HOUSE OF COMMONS

Science and Technology Committee

Oral evidence: UK Telecommunications infrastructure and the UK's domestic capability, HC 450

Wednesday 30 September 2020

Ordered by the House of Commons to be published on 30 September 2020.

Watch the meeting

Members present: Greg Clark (Chair); Aaron Bell; Dawn Butler; Chris Clarkson; Katherine Fletcher; Andrew Griffith; Darren Jones; Mark Logan; Carol Monaghan; Graham Stringer; Zarah Sultana.

Questions 315 - 387

Witnesses

I: Professor Ciaran Martin, Professor of Practice in the Management of Public Organisations, University of Oxford; and Dr Mike Short, Chief Scientific Adviser for the Department for International Trade.

II: Marcus Weldon, President, Bell Labs; and Kip Meek, Director of Communications Chambers and the Wireless Infrastructure Group.

III: Diane Rinaldo, Executive Director, Open RAN Policy Coalition.

Examination of witnesses

Witnesses: Professor Martin and Dr Short.

Q315 **Chair:** We are continuing our inquiry into the UK's telecommunications infrastructure and our domestic capability, with a particular focus on 5G. I am delighted to welcome this afternoon our first panel of witnesses. Ciaran Martin is newly a professor in the management of public organisations at the Blavatnik School of Government at the University of Oxford. Until the summer, he was the chief executive—in fact, the founding chief executive—of the UK National Cyber Security Centre.

Dr Mike Short is the chief scientific adviser at the Department for International Trade. Mike has had a 40-year career in electronics and telecoms, including a stint as vice-president of Telefónica, the parent company of O2, at the time when he helped manage the launches of O2's 2G and 3G mobile networks in the UK. Welcome to both witnesses; we are very grateful for your appearance with us today.

I will start with some questions to Ciaran Martin. The National Cyber Security Centre advised until as recently as 28 January that it was better to cap the market share of Huawei and allow it to continue than to exclude it. It was the imposition of US sanctions that caused that advice to change.

Respecting the fact that some of your assessment is confidential to your time there, but drawing on what you have been able to reflect publicly, can you give us your assessment of why it was considered safe to continue with a market share cap and why, more recently, the US sanctions caused such a problem?

Professor Martin: I will do my best, Chairman. Thank you for the invitation. I caveat everything, in that I no longer speak for the Government or the NCSC, but I will obviously do my best to draw on the experience of the time.

It is all a question of risk judgment. There is no such thing as a risk-free telecommunications network. What the NCSC under my leadership tried to do was to take the market as it is rather than as we would like it to be, and to work out the optimal position for the UK. The reason why the Government took two different decisions in January and July this year, based on the NCSC's advice, was, as you indicated, a material change in the facts on the ground.

The background to the proposed cap of 35% in the radio access network reflected a number of things. It reflected that Huawei had been an important part of the UK's mobile and fixed telecommunications infrastructure since 2003, and a growing one, and recognised the unique set of concerns around having a Chinese vendor in the UK's networks. The UK had for many years, initially informally but for more than a decade very formally, evaluated the way in which Huawei's kit worked in UK networks and had a centre under GCHQ supervision. I chaired a board

that monitored it, working out the sort of equipment Huawei was deploying, the way it worked and so forth. We had developed a sophisticated understanding of how Huawei's equipment in the UK worked.

That was combined with, frankly, a relatively unhappy position with the consolidation of available suppliers for radio access networks—the big physical infrastructure that one gets in base stations and masts on hills and so forth—from around a dozen providers from the UK a decade ago to only three: Huawei, Nokia and Ericsson. The security analysis was that having two providers was quite a shaky basis, security-wise, and that resilience was better provided with three; and that provided Huawei were excluded from the core, highly intelligent, functions of a network, it would be safe to accommodate a reduced market share capped at around 35% in that big physical infrastructure, and we could accommodate the risks. That probably optimised security on the basis of the available choices.

What then changed was the new US sanctions—the second set. There was a set in May 2019 that did not really affect the security model that had been going since around 2010 in formal terms. The second set of sanctions in May 2020 profoundly affected that arrangement; by effectively excluding Huawei from purchasing anything with US intellectual property in it, particularly microchips from all over the world, it meant that the NCSC's understanding of how Huawei's supply chain worked evaporated. Huawei will now have to get a new supply chain of hardware, and it is one that the NCSC could not evaluate, as I judged at the time. I understand that it continues to be the NCSC's judgment.

Every year for five years, I provided a statement of assurance to the National Security Adviser, which was then published in Parliament, saying that the arrangements were working sufficiently well that we could provide sufficient assurance that Huawei's presence in the UK telecommunications network could be managed. Under the new US sanctions, that sort of statement was no longer possible for new kit, which included of course primarily 5G but also full fibre and other things that we might come on to. It was on that basis that we reached the decision in July.

Q316 **Chair:** In terms of the supply chain that would have to be created, was it not possible or appropriate to wait to see what supply chain was developed? Why was it thought necessary to make a judgment ex ante that it was impossible to establish a supply chain that would meet the transparency and security requirements?

Professor Martin: Candidly, Chairman, creating a new one that does not rely on US-based IP means, from our point of view of understanding it, that it would be entirely new and probably indigenised in China, and therefore operating in a system that we could not possibly evaluate. The US-based intellectual property, first of all, has been around for a long time. Organisations like the NCSC have developed a deep understanding of it, but also it is all publicly out there in terms of how it works. There

are published standards and protocols. Cybersecurity researchers evaluate it and so forth.

An entirely new ecosystem would have taken time, and of course the roll-out is required rather more quickly than that. Secondly, the way China's technological ecosystem works would not match the same standards of transparency or auditability and so on that would enable us to reach a similar sort of judgment.

Q317 **Chair:** You said a moment ago that, until the US sanctions, the market share cap arrangement of 35% optimised security. I am reading into that that there is a combination of the resilience in having three suppliers against concerns about a particular vendor. Is that right?

Professor Martin: That is exactly right. No doubt the Committee will want to come on to that. While it was necessary and right in my judgment to exclude Huawei based on the new US sanctions because we could not assure it, given concerns around country of origin, it leaves the country in the short term, in the interim, with a different problem. Most industry experts would agree that having two radio access network suppliers is an uncomfortable position to be in. It is not impossible, but it is harder.

While the whole debate around 5G security in this country and most other countries has been around Huawei and its presence, there is a huge and significant part of the 28 January announcement that still stands, which is the NCSC's security analysis for the telecoms sector and the five areas: management plane, signalling plane, virtualised networks, supply chain and loss of service. There is a huge amount of that still extant. Some of it is a bit harder with only two providers. It is not impossible, but it is harder for reasons I can explain later if that is of interest to the Committee.

Q318 **Chair:** Thank you. Obviously, the big policy change has been the prospective exclusion of Huawei. Would you describe to the Committee what Huawei might do that is so concerning?

Professor Martin: There are two different aspects. One is why we do risk mitigation in the first place, and the second is why the equipment was excluded in the July decision. Why do we do risk mitigation in the first place? Huawei's involvement in the UK was always based on two assumptions, one generic and one specific to them. The generic one was that you must assume when you build a telecoms network that any piece of equipment anywhere can fail or be compromised. It is that sort of zero trust point. For example, when Huawei first came into the UK, way back, and their equipment was poorly understood, the GCHQ model of supervision was to confine it and ensure that, if it did fail in that way, it would not cause large-scale national harm.

The second assumption, which is specific to Huawei, is that, wherever one stands on the debate as to the nature of Huawei's relationship with

the Chinese Communist party, for the purposes of risk management and national security we have to plan on the basis that at some point Huawei could be made subservient operationally to the Chinese state. Therefore, you always had to have in mind a scenario where every bit of involvement of Huawei was turned against the UK. You do not make that assumption for Nokia or Ericsson, so you would have to make sure that you could withstand the compromise of Huawei by a hostile state and Huawei had to do its bidding. That is why we have had risk mitigation for Huawei for more than a decade.

The specific point now is that it is a general quality point. The UK's new approach to telecom security regulation involves quite high standards—among the highest in the world I would argue—for the security of equipment and the regulations as to how it operates. Under the US sanctions Huawei cannot meet those, in our judgment, which is why the NCSC, under my leadership, earlier in the summer advised the National Security Council to take the decision that it did.

Q319 **Chair:** Would you say that currently, rather than prospectively, the principal risk is from hostile state actors using or subverting particular vendors over which they have influence or control, or is it that those actors or others can exploit weaknesses in technology from a range of sources in general?

Professor Martin: There are broadly two risks that you worry about in this sort of space. One is espionage. You worry about the exfiltration of data, and there is a lot of data transiting through telecommunications networks. The other is potential disruption. You get that from Russia, from Iran, from North Korea as well as from China. You can get it from others.

It is certainly not confined to telecoms networks. The vector of attack is not confined to suppliers that happen to be from that country. You get what we call in cybersecurity "pre-positioning", which is putting down an implant on a network. It can be used for reconnaissance and espionage against exfiltration, but it also gives you, in effect, a landing point for a future disruptive attack, where you could at a time of tension between the two countries potentially mess around with the way a network was operating, with potentially serious consequences. Espionage is a constant and ever-present threat. Disruption is more serious; it is of lower probability, but is a higher impact threat. You have to guard against both. Those are the sorts of things we were looking out for.

I stress that the whole approach to telecoms security in the DCMS-led review that the NCSC under my leadership supported was about general standards of security because of the whole range of threats and threat actors out there, but it was also about resilience. Accidents and outages happen, and you want to ensure that there is no catastrophic loss of service, whatever the reason may be.

Q320 **Dawn Butler:** Thank you, Professor Martin and Dr Short for attending

today. Professor Martin, I must say that I think your knowledge and expertise are going to be missed at the NCSC. You said earlier that you were no longer able to provide sufficient security or assurance, especially around Huawei. I hope that is not part of the reason why you are no longer with the National Cyber Security Centre, but I will not ask you any more than that.

Professor Martin: I can assure you that is not the case.

Q321 **Dawn Butler:** We are 20 years behind China with regard to forward-thinking technology. Do you think that the Government have enough in-house expertise to take us through what we need to do in the next stages?

Professor Martin: We are at an important point. I am generally supportive of the way the Government's thinking is going on this now that I am outside it. I assure you, by the way, that it was a long-planned change of career, which I announced before either of the 2020 Huawei decisions.

There was an interesting speech given yesterday by Mircea Geoană, who is the deputy Secretary-General of NATO. He talked about a potential Sputnik moment in technology for western countries like ourselves. There is something to that. We have to give it a lot of thought. It is not so much a question of capabilities in Government, but thank you for your nice comments about the NCSC; there is a lot of technical expertise in the NCSC, and it is respected globally in industry in relation to how the telecommunications industry works. I think the challenge for Governments—particularly open democratic Governments like here in the UK—is how to align security and economic policy.

A lot of the challenges and solutions around not just maintaining the pace and, hopefully, outpacing the likes of China but getting the security right lie in economics. Fundamentally, there is a much longer discussion, and I will not detain the Committee too much with it. A lot of the problems lie in the fact that the last two decades have been pretty miserable experiences for UK telecommunications operators. Dr Short may have a view on that, having been a very senior figure in one of them for a long time.

What should have been a golden age for telecommunications companies has actually meant a lot of squeezed margins and a lot of churn in the market. We have seen that in the vendor market, where we are in the unhappy position that there are two European titans, two big Chinese companies, a Korean one and a Japanese one that do not sell to us at the moment, and that is basically it for the vendors. There are complicated economic factors as to how that happened.

The solution lies not just in co-operation across "Five Eyes" and European security and intelligence agencies, like the one I used to run. It also

involves some quite complicated and hard-headed thinking about the way in which our telecommunications markets work.

Q322 **Dawn Butler:** I agree that economics is the reason why we are so far behind. We did not make the initial investment. I am not quite sure that we will ever be able to catch up. Until a new vendor of fixed access equipment enters the UK market, Huawei equipment is still embedded in a lot of what we are using at the moment. Even though it is not necessarily at the core, how much of a risk do you think that poses to us in the UK?

Professor Martin: For the stuff that is already here, in the pre-5G era, the NCSC will be able to continue to manage the risk. There are ongoing concerns about the quality of Huawei's security performance at a technical level, rather than concerns about hard evidence of Chinese state interference. That is an ongoing process of remediation.

The US sanctions are very tightly defined. They have an impact on new deployments, so that is why there is a bar on new deployments. As part of the package announced in July, contingency plans were made so that existing stuff could be serviced in a way that was adequate for existing security. I hope that when the Government give evidence to the Committee they will be able to reassure you. My departing view last month was that for the stuff we already have there was a viable path to continuing to provide that assurance; we just could not sustain it in the future for new stuff.

Q323 **Dawn Butler:** Do you think that the Government's three pillar strategy for improving telecommunications security is the right way forward?

Professor Martin: Yes; they are the right three pillars. It is definitely, in my view, the right strategy. The challenge will come in its delivery across multiple countries. It is a variant of the point I just made on aligning economic and security policy. For it to work, if you talk to any of the industry executives—I have just come off a private seminar with quite a few of them—scale matters in this market. The UK, big economy though it is, is not sufficient to sustain scale in its own right.

It is about trying to make sure that these things work in multiple countries. That is going to take a lot of time, concerted effort and money. That is what we will need to watch. I do not think mechanisms currently exist for the co-ordination of such an effort. I would welcome greater thought on how to develop those things and give them some impetus.

Q324 **Dawn Butler:** That is going to be vital and important in terms of where we go next. My final question to both Professor Martin and Dr Short is this. One of the biggest single and immediate risks is that we lose a vendor, and we only have two vendors. How much do you think we need to invest now to make sure that we secure at least three vendors? What would you think if we were to lose a vendor?

Professor Martin: We only have two at the moment—Nokia and Ericsson. You will have seen in BT's announcement yesterday with Nokia that we are living with two. In terms of the future deployment of 5G, I am not going to speculate on the commercial health of the two giants because the only thing worse than a serving Government official speculating on commercial companies is a former Government official doing the same thing. Obviously, in an open market there is the potential for commercial failure or for a merger. I am just saying that theoretically. If it came to that, Governments—plural—would have to think very hard about how to sustain it.

I think you are right, Ms Butler; the economics are paramount and really important. The economics become quite complicated. The first pillar of the Government's strategy, which is right, is to shore up the existing two; then it is to bring in new existing players; and then it is to diversify. Of course, at each stage, there are competing incentives for those operators. The existing two do not have an automatic incentive to have a third player from the existing crop; and none of them has an obvious incentive for a new entrant. Holistically, we have those incentives and that is why we need to do some complicated thinking to make the market work better.

Q325 **Dawn Butler:** Dr Short, do you want to come in?

Dr Short: In relation to the three pillars strategy there are a few things that I would like to add. In particular, in Ciaran's analysis he talks about the complexity, but we could put in place a more robust testing and certification programme with the help of Ofcom and the NCSC. We could think longer term about it to make sure this sort of situation does not happen again, but that requires investment in longer-run R&D and making sure that we can nurture other suppliers. For other suppliers to enter the market, they need the possibility to trial and collaborate, and to research together in that area.

Lastly, we should not underestimate the important role of standards. It is very important to collaborate internationally on standards to make sure that we have the right levels of security and the right levels of supply and choice.

Q326 **Chair:** I want to pick up something that Ciaran Martin said to Dawn. You talked about some ongoing technical security issues with Huawei that need to be addressed. Do you know whether they will be motivated to co-operate with solving those security and technological issues, given that they have been given notice that they have to leave the UK network?

Professor Martin: I can understand why you ask the question, Chair. All I can say is that, up to 31 August when I left, there was no evidence that the mechanisms for the existing supply and security evaluation were under strain. They were continuing to function as normal. There were difficulties in that relationship and the last few oversight board reports make clear what those are. I understand and appreciate why the question

was asked, but all I can say is that until four and a half weeks ago the company was still operating the arrangements in the way they were designed.

Q327 **Chair:** As far as you could observe during your time there, between the announcement and the time of you leaving, there was no change in the behaviour or demeanour of Huawei in those co-operative arrangements.

Professor Martin: There is a facility staffed by UK nationals with security clearance, but they worked for Huawei under a board that I chaired when I was in post. The period in question is only about six weeks between mid-July and the end of August, but all of that was functioning normally. Their discussions about the latest oversight board report were well under way. I am not privy to what happened in September, but certainly I have not seen anything that leads me to believe that the arrangements have deteriorated.

Q328 **Carol Monaghan:** Before I move on to standards, I want to ask about market diversification. In a submission to the Committee from the Photonics Leadership Group, they were asked how the Government could encourage additional vendors into the UK market, and they said: "Measures should include a requirement for a minimum and increasing UK or '5 eyes' content in network equipment. This should be coupled with a requirement to open-up interfaces and use more open standards that enable mixed vendor…provision." To what extent will rapid market diversification need regulatory requirements forcing operators to increase vendor diversity?

Professor Martin: Regulation will have some role to play, but industry opinion is that interoperable standards and opening up has an important role to play in opening up markets. As one senior industry executive put it to me in discussions, the current shortage of diversity in the market was not caused by standards; it was exacerbated by standards but it was not caused by standards. It was caused by fundamental problems in the market from competition from China, by fair and foul means, and so on.

I agree with Dr Short's point in response to Ms Butler. The Government have a role to play in proving that some things work; doing test beds on some of the security requirements and proving that some of these things will work. For better or worse, it is a scale business and you cannot conjure up a scale player just through regulation. It has a role to play. At the moment, we could in theory demand through regulation more than two players, but we do not have two viable players selling if we exclude Huawei. The regulatory intent has to be matched by commercial reality. It has a part to play, but it will not in and of itself create the conditions that we need for a more diverse market. That would be my view.

Q329 **Chair:** Dr Short, do you want to comment on that?

Dr Short: We need to allow for experimentation, but I think regulation should not lead the way. I would put more attention on demonstrators that help to bring the industry and the ecosystem together. I would like

more attention on standards work, which I am sure we will come on to. I would also like to see how some of the R&D programme might bring out some of the best electronics or photonics capability we have in the UK. That will not come overnight. It takes time. It needs a concerted longer-term programme.

Q330 **Carol Monaghan:** In a longer-term programme, what should the UK Government do to support the adoption of open interoperable standards, and indeed support the electronics and photonics industry to scale up the research that is being done at the moment?

Dr Short: The UK Government have already done a lot over the years, particularly through UKRI, the research councils and Innovate UK. What we now need is more of an industrial strategy for telecoms, which looks out five years at least, preferably 10 years, and then takes concerted efforts towards supporting standards that are more open and inclusive, but also allow for more diversity of supply.

We need a stronger test and certification centre. One of the big trends we are going to see is the softwarisation of networks, and the interplay of those networks requires consistency across the network boundaries. I think a test and certification centre is needed.

On the standardisation front, we need to work with international partners because this is a scale business that needs a lot of international support. I welcome ongoing support for standards on a European basis, and with north-east Asian players. I think all can play their part. The reality is that it will probably take some years to get a fully-fledged third supplier, even if we do a lot of work in the short term with things like open RAN, softwarisation and testing.

Q331 **Carol Monaghan:** Dr Short, could you say a little more about what you mean by international standards? How would that work?

Dr Short: Most of the genesis of mobile since 2G has been developed through standardisation with ETSI and through 3GPP. That is the main European standards body that started off as a European standards body but is now the de facto place for global standards. We also need to think a little bit more about software standards in particular areas of networks. Open radio access network base stations may need more international help, beyond what ETSI and 3GPP can offer.

We can see big trends, particularly to do with software, where the internet will play a big role, with the cloudification of networks and the increased release of software for provisioning and making networks more efficient.

I would say three things: ETSI 3GPP; more of the specific standards on things like open RAN; and thirdly, more of the softwarisation standards.

Q332 **Carol Monaghan:** If we are talking about mobile networks, it is my understanding that different countries would use different parts of the

spectrum. Does that present a challenge at all for international standards?

Dr Short: It presents some small challenges, but I do not want to overstate those today. Traditionally, because of interference and radio questions, we have had good collaboration mechanisms around spectrum standards with Europe, but spectrum planning in the Americas is quite different. Some of the spectrum planning in north-east Asia is quite different. That may reduce some aspects of standards, but the mechanisms in those areas work quite well. I do not think that is the main problem to face.

The main problem to address is how we get a third or a fourth supplier from some of the more immediate ones that we can see from north-east Asia or north America, some of which will do parts of the network initially, be tested and then implemented gradually. It needs the longer-term programme.

Q333 **Chair:** Dr Short, you mentioned in answer to Carol certain things that we need and should have. You mentioned a telecoms strategy and a testing and certification centre. You are in government as an adviser to Government. Do you know whether those things are under way?

Dr Short: They are largely under way. Clearly, I sit in International Trade, but I work with the lead Department, DCMS. There are some proposals for longer-term R&D and for test centres in the current spending proposals—in the CSR bids, for example. We also need to work with the operators, with the vendor community, to make sure that supply matches demand. The policy driver, particularly with Government, is under way. Some of the areas of matching supply and demand or of trials and test beds need a bit more work.

Q334 **Andrew Griffith:** Following from Carol's question, you have both touched on broader industrial strategy. Thinking very widely, do you have any observations about the industry structure? In particular, if we want to be a first-tier player in the quality of our infrastructure and innovation, is the current consumer market fragmentation acting as a brake on that?

Professor Martin: I am not an economist, but I think that is a point well worth exploring, and not just in the UK. As I said earlier, telecoms companies have struggled. One manifestation of that, to go back into my area of expertise, is that we have under-regulated security; security does not really sell in this market. Having a hard look at consumer economics is a really important part of it, so I agree with the premise of your question.

Dr Short: There is room for the review that Ciaran referred to. We are already experimenting with things like network sharing and neutral host solutions. I think the balance of mobile and fixed networks needs to be looked at in a more rounded way, not just mobile separate from fixed. The role of the internet players has a part. It affects security as well as resilience, and we therefore need that more rounded approach.

The future telecoms infrastructure review touched on some of those areas, but in the light of the circumstances of the last 18 months there is a good case to revisit them from the point of view of resilience, as well as from the point of view that, where it is critical network infrastructure, does it have the right support mechanisms and do we need to rebalance competition policy as a result? Clearly, customers expect choice, but if the competition policy reduces security or resilience we need to think carefully about that.

Q335 **Zarah Sultana:** My first question is a hypothetical based on the November elections in the US. Potentially, if a Biden presidency is what we are dealing with and the loosening of sanctions on China, could either of you see the return of Huawei to the UK 5G infrastructure?

Professor Martin: I might have a go even though I am no longer in government, because we had to grapple with that when we did the July question. Even when I was in government, one can never say never about anything, particularly with something that is generational evolution, like a new generation of telecommunications technology. If you look at the details of the framework that DCMS asked the NCSC to look at, the risk that US sanctions, for whatever reason, might impact the UK's decisions were always part of the framework right from the start, in autumn 2018. Clearly, that risk went up massively and was then realised.

Given that it is a 20 to 30-year programme, the analysis is not so much what will happen from each four-year presidential term to the next, but that the power of the US legal system and sanctions system has been demonstrated. Under a different hypothetical—let's say there is a change of President in January 2021 and then a further one in January 2025 that reinstates them—a UK system has to be mindful of the fact that US federal government has the sort of power to impact the technology available in markets like the UK. It is not just a question of whether you swing with the wind of changes in US politics. From a risk management point of view, you have to take into account that this could happen and could happen at some point in the 2020s or 2030s.

Q336 **Zarah Sultana:** Dr Short, do you want to come in on that?

Dr Short: It is not just a short-term issue. Some of the consensus across the USA seems to be quite strong in terms of their views on China. However, the reality is that we need to plan for our own strategy for several sectors. As per Ciaran Martin's point, that may affect several sectors and not just telecommunications. We need our own strategy to deal with these issues.

Q337 **Zarah Sultana:** How can the UK work with allies to foster a sustainable and diverse telecommunication infrastructure market? That is something that Professor Martin touched on earlier about working with allies, and so did Dr Short. Could you expand on that?

Dr Short: Traditionally, in telecoms we worked with our European allies, if I can call them that. That has been the basis for a lot of success, not

just with GSM but also all the way through to 5G. There is a broad thrust of opinion already looking at other alternatives, whether it is the Vodafone group or Telefónica group, both of which are in many countries. We are already starting to work with some of our allies, particularly the USA and Canada, in looking at what they are doing with their supply chain. We are also working with allies in north-east Asia, whether Japan or South Korea, to see how we can learn lessons from some of the supplier choice factors that they use.

Not all the markets are in step with each other. We are more in step with the European markets right now, but for the next two to three years we can look at how we can learn lessons from other countries like North America or in north-east Asia.

Professor Martin: I would take what Dr Short says as a good basis, but I would welcome further imaginative thinking about it. There are long-established private sector mechanisms. Dr Short mentioned the power of things like ETSI—the European Telecommunications Standards Institute—and 3GPP in recent history.

To go back to the quote from the NATO deputy Secretary-General about a Sputnik moment, some others have likened the challenge of diversifying to a really complicated 21st-century Manhattan project, only in the open with commercial economics. While the private industry mechanisms across the globe exist, they are being contested by China. There is now, for the first time in telecommunications history, an alternative version of standards and new standards being proposed that are more authoritarian. We have to make sure that we get that right in terms of the private sector.

Governments, for perfectly understandable reasons, lack the sort of mechanisms to grip that. The "Five Eyes" has already been mentioned, as it should be; it is a hugely important security alliance, but the "Five Eyes" is at its heart an intelligence-sharing alliance. It has never co-ordinated economic and commercial policy. It was not designed to do that, but that is the sort of territory we are now in.

I do not have specific ideas to impart now, but I would welcome a discussion about what sort of mechanisms Governments have. I would welcome a standing intergovernmental mechanism among like-minded countries to keep an eye on this, to drive things and to have a look at Government level as to whether standards and markets are developing in the right way. At the moment, we are designed for national security agencies to talk to each other about stuff like this. National security agencies do not decide whether or not big telecoms operators are going to buy from a new scale player. Commercial entities do that, and that is the sort of thing that Governments need to think creatively about.

Q338 **Zarah Sultana:** Professor Martin, you talked about vendors existing in the Japanese and South Korean markets that we currently do not have access to in the UK. What could be done to attract those established

vendors to the UK?

Professor Martin: There are plenty of things, and Dr Short alluded to some of them. It is a long and slow process. We are talking about the likes of Samsung and NEC. In terms of the answer to Ms Monaghan's question, there is a part for regulation, and there is a part for research and development sponsorship. There are things that can be done, but of course it will take a while for them to scale up in this country.

Q339 **Chair:** In terms of the visibility of different suppliers, how confident can we be that there are not embedded either Huawei or less secure components in all of the different networks? Can we be sure that Nokia and Ericsson are free of any componentry that might give us cause for concern as in the case of Huawei?

Professor Martin: This goes back to the point I was making earlier about reforms to the general telecoms security framework. The NCSC, when I led it, always took that approach to everybody: any piece of equipment could fail or be compromised. I think that has to be the starting point. I said that I thought that UK telecoms were at the moment under-secured and under-regulated for security, and that is what the 28 January NCSC security analysis for the UK telecoms sector set out a plan to develop. You are obviously all Members of the House of Commons. When the telecoms security Bill comes before you, it will set out telecoms security standards. Obviously, it has to deal with the high-risk vendor supply chain question and the Huawei exclusion, if you can call it that.

One of the things that I think was really important in the security debate for future telecoms infrastructure is the experience in 2017 and 2018 of a Russian state-sponsored attack on one of the telecoms operators in the UK. It was nothing to do with Huawei. It was nothing to do with a Russian-owned company because there are no serious Russian-owned companies in the UK telecoms infrastructure. The attackers were able to get from the open internet on to what is called the management plane—the controlling brain of the operator.

There is a load of NCSC pragmatic operational work with the companies to make sure that those sorts of problems are fixed at a technical, operational and organisational level. If the TSRs—the telecoms security requirements—become law, in a sense you are regulating that. You are saying, "No, you cannot build a network where it is possible for an attacker to get easily from the open internet to the management plane, and, if you do, then that is a regulatory offence and we can impose penalties on you." That seems to me absolutely right. If you look at the 30-page paper that the NCSC published in January 2020, most of that still stands. The only bit that has changed is the Huawei bit.

You are absolutely right that Nokia and Ericsson have globalised supply chains. They do not have a China-free supply chain, so you have to apply the same sort of assumption about the potential for failure of equipment. I think the proposals the Government have made will make for better

regulation and better security regulation of UK telecoms. Until that becomes law, we have to rely on the good work of the NCSC, with the operators, to try to minimise those risks. It is not risk free at the minute; absolutely not.

Q340 **Mark Logan:** Professor Martin, looking at the geopolitics of this, I would like to take you back to what my Committee colleague Zarah said a few moments ago, using words like "allies". About 10 years ago, Eric Schmidt said, in "The New Digital Age", that the world is going to go into Balkanisation. Is there a risk when we use such terminology, and talk about partners and D-10 alliances, that we will increasingly move into the Balkanisation of telecommunications, or do you believe it is all avoidable at this stage?

Professor Martin: How long have you got? There will be as many views as there are people in the hearing. Some form of greater polarisation, if I can use that word, is inevitable and already happening. I do not think full polarisation is likely any time soon. There is some sort of trading relationship between western or like-minded countries and the non like-minded—China or more authoritarian countries. I am not sure that talking about those sorts of alliances augments it. There are various drivers. US policy has been a big driver. The increasing authoritarianism of China has been a big driver. The sorts of alliances we are talking about are a response to that. Clearly, a big single-nation state of 1.5 billion people with central planning can do things that multiple disparate democratic countries cannot in terms of long-term planning. It is inevitable that we talk a bit more about that.

Q341 **Mark Logan:** Do you think that the UK is doing enough to work with international partners on diversifying the telecommunications market in security?

Professor Martin: We have the right ideas, the right framework and good influence. As I said to Ms Sultana, I would like to see more of a standing mechanism to try to achieve those goals and to build on the sorts of things that Dr Short said are already in existence.

Chair: Thank you very much. I thank Ciaran Martin and Dr Short for their evidence today. As Dawn Butler said, Professor Martin, we have been very grateful for your services leading the National Cyber Security Centre. While we would like to have you there, we are delighted that you are willing to continue to help inform the public and to guide our thinking on this. In the case of Dr Short, we are very pleased that someone of your practical experience is in government and advising Government. We are very grateful for your evidence today, which will help us as we make our recommendations.

Examination of witnesses

Witnesses: Marcus Weldon and Kip Meek.

Q342 **Chair:** I am very pleased to welcome our next two witnesses. From the United States, we welcome Marcus Weldon, who is the president of Bell Labs, one of the most productive sources of discovery and innovation in communications over the years, with nine Nobel prizes awarded for the work at Bell Labs over the years. It is now owned by Nokia. Mr Weldon is chief technology officer for Nokia as well as being president of Bell Labs.

I am very pleased to welcome Kip Meek, who is a very experienced telecoms industry executive in the UK and a former board member of Ofcom, and has substantial regulatory experience as well. Thank you very much indeed for helping us with our inquiry today.

Mr Weldon, conscious that you wear a Nokia hat but that you also have a very long and distinguished career in telecoms as someone who has been part of the development of the technology, I would be interested in your reflections on why there are so few players in 5G and why there are no significant US or UK domiciled players.

Marcus Weldon: Thanks for having me, Chairman and the Committee. My Bell Labs role gives me impartiality even though I have a corporate hat. I will try to remain entirely transparent and impartial in all my comments, so I hope that is palatable to you.

You ask a very good question. By the way, I thought the prior panel was superb and touched on all the issues in very correct ways. I think the question was touched on a bit but I will add a tech aspect. Building radio networks is hard in terms of the amount of work it takes to build radio components, antenna components, backhaul components, baseband components and IP and optical components, and all the software that runs them. It is a tremendous effort and there used to be a marketplace where that effort was fully recognised, so many vendors existed and thrived and could afford the R&D it takes to build those networks.

To add to the comments from the earlier panel, I think that marketplace has become constrained in size and in perception of its value, and, as a result, the number of vendors that can survive has been reduced; in fact, they have been forced to consolidate. As you know, my own company, Nokia, is a consolidation of bits of Nortel, Motorola, Siemens, Nokia, Alcatel, and Lucent. All of those have come together to form one thing. Ericsson has been slightly more continuous in its operation, but it still has a number of pieces.

That was all driven because the market is almost overly constrained financially. One of the recent factors, although it has probably been ongoing for decades, is that the value of moving into the device segment, and the value of moving into the web segment, has been the leeching of value out of the telecoms segment. That has made it particularly hard to maintain a large vendor set because all the value has gone into device companies like Apple and web players like AWS, Google, and so on.

That is the reality of where we are. It is a hard business in terms of the amount of R&D. There is a constrained market that is constantly being re-constrained in some way, and that is the reason we are where we are.

Q343 **Chair:** You might have heard in the previous session—we are very grateful for you listening in—that Dr Short said there is a need for a prospective strategy. Is the position we are in the product of a failure of strategy, either by this country or other countries, or was it, as it were, a technologically inevitable consequence?

Marcus Weldon: Again, that is a really good question, a bit of an economics question. I am not an economist, a Government regulator or a policy guru, but I think there was a common perception of lower value to the segment. The previous panel talked about the consumer nature of the current telecoms segment, and that was not the case in prior decades.

I would argue that the telecoms segment was more focused on enterprise and industrial services that consumers then used. Phones were initially used in offices; even mobile phones were initially used by enterprises. Consumers have obviously become the dominant user and that has enabled great utility in the consumer space. As a result, I think there was devaluation of the fundamental infrastructure piece; it became more interesting to have a cool device in your hand and a nice web service that was available for free in most cases. That value loss was economically driven when we put consumers in charge of strategy, and I think Professor Martin said that quite well in a slightly different way.

We have to recognise that the 5G era is actually about building mission-critical infrastructure for industries and enterprises, which consumers will leverage—don't get me wrong. When we think that way, we have to think differently about value in that segment.

Q344 **Chair:** Is it the case that what drives revenues are consumer preferences, but they may not result in public interest or public need in the way of resilience, security, and considerations like that? Would that be a fair description of the landscape?

Marcus Weldon: It is, but even more than that is the fact that it will pay no attention to the need for mission-critical infrastructure to increase productivity in industries and enterprises, which is really what 5G was built for. One point I need to make that was not made in the previous panel is that 5G was not designed as just LTE-plus. It is not 4G-plus in the sense that it is just wide-area network coverage with more capacity. It was not designed for that. It is good for that, but its real guiding design principles were low-latency, high-reliability capabilities for industries and enterprises to use as their fundamental digital fabric.

Today, enterprises and industrials mainly use wires to connect their mission-critical systems, and those work very well of course over ethernet and IP protocols. But that constrains those businesses to operate only in one mode, meaning fixed configurations that result in

fixed productivity and degrees of flexibility. Those industries want to move to wireless, so that they can reconfigure and optimise how they produce goods for each point in time and interact with mobile robots and mobile people, and so on.

In that reality, the real 5G reality, I would argue that there is a different set of criteria we need to apply that are nothing to do with consumers; we need to think about 5G as mission-critical infrastructure for industries and enterprises that consumers will benefit from. If we flip it around that way, we will start viewing 5G a bit differently, and we will have good policy and governmental regulation that actually enables some of the business and industrial part of wireless networks, and will be less concerned with the consumer part, which will always look like a consumer part in my view.

Q345 **Carol Monaghan:** Thanks very much for that initial contribution; it is really useful to have clarity on the differences between 4G and 5G. Unfortunately, that is not how 5G is being marketed at the moment. Is there a danger that rapid 5G roll-out could damage future market diversity by locking in the vendors we have currently?

Marcus Weldon: That is a tricky question for me. The term lock-in, with my employment, is a difficult one. What we have to keep in mind is that the future versions, which are called release 16 or release 17—we are on release 15 so you just get that—generally come out every 18 months. Covid-19 has slowed down some of that, but assume that every 18 months there is a new release.

Generally, those features are built on already deployed hardware. There are occasional needs when we did not see a feature requirement coming, so you have to operate the hardware, but in general, they are software upgrades to existing hardware. That should work just fine with the existing deployment plans. You have to pick a vendor who can cover all those bases, but I think that should be fine.

I know we are going to get to the openness topic, so maybe I will start it now. There is merit to openness. That may seem like a strange thing for one of the two big incumbents to say, but I think we have always been a bit of a thoughtful company. Whether it is our Bell Labs heritage or whatever, we have always driven many of the openness initiatives. We think there is a place where we can open interfaces that add value that other vendors can then leverage to provide innovation on top of our base solution. I can talk about which interfaces those are or what the purpose is.

That is where the new part of the story can be. It is not thinking about how to manage the fact that you only have two major vendors. I do not think that is problematic if those vendors then open interfaces to allow others to innovate, which then allows us to solve the UK question. Each of those pieces can be a smaller piece to start with that leverages the open interface, so that I do not have to own everything or build

everything from the start, which is very hard for a new vendor. To go back to my earlier comments, these are complicated things to build. They take tens of thousands of R&D engineers, and we are not just doing it for fun; it is the requirements of the specifications.

That is how I view it. The incumbents are generally doing a good job. They need to open interfaces, and we are, as Nokia, and then let the innovation ecosystem leverage those interfaces, including UK vendors that can enter leveraging those interfaces.

Q346 **Carol Monaghan:** Kip Meek, do you want to come in on that point?

Kip Meek: Sure, I am happy to do that. Could I back up a bit to the three pillar strategy? Two pillars look to me completely uncontroversial. We obviously want to secure the participation in the UK market of the two big players, one of whom is obviously represented on the call now. We want to encourage another obvious player—Samsung—to come in.

The question then is what about the third pillar, which, as I understand it, is about looking at diversifying supply. The obvious route to diversifying supply is through the open RAN route. I should stress that I talk to you today more as a public policy person—that is my expertise—than as a technologist.

If one is to try to encourage the development of open RAN, the question is how. Again, there seem to me to be three different ways. One is to facilitate it; for the Government or Ofcom to facilitate that process. The second is to regulate in the way that is the natural territory of Ofcom. The third is to spend money to be more active on the Government side.

It seems to me that the facilitation role is the most attractive at the moment, because open RAN is at quite an early stage and there are some barriers to doing it. What it actually means is probably not answered in precisely the same way by different players. The other forms of intervention have potentially some big downsides. Regulation is basically persuading—coercing is probably the better way to say it—third parties to spend money. If we are not absolutely sure what the effect of regulation might be, we need to be cautious.

That is my philosophical approach. Government have a role to play, but one step at a time at the moment. It is quite early days.

Q347 **Carol Monaghan:** How significant is the risk of the UK losing Nokia or Ericsson as vendors as a result of the new restrictions on Huawei equipment?

Marcus Weldon: The question of my future employment. There is no issue with either of the two vendors that is foreseen. Professor Martin answered that really well, so I do not need to add much to what he said.

The new value creation of the 5G era is something that makes the market more attractive, meaning that if there is a place where networks can be

revalued—industrial and enterprise services—and if digital networks, 5G networks, are a foundational part of that, we believe there is real potential to increase the amount we can contribute and, therefore, be valued that way. Therefore, the market will be stabilised naturally going forward and less dependent on just consumer network economics, which are tough, as we have already described.

It is up to us to build to that opportunity. It is up to service providers to build to that opportunity, and new entrants. By the way, we have not mentioned the web-scalers. The web-scalers are quite open in their plans to build industrial and enterprise networks, leveraging open components and cloud-based software, so there will be that set of ecosystem entrants. We need not just to talk about NEC and Samsung, because that is more of the same and I am not sure it gets you very much. The web players will be building some of those networks too, using different spectrum that they can get access to or that is sub-licensed from operators, or made available like the CBRS spectrum in the US or the industrial spectrum in Germany.

There are enough players in the ecosystem that it does not seem likely to me that there is ecosystem risk. I agree with Kip's comment that facilitation is a good thing. It would help to have facilitated governmental guidance as to what the Government would like to see, so that when operators make selections they know that they should listen to that. I do not know that it has to be penurious in that, if they do not, what happens? I certainly think clear guidance as to what the Government would like to see in order to value and stabilise the UK's ecosystem would be a good thing to have.

Carol Monaghan: I think we heard similar things from the first panel, as well, so thanks for that.

Q348 **Chair:** Can I take up the theme that Kip Meek introduced about the choice between facilitation, regulation, or throwing money at the problem? Regulation and spending money are things that Governments could do. They can pass laws and they can spend taxpayers' money. What is facilitation?

Kip Meek: I thought Professor Martin raised some very interesting points about it. We cannot solve this problem in the UK in the UK; it has to be solved internationally. For example, if we are blessing open RAN, which is probably right—I am not close enough to the technology to know that that is the right solution—it apparently offers the ability to separate hardware and software within RAN, and, therefore, opens up the possibility of a more diverse set of suppliers. If you are doing that, let's do it internationally.

A very common problem in the industry I operate in—telecoms, media, tech—is that we need to do things internationally to be effective. If the UK is serious about global Britain, this is exactly the sort of thing we can get involved with. It is ridiculous to say that we will play a leadership

role, but equally it is ridiculous to say that we do not need to do it internationally. As Mike Short was saying, we need to think not just about "Five Eyes"; we also need to think about our previous European partners, who are still our European partners, and about north-east Asia, Japan, and Korea in particular.

Marcus Weldon: Building on that, I think it would be wrong for any Government to try to pick the winning technology forum, and in fact winning technologies in general. Open RAN is one option. As you know, we are one of the founding members of that, and we joined the Open RAN Policy Coalition. The marketplace should determine which are the fora that win based on their merits—technological, security, reliability and latency.

I agree with Kip's comment that the Government should have a view that openness is important, but they should not say that openness equals O-RAN, or openness equals the O-RAN Policy Coalition. Immediately you politicise those organisations, they will run off and do something that is probably rather self-serving and maybe not constructive.

It is definitely true that we should have mandates; Professor Martin had an interesting example about the management plane. There could be mandates about what should be open and what should not, and what it means to be open philosophically, and they could be testable. They should not pick winners in terms of those things, partly because O-RAN has not actually finished specifying all the interfaces, so it would be very hard to say, "We are picking that as the answer." You would not know what you were picking, and not all the interfaces in O-RAN are tremendously value adding. It is a broad-brush thing; you would have to be tech experts to do that correctly. I agree about a mandate for a degree of openness that allows an innovation ecosystem to appear, and some guidelines like that.

Kip Meek: To be clear, I totally agree with that. I was using O-RAN as an example, not as "the way forward". It is an example of the way forward. Being technology-neutral, as far as one can be, is obviously what Governments should be.

Q349 **Chair:** Doesn't it come down to regulation or cash, Mr Weldon, in the sense that, if you are mandating a required openness, it is mandated through regulation or a specification that any public money has to be used in a certain way? Is there a way of facilitating that does not use either of the powers that Government have?

Marcus Weldon: I think there is, but I agree that those are the normal governmental measures. The problem I have with them is that they are always out of step with what is happening. Let me explain that a little bit.

I have already mentioned that the standards are evolving rapidly, so what may be part of a specification today may not be tomorrow. I come back to my point about the web-scale infrastructure. You may have heard

the term cloud-native, which means that you can deploy your application, which can now be a radio application, on top of web-scale infrastructure with a process called CICD—acronym soup for continuous integration continuous delivery. What it means is that, daily, your web services are constantly changing but you are unaware of it; they just seem to be evolving. One of the founding principles of cloud-native is that we are continuously changing things—every day, possibly even every hour—and moving to new variants of things. That is where innovation is so high; things are being tested, verified, withdrawn if they do not work, and replaced by other things.

One of the principles of open RAN is that everything is running on web-scale infrastructure in a cloud-native way, so it becomes hard to know what to regulate because it will change daily, and that is not the world we are in today. I go back to the point that the way telecoms infrastructure today has been built is what we call in the industry set and forget. You set it up once and you pretty much let it run that way for 10 years and then you replace it. That is how networks are run; they are rather statically configured, even though they look dynamic. In the web world of that—the O-RAN or virtualised world—it is the opposite, so it is very hard to know what to regulate.

To answer your question about whether there are other mechanisms, I would go more for R&D stimulus packages towards things you want to see. That could go after the UK vendor point of actually investing in modules that are able to be deployed on infrastructure, and maybe you could even give a stimulus to operators to deploy those modules. I would go with that sort of approach, of encouragement, rather than the punitive approach, because it will always be hard to know what to punish.

Q350 **Katherine Fletcher:** We have heard evidence previously, in the R&D world, about the role for Government to create a test bed or a test site that starts to facilitate some of this stuff early. Mr Weldon, and then Kip, what do you think about that? Is that one way to facilitate it?

Marcus Weldon: It sounds good in principle, but invariably, to go back to my point about continuous integration continuous delivery, you will have to retest every day, or every week or every month, against all the known vulnerabilities and the new vulnerabilities. There is a practical issue with that.

If we think about networks as they are built today, you could make that schema work. In fact, there are testing and interoperability centres already in existence for DSL and PON, and all the access technologies. Those access technologies typically have different vendors on both sides of the link, so that is why you need to do interoperability testing.

In the new world order of dynamically cloud-native networks, it will be too hard to know what to test. There could be a false sense of security in assuming that a testing centre is validating something. In fact, perhaps it

could create a vulnerability because everyone would know what the test configuration was and they would bypass it.

Kip Meek: I do not have much to add. A point that I think is relevant is that, when Governments intervene, they are basically trying to align the incentives of the parties that are being affected by the intervention with the Government. I tend to agree with Marcus, I am not sure that in this particular instance a test bed feels right. I think it is applicable in other instances.

Q351 **Katherine Fletcher:** Thank you for your candour, gentlemen. What I am trying to do is pick up the Chair's point, which is that we would love to do it, we want to make it secure, we want to work with the rest of the world, but what is that?

Kip Meek: It is a very fair challenge. I would turn it around and say be careful about what you do. It is hardly worth making this point, so excuse me if it is too obvious. An intervention often feels like it might be useful but it might not be in practice. A regulatory intervention, particularly in the early stages when the technology is not settled, can often have unintended and sometimes damaging consequences. That is where we are, it feels to me.

Going back to the two pillars, the first two pillars are completely uncontroversial. With this one, although I think it has a big upside, the Government need to be quite careful and cautious at the moment in what they do. They should talk to their international partners. They should talk to the industry about the barriers to introducing openness in the way that Marcus has been describing, and think about that. Go from a very specific problem statement to a solution rather than a general problem statement which is—

Katherine Fletcher: Perhaps, if time permits, we can get into some of those barriers later.

Marcus Weldon: Let me respond as well, if I may, with just one point. I am not super-convinced that the second pillar is as valuable as the third pillar. That may seem a little bit self-serving, but let me explain. I do not think adding more of the same enhances anything, whoever the vendors are. If the future reality is very different, meaning cloud-native, dynamically deployed networks, that is where the focus should be. I would rather favour pillars one and three. I understand the logic of two, but if we want to look forward and not backwards, pillar three is actually more important than pillar two.

Q352 **Aaron Bell:** Thank you both for your time. It has been a fascinating discussion, and, as you have said, there are some tricky areas of public policy that I think we need to try to get right. If I could go back to the diversification point, Mr Meek, do you think network operators would work to diversify their supply chains without any regulatory requirements to do so?

Kip Meek: Going back to incentives, they would apparently have an incentive to do so. The general thrust would be that they would favour as diverse a supply chain as possible. However, I think there could be barriers.

I am not saying that open RAN is the solution; I am just using it as an example. If you go from the current environment to one that looks a bit like open RAN, or is more open generally, there could be an investment barrier to overcome. There could be an issue of managing. At the moment, although there are some downsides to having a very small set of suppliers, there are also some upsides. If there is a problem, you know who to go to, whereas that might not be the case in a more open environment. There might also be security issues about which I cannot comment because I do not know anything about them.

There would seem to me to be very practical issues for mobile operators to overcome to introduce a more open environment. It is almost bound to be the case. Professor Martin was absolutely right when he stressed that mobile operators operate in an environment where they are not making lots of money and, therefore, although overcoming those barriers might be in their long-term interest, there could be some short-term pressures on them to do otherwise.

Marcus Weldon: I have never found the mobile operators to be against innovation or trying to protect their market. They are in a constrained market where they are trying to survive mostly, and then they transmit that pressure to us, which gets to your vendor problem.

The thing we have to recognise is that incentives are always good to encourage new behaviour, particularly where you do not have infinite degrees of freedom. Remember that the web-scale players and the device players have taken value from the operators, but they are also under the same constraint that I talked about at the beginning. That does not make it an easy role to be a telecom operator. Just when they thought they were done with LTE, the vendors came along and said, "Here's 5G." Then they have to deploy 5G, and now there are new flavours of 5G, so they are going to have to upgrade. They constantly need to upgrade their innovative infrastructure, yet they are viewed as against the public interest, which I think is a bit odd.

We have to recognise that they may need some incentives, or the industry will need some incentives, to do some new things. Perhaps they will also need some degrees of freedom that allow them to innovate, so that they can expand their potential. I do not know what those would look like, but I think they live in a difficult world.

Q353 **Aaron Bell:** We have had a number of recommendations on how to increase diversity and, to speak to your point, measures to increase the profitability of network operation. There are various options. I do not want to tempt you too much to increase your own profits, but do you think it would help with the diversity point as well if there was a bit more

of the cake for the operators in this whole process?

Marcus Weldon: I am not an economist or an operator, but I am a sort of technical strategist who looks at the industry as a whole. I would go after the enterprise and industrial segment. That is where new value creation is. Operators should be encouraged to participate in that segment and, as a result, grow their market in a way that does not change the consumer market dynamics, because they are hard to manage. I would go after that. Maybe that is the place to look for new value creation and support.

The Government can do a lot in that domain because it is mission-critical infrastructure. It has to be secured and it has to meet certain criteria. It is good for the economy because productivity enhancements generally stimulate GDP. It is an interesting area where we should perhaps re-think how we think about telecoms infrastructure and not just focus on the consumer market. The answers might lie over there.

Q354 **Aaron Bell:** Do you want to comment briefly, Mr Meek? You seem to be agreeing.

Kip Meek: Although I agree with everything Marcus has said, in this area, if I were running a mobile operator, I would not quite know what to do with that piece of advice. If Marcus is suggesting that Government should in some way invest in mission-critical infrastructure that enabled mobile operators to do something different, I would understand it. I do not quite understand how that will help, because every mobile operator would say, "Look, we want to build the enterprise part of our business as fast as we can."

The way I look at it is that the fundamentals of the business are as has previously been discussed. The mobile operators are very much squeezed and the suppliers—vendors like Nokia and Ericsson—are very much squeezed. Apple and the handset suppliers seem to be the ones making good money. That is less true in the States than here, but it is very much true in Europe. Mobile operators' margins are very, very tight.

Marcus Weldon: I think you could use spectrum policy and things like that to encourage the deployment of industrial and enterprise networks.

Q355 **Aaron Bell:** We do not have very long so I would briefly like to turn to why UK operators are going for non-standalone 5G, whereas some other markets are deploying standalone 5G. This obviously relates to what you said earlier, Mr Meek, about looking at it from an international perspective. What do you think the right solution is, and should the Government actually be encouraging the deployment of standalone 5G networks?

Marcus Weldon: This gets quite technical actually, I am afraid, so I will try to be quick. Standalone 5G networks are where new value creation happens and I will explain very simply why. A standalone means you have a new core. The core is the part that does the data processing and

the voice processing, but in the 5G era it also does all the IOT processing, so it has all the new value bits. It is built as cloud-native, so it can scale in, scale out, and adapt much more rapidly so that it is not monolithic.

When you build that core, it is not meant to interwork back with the LTE layer. That is what standalone is; it basically means that, if you want maximum new value creation, you deploy a 5G core that does all the nice services creation, even for enterprises and industrials. That means it ties only to what are called NR—new radio—5G radios.

That is the route to value creation. There is a lot of sophistication in how it then connects to the existing LTE network. For that to work well, the reality is that probably the same vendor is required in 5G and LTE, just to make the radios work together in a way that I cannot explain in the short time we have. In order to migrate spectrum from LTE to 5G on a given radio band, you basically need the same vendor's baseband units to make it work. The core could come from a different vendor, by the way, so you can have that openness.

Standalone is where value is. It mandates that the same vendor exists for LTE and 5G probably. I then get back to my openness point; you can expand that with openness in other areas.

Q356 **Aaron Bell:** Mr Meek, do you want to add to anything? Is the UK on the right track?

Kip Meek: I am afraid I defer to Marcus on that issue.

Marcus Weldon: I have an unfair advantage on that one, Kip.

Q357 **Andrew Griffith:** Marcus, because of your track record of formidable innovation, I want to put this to you before we conclude. There is a lot of talk about open RAN and open standards. It seems to me that there is a history of both abstraction of the hardware layer and, typically, a re-verticalisation of the hardware layer, often driven by things like a desire for security and reliability as well. Could you give us your take on that? Because the whole thrust has been about the prospect of potentially that abstraction, what are the forces in a concentrated vendor world such that you think that is a persistent state?

Marcus Weldon: It is a super question. What happens in our industry is that generally when you want high performance, low latency, high reliability and ultra-security, you tend, as in any industry, to verticalise it. You maintain control over every part of it and there is only one throat to choke, which is the phrase we use. It means that there is one entity that is always securing that, and in my continuous integration model it is easier for the vendor to own all the bits, and you get to certify things more readily.

Counter to that is the need for innovation. What you have identified is the tension in the industry. That is why I said that not all open RAN interfaces make sense to me, but some do and that is why I am an advocate for

some of those interfaces. There is going to be tension between a tendency to keep some things integrated—I would not call it vertical—and some things open, but it is a very technical question about what should be open and what should be integrated. We have a view on what that should be, which I am happy to share but I cannot do that here. The conundrum is that you will have that tension; you cannot be completely open or completely closed. It is somewhere in the middle, and it is difficult to navigate.

Q358 **Katherine Fletcher:** I want to carry on exploring how we enhance this and what barriers we need to pull away to get more vendors in, especially in the short term. On intellectual property, obviously there are different laws and different legal jurisdictions. We are talking about working with partners across the globe. Are there any barriers there that the Committee needs to investigate?

Marcus Weldon: Professor Martin highlighted a recent issue on standards. It looks like China will be publishing something called China Standards 2035. By the way, it is focused mostly on industrials, so it goes back to my favourite point, but it really is about using Chinese native standards for that industrial revolution. The assumption is that all belt and road countries will do the same. That bifurcation is happening.

In the mainstream communications service provider 3GPP networks we have not seen any bifurcation yet. They have remained largely aligned. Participation in O-RAN, on the other hand, is very different among the different vendors, so there is a lot going on. The industrial segment already seems to be bifurcating. The service provider segment still seems to be mostly aligned through 3GPP, but there are different views on O-RAN. It is a complex landscape. I am not sure I can give you an answer on how to resolve that, but Professor Martin is right; it is going to remain complex. That is true even if there is a change of Administration in the US.

Q359 **Katherine Fletcher:** When you talk about bifurcation, are you saying that effectively there will be almost two sets of intellectual property operating in terms of the two different ideas?

Marcus Weldon: Yes, I am. For the ones that truly bifurcate, there will be two sets of intellectual property. I emphasise that 3GPP intellectual property is still owned by the normal players: Huawei, Ericsson, Nokia, Samsung and so on. The new China Standards 2035 initiative—I have not read the document in full—seems to be focused on Chinese intellectual property, so that is something to be aware of. O-RAN has different intellectual property policies for different interfaces, so that is a sort of overlay.

Q360 **Katherine Fletcher:** Are there any problems there that we need to address?

Marcus Weldon: There probably are, but they are beyond me even to know what to tell you. It is a rich landscape.

Q361 **Katherine Fletcher:** Mr Meek, is there anything about IP that we need to think about in getting businesses to work together, and confident that their ideas will not be stolen and used?

Kip Meek: I do not have anything to add to what Marcus said.

Katherine Fletcher: That has been incredibly helpful.

Q362 **Chair:** Mr Meek, a lot of these policy interventions, or the facilitation you recommended, will take some time to have an effect. Is there a danger that the rapid roll-out of 5G will embed a lack of diversity that means that it will be too late, when they come, to make a difference?

Kip Meek: There is that danger. It is one of those things where one would not start from here; one would have addressed those issues a long time ago. I am sure there is tension between the completely natural desire of the UK to get on with 5G and the dangers of a non-diverse set of suppliers. I do not think that any solution this Committee, or the taskforce that has been set up, arrives at will be a complete one. We will just do the best we can under the circumstances.

I was very interested in Marcus's view on pillars one and three. He may be correct in that. There is nothing to be lost by looking for more openness. It may deliver something similar to open RAN, but it may not deliver as much as one would like in a timescale that is useful.

Q363 **Chair:** Policy often involves some pretty hard choices. Would you guide policymakers to slow down the roll-out of 5G to allow more potential sources of diversity to come in?

Kip Meek: To give you an instinctive response, my answer is no. Diversity is important. Most of my day job at the moment is working for the Competition and Markets Authority, so I am very interested in competition issues. My instinct is that we were slow on 4G. We have enough economic challenges. I think 5G is so interesting and exciting that artificially slowing it down because we have not solved the supply problems seems to me to be wrong. I am very happy to be persuaded otherwise, but that would be my instinct.

Marcus Weldon: I am not going to try to persuade you otherwise, Kip. I go back to new value creation. It seems an odd argument that, in order to protect against a perceived problem that does not yet exist, you slow down new value creation. Other markets will not, so you will be at an economic disadvantage, and one that will be hard to recover. These networks take time to roll out. If you get years behind, that will be years of economic disadvantage for a concern that has not yet manifested.

Chair: Gentlemen, we are very grateful for your time with us today. This is a fascinating and challenging area, in the sense that it is easy to think we ought to have a strategy for the years ahead, but, as you have been very clear, there are pitfalls in adopting strategies that might tie us to technologies or approaches that may be out of date. The confluence of

technology, consumer taste and preferences and regulatory policy means that decisions have to be weighed very carefully. We have been grateful to have some of the best expertise available to us on both the technology and the public policy side in the persons of both our witnesses today.

Examination of witness

Witness: Diane Rinaldo.

Q364 **Chair:** We are pleased to welcome to our third witness session this afternoon Diane Rinaldo, who is executive director of the Open RAN coalition and joins us from Maryland in the United States. The Open RAN coalition is a grouping of over 50 global telecoms companies, which, as the name implies, are advancing the adoption of open and interoperable solutions in the radio access network.

Diane Rinaldo has served in US Administrations, including as acting assistant secretary for commerce and acting head of the National Telecommunications and Information Administration. Ms Rinaldo, thank you very much indeed for joining us today.

Perhaps I could start with this question. Is it now too late for open RAN to impose itself, or be accepted, as a solution, given that 5G is in the process of being rolled out at pace around the world? Is it a solution that could and perhaps should have been adopted years ago, but we have missed the window?

Diane Rinaldo: Thank you so much for having me today. It is an honour to be with you.

To answer your question, open RAN is deploying around the world. Rakuten in Japan and Dish Network have just announced they are building up their network with open RAN standards, as has Reliance Jio in India. It is here and happening now. The question is how we can shrink the timeframe to make it more ubiquitous. The coalition of 56 global companies has come together to discuss what they are doing in this area and the policies we can help to promote around the world to shrink that time. It is not too late.

There is some confusion about greenfield versus brownfield and, as new spectrum bands come online, whether you are a brownfield that can be built out with open RAN standards. A big part of what we do is helping to promote policies as well as educating people about what is occurring in this space, because there is a robust business case occurring today.

Q365 **Chair:** In this country in particular, where a certain model of 5G is being rolled out already, what needs to be done to create the space for a more open RAN-type approach in future? What needs to be done by Government, operators and other players in the space?

Diane Rinaldo: I like to think of it as a three-legged stool. First, there is funding, research and development, deployment and international

development, to help developing nations that support these leap-ahead technologies.

Secondly, there are the ways we can co-ordinate public-private partnerships. There was a lot of conversation around test beds in your previous session. We believe that is vital. While our coalition does not support mandates or heavy prescriptive measures, we believe that Governments can help give the thumbs-up stamp of approval to help move it along.

Thirdly, we look to opportunities to educate people, and there is no better convenor than a Government. How can we bring together the public and private sectors to have conversations about what open RAN is and is not? Events like this one today help to educate and promote what we are doing in that space.

Q366 **Andrew Griffith:** I would like to give you the opportunity to say what open RAN is not. What things are not is as illuminating as what they are. In the same vein, which of the major telecoms operators or vendors are not part of open RAN?

Diane Rinaldo: Open RAN is not a technology; it is a different way to structure the architecture of the network. I liken it to the stereo system I got as a kid. The speakers, tape deck and turntable all came in one box. If you wanted to exchange one of those components, you could not.

Andrew Griffith: You are making us feel old.

Diane Rinaldo: It was different from our stereo systems today, where you can exchange parts. If your CD player breaks, you can put in a new one, or just get rid of the CD player and stream. That is what we are talking about today. We are talking about the ability to be modular and mix and match.

What you are doing is creating and optimising the network that is best for your area. Whether you are in London, New York City or my small home town of 5,000 people, you want to be able to create a network that best suits people's needs, as well as being able to layer on it as we go. A good point is what Rakuten is doing. They built out their 4G network using open RAN and now they have built the 5G network on top.

As I mentioned with international development funding, it is about investing in leapfrog technologies that you can layer as you go. As new technologies come online that we have not even thought of yet, we can incorporate them in the network in a more modular way than the current closed proprietary system.

Q367 **Andrew Griffith:** That is very clear. Similarly, 50 major parties are involved. Who is not involved? What are the gaps?

Diane Rinaldo: When I started with the project in March, there were already 10 companies; there were 31 at launch and 56 now. We never

expected the reception we received, and we have never done a push to get new members. When people call us, we listen, and we have brought on new folks. We encourage people: "If you're interested in joining, please reach out through the website." We are always interested in getting more eyes and ears on this issue.

We have 56 companies, which include 20 large Fortune companies. We have one company called DeepSig with 20 employees in a WeWork building on the other side of the Potomac. It is great to have long-standing institutions like IBM, which is 110 years old, and companies and start-ups that are two years old. It shows the breadth of the movement and how open RAN is going to help lift the start-up community, which has not existed. Due to lack of venture capital money, it has been hard to get into that space with a closed system. I encourage anyone you see missing from our list to call and have a conversation.

Q368 **Andrew Griffith:** Would it be fair to characterise your participants as global, or are they geographically concentrated?

Diane Rinaldo: No, it is definitely global; we have Vodafone and Telefónica. The majority of people calling me today are international companies like Nokia, Samsung and Docomo. I am not sure of the exact split; I will have to look at my list to break it down, but I can tell you that the majority of people calling me today are international companies.

Q369 **Andrew Griffith:** Is the process by which a standard becomes a standard and innovation becomes embedded something we should think about in terms of the JPEG file standard or an ITU-mandated seal of approval, or is it a de facto standard that is simply adopted and becomes part of the common hardware layer for every device?

Diane Rinaldo: I have to admit I am a policy person, not a technologist.

Q370 **Andrew Griffith:** Believe me, that was very much a policy question. I am not a technologist either, as my colleagues will attest. Is there a process by which we can sit back and say, "Job done. This has now become a standard with mass adoption"?

Diane Rinaldo: I think what we are looking at is just standardising the interfaces so you can plug and play, and there is one standard. To go back to my stereo, there is just one standard that allows you to mix and match and plug and play.

In the coalition itself, we stay pretty high level. We are technology agnostic. We are not saying there should be a software, hardware or virtualised solution. We are saying that, if you standardise the interfaces, you allow competition to take hold, which will drive innovation and things we have not even thought of, and allow technology and innovation to grow in future with the ability to layer on top.

Q371 **Andrew Griffith:** I am not sure that I fully understand what success looks like in that respect, if I am honest. Let me try it from another

direction. You have an adoption today in Rakuten in Japan. Of the networks under construction or in deployment today, what is the market share of open RAN, and what would you expect it to be in five years' time?

Diane Rinaldo: I am comfortable saying that I believe the future is open RAN. It is just the time. Rakuten and Dish Network could have chosen multiple different vendors, but they chose to go with an open RAN standard.

A big part of that is the capex and the opex; it is significantly less expensive. As you pull away that string, you see that it is passed on to the consumer, as well as being a value proposition for companies to build out in areas where they otherwise would not build. We see that in the UK with Cisco building out 5G rural first. They are proving the concept that can demonstrate that there is ability to make money in rural areas by dropping the cost. You can already see the benefit.

Pulling the string will allow consumers in those areas to get additional learning and have jobs they otherwise could not apply for because of weak connections. As we pull away the string, we see ripple effects in the economy.

Q372 **Andrew Griffith:** I am glad and share your confidence about the future, but I am going to look for a little bit more certainty along the way. As we see networks built out, is it consistent with your thesis that we should be seeing them all built to open RAN standards? If some of them eschew that path, is that fatal to your thesis?

Diane Rinaldo: As an organisation, we do not support mandates. It is the interoperability of the component parts that will help drive it. When I was at NTIA and led that organisation, the question from policymakers was, "If not them, then who?" There have been a lot of ideas on how to solve that problem, and ensure diversification and vitality in the supply chain. There have been a lot of ideas in the United States and other places. Should we prop up? Should we stand up? Our coalition came together to talk about what we were already doing in that space.

From the United States standpoint, up until Dish Network it had not been much of a robust conversation. It had been happening in Japan and in Europe, pointing to use cases where it was already being deployed. When carriers have a decision, they decide to go with open RAN. It is not just greenfield and building a brand-new network from scratch; if you get a new spectrum band, it can be built out with open RAN specifications. I think there is some confusion at times and whether, if it is brownfield, it becomes much more difficult. There are opportunities to start right now in helping brownfields to become operational with open RAN standards.

Q373 **Chair:** You said that as an organisation you do not support mandates. Why not if you see open RAN as the future? Doesn't that help?

Diane Rinaldo: We believe that the industry is moving in that direction anyway. We prefer to stick to our positive message on what we can do as an organisation and how we can communicate with policymakers on making it a reality, shrinking the timeframe. It is about the convening authority, public-private partnerships, funding research and development and leveraging already existing programmes and helping them to get up and running. We believe that that positive message resonates better than just asking for a de facto mandate.

Q374 **Chair:** Does it reflect a conflict of interest among your members when some are part of the existing policy framework, and perhaps are part of your coalition as a kind of insurance policy or safety net? If you were unconstrained by the membership, would you be advocating a more muscular approach to advancing open RAN, perhaps including mandates?

Diane Rinaldo: As I am sure you can appreciate, trying to get 56 companies to agree on something is always hard.

Q375 **Chair:** That was my suspicion about why the policy is the policy.

Diane Rinaldo: Sustaining things at high level, educating and promoting policies is how we get things accomplished. We are coming together in a positive fashion and ensuring that we push the ball uphill. I have been in the policy arena for 25 years, and I personally believe the best approach is to come to the table, have conversations with policymakers and other companies and figure out the way forward. It has worked well for us.

Q376 **Aaron Bell:** To follow on from the Chair and continue playing devil's advocate to some extent, why does open RAN require policy support? Do network operators not have an inherent interest in driving its adoption themselves?

Diane Rinaldo: Absolutely, they do. It is definitely a value proposition for them. It is about truncating the time to reach scale. That is what we are talking about. When we first formed as a group, we were thinking just domestically, not trying to boil the ocean, but we quickly realised this was global in nature and we should be having the conversation internationally. If you are working in the United States, or just a small microcosm, you are not going to be able to bring it to scale. That is truly what is needed in order to proliferate open RAN.

Q377 **Aaron Bell:** Assuming that there is going to be some policy support—I don't know how much you know about the specific situation in the UK—what are the most important things that the Government here could do to support the development and adoption of open RAN? Is it the test beds you have talked about already or something else as well?

Diane Rinaldo: I would say funding, research and development, deployment and leveraging international funding that you may give to developing nations. How can public-private partnerships come together to work in different areas, whether it be test beds or other aspects you are thinking of? Again, it is about a convening authority to educate people. It

is amazing that the biggest driver of innovation is getting folks together and having a conversation about what open RAN is and is not. It helps to shine light on what our companies are doing, as well as giving people peace of mind that there is a solution at hand.

Q378 **Aaron Bell:** My colleague Andrew Griffith was talking about standards earlier. You are already deploying, so you already have a certain set of standards. Is it something that will continually evolve? I think people want some certainty before they commit to open RAN in these projects. Obviously, we can run pilots, test beds and so on. Is it, as you say, an interface standard? Are you there now with what the standard is going to look like in two or three years' time, or are you still in that evolution yourselves?

Diane Rinaldo: Open RAN is about open architecture; it is not the technology, but technology is going to be within the sub-component parts, within the software, within the hardware and within the radio, and that will continually evolve like technology itself. It is all iterative.

When I worked with the House Energy and Commerce Committee, I worked for a member from Michigan, from the Motor City. A car vendor came to have a conversation with me and said, "We're going to bring car deaths down to zero." I said that was impossible. It is probable that neither of us was thinking about 5G, but with autonomous vehicles and vehicle-to-vehicle communication it is a real possibility that, with 5G dropping the latency, your car can detect a car crash ahead and brake. It can do that much faster than my brain seeing it and braking. It will have real-world implications for all of us.

Q379 **Aaron Bell:** We are hoping to get a test bed in my area of Staffordshire. To do that with open RAN would probably be a very good thing. It sounds like the future. On standards, and what you are doing so far, are you able to give us any feedback from the deployments so far and lessons you have learned where open RAN has been tested and deployed around the world? What have you learned, and how has the system been evolving as a result of those tests?

Diane Rinaldo: There has been a lot of excitement around that area. Rakuten has just announced that it is moving its 4G network to 5G, so again it is a layered approach; you can build on top of it. That is the real benefit of an open system. You build out once and, as you move on, you do not have to replace the entire system, so it is an investment. While we see prices dropping immediately, the long-term costs will drop as well because you will not have the upkeep you otherwise would with an entire system. You do not have to replace my 1980s stereo system; you can take out the CD player and stream music from Spotify.

Q380 **Aaron Bell:** Have there been any unanticipated issues when you have been launching those projects around the world, or has everything gone very smoothly as far as you are concerned?

Diane Rinaldo: I don't have anything specific to point to. There are always stumbling blocks. Time is usually the biggest stumbling block in trying to get networks built out. I am happy to reach out to my members to see if they have any special use cases and would be happy to report back to you on that.

Aaron Bell: That is very helpful.

Q381 **Katherine Fletcher:** You make a very eloquent case for why 5G could be transformational. Let's assume that everybody on this Committee thinks that's sold and we are just looking for the barriers to moving it forward. I asked the previous panel whether test beds had a role to play and what Government could do to facilitate them. What is your view on test beds and what they can or cannot do to accelerate us in getting access to 5G?

Diane Rinaldo: Test beds are a great example of how you bring the private sector together with Government. I was a little confused. I think they were coming from the idea that open RAN is modular, so you can build the network base to your standards for any given area. You could do five different test beds with five different modular standards with open RAN, so there is no cookie-cutter network you would build out. That was my only thinking as to why they would not consider test beds were necessarily a good path forward.

The benefit of open RAN is that you are able to create and optimise a network based on where you are. In the United States, our Department of Defense is currently moving out on 5G test beds to build their bases of the future, whether it be logistics or in manufacturing. How can you have a manufacturing floor that is using 5G? They have multiple test beds that are testing different aspects. That is what we are discussing too.

Q382 **Katherine Fletcher:** Do those test beds have variegation in the supply chain? What we are trying to understand is how we get more vendors in to help accelerate the process and how to de-risk it.

Diane Rinaldo: That is absolutely right. What you are doing by bringing vendors together is highlighting the diversity in the vendor space. Whereas before there was only a handful of vendors, now that you are opening up the networks you are allowing for additional competition to come in, so companies you may not have heard of five years ago are proliferating in that space. You give credence to the idea that there is an open business use case for open RAN and you allow new entrants into the market; you are shining a light on them and the good work they are doing.

If I may, I will add a comment about the idea of a systems integrator. If you are Vodafone putting together a modular network, you have lots of engineers on staff who can do that. If you are a smaller more rural carrier, you might employ what is known as a systems integrator. Those are companies like Cisco, IBM or Fujitsu, long-standing tech innovators

that help bring all the parts together. They can help build your network, optimise it and service it to ensure security standards are up to par.

When I was at NTIA and travelled around the world to talk to my counterparts about why they chose a particular vendor, first and foremost it was about cost; secondly, it was the easy button. It was easy to pick up the phone and call the person who built their network to come and service it. That is where the system integrator becomes so important, because it gives you that one phone number to call. They will come out and service your network. With open RAN, a lot of these things are happening on the computer—

Q383 **Katherine Fletcher:** Not to put words into your mouth, that is potentially something the UK could consider. To facilitate international co-operation, you could define a UK test bed systems integrator that would allow for smaller firms to engage within whatever open RAN or multiple standards were held and managed by a systems integrator.

Diane Rinaldo: That is absolutely right. Talking to our own rural carriers in the United States, one of their big issues is who is going to put it all together. That is the idea having a systems integrator. The best convenor is Government—to be able to bring people together to have a conversation and build that comfort level.

Q384 **Chris Clarkson:** I want to ask a few questions about international co-operation. Obviously, your organisation will be involved in that at some level. I want to get an idea about how co-ordinated efforts have been in supporting open RAN as a technology at international level. Which countries are leading the way? In particular, which countries outside the "Five Eyes" alliance are taking an active role?

Diane Rinaldo: In the UK, it is the D10 and the Prague security conference. All of those organisations have brought together the industry players to have that very important conversation. Outside organisations like TIP, the telecom infra project we work very closely with, have gone out of their way to ensure that we pull in all the voices to have the conversation. Education, education, education; I cannot say it enough. We have to find different venues to have those conversations and bring in the important voices from policymakers as well as businesses

I mentioned the more rural carriers that would benefit from open RAN. International co-operation is very important if we are to be able to bring that to scale. A lot of smaller countries that are looking to the "if not them, then who" question need international co-operation to help them answer that question.

Q385 **Chris Clarkson:** What could the UK be doing to support the roll-out of open RAN as an international proposition? What should we be looking to do? What are the next steps?

Diane Rinaldo: You are probably ahead of the curve on this one. It is about working through D10 on international co-operation and

development, and how you are spending your funding. It is about investing in leap-ahead technologies and making sure that you have conversations with Vodafone, BT and Telefónica—companies that are currently servicing your networks. They have a lot to add to the conversation. They want to work with you, reach out and figure out the best path forward. It is about communication, and there is no greater convenor than Government.

Q386 **Chris Clarkson:** We have seen Vodafone in India with Mavenir, and Rakuten. What are the learnings from that? What are the messages we can take away? What can people take away from the deployment of those networks? What can we do better? What can we do differently? What is going to make it work better in future?

Diane Rinaldo: Those companies had a choice about what they were going to use in their networks and they chose to move forward with an open RAN standard for several reasons. It has dropped capex and opex and it has allowed them to be nimbler. Open RAN is the future; it is just about the timeframe for scaling it up. I think it should give a comfort level that carriers want to make that choice. How can we then all work together towards ubiquitous deployment at some time in the future?

Q387 **Chris Clarkson:** Were there any teething issues you would highlight? Let's say that tomorrow I want to start my own open RAN network. What should I be taking away as a salutary lesson from those processes?

Diane Rinaldo: You should take away that a lot of companies out there can help build out that network for you. There is the use case and value proposition ad. There are more entrants in the market than ever before.

In the telecom market, especially in the United States, there has been hardly any venture capital money because it has not been worth the investment. If you are a really smart person in Silicon Valley or London with a great idea, you will not necessarily spend all your efforts trying to get one of the current vendors to include it in their systems—the idea that you could create the next best innovative radio and go to Vodafone, BT, AT&T or Verizon. It is going to create a new innovative approach because you are able to get out there and have a broader market of buyers, not just a handful of companies. That is where we will see innovation come into play, and the value proposition in opening up the market.

Chair: That brings us to the end of our time. Ms Rinaldo, we thank you and all our witnesses for joining us today in what has been a fascinating and in-depth look at some of the opportunities, but some of the regulatory, technological and consumer challenges we face on this issue. We will reflect on the evidence that has been given to us, and it will be very useful in informing our recommendations to Government. Thank you very much indeed for your time.