much our audience here knows about goings-on, in part concerning the so-called 'tourist flights'. The first tourist was Dennis Tito, an American who had made a fortune and agreed to pay a pretty penny – USD 20 or 30 million – to spend a week in space. It would be inaccurate to call him the first 'non-professional' in space. He was the first tourist for money, but there were other non-professionals before him.

Remember the tragic loss of the *Challenger* during lift off? The Americans had declared that near-earth flights were old hat, that the method had become normal and reliable, and that now we could start launching non-professionals. Among the crew was teacher Christa McAuliffe. Her job was to popularize space science by conducting lessons in space. She died on that shuttle. There was a lot of discussion, and NASA acknowledged that space, as before, was a rather dangerous and tricky place. It is one thing for a test pilot to die, when he understands the risks and knows what he is doing. It is another thing when a passenger comes on to a spaceship for quite different reasons and dies. For the latter, it is mere transportation, from point A to point B.

So non-professionals have been in space previously. We had many discussions, we had international cooperation: researcher cosmonauts, as we called them, or non-professional cosmonauts, flew into space and performed scientific experiments. The Americans had a similar system. The shuttles had professional astronauts, pilots, mission specialists, and also payload specialists, who were non-professionals performing certain specific tasks.

As for paid flights, I do not think Tito was the first either. I took part in the Soviet-Japanese programme, when a Japanese company paid for its journalist to go up in space. Journalists, incidentally, happen to forget about this a lot and keep offering to

launch their 'first journalist'. It is a common thing: something old and forgotten becomes new again, and we decide to do it 'for the first time'.

I have some interesting statistics for you. Tito flew to the International Space Station. On the eleventh voyage I flew with Gregory Olsen, he was the tenth tourist I think. None of the paying tourists have been Russians, unfortunately. But we have more Mercedes cars in Moscow than in the whole of Germany, according to statistics. It is not that Russia does not have people who could pay. It is a matter of mindset. The rich people who can pay a handsome sum to live out a childhood dream are found in America, for some reason. We in Russia do not have any. I think sociologists could look into the why of that. Either something is wrong with business here, or there is something different in the heads of our high earners.

But I would like to get back to the other questions you posed. You raised the topic of manned and unmanned flights.

The first satellite was unmanned. Then people began to go to space too. And just like with manned aviation, the process of manned spaceflight was honed over time, becoming more complicated and forging ahead. These questions appeared for aviation much later, of transporting passengers like cargo, without a pilot.

S. Nedoroslev:

As we know, any plane today can take off and land automatically at a properly equipped airport.

S. Krikalev:

Not always, and not in all conditions. That is why we do not have a completely automated system. Although the automation is getting close. Here we are touching on an old topic, one discussed even by the professionals at the Korolev Design Bureau where Georgy and I worked. These conversations and this divergence of opinions have been going on for a while. There are the 'automatics' and the 'manuallers'. Some people are responsible for the manual modes on manned craft, others are responsible for automatic modes. This back-and-forth, this tug-of-war, is

old news. The public has long been discussing the degree to which we need manned flights or automatic ones. These arguments are pointless though. 'Either/or' questions are the wrong way of looking at things. If we want to go and forge ahead, we need both. I would like to mention aviation, by way of comparison. What if the Wright brothers, back when planes were made of gears, bailing wire, and old wash rags, had said: OK, let us first make an automatic machine that can take off and land, and then we can start taking to the skies. Then we would all still be planted on the ground. Fortunately, they did something else. Manned flights were performed from the very start, when things were not so reliable, and when people really were risking life and limb. The first pilots were considered something special. People knew the names of these pilots, Nesterov and the others; they knew the Frenchmen who took part in the first distance flights and the Americans who traversed oceans. Aviation grew through manned flights, which helped it to advance quickly.

A tendency to automate is good, if we keep it in perspective. We need to have a reasonable balance. Attempting to automate everything will probably just halt technical progress. Incidentally, we can already see that progress is slower than we would like. And one reason is the attempt for total automation. I can give one example which my colleague here surely remembers. There was a docking system, the *Igla*. A radio system transmitted information to the navigation system in order to perform automatic docking. Then we developed the *Kurs*, a new system that was more complicated and more modern. It allowed for approaching a station even if it was not giving approach directions. This system was installed on manned spacecraft. There were a lot of problems. When the automation broke down, the people performed these tasks themselves and communicated what went wrong and how. When I was flying, this new system was on the manned spaceships. The automated cargo pods – the 615, if you remember – kept using the *Igla*. The *Mir* space station had two systems for docking. When they had worked the kinks out of the *Kurs* system, it was installed on the automated ships too.

That is when we started saying, “No, how about we try this out on the unpiloted craft first?” You may have heard about how they are making control on the *Soyuz* more

automated and computerized. 'Digital ships' too: cargo ones, initially, supposedly to check for crew safety. And then for manned craft too. That is one potential path. But we can see that it is progressing more slowly than we would like.

I think that a reasonable combination of manned and unmanned flight will allow us to progress further and with good speed, instead of getting caught with minor problems in the automation system.

S. Nedoroslev:

Thanks. Since this is a discussion, Mr. Grechko, you would like...

G. Grechko:

I would like to say we can divide people flying into space into those performing governmental/scientific/commercial tasks and those flying into space for pleasure. Professionals versus tourists, basically. I do not think it right to transport tourists like we are. Tsiolkovsky once said that manned flight would give us endless power and mountains of bread. After tourists, we will have only heaps of rubbish. They get in the way of the main tasks. So what is the right way? Private ships are being designed in order to take people into space not for USD 20 million, but USD 200,000. Never the twain shall meet, I say. As professionals, we are to perform the serious tasks placed upon us. Tourists can go on tourist ships and stay in tourist hotels. Both the ships and hotels are being planned: there are five companies in the world working on this. Virgin, for example, wants to take people on suborbital flights, where the plane goes fast to a height of over 100 kilometres. The atmosphere extends up to 100 kilometres, and anything over that is spaceflight. So tourists can savour their visit to space. The ship does not have any power, however. It cannot stay in orbit and return to its original launch site. And since this is all over a desert, I would not pay USD 200,000 for that kind of flight. Taking off over a desert, turning around, and returning to that same desert does not sound very interesting. When tourist ships really start taking tourists to space hotels and tourists can enjoy the

window view, now that will be something. I am a professional, but work aside, I could not be pried from that window.

Incidentally, Sergei Krikalev here, who has had more flights, has taken some incredible photos. When you look at them, anyone can imagine being in space and gazing at the earth. It is so beautiful, mesmerizing, educational, thought-provoking, it makes you want to cheer and laugh. It is something incredible. That applies to both professional and tourist. This suborbital business, of taking off and landing right after, for me is like kissing a lioness – a lot of fear and no pleasure.

S. Nedoroslev:

Thank you, Mr. Grechko. I think the difference is something like that between a military plane and the planes that take 500 passengers at a time to Ibiza. But do you think that physically and psychologically it is possible for the average tourist to go to space? Can this catch on in a big way if the technology gets there?

G. Grechko:

The technology will of course get there, and it could be on a mass scale if...

S. Nedoroslev:

If 50 people all fly up together and say: “It is so crowded and uncomfortable, all these G-forces, next time we should probably all go to St. Petersburg to check out the museums.” The romance fades away.

S. Krikalev:

I absolutely concur with Georgy. The G-forces on spaceships are greater than what people are used to in everyday life, but I think they are no barrier for any average healthy person. There is no need now for super-strict health requirements on passengers. I was saying that for the professional teams, they would pick only one out of hundreds. Tourists are a different story entirely. We do not have so many millionaires or multimillionaires who can simply splash out tens of millions on a

whim, so the health requirements for them are less strict. Why? Simple. First, as far as the normal mode, yes we have G-forces during take-off and landing, ones much stronger than those on the shuttle, but even these are quite bearable. Anyone without any obvious disqualifiers like heart disease or impaired organ function will do just fine with the G-forces, in normal mode. But flights are still a bit complicated, including as regards testing equipment and the likelihood of failure under high G-forces. They increase when we go from one mode to another, when we go from navigated entry to ballistic entry in emergencies. Remember when Lazarev and Makarov had a very steep return to earth after they aborted during take-off. Nobody on earth had ever experienced such G-forces!

G. Grechko:

Up to 23 g...

S. Krikalev:

Yes, about 20 g! The machines could not even record it; the system said it was only some 19 g. They had to mathematically calculate the actual load, which reached potentially lethal levels. They looked at the telemetry later. At peak exposure, both of their hearts stopped for several seconds. Only thanks to the cosmonauts' robust health did their hearts restart. They returned and reported on the results of the testing.

Another analogy with aviation comes to mind. The requirements for passengers who wish to fly are not strict. The pilot controlling the plane experiences the same G-forces as the passengers. So you would think, why would you impose special requirements on the pilots during normal operation mode? But there are special requirements, and for good reason. If the plane is suddenly depressurized and they need to do some tricky manoeuvres, then a passenger losing physical control or even consciousness will not be a disaster. If the pilot loses consciousness, however, the consequences will be catastrophic for the whole plane.

The same goes for passengers in space: the requirements are lower because even if they do not know what is happening during an emergency, nobody is the worse for this. Professionals though must be able to function no matter the atmosphere on board or the pressure. Nobody cares whether he gets a headache or not. He has to perform his task. So the requirements have been, and will be, different. To the question, “Can the average person in good health withstand the conditions of spaceflight?” my answer is “Yes”. The tourist flights have proven that already.

G. Grechko:

I think that the requirements for tourists are quite simple: a healthy heart, so the tourist does not die; good balance, so they do not get nauseous (I know cases when people in space vomited for three days straight); and the small matter of USD 200,000.

S. Krikalev:

I think the list is a bit longer, but I agree with Mr. Grechko. We already have the methods, and the requirements for non-professional space travellers are laid out; they are pretty tried and tested.

G. Grechko:

And one of the requirements is, do not touch anything!

S. Nedoroslev:

Thank you. I wanted to ask a question on the mind of everybody in the room. Mr. Grechko here said right out that he would like to go to Mars. What do you think: what is humanity's next destination?

S. Krikalev:

It is a law of nature: all that lives, expands. Fish swim away from the shore and birds fly beyond their native glade. And since we lived in caves, people have been

expanding their sphere of inhabitation. No matter the dangers, they opened up the world around them, crossed rivers and then seas and oceans. Now we are starting to go beyond the earth's limits. We often get questions: “But why?”, “Can you justify it?”, and “Why not here?” Because that is our way, the law of our development. I would rather take this law of human expansion as a given in all such discussions, so instead of discussing it we could think of how to make this expansion happen.

There are different steps to this end. At the experimental stage, we should master near-earth space more thoroughly, so we can use it as a launchpad for distant flights. We must, must keep moving forward. Mr. Grechko talked of Mars. Mars is one destination. The moon could be an intermediate destination. There are other very interesting places. At the Lagrange points, the gravitational pull between the earth and the moon is equal. Ships can spend extended periods there while using practically no fuel. These points could be a stopping point between the earth and the moon, or for flights from earth orbit to somewhere else. It is possible to move by tilting the orbital plane just the right way. These points have a lot of curious properties. You can fly to asteroids and mini-planets. Flights there could enrich our knowledge of who we are and how the universe and solar system developed, and what the future holds. At one point people, in the same way, found new food, new tools, and moved forward, picking up or mastering things to use along the way.

G. Grechko:

I am for Mars in a roughly three-step plan.

First, we develop something equivalent to a Mars spaceship and it orbits the earth for 18 or 24 months, say.

Second, it spends those 500 days, this time in real orbit. If something happens, we can figure it out or land quickly. When we have worked everything out in near-earth orbit, we launch the same ship at an asteroid. With some asteroids, we could fly there and back in just six months say, instead of two years, like it would be to Mars. What other reasons are there for visiting asteroids? They can present a threat to life

on earth. We need to be able to fly to them, land, and maybe even leave some sort of engine there to divert the asteroid in another direction.

And stage three, of course, is a flight to Mars.

I am not a madman; there is no reason to think so. First of all, Chinese unmanned craft have already been in the Lagrange points, can you imagine? The Chinese and, I think, even the Americans are ahead of us here. The madman is Aldrin, who went to the moon with Armstrong. Aldrin says that we should go on a one-way trip to Mars. When the Europeans sailed to America, they were not hopping from continent to continent. They stayed in America. Similarly, we need to go to Mars and stay there. Colonize it. The only thing is that when they asked Aldrin whether he was ready to take part in colonization, he said no.

S. Nedoroslev:

Much appreciated.

Since this is a conversation, any audience questions?

From the audience:

Both Mr. Grechko and Mr. Krikalev have participated in spacewalks. What does it feel like to do that? What sensations do you have? Are they different to the sensations that cosmonauts feel inside the spaceship, and if they are different, then how? Could you talk a little about this?

G. Grechko:

Then we should start with Leonov's flight, since that was the first spacewalk. Korolev had an interesting argument. He said that a sailor cannot sail a ship if he cannot swim, and that a cosmonaut cannot fly to space if he cannot leave the ship.

Now, I am a good cosmonaut. And Sergei is even better. But I might not be able to do what Leonov did. If I remember correctly, he had enough oxygen for six minutes. When he tried to come back, the spacesuit puffed up and he could not get back in the ship. He flipped over, even though it was almost impossible to do so in the suit,

reduced the pressure inside, which was also critical, and managed to return. The first spacewalk was a deed of great courage, of course. Very, very dangerous as well. We have to give Leonov his due.

It was easier for me. I tested a working spacesuit that had enough oxygen for six hours. I had to combine testing the spacesuit with my real work out in space. Of course, the first flight had a few snags. In the first suit, for example, my legs were completely frozen. It turned out the cooling system had been misconfigured. Sweat fell in my eyes and got in the way of my work. I took off the spacesuit and the first thing I did was grab my legs, to see if they were still there. They were there. I climbed in a sleeping bag, took a 10-day dose of cognac – our daily ration was 3.5 grams, or was it 7, I don't remember – and when I woke up, my legs were back. When Svetlana Savitskaya was in the same situation, she used tea to heat her legs: she filled up plastic bags and put them around her legs.

There were psychological difficulties too. It starts when you vent air out of the station. It seemed it all went through a valve. After that you open the hatch. If any atmosphere was left by mistake, whatever did not go out through the valve will head for the hatch. I was dragged in the direction of the hatch, outside. I started resisting. I was supposed to go out into space, but I do not like it when I am dragged. I am supposed to do it myself. I waited for this to finish and went out. There were other aspects, such as testing the spacesuit. And Sergei, of course, he will talk about working in space.

There is another interesting analogy. What are things like there? You work during the day, and when the sun sets at night, you cover the helmet with the protective visor to keep it from freezing. The visor is a thin layer of gold, you cannot see anything through it. For twenty minutes you do not have work, and you can think. As Mayakovsky said, shallow philosophy in deep places. Suddenly I noticed glimmers on the edge of the docking unit. First I thought, well, we are flying in a certain orientation, it must be the orientation thruster working. Then I saw that the light from the thruster is going in an arc, which is impossible. A fire, maybe? Here I thought: if you prick a man with a needle, he hurts; if the pressure goes down slightly, he grabs

his heart; if the pressure goes up slightly, he does the same; if it gets slightly colder, he shivers. The human body is a very delicate thing. It is no elephant, no turtle, no brontosaurus. Yet I was out there in the middle of space, where there is no air, the temperature is unspeakable, and the height is astounding. Such a delicate, fragile creature, like a drop of water. But what it creates, where it flies to; it does what needs to be done. I looked at the earth and noticed we were flying over Africa. There are always thunderstorms there for some reason. And the lightning – which there is round like saucers, not like the lightning here – is being reflected on the docking unit. I had just started pondering man's power when nature decided to remind me who is boss.

S. Krikalev:

Work now is planned differently than when Leonov made his spacewalk. Leonov's walk was supposed to take ten minutes, according to plan, to get in and out. It actually took twenty. Mr. Grechko was planned to be out there for two or three hours, which is a lot. But he had plenty of extra oxygen in his suit. A spacesuit is really a small spaceship, complete with almost all the systems that an ordinary spaceship has: temperature control, radio, oxygen supply and carbon dioxide removal, telemetry, etc. The spacesuit weighs about 120 kilogrammes, which becomes over 200 once a person is inside. To move, you have to first get that mass up to speed and then stop it. A spacesuit is filled up like a football: the difference between the internal and external pressures is nearly the same. You know the long balloons that you can twist? You can twist them easily, but if you inflate them like a football then you cannot anymore. The sleeves of a spacesuit are just like that. You can bend them thanks only to special joints and folds, but it still requires a lot of physical effort.

The emotional aspect of spacewalks is more important. For the professionals, a flight without a spacewalk is something less than the real deal. Looking at the earth from the window at that height and speed, for days and even months on end, you get used to it. You feel protected. But you walk outside, and you discover that you

are alone. On the other side of your thin spacesuit is an unforgiving environment: a vacuum, temperature, radiation, all that. But even that is not the main thing. You can think of it like mountain climbers, who drive in spikes and attach carabiners to ensure their safety. For them, going up a wall is a normal thing. As Georgy said, we humans are very sensitive creatures. Our conditions allow us to live in a fair degree of comfort. But even at normal temperature and pressure, when you are climbing up a cliff you realize that if you make just one mistake, your life will last only as long as it takes you to hit the bottom of the gorge. If you become detached from the station when you are in space, the result is the same, except you will last a bit longer: the six or seven hours provided by the life-support system. And the mass involved is pretty large. You have to work very accurately with the tools and take great care to not break anything on the station when moving about. Antennas are pretty delicate devices. It is a very emotional time when you see the danger and feel vulnerable, but you walk out of your now-customary environment into open space. It is very interesting work.

S. Nedoroslev:

Thank you.

From the audience:

I know that you are in charge of training adult cosmonauts. But few know that you created a space centre for youth this year. What is the outlook for this space centre, how about the possibility of making a network of such centres throughout Russia, and what about coordinating work with youth to popularize space?

S. Krikalev:

I will return to the starting topic of the conversation: for us to have replacements, we need people interested in our field and who know what is going on in it.

The space centre is based on the trainer for the *Mir* space station. It went unused for years, and is not in the best condition. There was the question of how to use it.

For a long time we knew we needed to create educational programmes that used the centre's existing infrastructure. So instead of throwing out the trainer, we decided to restore it. We got the people who created the trainer unit 20 to 30 years ago and overhauled the facility.

You can say it is a centre for youth, but I would say its training functions go beyond just cosmonauts. The Centre's potential is much greater. Students with aeronautical and space specializations can have internships there. We can give our youth professional training. We could make programmes for children in schools, so they can get interested in this field. We could even have classes for space-industry professionals. Based on my experience at the flight-control centre and a company that makes spaceships, I think that people who work on specialized niche systems, even on a manned spacecraft, often cannot grasp the overall picture. Even the people who sit at the flight-control centre do not always see the overall picture. When they are relaying the message “Take the equipment behind that panel, put it somewhere else, and perform the experiment in that area”, they do not have a very good idea of what the process actually is. So it is very useful when cosmonauts work at the flight-control centre. When I worked at the design bureau, I received multiple requests to arrange visits to the cosmonaut training centre: people wanted to see the training units and the environment in which the cosmonauts work. Figures, papers, and terms do not give a good enough idea about their work.

One of our tasks will be to integrate the space centre into the system of the larger centre, to integrate our computer networks so that the larger centre's data can be accessed by our school kids. If they come and nothing is being immersed in the hydrolab, for example, then these kids can look at the notes we take when we are in our spacesuits in the water environment for real cosmonauts to analyse their errors and improve their methods.

I hope that the space centre will be integrated with the larger centre through the preparation of younger students, university students, specialists, and cosmonauts too. We will try to make the most of these opportunities.

As for making a network of these major centres across the country, it would not be advisable. Maybe in locales we could have centres performing tasks that are up to their abilities. A very good centre has been created in Yaroslavl. It is really a planetarium, where school kids can look at the stars, see how some of the programs run, and try to solve some 'virtual' tasks. So we could have a network, but there is no need for them to be identical. They would need to work together.

I see representatives from the Federation of Cosmonautics in the audience, which does a great deal for training and working with children. The cosmonaut training centre and the space centre are the tip of the iceberg. But we need the base of the iceberg, too. We have to have classes with school kids on a local basis, encourage them to study aeronautics and space-related specialisms. And people working in these specialisms could receive continuing education at the very same cosmonaut training centre. Not necessarily to become cosmonauts, either: they could be engineers or people active in space biology, medicine, radio communications, etc. The range of activities is quite large.

S. Nedoroslev:

Thank you.

G. Grechko:

You know, the Americans have a very interesting solution for this. When the *Challenger* exploded, they paid the wives of the deceased astronauts a lot of money so they could build a memorial. And the wives said what kind of memorial they wanted. This money went to create the Challenger Centre. What is it? It is a building, split in two. So kids come in and sit down. One half is a spaceship, and the other half is the flight-control centre. They perform a mock flight from launch to landing, and everyone receives a certificate that they have flown into space or managed the flight. Then they switch. The Challenger Centre showed such impressive results that they have made more of them in America, England, Canada, and Germany. We also have to make sure that six-year-olds are not able to say with

such certainty that they want to be bankers. What if one of them wanted to be a cosmonaut, you know?

I do not know the current state of things. But the question initially was: if the country were to allocate a space and the money, they are responsible for the technical and methodological aspects, make everything available so it can work, fine-tune it, and so on. It would be so good. At any rate, this year we had 300 would-be cosmonauts apply. The Americans had 6,300 applicants.

S. Nedoroslev:

Thank you very much.

Our session is coming toward its end. My impression is that things are not so bad if they are in the hands of professionals. Sergei said that there is a programme.

I think that Russia's difficult 1990s left an impact on manned spaceflight, like they did on everything else. But it is being reborn today. The fact that you personally are part of this is also one of the signs of this rebirth. The truth is, not all young people are trying to be bankers. They go to design things, we have an engineering centre, we started a competition there. There are more and more competitions. A lot of young people are going into production. We may not have attained the previous level of interest, but I see many signs that the situation will work itself out.

As Georgy said, we need to look at the stars, especially if there is a clear programme for both near space and further out.

Mr. Krikalev, you were right when you said that man must always be pushing his boundaries further. Nothing is in the way of spaceships. They will still fly throughout the whole universe. You are people who have contributed to manned spaceflight in an enormous way, and changed humanity. We all are grateful.

S. Krikalev:

We have covered a lot of topics today. We need to sum up and figure out what we are going to do now.

Back to manned spaceflights: what will it be, machines or people? What will we spend money on? Where will investments make the most economic sense? It is a philosophical question, I think.

We are saying that fewer school kids and university students want to be cosmonauts. The difficult 90s affected our mindset, including in the area of systems management. We think about how to make every last effort economically beneficial. We are creeping from one extreme, when money meant nothing, to another, where we use money to measure each step we take. There are things that money cannot measure, or at least not measure quickly. We cannot measure them during the initial stage and provide economic justification for our every step. There should be no need to.

It was good we talked about commercial flights and commercial investments in programmes. To offset this though we have to ask what the government is going to do. Basic research, education, and manned flights are birds of a feather, I think. Manned flights are a lot like basic research. While they have the authority to attach strings to the money for basic research and demand to know what discoveries you will make and what the return on our money in a year will be, it would be foolish to do so. It would stop some research in its tracks, because there is no way you can report on research expenditure down to the finest detail.

There is the example of a car factory. At good car factories, at good German or Japanese car companies, they always have departments working on experimental concept cars, which are a testbed for technologies and can be used for racing. Price-wise, these cars are in a league of their own compared to the ones off the assembly line. You would think that this R&D department is running at a loss, since the cost of a car that is made by hand with custom equipment and is redone several times before they come out with something you can drive is just enormous. And at normal car factories, assembly lines give economy of scale. But if managers have only the assembly line on their minds, we get something like the Togliatti car factory, which decided to skimp on new development, instead pushing what was most profitable. And the assembly line is what is profitable. So they churned out these

Lada 2101 and 2109 passenger models until just recently, when people finally stopped buying them altogether.

Such areas as manned spaceflight are closer to basic research than anything else. Commercial spaceflight should have its place. And it will take place. It will start when the government has gone through this period of maximum risk and maximum uncertainty, and when the business process becomes clear. Then it will be possible for commercial firms to take part. But the government needs to act first. The government should turn down demands to give an economic rationale for each stage: usually this requirement drives the process into a dead end. It is the system that needs to be economically justified.

That's the final thing I wanted to say. Things like manned spaceflight should remain with the government, and the government should be responsible for the growth of this area and investing in it.

S. Nedoroslev:

Thank you very much.

Mr. Grechko will wind up our conversation.

G. Grechko:

I will be very brief. The controversy of manned versus unmanned craft in space will never be resolved. We should rephrase it: what is the optimal combination of man and machine in space? I think that the Americans' Hubble Telescope is one such optimal combination. The Hubble worked for years, 24 hours a day, every second, without human interference. But when something up there broke, went out of service, or needed replacement, the astronauts went up there. The first time when the Hubble went completely blind, how could they have dragged it down from orbit, worked on it, and launched it again? The Americans were smart to include the possibility of in-orbit repair and maintenance. I think that machines should ordinarily run without human involvement. But people are needed in case something breaks. To fly up there, figure it out, and fix it – that is the human touch. The last flight to the

Hubble was very dangerous. Ships were going out of service, the orbit was not at all one from which we could provide help. The Americans wanted to make a robot. An android that would fly there, instead of a person, and fix everything. But nothing came of those efforts. Man and machine should complement each other, not interfere.

S. Nedoroslev:

Thank you to everyone for listening.