

SESSION 2

KEYNOTE PRESENTATION (1)

Sir George Cox
Chairman, Design Council

I am delighted to be here. I was very pleased with the fact that we started the proceedings not by diving straight into the subject on which we are about to focus, but by stepping back and looking at the way the world is going - to see not so much what the future holds but, much more significantly, what is actually shaping it. Too often, we fail to see the likely advances of technology because we fail to put them in context. The consequence of that is that we fail to exert the influence that we should.

As you have just heard, my background was in aerospace engineering and then I went into production engineering. Then, in the mid-1960s, by pure happenstance I became involved in what was to become known as IT. If I had told my parents or my professor that I was going to make a career in information technology, that would have been quite meaningless. My parents would probably have thought that I was going to sell typewriters or something. I have spent most of my working life in an industry which did not exist when I took my degree. That is the extent of uncertainty about the future.

The advances in that whole area have been quite stunning and, I would say, without parallel in any other area of human experience. Thanks to Moore's law, with the doubling of computing power every eighteen months or two years, we have seen advances which are just hard to describe to people. A friend of mine puts it into nice perspective with an analogy. He says that it is very similar to a game of chess. Apparently, when the game of chess was invented by a dignitary in the court of Emperor in China, the Emperor was hugely impressed and thought this was a tremendous way of wiling the time.

He decided that the dignitary should be rewarded and asked what he would like. The dignitary said: 'There is the board, which you see. You could put a grain of rice on the first square; two on the second; four on the third; eight on the fourth - ' The Emperor said, 'I have the idea. If that is what you want, that is fine.' Idiot! Of course, as you will appreciate, it works out that by the time you are halfway across the chess board, you need paddy fields which would cover most of southern England to satisfy the requirement. If you reached the

other side, you would bury the whole of the earth to about 3 metres deep in rice. Whereupon, I understand, the Emperor had the man executed for his cheek. [Laughter]

The analogy with this is that, since we first started the modern era of computing in about 1950, we have now got halfway across the chess board. The computer power available then was the grain of rice, and today it is all the rice you can produce from covering the whole of southern England with paddy fields. And it is still progressing.

As part of my career, I headed up a company which made much of its revenue from guiding big companies, both suppliers and users, in the way the technology was going, and I look back with great embarrassment. I could show you a paper now, very well argued by me in 1977, on the imminence of the paperless office. However, far from the demise of paper, the use of paper was going to explode. I do not know about you, but there was a time when we, as a family, would go round to Smiths once a year and buy a little pad of paper. Now, I go into Staples and buy big boxes of paper.

How did we get it so wrong? If you look at all those developments in technology, when you talk about processing power, speed, costs – all of them – they are fantastic curves. They are fantastic curves but they are continuous. As we went from valves to transistors, to increasing states of integration, they blend into a smooth curve with no discontinuities. The whole of the development of information technology has not thrown us any surprises at all, I would argue. There has been no major invention which was a big breakthrough, but it is the continuous evolution in transmission technologies, storage technologies and processing technologies and software, and these are all continuous – and yet we have got it wrong repeatedly about where it is going.

Back in 1977, Tim Wilson was the President of the Digital Corporation. He was one of the giants of the industry, both in terms of his technical abilities, understanding and insights, and his commercial abilities. He famously said, 'I can see no reason why anyone would ever want a computer in the home.' This man is not a fool – this man has a technical brain that would rival any in this room, and commercially he is much more successful than all of us put together. He is not a fool, but he gets it that wrong. Why?

The IT industry is not unique in that, although it had probably spent more money studying itself and its future than anyone else. Let me give you another example – that of air travel. Air travel is thoroughly unpleasant. It is undignified, it is pressurised and it is unreliable. Whatever class you travel, you crawl into this long tube through a tiny hole. It is unpleasant and, whatever they do, I find it is a grim experience.

The one thing that air travel has got going for it is that it is quick. That is its only merit – it is quick. Back in the late 1950s, when I was going into the industry, we had seen that

aeroplanes had become successively faster and faster. When the jets came in in the late 1970s – the intercontinental jets, the 707 and the DC8 – they rapidly obsoleted all of the propeller-driven aeroplanes that were then within service. Who was going to sit on a plane for 12 hours going across the Atlantic, when you could do it in seven?

The next step was clearly a faster plane still – quite obviously. And the next step had to be a big one, because you cannot cruise – as many of you here will appreciate – close to the speed of sound. The drag curve just makes it uneconomic, or certainly it did with the technology of that time. You therefore had to go at twice the speed of sound, and that was a huge jump. You are halving this time of air travel and that is a massive jump, and it was just within the scope of the technology of the time. You could just get there with an aluminium airframe and the engines then available.

British Aerospace, or the British Aircraft Corporation as it then was, and Aérospatiale, thought they would steal a march. They were well placed to steal a march on the Americans. IATA, the international transportation body estimated a market for something like 1700 supersonic airliners. Aérospatiale and the British Aircraft Corporation hoped that they would have at least 200 before the Americans came into the market.

The Americans had a plane that was bigger than our own offering, with about the same speed or slightly faster, but a longer range, and that would clearly take the market. The Boeing 2707, as it was, as the favoured American solution, would take the dominant part of the market, but we would have a good slice first.

The product that had everyone doubting its future – both in the industry and also internally within Boeing – was their other idea, which was a failed design for a military freighter. This was a bloody great barn on wings, no faster than a 707. Where is the logic in that? Who would take it? The future was clear – but what happened? Fourteen Concorde were built and went into service, having to be given to the airline to use, and the Boeing 747 is still in production today. How can you get it so wrong?

What went wrong? Nothing went wrong with the technology – until that recent and completely flukey crash, following a concurrence of circumstances that you just could not repeat. Concorde was the safest airliner ever. Its development was very smooth with very little change in the design at all, from the drawing board to going into service. What happened, however, was that the world changed around it.

The concept of environmental issues just did not exist when it was being designed. Noise – airport noise – and pollution were not issues. Moreover, through conflict in the Middle East, fuel prices went up and stayed up, and became a much more substantial cost to air travel. Add to that the political opposition from America, and it killed it. When we look at

the future, therefore, we cannot just look through our own discipline, nor can we necessarily extrapolate from the past.

There are also changes that creep up on us in society and you do not realise it at the time, until you look back. Let me give you an example. If you compare life now with life a century ago, do you know what the big difference is? It is clear for every person: the difference is that today, everyone knows the time. People at the beginning of the 20th century did not know the time, and they did not need to. Your life was not run by the clock in the same way. You did not have wristwatches. If you were the foreman, you would have a watch, and perhaps there might have been a family heirloom which you wore on Sundays, or you might live near a church steeple and know the time. The rest of the people did not know the time and they did not have to because they were not worried about what time their programme was coming on television – things did not run like that. Today, we all know the time, all the time. You are not often stopped in the street nowadays by somebody asking the time, which used to happen. I saw it happen to someone recently – they stopped a girl and asked if she could tell them the time, and she used her mobile phone.

Another change is happening now which is similar to that. Let me lead into it. I used to be a very keen glider pilot. I had a nice glider and I used to go each year to fly in France with it, because they have massive of open air space and lovely conditions. I was a pretty fair pilot, if I say so myself, but my weak suit was navigation. It was not that I did not understand it – I could lecture on it – but when you are going round in the sky, trying to stay up in the thermals, and trying to avoid bumping into other gliders, and you want to progress across the French countryside, it is quite easy to get lost. And, when you are lost in the air, you *are* lost. You are lying on your back in this little streamlined plastic bubble and you are trying to read your map, and the one thing about central France is that every town looks the same. You look down and say, 'Yes, there it is – there is the church and the railway station.' Periodically, I would end up in some farmer's field at the end of the day, 100 miles from where I wanted to be. I would go to the farmer and say, in my poor French, that I had just dropped out of the sky, and I would ask if he could tell me where I was.

That does not happen today – and that was only 15 years ago. Today's glider pilot, going cross-country, knows where they are to within two metres, during the whole flight. We are the last generation to whom the concept of getting lost will have any meaning. Whether you are in the middle of the Atlantic, the Sahara or a strange city, the technology is improving so much in power with satellite positioning, and tumbling in cost, that it will be like digital watches – it will be throw-away cost. The idea that you can lose a child just will not exist.

Things like that change. There are other changes in society which you do not perceive happening. I used to head up the Institute of Directors and we had an annual convention each year. When we had our centenary convention, I wanted clips between the speakers of past speakers. We had one of de Klerk, talking about the ending of Apartheid, and we had Kissinger and many of the great political and business leaders. We had Gerald Ratner bringing his company down – magic moments. Interestingly, in recent years, we could have the videoclip while, before that, of course we wanted photos. For the speakers in the 1950s, you could only get a decent picture in the Albert Hall of the first speaker of the day. Do you know why? Because, for the rest of the day, the smoke was so intense that you could not get a decent picture – everyone in the audience had a pipe or cigar.

It is only when you encounter something like this that you realise how fundamental change is, and that just seeps through. If someone lit up a cigar now – would you get lynched first, or would you be soaked? It would not happen. These changes take place – and this is where we are talking about a changing world. Often, when we are talking about inventions and new developments, we just do not see what they mean.

Marconi never foresaw the concept of broadcasting but he saw radio entirely as a point-to-point communication, which would replace semaphore rather than supplement or complement newspapers. The concept of broadcasting and radio did not occur to him at all.

Alexander Graham Bell was not working on the telephone, but he was working on a device to aid the teaching of deaf children. There is a lovely story that is told about the invention of the telephone, which is one of the prize examples of just not seeing what something means. Apparently, Bell demonstrated the first telephone to the Mayor of New York. He set up a demonstration and, between the mayor and a colleague's office down the corridor, he set up two of these devices and enabled the mayor to speak to his colleague. The mayor was apparently enormously impressed and said, 'This is a terrific trick. Next time I have a children's party, could you come along and demonstrate it. It is magic, is it?' And Bell replied, 'It is not a trick, Mr Mayor, it is a practical device.', and the mayor said, 'Look, I can walk down a corridor.' Bell said, 'No, you are missing the point. With the same device, you could talk to a colleague or friend 50 miles away.' The mayor thought about that and said, 'I don't know anybody 50 miles away.' [*Laughter*]

We cannot predict the future – that is my belief – or at least you cannot predict the short-term future. On every board on which I have ever sat, I have run a little competition and you might like to do this with your own companies. At Christmas, you get everyone sitting round and they make their predictions for the coming year. We would predict things like the company share price, the performance over the coming year. We would do things like the

FTSE level at the year end, the exchange rates, the Bank of England interest rate and so on. There would be a catch-all question about politics and sport. You all put a tenner in the envelope and you open it the next Christmas – and you just realise how wrong you are. Astoundingly. Interestingly, the finance director and the accounting guys were always most wrong, and HR seemed to be the best. Remember, these people are making plans on this basis, and it is enormously difficult to predict the coming year.

We did this at the Institute of Directors and we put it out to members. In 1997 one of the questions was, which event will have the most significant impact for business during the year? It was obvious by half-year – there was foot and mouth, one of these big events which took £6 billion out of the economy and was devastating not just for agriculture but everything that supported it. It was devastating for travel. That was going to be it. But then there was the collapse of Enron, which was pretty big. And then there is 9/11, which makes the rest insignificant. That is the short-term. So you cannot predict the future but you need to understand the changing world if you want to influence it – if you want your products to sell in it, and if you want to solve the relevant problems.

One of the trends we can see very clearly in this changing world – although we cannot see where it is going but it is interesting that it came up so strongly today – is the changing economic balance of the world. With a changing economic balance, there come changes in political influence and, God forbid, military influence – influence generally, and cultural influence. We have always known that, as the world developed, the countries that we have rather patronisingly called ‘the developing economies’ were going to take the low-skilled jobs. With their low cost rates, low overheads and low labour rates, they were going to bash metal and weave cloth more cheaply than we could. Good luck to them – that is their birthright. That was the attitude. That was fine, because we were going to keep the high level jobs, the highly skilled jobs, the intellectual jobs, the value-added jobs. That is a lovely scenario – and totally unrealistic.

Why should a country like China aspire to be the world’s supplier of cheap labour? If you look at what is happening in these countries, they are putting an enormous amount into research. They have bought up high tech industries, and they have indigenous design capability. A quote that James Dyson comes up with, which was given to him by a minister from China, looking through a whole group of pictures, was, ‘I do not want all these super products with ‘made in China’ on the bottom; I want them to be labelled, ‘*designed* and made in China’.

Believe me, this is not just a threat to manufacturing. In my career, I have headed up big manufacturing organisations and big service organisations, and it is usually easier to

move services than to move factories. There is no aspect of the economy that can be isolated from this. This also has great opportunity, if you can seize it. Through these vigorous economies, the world is going to develop enormous markets, and it will develop enormous wealth. However, to seize that opportunity, you have to ask, what do you offer that is special? It cannot be cheaper. What do we offer?

The good news in this scenario is that we have a terrific record as a nation of inventiveness and creativity. If you look at our record of scientific achievement, discovery and progress, it is remarkable. You do not have to go back just to the jet engine and radar – despite comparative under-investment in research, we have a fantastic record of achievement, and this goes through to today. If you look at our creative industries, they are acknowledged world leaders in architecture, fashion, product design and many aspects of the media. They are world leaders.

If you look at individuals, there is the Internet and Tim Berners-Lee, or if you look at the product that has probably had the most dramatic effect on a company's fortunes in recent times, if not ever, there is the iPod. That was designed by Jonathan Ive, who is as British as you can get – he lives in California but he is *British* and he has terrific skills. So you could say that, in this world, where we have terrific rates of technological advance, and a huge appetite for new solutions and new ideas, that is a pretty good suit to have.

The bad news is our record on exploiting and taking advantage of those skills. Even in the industry like information technology, where I can name tremendous Brits and companies, where are our Googles, our Microsofts and our Dells? Why are we not developing companies like that? Don't tell me that it is because of the size of the market, because Nokia did not become a global supplier of mobile phones on the basis of its local market. Why? What is stopping us?

I have banged on about this. I was banging on about it last year, just before the budget. I was at the Treasury giving some views on things I would like to see in the budget and I was going on about this. They asked why we have this situation and what could be done about it. I told them they had to look at it. I have often wondered how government reports are triggered off, and now I know. After I said they ought to look at it, the next day I received an email which was the terms of reference for a review – that was good. And it was headed 'the Cox Review', which was not what we had discussed! I decided not to argue about that because the main point was to get the review underway.

I went through it and suggested that they should focus it down a little because it was too broad. For example, they should exclude the top companies because the FTSE would not be influenced by a report. They should concentrate on the companies with potential

below that – because there is a whole raft of companies with potential that they just do not realise. I said we needed to tighten it up, and change the words. And they said, ‘We have to change the words by two o’clock’. Why? Because it was in the Budget Statement at two o’clock, and that was it. That was the review that I did.

What I look for in a review is that the issues that you have to address should be fairly clear. They are concerned with understanding and they are concerned with appetite for risk. They are concerned with knowing where to turn for guidance, and seeing the potential. Those are the kinds of things by which small companies are held back. I therefore looked for ideas that would make a difference. There are plenty of good ideas, but you ask whether they will have a national impact. I was looking for things which, if implemented effectively, could have a real impact. Secondly, I was not looking for the one big idea, the big wheeze. I also was not going to recommend an innovation czar, or an award.

I came up with five recommendations. One was to change the whole climate of the one area of government incentive for innovation – the financial incentive – which was the R&D tax credits. That was a terrific scheme, but badly applied. My view was summed up by the fact that the Inland Revenue had to start viewing the scheme as an incentive scheme to be promoted, rather than as an avoidance scheme to be policed. I recommended a number of changes to it.

The second idea I came up with was to roll out a programme which a number of the RDAs and the Design Council had been pioneering, called the Design for Business programme. This was designed to expose smaller companies to professional design skills and those that had the potential opportunity to take them through and see them in effect. There were great case studies coming out of that – terrific case studies from all sorts of companies. My view was that if you could roll this out on a wider scale, you could have a real impact – you could get away from case studies, to real impact. The recommendation was that we found a way of rolling it out to 6,000 companies over five years. Six thousand companies does not necessarily change the economy but I have found in my career, particularly with the Institute of Directors, that nothing influences a small company more than the performance of the small company up the road. What they will listen to via megaphone from Centre Point or Pall Mall or Whitehall is very limited. We have therefore recommended rolling this programme out.

Another way was to put in place a number of centres – one in London – which brought together many design innovation facilities in a single location, to give it real visibility.

A fourth was to tackle the whole area of government procurement – public sector procurement – which militates heavily against innovation. I am sure that many of you here

have bid for government contracts, and you often find yourselves responding to an over-specification of the wrong problem, to which you have to come up with the cheapest solution. That is important, because I believe that there is no problem in society that the government faces, which will be resolved by throwing more resource at it. You cannot do it: you just cannot solve the problems of health with more nurses. You cannot just put more money into it, but it needs innovative thinking and new approaches. The whole attitude of public sector procurement, from top to bottom, militates against taking a new approach, taking the risk of a new approach. I made some hard recommendations there.

The final one was concerned with education and I focused on higher education. I felt that part of the problem was that we were educating our specialists – whether they be in technology, science, engineering, business or the creative arts – in too much of a silo-ed fashion. We were turning out people – engineers – who did not understand business or design, and were lacking in communication skills. We were turning out scientists with the same issues, and we were turning out business people who did not understand how you actually managed creativity. Our creative arts schools were doing a fine job turning out people who had no idea of the world in which they would have to apply their skills. That is rather harsh and I can show examples which do not support that, and which show what people are doing but, by and large, those were my concerns. As we saw earlier, unless you have a broad understanding of what is happening, and can work with other skills, you cannot rely on specialist skills.

Those were my five areas of recommendations. The report came out a year ago and it was well received. The Chancellor endorsed it, which was a good start. Interestingly, however, if you think of those recommendations, there is little that government can do about them. The Government cannot tell universities what to teach, nor can it tell the RDAs how to spend their money. One has therefore had to do a good deal of work since then, trying to turn the good reaction I received into positive action.

We have been making good progress. Interestingly, in the one where the Government could take action, it did. The HMRC, as it now is, acted on the R&D tax credit recommendations. They set up special units to deal with R&D claims, so that you did not get your average tax inspector who might get a claim once a year, having no idea what research was, or what might qualify.

They have also announced in the budget recently that they will double the size of companies who can have the full benefit of the scheme from 250 to 500 employees. There is a recent ruling which you may have seen, where Nissan's design centre in this country has

been able to claim back under R&D tax credits a fair amount of what it puts into design. That is very significant. I was enormously impressed with the reaction there.

The programme to roll out the Design for Business Programme has been supported by the RDAs, who have put a good deal of money behind the plans. They will be announcing in the next month the plan to roll that out nationwide. I was speaking to the Deputy First Minister in Scotland the week before last about taking this programme to Scotland.

In government procurement, there is a great deal of work going on. Lord Hollick is working on this, and it is big culture change – it is the toughest one to change. With regard to the centres, the London Development Agency has commissioned a feasibility study which is now in its second stage, looking at a London hub for these innovation centres around the country.

With regard to education, I have been delighted by the reaction from the universities. I know that a number of bids have been put in to become what I said was half a dozen centres of excellence, bringing together business students, design students and engineering students, into a common programme or module. I am quite pleased with what has happened in the intervening year.

The report does not change the world and I recognise that. All one is trying to do, however, is to push a process which will have to happen anyway. Companies that do not respond to a changed world really will not survive anyway. It is better to move before one learns the harsh lessons of competition.

I believe that technology in engineering has never been so important. The ability to innovate will be absolutely a part of economic success, not just for individual companies but for the nation.

It is also about solving the problems in society. Whether you talk about energy, or about health, or about waste, it is a question of finding innovative solutions. An engineering career should seem more exciting than ever. It is about solving problems – big problems, challenging ones – but we are not getting that across to young people, nor indeed to society, and it is a tragedy that more young people do not see engineering as an exciting career. It is not just a career, but it is possibly also a basis for other careers. Perhaps that is where we go wrong – perhaps people feel that, if they choose engineering at 15, they are committing themselves to a career. That does not happen with law – most people who read law at university do not become lawyers, but that does not worry the legal profession.

Most of my time is now spent on the boards of financial institutions and the like, and government bodies, but I have never regretted studying engineering. It has given me an

excellent grounding. I have a meeting on Friday with the Chief Executive of the New York Stock Exchange, John Thain. Before he took over, he was the head of Goldman Sachs, one of the glitziest jobs in the whole financial community. He is not a banker: he is an engineer and I am sure that he feels, as I do, that the ability to solve problems, be numerate and understand the fiscal world, is a terrific grounding for other things.

We face a real challenge. I have had excellent discussions with the Royal Academy on this whole theme. We have a terrific and exciting challenge to bring the teaching of engineering much closer to the business and the engineering world. There is a great deal to be done in turning out engineers who have a much better understanding of the world in which they operate.

Those are some personal views and I hope very much they will help and contribute to the discussions that we will have later today and tomorrow. Thank you very much for your attention. [*Applause*]

Hugh Norie: Thank you very much for giving us a fascinating view of the field as it really now is, and what is happening – at least in parts of government, and how it is affecting them and how they are thinking. You will have the chance to ask Sir George some questions later, but I would now like to introduce Professor John Roulston – except that he asked me not to introduce him because he would like to introduce himself. I will just guarantee that, if he misses out any nice bits about himself, I will fill those in at the end.

KEYNOTE PRESENTATION (2)

THE HIGH TECHNOLOGY CHALLENGE AN INDUSTRY VIEW – SLIGHTLY UPDATED

Professor John Roulston, OBE, FEng, FRSE, FIET, CEng

Ladies and gentlemen, I am very pleased to have an opportunity to talk to you on a subject which, you may judge, comes from the gut, the heart and the head all at the same time. This is a slight revision of a talk that I gave in March, when the Royal Academy held a symposium with a launch of the Henley report. I have made a few slight updates.

Background

Let me start with a comment about background, because I shall be saying some opinionated things. I know that they are opinionated and therefore you need to understand a little about the background that has generated these. This is a personal view parading as an industry view. There is no such thing as an industry view, and every view is really personal.

I spent 35 years in defence technology, largely in electronics, and I came into it to be in high-tech, and I exited at a time when, in fact, it had been overtaken in technology terms by communication electronics. I have a good deal of international experience, working on projects that develop complex things that would be too expensive for one nation to develop on their own. I have had to learn the hard skills of melding international engineering teams together, in order to achieve complex objectives.

I had 35 years of that and then decided that I wanted to try to work at a different level – a management level – and I think had two years in Filtronic, at which point my differences with the Board became so acute that I decided that I should work on my own and be answerable to no one else. For the past year, I have been working as an international engineer. Most of my earning is abroad and I am finding this is a very stimulating thing to do, towards the end of an engineering career, to come back to design and to be using the skillset that I started my engineering with.

Outside of professional engineering, I try to take a strong local social interest in engineering education. I chair the engineering policy group for the IET in Scotland and I am involved in many things that are connected with education and with trying to promote education among the youth community in Scotland. I will come back to that at the end of my talk.

Comment on the “Henley Study”

Let me move to a comment on the Henley study, because this talk was from the Henley study. In the high technology sector, the issues dealt with are probably more acutely felt that across the engineering remit generally. High technology has more acute difficulties with education and with the quality of the graduate stock which universities are producing.

The study did not produce any really new and radical information but it gave us a very important update – a good calibration point – and perhaps we have some solid ground to stand on. That is very important. It was very important to make that update, because the subject is so emotional. One of the previous speakers discounted education on the basis that we are all too emotionally connected to it, and the Henley study is a way of taking emotion out of calibrating the subject. From that point of view, I have to applaud it. As an

industrialist, I felt it contributed greatly. I am working more and more with SMEs and I think it dealt with the SME issue particularly well. It is, indeed, something that most people in industry would applaud.

Following that, the Royal Academy asked the universities to comment on the industry view, and that in itself has also been very interesting – although it is still somewhat embryonic. It is not a completed and mature view yet. In the small amount of feedback that I have seen, I have found some evidence of insularity, and there is some concern that some people in universities might sacrifice fundamental fundamentals of engineering education in order to increase the scope of education. I hope this is a topic that we will be able to debate over the next day or so, because we have to deal with an increasing scope – but how do we protect the fundamentals while including the increased scope? It is very difficult to do that. The Europeans have extended the time in order to be able to do that and perhaps they are on the right track – it is a controversial matter. I bring that to your attention and I hope that it is something that we can debate.

Positioning of high-tech industry in the UK

A previous speaker mentioned the positioning of the industry in the UK in global terms. We do not have a Nokia, a Siemens or an Ericsson and it is true to say that we have been as innovative as any of those companies. We have lost Marconi, by and large. Thank goodness Rolls Royce is still doing very good things in manufacturing and design and thank goodness that BAE Systems at Loughborough are doing good things in systems engineering. Also, thank goodness that many of the multinationals that we have are very responsible companies and that they demonstrate first class initiatives in education. I point to the Oracle Academy of one example of that, and I have had the privilege to work with them recently.

By and large in the UK, however, our economy in technology terms is one of small firms supplying global giants in electronics, in communications, automotive and in advanced materials. All of these small suppliers find the pressure of global markets. I had the experience of being one of those small suppliers when I ran Filtronic, because our major customer was Nokia, or companies like Nokia and Motorola, Nortel, Alcatel and so on. Probably Alcatel will be the giant in that sector.

Fifteen to 20 per cent per annum 'price-down' is a reality if you work in that type of industry, and you have to face it with design improvement and continuing design insertion and design replenishment.

On the manufacturing side, the migration to low-cost manufacturing is not an option, but it is absolutely essential. Increasing levels of product integration is one solution that you may choose and yet those people who purchase from you might decide that that is a threat

to them because it might reduce their purchasing options. However, I see that many UK companies try to improve the economy of their product by integration of the product – by producing more functions, in a smaller material bill while, at the same time, I see the buyers being threatened by that because it means that their options for purchasing from the lower cost economies are diminished. If you work in the technology industry, there is an increasing call on innovation for competitive response, and competition is certainly very severe.

Economic value of low-cost global sourcing

I thought I would quantify for you the economic value of low-cost global sourcing. If you look at a product that is built in Europe then, very typically, 73 per cent of the product will lie in the materials bill and about 27 per cent in the process. If you take that product to China and manufacture it there, then you will save 35 per cent on materials and manpower in China is very cheap and so you will save 86 per cent on the process.

When manufacturing for the cellular communications industry in China, we found that we could put 10 people on the production line in Guangzhou, for the price of one person in Yorkshire. Sometimes, that meant entirely the difference between turning a profit or turning a loss.

There are some overheads in terms of freight by sea, and the hidden cost of freight by sea is the amount of capital that applies. The cost of capital employed for British companies trying to use global manufacturing is extreme and when they succeed at being in business by that route, very often the cost of capital employed comes back to bite them after about six months or so. On sea freight, you tend to have your product on the ocean for about eight weeks, and your product value, if you are talking about a company turning over, say, £250,000, you could have £40 million on the ocean for eight weeks. This really means that the cost of your sea freight is a little more than five per cent. Air freight is 11 per cent, and I imagine that that really is the cost, even if you ship by sea.

VAT in China came in in January 2004 and it is not now unrecoverable. Most companies that move there into new areas tend to have a VAT holiday for a period. Thus, when you look at the cost structure for that type of product – an electronics product manufactured in China – it has 86 per cent materials cost and seven per cent process. This gives you a saving overall of 45 per cent but there just is no decision to make to do it. Until now, it has effectively been a dollar-based economy. Everyone feels that the Chinese government is not so irresponsible as to change that rapidly. Obviously, you have to have an international currency at some stage, so that it will change in small increments. For reasonable planning periods, however, you can count on a dollar linkage.

Globalisation progress pattern - example

'Made in China', 'Designed in China' – absolutely true. I was facing that even a year ago. The path to manufacturing in China is not so short and you do not immediately design and manufacture sophisticated product in an economy like that. You start by testing and packing sub-assembled product and then you move through all of the steps of qualification of indigenous suppliers – and having local material is very important. There is then the full procurement, assembly and test.

Eventually, you stand where I stood a year ago, making decisions as to whether or not you will design in China. The major issue that drives you there is that your customers are designing in China and they want your design team beside their design team – so that you do not really have a choice on that matter either. New product development in China happens a few years after you start to manufacture there. I do not have experience in India but I suspect that it is much the same.

There is significant technology leakage in doing all of that. You do not protect your product. You can protect it for a short time but you find that all the techniques that you have hard won and which have made you a leader – and sometimes made you a global leader – eventually get into the hands of competitors who may be in a better subsidised position than you are. They may take your market in a way which you would consider unfair, but nothing in the business world is fair or unfair – it is just a reality that you have to face. Your customers will help your competitors, no question, because it is in the interests of your customers to help your competitors. No matter how good the relationship you have with them, that is what their purchasing departments are hired to do.

That drives you, as a British company, towards increasingly sophisticated product, with higher technology content and with more invisible content. You try to embed software and algorithmic knowledge, and migrate your product to a more service-based activity where you can. We saw the graph showing 15 years to a service economy.

The demand is for higher skill and greater sophistication from your staff in order to do that, so that you are calling for more and more skill on the part of your workforce. Their communicating ability, their interpersonal skill and their language ability become extremely important. By that, I do not mean their language ability insomuch as it is their ability to speak a foreign language, but it is very often their ability to understand how difficult it is for a foreign person to speak their language. That is where I find major failings in staff that we have had to employ in the international market place.

The fundamentals of the product science are important to you because it drives your cost reduction and it helps you to keep a competitive edge. I strongly and passionately

believe that the physics and the mathematics behind the product is something which can help you to control the product for a long time, which is very important. It helps the migration and the expansion of the product perimeter in the most fundamental way. It feeds the innovation and entrepreneurship. Cross-discipline is so important that every one of your engineers has to become an entrepreneur and a business developer at the same time when you are in the competitive global market place.

You cannot allow your engineers to adopt the posture that I saw when I came into engineering, as I came into the defence industry, to be a high technology engineer. I felt that there was an impurity in management in my first few years in the defence industry – I simply wanted to do science and to do electronics, but you cannot let your engineers do that at all, or you will certainly be a loser if you do. They have to sell for your company, and spot development opportunities for your company.

What is important for graduate engineers in addition to their engineering specialisation?

What is important for graduate engineers, in addition to their good engineering? I was a little hurt by a comment which I saw, coming back from the universities, which said that we should recognise that we have had enough of the ‘Victorian mathematical modelling school’. I absolutely repudiate that – I do not believe that you can have enough of the Victorian mathematical modelling school. We have to have a very strong model behind everything we do. Time to market is so short that we have to cut out the experimental stages and we have to cut out the design iterations. If we did not have the strongest mathematical modelling behind what we do, then we absolutely cannot do that. The days of empirical engineering were over a long time ago.

I believe that things that hurt your head, like algebra, basic calculus, trigonometry and so on, have become diluted over the years in both the schools’ syllabus and in the university syllabus. I really hoist my flag when it comes to deciding whether we trade the fundamentals of engineering against the scope of engineering, and I say absolutely no. If we have to expand the time needed to train our engineers then that is what we need to do.

It is the same with classical physics. An engineer cannot be an engineer without understanding how things work – without understanding the basic formulae and the range of application, and the best understanding that we have of the way the world works in physical terms. That is very important.

I mentioned the English language. We are very privileged to be born speaking it but we forget how difficult it is for other people to speak it when they were not born with it – and

yet we have to co-operate with those people because so many of the opportunities for British engineering, going forward, are international opportunities.

I had to take the almost embarrassing step in one large company for which I worked, to employ a local college of education to come in and run night classes, to teach engineers to write simple English, and to do simple reports in English. I found that that college was wonderfully equipped to do that: they knew nothing about engineering but, by goodness, they were equipped to teach my engineers to write.

The biggest fault which I wanted them to eliminate was the use of jargon, where engineers would use colloquial English and jargon for emphasis. By about three o'clock in the afternoon, they would cause terrible confusion when their peer German counterparts had been speaking a foreign language since nine in the morning and were in a state of fatigue. They simply did not understand the nuances of the colourful language that they were hearing. With their anxieties about whether it was 'yes or no', they always came to the wrong conclusion. Very often, you dealt with foreign engineers who could not take yes for an answer, and carried a controversial 'no', and reported that back home. Then you would have to go on to an aeroplane and meet their senior management and untangle it, and I have spent a good part of my time doing that.

Engineers also need a grounding in engineering professionalism, in product safety and ethics, and in professional responsibility. This is something that we need to give them formally within their courses. I would like to see them have a basic understanding of commerce, finance and a little bit of business law – not that we overload them with the nuances of intellectual property protection, but we give them at least the fundamentals of understanding what a non-disclosure agreement is, what confidentiality is, and how to communicate responsibly within a business situation as well as a technical situation. These are the wishes of someone who had tried to do engineering in British industry.

High technology industry's major concerns

The major concern is definitely winning the future. This depends on product excellence, and this depends tremendously on people who can create excellence and who can lead in a creative environment. As a society, we have to understand that – so it is a social mantra. We have to invest in those people.

Today, commodity technology is so accessible to everyone that it has banished the hobby technology which brought many of us older people into the industry. Many of us had to build our hifis in order to enjoy our music but, today, these things are so cheap as a result of commodity electronics, that it has destroyed a good deal of the intrigue. I hear my peer group, all over the world, talking about how sad it is to learn that youngsters do not

understand how things work – how a television remote control works, or how a CD player works. I have heard engineers of all nationalities lament the fact that the youth does not understand the way things work. We need to teach them how things work.

The real problem that I see – and I see it very strongly in Scotland, and Scotland depends a good deal on high tech industry – is that bright youngsters do not want to follow the scientific path. At a very early stage, they may make a decision which locks them out of a scientific education. The problem is the perception of the work – that they feel that the work is not good enough. A good deal of their influence comes from the society around them, and a good deal from their parents. It is not so much that 14-year old that you have to convince, as the parents of the 14-year old that you have to convince. No matter how good a job the universities do, the good raw material flow is necessary to provide the entrepreneurial and the innovative engineers that we need.

I therefore suggest that we should focus on parental perception and on trying to do everything we can do as an academy, to emphasise the social value and to improve the public perception of engineering. We should also look for media assistance in doing that, because the media is so powerful. Frankly, the media does not care very much what message it delivers, as long as it is being paid to deliver it. If we, in professional institutions, can collar the attention of the media and make them understand that it is worth their while to deliver our message for the social benefit of engineering, then I am absolutely sure they will do that.

In a technology-based industry, wealth comes from innovation

In a technology-based industry, innovation is very important. The best studies of innovation would recognise four steps in innovation that are distinct steps, but which very often are seriously mixed up.

The first step is intellectual, and it nearly always is the province of the individual mind. I have very often heard it said that you cannot teach design, or that the individuality is so important to innovation that it is not something that you can handle by process. In fact, the individual contribution to innovation is the intellectual contribution and this happens at a very early stage – it has almost fallen away from the commercial innovation that we want to exploit as industrialists.

I feel that the intellectual climate changes as a result of someone inventing a theorem or understanding something fundamental about how the world works, and there is then the technical interpretation of that and the materials and techniques for exploitation must exist. At home, on my bookshelf, I have the 28 volumes of the MIT Radiation Laboratory Series, that were published in 1949 – a year after I was born. These have been my greatest assets

throughout a career in radar because, during the war, the MIT developed the radiation laboratory with some of the greatest minds in the US, when Britain was greatly stretched. After the war, they had the foresight to publish it all in 28 volumes. A large part of my innovation, throughout my career, has been in going to those 28 volumes and finding where the technology now allowed me to make another breakthrough, or to produce another product.

Frankly, I am doing that today in rolling out projects, which is going back to radiation in a conductive medium, and looking at what I can squeeze out, what I can eke out of electromagnetic propagation under water, because I happen to believe that a little electromagnetic propagation under water is now very necessary, and that the technology has come of age to do it with advanced digital processing. That is largely the path of innovation – it is not the intellectual part but it is the technical part.

Then there is the social environment that has to support it, where the idea passes from the intellectual to the artisan. If you look back in history, you find many examples there where there have been social constructs that have prevented that from happening. We can see that social hierarchies have held, for example, the Eastern world back for a very long time and, as those are diminishing, we may expect their potency to be unleashed.

Then, of course, there is the economic benefit. Occasionally, as I did yesterday at King's Cross station, I buy a copy of the *New Scientist*, but it never fails to embarrass me to turn to the appointments pages of that and to look at the miserable salaries which we are offering for highly scientifically educated people in this society. That is a great barrier to our success as innovators and as continued industrialists.

I said that in the UK we are not alone in our concerns about quality and quantity of engineering graduates. We have problems with both quality and quantity. I try to make my living today as an international engineer and I hear views all over the world – in Germany, Italy and France, and surprisingly in Israel where I am working a good deal at the moment, and in the USA, and even today in Singapore. I see better conditions in Australia and Scandinavia and actually in Ireland, because they have tampered less with what was a proven educational system.

We have enormous sympathy for these views all throughout the technical community in this country, that they are not co-ordinated. That is where the professional institutions come to play, to come to help to pull some of that sympathy and empathy together in a much more co-ordinated way. I will choose my words carefully to say this but I have found in my interactions with many people who basically are public servants and who are charged with assisting this, that they actually find the enthusiasm of these people who want to help them

to be a threat. That is a major barrier in the regions, when independent engineers want to assist, for example, with investment policy in the regions.

Those people who are professionally charged with creating those policies often find it threatening to meet people who are experienced, knowledgeable, and actually do not have a political agenda – they only have a logical agenda and they inhabit a logical environment rather than a political one. All of our public servants inhabit a political environment and there is such a world of difference between operating in a logical environment and operating in a political environment.

I have said a few serious things and I have a few minutes left. I will finish with a little entertainment. I will take a minute to give you some background and then I will play a movie clip. A group of engineers in Edinburgh wanted to do something to put engineering on the map with young people. I was fortunate enough to be in their midst and we sat around the table and asked what we could do. One bright spark said that we could win the *Robot Wars*. We all thought that was an extremely good idea, although not so easy. We spent the next few hours, and then over a period of weeks and months we met occasionally to come up with the ideas that would do it.

We started with rather simple Newtonian mechanics and worked out how we could make a machine that could dispose of other machines – and it did that. In fact, it has considerable international presence today. Later on, one of our number published a book describing exactly how it was built because he felt that, once you have done it, you have done it, and there was not any great kudos in staying at the top – he wanted to bring other people there and show them how we had done it. So, behind this little clip, and behind the success of this robot in *Robot Wars*, there is also a book which I tried to inspire, although it rather departed from my vision – as many books do. I thought it might be good for applied maths and physics teachers to use this book as a set of examples for their teaching but in fact it turned out to be more of an electronics and mechanics manual. Nonetheless, I know that it has given people a good deal of fun.

Here is an example of how you can use the media. [*Plays video*] That is the power of angular momentum – we made a big gyroscope, and that is quite a powerful weapon. It could go through a brick wall and the amount of energy it contains is enormous. I will not bore you with the detail but I tried to make my point that we needed to capture the media – we needed to capture the attention of parents and children. This one was particularly good. I am no longer a member of that group but those people have gone on to do some other very good things.

Thank you very much for your attention. [*Applause*]

Hugh Norie: Thank you very much indeed. We will just take a few questions

QUESTIONS & ANSWERS

Barry Mould (Brighton University): How do we make engineering 'cool'? For the youngsters I know, you have to have the 'cool'. It does not matter how intellectual you are, unless your peers consider you to be cool, or your girlfriend or boyfriend considers you to be cool, you will not do. How do we make it cool?

John Roulston: How do we make engineering cool? I suppose you look for those topical things that are in the news, to which you can attach engineering. Engineering is so all-pervasive and it has been going around for such a very long time that it is taken for granted. I suppose that you would consciously try to look for topics that are exciting the public and then try to articulate the engineering value that is resident within them.

For example, if engineers could do something that prevented you taking off your shoes and your belt at Heathrow airport, you would probably consider that to be cool engineering. Therefore, you take the topics of the day and you try to distil, against those topics, the value that engineering might contribute – either that which is currently resident, or which you can add. That is one thought.

Sir George Cox: It is a complex and many-faceted issue, with no simple answer. It is partly also a matter of getting to those who influence children – the school teachers. I heard a horror story from the Chief Executive of British Aerospace, with a party of children going around Wharton. He went up to them and spoke to the teacher and said, 'I'm glad that you have come to look round here', and she replied, 'Yes, I want them to see where they will have to work if they do not study hard!'

Something that perplexes me is that we lose it. I have two young daughters, aged nine and 11. What they do in their technology lessons at school is very exciting compared with what I did at their age. It is terrific, and they are thrilled by it. However, you know that by the time they come to make a career choice later on, that will be squeezed out of them. We are losing the excitement – even though we create it now in primary education and the first years of secondary education.

Part of it, too, is not trying to convince people in their teens to go for a career in education [*sic*]. As I touched on earlier, I think people often are not ready for a career

choice. Most people going to university now do not make a career choice before they go – yes, they do if they are studying medicine, but most do not. So to suggest to someone aged 15 that they should opt to become an engineer is asking a lot, and you will only get the dedicated few. I would rather that we concentrated on letting them see that studying engineering is good fun and it is exciting. It is an exciting topic, particularly if we broaden it.

Many people stay in engineering, and many will go out of engineering but they will understand the discipline – which is also a great advantage to us. Part of it is getting people not to say, ‘this is what a career means to you’, but that this is a really exciting topic to study beyond that. That is part of it.

Hugh Norie: The concept of cool is also a concept almost purely of fashion and, like most fashions, one hopes it will change. It can be very destructive, and I have seen it in school children too – it is basically not doing the sensible thing which actually progresses you, but it is cool to be seen hanging out, being lazy, getting into trouble and all the rest of it. It is extremely difficult to know how you deal with that, except that it must surely change as people realise that they have to have a future if they are going to survive.

Sir George Cox: Could I just come back on that point. There is another facet to this, which we can perhaps touch on now and discuss further as the day goes on. It would help if they had some role models. It was interesting how Brunel was rated but then if you talk about a current engineer, the only role model to which youngsters would aspire – and I am pleased that he is doing so much to encourage young people – is Dyson. He certainly does not suffer from lack of reward. If people say that this sort of career could lead to being a multimillionaire, I would not mind too much of that. It is interesting, however, that Dyson never studied engineering – he studied at the Royal College of Art. We need a few more role models.

Hugh Norie: I think the Academy has been very aware of this and it is looking very strongly to find and promote role models. It devotes a good deal of time, at the higher policy levels, to thinking about how to do this. I do not think they have got there, yet. Barry, if you have any more suggestions about how to do it, from experience, that would be good.

Roger Venables (Crane Environmental): I am Visiting Professor in Sustainable Development at Queen’s, Belfast.

If I may answer the first question, I used to play the cello and that was seriously uncool – until the Beatles started using cellos as backing instruments, when suddenly it

became extremely cool. I would therefore support the idea of role models finding ways of introducing engineering into the things that other people see.

My question – surprise, surprise! – is about the environment and sustainability. Please forgive me, John, but I was extremely surprised that your list of things that you thought graduate engineers needed to know omitted to mention anything about environmental knowledge and awareness, or sustainability knowledge and awareness. I wondered whether you could comment on that.

The second question, to both of you, is about the potential for dramatically increasing adverse environmental impact as a result of moving production of manufactured goods from Western economies to non-Western economies.

Hugh Norie: Could you just give us the first part of that question once again for John?

Roger Venables: The first part, John, was that your slide of skills that you expected graduate engineers to have omitted to mention environmental awareness and environmental knowledge and sustainability. I would welcome your view on how important you think that is.

John Roulston: Well, of course, it is a 'cool' topic. You expect that a professional engineer – and we have to emphasise that you want your engineers to have a strong social awareness as part of their professional training – undoubtedly should appreciate that their skillset can contribute to the solution of environmental problems. There is a good deal of education to be done, which can be led by engineers, which can help society to understand that technology brings problems but it also brings solutions in its wake.

I remember very well – and some of the audience might also remember – that a long time ago, in the early 1970s, Jacob Bronowski, in his *Ascent of Man* lectures, pointed out the horrors of technology but actually gave us the very strong thought that every time technology created a problem, it also brought the solution to that problem in its wake if we applied it correctly. We have seen that happen many times.

I remember personally the day I understood the concept of a computer virus. It hurt me tremendously because I was enjoying the freedom of the PC, which was allowing me to calculate things that I had never been able to calculate before. The idea of the *evil* of a virus applied to such a useful machine was an affront to me. Then I watched the technology adapt to that and create its own solutions. We should therefore help our engineers to understand that, by being purveyors of technology, they can put themselves in dangerous positions, and

put society in danger, but they can also negate that by responsible application of engineering.

I guess there are few engineering disciplines that do not need to observe environmental impact today. The 'Spaceship Earth' concept is widely publicised and it is very topical, and it is not too difficult to get people to take an interest in that. With our younger engineers, that is really an open door and, if we push on that, I think they want to respond.

Sir George Cox: I think the second part of your question was about the environmental impact of moving manufacturing to other countries. There are a number of downsides to moving it. You move it to countries which, as yet, have lower employment standards; lower safety standards for their own staff, and negative environmental impact in terms of less environmental standards. That is all true, but none of it will stop it: economics will determine where people go. The buying companies, by and large, will not take that into account.

Something you will see, and this is the positive side of it, is that I do not think those standards will lag behind indefinitely. The idea that these people will employ slave labour in dirty factories – I think they will move forward quite quickly. There are a number of influences. These are partly out of self-interest, and partly due to the influence of multinationals, by the way. Multinationals, for all that one says about them, do a huge amount to raise standards around the world and this is therefore a temporary type of issue. I do not think we would get anywhere by saying 'Don't let manufacturing go elsewhere, because it will not be as clean. That will not be a viable defence, any more than you see at present with animal testing: all the work against animal testing here does not end it, but it drives it to places where there are less stringent standards – but that does not stop people campaigning. It is outrageous, really.

John Roulston: I can add a little to that from some experience. It is wrong to think that the Chinese government, for example, do not care for their country. The Chinese government are actually plotting a very strategic path and they have to accept the art of the possible along the way. In early industrialisation in China, they took on board some very dirty industries and they caused a great deal of pollution – and, indeed, much of that is still going on, particularly in the South of China.

If you look at the growth of electronics in China, however, this has been handled very responsibly. I speak from the position of having had 5,000 employees in Guangzhou near Shanghai. I had the experience of moving a silver plating shop – silver plating was very important in my business in making microwave filters, because silver is the only conductor

that matters in a microwave filters. It is only a few microns thick, but it is vital to the operation of the filter. In moving the manufacture of filters to China, we had to set up to plate in China. Initially, there was a perception that it would be pretty easy to do that, but then we had to deal with the Chinese authorities in terms of health and safety. We discovered, in fact, that it was stricter than it was in Yorkshire, and for good reason. I felt significantly better, as a result of that, because the chemicals used in that plating shop always were a worry to me and I was very pleased to know that the standards were extremely good.

With the ingress of the new industries into China, therefore, we need not worry too much about the irresponsibility of the government. They will do what they have to do, in order to gain the social advance that they need, but regulation will come pretty quickly.

Tony Stevens (Loughborough): This question may be too broad, but it troubles me and so I will share it with you. UK plc is trading insolvently and, as far as I can see, the current directors have no viable plan for bringing it back into profit. We need to find £1000 million worth of goods per week that somebody else in the world wants to buy from us, to balance the books. Any ideas, gentlemen?

Sir George Cox: I put most of my ideas in my report! The first point to make here is that we have to be careful about just talking about goods – we have to talk about services as well. The ground between those two is becoming very blurred, by the way.

Tony Stevens: Whenever I mention these figures, people say, ‘What about the invisibles?’ These are Treasury figures including the invisibles.

Sir George Cox: In terms of potential, I think the potential comes together. The sheer fact is that we have to correct that imbalance and we have to do more. Part of it is obviously in getting our industry to be much more enterprising. It is not just a question of innovation, but more of a spirit of vigour and enterprise. A feature that is also impressive about the rising economies, if you go to visit them, is not just what we said earlier about the way they are investing in education, engineers, research and so on, but it is the sheer *vigour* of the place. That is something that you have to correct as well – it is the *enterprise* of the place, and it goes with that as well. Whatever you are doing, it is a matter of getting ambition into companies and thinking of ways forward. That is part of the challenge that we face and it is not just, on the one hand, looking at how we get more technical innovation.

It is a broad issue, but something that gives me encouragement is that there is now a very widespread recognition of the issues. There is a genuine concern about them, certainly in large elements of government. There certainly is in the Treasury, and it is foreseen like

that. As someone touched on earlier, government tends to be driven too much by the short-term but there is an awareness now. In every community that you speak to, whether it is business or academia or government, there is a real recognition of the issues, which is a prerequisite to doing something to about them.

John Roulston: This is a big topic. I suppose what I can add to it is, how do you feel about what you see outside the UK? What I see, particularly in the Far East – and I spend a reasonable amount of time there – is a very strong can-do attitude. I also see that, believe it or not, in Ireland. It seems to be an outgrowth of the Tiger Economy, or a transient Tiger Economy has existed there. There are times when I have felt that there is some similarity between the social attitudes that I see in the Irish economy and what I notice in the Far East, in Korea and in Singapore.

Basically, these people will strive so hard to find a commercial opportunity and to capitalise a commercial opportunity, that there is no limit to the effort that they are prepared to put into it. I am always struck by the can-do attitude in the East.

Mark Fletcher (Arup): I am the Royal Academy Visiting Professor to Bradford University, and I am also a director with Arup.

I took an expression, 'winning the future'. I have experience that, if you really want to relate to and engage our prospective graduates, going forwards, we have used recent graduates and postgraduates who are in work, who can actually give that initial experience of what is happening and how exciting it is. That promotes a positive role model that is much closer to where people are going. That gives a reassuring perspective.

The only other thing I would say is that the role model that I think of, coming up through the media, other than Thomas the Tank Engine, is really Brains in Thunderbirds. There is a real gap there, for us to promote positively. I know that my children are not seeing that being positively promoted in a way that could really enthuse, engage and excite them. Those have to be the sorts of words that we are using. Are there any views on that?

John Roulston: I would endorse that.

Sir George Cox: There are two different kinds of role models. There is the high profile role model, and Dyson is the example. If you are trying to get to young people generally – and I had this with an enterprise programme that we were running at the IOD with the CBI and others – if you want to get to school children locally, then the kind of role model they want is someone who is not that much older than they are. We found people who started businesses and then went back to school when they were in their twenties, and the

schoolchildren thought, 'I could be like him – I'm not going to be a Branson'. You do not realise it but, to young children, Branson is an old fart – to me, he is a young hero, but not to them. However, the guy who parks the flashy car outside the school and talks with excitement about what he has done has a big impact on people. We could make plenty of use of that – people will say, 'Yes, I could be like him in two or three years' time', or 'I could be like her'.

I have seen some terrific role models when I have been a judge on the Year in Industry programme – terrific. I went to one judging competition a couple of years ago. There was a very articulate young lady there, very presentable and very smart, who gave a terrific presentation. I was hugely impressed. Then one of the judges asked her what she had learned most out of the year and she, 'I learned how exciting engineering can be.' I was in love by that point! That was it – it was exciting, she had enjoyed it and it was fun. She had been solving problems and influencing the company – and that is what you have to get across to young people.

There is another avenue, which is a hard one to crack. We commissioned some research to see what influenced young people. Do you know what has a big influence on them? We hear more about the business, but the media has a down on business. They came up with the impact that the media has, by which I do not mean Radio 4 and the *Today Programme*, because you will not influence them anyway, but it is the soaps. We found, for example, that if they were talking about business, every businessman in a soap was crooked. They are all dodgy! If you have a businessman on television it is Arthur Daley or the Trotters, and that is the image. We actually worked and got positive storylines in *Crossroads* and so on – if you could actually get into one of the soaps with a very successful engineering company that was having a lot of fun, being successful and doing well, then people would see that. You do not realise what influences young people, but apparently soaps have a huge impact on attitudes.

John Roulston: There is one observation I would like to share with you. Having worked with young people, particularly in mathematics, I find that there is a huge difference between those who come from the urban areas and those from rural areas. Since I live in Scotland, I have plenty of opportunity to meet the people from the rural areas. There are many fewer distractions, particularly at weekends, for young people who live in the Highlands, for example.

A couple of times a year, I run mathematics weekends for schoolchildren and I am always astonished at the difference between the attitudes I find in the children from the central belt and those who come from, let us say, the Moray region near Inverness. It really

has to do with having fewer distractions and, as a result, there is a more old-fashioned attitude to education and to the fundamentals of science. It is amazingly different.

You find it not only in that, but you find, for example, that the rural kids always play musical instruments, while town kids rarely do. The town kids tend to have weekend jobs in order to make money, so that if you organise a weekend activity for them, they have to trade off their loss of income against the value of the activity – but not such trade off exists in the minds of our country brethren. You find therefore that the UK is not homogenous but it is very different across its regions. Surprisingly, when I was in industry, I tended to recruit a good deal from the more far flung parts of the empire, and beneficially so.

Raj Agrawal (University of Bath): My first question is that, since we are very much a part of Europe now, why can we not do something about raising the status of engineers in the UK compared to Germany and France, for example?

Secondly, one of the difficulties that we have with youngsters is that they look upon advancements in technology and problem solving as ‘somebody else’s problem’, and they are merely there to enjoy the technology. That is also a serious problem, namely that there is a lack of curiosity.

John Roulston: I agree with you that the status of the engineer in Germany and France is very high. They take a longer time to train their engineers and there is a social reward for that which is very evident when you work with them.

Germany has a reputation for being the most logical of the European nations, although I would say that that is not true and I would say that France is the most logical of the European nations but they never implement their logic. The Germans are more comfortable in a well-regulated and process-led engineering environment and they tend to miss the best solutions because of that. I have had the privilege of leading a consortium which included German, Spanish and Italian engineers, and their personalities were all very different. Even though the status of engineering was high in all of those countries, I found that the mixture was extremely good in design and innovation. I found that the British engineer tended to lead with his gut, while the Germans would do the calculations and prove him wrong – but he would have a new idea tomorrow. The combination of the European attributes works very well in high-technology engineering.

Coming back to answering the question, I think the difference has something to do with the short-termism of the UK. We are rampantly short-termist. You can see it in almost everything we do. After all, we are going to have the misery now of having to replace the

Forth Road Bridge shortly and I think it is endemic that we do not take the long-term view socially and therefore we do not appreciate what engineers can do for us – because, generally speaking, their impact is longer-term. In Germany, and particularly with reconstruction, you would of course see that there had to be a social anomaly in Germany that led to that, and then the reunification. The particular history of Germany probably merits special study in interpreting that question. However, I agree that the social status is much better, although I do not necessarily agree that they are better engineers.

Hugh Norie: Could I just say that this question is one that British engineers have been asking for a great many years. It is one which, perhaps in 10 years' time, they will not be bothering to ask because status undoubtedly goes with wealth and with personal reward. There is no doubt about that, and that is respected out there – and if you are making a lot of money, you are fine and you are not worrying about status.

As we have all been saying today, we are seeing potentially the movement of technology into centre stage. It will be driving so much in this world now and if we, as engineers, cannot take that opportunity to get ourselves up the social ladder, then we are not as good as we should be. I think we will see real changes.

There has also been a tendency in education in many other subjects rather to decry any form of elitism but, as we see in France, its engineering does so well because it is profoundly elite. In a way, elitism breeds itself, but it also breeds success and leadership. I think we will start to see changes now and I hope that this sad cry will not go on.

Sir George Cox: That really covers the point. Like most people in the audience, I have bemoaned this over the years. It is a problem which has been a long time in the making. When you have attitudes like that, which have been ingrained over the years, you do not change them quickly. However, if we are to raise not just the status of engineers but an appreciation of what engineering is about, then it is down to us. We cannot sit here and think that we are unappreciated and wait for the rest of society to realise it – we have to change the attitudes.

I see the kind of work that the Royal Academy is doing as being key to this but let me tell you that, although it would be very easy to become depressed about these things, I do not. When I was doing my review, I saw so many examples and I thought that if these were the norm, we would be a different nation. I can show you small companies – manufacturing companies – that are doing extremely well and flourishing. I can see programmes at university and think that this could be a model. I see examples everywhere. If you look at my report, if you were to take some of the best examples and roll them out nationally, that has the effect. I can therefore see sufficient signs that give me great hope.

Peter Broughton (University of Oxford): I came here today thinking that I was going to learn about what these other very eminent visiting professors were doing, and that I may learn something from them. However, I have been quite enthused by the debates about something quite different. It seems to me that we have a discussion about what we can do to improve the performance of the UK, improve the status and all these various things.

A comment has been made about the shortfall in the UK economy of about £1000 million a week. By sheer coincidence, I was reading the papers the other day about the Norwegian economy – can you guess what they are making, which goes into the economy, from the oil industry alone? It is \$1000 million per week. Forget what the oil companies are making – their economy is taking in \$1000 million - \$1 billion per week. Someone said that the oil in the North Sea is finished, and it will be if it is left to Mr Chancellor, who has made two big tax hikes on the North Sea, while the Norwegians have not even started their work. The Barents Sea has yet to be started, and our West of Shetlands has yet to be started. But if you are going to address all of these things and put a big environmental/political thing around it, you will never get the job done.

The second topic I want to address is the importance of maths and physics, which was mentioned earlier. We all hear every year how brilliant our children are – they are becoming progressively more intelligent and have better A level results, and we all believe it. None of the leading academics even challenge it. However, when you look at the statistics below, and you look at maths and physics and the A grades, you find that the people who go to the private sector, who make up about seven per cent, achieve something like 60 per cent of the A grades in the so-called hard subjects like maths and physics. So our system is falling short by massive amounts in the state sector. This Academy should say something to the politicians. You have to do something about that because there is a whole swathe of people – you mentioned 14-year olds – who are missing out. They have missed out for ever, and the economy is missing out for ever because of that.

One of the reasons, and I was interested to discuss these political and social issues downstairs, is that the politics will not allow them to pay maths and physics teachers more, to attract the good maths and physics teachers into those schools. Our message to the politicians should be that they must sort it out, before it is too late.

Sir George Cox: Those two observations are very valid indeed. You are absolutely right and this is a message that we have to get across to politicians. Business should be a natural ally in doing this, and the body itself should be an ally in doing this. You are absolutely right and I could not agree more.

There is, of course, also the broader issue of numeracy in the general population. We have to realise that, when we are talking about engineering, we are not just talking about the cream at the top, but you are talking about the continuum of people, right the way around – technicians and all the way down. The standards of numeracy generally among people leaving school are *woeful*. This message has to be got across to government.

John Roulston: Our position in mathematics can best be described by looking at where we are in the International Maths Olympiad. This is a competition for people under the age of 19, who have not started full-time higher education. We are ranked about 23rd. The only point that makes me take some heart is that the US is about 25th. Eastern Europe ranks very highly, and China is right up at the top. I feel that there is a very strong correlation. Very often, when I was interviewing in industry, I would look at maths grades and higher grades, and I would often make my employment decision on those grades, rather than on the interview. I observed a very strong correlation between the productivity of the individual and the grades they were able to attain in those fundamental subjects.

I strongly agree, and I worry that we drink our own bathwater to some extent. Metrication, of course, has that profound trap built into it that, as soon as you start to measure, you perturb. The metrication that we have put into education, while of course having its benefits, also has some dubious benefits. I agree with you that we should be more fundamentalist in our teaching of mathematics, like the Eastern Europeans are.

Hugh Norie: Ladies and gentlemen, I am afraid that we have run out of time and we will have to stop here. Let me thank our two speakers very much. [*Applause*]

- *End of Day One* -