Get Me Into Orbit – Video 2 – Ready to Launch

Hello! I'm Zara from Glasgow Science Festival. Welcome to the second part of Get Me into Orbit!

We've been really impressed by the awesome satellites that you made after the last webisode - excellent work!

So… you've made a satellite… but how are you going to get it into space?

That's right! This week is all about launch. To get into space, you'll need to load your satellite onto a rocket. Now that's rocket science!

More on that later. But first of all, we need to decide *where* to launch our rocket from. Let's have a look at some options for our space port.

Shall we launch from….

1. Glasgow city centre
2. The Kazakhstan desert
Or 3. the Amazonian jungle

Where do YOU think we should launch from? Pause the video and vote now!

Have you voted? Good! Let's run through the options. With me now is Dr Kevin Worrall from the University of Glasgow who is going to tell us more.

The first option is… Glasgow city centre. Would you launch a rocket from there?

No. It's an unsuitable location because you've got a city, you've got lots of people and they would all be affected by the rocket launch. You've got noise, you've got smoke, you've got the explosions. Also there's no safe ditching area. You need an area where if anything goes wrong with the launch, you need that rocket to be able to land somewhere without harming anyone. And there's nowhere local enough, near Glasgow, to do that. It's a brilliant location for getting the equipment there, getting people there, getting everything you need there for the rocket but for launch it's not safe and you'd probably disturb quite a lot of the city.

It would be a bit noisy wouldn't it? It would be a bit noisy.

OK, the second option was the Kazakhstan desert. What do you think Kevin?

Brilliant location. it's isolated, there's no people round for hundreds of miles in any direction, depending on where the site is. You can keep on building, you can store your fuel safely. In fact, you could just leave it out in the open, there's no one there to harm it. No one's going to be affected by the smoke, the noise, the explosion itself and there's plenty area to ditch. If you have to abort the launch for any reason, it can go down and it's not going to harm anyone or any animals. The biggest problem is getting people there, getting the equipment there, it's going to take you days to get there to the site. Once it's there, it's all there. However you will be following in the footsteps of some really famous explorers.

Sounds good! The final option was the Amazonian jungle.

That's an interesting one. The Amazonian jungle is near the equator which is good for launch sites and getting rockets into space. The problem with that is indigenous life. You've got indigenous tribes in the Amazonian jungle; you don't have a lot of space because it's all jungle; you've got the animals there that are going to be disturbed by smoke, noise – you're going to disturb nature. The infrastructure's not so good either. You're going to have to tear down a lot of rainforest if you want to do anything. But it is near the equator so that's an advantage.

So, what would you say makes a good space port?

Space ports in the past are kinda different from space ports we're looking at now. So originally you want a big area where you can store your fuel and have all the rockets and have areas and warehouses for the rockets to be stored in. You then want to be able to launch and all that smoke, explosion and noise doesn't harm anyone; but also you want an area where you can dump the rocket if anything goes wrong. So if you're launching it and you have to abort, you want an area where there's no people, it's not going to cause any natural disasters, it's not going to cause any infrastructure damage. Also you need really good transport links there, so you can get all the equipment there. Some have their own runways where you can land the equipment. Others have got boating areas where you can bring it in by boat. Also now they're looking at long runways, because they're now looking at other ways of launching into space.

Great! Well thank you Kevin. We'll be hearing a lot more from Kevin later on.

Did you know Scotland's first satellite, UKube-1, was launched from Kazakhstan in 2014. At the moment, the UK doesn't have its own space port but that might change in the future.

So, we've made our satellite. We've chosen somewhere to launch it from. But how do we get to the launch site? Kazakhstan is quite far away. And I think my satellite's too big to fit in hand luggage.

Getting into orbit is a journey that begins long before you've left planet Earth.

Kevin, what's the first step of transporting a satellite?

You've got your satellite, you've done all your testing, it's really nice, you've spent a lot of time – maybe a lot of money – on it. The first thing you want to do is pack it well. I don't mean you pick it up, you put it in a box and put Styrofoam beads round it and then seal it up with tape. You put it on a platform, you lock it to the platform, you then put an outer casing on it. Then you probably put another outer casing on that. And depending on if there's any chemicals in there that need to be kept cool, you may need to put it in a refrigerated container. So potentially, you've got a very small satellite and a very large shipping container which is like a Russian doll, where there's actual levels. And depending on what you need, you may be pumping chemicals in there.

Wow. Now it looks like the people in that photo are wearing protective suits. Why are they doing that?

If you have a look at me, I've got this jumper, it's got fibres coming off it. Now on a satellite that's maybe an Earth observation satellite, it's got cameras in it, that little fibre could end up in the lens, which means you've just spent a lot of money building this satellite, getting it into orbit, taken a picture of the Earth and you see my little jumper fibre. That's not going to go down too well. So they wear the suits to protect from fibres getting on it; they wear the boots to stop mud getting on it; they wear the caps for the hair; and for the very lucky ones you can wear beard guards to make sure there's no beard.

So have you worn a beard guard before? Yes, I have. And they're extremely uncomfortable.

Uh oh. But important to keep your satellite nice. You've got to keep it clean.

So what happens after it's loaded onto a lorry, what happens next?

The lorry goes – hopefully very slowly – to its final destination. That destination might be a port where it gets loaded onto a boat. Or it might be a plane where it drives onto the runway and they carefully back the lorry into the plane and they take the container and put it onto the back of the plane. That plane will then take off and go to the nearest location to the launch site.

So it's a little bit more complicated than just sticking it in the car boot?

Yes it should be. However some of the smaller satellites are transported like that. But I didn't say that.

What happens at the launch site when they arrive?

So, you've got the big container. They unpack it one stage at a time. Then you've go the satellite. What happens is it then gets attached to the launch vehicle.

There's normally a little area in the launch vehicle – rocket – where it's dedicated to your satellite. It gets put in there.

We've got a bit of video here now of the launch of the LISA Pathfinder's rocket. Scientists in Glasgow were actually involved in this launch which is very exciting. What are we seeing just now, Kevin?

We've got the satellite, it's already on a sort of launch platform. And what's happening is the satellite is being encapsulated in the top of the rocket there. So the pointy bit there is normally how you would draw a rocket and inside there is the satellite and that's now fully encased. What will happen is that gets moved out of the clean room, put on another platform and then that whole unit will then get attached to the top of the rocket. This is it going from the warehouse driving all the way to the launch vehicle which is probably right beside the launch pad at this moment in time. As we can see, beautiful weather which is ideal for a launch facility. And there you go – in there will be the rocket.

And what happens is, that encapsulated satellite will get picked up and taken right to the top where there will be a team of people and they will bolt it down to the rest of the rocket. You can see there, there's a platform.

The black area there is the platform. They're putting it down onto a rig first. And then they seal it all in just so that there's no moisture getting in there, there's no environmental elements. And then they lock it down. Every bolt is put in and they'll check. There's a whole team of people there – they're doing one bolt and then they're checking it, and they're checking it again. As you can see that's now fully attached to the rocket, ready for launch.

Wow. So where is this launch happening? The LISA Pathfinder was launched from French Guiana on the north coast of South America, and that is the main European launch site.

And there we go, it's launched!

We have our satellite. We've travelled to the launch site. And we've attached the satellite to the launch vehicle. Now for the fun part - launch!

On Earth we are affected by an invisible force that drags us back down to the ground.

If I throw my satellite up like this it falls back to the ground. This is because of gravity.

We can counteract the strong pull of Earth's gravity by moving very, very quickly upwards. Instead of falling straight back down to Earth, we fall into orbit.

So how can we move really, really fast, upwards? With a rocket!

To launch a rocket, you need to burn rocket fuel. Let's imagine this is my rocket. And this is the fuel.

When the fuel is ignited, there's a chemical reaction. Hot gases build up and push downwards out the back of the rocket. This downward force pushes the rocket upwards in the opposite direction.

The same idea applies with a balloon. When you let air out of a balloon, the air goes one way - and the balloon moves in the opposite direction. This action is called thrust.

When rocket fuel burns, this chemical reaction is called combustion.

Here's Kevin, back to tell us about few different kinds of rocket that can be used to blast your satellite into orbit.

Hi Kevin. Hello.

So, what's this first one?

Rocket one: Vega. A small European rocket that can place small satellites weighing 300-2000kg into orbit. Vega's first launch was in 2012 from Kourou. Its mass is about 137,000kg and it's about 30m high.

Wow, OK. What about this one, rocket two?
Rocket two is the Soyuz. This is an amazing rocket, it's a work-horse of getting into space. It's a mid-sized Russian rocket, the most commonly used launch system in the world, one of the most successful launch systems in the world. It's been used to launch astronauts, cosmonauts into space on board the Soyuz spacecraft; it's also launched satellites like UKube-1 from Kazakhstan. Its mass is about 312,000 kg and it's about 46.3m.

Cool. And what about this last one, this looks like a bit of a beast?

Ariane-5, it's a heavy rocket. It's used for putting very heavy loads into space, we're looking at two to three satellites at a time depending on the size. Mass 777,000kg and you're looking at 46-52m high. So it's a massive rocket designed to put really big satellites up in space.

But more are being designed. A lot of commercial private companies have got involved, now creating some really small rockets like the electron. This is a New Zealand company, it's about 17m tall. It's designed for the satellites we've been talking about, the cubesats, the pocketqubes, the really small ones. However there are some really massive rockets coming along. SpaceX who've

launched quite a few satellites and quite a few rockets - they're also most famous for landing rockets - they've got a really big rocket launcher coming up called the BFR. It's just over 100m tall and it's designed to get things potentially to Mars.

So why are the rockets different sizes?

Rockets are different sizes because it depends on the payload and it all comes down to what it is it's launching.

What is the payload?

I'll give you an example.

So we've got a bunch of materials here for our demonization. My first question to Kevin is: what is the payload?

With respect to a rocket, the payload is the weight of the stuff you want to carry into space. For example, the weight of your satellite. However you've also – to launch the satellite – the payload would encompass all the fuel that you need to launch your satellite into space. So this is an example of a large satellite, this is an example of a small satellite. Depending on which one you were launching, the fuel you would need changes. So for this large one, you would need quite a lot of fuel to get it into space. Whereas the small one wouldn't need as much.

So it takes more fuel to take the big satellite into space that it would take a small satellite into space so the overall payload is going to be bigger because if you need more fuel, you need a bigger fuel tank.

You need more fuel, you need a bigger fuel tank but because you're transporting more fuel, you need more fuel to launch that additional fuel into space as well. So it all gets quite complicated.

Let's put together our satellite ready to launch. We've got this satellite here, what normally happens is, panels are stowed. We put it inside its encasing, lock it and then place it on top.

However, that's one large satellite. We've also got a small satellite, again you would go through the same process where normally all the solar panels are launched stowed, and any other peripherals. Then again that would become encapsulated but then you could place that on top. It's the same but this rocket can put more payload in and this rocket smaller.

It's now time for you to do some rocket science of your own.

With the help of your teacher, you're going to do some important rocket calculations and built your own model rocket for getting our satellites into orbit. just like last time, you can share your creations with us on twitter @GlasgowSciFest. Good luck!