

Science, Innovation and Technology Committee

Oral evidence: Asteroids and planetary defence, HC 1071

Tuesday 24 June 2025

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[Watch the meeting](#)

Members present: Dame Chi Onwurah (Chair); Emily Darlington; Tom Gordon; Kit Malthouse; Jon Pearce; Dr Lauren Sullivan; Martin Wrigley.

Questions 1 - 79

Witnesses

[I](#): Dr Sarah Crowther, Research fellow in Planetary Science, University of Manchester; and Professor Chris Lintott, Professor of Astrophysics and Citizen Science Lead, University of Oxford.

[II](#): Dr Cyrielle Opitom, Chancellor's fellow, University of Edinburgh; and Edward Baker, Planetary Defence lead and Programme Manager, National Space Operations Centre, UK Space Agency.

Examination of witnesses

Witnesses: Dr Crowther and Professor Lintott.

Q1 Chair: Welcome to the Science, Innovation and Technology Committee's one-off investigation into asteroids, their detection and potential impact and why they matter. We are going to talk about the science of detection and potentially deflection, and all the other aspects of asteroids, but I want to start with an open question to each of our witnesses for this panel. What are we talking about here? What is the worst-case scenario of an asteroid impacting the Earth? Could they represent a credible threat to the human race, or a substantial portion of it? I ask Dr Sarah Crowther to start, and perhaps you could introduce yourself at the same time.

Dr Crowther: Good morning. I am Sarah Crowther, a research fellow from the University of Manchester. I work in planetary science, so my research primarily focuses on lab-based analyses of extraterrestrial materials. That is things like pieces of meteorites and samples collected by various missions that we have here, on Earth, in the lab. We can do analyses on those.

In answer to your question, yes, asteroids pose a credible threat and could be catastrophic. The good news is that there are no known serious threats for at least the next 100 years. We know that in the past the Earth has been hit by asteroids. The dinosaurs became extinct due to an asteroid impact. There is potential in the distant future, in terms of our lifetimes, that something could happen.

Q2 Chair: Thank you very much.

Professor Lintott: Good morning, everyone. I am Chris Lintott. I am professor of astrophysics at the University of Oxford, although I am currently talking to you from a borrowed office at the University of Warwick, where I am filming for the BBC's "Sky at Night" programme today.

My involvement in the subject is that I am an observational astronomer. I play with telescopes, particularly on large surveys designed to conduct a census of what is out there. That includes discovering populations of asteroids, and in particular asteroids that might threaten the Earth. My own work is on interstellar objects—asteroids from other solar systems, which are unlikely to pose a threat.

To add to what Sarah said, there are a couple of characteristics of the asteroid threat that make it unusual. The first is that the impact could be very large. We are talking about something that could threaten life on the planet, or indeed our civilisation, although we think that things large enough to do that hit only once every tens or hundreds of millions of years. We have a high risk but a low probability. Our systems of thinking about risk are rather poor about doing anything about that.



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The second thing that is unusual is that this is a natural disaster that we can do something about with new technologies, as I hope we will discuss today. We are beginning to get the hang of dealing with the threat, so it may be a risk that we will be able to retire in the next 20 to 30 years or so.

Q3 **Chair:** Thank you very much. As you say, we are talking about something which is a high risk but a low probability. Putting that a little bit more in context, you mentioned the extinction of the dinosaurs, Dr Sarah Crowther. How long ago did that happen? Did you say we are talking about an existential threat event every 10 million years or so?

Dr Crowther: I forget exactly when the dinosaurs—when that impact was.

Q4 **Chair:** I am told it was 66 million years ago. If we are talking about a one in tens of millions of years threat, haven't we gone tens of millions of years since the last one? Is it also the case that there may be bodies outside the solar system which could hit the Earth and which we would have less knowledge of?

Dr Crowther: Yes. There is a really nice summary graphic that NASA has produced that I can share with you afterwards. It summarises the different sizes of asteroids, how many there are, how frequently they are likely to hit the Earth and what sort of impact they would have. According to their numbers, we are talking about something that could cause global devastation roughly about once every 500,000 years. Yes, we have gone further than that, but that is probability. Just because it is the probability doesn't mean that it absolutely will happen.

Things from outside our solar system are more Chris's field than mine.

Professor Lintott: Interstellar objects are rare enough that we do not have to fear those. It is mostly asteroids. Maybe we should set the scene geographically. Most asteroids in the solar system exist in the asteroid belt, which is between Mars and Jupiter. They become disrupted usually by encounters with either of those planets. They can move into orbits that cross the Earth, and then it is just a case of whether we are in the wrong place at the wrong time.

It is the smaller asteroids that happen to hit us more frequently. For example, if something about 5 or 6 metres across hit the Earth it would cause an explosion about the same as the nuclear device dropped on Hiroshima. Those impact the Earth about once every five years. I think that number is shocking and it is really high if you haven't heard it before, but that is because most of the Earth is ocean of course, so we do not see those impacts and there hasn't been an impact that has caused a death. That gives you the baseline threat from these things.

Bigger asteroids are about 50 or 60 metres across. In the slightly disturbing jargon of the people who work in this area, they tend to be called city-killer asteroids, which would be enough to threaten whatever



they landed on and perhaps to require evacuation if we could predict them. Those numbers are a little difficult, but maybe between every few hundred years and every few thousand years. A lot of the attention has been on trying to discover whether we can detect the population of things of that size and then do something about them, if we knew, for example, that there was going to be an impact in a decade or in 20 years' time.

Q5 **Chair:** Indeed, towards the end of last year a near-Earth asteroid YR4 was detected in December. The initial concern was that there was a 1% chance of it hitting the Earth, which to me sounds very large. Indeed, the fact that a city-killer asteroid could hit the Earth every five years, as you say, sounds very concerning. That YR4 is no longer thought so likely to hit the Earth, but it is thought that it might hit the moon. What kind of impact might that have?

Professor Lintott: YR4 was a really interesting test case. It is the first time we have had a substantial asteroid. It is about 50 metres across and, as you say, there was a few per cent chance of it hitting the Earth. It was discovered in December. Further observations, which help us to refine the orbit, to predict where it is going to be in the years to come, raised the probability up to about 3%, before observations showed definitely that it will not hit the Earth in the next few decades.

There is currently a 4% chance that on 22 December 2032 it will hit the lunar surface. You may have seen some press coverage of a new paper out in the last couple of days that looks at secondary impacts. If it hits the moon, bits of the moon could fly into space. If this thing hit the moon, it would create a crater about a kilometre across, as well as great excitement for astronomers who have longed to see the process in action. There is some small chance—it really is in the low hundredths of a per cent—that some of the debris may end up impacting the Earth. While that would not impact us on the surface, there are threats to satellites and so on.

There are two things to draw from the YR4 story. One is that the system worked. We detected it, with nearly a decade's notice. International follow-up observations were quickly co-ordinated to allow us to determine what the risk was. The second thing is that the story about whether it hits the moon shows that there are non-linear effects, and that we cannot predict exactly what is going to happen across quite a complex system, so continued calculations and vigilance are needed.

Chair: Thank you very much. We will get into more of the detail of that complex system now.

Q6 **Kit Malthouse:** I was going to ask a little bit more about YR4, but you said previously—did I hear rightly?—that an asteroid 5 to 6 metres across hits the Earth on average once every five years and they are plunging into the ocean, and we are just not observing them. If a nuclear bomb was dropped into the ocean, you would spot it. Is it really that frequent? It sounds quite frequent to me.



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Professor Lintott: Yes. It is the effect of the atmosphere as well. As we will go on to talk about, Sarah's expertise in the composition of these things is crucial. Whether these things are stony or made of iron or rubble piles will make a big difference. Going from size to size of impact is rather difficult. It is true that based on the population that we see encountering Earth, that is about the right number; things about 5 metres across hit every five years or so.

The most recent example of damage being caused was an impact called Tunguska in Siberia in 1908. Luckily, it was an uninhabited area, but trees were knocked down over quite a substantial radius, hundreds of miles from the impact site. That impact is believed to have been an airburst, something that exploded in the atmosphere. We see evidence of these things in the historical record, but I think we have been lucky in the last 50 years that we have not had a substantial impact on land.

Q7 **Kit Malthouse:** That was going to be my next question. What does that say about the probability of it hitting the land? If you combine the once-every-five-year incident with the fact that the Earth is, whatever it is—

Professor Lintott: Two thirds water.

Q8 **Kit Malthouse:** What is the likely frequency of an asteroid of that size? I have seen pictures of the one in 1908, which was a pretty huge impact. How often can we expect one of those to hit land?

Professor Lintott: I think it is every few decades. There was a 2012 impact in a place called Chelyabinsk, by coincidence also in Siberia. There were about 500 injuries, mostly from a blast that shattered windows and so on. There is a lot of footage from dashcams and amateur recordings that showed the kind of impact it would have if it came in over a city, so there is some risk.

Q9 **Kit Malthouse:** Obviously your primary concern is about asteroids hitting the Earth. You have talked about YR4 hitting the moon and there being possible impacts. Should we be concerned about a significant impact on the moon affecting its relationship orbitally with the Earth?

Professor Lintott: It is a good question. Calculations have been done for YR4, but the difference in size between even the largest asteroids that cross the Earth's orbit and the moon means that that system won't change, so—

Q10 **Kit Malthouse:** Forgive me. If, say, an asteroid of city-killer size was heading towards the moon, and was therefore going to impact on the moon, would that have the potential to divert its orbit, with a devastating impact on, for example, tides and all the rest of it in the UK?

Professor Lintott: No. The moon gets hit by these things reasonably frequently with no change to its orbit. You would get some excited astronomers and we would have to worry about the secondary risk, but there is no change to the lunar orbit.



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Q11 **Kit Malthouse:** This is my final question. How much of a shield for the Earth is the moon?

Professor Lintott: That is a very good question. It is true that, because the moon exists, we get hit with much less frequency—about 60% less frequently. People have used that theoretically to argue, for example, that if we look for life elsewhere in the universe we should look for planets with large moons so that they have a similar protective power. We should be grateful that it is there.

Q12 **Kit Malthouse:** The presence of the moon reduces the probability even further of something hitting us.

Professor Lintott: Yes, but that is included in the numbers that I have given you. Without the moon, you could increase those. Our solar system also benefits from Jupiter, which does quite a good job of removing asteroids from the solar system when they encounter it.

Chair: It is fascinating to understand the planetary impacts on protecting our planet.

Kit Malthouse: It is not just that, to be honest with you. It is an interesting theory about the evolution of life on Earth that part of the coincidence is that the alignment of the planets and the moon, not least the effect of the moon on tides, meant that organisms in the sea found a way of existing. They had to because of the movement of the tides. Anyway, that is for another day: the theory of life on Earth and its random nature.

Chair: All human life is in this Select Committee.

Q13 **Emily Darlington:** Just before I move on to how we measure all of this and what amazing bits of kit you guys get to play with, does the moon attract the asteroids because of a gravitational pull?

Professor Lintott: Yes, but it also literally just gets in the way.

Kit Malthouse: Because it goes around so frequently.

Emily Darlington: Yes, but it's not that fast.

Professor Lintott: If you imagine a near-Earth asteroid on an orbit that crosses the Earth's orbit, such that every time it comes round there is a chance that we get in the way, there is also a chance that the moon gets in the way. It ends up taking about half the impacts that we would otherwise have suffered.

Q14 **Emily Darlington:** It is interesting that the moon is smaller, yet it gets hit more frequently than we do, so there must be something different about the moon.

Professor Lintott: There is a detailed study which I can share. There is an event called gravitational focusing, which means that you are more likely to hit such an object. By the way, I believe there is a fire alarm test



happening in the background. If you can hear an alarm, apologies for that.

- Q15 **Emily Darlington:** I want to know a little bit about the kit you guys use to really understand this. Sarah, how are we placed in terms of science and kit in the UK? What kind of kit is it and what kind of scientists are we talking about?

Dr Crowther: For analysing the asteroid samples, whether those be meteorites or samples that have been returned by missions like the NASA OSIRIS-REx mission or the Japanese Hayabusa missions, we are in a good position. We have researchers who were part of the mission teams for those three asteroid sample return missions.

We study them in exactly the same way that we would study terrestrial rocks. Many planetary science researchers are based in geology or Earth science departments, and we use the same techniques. We just have to remember that the material is limited. If you are studying something about volcanos or other rocks on Earth, you can go and collect bucket loads of it and study as much of that as you want. If we are studying samples from asteroids, we may have only a few milligrams. That might be all there is from a particular meteorite sample.

We have to use techniques that are really sensitive so that we can get the most information possible out of the smallest amount of material. People use techniques like microscopes, electron microscopes in particular, to look at what the material is made of and what minerals and things are there. We use mass spectrometers to look at their chemical compositions, from which we can do things like date how old the rocks are and work out their histories and whether they come from an asteroid that is what we call a rubble pile, which means it may have been a large, single rock originally but at some point in its history it got broken up and then loosely reconsolidated under its own gravity. In particular, in my research, I just study the noble gases in the meteorites. We use very sensitive mass spectrometers to measure the noble gases. In fact, the one I use at the University of Manchester is unique. It is the only instrument of its type worldwide.

- Q16 **Emily Darlington:** Fantastic. What does it tell you, not just about the meteor, but about life on Earth or life potentially elsewhere in the universe?

Dr Crowther: Yes and no. No, because we have never found evidence of life anywhere else in the solar system, but we believe that some of the asteroids delivered the key ingredients for life to Earth. There is a particular type of material that we call carbonaceous chondrite that is rich in organic compounds, water, volatile compounds and species, all of which are essential key ingredients for life. We believe that those ingredients were delivered to Earth by asteroids in the early solar system.



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In particular, recent analyses of the samples from asteroid Bennu, which were collected by NASA's OSIRIS-REx mission, found that it contained the conditions where the key building blocks of life were produced. They found evidence of all the amino acids that are used by proteins, as well as the nuclear bases of DNA and RNA in the Bennu samples. Those are the key building blocks of life that we think were delivered to Earth by asteroids.

Emily Darlington: Fascinating.

Q17 **Chair:** Why were they on the asteroids and not on the Earth to begin with?

Dr Crowther: That's a good question. Early in the solar system's history the Earth melted, and it formed a metal core and the rocky surface that we are stood on. That meant that all the building blocks of the original Earth got mixed up together and their signatures got lost. They may have been there, but their signatures may have got lost in that early processing.

Some of the asteroids never got hot and melted, so they are like time capsules from the beginning of the solar system. We can see the very first solid materials that formed in the solar system in those asteroids. I have brought a couple of examples if people would like to have a look at them.

Kit Malthouse: Oh, yes.

Dr Crowther: In one of them you can particularly see the very first solids that formed in the solar system.

Chair: We want to see the origin of the universe.

Q18 **Kit Malthouse:** I have a follow-up to Emily's question. Why is this unique spectrometer in Manchester?

Dr Crowther: That would be down to my boss. The research group in Manchester at the time originated at Sheffield University. Some of the original work that Professor Grenville Turner did was dating the Apollo samples. He was one of the first people to get Apollo samples and one of the first people to determine ages for them. In the mid-1980s, the group moved to Manchester University, and my current boss, Professor Jamie Gilmour, took over the instrument that they had started developing in Sheffield.

Emily Darlington: Is this a UK—

Q19 **Kit Malthouse:** I'm sorry to interrupt, but does the world then flock to your door to use this instrument?

Dr Crowther: I'm not sure "flock" is the word, but we have international collaborators who come to use the instrument because we can do



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analyses on really tiny samples that could not be done anywhere else in the world.

Chair: That is a fascinating and quite inspiring example of investment following excellence and then leading to more scientific research excellence. An interesting journey, but back to Emily.

Q20 **Emily Darlington:** That is absolutely fascinating. Dr Sarah, you have now made me think about the probability of asteroids hitting other planets that may bring—

Kit Malthouse: Time capsules.

Emily Darlington: —little time capsules to them. Even if there is no life there yet, there could be life created.

Dr Crowther: Yes, and we can see examples of asteroids hitting other planets. The Martian rovers have seen meteorites made of metal on the surface of Mars. We have pictures of those from the Martian rovers—I forget exactly which one—so we know that meteorites have hit other planets. Yes, in principle they could have delivered those key ingredients, but you also need the conditions where those ingredients can flourish and ultimately produce life. They didn't deliver life; it was just those ingredients. Having the ingredients does not necessarily lead to life.

Q21 **Emily Darlington:** It's fantastic. Professor Chris, this is a similar question. What is the kit that you are using to spot these asteroids? How are you measuring their trajectory? How are you understanding their composition before they hit the Earth, if that's possible, or predicting it? Where are the UK's strengths in that?

Professor Lintott: This is a very good day to be asking that question because yesterday we had the first images released from a telescope called the Vera Rubin Observatory, which is in Chile and is an American facility with substantial contributions from all of the UK astronomers' operations. We are a major part of the survey.

One of the reasons to build that telescope is that it has a huge field of view. It covers a large part of the sky at once, and it will be brilliant at spotting these asteroids. We predict that in the course of the survey, which is the next 10 years starting in the next month or so, we should find about 180,000 near-Earth asteroids—those that cross the Earth. That is an increase on the current number of about 35,000. We will have found about 70% to 80% of everything that is 150 metres and higher. This is the technology that will give us a census of things that might hit the Earth. That is discovery where, here in the UK, we are playing a leading role through colleagues at Queen's University Belfast, in Edinburgh and many other institutions. We now have this new tool for discovery.

Follow-up is globalised. As soon as one of these things is discovered and seen to be potentially a threat, pretty much every telescope on the planet moves, including the European Southern Observatory, to which the UK is



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a major contributor. We only ever see these things as points of light that are moving. We can work out their orbit. We can work out their colour. The colour sometimes tells you what they are made of. That is the first clue as to whether they are stoney meteorites or, like Bennu, which the OSIRIS-REx explored, a rubble pile. Distinguishing them is very important if we get to thinking about intervention and stopping them hitting. We might see them change in brightness. That gives us an idea of shape as well as size.

The astronomy piece is a strength and, as Sarah talked about, we have world-leading expertise on the ground studying existing samples of meteorites that have come to Earth. Where we are less strong compared to some of our competitors is in the observational study of the objects while they are in space. Other countries have invested, for example, in radar systems that can, for very near-Earth asteroids, give you a shape and a size definitively—crucial for near-Earth asteroids—or in the study of particular populations that might impact the Earth, which is not something where we have typically invested in this country.

Q22 Emily Darlington: When you say it will be able to detect near Earth, how far away is that in terms of years?

Professor Lintott: My apologies. Near Earth means that it has an orbit which crosses our own. That is a potential impact.

Q23 Emily Darlington: Days away or years away?

Professor Lintott: We would want to discover these years away, for sure. The idea is that in the next few years, with Vera Rubin playing a major role, we would like to be able to have a complete census of everything that is 150 metres or more across. We can predict for about a decade how these things will move, based on current technology and data. That would give us maybe five to 10 years' warning of any impact of something that large.

We haven't yet mentioned the recent DART mission, which carried out a test on impacting an asteroid and deflecting it. We think something like a five to 10-year timescale would allow a deflection mission to take place if the space agencies of the world were able to co-ordinate such a thing.

Emily Darlington: That is probably a pretty good place to hand over to Kit. I know he has DART questions.

Q24 Kit Malthouse: I was going to ask about DART in the second panel, but I have a question for you, Professor, about the predictability, following Emily. Is it feasible that some massive chunk of rock could come slicing through the universe at enormous speed, effectively evade the gravitational pull of the various planets and the sun, and slam straight into us? What kind of speed notice would we be talking about? My assumption is that there are things winging across the universe that are so large and so fast that there is not a lot that the planets can do to deviate the course.



Professor Lintott: One of the things that we want to investigate with the Vera Rubin Observatory is interstellar objects, where we do not really know what the flux may be. The thing you have to bear in mind is that space is incredibly large, which sounds silly, but it is fundamental. The odds of anything coming from beyond the solar system and scoring a direct hit, on a first pass through the solar system, on the Earth are minuscule. The background threat from asteroids in the solar system far outweighs anything from beyond. We should worry about things in the solar system first.

We have blind spots with asteroids coming on orbits that head towards Earth from the direction where the sun happens to be. We obviously cannot search for asteroids close to the sun. One of the solutions to that is the switch from optical telescopes, using the kind of light that our eyes are sensitive to, to infrared telescopes, which can do a better job of spotting asteroids wherever they are in their orbit. There is an American mission called NEO Surveyor, which is a space telescope that will contribute to that and will complete our census. It is due for launch in 2027, but it is obviously subject to—let's say—current uncertainties in US budgeting. That is a place where we are entirely reliant on the US. No one else has plans to do an infrared survey of that sort.

Q25 **Chair:** To follow up on that, to get an idea of the risk, you talked about being able to identify 90% of NEOs—near-Earth objects—larger than 140 metres, which is very big and a huge risk. The expectation is that that will still leave 10% of them unidentified and unrecognised. Do you have an idea of how many that is?

Professor Lintott: Yes. We think it would be about 20,000 to 30,000 if our estimates of the population are correct. That is based on the 10-year survey with the new Vera Rubin telescope. That is the current plan. It has been shown that by extending the survey one could do better than that.

Another aspect that is hard to understand is that there is a sense that astronomers are good at this and when we find something we will know its orbit forever. Actually, the push and pull of the gravitational attractions of the other planets means it is very hard to predict these things a long way in advance. The sun and sunlight has an effect on the asteroids as well, so we will need continual monitoring even after the end of the survey to keep track of these things and to assess any risk that we find.

Q26 **Chair:** You diplomatically suggested a concern regarding funding in the US for programmes. Can you say a little bit more about that?

Professor Lintott: Yes. In general, in this area, we have depended on a small number of crucial facilities. I mentioned the NEO Surveyor mission. Vera Rubin is now successfully funded, thanks in particular to support from UKRI, and is playing a vital role; but, for example, recently we lost the capabilities of the Arecibo radio telescope in Puerto Rico, which was the main facility doing radar work. When one of these asteroids comes



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near the Earth, you can use radar to get a sense of its size, shape and composition. Arecibo collapsed a few years ago and has not been replaced. It is an example of where we have been relying on a single country to fund infrastructure that forms part of planetary defence that helps us all understand the threat from these things. I am concerned that the funding is always dependent on national priorities in this area for what should be, and will need to be, an international effort if we ever discovered something that was threatening.

Q27 Chair: We recognise that concern. It is a concern around public sector funding. There is commercial interest in asteroids. To what extent do asteroids matter in terms of their potential and opportunity for commercial mining?

Professor Lintott: Maybe Sarah could talk first about the kinds of things that we might find in the asteroid population that we would want to mine, and then we can both perhaps speculate on the possibilities.

Dr Crowther: We know that some of the asteroids are rich in metals. One of the pieces of meteorite that has been passed around, as you will have noticed, was basically a lump of iron. Metals like that on Earth are generally in the core. The amount of metal in the crust is quite rare. Mining on Earth, particularly of some of the precious metals on which we are so reliant for technology, phones, computers and so on, is difficult. There is a limited supply.

In some of the asteroids there are relatively high concentrations of metal, which may have been in a core, like the meteorite that I passed around, but that has since broken up, so it is more easily accessible in the asteroid. Some of the other asteroids never got hot and melted, and you can still see the metal mixed up among the rocky material. The metals, and the precious metals in particular, are there, but the technology to mine them is still a long way off. We sent people to the moon in the 1960s and 1970s. We have not progressed beyond there. In fact, right now we cannot even do that. The technology advances that we need to be able to mine asteroids and make that financially viable are still a long way off.

Q28 Martin Wrigley: I am glad you mentioned that, because when I look at the piece you passed round, it seems like remarkably pure metal. It may be a mix of metals, but I am surprised it is not like iron ore. Why is it real metal, and not an ore?

Dr Crowther: That is predominantly iron, with a little bit of nickel in it. You might have noticed that it has some criss-crossy patterns in it. They are real, not scratches. They are two different minerals, containing iron and nickel, that have crystallised out. It is pure metal because it came from the core of an asteroid that got hot and melted. The metal is heavy and it sank to the middle and formed the core, exactly as happened on Earth. The lighter, rocky material rose to the surface. It then cooled down



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and became solid and, at some point in the solar system's history, it broke up, probably owing to an impact with another asteroid.

Chair: Fascinating.

Q29 **Dr Sullivan:** Wow, this is really exciting. I am so grateful that you guys are here. On the threat to funding for these international programmes, and looking into the future, can you imagine who would own those asteroids, for that mining space? Where do you think we need to be in our world view of that?

Dr Crowther: There is already some space law, if I can call it that. I don't know the details, but there is a UN office for space law and in the UK there is a space Act from 1960-something; sorry, I didn't make a note of it. The gist of the UN law is that nobody owns objects in space, and they must be used for the benefit of all countries and all mankind. For example, we could not lay claim to the moon or to a particular asteroid. If it got to the stage of mining, that would be tricky. I don't know how it would work out.

Professor Lintott: About a decade ago, a couple of commercial companies were established with the aim of carrying out test asteroid mining. None of them got very far, because of the cost of access to space, although that is a field that is evolving rapidly. The argument used at the time was that, while, as Sarah says, the outer space treaty requires anything in space to be used for the benefit of mankind, there was case law or at least accepted practice that countries that had gone to the moon and returned samples made use of them as they liked, without regard to that proposition. The argument was that asteroid mining would be fair game under the treaty. You would need a lawyer, or perhaps your next panel, to disentangle that.

There is a slight problem with the economics of it all, as well. It has been stated that one of the asteroids one might want to go to is particularly rich in platinum, and you would then certainly have enough platinum to make money, except that there is so much of it in one of those asteroids that you would instantly collapse the price of platinum here on Earth.

Asteroid mining is often talked about in terms of resources, should there be more space flight into the outer solar system, towards Mars or perhaps even further. In that sort of science fiction scenario, one often thinks of asteroids as providing stuff one might need, like water, for both rocket fuel and human consumption. For that sort of scenario, we need to be in a world in which the cost of just getting stuff off Earth is dramatically reduced. Some of the people who work in commercial space flight will tell us that we are heading rapidly towards that world, but I am still reasonably sceptical, and I suspect that it will remain science fiction for at least the next 30 to 40 years or so.

Q30 **Dr Sullivan:** Off the back of that—science fiction and engaging with the public—this is a topic that captures everybody's imagination, so would



you be able to tell us a bit more about your Zooniverse, which you launched in 2008, and how that has helped science?

Professor Lintott: I can, and perhaps I could talk about citizen science more generally. Astronomy, and in particular the study of small bodies in the solar system, is an area where the public have contributed. Zooniverse, which we run in Oxford with collaborators, is a platform for what we call citizen science. People can log on and take part in about 200 projects, from classifying galaxies, to discovering planets, to a host of non-astronomical things. The relevant piece is that we have a partnership. In fact, Zooniverse is part of the UK's contribution to the Vera Rubin observatory project. We have used it as part of our buy-in to get access to the data, and we will ask volunteers to look through the data released by the telescope and, in particular, to keep an eye on asteroids for signs of activity, to see if they are becoming comet-like, as a clue to composition and how they evolve.

There are other aspects. There are several amateur observatories in the UK that contribute to the follow-up of minor planets, and the international effort to track these things. I want particularly to highlight the UK Fireball Alliance, which places cameras around the country, particularly working with schools, to look for meteorites that might land in Britain. It is nothing threatening, but it is an effort to connect what we see in the sky to things that land on Earth, and to close that loop.

Q31 **Chair:** That is fascinating. We have not really talked about the number of asteroids that land without doing any damage, but which could be picked up and identified by schoolchildren. Is that a significant number?

Professor Lintott: Sarah will probably know the numbers. A lot of small things hit the Earth all the time. Of course, most burn up in the atmosphere. We had a famous fall in the UK, at Winchcombe in the Cotswolds a couple of years ago, which produced a magnificent carbonaceous chondrite, a particularly old type of asteroid, which tells us about the formation of the solar system. Samples from it are on display at the Natural History Museum and, indeed, in Winchcombe. We could do more of that; we want to be able to go from seeing something in the sky to connecting to the composition, sort of connecting my world and Sarah's, or the dot that you see in the telescope with the thing you have in the lab. If we can find more samples as they land, it will help with that effort.

Q32 **Kit Malthouse:** Can I ask a couple of follow-up questions? Dr Crowther, we talked about beneficial materials. Is it possible that one of these things could hit the earth with something really unpleasant on it, like isotopes or polonium 210, that lands and spreads?

Dr Crowther: To the very best of our knowledge no. They are made up of the same elements that we have on Earth. There are no elements in the asteroids that we do not have on Earth. Some of the minerals are a bit different because minerals form from combinations of elements that



depend on things like temperature and pressure. The ratios of isotopes—the different types of a particular element—can vary, but there is nothing dangerous about them. People often think they are going to be radioactive, but they are not. They contain the remnants of radioactive elements that were around in the early solar system, but that is how we can date them and determine how old they are. There is nothing harmful to us in them. When you see pictures of people handling the samples in their white suits, or working in a glove box, that is to protect the sample from the people, not the people from the sample. We don't want to get our greasy fingers on it, or sneeze on it.

- Q33 **Kit Malthouse:** Are you able to detect the levels of radioactivity in these things at a distance? When they are winging their way towards Earth, do your instruments allow you to detect that?

Dr Crowther: I don't know that, but they are not radioactive.

- Q34 **Kit Malthouse:** I think the colour will tell you something about the composition, but is there any other metrology that allows you to—

Professor Lintott: In theory, if we could get spectra, we would have some sense, but we are talking about broad categories. We would know if something was very unusual, because we have connected the common things that we see—asteroids of particular colours and spectral types—to meteorites that we have on Earth. Most of them are fairly well categorised. If there was something spectacularly unusual, of the type that you are suggesting, I think it would stand out. Whether we would know why it stood out, I don't know. We did a fun project a few years ago when Elon Musk launched a car towards Mars in a test of one of his rockets. We checked that the car stood out in our data, and that we were able to distinguish it from the natural background population. It sounds silly but it gives us a sense that we would spot anomalies. I think we would know that there was something unusual about a particular system, but we would not necessarily know what it was.

- Q35 **Kit Malthouse:** Can I have just one more question? The public are not very good at understanding probability, which is why we have a national lottery. Could you give us an illustration of size and probability? If the known universe that you are examining is a football pitch, what are we on that football pitch? Are we an atom, a ladybird or a football? What kind of comparative size are we?

Professor Lintott: That is quite a difficult question in this context, because everything is moving. We are a tiny fraction of the solar system, so if you take your football pitch analogy and we, say, put the orbit of Neptune around the edge of the pitch, we are something like a peppercorn a few centimetres from the centre spot. That gives you the scale, I think. I said earlier that space is big, which may not be the most profound thing ever said to a Select Committee, but it is important here.

I want to comment on your point that the public and, indeed, all of us humans are badly wired to think about probability. The 2024 YR4 was a



great news story, because the papers could update each day with a new percentage as to whether the thing might impact, but I don't think we are well equipped to talk about a 3% risk of impact. If I tell you there is a 97% chance of a pay rise, most people will have gone and spent the money already. If I tell you that there is a 3% chance that you are very ill, you take it very seriously. As we find more of these things, and maybe we live in a world where there is always an asteroid with a 1% chance of hitting us, because it has just been discovered and the processes are playing out, we will need to find a better way of talking about it.

Chair: That is exactly what Tom is going to lead off on now.

Q36 **Tom Gordon:** We have all seen big Hollywood movie takes on asteroid threats, from "Armageddon", which I fondly remember watching when I was a little kid—sorry to make anyone feel older—to "Don't Look Up" a few years ago. Are such films helpful in raising awareness, or do they end up tipping people over the edge into panic buying and bunkering down?

Dr Crowther: I haven't actually seen "Don't Look Up".

Tom Gordon: I highly recommend it.

Dr Crowther: I have seen "Armageddon". It is a mix. You have to allow people a bit of storytelling, to make a good film or TV show, so those things often have a basis or background of true science, but they have to embellish a bit to tell a story. Personally, as long as it is vaguely believable that it might happen in the future, I don't have a problem with it, but I know that some people get very wound up about picking apart everything that is wrong with these movies. From my point of view, if these types of movies or TV shows get people, particularly young people and children, interested in pursuing the study of science and, potentially, a career as a scientist, they are really important.

I am tempted to repeat a colleague's remark that the most unrealistic thing about "Don't Look Up" is that the senior professor does the calculations himself, instead of getting students to do it for him; obviously there is some work to be done.

They are useful in raising a broad understanding of the topic, but I think there is one thing that is dangerous about the stories they tell, although I understand why it is done from a storytelling perspective. It is that these things are always handled at the level of shady Government organisations. The astronomer picks up a phone and the Government or the military turn up, and then it is secret; and there is always a big discussion about who to tell, and when. The one thing I would want to get across to the public is that this has to operate in the opposite way because, long before we know that an asteroid is the kind of threat we would want to bother a Government with, we will have had to co-ordinate observations around the world with other astronomers.



A realistic version of these films would always have things playing out in public. That is a really important message to get across, because that is where we build trust, I think. Anyone can go to the web pages maintained by the European Space Agency or NASA and look at the current list of known asteroids, and the threats that we think exist. If films portray a secretive world, I think they are doing some damage, even if it makes for better stories.

Q37 Tom Gordon: To follow up on that, Professor, there is a quote in the film "Don't Look Up" from Meryl Streep's fantastic Trumpesque president character. She says, "I hear there's an asteroid or a comet or something that you don't like the looks of. Tell me about it, and then tell me why you are telling me about it." With that in mind, could you explain a little more about the role played by communicators such as yourself in engaging with the public about asteroids and planetary science?

Professor Lintott: The 2024 YR4 was a really good example of that, because there is strong public interest. I think people know it is a threat and want to understand it. Our role is twofold. One part is translating what, as we have seen in this Committee discussion, can become a discussion full of numbers and probabilities that get technical quite quickly into statements that people can use: essentially, should I worry about this over my cornflakes or not? I think we can do that.

The second thing, which is one reason I like this area and have moved into working in it a little, is that it is a good place for us to communicate, particularly with young people who are considering a career in STEM or science, that it is a place where discoveries are being made. It is not textbook science, but stuff that is changing rapidly. We can use the hook of the asteroid that did for the dinosaurs to talk about the wonderful science that Sarah and her colleagues are doing, and the potential for discovery with telescopes like Rubin. These are good stories for us to tell.

Q38 Tom Gordon: Is there anything you want to add to that, Dr Crowther?

Dr Crowther: I guess the kind of public engagement work that I do is a bit different from Chris's. We do a range of family science fair-type events. I see it as really important to engage children and the parents with them, so that the parents are interested, to inspire the next generation of children, who might want to make that fantastic discovery, or who might stop the asteroid that is a threat in the future. We have a great topic. We go to these events with those meteorites, and more. We offer people the chance to hold them, and we get their interest and engagement easily.

The difficulty is in maintaining that. By no means am I criticising schools and teachers. Schools have a very prescriptive science curriculum. They have to do chemistry, physics and biology, which are distinct and separate subjects in how they are taught. That does not really give an opportunity for all the places where they overlap, or all the topics or fields where you use those sciences without studying them directly. It is



important to get young people and children to be aware that they can study these things in future.

- Q39 **Tom Gordon:** Thank you very much. The final one from me is, again, another quote from “Don’t Look Up”: “You cannot go around telling people there’s a 100% chance that they’re gonna die.” To what extent can rare event statistical modelling, of the sort that predicts a 1% likelihood scenario, be effectively communicated to the wider public, and how does it affect understanding and decision making in the event of an asteroid threat?

Professor Lintott: It is difficult, but we talk about specific examples. The abstract threat is very hard, but the stories of YR4 and Bennu are compelling. The UN has designated 2029 the international year of planetary defence, timed with the close approach of an asteroid called Apophis, which will swing only 30,000 kilometres away. It will be visible to the naked eye from the UK as it goes overhead in April. That might be an event we can use to talk about the fact that we are understanding and tracking these things, and taking action.

- Q40 **Chair:** The film “Don’t Look Up” included the scenario of a mad tech billionaire trying to stop the asteroid being deflected, because of its rich mining potential. I think you are saying that that is unlikely, for commercial reasons, for some time to come.

Dr Crowther: I would say so.

Professor Lintott: Yes; let’s hope I am right.

Chair: No examples of that potentially spring to mind. Thank you so much. Before we finish the session, I want to ask each of you for your top three asks of the UK or other Governments.

Emily Darlington: I have a question to ask just after yours.

Chair: We are coming to the end.

Emily Darlington: It is related, in terms of funding. In addition to the top three funding asks, this is your pitch. Obviously, we have increased science funding but there is still a limited amount. Why should it go to something that has such a small probability of happening, versus something like climate change research, which we definitely know affects people today?

- Q41 **Chair:** Great, so what would be your top three asks of the UK Government, for resources, support or facilitation—it does not necessarily have to involve money—and why should we focus on that and not on other demands on the public purse and attention?

Professor Lintott: I think I have two. It was clear from the YR4 example that the astronomy co-ordination worked well. I am less sure about co-ordination among space agencies. I would like the UKSA—I know you have a panel on it coming up—to take a leading role in co-ordinating



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thinking about missions, and responses if we find an asteroid. Of course there is funding, but I am thinking particularly of early-career researchers who want to work in this field. As you have heard, we need long-term monitoring projects. Vera Rubin lasts 10 years at least. Dedicated funding that would help early-career researchers to invest in making this part of their research portfolio would be really helpful.

Why this and not climate change? It is difficult to leverage different areas of science against each other, but I will point out the crossover. This is an investment in technology, processing, machine learning and AI, how we use supercomputers to predict things, and lab facilities. I would always favour interdisciplinary areas, because they have the potential to affect many different parts of the scientific portfolio, and many different risks that we face.

Dr Crowther: To add to what Chris said about the long-term nature of funding, some of these missions, from inception to planning, to the mission launching, collecting the samples and bringing them back, can be somebody's whole career. Early-career researchers on three-year funding cannot play a full part in that. UK funding is a bit disjointed in this area, so astronomers like Chris and planetary scientists like me are funded through the Science and Technology Facilities Council, generally speaking. The people looking at things like orbital dynamics, and the engineers, are funded through the Engineering and Physical Sciences Research Council. People are working on different aspects of the same project through completely different funding sources, which makes it rather disjointed.

There is no dedicated support for people involved with asteroid missions. The UKSA has calls for people involved with planetary missions, but there is no dedicated support for people involved with asteroid missions. The funding cycles of, let's say, STFC do not necessarily coincide with the timescale of a mission. They do not necessarily match up. If funding could be dedicated to people involved with the missions, that could make a big difference.

To add to the point relating it to climate change, it is hard to pit one against the other, and, as Chris said, technology advances in one area can benefit another. On the train yesterday I read something comparing the risk of asteroids to the risk of a house fire. The chance of a house fire is quite small, but you buy home insurance, because its cost is quite small. The risk of an asteroid hitting is quite small, but the potential consequences could be significant. The relative cost is smallish. There is no point in saving that money if there is going to be a catastrophic impact that wipes out most of humanity, and there's no one left to spend it. I thought that was quite a nice way to look at it.

Chair: We started with the potential catastrophic impact on humanity and we have come back to it at the end. Thank you so much for your contributions. It has been a fascinating discussion and we really

appreciate your time. We will continue in a few moments with the next panel.

Examination of witnesses

Witnesses: Dr Opitom and Edward Baker.

Chair: Welcome to the second panel in the Science and Technology Committee's investigation into asteroids and their potential impact. Kit will kick us off with this panel.

Q42 **Kit Malthouse:** Thanks very much indeed for coming. If you could introduce yourselves, in answering the first question, that would be helpful for our viewers. We have had some reassurance from our first panel as to the probability of our all being wiped out by an interstellar object, and we have been through the probabilities, surveillance and measuring. I want to ask you some questions about what, if anything, we might be able to do about it if one of these things were to come slinging through the universe towards us. My first question to you is: what does our own effort and our international collaboration look like? In particular, are we participating in the DART programme?

Edward Baker: I am happy to kick off with an introduction. My name is Edward Baker. I am the programme and planetary defence lead at the UK Space Agency and the National Space Operations Centre.

Kit Malthouse: Sorry, what was your job title?

Edward Baker: Programme and planetary defence lead.

Q43 **Kit Malthouse:** When you tell people in the pub that that is your job, it's quite a job title.

Edward Baker: Yes, it impresses people. It is a cool job title.

I will give a little background on what NSpOC is. It is a joint civil-military organisation in partnership with the Met Office. The staffing is made up of UK Space Agency and UK Space Command. We co-ordinate and combine UK civil and military space domain awareness capabilities, in order to enable operations, promote prosperity and protect UK interests in space and Earth from space-based hazards, threats and risks.

Our involvement in planetary defence has taken place over the last year. NSpOC was formed in May 2024. At the start we didn't have a UK planetary defence alert capability, but over the year we have developed that. It was launched in October 2024, and in January 2025 the UK Space Agency joined the International Asteroid Warning Network, or IAWN. That took place seven days before the first global alert for YR4 was released, so it was good timing on my part.

We are also a member of the Space Mission Planning Advisory Group, which is the other of the two UN-facilitated organisations dedicated to planetary defence. IAWN is focused on protection, tracking and



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characterisation, and sending out a global alert if a threat is identified, whereas SMPAG is focused on the planning of reconnaissance and mitigation space-based missions if a credible threat is identified. I can go into a bit more detail about what they define as a credible threat later.

Q44 **Kit Malthouse:** We can come on to that in a bit.

Dr Opitom: As an introduction, I am Cyrielle Opitom, based at the University of Edinburgh. I am a reader there, and I work generally on small bodies of the solar system, like comets and asteroids, trying to understand what they are made of and what that tells us about the history of the solar system. I was involved with the DART mission, mostly from the point of view of watching its effect from the ground: what did it do?

In terms of contribution to the UK, and the missions we are involved with—

Q45 **Kit Malthouse:** Just before you come to that, Dr Opitom, perhaps, for our viewers, you could briefly explain what the DART programme was.

Dr Opitom: Your question earlier was about what we can do if we find an asteroid coming towards us. It is a very good question. There are different options. An easy one is that, if we do not find it early enough and it is of a particular size, we could just evacuate. That could be an option. It is civil defence; you just evacuate. If you find it longer in advance, you have a few more options. One of those options is what is called kinetic impactor, which is basically playing pinball where you hit the asteroid and deflect its trajectory. You just nudge it slightly. If you do it long enough in advance it has sufficient effect to pass us by. That is what DART was; it was a demonstrator of the technology of kinetic impactor.

The DART mission in September 2022 impacted a small asteroid called Dimorphos, which was about 150 metres across. Dimorphos was a very interesting asteroid, in the sense that it was part of a binary system. It was a small asteroid rotating around a big one. The reason for picking it was that when it passed in front it blocked some of the light, so you would see a little dip—that happens often—and you could determine its orbit around the big one. We could see the change before and after; we could see by how much we changed the orbit of the asteroid with the mission. That was critical for seeing not only whether it worked but how efficient it was. That is what DART did in 2022.

Q46 **Kit Malthouse:** How far away was the asteroid? How long did it take the spacecraft to get there? Basically, did they just smash the whole thing into it?

Dr Opitom: It took about a year. I am terrible with numbers, so I don't remember the exact distance, but it took about a year for the spacecraft to get there, so it was far enough away that it didn't pose any risk. There was no risk of it being nudged towards Earth and causing a catastrophe.



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Basically, the spacecraft did not survive; it did not release mass to the asteroid. The spacecraft was crushed. It had a few cubesats that it released that provided images immediately after the impact that let us see from nearby what it looked like. The rest of it we audited from the ground.

The combination of the space mission itself and all the support and international collaboration from the ground was absolutely essential in knowing how efficient it was. If I remember well, the mission had the requirement of changing the orbit of the asteroid by seven minutes. It changed it by 32, so it was very efficient. That tells us a lot about what asteroids are made of, for example, and how efficient that technique is for that type of asteroid.

There was UK collaboration on that. The mission was led by NASA and there wasn't any funded effort by the UK, but there were a lot of individual scientists like me who got involved either in modelling the impact ejector—there is huge expertise in the UK on that, particularly in Liverpool—or just observing the effects, for those of us who are observers. I can tell you a bit more about the content, if you are interested.

Q47 Kit Malthouse: We are talking about a year away for a spacecraft and tens of thousands of miles away, and this thing was 150 metres across.

Dr Opitom: Yes.

Kit Malthouse: How accurately did we hit it? What was the probability of us missing?

Dr Opitom: I don't know whether we have a probability. We didn't just launch it and let it follow a trajectory. There was an autonomous navigation system that locked on to the asteroid and corrected the trajectory without us. For the last day or so, there was no alteration of the trajectory from Earth; it was autonomous navigation. It is not only a feat in terms of planetary defence and demonstrating that the technique works; it is also that technologically it demonstrates the ability to carry out autonomous navigation near a body like an asteroid.

Q48 Kit Malthouse: It was effectively a self-guiding missile.

Dr Opitom: Yes. And very cleverly made, because you approach it and you need it to be able to say, "Oh, that's the big one. That's not the one I want; I want the small one," and then centre on it and keep going. Watching it was very nerve-racking.

Q49 Kit Malthouse: As a matter of interest, Chair, if you go on to the DART programme website, you can watch a video of the last moments of the missile before it hits the asteroid and see it closing in. It's extraordinary that they were able to do that.



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Dr Opitom: It is the only time where it becomes all red or all black, and that is not usually when you want to do a first test mission, but everyone was happy because it meant success; it hit.

Q50 **Kit Malthouse:** What is the successor to DART? Are they going to try something bigger or better? Moving it by 32 minutes may not be enough deviation, presumably, for something bigger that might be coming towards us.

Dr Opitom: In a way, the successor would be the Hera mission, which is the European counterpart to DART. That will undertake a crash scene investigation. It will arrive in 2026 and will see what is happening, how it has affected the asteroid and what is left of it. Is there a crater, or did it all get reduced to rubble so there is no sign of it? It will be very interesting to see how the asteroid reacted to it. It will tell us a lot about what it is. For Hera, there is UK involvement with a science team. There is even UK leadership of a working group, but no formal UK involvement. A lot of the researchers are doing it in their own research time with very limited resources, even to attend conferences.

Q51 **Kit Malthouse:** Edward, on the new organisation that you established in the last 12 months or so, we didn't have that kind of capability before. What was the reason and the decision-making process for its creation?

Edward Baker: I cannot go into the details of what led to the creation of the National Space Operations Centre. I believe it was a desire to combine civil and military mission sets to do with space, but that is not to say we did not have some of those capabilities beforehand. For example, severe space weather is led by the Met Office, but before the establishment of NSpOC there was a space surveillance and tracking team in the UK Space Agency. That was the team I was a part of beforehand. Our responsibility is to provide alerts, report on and monitor activity in the space domain, report on risks, provide services for collision avoidance between satellites and report on satellites or rocket bodies that fragment in Earth orbit and uncontrolled re-entries of satellites and rocket bodies, and also now launch notification. For example, we led on the reporting earlier this year of the Starship break-up over the Turks and Caicos Islands.

It is more about bringing together all those different capabilities. When NSpOC was formed I noticed that there was a capability gap. We were not really doing anything on the reporting and alerting side of planetary defence. I felt that we should because it seemed like the right thing to do and to bring us into line with what loads of other countries are doing, not just the very large space agencies like NASA or multinational organisations like the European Space Agency, but the national space agencies of France, Italy, Germany, Japan, South Korea and China.

Q52 **Chair:** In terms of what other nations are doing and what we are doing, or planning to do, would you say we have a plan for planetary defence?



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Edward Baker: I think it is that, and how prepared we are. You can break it down. On the alerting side, the UK has—

Q53 **Chair:** You can break it down, but do we have a plan? Is there a document somewhere that says we will do that, or are we relying on global planning to tell us what to do?

Edward Baker: Not to tell us what to do, but how to co-ordinate the response. The two organisations I mentioned—IAWN and SMPAG—which are facilitated by the United Nations, cover the requirements for detecting the asteroid, characterising its threat and sending out an alert to the United Nations General Assembly, if the risk is credible enough. For SMPAG, its threshold is that the asteroid must be estimated to be over 50 metres and have a greater than 1% chance of hitting Earth within the next 50 years. When that happens, SMPAG's members gather together to collate, and to figure out a reconnaissance mission to study the asteroid and what a potential mitigation mission should be. That is presented to the United Nations Committee on the Peaceful Uses of Outer Space, or COPUOS, for them to make the decision. Those organisations will find the threats and provide a recommendation on what to do. Then it is up to the global community to decide what the response should be.

Q54 **Chair:** Does the UK have in place the resources and ability to respond, with the hardware or whatever it is we need to play our role in responding?

Edward Baker: The UK Space Agency has only recently started engagement with the academic community, so I am not really in a position to say yes or no, but we are building an academic network; we are starting to bring academia and the space sector into the delegations of SMPAG and IAWN so that, if there is a credible threat, they are involved in work on that, as well as work taking place before that on training and exercising.

Q55 **Chair:** Do we have an idea of what we might be asked to do? Can you give an example of what the UK might be asked to do in response to a 100-metre asteroid that is going to hit the Earth in five years?

Edward Baker: I wouldn't be able to say. SMPAG runs exercises to work through a scenario and figure out what a reconnaissance and space-based mitigation mission might look like. Some UK academics have had involvement in that, but it has not been facilitated by the UK Space Agency. We haven't been involved in that because our work on this is relatively new.

Q56 **Chair:** The UK Space Agency is not involved in planetary defence.

Edward Baker: I wouldn't say that.

Q57 **Chair:** Sorry, I thought you just did say that.

Edward Baker: We are starting to take more interest in planetary defence, but it hasn't really been a risk before.



Q58 **Chair:** Is the asteroid threat on the national risk register?

Edward Baker: No, it is not on the national risk register. It was considered for the NSRA between 2019 and 2021, but the scenario presented did not meet the criteria for inclusion. I don't know the ins and outs of the scenario that was presented because I wasn't involved in that, but I believe it was rejected primarily on the basis that it was submitted as a one in 200,000 probability, which did not meet the criteria for inclusion.

Dr Opitom: Maybe I can comment on what Ed just said about scenarios that are being played out. As he mentioned, SMPAG prepares scenarios. A conference happens every two years—the planetary defence conference. It is basically a giant role-play—not all of it; there is a conference with talks about planetary defence and the latest techniques and observations.

Q59 **Kit Malthouse:** A planetary defence conference. Very cool.

Dr Opitom: It gets better. They run a giant scenario: we discover an asteroid that is en route to Earth, so what do we do? They play out the entire scenario from its discovery, and we characterise it. It is not only an academic conference. The main point of it is that it brings together people from space agencies and Governments to work out internationally responses to potential threats. As Ed was saying, academics in the UK have been participating in that conference, but I do not think there has been official UK Government involvement in that exercise in the way some other countries have engaged in it.

Q60 **Chair:** That seems rather concerning. We spoke earlier about high risk and low probability. It would seem to be something the Government should certainly be aware of and engaging with actively. Do we know what the UK Space Agency spends on planetary defence and asteroid tracking?

Edward Baker: I can speak from the point of view of the National Space Operations Centre. We haven't directed any funding to planetary defence. What we have achieved has all been under the regular work that we do. The UK invests in the European Space Agency's space safety programme. We have had minor involvement in the ground-based telescope Flyeye, which is now operational in Matera, Italy. We have some additional small returns coming from Hera, but there is an opportunity for the UK to be involved in the upcoming Ramses mission which will study the asteroid Apophis in 2029. That is dependent on the level of funding that DSIT allocates to it, but there has not been any direct funding of planetary defence by the UK Space Agency in the last 10 years.

Q61 **Chair:** Has there been indirect funding through the European Space Agency?

Edward Baker: I am not entirely sure about that. Going back perhaps 25 years, the topic of planetary defence was raised in the House of Lords



in 1999. One of the recommendations from that was a taskforce. It made a series of recommendations to the UK Government, most of which were not implemented. I believe there was some funding for a UK new information centre. I don't know the current status of that, but the funding has not been in place for a number of years.

Dr Opitom: To add to what you said, there are elective paths to the ESA programme—for example, the Hera mission. There are paths where all countries have to contribute. On those that are elective, in terms of planetary defence the UK has generally elected not to participate. That is the case for the Hera mission. There is a little bit. I do not know exactly what it goes to, but there is no formal involvement in such a way that the UK could lead on instruments. It has the technical capability to do so and the academic support as well, but without commitment from the UK state that is not possible.

Chair: Following this session, the Committee will be very interested to understand what funding we are making available for planetary defence, and why.

Q62 **Jon Pearce:** Before I turn to internal UK governance and policy responses, on what you have just been talking about, how is the international decision made on planetary defence? Who would make the decision on what the reaction was? Is it a specific body? Is it effectively who has the technology? In your role-playing at these conferences, who are the decision makers?

Edward Baker: For example, in the exercise I attended hosted by NASA and the Federal Emergency Management Agency last year, and from the experience I have had in some of the other workshops, the decision makers are the heads of Governments and heads of space agencies. It is co-ordinated by the United Nations, which has the capacity, technology and money to fund these missions. I suspect that NASA, ESA and increasingly China are taking an interest in planetary defence. A lot of the co-ordination would be done by NASA, ESA and China. They have whole teams dedicated to planetary defence. I suspect they would be leading that charge, mostly.

Dr Opitom: I agree that a lot would be done by space agencies, probably through the UN. The UN plays a large role in ensuring that these bodies are on the same page, and the UN Security Council would probably play a role in the decision.

Q63 **Jon Pearce:** Given how important it would be to make the right call and that there may be lots of differing views, there is no legal framework or agreement on the decision-making protocol for what the response would be.

Edward Baker: No, but SMPAG has a legal working group whose purpose is to work through some of the policy questions. I think this is being considered, but the membership of SMPAG is made up of space



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agencies and they are not necessarily the absolute decision makers. I wouldn't be able to comment.

Chair: We need to move on. Unfortunately, we are running out of time.

Q64 **Jon Pearce:** Looking specifically at the UK, how well prepared would you say the UK would be to respond to an asteroid impact? Do we have policy protocols? Have we run through scenarios, simulations and the decision-making process of what happens? Would it be the case that once a threat was identified we would then start going through that process, or are we already a long way down that line?

Edward Baker: The alert procedures are firmly in place and the interfaces that we have with the organisations of IAWN and SMPAG are well established, but there has not been an exercise looking into how the decision makers would go about making that decision. Earlier this year, NSPOC hosted a small-scale walk-through exercise testing our alert procedures before the 2024 YR4, but there has not been an exercise looking into what our response would be and how the Government structure would go about that. It is worth noting that, while it is not work that the UKSA and the UK Government have done, there has been considerable work looking into what the effects of an asteroid impact would be and whether Governments have national frameworks in place that could be tailored and adjusted to deal with that. The US has done a lot of extensive work on that, and, broadly, the result is that frameworks for natural disasters can be tailored and adjusted to meet the requirements of what the effect of an asteroid impact would be.

Going back to the NSRA, while it was primarily rejected on the grounds of its probability being one in 200,000, there was also an understanding that many of the effects we would see from an asteroid impact were already covered by other risks in the NSRA. The whole point of this is not to duplicate work; it is to understand what we already have in place that can be adjusted for the risk. It is also worth saying that as a member of the European Space Agency, and its fourth largest contributor, I believe, we get a lot of returns from ESA for planetary defence. A really interesting tool that I want to highlight is the impact visualiser tool. I have been sent some graphics to show that, if there had been a scenario where 2024 YR4 had impacted the UK, ESA would very quickly have been able to tell us exactly where that impact would be and what the effects would be and put that on a map. That is very useful for first responders. It is very useful for decision makers. You can overlay critical national infrastructure sites. Critical national infrastructure is one of the areas that the US has looked into, and has come to the same conclusion that the frameworks in place can be adjusted and tailored. Some light work in the European Space Agency has gone on in this area as well. I am happy to share these graphics around.

Q65 **Chair:** We will study them. Thank you very much. It is very useful to know that we have graphics of the impacts.



Dr Opitom: Something that might not have been considered in the past, and Professor Lintott mentioned earlier, is the impact to assets as well. New models have shown that, if YR4 hits the moon, it might not have an impact on Earth—there might be a spectacular meteor shower that would be pretty—but it could have an impact on satellites in low-Earth orbit such as Starlink satellites. You have the impact of small particles in space all the time, but you would get the equivalent of 10 years, potentially, within only a few days. It is not only the impact it can have here in the UK potentially but on assets in space as well that needs to be considered.

Q66 **Jon Pearce:** To be clear, we are not an outlier in terms of our planning and our response; we are consistent with the US and other EU countries.

Edward Baker: Obviously, the US in terms of scale and scope far exceeds the UK, but within Europe and the global community we are a valued and trusted partner on planetary defence. We take the risk seriously in the alert capability that we have established. We are one of 14 space agencies that are members of SMPAG. By virtue of that and our membership of IAWN as well, we co-sponsored the UN resolution to designate 2029 the International Year of Asteroid Awareness and Planetary Defence. On the advocacy front as well, among our peers we fare well.

Q67 **Chair:** Thanks very much. The National Audit Office report “The National Space Strategy and the role of the UK Space Agency” states: “The UK does not yet receive contracts from ESA proportionate to the value of the funding UKSA” gives the European Space Agency. You said that we are one of the largest funders. Do you think that lack of return is impacting our engagement on planetary defence with the European Space Agency?

Edward Baker: I am not involved in the investments that go into ESA via the UK. That is managed by another team in the UK Space Agency. I am not involved in that process, so I don’t think I would be able to comment, but I will happily write to the Committee afterwards. I represent the operational side of what the National Space Operations Centre does for planetary defence.

Chair: I wondered if that was impacting our readiness to put more into the European Space Agency generally, and particularly when it comes to planetary defence. Please write to us on that if you are not in a position to comment. We have a hard stop at 11.30, but we can go a few minutes over.

Q68 **Dr Sullivan:** I want to ask a little bit about the DART project and whether there have been further spin-outs or further information and education that we have learnt from that whole exercise.

Dr Opitom: There has probably been a lot of worthwhile impact from all of that, one of them being education. One of the advantages of planetary defence is that it is incredibly easy to engage the public. In comparison to climate change, it is very easy to convince people of the risk: “Let’s not be like the dinosaurs.” It is a really good way to engage. People are



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immediately interested, particularly kids. There is a lot of public engagement by the UK team in the UK. It is a very good way to engage people in STEM subjects.

I can talk from personal experience of the unintended consequences that participating in these projects can have. I was involved in a project to put a telescope in Kenya to observe the DART impact, because at the time it happened it was located above the Indian Ocean, meaning that all the great telescopes that we used in Chile to look at it a bit after could only catch it six hours after the impact. The only professional observatory that could catch it at the time was in South Africa. If you rely on a single place, it will be cloudy there; that's the limit of astronomy. We got some funding from the University of Edinburgh and installed a very small 40-centimetre telescope in the northern part of Kenya, and we successfully observed the impact. We engaged with the Kenyan Space Agency. They came to the location where we installed the telescope and were there at the moment of impact. It had a lot of publicity here and around Kenya.

We kept engagement going with the Kenyan Space Agency. It is also interested in planetary defence. We used its facility to engage with a project called DARA, which is aimed at driving development in Africa using astronomy. We are now using that telescope to train 60 African students a year from different countries in astronomy. Some of those students went on to work for the Kenyan Space Agency. Some work in a pretty high position in the International Astronomical Union. We are creating those skills in African countries using that project. It has had unintended consequences that have a direct impact on real life. We got about £15,000-worth of funding from the University of Edinburgh, but it has an impact that is going to last for years. It is not always about having a lot of funding for things. Even a small amount of funding can have a lot of impact because these are subjects where it is easy to engage people and impact skills using that as a base.

Q69 Dr Sullivan: That is interesting. I wonder if you wrote that on the impact assessment when you applied for the grant.

Dr Opitom: It is coming in the next REF. It will be there.

Q70 Dr Sullivan: This is it. It is difficult. When you apply for funding, you are supposed to give all the potential impacts, and sometimes there are wonderful impacts that are unforeseen.

You talked about engaging with children and youngsters, and the idea of mining asteroids. I have seen many diagrams about how they can do that. I know from the earlier panel that we are a long way off from that, but in terms of the regulation, what do we need to consider to make it a reality? That is to both of you.

Edward Baker: In the short to medium term, it is likely that all the space resource activities will take place in situ to support further space-based activities. In the longer term, it is possible and it is something that the UK can look at. While we do not necessarily see a commercially viable



model for the extraction of space resources and returning them to the Earth for sale in the short term, it does not preclude UK companies looking into that, collecting data, prospecting data and conducting small-scale demonstration missions. Internationally, the United Kingdom has taken the view that international discussions should focus on the principles of in situ resource use and extraction first, with more future-focused space resource issues such as commercial return to Earth of space resources for sale.

Q71 Dr Sullivan: Can you expand on what you mean by “in situ”?

Edward Baker: In place; not disturbing it. Is that correct?

Dr Opitom: Yes. Basically, it could be that you go there and you mine water to make space fuel for a rocket. You don’t bring it back.

Edward Baker: Yes, exactly.

Q72 Chair: You don’t extract something and bring it back to Earth.

Edward Baker: That does not preclude states or national space agencies from benefiting from commercial arrangements in place, whether it is to support scientific investigation or commerce.

Dr Opitom: Maybe I can comment further. There is very little legislation. Professor Lintott mentioned that earlier. The main regulation is still the outer space treaty from the late ’60s, if my memory is correct. That is not very appropriate to what is happening now. There is a lot of fuzziness because you cannot own the asteroid. You cannot claim an asteroid and you cannot prevent other people from accessing it. If you have a mining station on an asteroid and if multiple people want to mine the same asteroid, you can easily enter a conflict situation if there is no regulation. That is where the UK could potentially have an impact. There are degrees in space law now in the UK. We have people who are ready to work on these kinds of subjects. The UK has a lot of soft power, so it can pave the way in terms of legislation.

There are not only the considerations of avoiding conflict but also ethical considerations. Professor Lintott mentioned the risk of crashing the economy for rare earth metals, but there is the impact for countries that are currently mining the minerals, such as countries in the global south whose economies unluckily rely on those minerals and are the ones that do not have the capacity to take part in that. How do you make it fair if you are using resources that have to be used for the benefit of all? Do you make it fair for all countries, or do you make sure that it is sustainable and that it does not harm the environment more than it brings in? There are a lot of questions that need to be worked on where the UK could use its soft power to lead the way, obviously in collaboration with the United Nations bodies that are looking into that.

Dr Sullivan: Brilliant, thank you.



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Q73 **Chair:** I wasn't aware that we had degrees in space law.

Dr Opitom: I can't remember where it is. I have seen that somewhere.

Kit Malthouse: You just come up with cool stuff all the time: "I've got a degree in space law."

Dr Opitom: We have people in Edinburgh working on space law, so that is something.

Q74 **Chair:** You made a very good case for the UK using its soft power to make progress in the area. One of our inquiries that we are launching soon is on science diplomacy. Do you think that right now the UK is doing enough on that? Should it be something that the Committee should request?

Edward Baker: I am not really involved in the regulatory side of the UK Space Agency.

Dr Opitom: I am not entirely sure where exactly it is being done. It is being done a lot by individuals, as far as I am aware.

Chair: Right. There is no co-ordinated action by the Government to help bring space law up to date.

Q75 **Dr Sullivan:** It seems like our academic universities are across the globe already.

Chair: Getting there already. Right.

Dr Opitom: There was a recommendation from a report from the Regulatory Horizon Council that came out last year to contribute to space regulation in the UK and work with the United Nations to build space laws.

Edward Baker: The UK Space Agency sends delegates to Vienna to the United Nations Committee on the Peaceful Uses of Outer Space and engages with international partners to highlight good practices and ensure that space activity remains peaceful, safe and sustainable for all humankind. Some of the discussions focus on norms of use for the moon and other celestial bodies. We are involved. We regularly engage with the United Nations on it.

Dr Opitom: I forgot to mention this. Some countries are delivering mining licences already. There are three countries that have delivered mining licences for asteroids and have a framework to do that: Luxembourg—it was the first to do it and has attracted a lot of venture capitalists through that—the United States and the UAE.

Q76 **Chair:** The United States and the UAE have given mining licences for asteroids?

Dr Opitom: Yes, some countries have.



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Q77 **Kit Malthouse:** They have identified asteroids that they have claimed as their own.

Dr Opitom: I am not aware of the detail. I know that those countries are—

Q78 **Chair:** We will want to understand that better. I have a final question for each of you. You may have answered this question already. What is your top ask of the UK Government, or any other Government, for supporting the facilitation of planetary defence research and practice?

Edward Baker: For the National Space Operations Centre, my top ask, or requirement or urgent need, is to bring the academic community and the sector into the delegations of SMPAG and IAWN to ensure that they contribute to the work that they are doing and to ensure that the UK's reputation in planetary defence remains strong.

Chair: Fantastic.

Dr Opitom: Most of it will be funding. There is one thing that could be done without even requiring funding. There will be an ESA ministerial where they will make the decision on whether the Ramses mission, the next step in planetary defence, happens. UK support for that would be very welcome by the community just to make sure that the mission happens at all.

In terms of funding, as was mentioned before, even a little bit of funding is useful, if only to organise the community, to have meetings within the UK or to allow people to travel. A lot of people who have been involved were involved on their own time. I was lucky enough to get involved because I am on a fellowship from the Royal Society, and I have a lot of academic freedom and funding. Funding to travel to conferences to present the work that they are doing is already making a difference, particularly because, as was mentioned before, the communities are a bit siloed and depend on different councils, which sometimes makes it hard to have continuity and a long-term view. We are at the moment seriously at risk of losing critical expertise. There are fields of expertise like radar observations of asteroids that are essential to get their shapes and some of their orbits or study their non-gravitational forces. We are at the top of the field in the UK, but we are at risk of losing people because there is no funding priority for that. It is really difficult when people naturally retire to keep the expertise in the UK. A consistent way of getting funding, whether or not it is through UKSA, so that people can participate in space missions and potentially have a hardware contribution to the UK would be very welcome.

In terms of visibility, there are conferences like the planetary defence conference. The next one is happening in 2029 when the asteroid Apophis will make a very close passage to the Earth. Everyone will have eyes on that. It is going to be visible with the naked eye at the time and it will make a huge splash. There would be an opportunity for the UK to



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organise the planetary defence conference and host it at the time, which would give it really good visibility on the international stage, and not with hundreds of thousands of pounds in funding.

Q79 **Chair:** Very good. Mr Baker, would you be able to help in the organisation of that conference?

Edward Baker: Personally, yes. It is a really positive and good idea. The UK has hosted similar conferences on other risks before. It is an interesting opportunity. Apophis is a once in a millennium opportunity.

Chair: Great. We look forward to progress. You heard it first in this Committee. Thank you very much for your contributions. It has been an absolutely fascinating debate. We look forward to a planetary defence plan that keeps us safe from the high risk although low probability potential of the extinction of humankind through an asteroid. Thank you very much.