



Select Committee on Science and Technology

Corrected oral evidence: Off-site manufacture for construction

Tuesday 15 May 2018

4.35 pm

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Members present: Lord Patel (Chairman); Lord Borwick; Lord Griffiths of Fforestfach; Lord Hunt of Chesterton; Lord Kakkar; Lord Mair; Lord Renfrew of Kaimsthorn; Lord Vallance of Tummel; Baroness Young of Old Scone.

Evidence Session No. 8

Heard in Public

Questions 57 - 63

Witness

Andrew Wolstenholme OBE, Co-Chair Construction Leadership Council, Former CEO of Crossrail.

USE OF THE TRANSCRIPT

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Examination of witness

Andrew Wolstenholme OBE.

Q57 **The Chairman:** Good afternoon, Mr Wolstenholme. Thank you very much for coming to help us with this inquiry today. Would you say who you are for the record and what your current position is and, if you wanted to say anything to start with, please do so, otherwise I will go straight to the questions.

Andrew Wolstenholme: First, thank you very much for giving me the opportunity to come here today. I am Andrew Wolstenholme, the ex-chief executive of Crossrail. I find myself in a curious position because as of now I do not have a position. I am about to take up the group managing director role of maritime and land for BAE Systems, so a slight shift in sectoral balance.

I have just come from the Department for Business, Energy and Industrial Strategy where I got an update on something that is extremely exciting and will act as a catalyst for much of what you have been talking about, which is the construction sector deal. If I may say so—and apologies if it is not my position to do so—it is a slight frustration that this sector deal has not yet been announced, and over the course of this questioning I would like to tell you a little about the three elements of it.

The central one is an industry-led innovation programme with manufacturing sitting at its heart. I came in a few moments before the end and heard some of the debate and dialogue going on, and I would say this is a very important strand of UK plc. Infrastructure and construction represents around 8% of the UK's GDP. We represent somewhere around 10% of the employment opportunities. For rather too long now, this sector has not attracted the sort of debate we are having here today, so thank you for the opportunity, and over the course of the questioning there are very many points of a very positive and constructive nature that I would like to draw out.

The Chairman: You are a key witness in lots of ways but if I might start with a question given your statement: do you have any idea as to when the sector deal is likely to be published?

Andrew Wolstenholme: I know that it has been signed off by all the respective stakeholder groups. I know that, unfortunately, it has got stuck because Judith Hackitt is going to issue her report soon around the tragedy this time last year in north Kensington. I also know that it got stuck because of the inconvenience of the activities around Carillion's failure. All I would say is that we cannot wait too much longer for this important sector deal to come out. In politics there will always be a reason why you should not push the boat out a bit, but if there is any help or support that this Committee can give, I would very much welcome that.

The Chairman: What kind of support can this Committee give to expedite that process?

Andrew Wolstenholme: My expertise is not in bringing statute to the start line, as it were. We need to do whatever we can to convince BEIS that now is the right time to deliver this sector deal. If anyone around the table could influence that it would be welcome. If it is not the position of this Committee to do so, I apologise, but we need this thing to be out because, in many ways, it is the catalyst that is going to unlock much of the intent and the opportunity to go down much more of a manufacturing route.

The Chairman: Let me come to a different question. Is it correct that you currently lead the Construction Leadership Council?

Andrew Wolstenholme: I am the co-chair of the Construction Leadership Council.

Q58 **The Chairman:** We are told that this leadership council is crucial to encourage wider use of off-site construction and that it needs to take the responsibility because it has the authority to drive this process. Is that correct and, if it is, how do you intend to do that?

Andrew Wolstenholme: About two years ago I was asked by Sir David Higgins, who was the chairman of the Construction Leadership Council, to take over the co-chair role. If you look at my background, I have been in the major programme sector for about 30 years, originally as a consultant with a group called Ove Arup, then with the airport operator in those days known as BAA, and subsequently with Crossrail. On each of those occasions I spent about seven years looking at infrastructure and critical assets from different directions.

This sector has lacked a very simple and compelling agenda with a very strong business case to go with it. I asked a private consultancy to help put some numbers together. If you look at the simple facts, here is a sector that represents around 8% of GDP and 10% of employment. If you look at the pipeline of critical assets ahead, we have somewhere between £450 billion and £550 billion. The analysis that was done showed that on our current levels of production and productivity, we will be somewhere between 20% and 25% short of resources or raw productive outputs. The start point from the CLC was to put forward the thesis that unless the sector came together around a compelling and simple agenda that could attract the attention of a very diverse sector and industry against one set of initiatives, we would, like many others previously, fail to get critical change across the different parts of the sector.

The sector, as you have learned, represents housebuilding into private commercial developments into public sector social and economic infrastructure. This is a huge opportunity and the question for this sector is: what is it that brings the common denominators together? We went out to a leadership group, and some of the individuals who were here a moment ago helped me do this, to try to get the three strands. I looked first at the automotive and, secondly, at the aerospace industry. Aerospace has attracted £4.5 billion of match funding from government over the last 10 years. The two things that aerospace has focused on are wings and engines. We do not make complete aircraft here. The two

things that the automotive industry is focusing on right now are driverless and battery—in other words, power plants beyond those that are carbon dependent. I asked myself the question: what are the wings and engines of this sector? What are the three things that make it very simple that everyone, from a housebuilder to someone building a school, a hospital or a major programme such as Crossrail, can hang on to? The three strands were, first, the definition of the outcomes at the front, so using digital technologies to deliver better, more certain outcomes. A car, for instance, has a digital model that is 98% mature before you start manufacturing possibly 10,000; a building's digital model is probably less than 60% mature before you start building, so it is absolutely vital that you get the definition and the outcomes understood before you start what we traditionally call build.

That gives you two opportunities. The first is to improve the productivity of delivering the asset and that may take two, three or four years. For Crossrail it has taken about eight years. There is a huge opportunity to improve productivity. Why do we want to improve productivity? First, it brings that asset to market quicker; secondly because it relies less on the resources we are currently importing from eastern Europe—and I suspect there will be less of them in the future, certainly post Brexit—and, thirdly, instead of constructing on-site by importing those skills, it provides high-value manufacturing jobs in the areas where jobs are needed most. The opportunity through digitalisation is to improve productivity. Manufacturing is part of that and I have given you some very good examples.

The third opportunity—and I am going to point to Lord Robert Mair here and the fantastic work that he has done at Cambridge University, and forgive me, Robert, for introducing any conflicts here—is the opportunity to understand how that asset behaves over its entire life cycle. Bombardier has a train set on Crossrail that pretty much diagnoses and self-analyses on an hour-by-hour basis the state of that infrastructure. Down the road in Derby, Rolls-Royce also, incidentally, knows exactly what its engines are doing hour by hour. Unless you digitalise at the front end, you lose the opportunity, first, to improve productivity through the delivery, and, secondly, to introduce smart technologies, monitoring and datasets to the life of that asset. In infrastructure and building we have missed the opportunity to deliver both of those, principally because of the slow uptake of digital technologies at the front end.

The sector deal is about three things: better and more certain outcomes for the delivery of digital technologies, improved productivity by the introduction of manufacturing, and improved life cycle performance by the introduction of smart technologies, including sensor technologies. All of these are available and we are at the forefront of a potential revolution that can take us back into a leading role, not only nationally but internationally across the different marketplaces there will be post Brexit.

The Chairman: What state is the UK in regarding the digitisation of the construction industry?

Andrew Wolstenholme: It may come as a bit of a surprise to learn that we are not badly placed. The Government have done a very good job in promoting what is called BIM—building information management. It is probably the wrong word, but it has gained some traction and it is here to stay. I call these digital technologies. It is mandated at BIM Level 2 that public sector programmes use this. If you go round the world—and I have not done much international travel as I have had my head down on Crossrail for the last seven years—you will see it is the envy of many other nations. America has technology that is much better advanced but is unable to deploy it on programmes. We are very good here, even though we rock ourselves quite often, at working collaboratively in projects to make sure that the technology is spread across all the different departments. If you only have 10% of the project using the same technology, you will get 10 different interfaces. If you have, as they do in the car industry, one model that represents the concept design of that car, and it goes right the way down to looking at what rivets you use and how the different componentry comes together, that is the environment within which you have the opportunity to go away and manufacture.

In my time at Crossrail and terminal 5, we have been promoting a collaborative way of working to make sure there is the opportunity for the digital model to speak a single language across the whole of that project. Where you have that, you have the opportunity to talk about manufacturing.

Lord Griffiths of Fforestfach: It is a great pleasure to ask you questions. You have described yourself as a revolutionary.

Andrew Wolstenholme: I have?

Lord Griffiths of Fforestfach: Yes. You have said you were one of the people leading this revolution, which is terrific news.

Andrew Wolstenholme: With many others in this room, I am sure.

Q59 **Lord Griffiths of Fforestfach:** I have two questions. The first is because of what you said at the beginning. I can see the case for the sector deal being spelt out as soon as possible. Where do you think the capital to support it will come from? A lot of evidence we have taken is to do with buildings going up whereas you have been at the horizontal level. My second question is: what have you learned from that about a model of construction which might be relevant to us?

Andrew Wolstenholme: Let me start with that one because I was anticipating something along those lines. You can see what we have done on Crossrail. I started when the programme was 4% complete and it is now 93% complete. It will open in December and it will transform London. Some 42 kilometres of bored tunnel has been done completely through a manufacturing process. There is no need to worry about certain elements of this. This is not off-site manufacture; this is on-site manufacture. A tunnel-boring machine only has two roles to play. It takes away around 6.5 million cubic metres of clay and replaces it with off-site manufactured concrete segments. It does this with a team of somewhere

between 15 and 20 people. This is a factory working 24 hours a day under London building a tunnel and it is completely manufactured. If you look at what we need to tie these running tunnels together—these are 7 metre diameter tunnels—to the passenger spaces, to the concourses, to the various escalator barrels and all the rest of it, you do not have a machine as a tunnel-boring machine; you have to hand spray concrete. It is called a sprayed concrete lining. When I was at Heathrow you had a pack of strong people holding nozzles. Today these are people dressed as if they were space people—men and women—operating robots in a manufacturing process. We are manufacturing the principal elements of Crossrail.

If you look at how we introduce the technology into the tunnels, for the running rail, of which there are 50 kilometres, the sleepers were built in a factory, the running rail was built by the steel industry and is handled by specifically designed componentry. In introducing the notion that our supply chains should look very carefully at the IP and innovation models they carry, we persuaded people to introduce robotics into our tunnels. The joint venture of Alstom, Costain and a French railway engineering group, for the first time, brought in robotics to the tunnels to do simple activities such as drilling holes. There happened to be three-quarters of a million holes to drill. There is a social side to this because instead of the 28 people who would otherwise be needed to drill the holes, this now needed a gang of two. There is plenty of opportunity on linear programmes.

If I look at things such as High Speed 2, I am quite sure those technologies will be taken forward and the opportunities will be built upon. I have just come back from Sri Lanka on a slight break and every time I passed over a bridge in Sri Lanka it was a government bridge. The handrails and the components were identical, and that was British engineering in the 1880s. I very much hope that High Speed 2 will adopt a standardisation process to cope with those linear components that have the opportunity of being different through lack of climate control, lack of direction of travel. I very much hope that we can finish the job off and ensure that every opportunity to standardise and to build off-site is taken, creating higher-value jobs in regions that do not have them.

We surprise ourselves when we talk through this commentary by how many of these things are delivered on-site. I want to give you one example, if I may, and I do not know if you have heard this one before. There were two platforms built on Crossrail, one at Tottenham Court Road and one at Liverpool Street. They were identical platforms, about 250 metres long, times two because there is a western and eastern-running tunnel. They were both built by the same employer, Laing O'Rourke. This gives you one answer as to why you do not mandate it and this has to be a value-driven equation. At Liverpool Street we had a huge hole in the ground at Finsbury Circus. It used to be a bowling green in 1880 and we are going to put a bowling green back there, but it is now a huge hole in the ground. Logistically, we were able to put a huge gantry crane over the top of it and lift huge components down, weighing about 18 tonnes each. These components were the

platforms and they were built in Derby. On site we had seven people and the skills of those seven people were not traditional concrete-laying skills. These were people who understood logistics, assembly and manufacturing-type techniques. They walked along large craneages that lifted big components in place and they put them in place against the digital model. In Derby, there were 27 people with high-value manufacturing jobs and it took 27,000 man hours to build this platform.

If you go to Tottenham Court Road, with exactly the same platform, there were 67 people on site, around 40 of whom were eastern Europeans, all of whom were good construction workers, but because the logistics of Tottenham Court Road did not allow us to put large components down, they were constrained into doing it traditionally. It took 67,000 man hours against 27,000 man hours. You can stand back and ask, "Why are we doing this?" It is not just the pursuit because off-site is fun; it is because you solve a production issue, you solve a resources issue and you inspire your supply chains to innovate and to research and develop the ways of doing that. One way of unlocking this is, yes, to have clients who are engaged and enlightened, but, secondly, to try to create an industry where it is worth their while to put some of the very thin margins that occur back into researching and developing these techniques. Unless you create the business model that allocates some of the win to the client, some of the win to the supply chain and some of the win to the stakeholder part of this, you will never get this model to work.

I look at Skanska's model. It was a huge exponent of helping me deliver an innovation programme. We asked Skanska to share its IP and we match funded Mike Putnam's own money, to encourage people to find the solutions in getting this more productive way of doing it. Off-site was a very valuable solution here. We have to break the current paradigm. If the public sector wants to procure for the lowest cost, we will never get out of this loop of hysteresis we are in. If the public sector wants to stand back and say, "We want to create more value over the whole life of an asset", it is going to do it by mandating a direction of travel, and perhaps even a percentage of research and development in that programme for which they will have to match fund.

On Crossrail let me give you a very simple example: we said for every £3 million of work we would like you to put forward an apprentice. It was in some ways distorting the market. I ask myself: are we pleased that Crossrail has 1,000 apprentices right now? Can we not take that sort of behaviour and match it elsewhere? The market responds by the client asking some pretty bold questions. We are now in a cycle where public sector clients, in particular, should put down some very strong indicators about the percentage of manufacture they would like off-site, and perhaps a suggestion that they will match some of the R&D that is going to be put in, which is what the automotive and aerospace industries did, and certainly by saying, "For a percentage of the work we give you, we would like you to employ an apprentice". By asking these questions on a level playing field, the market will have to respond.

Lord Griffiths of Fforestfach: We heard earlier it is a fragmented industry with 230,000 companies. When you first started you said the

sector deal is fantastic, and we are prepared to accept that. Where will the capital come from to back it?

Andrew Wolstenholme: There are three elements to the sector deal. The first is the most difficult and requires no money. It requires leadership and behaviour change. It requires public sector clients to write something different in their procurement strategies around the presumption for off-site. We need to be able to measure every project and work out whether the industry is getting more productive by doing more manufacturing and whether we are getting more highly skilled because we have a greater percentage of apprentices. This is not going to happen a week on Tuesday. The next thing the leadership council needs to do, plus Tony Meggs at the IPA, is to have this very simple and straightforward measuring process. The first element does not you cost you any money; it is a behavioural change.

The second element is already funded and this comes with the industry-led innovation programme, and it is the innovation challenge fund. About £170 million has been committed on the presumption of match funding by the industry. This is fairly small beer. Let us call this £400 million that did not exist currently. This is a sector that invests less than half of 1% in R&D. To make meaningful change, you need to convert that to somewhere around 3% or 4%. This is what the automotive and aerospace industries have done. If we put in 3% or 4% R&D money, by focusing attention on a few things and doing them well, we can begin to see results. That money has already been committed but we have not yet launched it.

The third level is skills for the future. At the moment, there are two ways in which you raise money for that. The first is a levy through the Construction Industry Training Board—the CITB—which has had quite a rough ride recently because the industry has questioned the value that it provides, and quite rightly, because there needs now to be modernisation of the CITB, which is happening.

The second element is the Government's apprenticeship levy. Some organisations will be required to pay at least 1% toward apprentices. We are saying let us work out a better way of spending that 1%. That is not new money; it is smarter ways of directing that 1% towards the skills we need for the future.

Where does the capital come from? First, it is around procuring for better value and is about understanding the risk out there, understanding a total value outcome as opposed to a low-cost outcome and somehow representing that through consistently procuring public sector programmes in the future. That is probably the most difficult one we have to do. On the one hand, it is saying, "Am I going to distort the market by telling people what to do?" For a moment in time I believe we have to be pretty bold in that. The central and exciting one is about using the very limited resource we have sitting on people's balance sheets and government match funding it. That is where the £190 million is coming from. The third one is about money currently in the system being used better.

Baroness Young of Old Scone: Could I take that a tiny bit further? We kind of think that if the economic case was powerful that private sector clients would go for it and there would be an indubitable case. You seem to be saying that this will only get legs and run if the public sector gets behind it. Is that absolutely the case?

Andrew Wolstenholme: It will not happen across the whole of the sector unless the public sector, which by a country mile is the largest construction client, understands the part it has to play. I have explained my career. I have not worked for very many people, but one of the very informative times was working with BAA—the British Airports Authority. In those days, we owned seven airports in the UK and three internationally. I was there with Sir John Egan, who came from Jaguar Land Rover, who absolutely understood the manufacturing process and had just gone through the crisis of the UK car industry. Unless that industry changed, it would have been obliterated. He brought in that sense at BAA. He wrote a report called *Rethinking Construction*. He brought much of the technology and the process management from automotive into the industry and so BAA, a private sector organisation, because there was a very powerful business case for it, introduced a lot of standardisation, digitalisation and off-site manufacture. At terminal 5, 85% of the mechanical and electrical services were built either on the Firth of Forth using oilrig technologies or further downstream using off-site manufacturing technologies. There is an example of the private sector. There are many others.

If you look at the regulated utility industry, smart regulation can be a huge benefit in being able to pull supply chains and utility owners into delivering better performance, for instance at the start of a quinquennium to the end. These are private companies responding to smart regulation. There are many great examples—private asset owners, for instance, BAA, private sector property companies, British Land, Land Securities, Stanhope. All previously have understood the value in getting their product to market, have worked with a limited number of suppliers and have invested vertically through the supply chain. They take a team of players, invest in those players and use them on projects over and over again. Where you have consistency in the process and in the team which does it, you can see great examples of where value is brought to bear.

I feel the public sector now has an opportunity to lead on this. The big one-offs—the Olympics, the terminal 5s, the Crossrails, hopefully the High Speed 2s—have an opportunity and a responsibility to work this sector at what I call an enterprise level. The problem is that if you have discrete investments called projects, there is very little opportunity to work at an enterprise level in the same way that the automotive industry has worked over decades. They have improved manufacturing not because they have had one car to build but because they have had 10 series of 100,000 cars to build. Organisations such as the Construction Leadership Council and the Infrastructure Client Group—and I am very pleased that the small innovation programme we produced on Crossrail called Innovate 18 has become an industry platform called i3P—are enablers and critical components of an industry that has not found it easy

to work as one hybrid enterprise model. It has only ever been encouraged to start and finish a project and try to make 1% profit on the next one. We need to work out the wings and the engines—the digital, the manufacturing and the through life—and, whether you are a housebuilder or a public sector or private contractor, all of those things are going to bring long-term value.

Q60 Lord Borwick: Can we talk about the business models in the construction industry? A big contractor works off a remarkably little amount of capital and has an enormous turnover. With off-site construction, is he going to need more capital than he had before and does his cash flow change with this? It would seem to me that with properly organised off-site construction he would end up having to pay a lot earlier for the products that he sells to the client at the end of the process.

Andrew Wolstenholme: I think that is a very good question. In a sense, this goes to the heart of it. Mike Chaldecott is a member of my Construction Leadership Council and he looks at housing. The housing crisis has meant the Government have demanded 200,000 units a year. It is fair to say that over the last 10 years, I am not quite sure, and do not quote me on the figures, it has been somewhere between 100,000 and 120,000. How do we develop another 80,000 houses per year? Some people feel that there are simply not enough bricklayers and plasterers, and I am sure that the lack of resources is part of that. Some people know that the housing developers are rather smarter than that and they are holding on to a land bank and waiting for the market to come back before they start investing. You can look at the one or two organisations that are putting a huge amount of their own capital into the factory output to deliver houses, and imagine you are that chief executive or managing director and you are going to the bank saying, "I would like to borrow £50 million, £60 million, £70 million, £100 million to deliver this output", and they say, "What is the guarantee on your market? How can you make sure that this is a good capital asset to invest in over the next 10 years which we the banks are exposed to?", and they will say, "We can't because the housing market is cyclical".

The secret in getting the investment in the market is to understand from the supply point of view how you provide a regular pipeline against which you can invest and develop the overheads that one contractor alone is unable to deliver. You have to take a slightly different market view on this. I am afraid this is one of the inhibitors. If I can cite Laing O'Rourke, Ray O'Rourke is inspirational and has invested tens of millions of pounds of his own money and he is uniquely positioned in being able to deliver things off-site. He would love to invest in a housing factory, and has all the skills, capabilities, technology and leadership to do that, but is that going to be a good investment in a market which for many reasons is out of his control? My personal view is these overheads have to be owned probably by a co-operative more than by a single unique organisation. The Government have to understand the value of a consistent pipeline.

I am disappointed that my next job does not start a week on Monday and is not called Crossrail 2. We have the machinery, expertise and momentum built up in the sector and, all of a sudden, we will stop. All of those technologies and resources are going to be dispersed elsewhere, some internationally. If Crossrail 2 was part of a pipeline—and forgive me, this is difficult—and national infrastructure programmes had a pipeline that was consistent and optimised, two things would happen in the sector. The first is they would feel less exposed to investing their capital in the equipment needed to keep these things going, and, secondly, they would have a resource platform that was not cyclical and imported; a resource platform again owned by the organisations that were delivering that capital output.

Lord Borwick: Is it not inevitable in the housebuilding market particularly that it starts, stops and stutters because of the planning system and because of so many people wanting to be involved in the details of the house and whether or not houses are built in that particular area? Does this not therefore suggest that if it is hard in the infrastructure sector to achieve this consistently, it is going to be nearly impossible in the housing sector?

Andrew Wolstenholme: All of these are constraints, which is why Mike Chaldecott has not looked at trying to anticipate the technology. He is asking what the circumstances are around which people would invest in that capacity. The circumstances are consistency of pipeline, access to finance and some sort of consistent behaviour around housing authorities, public sector housing or even private sector housing specifying what that house should be able to do over its life cycle. With a relatively small amount of recalibration of these things, I think one would be surprised by the opportunity that was exposed.

Lord Borwick: Do you have any idea about the quantum of money that would be required for this extra capital to transform the housing industry?

Andrew Wolstenholme: I do not, but we could take it within the Construction Leadership Council and do some sort of equation around it. Consistency of pipeline is a very interesting question of whether that costs you any money. Yes, because housebuilders would not traditionally expose themselves to a market for which house prices were reducing and for which there was no immediate uptake. They do that because it is in their economic interests not to be exposed to that shortfall. There must somewhere be a cost to this, but it would be an interesting piece of work to do.

Lord Hunt of Chesterton: You began by comparing aerospace and wings and engines. As you know, with aerospace, you have Rolls-Royce with the golden share and the aerospace without the golden share. We are no longer a dominant partner of Airbus and we do not know what is going to happen. Rolls-Royce is a good example of where there is very strong UK investment by the Government that works. The car industry is largely owned by foreign companies. Do you see massive national investment as being required?

Andrew Wolstenholme: Again, these are good questions. It is always interesting to talk about the mechanics of off-site, but understanding the circumstances of where that happens naturally as a consequence of the market is what we should be talking about. If you go to the advanced manufacturing centre at Coventry, one of the seven government catapults around manufacturing, you will see that Rolls-Royce's logo is in six-foot high letters. You will also see it is not alone and even though Rolls-Royce holds huge respect in international markets and has the market share that it does, it realises that it can only operate if the industry around it operates at enterprise level. That is why you have 50 or 60 different logos sitting around Rolls-Royce representing its supply chain, all trying to find that answer in collaboration together. That is why the Government have decided that if you match fund this, the industry will respond in kind. The consequence of that is continuing to have, whether it is golden or not golden, a share in the global market and very focused high-value resources sitting around an industry that is high in R&D and easily exportable. It requires the sort of support that I am sure all other international aero engine manufacturers have: this collaborative enterprise model where Governments match fund.

These industries do not operate on their own, in the same way that the pursuit of battery or driverless technologies is not going to come from Jaguar Land Rover or Ford, or whoever our wonderful foreign-owned car operators are which still hold the technology. It will not be done unless the sector operates as an enterprise platform. That is why the Construction Leadership Council's agenda is very important, because it is beginning to define the three prerequisites we need to become more productive, more international, more high-value skills orientated and more exportable. Those three prerequisites are: digitalisation at the front end to understand the outcomes, the manufacturing elements, of which off-site is one, and through-life performance through the digitalisation of assets.

You have the most phenomenal project ahead of you in this Palace of Westminster. Several billion pounds will be spent on this and it is a fantastic opportunity to almost hold the international market of undoing and re-doing these buildings. You need to absolutely understand almost shift by shift what you are going to do by digitalising this complex building. Behind some walls there is probably 350 year-old plaster and horsehair and behind other walls there are complex mechanical and electrical componentries. Unless you completely digitalise that and have the opportunity to do a lot of this work in factories around the country, for which you will be an exemplar and role model, this will be very complex indeed. The length of time that you are debating about whether you stay in the Chamber or leave is a difficult inconvenience, and the only way you can minimise that is by absolutely understanding the outcome, the process of politics when you get your new parliamentary building and the process of delivering that, as much of which must be done off-site as possible.

Q61 Lord Mair: In the earlier session we heard evidence about this issue of five government departments saying they will adopt a presumption in

favour of off-site construction by 2019 where it represents best value for money. What does the Government need to do to advance that case? They are saying a presumption in favour of off-site manufacture but it does not feel like a really big push; it is not mandating. What are your views about that?

Andrew Wolstenholme: Two or three questions come up, all of which are relevant here, and one of which is around the business case that makes it compelling that the right way of delivering this particular asset is to introduce manufacturing—and the presumption is off-site manufacturing. Over the next generation of asset development we need to be able to measure the outcome of that. This will really accelerate. At the moment, we should rely on the market leaders, but over the next half generation we need to be able to prove convincingly that those organisations and supply chains that deliver efficiencies on-site—and that could be through off-site manufacturing or taking a smart logistics process or robotics process—have the opportunity to either make more profit or share the savings.

If you look at housing in particular, with a very small local architect who has just invested in off-site manufacture for wooden-based houses, he thinks he can take 35% to 40% of the time off. It takes him just weeks to put up a house once he is out of the ground, and he is pretty close to understanding the percentage cost reduction. He has to figure how much he retains himself and how much he gives back to the market. This needs to be a combination of taking the benchmarked examples and breaking them down into the different components to prove the value equation. It is setting up a long-term set of key performance indicators across the industry rather than measuring, post-Egan and *Rethinking Construction* cost, profit and time to market. Time to market is important, but let us say we start to measure this sector's ability to export, to off-site manufacture, to take up a percentage of apprentices and to invest in research and development. These are very different key performance indicators. These are indicating smart modern sectors rather than ones that have no opportunity of investing in themselves.

First, the public sector has to ask the right questions. Secondly, it has to illustrate this on an annual basis by exemplar programmes that are leading the way. Thirdly, the market has to follow by having a set of KPIs that makes it very difficult for supply chains in the future, because otherwise they would go out of business, not to follow a more value-driven outcome, which, incidentally, will give them superior profits.

Lord Mair: Do you think all that leads to a change in mind set about procurement?

Andrew Wolstenholme: I do. We have been back over many years talking about the value of the work you have done at Cambridge. On its own, a smart sensor providing valued information is worth nothing, unless that information can be locked into a life cycle model, or can be locked into a delivery model. Unless the client asks the right questions, he will never get that. If I look at the letter that was written to me by Chris Grayling, Secretary of State for Transport, he absolutely supported

what we are doing on the CLC. If I look at the Ministry of Justice around their prison programme, there is absolute support. There is an energy around education and health, too. With the Infrastructure and Projects Authority, we are beginning to get an organisation and a realisation that a set of processes at IPA level and change programmes in each individual government department that are consistent with the CLC and sector deal, these are all pushing the barge in the same direction. This is a very exciting opportunity, but it starts with an alignment of each of the different spending departments understanding the same type of question that you need for the supply chain which is very diverse, to give you the same market response.

We heard about three different roofs going on three identical hospitals. That is because there is lots of variation in how the questions are asked. If we can begin to get some consistency in how these questions are asked, the market will begin to understand at an enterprise level that there is a more efficient way of producing it. There will never be a single set of solutions. The direction of travel will be towards buildings that have a higher percentage manufactured and a higher percentage that is built by robots and a higher percentage that is built off-site and, therefore, has a much better opportunity of beginning to export not buckets of concrete but the expertise as to how you create this. I am very pleased to say that Crossrail International is something that the Secretary of State for Transport Chris Grayling has supported. What is of interest to international markets is not how to physically do the work but how to bring this to market, how to set up apprentice programmes and how to set up off-site manufacturing in the environment within which it is. There is a really inquisitive interest as to how you share some of these technologies.

Q62 Lord Hunt of Chesterton: My questions are to do with skills. What types of skills are needed to facilitate a move to off-site manufacture? You have told us a lot of marvellous examples in your work on the tunnel for Crossrail. How do these differ from traditional skills? What organisations will be responsible?

Andrew Wolstenholme: Skills for the future is a very important strand within the Construction Leadership Council. It is very interesting that if we demand more of the traditional skills, we have completely missed the point. When we talk about skills, we probably think of traditional apprentice-type skills; skilled and semi-skilled trades. We should also consider the skills of a civil servant who is presented with a procurement problem and a risk profile, and who needs to understand them. I am delighted to say that the Saïd Business School is providing some sort of skills opportunity for civil servants, not just to be good at delivering policy but at understanding how to manage portfolios of risk. You can look at that as one set. Another set is clienthood skills, and again understanding the risk profile and the different ranges of procurement opportunity you have. We need to attract in this sector the sorts of skills that go to Google and Amazon. The digitalisation of those sectors has been enormously successful and progressive. We need those skills to be attracted by our universities. From a university perspective, we need to

understand how graduates are trained. I went back to Southampton University the other day and there was still the same machine that bent a beam today that was there 35 years ago. We need to do that, but it needs to occupy slightly less of the curriculum. There are the clienthood skills, the civil servant skills and the graduate skills. Do not in any way think that any of those people are let off the hook.

When you go down into the trades, in this building you are going to need stone masons. I happen to know that on your critical path is the question of getting enough stone masons because there is a lot of stone masonry. In a housing site, I would expect that over a 10-year period you would have a smaller proportion of bricklayers and a bigger percentage of people who understand manufacturing skills back in the manufacturing departments, and fewer plasterers because the walls are going to be preassembled in prepacks in factories.

When you look at the 67 people we had at Tottenham Court Road, those 67 people were bar benders, putting steel in reinforced concrete, shutterers, support labourers with wheelbarrows and brushes; they were skilled and semi-skilled. The seven people we had at Liverpool Street were people who operated robotics, logistic equipment and on the just-in-time model. There needs to be—and I will use this word—a revolutionary shift in understanding, and part of what we within the sector deal are doing is trying to identify, through something called Trailblazers. If you have a Trailblazer, you can draw down some of that half a per cent from your apprenticeship levy and get modern apprentices from it. We need to identify through Trailblazers what those skills are, probably starting from the top and going right the way through a vertical section of the supply chain. I kid you not that we need people who can mend robots, because brick walls in the future will be built by robots. It will not be the lack of skip loaders; it will be the lack of people who repair the robots. Let us think radically about what we need for this sector and how to revolutionise what we do best to a world-class standard.

I have been around the world a lot and there are very few programmes in Asia or in the Middle East or in America that do not have a British architect or engineer. We are world class at this and where we have exemplar programmes, this is the envy of the world. We have to be positive about the sector deal, back it and do whatever we have to do to get it launched. We must rely on the industry to respond to subtly different procurement questions and allow the market to be able to cause the adjustment that we so badly need right now.

Lord Vallance of Tummel: Earlier on you said that a major block on progress in the housing market was its cyclical nature for one reason or another. Does the sector in any way try to handle that problem? Are you trying to deal with the cyclical nature? There are ways of dealing with cyclical nature. There are other cyclical industries. You can go right back to the Milk Marketing Board. Are there governmental ways to try to deal with this or how do you take the risk out of it or spread it in a more fair way?

Andrew Wolstenholme: We have to draw a line around those things that we are responsible and accountable for. I am not responsible or accountable for Brexit, for economic fluctuations or fluctuations in the housing market. We try to point the mirror back and say, "If you did not think it was a significant part of the future model, the cyclical nature is a fundamental reason why the capital is not going in to the capability of putting in manufacturing components". The answer is no, we are not accountable or responsible, and we are not trying to change the cyclical nature. That is because of market forces, land ownership and planning as well as resources. Mark Farmer wrote a report with the awful title of *Mordernise or Die* and pointed out that, unless we took up some of these important themes, we should not anticipate huge fundamental sustainable change within this sector. In some ways, it is never going to be perfect. There will never be a Crossrail 2 or Crossrail 3 or High Speed 2 that completely follows it, but there needs to be the capacity and the pipeline in the industry to make it a first choice, and to make housebuilding attract not just those who build traditionally with brick—who are very important—but those who see there is a technological, design and market challenge to it. In that sense, market share and market cyclical nature are very important issues.

Lord Vallance of Tummel: I buy all that, but I come back to the earlier question and that is: if cyclical nature is such a significant block, is there anything that you can do about it and who should be doing it? If it is not you, is it government departments?

Andrew Wolstenholme: I have heard of a political aspiration of 200,000 houses built every year. That seems to be a level output/outcome, which must mean that at some point there will be a set of tools that creates the opportunity to level out the cyclical nature. I do not, with respect, think it is the construction sector's responsibility to do more than point out why investment is not being put in. You have organisations such as Legal & General. Legal & General is a pension fund manager. Why is it that it is investing in the prepack housing market? It is because a lot of the long-term stable monetisation they are getting is from the investment in housing and the income that it gives.

Someone said that ownership is very important. It is really interesting if you look at Bouygues or VINCI from France, or Ferrovial from Spain, why is it that their balance sheets are 10 times bigger than any UK contractor's. It is because they own long-term assets. They do not make much money out of building toll roads or toll bridges or car parks, but they gain a market stability and a balance sheet strength by holding an asset that is worth a monetisation over its entire life cycle. PFI gave the opportunity for the UK contracted infrastructure market to gain a critical mass on its balance sheet. I know I am digressing here, but if Carillion had had a balance sheet the same size as Skanska or Bouygues or VINCI had, I doubt whether the adjustments they had to make in their cash would have been necessary. There is a value in having balance sheets that allow you to invest in research and development, take risks over a life cycle and have a monetisation that allows the market to be able to support and capitalise you at times of leanness. Our own industry,

because this sector has been designed this way over many decades by both the private and public sector, has ended up too small and too vulnerable to market changes. That is a reason why the housing market and the UK construction industry cannot bridge some of these cyclical events.

Q63 Lord Mair: That leads me to ask about R&D, which you just mentioned. You said earlier that with the very thin margins of our construction industry it is quite hard to imagine the private sector putting money into R&D. There is a big difference between those large French and Spanish companies that you mentioned. Do you see that as an intractable problem in the UK and that the likelihood of getting the private construction sector putting a lot more money into R&D is quite low?

Andrew Wolstenholme: The other day I spoke to the ex-chief executive of 3M, the organisation that is famous for Post-it stickers. They have delivered endless revolution and innovation and I asked what the critical mass was around an organisation or part of a sector that would allow it to grow disproportionately. He said that you need to reach 3% or 4% of turnover investment. How do you mimic that in this sector, which traditionally invests less than one half of 1%? You do it by having one or two clients such as Crossrail which get the ball rolling, which insist that their supply chain, if they are going to be part of the party, match fund that. We are talking about very low levels of funding. I asked Skanska over the duration of our programme to put in £50,000, which Crossrail matched. We had a pot of low millions of pounds, but that pot of low millions of pounds created an environment where it was okay to pass different ideas around. People became rather excited about the reward and recognition they got for something that was done very well in Tottenham Court Road on a Friday suddenly being the way of doing things at Liverpool Street the next Monday. There was a way of this good news travelling.

If we look at the sector deal, for which there is a limited amount of money, let us say £190 million, and double that in match funding, and the organisations that collaborate around the sector deal look at focusing the limited amount of money in three or four areas—we are suggesting digital, manufacturing and through life performance—if we can get a portfolio of programmes in the same way that automotive and aerospace did, to be able to focus this limited resource in these areas that manifest themselves in 2%, 3% or 4% R&D—this is the thesis—you can very quickly, I hope, get critical mass in those certain areas. It is through those benchmarked programmes, with consistent application of the right questions from procurement, and a five-year programme as to where the best value is spent, that you are going to get this sector believing that. A focus on R&D will come up with a long-term sustained solution and value that is good for our home market, our local job market, and it is exportable.

Lord Mair: The sector deal is going to be asking the private sector to put in £250 million.

Andrew Wolstenholme: The i3P, which is this industry-led innovation model, still chaired by Andy Mitchell, who is the current chief executive of Thames Tideway, was asked to do a study as to what money exists on people's balance sheets for R&D. That is where I have quoted this half of 1% from. We know this money is out there. We have to be able to bring together pools of expertise around projects which they are prepared to invest in and the Government will match fund. If these are well chosen projects, some of which should certainly be around the long-term life asset of infrastructure, private companies and public sector spending departments will realise that this is long-term value and the procurement model should accommodate this in its next round of infrastructure investment.

Lord Hunt of Chesterton: A cousin of mine wrote a book on economics. He was a BBC economics correspondent. I read his book and I said there was there was something wrong with it—I like to do that—and I said, "It's got no reference to the cyclical behaviour of economies". Different economists have different views about this. Could you give him a hint about what we have learned from recent events in economics that Governments should take into account?

Andrew Wolstenholme: All I would say is that having the fantastic opportunity to run Crossrail, and, incidentally I am also just about to join the board of High Speed 2, I would ask: what is the big "why" of Crossrail? Why have we done it? It is because London's population is currently at 8.6 million and predicted to be 10 million by 2030. If it is to remain a capital city, it needs long-term investment. This long-term investment far outbridges political cycles and, to a very large extent, far outbridges economic cycles. Unless one understands the real long-term value of economic infrastructure, we will not prepare UK plc to have the connectivity and the transferability that it needs; not for this decade or the next decade but the next 50 or 100 years. If you look at the wisdom of the people around this room and the reason why London is a capital city. it is because, for example, Bazalgette in 1863 built a sewage system that would last for 100 years and Brunel built economic infrastructure not for a return in three years or a market return in the next quarter. Politicians must understand the economics of infrastructure and the opportunity and ability it brings for the value of the nation. In a sense, until we put some of this into a special case, we will never make the long-term decisions to develop and enhance our prosperity for the future. Apologies, I am not trying to knock economics, but political and economic cycles are too short.

The Chairman: On that note, Mr Wolstenholme, thank you very much indeed for coming to help us today. It has been an enormous help and you have been a fantastic witness.