Hello, my name is Kate Underhill and I am a rocket scientist with the European Space Agency. I studied physics and space engineering back home in the UK, and now I’m based in Paris in ESA’s Space Transportation directorate. And today, I am going to be answering questions from all over Europe about rockets, so let’s see what our first question is.

**Could you describe a rocket launch step by step?**

To start at the beginning, at least for ESA’s rockets, Ariane and Vega, many parts of the rocket are built all over Europe and then shipped across the Atlantic Ocean to Europe’s spaceport in French Guyana. French Guyana is a really good place for a launch base because we’ve got lots of room to do our activities, because it’s on the coast of South America, so we can launch over the ocean and not over people’s heads. Because there’s not many earthquakes down there to worry about them shaking up our rockets, and because it’s near the equator, and with the Earth’s rotation every day, that means that our rockets are already going at 1500 km/hour before they even take off.

So all of the parts of the rocket are shipped down to French Guyana from Europe, some parts are built there, are made there, like the solid boosters of Ariane 5, or the first stage of Vega.

Then, the satellites we take into space are built all over the world and flown into French Guyana, and we assemble all these elements together. Put the rocket base together, put the satellite on the rocket, and then you put a protective cover on the satellite, called a fairing.

Now, there are so many bits of a rocket because a rocket is made in stages, and why we have stages is because to get to space a rocket needs to be going really fast, it needs to be going at nearly and over 8 km/s. In order to do this we have to burn a lot of fuel, but the more fuel we burn the heavier the rocket is, and the harder it is for the rocket to get off the ground in the first place – so we do it in stages. A stage is ignited, it burns up all its fuel, and then as soon as the stage is empty, it drops back down to ground and the rest of the rocket, the other stages, keeps going up into space, and we do this in the many stages that we need to get up to the speed we want. This staging principle, is shown by this animaltastic graphic of a Vega rocket. A Vega can take the equivalent of a hippo to space, a satellite of about 1,5 tonnes. Now, once we’re in space and to get the hippo, our satellite to exactly the right position, we need 0,5 or a polar bear worth of fuel, in the last stage. Now that polar bear and that hippo, up through the top part of the atmosphere and into space we need 2 elephants worth of fuel, 11 tonnes of fuel. To get 2 elephants, a polar bear and a hippo up through most of the atmosphere, we need a camarasaurus worth of fuel, 24 tonnes. And to get a camarasaurus, 2 elephants, a polar bear and a hippo off the ground in the first place we need a huge amount of fuel, a huge amount of power, we need 88 tones, a blue whale worth of fuel. It’s nearly 300 times more fuel in the big first stage that takes off the ground than the light top stage that manoeuvres us in space. We have built a rocket together, we have sent all the stages, we check that everything is right, we’re happy with the rocket. We take it out to the launch pad, then we get the green for the final countdown: 3, 2, 1, Lift off! The first stage engines ignite and the rocket takes off in a boom of noise and light. So, the rocket flies up in a trajectory or a path to space that we’ve predefined for it. It’s vertical at the beginning, and then lifts over horizontal – a manoeuvre we call a gravity turn. It rushes through the atmosphere, and then, as soon as it is out of the atmosphere, we can drop the fairing around the satellites because there is no more air drag on them. Then it keeps flying upwards dropping stages each time one is empty of fuel, and then eventually getting into space, and getting to position where it releases the satellites at the places they need to be. The final stage of the rocket will manoeuvre itself into a safe orbit to avoid any kind of collisions with any other spacecraft.

**How fast can a rocket go?**

Now, this is a really great question because how fast a rocket goes is linked to what the satellite is going to do that it’s taken into space. So for example, Europe’s Ariane 5 took the Automated Transfer Vehicle or the ATV to space so that it could deliver supplies to the International Space Station. In order to get to the space station Ariane 5 gave the ATV a speed of 7 kilometres/second. ATV was 20 tonnes at lift-off. If we want to go a bit further up, so for example, geostationary orbit, where the telecommunications satellites are, 36000 kilometres up, then the rocket needs to give that satellite 9 kilometres/second to what we call a geostationary transfer orbit that will set it on the path to its final destination. Ariane 5 can take 12 tonnes up to 9 kilometres/second. If we want to go even further, to the moon for example, then we want to go on what we call a lunar transfer orbit, again on the path towards the moon, and to put a satellite on a lunar transfer orbit the rocket needs to be going over 10,5 kilometres/second, and that’s what Europe’s new rocket Ariane 6 will be doing when it delivers a lunar lander around the moon. Now, if you want to go even further, we have the escape orbit which means leaving the gravitational traction of the Earth and going out into the Solar System. In order to reach an escape orbit, the rocket needs to be going at 11 kilometres per second. This is exactly the speed that Ariane 5 gave the Rosetta comet chaser mission back when it was launched in 2004. Rosetta was only 3 tonnes at launch. For our last question, I am being helped by Tom here. Tom what’s the last question?

**Can a rocket lift-off from another planet?**

This is another great question, and the answer is yes, of course it can! And in fact, we’ve already done it. When the United States landed on the Moon over 50 years ago, the craft they landed on was in 2 parts: one part that stayed on the moon, the second part lifted them off the Moon, into orbit and back home to Earth. This is what I love about rocket science and about science in general is that the same rules apply everywhere. The rules we have today for designing and building rockets apply wherever you want to launch from – all you need to know is that the heavier the planet we’re on is, the harder it is to get into space. But to make all these ideas a reality, to launch from Mars, to make our own propellant, we need new rocket scientists, like Tom here, and like you, to make these ideas a reality.