JEAN-YVES LE GALL

President of the Centre National d'Etudes Spatiales (CNES), President of the International Astronautical Federation (IAF), co-Chair of the Council of the European Space Agency

Your Excellencies, ladies and gentlemen, it is a great honour for me to speak in front of you this afternoon about space. This meeting comes just after what was truly a 'golden week' for space in France and Europe, since last week we had four major events:

During the COP22 in Marrakesh, very important decisions about space and climate were taken by space agencies. I will return to this later.

In Europe, we decided to go ahead with the next generation of launchers, Ariane 6.
On Thursday morning, the four satellites of the European Galileo global navigation satellite system were launched from Kourou in French Guiana by an Ariane 5 launch vehicle.

And in the afternoon, you probably saw that we had the launch from Baikonur in Kazakhstan of French astronaut Thomas Pesquet. He is now aboard the International Space Station, where he will stay for six months, so that means he will be back mid-May.

These events show that space is everywhere we look. In fact, as you probably know, space exploration started out with the lunar missions of the 60s, to discover new stars, to study the formation of galaxies, analyse the composition of planets and seek out the origin of life. It is in our nature to keep pushing the limits of what we know and where we go. This urge to explore has led to human spaceflight and launching satellites and probes into space for science, Earth observation, telecommunication and defence.

In August 2013, Europe orbited Qatar's first telecommunication satellite using the Ariane 5 launch vehicle. We were very honoured to launch this first Qatari satellite. Over nearly 60 years, thousands of satellites have enabled humankind after conquering the land, sea and air to conquer the fourth element, space.

In particular, we have launched a host of robotic probes into our solar system and beyond to gain new insights into the world we live in. We have explored the Moon, all the planets of the solar system out to Pluto and even some of their moons. Saturn's moon Titan for example, was visited by the Huygens probe a few years ago.

Over the last two years, the world has held its breath as the Rosetta orbiter and Philae lander got close to the nucleus of comet Churyumov-Gerasimenko. When we launched Rosetta in 2004, we thought that the nucleus of a comet was a big ball of dirty snow. It is now clear from photographic evidence that we discovered many things: when Rosetta started viewing the comet close up, we thought at first that there was something wrong with the optics when we saw this very strange nucleus, but it was a reality. The success of this unprecedented mission, the first to land a manmade object on a comet, is also down to the European Space Agency working with the German Aerospace Centre DLR and the French space agency CNES for the first time.

Turning now to look closer to home, Earth-orbiting satellites have produced more complex pictures of the global environment and are helping us today to study it more easily. Satellites take pictures that allow us to forecast the

weather. They are also helping to protect populations from environmental threats, detecting natural and manmade disasters, improving soils, oceans and vegetation for the benefit of all.

Satellites are also crucial instruments supporting efforts to curb climate change. The French-US TOPEX/Poseidon and Jason-1, -2 and -3 satellites have revealed rising global temperatures and sea levels, which tomorrow will ensure that international accords like the Paris Agreement reached last year at the end of the COP21, are effectively implemented.

Now a few words about telecommunications. As well as satisfying our thirst for knowledge, discoveries and new frontiers, space is also serving very concrete applications in our everyday lives. All around the world, even in its most remote regions, satellites are delivering television, Internet access and fixed and mobile telephone services. They are also transmitting, broadcasting and measuring world events.

Satellites are also enabling pedestrians, hikers, motorists and pilots to locate their position with metric accuracy, choose between possible routes and find their friends wherever they are. In this domain too, European industry has achieved world-class status thanks to programmes funded by governments. With the launch last week, we now have a total of 18 Galileo satellites in orbit. This will allow us to announce by mid-December, the new services supported by Galileo, which will be a new system equivalent to GPS.

Last but not least, defence. Satellites are protecting cities and enhancing safety by providing precise information and services. For example, to locate distress calls and guide rescue teams. They are also playing a vital role helping to prevent and manage conflicts by providing high-resolution optical and radar imagery, secure telecommunications and signals intelligence.

Today, most of the weapons on the battlefield use satellites to exchange data between them and this will continue to develop. It will be more and more useful in the future.

I would also like to say a few words about the environment, because I have spoken about launchers, science, Earth observation, telecommunications and defence. What we see in this context of what I call emerging space applications is that we have a new world order that is taking shape with the United States, which is the uncontested leader, Europe, Japan and Russia holding their own, and the rise of China and India. However, there is an increasing number of emerging space powers are lining up behind these key players, some rich, like Qatar, the United Arab Emirates and Azerbaijan, a few others with the resources to build large, expensive satellites, and some less so. We are moving into space with smaller and cheaper satellites.

All of these players are developing their own space programmes or even space industries that will enable them to ‘play and win with the big boys’ while reaping significant rewards in terms of public policymaking. In total, we now have roughly over 60 countries developing their own space programme and this is going to continue. The countries that already have a space programme are going to have bigger space programmes and newcomers are going to arrive on the scene because space is proving increasingly attractive and useful.

Alongside these efforts mostly sponsored by national states, a new movement has emerged from the US and has taken hold around the globe. This new movement called ‘New Space’ is being shaped by rich and ambitious entrepreneurs eager to transform this business. While Sir Richard Branson was the first to set his sights on the stars, Elon Musk and Amazon founder Jeff Bezos have now followed in his footsteps.

However, they are only figureheads for hundreds of firms who, although they may have fewer resources, are equally ambitious. For example, a new space-imaging company has launched no fewer than 110 satellites in the last five years. That means during the last five years, this new company launched more satellites than all the satellites previously launched for Earth observation. And they did so with the aim of doing more with less money.

The launch industry is no exception, with a number of projects in the US and the rest of the world. That is why Europe responded as early as 2014, two years ago, with a historic decision to develop Ariane 6. Ariane 6 will really be a new launcher, because the impressive objective is to halve the cost of access to space. That means, for instance, that the cost of launching a telecommunications satellite in the future with Ariane 6 will be reduced from USD 20,000 to USD 10,000 per kilo. Obviously, it will be very, very difficult to reach this objective. This is why we face three defining challenges, and the first of these is innovation.

Innovation seeks to make space a means, rather than an end. Google, Apple, Facebook and Amazon (GAFA) are not focusing their ambitions on space as such but rather on space as a means for connecting, observing and a host of things yet to be imagined. Innovation is built on the foundation of space technologies and descriptive thinking. However, you cannot build a technological foundation without significant research effort. Indeed, the key to the success of the newest launchers is the low-cost engine, which is the result of more than 10 years of research at NASA, while the new satellite-imaging companies are leveraging developments accomplished by others in old satellites and new satellites.

Now, this foundation has enabled innovations such as projects to orbit constellations of several hundred or several thousand satellites. Google announced a project two days ago for 4,200 satellites. It will take time, perhaps we will not end up with 4,000 satellites but just 400, but it will be a huge step forward. All of these satellites are expected to be developed, manufactured and launched at an extremely low cost. The challenge now for the public sector is to prepare tomorrow's technologies and to nurture and the support these innovation opportunities.

The second challenge we face is climate. It is satellites that have provided the evidence of climate change. Without them, it would have been impossible to demonstrate that sea levels are rising 3.2 millimetres a year. Likewise, it is satellites that are enabling us to encourage nations' efforts to cut greenhouse gas emissions. We have coordinated international monitoring efforts that led to two declarations, one in Mexico and the other in New Delhi that we adopted months ago. We pushed for the use of space to monitor climate because out of the 50 essential climate variables, 26—more than half—can be only observed from space. Therefore, satellites are key for predicting and monitoring climate change.

The third challenge we face concerns exploration, because the current shifts in the space sector are likely to have the unexpected effect of stepping up the pace of Mars exploration. Only six months ago, the envisioned timeframe for the first crewed mission to Mars was 2040-50, meaning it would be in sight 25 years from now. But now, this prospect is seemingly getting closer by the day. Some proposals are now talking about 2030 or even 2025. Why? Because we are starting to see the benefits of the spectacular cost reductions in satellites and space launches. To send spacecraft to Mars large enough to support four to six people in space for two years was previously only a concept. Going to Mars will take two years: nine months from the Earth to Mars, six months in orbit waiting for a new launch window to come back and nine months to come back. The major issue is to be sure that the astronauts will stay in good health. This is why we now have astronauts aboard the ISS to learn how to live in space and to prepare for such a long mission.

Many companies and agencies are now working on this mission. At the 67th International Astronautical Congress in Guadalajara, Mexico, last September, full missions to Mars were everywhere to be seen. They were presented as a new space odyssey of modern times.

Europe, meanwhile, is pursuing two particularly ambitious missions called ExoMars. The first recently injected the Trace Gas Orbiter (TGO) satellite into Martian orbit to detect some elements of Mars' former atmosphere . We will study the planet's atmosphere and evolution. In 2020, four years from now, a second mission will land a platform and

rover carrying several scientific instruments on the planet's surface to collect and analyse samples that have not been exposed to radiation and oxidisers that otherwise will have destroyed all organic materials.

Space is changing at a dramatic pace. The many changes we have seen in recent years constitute the most spectacular shift since the start of the space era. In this fast-moving environment, all players have responded with a vigorous and determined innovation policy, by taking up the climate challenge and conceiving a full mission to Mars as the new frontier.

For while innovating is vital, inspiration is just as crucial. The world's young generation needs to grasp the importance of science and technology and be motivated to embrace careers in this field, the only one capable of creating value and delivering a constant source of data to inform decision-making. That is why our future programmes will take us ever further and no doubt to Mars.

We should also remember that from an economic and social standpoint, each euro invested in commercial space generates up to 20 euros in economic spin-offs. Spending on space therefore makes economic sense to keep advancing science, new technologies and environmental protection, as well as being a key element in assuring access to today's multimedia world. This is why in Europe, France and its partners are pursuing an ambitious space policy, funding exploration and innovation. Indeed, France has the second largest per capita space budget in the world, just behind the US. Many services which we now consider irreplaceable rely on satellite-derived applications, even though we do not always realize it. So, in a nutshell, space is definitely a major technological and governance adventure.

Thierry DE MONTBRIAL

Thank you very much Jean-Yves. We would like to put some questions to you because we like to dream a little bit. My questions are human missions to Mars. Firstly, in the short term, you mentioned that it would be a two-year rotation, that the human factor is probably the most challenging one. How to send people and to have them alive not only alive but in good shape when they come back after two years? My first question is, are we reasonably sure that this is feasible in a matter of 25 years? I have one or two medical doctors in the room, including my old friend Jean-Pierre Lablanchy, I think the question of human feasibility of such a mission is a key question.

My second question is very long term. Jumping a century from now, is it considerable that the conquest of Mars, could make it habitable again? Some of us may have read a number of papers talking about recreating an atmosphere on Mars. If we could have real human colonies on Mars, where people could live, but what would they do? What would be the benefit of such an adventure?

Jean-Yves LE GALL

On the first question, we are now gaining more and more experience with humans in space. They are living on the International Space Station, where the French astronaut Thomas Pesquet arrived the day before yesterday. He will be spending six months there. Yesterday, the US astronaut Scott Kelly reached one year aboard the station. He is in a very good shape. That's because we have a lot of protocols that enable us to prepare astronauts for such missions. Astronauts exercise a lot and after one year they are okay.

When we will send four or six astronauts to Mars for a total mission of two years, the idea is to have a kind of small space station. Today, we have the International Space Station orbiting 300 kilometres above our heads. It weighs 400 tonnes. We will send a mini-station weighing just 70 tonnes to Mars with two key features. Firstly, a place to grow fresh vegetables because astronauts need to have fresh food.

Secondly, a small cylinder to create microgravity-like conditions to allow astronauts to spend two years on a space station. Now, in 2016, NASA believes that launching such a mission in 2025-30 would be feasible, and I believe that, too. What makes the difference is the size of the spacecraft you will send to Mars. In other words, the bigger the spacecraft, the easier the mission. Today, with the cost of launching and producing a spacecraft coming down, it is probably possible.

Now for the second question about what we can do in 100 years. I do agree that a number of science-fiction books have floated the idea of creating a new atmosphere on Mars and so on. However, I think that is very, very long-term science fiction. In my opinion, 100 years is completely out of mind, because 50 years ago we were just at the beginning of the space era. Nobody could have thought we would be talking now about people going to Mars. In 100 years, I have no idea; however, changing the atmosphere of a planet seems very, very difficult to me. Even if today human activity is changing the atmosphere of our planet Earth and driving climate change.

Thierry DE MONTBRIAL

Thank you.