HOUSE OF COMMONS

Science, Innovation and Technology Committee

Oral evidence: Commercialising quantum technologies, HC 270

Wednesday 20 March 2024

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Watch the meeting

Members present: Greg Clark (Chair); Dawn Butler; Chris Clarkson; Dr James Davies; Katherine Fletcher; Rebecca Long Bailey; Stephen Metcalfe; Carol Monaghan; Graham Stringer.

Questions 258 - 360

Witnesses

I: Roger McKinlay, Director of Quantum Challenge Fund, Innovate UK (UKRI); and Anke Davis, Head of Quantum Technologies, UK Research and Innovation (UKRI).

II: Andrew Griffith MP, Minister of State for Science, Research and Innovation, Department for Science, Innovation and Technology; and Tom Newby, Head, Office for Quantum, Department for Science, Innovation and Technology.

Written evidence from witnesses:

- Department for Science, Innovation and Technology

Examination of witnesses

Witnesses: Roger McKinlay and Anke Davis.

Q258 **Chair:** Welcome to this session of the Science, Innovation and Technology Committee as we continue our inquiry into commercialising quantum technologies.

To help us with that inquiry I am very pleased to introduce our first pair of witnesses: Roger McKinlay is the challenge director for commercialising quantum technologies at Innovate UK. He has been involved in the quantum world for a long time and was a member of the 2016 Blackett review of quantum technologies. Joining Mr McKinlay is Anke Davis, the head of quantum technologies at the Engineering and Physical Sciences Research Council. Welcome, both of you.

I shall start with a general question, perhaps to Mr McKinlay first: how is UKRI supporting the commercialisation of quantum technologies through the programme? I will ask Anke Davis to comment as well.

Roger McKinlay: I am asked this question by international audiences and I always give the rather trite answer that the strengths of UKRI are many but the two dominant councils have been EPSRC and Innovate UK. EPSRC funds universities to work with companies, and Innovate UK funds companies to work with universities, and I have seen nowhere else with such a cunning combination.

We started out in 2014 with the creation of the hubs, which was commercialisation from the start, very much getting the commercialisation side moving on the science. Then, as you are well aware, in 2018, with the ISCF funding, we started a serious programme of industry-led collaborative projects, which included the universities.

That is the bulk of what has been happening to date, over and above, of course, the significant amount of work that Innovate UK does in supporting business generally.

Q259 **Chair:** So how does one do it? We know how you can do pure research into quantum, at the cutting edge of knowledge. How can support be given to commercialise it—to transfer that knowledge, in other words, into practice?

Roger McKinlay: The most important thing is that these collaborative programmes, in particular, are the only real gateway into a programme where we hear want industry wants to do. Government and academia are full of ideas. When we put a call out, we ask a company to come up with a good idea—a collaborative idea—that comes from a team, and we ask them to say specifically how they are going to exploit it commercially; and we hold them to account. We monitor, through benefits, how they are achieving. If they said they wanted to grow, how many more staff have they taken on? If they are going to produce a product, have they produced it?

What is important is that we are reinforcing what they want to do, and that has made us attractive to a lot of businesses, including overseas companies to the UK, because the starting point is: "You understand your business; you can spot the opportunities in commercialising quantum; we are going to help you."

Q260 **Chair:** As you say, Mr McKinlay, it was 2018 when the industrial strategy challenge fund was launched, in this and other respects. We are now in 2024. Is it possible, nearly six years on, to point to successes and to evaluate whether that ambition to commercialise quantum technologies has happened?

Roger McKinlay: It is, with a caveat. When a Minister announces money, it is hanging in the air—ethereal. When we put it into a competition and say, "We are running a competition to run projects of a certain value," it is becoming more real. When it gets offered, as a grant offer letter, it is absolutely committed. Finally, we give the money to the company as a reimbursement of allowable costs—so it is quite a long way down the line. We are still being invoiced and still putting money out the door—it will be £70 million this year—on that portfolio of programmes.

The money does not go in at the start, but having said that, we have to date put in about £220 million of grant funding. It is ISCF plus things like the technology missions fund. Some of those programmes are still opening. If we drew a perimeter around the companies that we fund—we have been funding since 2018—we would see that they have raised £610 million.

Q261 **Chair:** Raised in terms of matched investment.

Roger McKinlay: Raised in terms of money raised to put alongside our grant, to grow. It was not put into our programmes, but they went out and raised it. That is by far the best measure. Sometimes, of course, our grant is the first money a company receives, and the match will come later. It comes, in fact, but it is not reimbursing all their costs.

I think that that £610 million shows quite a healthy ratio. It also shows that we are not deluded or just helping what we call grant jockeys—people who live off Government grants—because they have already, as a portfolio, raised significantly more than we have put in, and have raised it in private money.

Q262 **Chair:** On that proportion of matched funding, if we can call it that—or leveraged funding, or whatever—did you have a particular ambition for the ratio, or a requirement?

Roger McKinlay: We had a cautious—I cannot remember the exact figure. I think it was £105 million or something, but I would have to go and check. We were certainly keen to see it matched. I would have said, "This isn't bad," if I had had £220 million of grants allocated to programmes and £220 million had been raised. I am obviously much more pleased that it is £610 million.

Q263 **Chair:** Very good. Anke Davis, you are the other half of the exceptional and unique approach that we have here. Mr McKinlay has talked about the Innovate UK side. From the research councils side, tell us how the programme to support research into quantum technologies has been conducted, and perhaps whether you judge it to have been a success.

Anke Davis: As Roger mentioned, we started in 2014 with hub investment into four different areas. The UK is a trailblazer in setting up large collaborative efforts covering all the UK—all the devolved nations—and involving a large range of companies.

At that time this was new to the world. It has been emulated by other countries, such as the United States. It has been seen as a success, in combination with elements such as a national quantum technologies programme, bringing Government, industry and academia together, and going alongside programmes such as the ISCF programme.

The reason hubs have been a success is that they work on technology development at the research level stage. They bring this to a certain range, where they have some company and end-user interests; but where can it go from there? The ISCF programme has enabled that research to go further, for those collaborations to be taken into the commercialisation space.

We see that through a number of spin-out activities that have come out from the two successive phases of hubs, with 30-ish spin-out companies. Those range from abstract quantum computing all the way through to gas sensing to allow for environmental sustainability, medical devices to improve surgical outcomes and provide cheaper approaches, or diagnosis of epilepsy in children and allowing for better treatment. There is a range of different application areas that we are keen to foster and support. That has been possible through the combination of the academic excellence base and collaboration with industry.

Q264 **Chair:** You said that the US has emulated this approach. I assume that you mean it did so by establishing quantum hubs. Is there evidence that they have actually emulated it, rather than just doing the same thing, or that we have emulated them?

Anke Davis: The US programme started significantly later. I believe that their five-year hubs are coming to an end later this year or at the beginning of 2025. Those were the first range. We had five years of hubs prior to their efforts in this area.

By launching a competition for a third phase of hubs, to start this year, we are already setting the scene for what is to come. We have strong ambitions in this area and have been outspoken about wanting to continue to support the academic excellence base in the UK. In the US, the discussions are at a different stage, but that is down to their discretion, of course.

Q265 **Chair:** In the funding landscape, it is great that there is obviously a kind

of complementarity between your two organisations, but you are still under the one umbrella organisation. Is it necessary to have a separate organisation, as it were, focused on business investment, working with universities, and a different one focused on universities working with business? Could this be better done in a single organisation?

Anke Davis: We are part of UK Research and Innovation, our umbrella organisation. By representing the two different communities, we can bring strength to the table. Roger's extensive industrial experience, for example, equips him very well in speaking to the industry community and being open to their ideas and approaches.

I think that it is equally important to have representation from the academic side. We need to be able to marry the different approaches to co-create the success that we have had.

Q266 **Chair:** That was certainly part of the vision of the Nurse report, in creating UKRI. As a kind of thought experiment, could the EPSRC deal directly with businesses, or would that be out of its comfort zone, as it were?

Anke Davis: We are doing that in some respects. Recognising that Innovate UK's strengths lie in that area, we are not trying to impose ourselves on to the same territory. We have some schemes that allow for academic and industry partnership at a 50:50 level. That happens through the prosperity partnerships; it is coming up more and more through the community, and there is increasing interest.

As for having a strong commercialisation focus, rather than an academic-driven research focus, I think it is very important to have the two alongside each other.

Roger McKinlay: I think there is a big difference. The principal investigators and hub directors have to be given freedom—it is discovery-led research, still.

At Innovate UK, we drive pretty hard to deliver the benefits from the programme. We monitor; we have significant teams of monitoring officers. Even our vehicles for collaborative R&D—the SBRI has been very successful—require quite a significant commercial team in carrying out due diligence.

Do not underestimate the maturity of these vehicles. I would even like to see a bit more of a divergence, in the sense that I think Innovate UK speaks very well for business.

As for some of the bigger industrial landscape features—companies of a certain size—industry is the engine of commercialisation and I think we could even do more for those. I think that the differentiation is well justified at the moment.

Q267 **Chris Clarkson:** Dr Davis, you alluded to the third phase of the national

quantum technologies programme. How are you ensuring that that is going to be a success, and what does success look like to you?

Anke Davis: To ensure success we have consulted the community and looked to define what the new areas of hub development should look like. We have refined, in line with evolution of the areas, the scope of the development and research programmes that we would want to see.

We have allowed the current and new consortia to form, and to put bids into the competition. We have seen nine high-quality bids, up to five of which will be funded. So success has been that in the past the hub teams have driven the technology development and have been able significantly to leverage funding through commercialisation streams such as the ISCF programme, to take those products into the commercialisation space. We are looking for equal successes in the future.

In addition to co-creation between industry and academia in developing the programmes, we have seen significant interest in co-investing in the programme. We are going to build on that and ensure that companies stay engaged throughout the research programmes. One way in which that is already being done is through the Government's national quantum strategy, which has increased companies' and academics' interest in this as a high-priority area. Quantum missions highlight those areas in which we would like to drive commercialisation forward. We can capitalise on the interest from academia and industry alike.

Q268 **Chris Clarkson:** Have you taken any specific learnings from the first two phases, to change your approach at this stage, or are you carrying on as is?

Anke Davis: Yes, as I mentioned, we have opened up the competition to allow for existing as well as new collaboration teams to come together. That means that at both academic and industry level we are open to new combinations of people. That ensures that we have the best teams possible coming together in the UK. We have seen some changes, with people specialising in a different area from their previous one.

In the first two phases, we had a set of groups that came together and formed a new construct. In the second phase, we have increased our support through a diversity of activities, which means that we have more strength, and more people we can draw on. It was important for us to give them an opportunity to come in and join a substantial hub programme over five years, if they wanted to do so.

Q269 **Carol Monaghan:** Dr Davis, how confident are you that UKRI can deliver on the national quantum strategy's aim to have 1,000 PhD students in quantum-related programmes by 2033?

Anke Davis: First, we are excited that UKRI is a strong partner in helping to deliver the postgraduate training aspects of the strategy. The strategy covers not just UKRI but other partners. We are in a strong

position, having just announced three new CDTs as well as additional doctoral training partnerships.

Chair: For people watching the debate, a CDT is a centre for doctoral training.

Anke Davis: Apologies: I meant to say that. I have to give a caveat, at this point, because the terminology is going to be changed by UKRI in a couple of months, but we will stick with the terminology that is being used by the Committee and members of the community at this point.

Q270 **Carol Monaghan:** To go into a bit more detail on CDTs, how are you making sure that the CDTs that are running or proposed are properly aligned with the quantum strategy?

Anke Davis: We had a highlight notice within the CDT call, to highlight the fact that quantum technologies are an important topic within the EPSRC remit, and thus specifically to encourage applications in this area.

We highlighted the fact that a number of different aspects are important, such as entrepreneurial training and links to industry. That is an important feature of the centres for doctoral training. We also highlighted the need to work with Government Departments and Government needs in general.

Through the peer review process, we have been able to assess the proposals, and the five bids that were successful cover a wide range of different topics, thus providing a strong base of training across all areas of quantum technologies outlined in the strategy.

Q271 **Carol Monaghan:** Which CDTs are working specifically in quantum?

Anke Davis: We have five—if I may refer to my notes so that I get them right. We have everything from quantum information science, quantum technology, engineering, quantum computation and communications, applied quantum technologies, quantum informatics and aligned areas such as semiconductors. Through that, we are able to cover England, Wales and Scotland.

Q272 **Carol Monaghan:** That was my next question—the geographical spread.

Anke Davis: Yes, there is a geographical spread, and the spread that is represented through current hubs will also be there in future hubs.

Q273 **Carol Monaghan:** We have talked about 1,000 PhD programmes in quantum-relevant disciplines. Fine—okay, you are confident about that. Is there any analysis, overview or check of whether money is following diversity, when we look at supporting young people in these hubs?

Anke Davis: Do you mean hubs?

Carol Monaghan: Sorry—CDTs.

Anke Davis: It is the same approach for both. I can clarify that at this point. Hubs, as well as centres for doctoral training, collate information on their recruitment. Hubs and CDTs follow an equality, diversity and inclusion plan. We have assessed that for hubs, as part of the peer review process— and for CDTs as well—as well as probing and questioning at the interview stage whether they are able to provide an inclusive environment that encourages people from diverse backgrounds to join. That goes across all the different criteria included in EDI. Hubs have an EDI plan as well, which we monitor on an annual basis, where we probe questions.

Q274 **Carol Monaghan:** Okay, so you are monitoring, which is stage one. What action is taken if you find that CDTs or hubs are not actually meeting targets in terms of diversity, in terms of women, and who they are recruiting?

Anke Davis: It is normally, I would say, monitoring, because UKRI has not taken active action in this area regarding recruitment. Through previous and current CDTs we have seen very positive diversity data. We would expect that to continue on a positive footing. I am not able to comment at this point on what the steps would be if we discovered that they did not meet the criteria. I think that is something to follow up.

Q275 **Carol Monaghan:** The Committee looked last year or the year before at diversity in STEM. Is there some way you could follow up with the Committee on some of the data that you are referring to? It would be quite interesting for us to have a look at that.

Anke Davis: Yes, certainly we can.

Q276 **Carol Monaghan:** Finally, how is UKRI working with industry to support apprenticeship and technician programmes in quantum?

Anke Davis: We have a specific part of the programme that colleagues on the Science and Technology Facilities Council are working on. I have a few brief notes on that, but I am not the expert. I am happy to follow up in writing if you would like further information.

It is important to note that STFC as an employer has won a number of awards for its apprenticeship programmes, and has facilities across the country to allow for apprenticeship training. It is working on creating a quantum-specific apprenticeship training programme and is consulting industry as well as other stakeholders to ensure that the design is fit for purpose. It is hoping to start in the very near future. I am happy to confirm the timings of that in writing, from our colleagues' expertise rather than our own.

Q277 **Carol Monaghan:** Thank you. I appreciate it. Something that is raised with us fairly regularly is the lack of skills or the skills shortage at technician and apprenticeship level, so it would be useful.

Roger McKinlay: The high-value manufacturing catapult, for example, runs apprentice schemes as well. Generally, what we have been doing on the Innovate UK side, of course, is creating the pull. This sector that we have been growing is placing demands, and we are now beginning to get from our own sector a pretty clear idea of the sort of skills that growing this new part of the economy will require.

Q278 **Chair:** Mr McKinlay, is it part of the remit and practice of UKRI at the moment to require apprenticeship programmes, for example, where you make commercial investments or disbursements, to bring forward the skills that are needed to commercialise technologies?

Roger McKinlay: I know we are keen on apprenticeships. As to a requirement, or quotas in the system, I do not have any visibility. Certainly, on the quantum side, one of the clear pictures emerging at the moment is that that little bit of quantum physics at the heart of a project creates an enormous number of what I think Ian Walmsley, in giving evidence, called fierce engineering challenges. I liked his expression. That is rippling down to the need for technician support and apprentices in a broad range and area.

Q279 **Chair:** Given that Dr Davis was talking about the centres for doctoral training, which are about making sure that the next generation of researchers is coming up, should there be a parallel requirement on the Innovate side to make sure that the supply of technicians is being created in the explicit way that the research council side of the fence does it?

Roger McKinlay: I think it should fall within Innovate's remit. I would be very keen that if we did something on quantum the companies contributed. It is very difficult to train up some of these skills in isolation from industry. If they are being trained within industry I would expect some financial support from industry. I think that is a picture that will emerge as our sector grows.

Q280 **Graham Stringer:** Mr McKinlay, following on from Greg's question, why is the requirement for apprenticeships not visible? Why do you not know?

Roger McKinlay: First, in a new sector how do we know anything? We conduct surveys.

Graham Stringer: A fundamental philosophical question.

Roger McKinlay: Absolutely.

Q281 **Graham Stringer:** It is slightly easier to know whether there are apprenticeships.

Roger McKinlay: There is a reason for that, which is that otherwise we are just guessing or thinking we know best—so we do conduct surveys of the companies we fund, and we look at their skills needs.

There is a broader issue, which is why a skills taskforce is being formed—I think DSIT can probably talk more about that—of looking at the whole

skills issue. From my experience, it is very easy to get into skills push discussions, because people in the business of education and training love to say, "Have more." It is difficult, as I have just articulated, to pin down what industry requires. Remember: industry will fix its problems in the best way it can. Some of the new companies are not looking at problems that they currently have; they are anticipating obstacles to future growth. That is not just going to be the skills. It is going to be the investment in infrastructure, etc.

Q282 **Graham Stringer:** What are the constraints and difficulties that you have found in running the challenge fund? Have you overcome them? How have you gone about that?

Roger McKinlay: Coming in new to Innovate UK, I think what I call its products—these well proven vehicles like collaborative R&D programmes, feasibility studies and the small business research initiative—have proven enormously useful. We do need to think about whether new products need to be added to that. One of the grumbles that we get from companies is, "Can you help us with capital?" Quantum is a capital-intensive business, so we have been giving some thought to that.

Every competition that I have run has been two or three times oversubscribed. Recently, the number of fundable programmes that I could have funded had there been more money has been quite high. So one of the obstacles that I have seen is that, even though seven years ago it looked like a brave decision to fund ISCF wave 3, I think we could have invested more.

Q283 **Graham Stringer:** It is interesting; my experience, and I suspect that of lots of witnesses who have come before this panel, is that, if you are funding or supporting business, people who have products try to fit into your definitions. Is there a definitional problem about what quantum is? At one level everything is quantum—every chemical reaction is.

Roger McKinlay: You should have seen the number of applications we had from AI companies, saying that AI is a sort of quantum.

Q284 **Graham Stringer:** I can believe that.

Roger McKinlay: We were very specific with a physical definition at the start, on which we worked with the hubs. We said that we thought that, if companies were addressing those particular physical properties, they were really addressing quantum—the physics we want them to address. Of course, we included the software. There had to be an understanding of the sort of software a quantum computer could run—not software generally.

Since then, we have broadened that scope, having learned what the kernel of the activity was, into overcoming some of the scaling-up challenges, which are broader engineering ones. I think we got it right, because we have now funded 150-odd companies and there is some cohesion there. They are not all start-ups. Some of them are applying

quantum. They correlate very strongly with the growing membership of UKQuantum, for example, so I think our initial physical criteria, if I can call them that, did a very good job of starting what is genuinely a sector, without—this is not an expression you used—too many hangers-on after the funding.

Q285 **Graham Stringer:** Is it possible for you to supply the Committee with that definition of the particular physics in which you are interested?

Roger McKinlay: I will provide it, but it was, for example, entanglement. We were very specific in wanting to support single photon sources and detectors. It is a bit of legalese in one paragraph. We will provide the Committee with the paragraph as it appeared in the competition.

Q286 **Graham Stringer:** That is excellent.

Another problem that we encounter regularly with funding projects is that witnesses tell us that funding is too short term and that they want more certainty about funding in the future. Do you find that is a problem?

Roger McKinlay: I am finding it now, but I was blessed when I picked up the challenge director's role, because after the initial £20 million I got seven years. The Treasury gave us seven years of uninterrupted funding, which took us from 2018 and we will finish at the end of March 2025. That has enabled us to focus on what is important, which is what we are funding, not getting hold of funding.

In terms of cash, about £70 million has gone out the door this financial year; another £70 million will go out next year. The problem is that the year after that it will be about £4 million, according to my current forecast, because we come off the end of the spending review. Having announced a £2.5 billion commitment to quantum in the future, I think that for companies to see that kind of cliff edge will be difficult to explain.

Q287 **Graham Stringer:** You were talking in your initial comments about businesses invoicing you as they went along. You were holding them to account for jobs created, and so on. What do you do if they are not meeting those targets? Do you withdraw funding? What is the consequence?

Roger McKinlay: It depends. If we are funding a consortium we have to address the non-performance of one company, but we do not want to pull the funding for everyone else. We have had discussions within a consortium. It is not just non-performance. What if a company ceases to trade, for example? It is much more difficult if the leading company of a consortium has submitted a great vision of how this is going to benefit them and help grow their business. If that company fails, it is more difficult. We would either have to find some kind of agreement or terminate the project.

Remember: we do not want a widget to be delivered out of these projects. There are 13 benefits that we are monitoring frequently.

Normally, we ask whether it is worth continuing the programme. Are we still accruing these benefits? These are pretty difficult discussions. I am very well supported by a commercial team in Innovate UK who not only do the due diligence at the start but can wade in.

What if we have a suspicion of fraud, for example? We have had to deal with that as well. I am reliant on some commercial support, which, I have to say, is as good as I have seen in industry. I can only sing its praises.

Q288 **Graham Stringer:** On how many projects have you pulled the plug?

Roger McKinlay: Several have failed to start. Sometimes, that is good news because there is a bit of honesty. They say, "Look, we have pivoted." A brand new start-up pivoted and left the grant on the table. Therefore, we have projects that fail to start. I do not know the exact number, but of the 200-odd projects we are running now I cannot recall something totally falling apart midstream.

Q289 **Graham Stringer:** The answer to the question is none.

Roger McKinlay: I would have to come back to you. To be very specific, if I came back with a figure it would be how many projects had ground to a halt with less than half the grant having been spent. That is how I would search the database.

Q290 **Chair:** Given this is a series of cutting-edge technologies, you would expect quite a few to fail. Looking at innovative businesses generally, some do not work out. If there were none or very few, might there be a concern that it indicated a too conservative approach?

Roger McKinlay: Yes. Let us disentangle two sorts of failure. Some of our projects have 15 or 16 collaborators. If there is a huge bust-up and they all fall out, that is not a good situation. Therefore, keeping these teams together and achieving things is important.

One machine breaking can put a six-month delay in a programme. Difficulty in supplying devices, or supply chain issues, can delay programmes. We fight our way through that.

What we do not do, particularly in the early collaborative projects—it has changed a bit with some of the recent small business research initiatives where we are buying products—is hold them to account for a particular technical level of performance, because it is very interesting to know that they cannot make it, as it gives us an idea of maturity. If someone says, "We can build a laser with these properties," and, at the end of a project, they have a laser and it is still marginal on line width, we now know how difficult that is.

As we move towards SBRI, we want these products to be usable, particularly the Government customer, and there we are paying more attention to the achievement of technical milestones.

Q291 **Rebecca Long Bailey:** Mr McKinlay, you mentioned the symbiotic roles

of EPSRC and UKRI. Will you elaborate a little on how Innovate UK has been able to double private sector investment into the commercialising quantum challenge fund?

Roger McKinlay: First, you have to understand why we have quantum companies, why they want to stay in the UK, why overseas companies are setting up in the UK and why I am desperate for that to continue. It is the ecosystem; it is the proximity of world-class research in the universities, many of which have been running hubs and all of which are part of hubs; it is the skills coming out of centres for doctoral training. It is the way in which clusters form and why some countries have found themselves stronger in certain technologies than others. On top of that, if we are getting that right, the sector is growing, but the real thing you need is a vibrant, healthy, growing industry and to keep it attractive.

The thing that has surprised me—this will sound rude to some of my colleagues—having come from a very technical industry, aerospace, is that when it comes to international collaboration and raising investment the sheer kudos associated with outstanding science has an enormous impact. The new hubs are so welcome because we need smart, high-profile people, and then industry is attracted to that. There's no doubt about it. It is attracted in terms of help with difficult problems; it is attracted in terms of getting hold of good people.

Q292 **Rebecca Long Bailey:** How are UKRI, Innovate UK and the Government working together to drive that commercialisation of quantum technologies?

Roger McKinlay: It gets more difficult as you get more ambitious and the sector grows bigger. How do you stay joined up? As for the new vehicle for this, it having being challenge-led in the past relationship with EPSRC—and you have seen that it has been very strong—now we are talking about missions and a grander vision. We have recently introduced some other players into the catalyst programmes, where we have Government as a customer. That is an important part of the mix.

Keeping all this together involves bringing in Government users and Government customers, partly because you then have educated people making policy decisions, future procurement decisions, spotting the societal benefits and so on.

An important element is to grow the Government footprint. One of the main jobs of the National Quantum Computing Centre is that engagement, both externally and within Government.

Q293 **Rebecca Long Bailey:** You mentioned a funding cliff edge going from £20 million out the door all the way down to £4 million, which is quite staggering.

Roger McKinlay: It is £70 million to £4 million in one year. We have yet to work out what the 2025-26 year will look like but there are enormous constraints, and it is between SRs.

Q294 **Rebecca Long Bailey:** First, what would you like to see from Government in future funding? Secondly, what would you like to see specifically in funding programmes for commercialisation of quantum technologies?

Roger McKinlay: I would like to see us being able to bridge that gap by a bit more than £4 million. We are working with DSIT. DSIT and UKRI are obviously working on that, and it is related to how much core funding UKRI can put in, but in the longer term remember that the demands of the sector grow. I mentioned the £610 million that we have seen our companies raise over seven years. They will probably have to raise that again in the next three years. That is what growth means. If in peak years we had been putting about £70 million out the door for the ISCF-type programmes, I would say that, if the programme is helping the sector to grow in the future, the figure for funding missions, for example, could be over £100 million a year. I do not want to pre-empt it where planning has not taken place, but it has to grow and we will get the benefits with a growing industrial sector and the UK remaining a go-to place for quantum, which it is at the moment.

Q295 **Chair:** It is clearly implicit in what you have just said in answer to Rebecca that your view is that this should continue and that it should not be the end of the programme. Is that accepted within UKRI? Another way of thinking about it is that you have these programmes to kick-start a sector that has commercial potential, it takes flight and you do the same for another. Talk me through your experience of the internal view on that.

Roger McKinlay: There are two aspects to this. As we have seen with ISCF, one is what we call managed funds and where I think the missions will go. Should UKRI still be using its resources to deliver that? The answer is yes, and I think that is generally well accepted.

How much of UKRI's core might go in future is currently unknown. I am saying that with my industry hat back on. Whether people appear to be supportive and what the general mood is is one thing. You have to get an agreed budget and see what your future funding is. Looking at core over the next five years, that conversation is still taking place.

Q296 **Dr Davies:** We have already touched on the infrastructure in this country around quantum technologies. Specifically, how are UKRI's national facilities supporting commercialisation of this technology?

Anke Davis: I will start. I am sure Roger has additional elements to mention.

We have a number of different facilities that help with that. Roger mentioned the National Quantum Computing Centre. You have had Michael Cuthbert here as a witness. In addition, the Hartree Centre in Daresbury is working on bringing together quantum technologies specifically in that area, and all across the country. The Rutherford Appleton Laboratory in Didcot also has a programme to bring quantum to

companies and bring companies into quantum. There are a number of different aspects where this happens with an official labelling of quantum.

There are other ways in which this is happening—for example, through engagement with catapults and other large existing infrastructures in nascent areas, such as semiconductors. What can these areas bring to the table for quantum where there are overlaps? The photonics industry is another one where we are bringing together different aspects that are beneficial to the quantum technologies ecosystem. All these facilities have the ability to include new partners. They will have a model of engagement. These models may vary depending on the facility, but they are all open to engaging with new partners.

Q297 **Dr Davies:** What work is taking place to develop more such facilities with universities and industry?

Anke Davis: You might have heard about the Royal Academy of Engineering review that is looking at industry support with regard to infrastructure specifically. We have seen keen interest from industry and academia to provide information around that. I believe there are aspects such as access for industry to academic facilities, thinking about smaller companies not being able to have their own fabrication facilities, for example. Where can they access those? There are several universities with individual strengths across the country that have those, and it is about ensuring that companies are aware of where they can tap into them.

Dr Davies: Mr McKinlay, do you have anything to add?

Roger McKinlay: Let me run quickly through a list. Who do our companies love when going for infrastructure? They love NPL, which is key.

Chair: That is the National Physical Laboratory.

Roger McKinlay: The Fraunhofer Centre for Applied Photonics appears in many collaborations. To a lesser extent, we have the digital catapult and compound semiconductor catapult—the catapults are involved. Remember: we get an indication of demand. We have not had a quantum catapult. We have been well served by the organisations I have mentioned so far.

Scaling up manufacturing will be a different story, and that is why we are watching the Royal Academy of Engineering report when it lands in, I hope, a few months' time.

Q298 **Dr Davies:** On the idea of a catapult, would a national advanced quantum manufacturing centre, similar to AMRC in Sheffield, be a good thing and, if so, would UKRI lead on it?

Roger McKinlay: There is such a broad spectrum of manufacturing associated with quantum that I personally would be unhappy to see the

"Q" word above the door. If we look at where the benefit could be greatest, it might be decided, for example, that we need a real boost in photonics. This is what the study of the Royal Academy of Engineering is looking at.

It is important to realise that universities will always make a strong case that they can help prototype and take the process so far, but remember that pilot manufacturing is done by somebody who intends to manufacture. What is missing from our landscape at the moment is attracting or creating manufacturing companies that say, "We think there is a job for us, and it is making the stuff."

Anke Davis: UKRI has experience of setting up different types of centres and programmes. As Roger said, it is important to note that for the quantum area there is a range of aspects to consider. Certainly, partnerships between different funders and different Government partners would need to be considered before making such a decision.

Q299 **Chair:** To push that a little bit further, Mr McKinlay, do you think that a catapult is missing? In the ecosystem of catapults, should there be a quantum one?

Roger McKinlay: I think that the ecosystem has been filled very effectively by the demand of companies—the digital and compound semiconductor catapults, in particular, the Fraunhofer and the SEG work of NPL. To some extent, we have got through the catapult stage without one, but I go back to the reason the Royal Academy of Engineering is doing this study: we need to look carefully at where there may be some barriers to scale-up.

Chair: I thank both witnesses for helping us in our first session this morning.

Examination of witnesses

Witnesses: Andrew Griffith and Tom Newby.

Q300 **Chair:** We are very pleased to welcome Andrew Griffith, Minister of State for Science, Research and Innovation in the Department for Science, Innovation and Technology, late of this Committee, of which he was a very valued member for a good part of this Parliament. Andrew, I think this is your first appearance as a witness before your old Committee, so welcome.

Tom Newby is deputy director and head of the UK Office for Quantum at the Department for Science, Innovation and Technology. He was appointed head of the UK Office for Quantum in September 2023. Thank you for coming.

Minister, you may have heard some very impressive statistics about the impact that the programme has had, but some concern that a prospective cliff edge in funding in the context of long-term commitments could stop

the momentum. What is your view of that as Minister?

Andrew Griffith: Chair, thank you for the invitation to appear today, and for the very thoughtful work you have done in this inquiry. As part of the preparation for today, I read all the witness transcripts. It is a good piece of work and very thoughtful. If you want us to react to your report in due course, I would be very happy to do so. There are some points that you raise that, quite rightly, we will take away.

Access to long-term funding is something we will all be familiar with as parliamentarians operating within cycles and the inability of Parliament generally to bind its successors. That said, there is recognition of the importance of quantum. I think that sends a very strong signal to the of the technology priorities that we see.

As you have heard from other witnesses, a very strong institutional base is now being built in quantum. It is that institutional base that will be coming forward with the detailed proposals as part of the spending review.

Much as I would love to hear—I am sure it will be one of the strong views that is not unhelpful for the Committee to hear—about the need to provide confidence, clarity and certainty of funding, there is nevertheless in that hierarchy broad-based cross-party consensus about the desirability of funding research and development in the UK, which will reach £20 billion a year for the first time in the fiscal year that we are about to go into at the start of April.

That is broadly based with the hierarchy that has been laid out about the importance of quantum, and the fact it is a transformational technology that operates across a number of sectors. We all know how broad it is as a set of technologies, and the sector, if it is listening, should understand that certainly this Government have the highest level of commitment to deliver that £2.5 billion of funding. I know that people are already starting to work on what that looks like in the spending review.

Q301 **Chair:** Mention has been made already this morning of the role of the report that the Royal Academy of Engineering was commissioned to undertake on the infrastructure supporting the UK's quantum capability. Has that report been received by the Department?

Andrew Griffith: I certainly have not seen it.

Q302 **Chair:** Mr Newby?

Tom Newby: We have an interim report and we are working to finalise the draft for next month.

Q303 **Chair:** You say you are working on it. Are you in dialogue with the Royal Academy of Engineering?

Tom Newby: The Office for Quantum is working with the Royal Academy of Engineering. It has given us its interim report. We have asked it to

look into a few additional areas for us before it hands over the final product, which we also expect it to publish next month.

Chair: That was going to be my next question. You expect to get the final report next month and publish it straightaway. That is the intention.

Q304 **Carol Monaghan:** Minister, how is the Department working with both academia and industry to define the quantum missions announced last autumn?

Andrew Griffith: There is extensive engagement. The five quantum missions were high-level missions. There is work going on in specialist working groups and engagement behind each of those that will come up to us later this year. We aim to publish that before the summer to turn those high-level missions into specific sets of plans, but the answer is that, using all the engagement architecture that exists, the Office for Quantum, which is the lead within government, and the quantum hubs themselves are condensing points for thoughts around that, and we know there is very strong academic leadership in that. If behind that question is any sense that that is not happening as it should, please let us know. We are very keen to make sure that engagement happens properly.

Q305 **Carol Monaghan:** Can I ask a wee bit more specifically about the missions? You have timescales attached to all the missions. One is 2025, which is fairly short term. Three are 2030, and there is one that is 2035 relating to quantum computers. We have had some evidence from Dr Chris Erven, who is concerned that the long-term nature of some of these missions could endanger the UK's position as a leader. Would there be some merit in shorter-term targets within the longer-term missions? Is there any sense of that within the Department, or has that been considered?

Andrew Griffith: I will let Tom come in, but I think it is a very good point. Clearly, as you go from a mission into a plan, that plan is likely to have a set of milestones so that one can rightly track progress towards that longer-term mission target being achieved. The answer to that is "yes", Carol.

Tom Newby: We have two short-term missions—one on computing and one on position, navigation and timing, out for two years, which are geared towards the current programme—and then we have the longer-term 10-year missions, and alongside those we have set out interim milestones. We think it is absolutely important that you break that down. That is what we are doing our industry engagement on now: how do you design programmes in the near term to move us towards those missions?

I would say that having that long-term ambition and making it concrete has been well received by industry, and they are ambitious but we also think achievable. We think there is a balance between outlining programmes that will help us to get there and setting a long-term ambition that sets direction and helps to guide investment.

Q306 **Carol Monaghan:** I suppose it is the vision rather than the nuts and bolts to get you there.

Tom Newby: Yes.

Q307 **Carol Monaghan:** In terms of the nuts and bolts to get there, is there going to be publication of the milestones that you are describing?

Tom Newby: We published the milestones in the autumn statement. They are published alongside the strategy at the moment. You have the high-level strapline missions and milestones underneath them. We plan to provide further detail on how we will deliver against those milestones before the summer as part of the plans.

Q308 **Carol Monaghan:** How you will deliver and how you will evaluate.

Tom Newby: Yes.

Q309 **Carol Monaghan:** If two years from now we find that things are not hitting targets, what are the actions? That is one for the Minister. There may be an election between now and then, Minister.

Andrew Griffith: Let us take it as one always would, one step at a time. We set out some ambitions. I think we have the right balance between ambitions and what has been told to us by industry that it can realistically achieve that will keep us on a par with other leading quantum nations—we are one of the three leading quantum nations—and those missions are sized to ensure we continue to do that.

The next thing we need to do is break down and have credible plans behind those missions. You set out the top level where you are trying to get to. The plans will be how we get there and the detailed milestones along the way.

Q310 **Carol Monaghan:** I am asking how you are evaluating whether you have met the milestones.

Andrew Griffith: Correct. As part of that, the Office for Quantum tracks delivery on all its objectives—whether it is delivering an extra quantum hub or how the National Quantum Computing Centre is doing—and we will provide transparency along the way. These are operating in an external market anyway. There will be transparency on how we are tracking towards those.

As for what is then the remedial action, it will be the same menu of tools that we always have, which is to divert funding to the right place, to be held to account by this and other Committees, and to use steering boards within the Department and within the Office for Quantum to hold people to account for their part of the delivery of those plans.

The first thing is to share with you those plans. They are being formed as we speak by the industry with the Department, and we will share them as soon as they are ready.

Q311 **Katherine Fletcher:** Minister, nice to see you on that side of the horseshoe with your continued enthusiasm, and not on this one.

We are talking about something that is really exciting. We are closing the gap between bleeding-edge research and things that have practical and commercial value. I want to dive into how we make sure we get a commercial bang for our buck. Unusually, putting aside my love for the pure science of it, almost as a follow-up to Carol's question, how are we making sure that we are not funding a load of stuff that is wonderful and theoretical but, at best, is a novel party game? What is the commercialisation approach in the Department?

Andrew Griffith: It is very strong. We track it strongly. That is always one of the considerations when we look at allocating funding. There is a big role for Government as a customer in these emerging domains, how we can use Government money to pull people through that process and look at where it is possible to match-fund, either by the design of a particular programme from something like Innovate UK or by simply looking at the areas of greatest interest and supporting those companies that are starting to scale and starting to be close to that point of commercialisation. We have a good track record.

When you look back at some of the big companies in this space, you can see exactly that: they have often come from what was a quantum hub or QTEC or something like that—the nomenclature changes over time—and then they have started to scale. The Government have been putting in grants. Often, the Government have put in capital through things like the patient capital scheme and they have scaled thereafter. We track as closely as anything the success of the UK companies—the spin-outs and the scale-ups—that are doing that.

Q312 **Katherine Fletcher:** Are you tracking turnover, commercial deals signed and profitability?

Andrew Griffith: Yes, and valuations and capital raised.

Q313 **Katherine Fletcher:** I am so old that I remember the internet bubble where there was an awful lot of people getting an awful lot of both private and public capital to do stuff that never actually turned into a commercial product even though it undoubtedly drove the internet forward.

Andrew Griffith: The internet was quite a big thing. We are tracking exactly that. Your biggest strength is often your biggest weakness, and the other way round. We do not have any of the domestic big, global tech players. That can be a weakness in trying to scale. It means that we have to use private capital and public finance well to achieve our goals.

The flip side is that we are in many ways agnostic. For something like quantum, we are supplying almost all the major technology companies with the enabling technologies behind that, so that can be our great strength as well.

If you look at quantum communications, a UK spin-out called Arqit is one of the world leaders in quantum-safe communications technology. It recently won an award at the Mobile World Congress. That is a UK spin-out start-up.

Q314 **Katherine Fletcher:** The UK has £2.5 billion in; we have already seen £4 billion of commercial revenues coming back to these companies; and we have an ambition for "pick a figure". Are you tracking it like that?

Andrew Griffith: Obviously, it is easier to track what has actually happened to date. Of that £1 billion that has been spent on quantum over the last decade, that has been matched already by about £500 million of private capital. That is quite early stage. If it was later stage, you would expect a greater amplification, but that is what we can already see from that first £1 billion. I have lots of tables of data, and I would be very happy to follow up with some more data, but I do not want to read out a table. It's not great.

Q315 **Katherine Fletcher:** No, that's cool. We are successfully drawing in private capital, but we are not necessarily seeing those companies at a point of profitability where they are returning tax revenues to the Exchequer.

Andrew Griffith: Correct. We should be realistic. This is a deep tech-style investment curve. A lot of the companies, if not pre-revenue, are predominantly deriving their revenues from other research and development programmes. They might be working on cryogenics and supplying those cryogenic tools to other companies in this emerging sector rather than end users as of today. We track all the major UK quantum companies, funds and how much they are raising. I have appendix 34 in my pack. I will write to the Committee and share that data.

Q316 **Katherine Fletcher:** Bless you. Thank you. Do you have a personal instinct, a ministerial instinct, about when this sector will start returning revenues to the Exchequer?

Andrew Griffith: It is quite a diverse sector. I would love to answer a simple question in a simpler way, but, as we know, quantum-secure communications are pretty proximate. There are financial institutions that, right now, are purchasing that. That is a revenue model. It will turn profitable in the very near term.

With quantum computing, you can sell a lot of shovels to gold miners, as it were, right now. If you are doing the enabling technology, the error correction software, the advanced cryogenics or some of the advanced photonic chip creation, there are markets for those products right now.

As for end-user-ready quantum computers, it is embedded in our quantum missions to be producing products out of the UK that would be the sort of commercial products that people would use in end-user applications. Medical sensing is very close. I have visited Nottingham.

They are using quantum-style technologies to do quantum sensing right now.

Q317 **Katherine Fletcher:** You are right; it is a simple and almost unfair question because you are spread betting on so many different options, effectively.

Andrew Griffith: Yes, it is a diverse sector, and different parts of the sector will have different return attributes. While not just purely looking through a financial lens, though that is incredibly important when we are allocating taxpayers' money, some of these are also enabling technologies for the work of Government. If we look at domains like position, navigation and timing, we see that the Government are a big end user of that, although not exclusively. Even in this market, when you think about medical sensing or quantum augmentation of AI applications for scanning body tissues, the Government are far and away and often exclusively the only customer. We should think about the returns as well as productivity tools to the Government sector.

Q318 **Katherine Fletcher:** That is very fair.

Mr Newby, coming back to that theme—I am very grateful to the Minister for demonstrating the depths of his passion and knowledge—how is the Office for Quantum picking that up? What are your priority actions now to drive this commercialisation?

Tom Newby: We have been established to help orchestrate activity across the programme under the new ambition of the £2.5 billion over 10 years, and commercialisation is right at the heart of it. As we discussed before, a large part of our focus at the moment is developing the proposed activity under the missions. We develop them in partnership with the sector and delivery partners in UKRI ahead of the autumn statement. The idea was to give concrete, ambitious outcomes that could help to drive private investment, and we are building the programmes underneath those now.

We are also working to build international partnerships, which will be absolutely key to maintain the competitiveness of the UK sector—making sure that we have the right R&D collaborations in place and the right supply chains in place. We are building the evidence for what next on the programme in other areas as well. We have touched on infrastructure. Skills and talent are absolutely critical. We are supporting the Quantum Skills Taskforce led by Professor Sheila Rowan to give us advice on those.

They are just a few areas where we are getting further advice on how we evolve the programme to drive commercialisation.

Q319 **Katherine Fletcher:** That's cool. Are you doing progress reports? Do you have one due?

Tom Newby: We provided a progress report as part of the refreshed science and tech framework in February, and we will continue to provide public updates as we have new updates.

Q320 **Katherine Fletcher:** Right. So, it is more a "little and often" on reporting back on the implementation of the strategy. It is not a big set-piece event that the Committee needs to wait for.

Tom Newby: I would not say that there is a single set-piece event because we are providing updates all the time. It was quite a comprehensive update as part of the S and T framework refresh. I expect that we will provide a further update by the summer on some of the activities that we have described.

Andrew Griffith: You have the infrastructure report; you have the detailed plans behind the missions to come out; and later you have a skills report. All those are in reports.

Katherine Fletcher: The plans are going to have specific, targeted and measurable outcomes. Sorry, you can tell what job I used to do.

Q321 **Chair:** Minister, can I ask about our participation in Horizon Europe, for which we agreed associate membership? Am I right in thinking that our access to research on quantum technologies is excluded from that?

Andrew Griffith: I do not know, Chair. I would be surprised, given we have talked about how broad quantum is. It is not one technology; it is photonics, some physics and some sensing technologies. No one has quite put it to me in that way.

Tom Newby: There are quantum-related calls that the UK has been excluded from for this coming financial year, because the Commission has judged them as strategically sensitive. We have made representations to the Commission that our programme is an open programme and that we are very keen to participate. That dialogue is ongoing.

It is worth saying that there are other calls that will be relevant to quantum companies that they may participate in. It will not just be the quantum-specific ones that benefit them. Obviously, the quantum ecosystem benefits from access to Horizon and the benefits that has to science and tech. There are also other European programmes such as Eureka on which we continue to collaborate on quantum on a pan-European basis.

Q322 **Chair:** Did we know that in associating with Horizon we would be excluded from those quantum calls?

Tom Newby: We were hopeful that we would be provided access. We did not know for certain at the time that that would be the case. It is worth saying that the door is not closed for future access on quantum. This is

an annual process that the Commission goes through in refreshing those calls, and dialogue, as I say, is ongoing on future participation.

Q323 **Chair:** Are you aware of other aspects of research funded by Horizon from which we have been unexpectedly excluded?

Tom Newby: I believe that high-performance computing is also an area of exclusion, but I am not aware of others beyond that.

Q324 **Chair:** We have only recently discovered this. It is very helpful to have that confirmed and explained. This is very unsatisfactory. Part of the point of participating in these cross-Europe collaborations, and beyond, is that we are bringing together UK expertise with others around the world in some of the most promising areas. To be excluded from some of the most interesting and promising areas is very unsatisfactory. Would you agree with that?

Tom Newby: I would agree that we would strongly like to participate, and the Secretary of State has made representations to the Commission on this matter. Dialogue is ongoing. We are continuing to share information on our own programmes and hope to be able to participate in future.

Q325 **Chair:** You say that this is for this year; this is clearly ongoing. When a decision is made about future calls, is there any reason to believe that that access will be restored for future programmes?

Tom Newby: I believe decisions will be made this autumn for the following year. Discussions are relatively positive and constructive in that lots of information is being shared—different conversations are happening with different parts of the system. Obviously, I cannot anticipate what the Commission will decide, but we are pushing as hard as we can.

Q326 **Chair:** Minister, I assume that you share my dismay at this news, this development.

Andrew Griffith: One is dismayed at anything that puts friction on international science collaboration. To be clear, we put no frictions on that. UKRI programmes explicitly fund up to 30% of participants in doctoral programmes from overseas. We want the broadest range of collaboration. I talked yesterday to the Swiss, with whom we have an MOU about collaborations in areas like quantum. It is certainly not coming from us. Of course, it is regrettable if anybody seeks to put frictions in the way of international science collaboration.

Q327 **Chair:** You were involved and certainly aware of the discussions about acceding to associate membership with Horizon. Were you in the Treasury at the time it was concluded?

Andrew Griffith: Yes. I was not involved to be truthful, Chair.

Q328 **Chair:** So, you do not know whether there was a warning given during those discussions that we might be excluded from certain programmes.

Andrew Griffith: I do not know that.

Q329 **Chair:** I see. It would be right to give your view on whether it would be unsatisfactory that, having taken this decision, we might be excluded from future programmes that are of great scientific importance without the right, as it seems, to insist on that participation.

Andrew Griffith: You put it well, Chair. On the flip side, we should be very positive. We are one of the world's leading nations in all these quantum technologies. We attract the second largest amount of investment into quantum from private capital in the world. Our technology is often in the supply chain of almost every major quantum project in almost every major market.

I agree with your point. It would be, on some levels, odd to exclude an outward-leaning, collaborative nation that is world-leading in this domain, as well as others, from international collaboration. The whole point of wonderful projects like Horizon, the world's biggest international collaboration project, is to collaborate. The clue is in the name.

Q330 **Chair:** Indeed. Britain, as we have established during this inquiry, has a particular strength in quantum technologies. For Horizon to say that it does not want to collaborate, or will not allow us to collaborate with that, is it not concerning that scientific discovery might be suborned to other perhaps more political purposes?

Andrew Griffith: As I say, Chair, you put it well, but in the meantime we will control what we can control. We have an ambitious set of plans. We are going to be announcing more quantum hubs in the UK in the future. There is a significant increase in our investments coming up for the next 10 years. I would put it to anyone that the UK has a great deal to offer as a collaboration partner in quantum as in so many other technologies.

Chair: Thank you very much for that. You have been very clear.

Q331 **Carol Monaghan:** Minister, we have heard a lot of evidence that there are concerns about the skilled workforce, particularly when we are talking about areas like quantum. What work is your Department doing with the Department for Education to try to look at this and tackle it?

Andrew Griffith: In particular, we have a piece of work ongoing led by Professor Sheila Rowan to look at skills in this space, and I look forward to sharing that with the Committee. They wanted a little bit more time to do that work in a little bit more depth. We will try to get the balance right between moving that forward at pace and giving those that we have asked to lead that work the time and space to do so.

We work very collaboratively with the Department for Education. We clearly have shared equities in continuing to promote our great universities as fantastic seats of research. That is vital. It is one reason

the quantum hubs are embedded within universities like Birmingham, Glasgow, Oxford—and York? Yes, York—I got it right.

Carol Monaghan: We were going to sit silently and wait until you got it!

Andrew Griffith: We have more hubs along the way. We are very embedded. There are a lot of either directly quantum or quantum-related technologies centres for doctoral training.

Q332 **Carol Monaghan:** You are talking very high level. How are we going to make sure that a pipeline of talent is coming through? What work has been done at school level to ensure that we have the right people coming through? What work has been done to make sure we have physics teachers in schools who are going to be delivering the subjects that are required in order to feed that pipeline? Apologies, I know this is slightly outside your remit.

Andrew Griffith: The best place to point that to is the relevant education department for the nation that we are talking about. It is not that I would not have a view; I just do not think it is particularly fair. We do not do sub-18 education. We fund research. Of course, we have very strong equities in making sure that there is a huge pipeline of STEM. As we see technologies like quantum come and occupy big parts of the research domain, the hunger for STEM is even stronger. Our Department has sponsored the new mathematics academy. That will go a long way to try to promote a new generation of mathematicians, and that will, of course, help. We have relatively limited equities in this space, Carol.

Q333 **Carol Monaghan:** I understand that. The reason I am asking these questions is that it is not good enough, I believe, for one Department to take responsibility to that point and another Department to take responsibility after, when what your Department is doing has been highly influenced or impacted by what is happening in another Department. It would be useful to know whether there were any plans to have discussions with the Department for Education in this area.

Tom Newby: May I come in on that?

Carol Monaghan: Please do.

Tom Newby: It is worth saying that DFE is involved in the taskforce that the Minister mentioned and it has been working with us really closely on our future plans. As you said, the priority in STEM investment has to start right at the bottom. It has committed £600 million over the next two years, including to help retain teachers in STEM professions, which is going to be important.

Q334 **Carol Monaghan:** Could you give detail on that? Is it by increasing salaries? How is it going to retain these teachers?

Tom Newby: I am afraid I do not have any further detail, but we will be happy to follow up on that. I suppose it has the building blocks for that.

From a quantum perspective, we have initiatives such as a quantum ambassadors programme that we are funding with STEM Learning and working on with DFE, which is about helping train teachers to deliver to sixth form students, basically, modules on what quantum science is and what quantum technologies are to raise aspiration to go into this field. It is a small part of the pitch, but it is an important one.

Many of the announcements that the Secretary of State made just two weeks ago at the maths summit will also support a pipeline from school onwards. The apprenticeship scheme that she announced will be picking up off the work that DFE is doing.

Q335 **Carol Monaghan:** Can I ask more about this quantum skills plan? I have a slight concern that people working in industry come to us and say, "We cannot get the people to do this." There are very few people with the skills required and there are lots of interested parties. Surely, what we need is bright, young people who can be trained to do what is required. Surely, they do not need a PhD in order to go in. Should industry be taking more responsibility to train people in the skills that are required?

Tom Newby: That is a big focus of the taskforce's work. To get the level of talent that we need for the sector to grow, it will not just be state-funded training; it will be on-the-job training. It will be taking technicians from broad engineering backgrounds and helping them to understand how to build a quantum computer.

Industry is really interested in this. It is worth saying that these are mostly start-ups. On-the-job training is challenging in that environment, but as they grow in scale they will be able to invest more. That is why we are looking at things like apprenticeship programmes to help to facilitate them in doing so.

Q336 **Carol Monaghan:** Will you be monitoring what companies are participating in such things?

Tom Newby: Absolutely. We have already had a lot of input from companies through the taskforce telling us their plans. A key part of any skills action plan has to be understanding how that evolves over time, and we will, of course, monitor it.

Q337 **Dawn Butler:** Minister, you obviously spend a lot of time thinking about quantum and its practical implications. What is your vision? How do you see quantum and its application, and how it is going to work—both positively and negatively?

Andrew Griffith: My vision is not a technology vision; it is for the UK. This is a big part of the answer to the question: how does the UK compete in a very competitive global world where access to skilled labour, capital and many of the other ingredients of a modern economy is in relative abundance? That is very different from the world I was born into.

The science and technology framework seeks to answer that. We have worked with industry and others, such as the royal academies, to identify the areas that the UK will be prodigiously good at: engineering biology, AI, future telecoms and quantum. That is a set of choices. It is a bit like an industrial strategy. This is the charter for the areas into which we want to put our mind time, in government, and some of your taxpayers' money to make sure that we have the right skills and are sending signals of leadership to the industry, so that they know that we have got their back and they can understand the Government's position when they are trying to figure out what long-term demand curves look like.

That is really the work of the Department. To be clear, these are not the only domains. We have things like the creative industries and the core life sciences, but that is the work of the Department. That is the role of the Secretary of State and Ministers in the Department.

My vision is that the UK is one of a handful of world-class competitors in this space, building on our really strong science base and some of the institutions. We have heard about the National Physical Laboratory and some of the assets that we have at Harwell, but there is the photonics in Scotland as well. We can successfully harness all these assets—our legacy, if you like—and turn them into global-scale companies, or we can have global companies choosing to operate here, creating jobs, ladders of opportunity for people and sectors adjacent to things like quantum that can be part of those supply chains.

I am sorry. It is a big question to answer.

Q338 **Dawn Butler:** That is a very comprehensive response. Some people must have said, "We should be worried about X, Y or Z," or, "This might be a concern." What have been those concerns that have been raised?

Andrew Griffith: I did not fully answer your question, so my apologies. The biggest concern that I have—the thing I wake up in the small hours worrying about—is that we get left behind: that we are just a bit too slow. My concern is that we are right about the opportunity and the impact on society—not one domain, but many domains—

Q339 **Dawn Butler:** Are there no fears at all about the technology?

Andrew Griffith: There are always fears about any new technology having nefarious uses. That is why we are working heavily with the NCSC and making sure that we are controlling exports of particularly sensitive parts of the technology. It is why, in a global technology race that has some geopolitical consequences, it is imperative that the UK continues to have access to the deepest capabilities—that we are not excluded or outcompeted in this domain.

There are some concerns. My biggest one is that we are just not agile enough—that we do not rotate skills or do not get the funding councils to allocate money across from different sectors quickly enough.

Q340 **Dawn Butler:** In that fear about being left behind, are we fully considering the security and privacy issues that might be—

Andrew Griffith: I think that we are. I would not be complacent about it.

Q341 **Dawn Butler:** How are we doing that?

Andrew Griffith: It is an emerging domain. We are working with the companies that are producing these technologies. With emerging technologies, it will tend to be the case that what is possible will be led by those who are operating at the cutting edge. We are also working with national security. We are working with the National Cyber Security Centre, which sees this every day. We are building some of those capabilities ourselves—for example, in positioning, navigation and timing.

It is very retail, but we saw the example of the Defence Secretary's plane losing access to the global positioning satellite signal. Part of the importance of the work being done by my Department and other Government Departments around positioning, navigation and timing is to provide resilience against that sort of new technology, to which others now have access.

Q342 **Dawn Butler:** How about natural resources? Obviously, the development of quantum is going to take a lot of natural resources, whether it be water or energy. What have you been doing in your Department to understand the need for natural resources? If there is a 360 innovation—what do you do with the amount of water that is needed, for example? What do you do with the water that is coming out the other end to cool quantum computers?

Andrew Griffith: I am very happy to have a follow-up discussion, because I do not know enough to answer your question fairly today. However, there are many fantastic environmental and climate applications of quantum: both quantum sensing, to detect particles like methane in the atmosphere, and single photon sensing, so that we are able to predict landscape movement and evolution over time.

My hope—my optimistic bias, if you like—is that as these new technologies come and scale, we as mankind will put them to good use. Optimising a traffic network so that we have less congestion and pollution and make a fixed amount of resources be more productive seems to me to be the likely way in which we can put these to good uses. If there are incremental increases in energy consumption, for example, we can more than offset them by making our society more productive and our resources more optimised.

Dawn Butler: Mr Newby, you wanted to jump in.

Tom Newby: I thought that I might add a couple of points. To go back to privacy, the Information Commissioner's Office has done some work on quantum technologies. They published a report back in 2022, which

was a scoping report. They are planning to publish a further study on it this year. They are starting their thinking on the privacy implications of both quantum computing and quantum sensing. Obviously, it will be gathering information. It is important that we have the controls in place to do that.

On environmental implications, these are technologies that are likely to rely on critical components—precious metals, minerals and things like that. Exactly which, depends on the platform that we take. The Government's current approach is to explore different kinds of quantum computing platform. That was the announcement that we made recently. We will be exploring seven different modalities at the National Quantum Computing Centre. That will allow us to assess the scalability of the platforms. Part of that has to be, what is the access to the minerals that are required and, realistically, what are the environmental implications of scaling that up? We will be thinking about that with the National Quantum Computing Centre as it tests some of that work.

Q343 **Dawn Butler:** Great. Do we have a strong ethical thread running through that?

Tom Newby: We are seeking and have received advice from the Regulatory Horizons Council on how we think about ethics in relation to quantum technologies. We plan to respond to that in the next three months. Ethics has to be key to how we think about these technologies.

It is also worth saying that, because we are at the early stages of development, we can put in place broad principles for governing how these technologies develop. The key thing is equipping our regulators and innovators with the tools to develop more detailed thinking on ethics as they understand the applications better. There is a lot of uncertainty about the path of these technologies at the moment. Part of our response to the Regulatory Horizons Council report will outline some of our thinking there.

Q344 **Stephen Metcalfe:** I am interested in the work that the Government are doing to stimulate investment in the sector. Do the Government have a specific programme to incentivise private investment? If so, how does that work? Do you have any concerns that, potentially, the work that you are doing could end up paying the dividend not here in the UK but somewhere else? Can you start with the big picture and then talk about some of the details?

Andrew Griffith: Yes, that is a concern. It is a concern more generally. Some of the previous speakers talked about that as well, particularly as it relates to deep technology—which is really code for a long runway from the moment when you are trying to scale to the point at which you become self-sustaining, generating revenue and cash flow. That is generic to the UK growth sectors and spin-outs from science and technology. Potentially, it is particularly specific to quantum, both

because the scale of opportunity is very large and because the runway to profitability is quite long, by definition.

Most of this sits within the work that our brilliant colleagues in the Treasury have been doing to mobilise additional private capital. A lot of public money has gone in, both for direct research and development and for a whole slew of innovations, from future fund: breakthrough all the way through to the latter stages of scale-up—things like the UK Infrastructure Bank, with its nearly £20 billion of potential investable resources.

There is a lot of public money going in. It is right that that continues, to make sure that it pivots towards the less-mature technologies. There is always a danger that they over-invest in things that look relatively low risk and do not rotate that public capital, which should have a high-risk appetite against it, into areas like quantum. As a Department, one of our roles is to ensure that all those public forms of capital investment are properly understanding the opportunities in quantum.

More generally, there is the work that the Chancellor and others did on the Mansion House reforms and the Edinburgh reforms, which are about trying to mobilise private risk capital. In the UK, the biggest pool of that is pension capital. We are blessed by the second largest pool of private pension capital of any country on the planet, but it is very fragmented. Some of the rules and regulations of the financial regulators have meant that it has to be very liquid, and liquidity is axiomatic if you are looking at long-term growth investment.

A lot of work has gone on. To give you a number, the Mansion House reforms, and the compact itself, talked about the opportunity to mobilise up to £75 billion between now and 2030. That is a fairly near-term time horizon when it comes to allocating that capital. As that goes into more illiquid asset classes, one may expect some of it—a proportion—to flow into the higher-risk, high-return end of things, like quantum.

The final point is the recently announced long-term investment for technology and science, which is almost directly at the core of this Committee. If there is ever a fund that would be of interest to this Committee, it is the LIFTS. The Government have recently awarded the mandate to manage that £250 million pot of capital, the idea being that that will condense other capital around it. Of that £250 million, £150 million will be directed squarely at the sort of technology that quantum represents.

Those are some of the interventions. We have the science. We have the smarts. We do not always have the scale-up capital. A lot has gone on there. There are some pots of money specifically for quantum as well.

Q345 **Stephen Metcalfe:** Okay. I will come back in a second.

Tom Newby: There are some other programmes that I would add to the mix that the Minister outlined. The national security strategic investment fund is a really important intervention for quantum. A number of its investments have focused on quantum technologies. A number of the British Business Bank programmes fund venture capital funds that, in turn, have funded quantum companies. They have helped to build some of the scale-up capital that the Minister has outlined.

Q346 **Stephen Metcalfe:** That was all very informative. If I as an investor have a pocket-load of dosh, are you incentivising me in any way to invest that in quantum start-ups—quantum technology companies? There is no greater benefit from doing that than from investing in other areas of potential growth with an equal amount of risk. There is no particular incentive that comes from Government.

Andrew Griffith: Depending on how large your pocket of cash is, Mr Metcalfe, I would advocate schemes like the seed enterprise investment scheme, the EIS or some VCTs—venture capital trusts.

Q347 **Stephen Metcalfe:** Right. I will do better out of that if it is invested in quantum.

Andrew Griffith: Ultimately, you will have to make your own decision. I hope that we have heard today about the potential of quantum and its attractiveness as a long-term investment, but we are not giving investment advice.

Q348 **Stephen Metcalfe:** No. Stocks may go up as well as down.

Andrew Griffith: If we look at some of the successful companies in this domain, we see that they have benefited from those schemes. You and others could have invested at the angel and seed level. Thereafter, some institutional support would be helpful.

Q349 **Stephen Metcalfe:** Okay. Where foreign investment comes in and fills those gaps, are you concerned in any way that, as they grow, the companies that are in their nascent state at the moment will not deliver the wider economic benefit here in the UK but end up moving off to other countries, where they will be scaled up to maximise their potential?

Andrew Griffith: Yes. That is a concern. That was the insight behind the work that the Treasury has done in this domain.

We should not prescribe outcomes. In a global market—and these technologies tend to be global enablers—it is inevitable that some of these companies will decide the right way for them, but we want every company to have a choice. At each funding round stage, we want there to be some UK capital that is available, if those companies choose to do it—without denying them the choice or putting up walls and barriers, but giving them that opportunity.

Of course, that means that they are more likely to stay here for longer, to list here, to build a supply chain here, to support small businesses here

and, ultimately, to benefit British pensioners or investors here. We want people to have that choice. That was the work that the Treasury led on those sorts of reforms.

Q350 **Stephen Metcalfe:** Great. I have a couple more questions. The first relates to the Government and their buying power. They are a great procurer of technology. You mentioned that you have acquired some quantum services.

Andrew Griffith: Yes.

Q351 **Stephen Metcalfe:** Are there any particular successes that you would like to highlight? You talked about positioning, navigation and timing. Are there any particular failures you may not wish to talk about but that we should be aware of?

Andrew Griffith: I hope that you do not take this the wrong way and regard it as recklessness, but there should be failures.

Q352 **Stephen Metcalfe:** I agree.

Andrew Griffith: If the Government never fail, the Government are not taking enough risk to pump-prime the sector. The Government have made some purchases. They were an early procurer of a quantum computer, from ORCA. We are looking in the positioning, navigation and timing space.

The Government have funded not just basic science but a significant amount of innovation. These are neither successes nor failures yet, but, to your point about Government as a purchaser, the quantum catalyst fund—I think that that is the right one—has given grants to different Government bodies or public sector organisations so that they can look at the applications and use cases of quantum.

It is not just about direction—it is about their having the understanding and knowledge to understand the potential of a new technology. The idea is to put Government Departments in a position to be early procurers of these services. Again, we hear from many of these companies that part of the journey to scaling up could be forward procurement—or, at least, smart procurement—from the Government early on.

Q353 **Stephen Metcalfe:** That is very helpful.

Andrew Griffith: To do justice to that—

Stephen Metcalfe: Sorry, Tom.

Tom Newby: Absolutely. If I may—

Andrew Griffith: Tom has no failures.

Stephen Metcalfe: Obviously.

Tom Newby: I do not have any failures to highlight, but I am sure that there will be, in time.

The Ministry of Defence is really focused on the positioning, navigation and timing space. A good example is the rim of the Pacific naval exercise, with Five Eyes partners, in 2022, where we joined up and trialled for the first time a particular form of quantum navigation that can be used in satellite-denied environments. Another trial was carried out by the Royal Navy last year with Imperial College. These could be really important, both for military uses, of course, and for civil uses. That is a very interesting application.

Q354 **Stephen Metcalfe:** I have one final question, which is around potential regulation assessing the technology. In its review, the Regulatory Horizons Council suggested a regulatory forum for quantum technology. Does the Department agree with that? What work is being done on it? What would the timescale be for regulation?

Andrew Griffith: In my view, it is quite early days. The Regulatory Horizons Council identified some high-level questions and some principles. We will respond, as we commit always to do, within three months of its report. I thought that it was a good, useful piece of work.

I will be quite open, Mr Metcalfe. Is the right thing a particular forum, when there are many forums? There is an Office for Quantum, which we in government would look to lead. I am not sure that we are devoid of forums or conversations about this. Do we formally designate a particular wise group as the forum or—in quite a diverse space, with some quite different regulatory threads and risks—do you just keep that conversation going with all those who have views to feed into it? In many ways, that is what the Regulatory Horizons Council itself does.

Q355 **Stephen Metcalfe:** When did you say that that report arrived on your desk, or in the Department?

Andrew Griffith: I think that I got it about 10 days ago. We commit to respond to all the RHC reports within three months. You can hold me to that.

Stephen Metcalfe: Perfect.

Q356 **Chris Clarkson:** I will stick with the Regulatory Horizons Council's review. One of its findings was that the UK should leverage its existing expertise in this area—its global position in quantum—to drive some thinking about global quantum standards and the regulatory pieces that we have just discussed. Off that finding, what steps is your Department taking at this stage to engage with domestic and international partners to realise that, especially since we have just heard that our friends in Horizon have said, "L'ordinateur quantique dit non," or, "The computer says no"?

Andrew Griffith: Very good. We are doing a lot of international engagement. I will let Tom add to the list if I miss any. We are working with the OECD global forum on technology. I will be going to the G7 Science Ministers meeting in Italy later this year. There is a NATO quantum strategy group, as you would perhaps expect, as well. There are quite a lot of international standards organisations. I will not read out the entire list of acronyms, but we are doing a lot internationally. Sometimes, those are at Government level. Often, they are at the level of particular institutes. The National Physical Laboratory or the National Quantum Computing Centre will participate in those forums.

Q357 **Chris Clarkson:** Is there any concern that we are going to end up in roughly the same space we are in with AI at the moment, where everybody is in a rush to try to regulate this thing to death, but in vastly different ways, so that we do not come to a single track on these things? Helpfully, we have had the AI safety summit. Do you imagine that there may have to be some sort of quantum forum where we all get together and start talking about what the optimal space looks like? For example, are you concerned that the EU is going to regulate it to death, the Americans will just let the market decide, and we will try to do something based on what we always do, which is to use what we have got?

Andrew Griffith: I am sure that we will do something brilliantly well.

I will go back a little. One of the things that we have got right with AI is trying to regulate the uses, rather than the technology itself. Remember, here we are talking about some very different technologies. One minute you are doing some organ tissue sensing. The next day, you are doing some geological work, on what is under the ground. Then you may be doing something around particular forms of encryption. That is probably one of the things that is coming at us from a regulatory space a bit further ahead of others. Then there is quantum computing itself, which, without over-simplifying, is just a much faster version of the sorts of computers that we have today. There are already some very powerful computers in the world that are many orders of magnitude faster than anyone else's computers. It is quite a complex domain.

I think that the right conversations are going on. I do not want to pass judgment on what has happened in the past to AI. This has also not moved at quite the same speed. Quantum computing is a mature field. The other day I met somebody who said that they had been working in quantum computing for 30 years.

Q358 **Chris Clarkson:** That was the thrust of my question. It has been around for a while. What we are finding now, as it becomes more prevalent and we move forward in the field, is that at some stage we are going to have to consider this. Because we are very well placed with our international position, are we taking a leadership role?

Tom Newby: I will add something on that. We have been instrumental in the creation of what we call the group of 13, which is a set of like-minded

countries thinking about governance and the approach to enabling quantum technologies. We are really setting the agenda there. A number of the fora that the Minister mentioned, such as the OECD's structure on this, are bodies that we helped to set up in the first place.

It was announced just recently that the first dedicated international quantum standards committee would have a British secretariat, the British Standards Institution, which means that we are extremely well placed there. We are the convener of a number of European groups on standards. We are really driving the conversations in lots of these forums.

They are early conversations, because of the nature of the development, but everyone is very mindful of the lessons from AI. They are a big part of the focus.

Q359 **Rebecca Long Bailey:** I have a very brief question, Minister. Earlier you mentioned controlling exports. Could you elaborate and set out what measures the Government have in place in relation to export controls? What future plans do the Government have to balance national security concerns against international collaboration?

Andrew Griffith: We are not the lead Department for this. We advise the Department for Business and Trade and the Cabinet Office on it. They have recently laid a statutory instrument to include some quantum technologies—cryogenics—in what is within scope for export controls. Quantum is one of the domains named in the National Security and Investment Act. We have a well-developed architecture. The individual determination is both by category and by each individual company and use case. It will be very familiar from the normal architecture that we have.

Tom Newby: The controls that were announced last week will apply to a number of emerging technologies. Among them will be quantum computers and related components. It is worth saying that those have been brought forward in anticipation that like-minded partners will put in place similar controls. We think that it is really important to put those in place for the security of the technologies. We also believe that having this licensing regime clearly set out will create stability for our industry, because it is predictable.

We have other levers, such as the military end-use controls, but they are applied more on an ad hoc basis. This up-front licensing helps to create predictability in the regime.

Q360 **Katherine Fletcher:** I go back to Carol's point about how we inspire the next generation. With some of the quantum sensing technologies that you are describing, it strikes me that we are effectively starting the journey to invent the Star Trek tricorder that stands on the planet and says, "The ore is over there."

Tom, you mentioned helping teachers with modular training, to bring their knowledge and skills up to speed so that they can do the brilliant

job that they do inspiring people. Do you have any plans to make that available more broadly? I get it that to some extent we want to maintain the UK's competitive advantage, but I am sure that there is a ton of 12-year-old little girls and boys who would quite like to go into a field that is going to invent the Star Trek tricorder. Are you going to put some of that stuff online?

Tom Newby: We do not currently have a plan to put it online, but this is something that we are asking the Quantum Skills Taskforce to explore with professionals in the field. What we want to understand is, what is the right way of doing this that is truly inspirational, and what is the right stage to come in?

I should be open about the fact that there is debate among members of the taskforce and the experts who are advising us on how early to bring quantum in. There is a risk that it is quite a complicated topic. We think that there are benefits to demystifying it, but there are also benefits to just promoting general access to STEM, because that will create the talent pool that benefits quantum technologies, as well as other technologies, of course.

Katherine Fletcher: What it could be used for is that often the most exciting part of science is an application, isn't it?

Chair: Thank you for your evidence today. Thanks to our earlier witnesses.