Space Debris

New Space Economy

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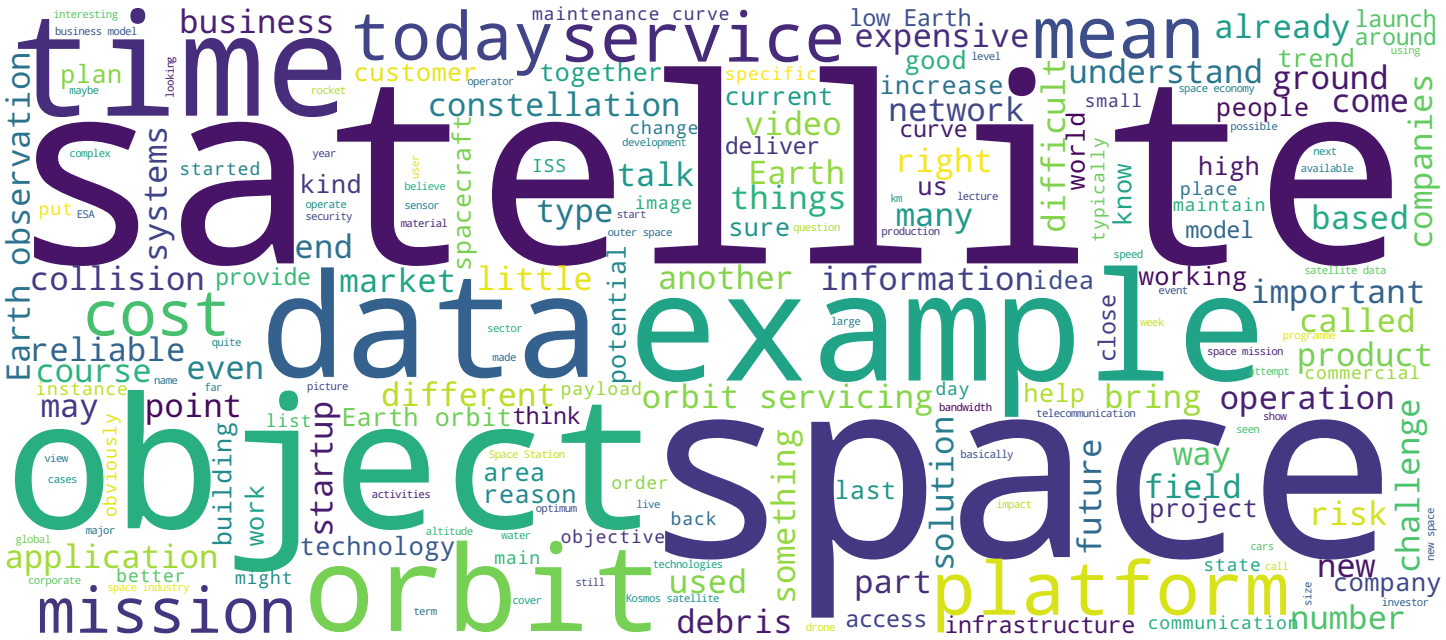
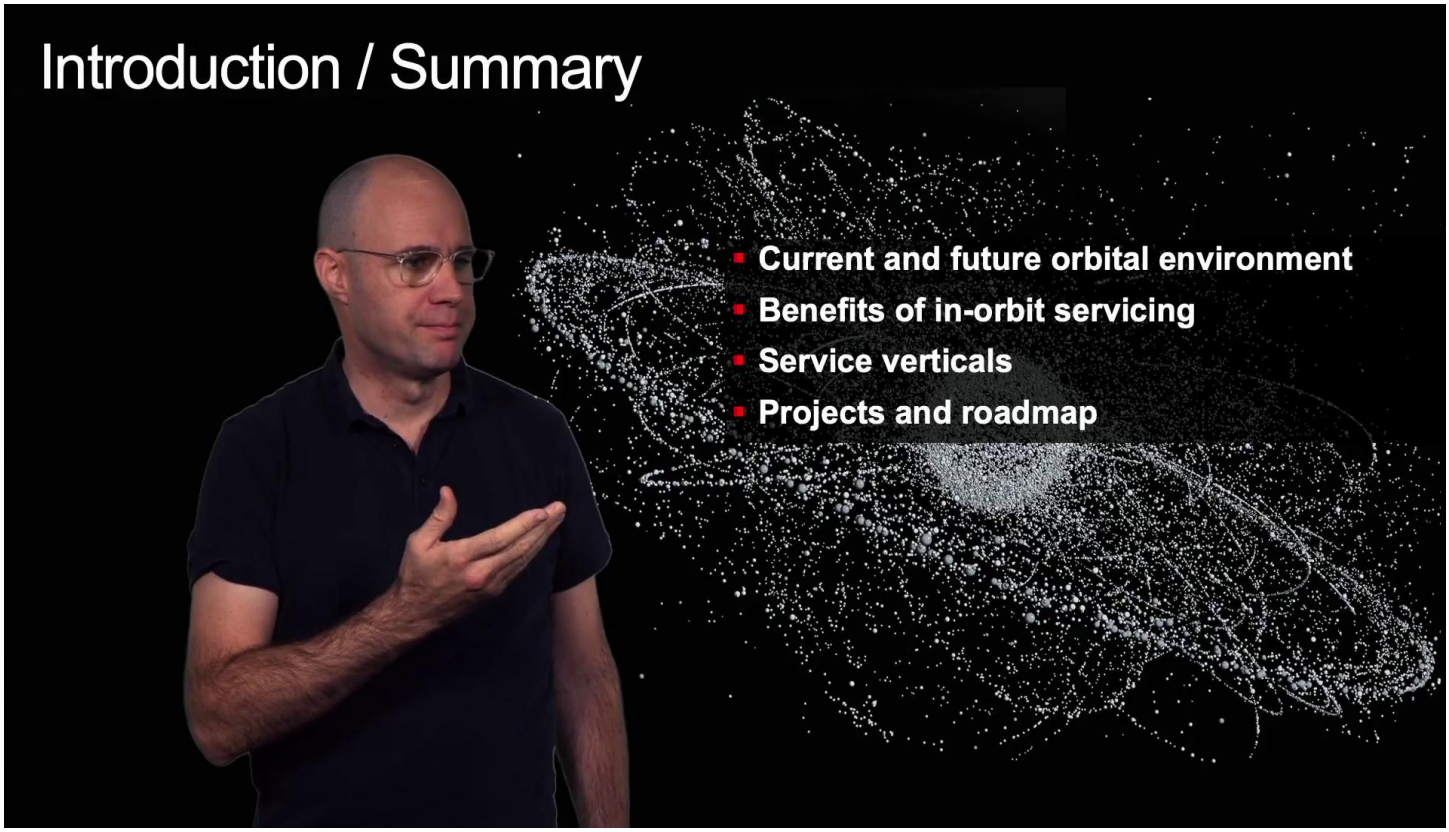


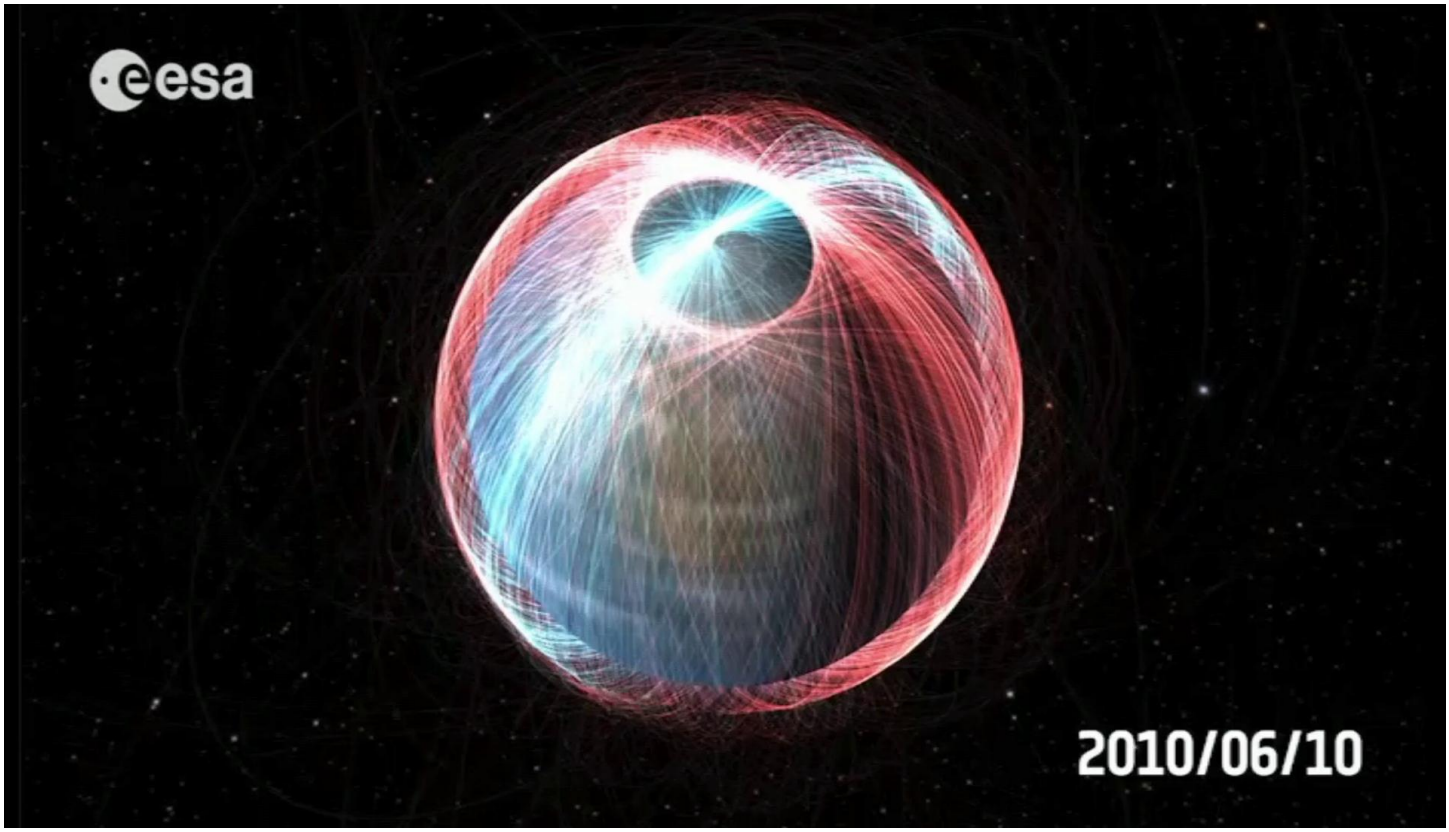


Welcome to this mark on in-orbit servicing. The objective of the session of today, which is a relatively short session, is to go first through the current and future orbital environment. Explain why in-orbit servicing is a necessity for what we need to be doing today and tomorrow. I'll look at a few vertical of in-orbit servicing, and then talk about a few projects and the roadmap for the future.

Notes

Summary

0m 06s

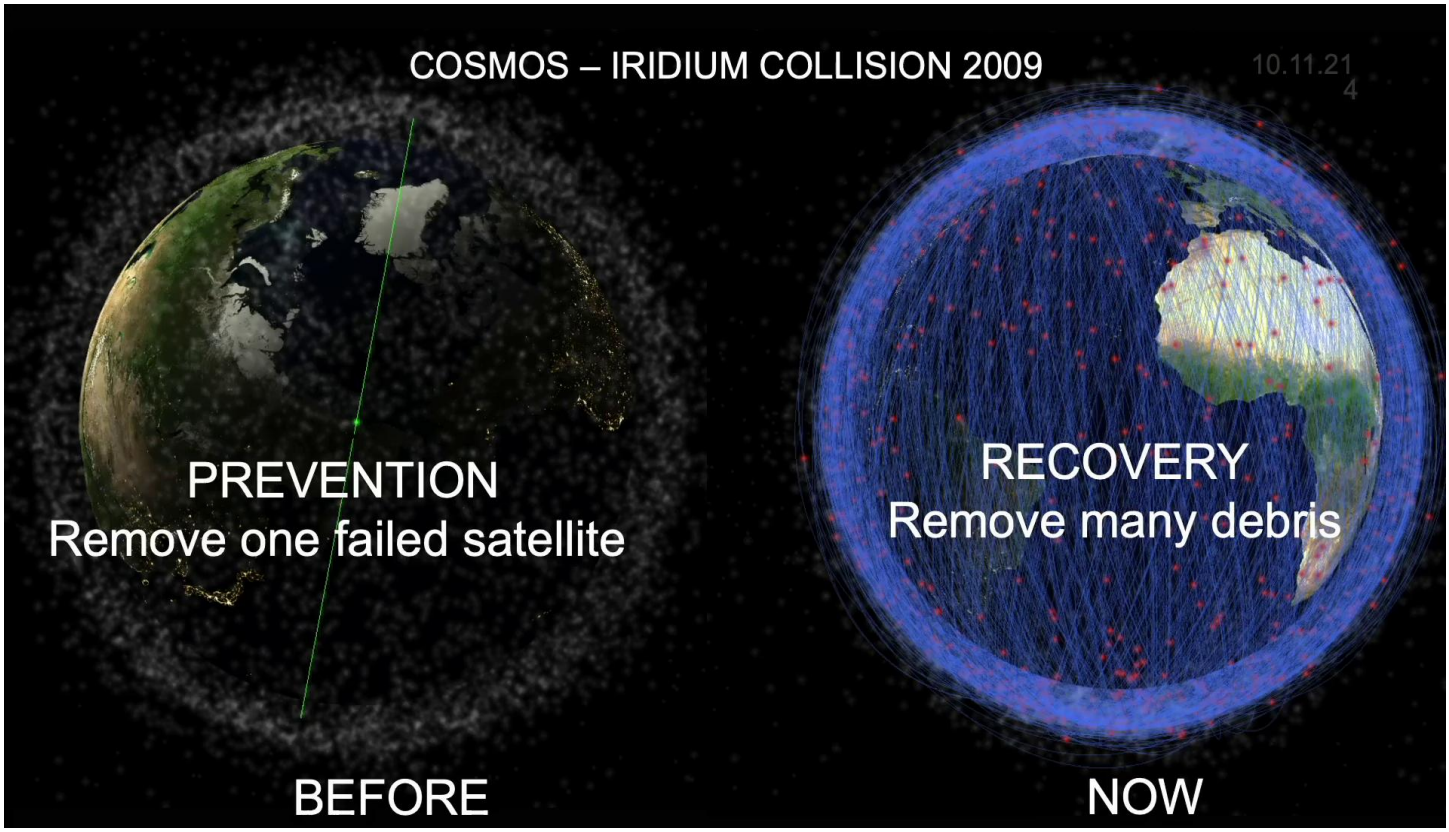


The space environment today is relatively crowded. We have a lot of objects. This is an animation made by ESA in 2013, so a few years ago. The objects are obviously much smaller than that, but the major problem we have today is the risk of collision or fragmentation of outer space objects. This animation shows the collision that happened in 2009 between the Kosmos and the Iridium satellite. As you can see, they collided somewhere over the pole, and generated two fields of debris of more than 2,000 tracked objects, tracked from the ground, which little by little starts taking distance one compared to another, and because they are different orbital altitude, their orbit starts drifting compared to each other. Which means that over a long period of time you end up having debris everywhere. All of those debris present a major problem in the space operation as they pose an important risk of collision with other objects. Today, the problematic is really the number of space objects that are not controllable, for which we're not able to actually either move or maneuver them, and in some cases where there's too small to be able to track from the ground, making it difficult or impossible to avoid potential future collisions.

Notes

Summary

0m 30s



If you look at the problem of prevention versus recovery on Earth, there are some statistics or studies that were made that compare how much it cost to prevent a disaster, compared how much it costs to actually recover from a disaster. In average, you end up with figures around one for 17, more or less. This means that every dollar invested in preventing a disaster saves you $17 of recovery after the disaster. In space, the problem is similar. Here what you see is on the left hand side, you have the orbit of the Kosmos satellite before the collision. The Kosmos satellite was a failed satellite. It was not operable anymore, and at the time, it was still difficult, but it could have theoretically been removed. On the right hand side, you see the field of debris of the collision between this Kosmos satellite and the Iridium satellite today, how it looks like today. You will see that there are debris everywhere around the world. The distance between those debris, the sizes of those debris, make the recovery extremely difficult and very expensive. You would have to navigate from one object to another.

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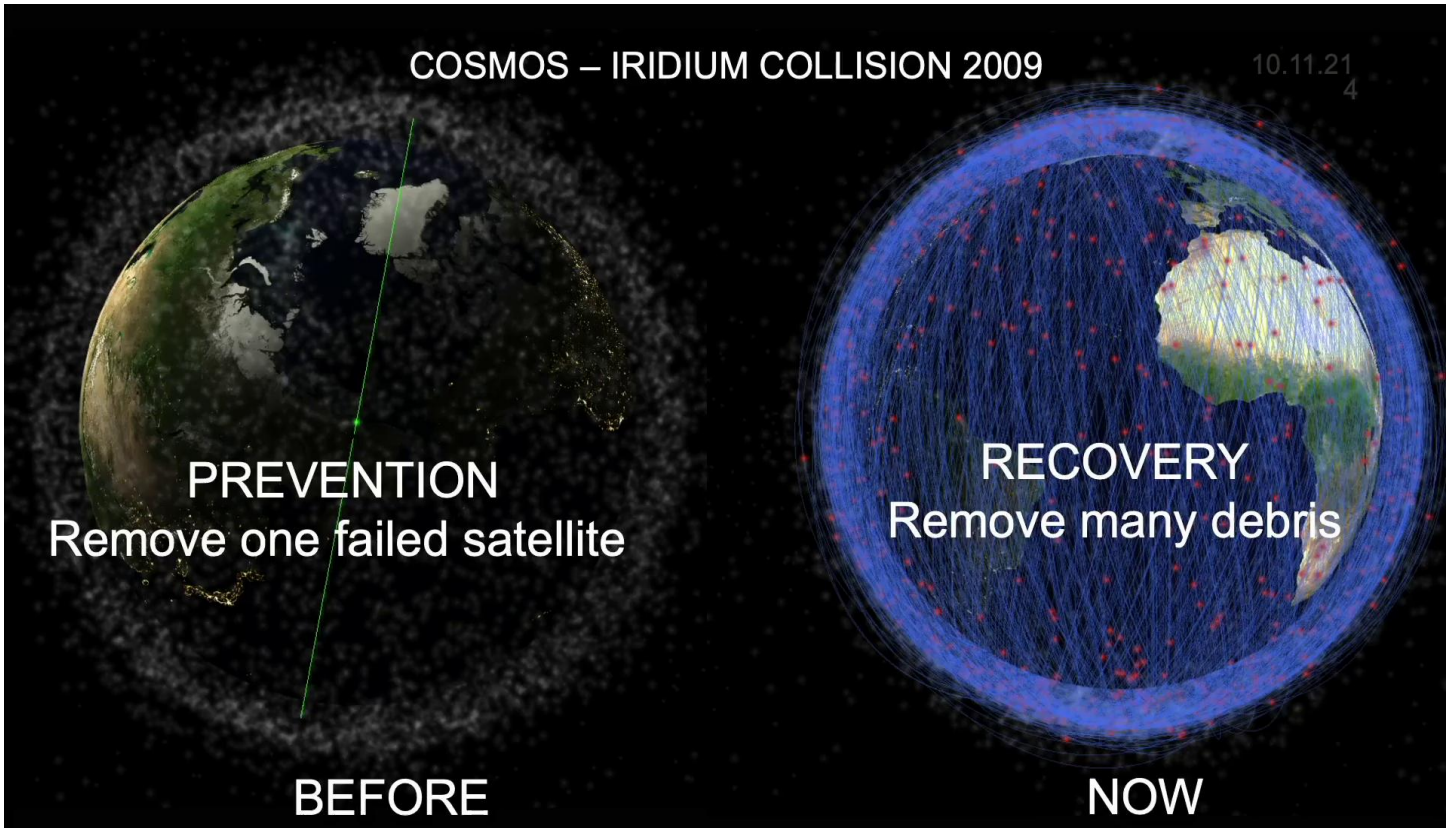
Summary

1m 55s



In the space industry, recovery is substantially more expensive than prevention, or it's so expensive that it becomes really difficult to implement because from one object, you end up having thousands of objects in case of a fragmentation event, which can be due either to a collision, as in this case, or can be due to explosions or parts of a satellite that are left behind or broken or that separate during the operation.

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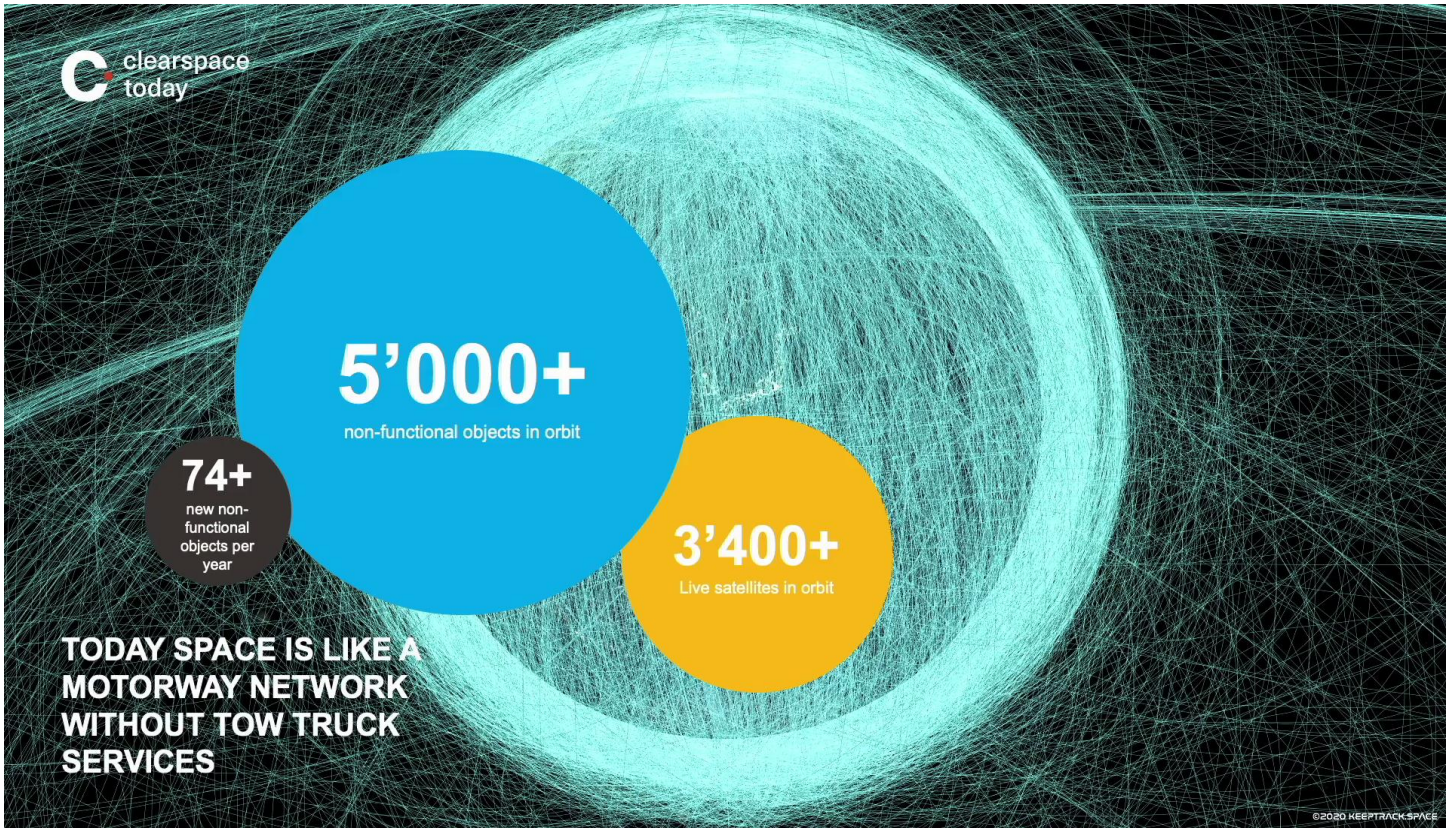
Summary

3m 14s



If you look at the space environment today in very simple figures, today we have more than 5,000 uncontrollable, complete objects in orbit. That's not all the fragments and the smaller pieces of debris, those are complete rocket bodies and complete satellites that are orbiting uncontrollably around Earth. Over the last 20 years, we have been adding, in average, every single year, 74 new objects to this list. This is based on a study made by Darren McKnight and a group of 11 experts from all around the world from different countries around the current population of debris as they are tracked in space tracking. To give a comparison today, and this figure is obviously going to evolve over time, we have about 3,400 live satellites, which means that we have more objects that are not controllable or not usable in space than objects that are usable. To give a comparison, it's a little like a motorway network that has been operating for 60 years without tow truck. This is the challenge in which we are today, and this is the reason why we believe that today this has to change. This is why in-orbit servicing becomes really important.

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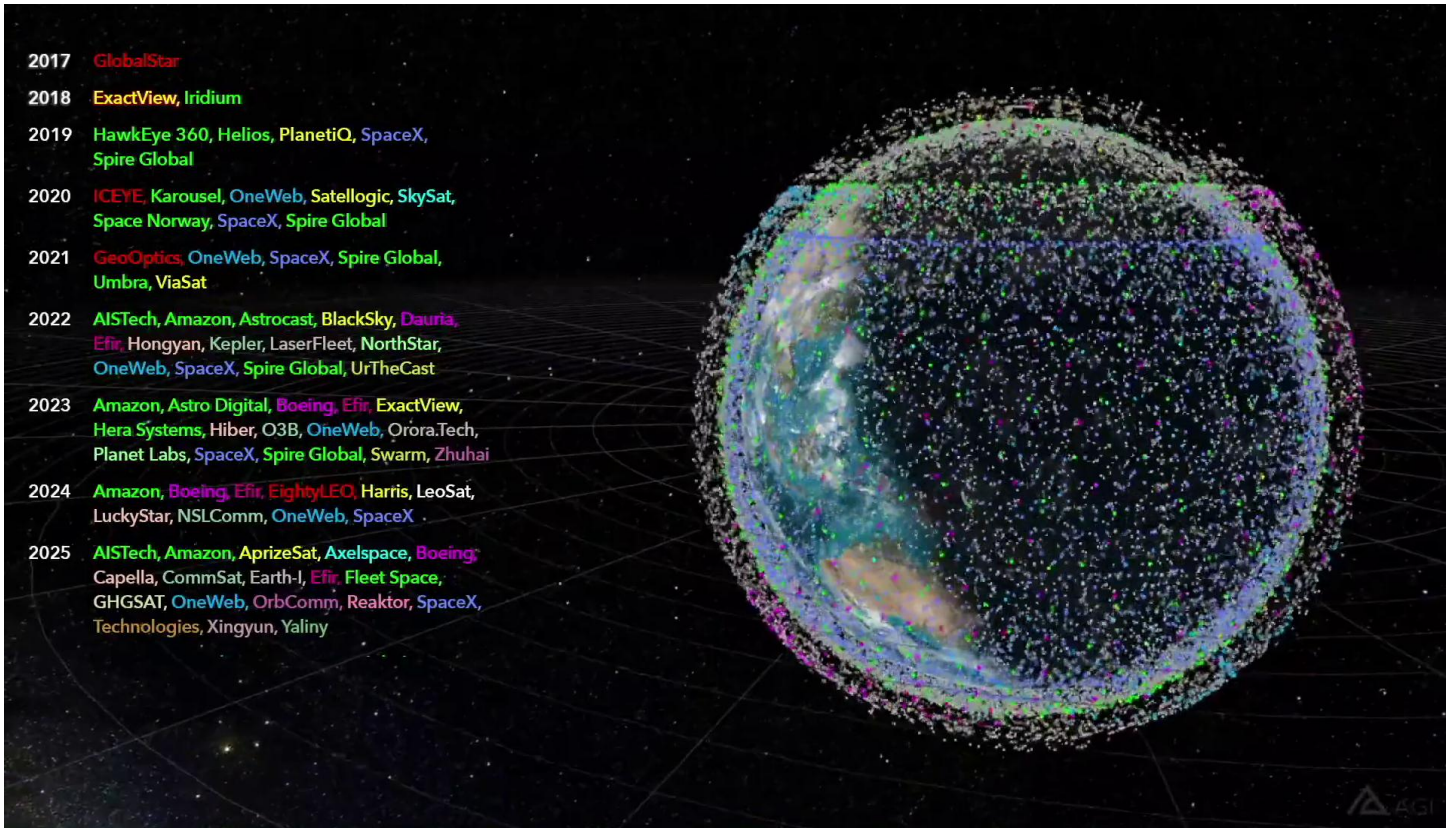
Summary

3m 47s



If you look at the evolution of the number of objects or constellations planned in low Earth's orbit over the coming years, looking at this trend is another very strong indicator of how this environment is going to evolve over the coming years. When you plan for an infrastructure, when you plan for an operation, you have not only to look at the past and where we stand today, but also think through, okay, what are we building today? Where is this complete environment going? By planning ahead, projecting yourself into the future and looking at how the environment will look like in a few years, you can start defining what kind of solutions, what kind of operation procedures are necessary to be able to maintain an environment sustainable over the long term. What you can see in this video is the animation of all the current and future constellations that are planned from 2017-2028. Those simulations made by AGI are made based on the list of requests for licensing from operators and present all the constellations that have been planned. Not all of those constellations will fly, but what we can see here is that the trend is a large number of smaller objects.

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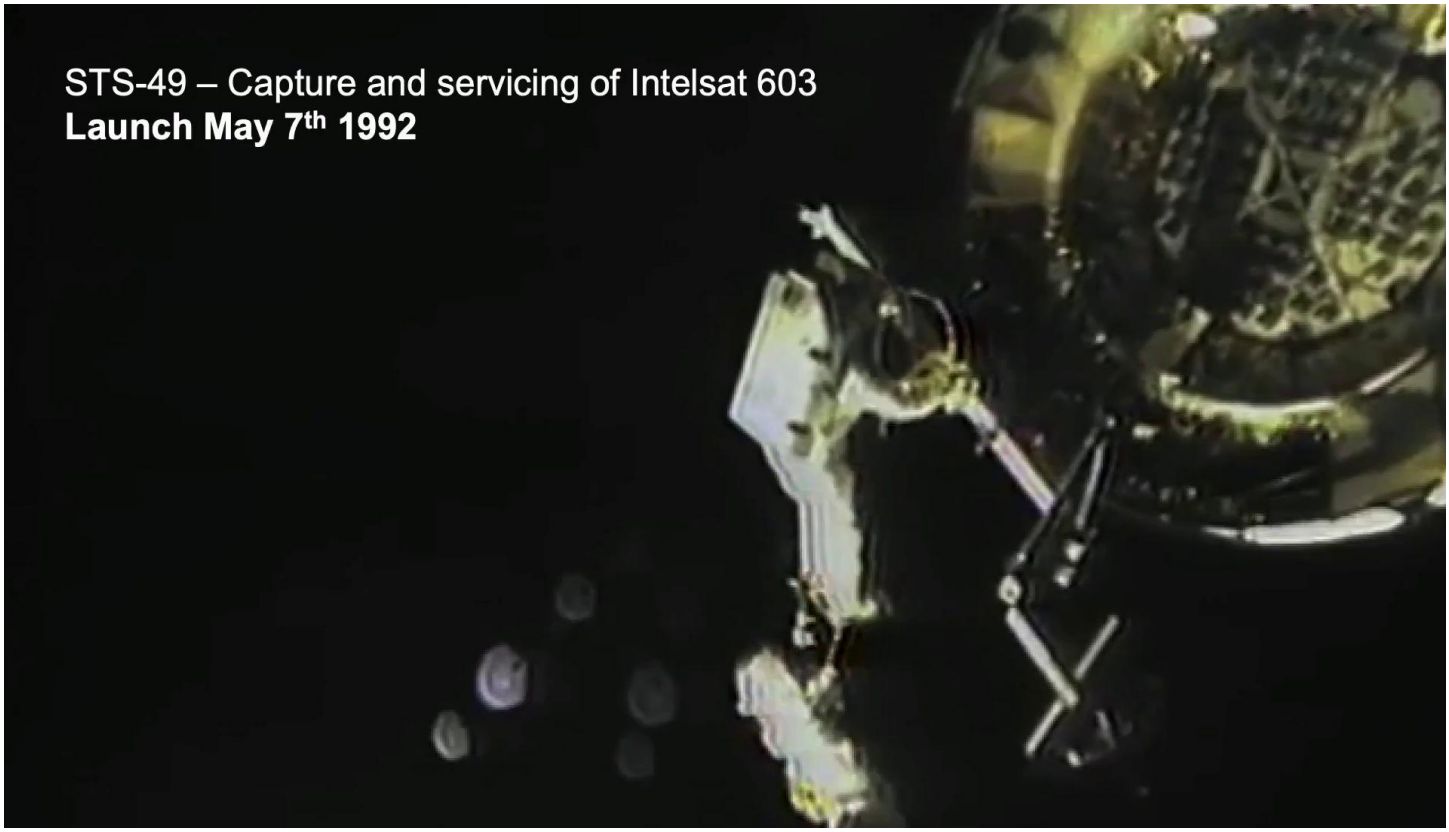
Summary

5m 08s



SpaceX has already demonstrated this trend, but there are other constellations that are in the launching phase, for example, OneWeb, which plans to put a lot of satellites in low Earth orbit. What we can see here is that there is typically two altitudes where we have more objects over time. One is below 600 km, which is between 500 and 600 km, and another one is above 1,000 km. The reason why we don't place more objects in between, is because in between we already have massive fields of debris. Those fields of debris are increasing over time. This means that we're not launching substantially more satellites in those altitudes, but we already have an increase of number of objects in those altitudes. Peter went ahead and moved the capture bar to a horizontal and started to make his attempts to attach it. This is a view from the elbow camera, and I believe this is the very first attempt on the first day. As Dan mentioned, it was a very dynamic situation. and it was something that I'm not sure we could really train for very well. Particularly with hindsight. It's a very dynamic situation, and trying to put all those elements together in one-G to try to simulate zero-G is very difficult and we found that out. We also found out with that first attempt that the spacecraft was not quite as stable as we had anticipated.

Notes

Summary

6m 42s

Capturing an object in space and interacting with objects in space is a difficult thing to do. It's not easy for many different reasons. The first reason why it's difficult is because those objects are orbiting around Earth at 28,000 km/hour. This means that you have actually to meet with them, and to align your speed and orientation with the speed of those objects. This is already a rendezvous, which is challenging to realize. The next challenge in this operation is to get close to the object without colliding. To be able to do that, you need to get into proximity of the object using safe orbits, you have to take a lot of care how you operate that kind of mission, and get really close to the object to the point of capture. But the later part is even more challenging. Capturing in orbit a satellite or an object which is orbiting in micro gravity in a frictionless environment is it can be extremely difficult. There's a couple of things we can see in this video. The first one that is really interesting is that in-orbit servicing is not something really new.

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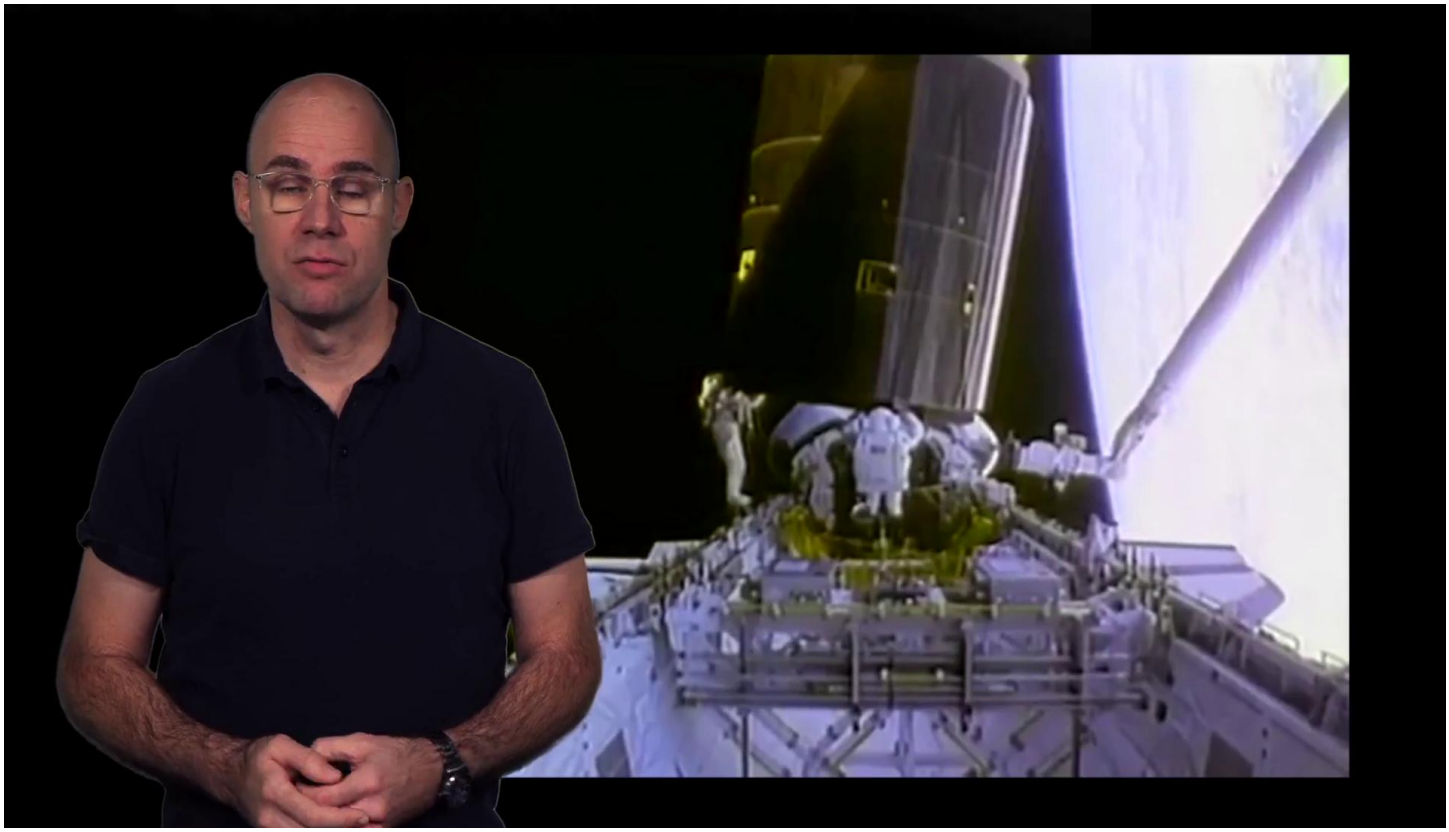
Summary

8m 04s



This is something that has already been done 30 years ago by NASA on shuttle missions. The challenge of bringing those operations today is not really the idea of doing them is to manage to do them at an affordable cost. The other element of this video, which is very obvious is that this capture is actually really difficult to do. Between this mission and today, there have been more missions, some mission actually flown by Claude Nicollier, where there have been multiple repairs of the Hubble telescope, for example, so this is an operation that has been repeated later. But this one specifically is really interesting because it lays out the main challenges. Touching an object in orbit generates movement, and any contact with an object, even like in this case, a three ton satellite, can generate rotations, spins, tumblings, that will make the capture operation much more difficult. Being able to do that in orbit autonomously, is one of the main challenges of in-orbit servicing tomorrow. So far, there have been several missions that have been demonstrating rendezvous in space and typically or autonomous rendezvous in space, and those have been always done on cooperative objects.

Notes

Summary

9m 17s

For example, when the Dragon capsule docks with the ISS, the ISS and the Dragon capsule communicate, both systems are stabilized, and essentially it's connecting on rails. The same is true if you look at the MEV mission we're going to talk about a little later. Both platform are stabilized, but being able to interact with a broken car on orbit is going to be much more difficult. Being able to do that at an affordable price is the challenge of in-orbit servicing.

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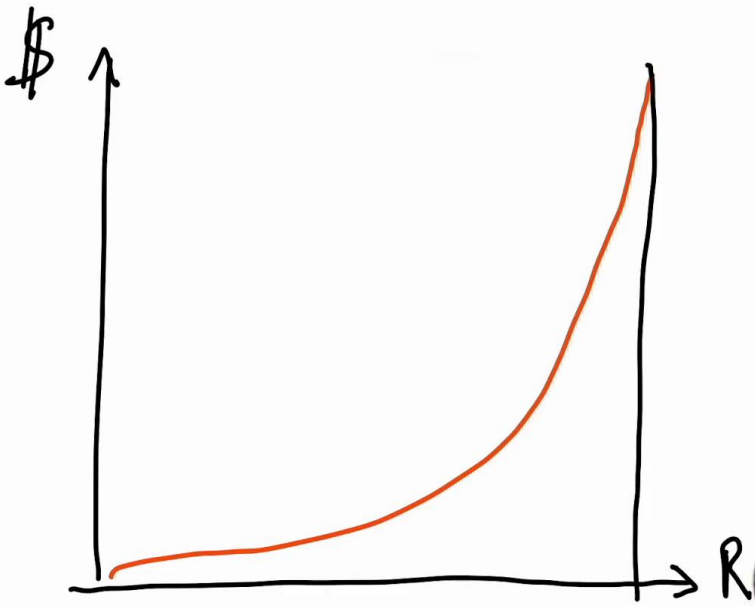
Summary

10m 35s

Benefits of in-orbit services:
Cost<>Reliability vs Cost<>Maintenance curves



One of the aspects of interest for in-orbit servicing is to have a look at the cost versus reliability curve compared to the cost maintenance curve. To explain you how that actually works, if you trace a graph where you have the cost versus reliability of any type of platform, this curve will look a little like this. It will be a curve that goes up more or less exponentially. Which means that if a platform is very reliable, it's going to be very expensive. If a platform is very cheap, it's likely to be very unreliable. This means that as you increase and get closer to 100 percent reliability, your platform becomes more and more expensive. Actually, 100 percent reliability is not possible. So when you look at space mission, one of the main driver of the overall cost of the space mission is how reliable can you guarantee the platform is going to be in orbit? Which means that if you want a very reliable platform in orbit, if you want to make sure that this platform is going to operate in any case in orbit, it's going to be very expensive because you have to do many more tests, you have to make everything redundant. You have to make a very complex and heavy design.

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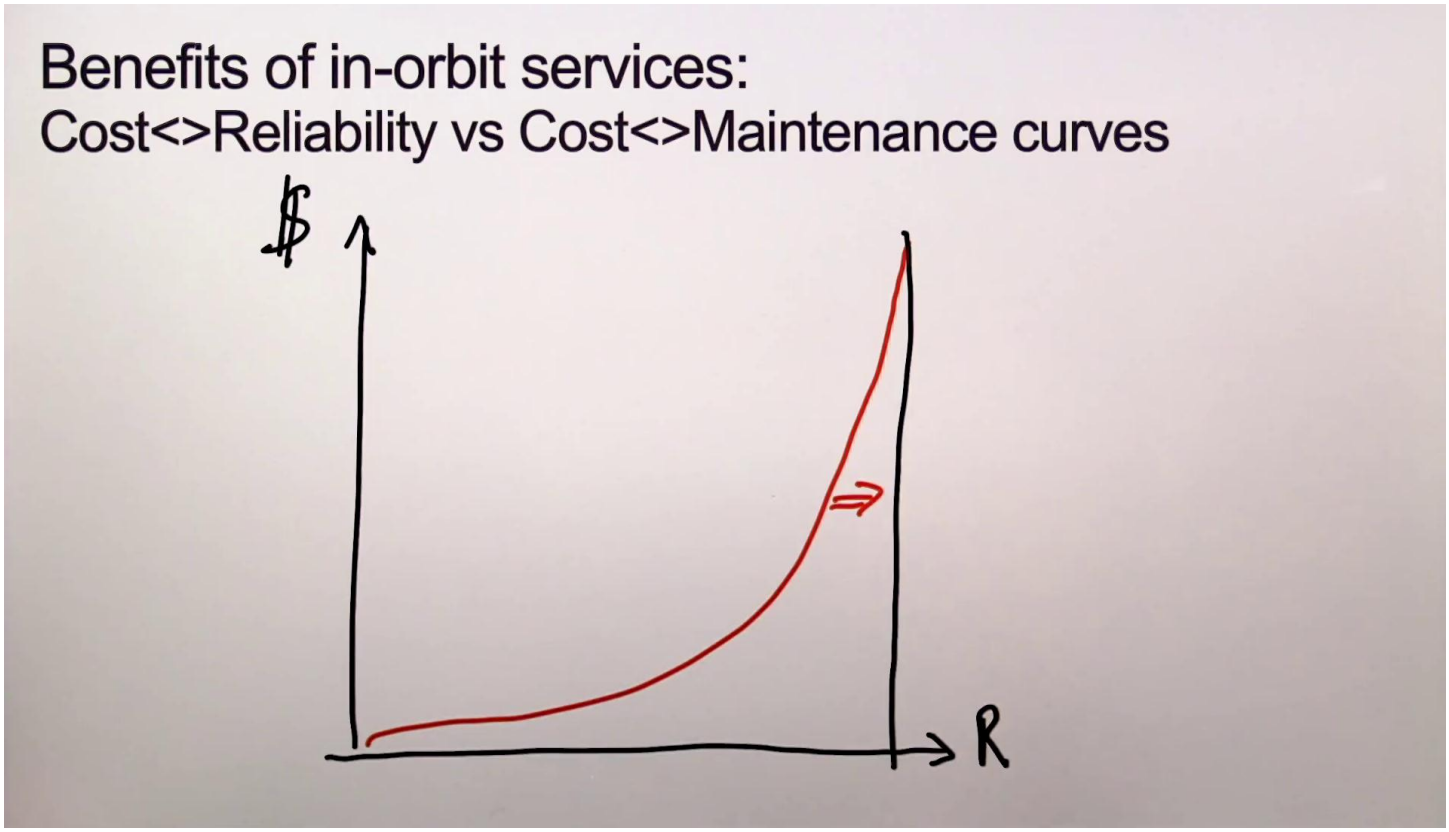
Summary

11m 08s



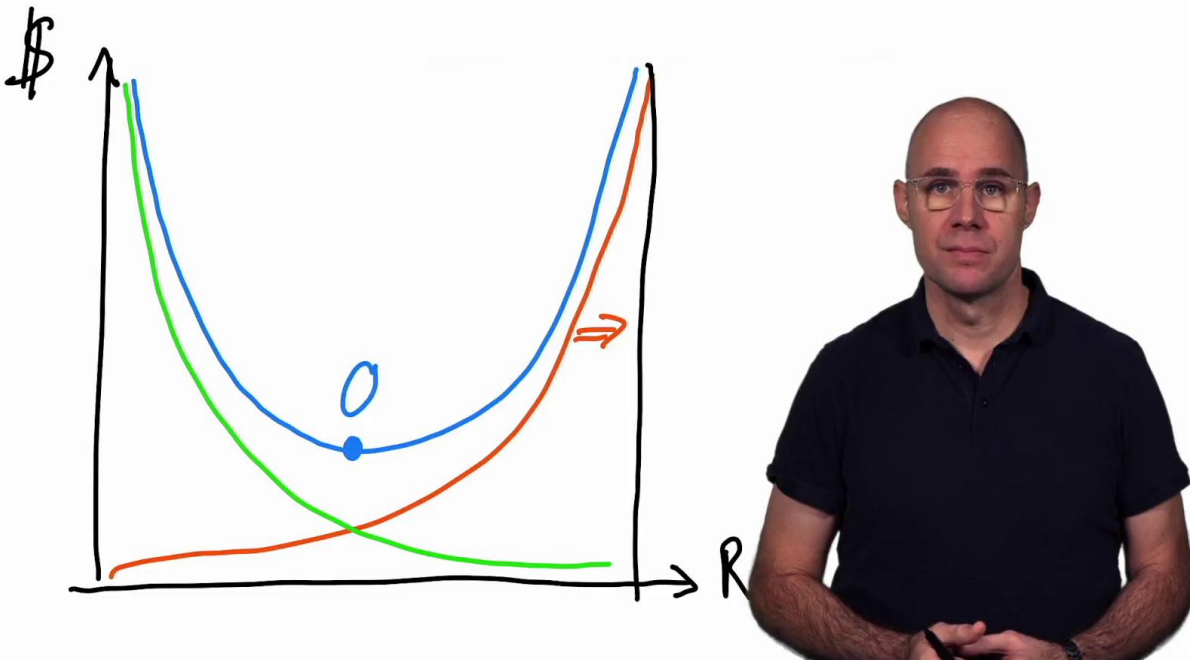
As you increase complexity, you take more risks that objects are failing. Then at the same time, you have to do extensive test campaigns to make sure you actually cover all the ground to make sure that the platform you actually produced here is going to be very reliable in orbit. The problem with that is that it makes the platforms very expensive. Now, if you need to do very large constellation, and have more and more satellites in orbit, the problem you have is that you cannot have a huge amount of money spent on every satellite. If you multiply by two the cost of a platform, it will have a huge impact on constellation of 2,000 satellite or 4,000 or 10,000 satellites, so you need to bring this cost down. The problem is when you bring the cost down, you actually take the risk to bring the reliability down and you have to accept to live with a less reliable product. It is the same for vacuum cleaners, it's the same for cars on the motorway, is that if you want a cheaper product, you have to be able to live with some failures. Over time this reliability curve might move to the right. You might be able to shift it a little to the right make the complete product a little more reliable.

Notes

Summary

12m 33s

Benefits of in-orbit services:
Cost<>Reliability vs Cost<>Maintenance curves



What we do on the ground is that we have a second curve. The second curve is the maintenance curve. This maintenance curve is that if your product is very reliable, your maintenance cost is close to zero. But you never have to maintain it because it always works. If your product is not reliable at all, your maintenance costs are going to be very high. They're going to be very high because you have to maintain this system all the time. So once you've got those two curves, then you can draw the optimum between the two, and that's what's happening on all the systems on the ground. There you get an optimum. You get the price optimum between maintenance and reliability. On Earth when it comes to cars, when it comes to vacuum cleaner, for example, this is what we do. We have a guarantee service, we do parcel client service, and we have maintenance service for cars which is a normal thing to do. In space, the problem we have so far is there's just one curve. Once the platform is orbit, that's it. You can't intervene on it anymore. The objective of building up in-orbit servicing is to bring this maintenance curve into the system, and change the optimum of the space industry.

Notes

Summary

13m 52s

Thank you very much for your attention. It was a pleasure to be able to share a few of the projects we are working on and our vision for the future of the space industry.

Notes

Summary

15m 23s