



Prof. Sir Martin Sweeting

Interviewed by

Jane Bird

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Via Zoom

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Welcome to the Archives of Information Technology, where we capture the past and inspire the future. It is Monday, the 10th of January 2022 and we're talking on Zoom has as... as has become customary during the Coronavirus pandemic. I'm Jane Bird, and I have reported on technology and the IT industry for newspapers such as the Sunday Times and the Financial Times since the early 1980s.

Our contributor today, is Professor Sir Martin Sweeting, a science fiction fan, who made his childhood dream of getting into space a reality. Sir Martin is Executive Chairman of Surrey Satellite Technology, a company he set up in 1985, to design and build micro-satellites. SST has pioneered rapid response, low cost, and highly capable small satellites on which much of our modern life depends.

The company was begun with £100 and four employees and sold a quarter of a century later to Airbus, for 50 million pounds. It now has 400 professional staff, annual revenues of more than 100 million dollars, and total export sales in excess of one billion dollars, to 25 countries.

Sir Martin was awarded an OBE in 2002 and won the 2008 Arthur C Clarke, Lifetime Achievement Award. In 2016, he was made an honorary fellow of the Royal Aeronautics Society and listed by the Sunday Times as one of the 500 most influential UK citizens.

Sir Martin, welcome, I have followed your progress since first interviewing you in the 1980s and I am very much looking forward to hearing more about your life, professional experiences, and insights on the future of satellites and space technology. So, to begin at the beginning then, you were born in 1951, in Highgate, I think, in London, erm, and erm, it sounds like, erm, a fairly sort of, er, happy, middle-class kind of upbringing, at the beginning, you have two older brothers I think, and a younger sister. So, how was your early family life, were you-were you, would you remember it with-with warm thoughts?

[00:02:19]

Oh, yes, indeed. A-as you mentioned, I was born in Highgate, sort of near the top of Highgate Hill and could look out over London and you know, see the, you know, how

London developed. But erm, yeah, I-I my early life was very enjoyable, I had-my elder brothers were much older than me, so, it was really my sister and myself that grew up together. Erm, and we were very fortunate in living right next door to an enclosed reservoir, so, it was a bit like almost being in a bit of the countryside in the middle of, er, of London. So, I spent a lot of time out in the garden and things like this, but my earliest recollections, are being still fascinated with communications starting with the traditional way of two baked bean cans and a long piece of string, and er, later, managing to get a-a little bit of a wired, er, sort of telephone. And my sister always complains that it was always her that was sent out into the garden, er, when I sat in the house in order to try and see whether these communication links, er, worked. I-I don't remember it that way, but I'm sure she is probably right.

A-and so, that would have been when I was, I don't know, 5 or 6 and-and playing with, you know, trick trains and so forth. Th-there was something about the ability to communicate beyond the-the-the-the limits of just shouting to somebody that really fascinated me and that started-started me off really in the whole-whole sort of career. Erm, and so, it was a-a very nice childhood, a lot of time outside and also, our parents very much left us to our devices, so, we would construct games, we would make little forts and, er, a-a-and do these other little sort of pseudo-technology things. So, technology was there right from the beginning.

[00:04:06]

And, they-they weren't really a tech family, were they, particularly, your father was, you said, write-wrote poetry and your mother was an artist, so, er, but-but your maternal grandfather, I noticed, he was a mechanic, so, perhaps it was in the genes somewhere.

[00:04:20]

I-I think it must have been because my-my mother as you say was an artist and my father was definitely not an engineer in that sense or a scientist. He was really a literary man, er, that is where his-his interests lay. Erm, but my maternal grandfather as you say, was a mechanic, but my... sorry, my maternal grandfather was a mechanic, but my paternal grandfather was a bit of an, er, a-a sort of an inventor. He-he had lots of you know interesting ideas and he was also a little bit of an entrepreneur

from what I can gather, you know, back in the sort of late Victorian times. Erm, he-he-he had a-a-a-an electric... a windmill at the bottom of the garden to generate electricity back in the 1900s, erm, you know, he-he-he started libraries and-and he-he was clearly an entrepreneur. So, somehow the genes of the entrepreneurial side from my father-father's side and-and possibly the sort of mechanical side from my mother's side, came together in me. And I was really the black sheep of the family, in the sense that my sister is an artist, my mother was an artist, my father was in that way, so, I was-I was very much the odd one out and very much left to my own devices and-and you know, I was left to play with electronics.

[00:05:28]

Well, thank goodness, because it's certainly been a very, er, er, fruitful experience. So, going back to your education then, you went to the local primary school, er, and then you went-you went to prep school and-and-and indeed, boarding school when you were, well, presumably about 13. How-how was your schooling and your early schooling?

[00:05:48]

Well, my, er, primary school was very miserable, erm, my-my [laughs] my mother complained that I, er, you know, it was really very difficult to get me to go to primary school. I-I-I-I have some recollection of it but not much, er, it was a very strict regime and I-it-it didn't suit me terribly well, but erm, I managed to get through it unscathed. I then went to prep school on the South Downs and that was a very interesting, er, place because my mother and my aunt spent some... Decided that it would be good for me to go to boarding school and we get toughened up, I suspect, and, er, they spent quite a bit of time going around various schools and they found this one, which was called Normansal, just outside Seaford, in-in-in Sussex, where they said, compared to all the other schools they went to, the-the children there, the kids seemed really happy. So, they decided to send me there.

This was, as I say, on the-on the-on the South Downs, right on the top, so, it was pretty exposed, erm, and it was a very curious school, which I don't think my parents ever really realised. Because, it had no rules, the-the... In fact, the only rules there were, were that you had to turn up for lessons and after that, you could do whatever

you want and so, we used to get up to all manner of things and-and spent quite a bit of time outside living, you know, sort of in the-in the grounds in little home-made hutches and even made an igloo in the-in the frozen winter of, er, 1964 I think it was, and lived in that. And-and we would get up to all manner of things, we were just basically left to ourselves to improvise, but we had to go to lessons. Everything else was sort of, er, er, yeah, pretty well open season. So, if we didn't turn up for, for meals, that was that, as long as we turned up at some point in the process a-and indeed for the next lessons, it was that. So, it was a-a very interesting, erm, environment which my parents had clearly no idea, but that's why the kids were so happy.

[00:07:49]

Well, that was obviously fostering creativity then, presumably.

[00:07:53]

It-it, without doubt, without doubt, er, we-we dug a deep-a big hole, I don't know quite why, we were thinking of something like the great escape, and, er, you know, we-we sort of dig-dug a big hole in the chalk and-and, er, communications with-with other kids with hoses to... It was a really, really interesting innovative place, and very fortunate my parents found it, although as I said, they-they had absolutely no idea what it like [laughs].

[00:08:19]

Well, many children would have been quite traumatised by being sent away to boarding school at such an early age, I suppose.

[00:08:28]

Yeah, I mean, I went, I'm trying to think when it was I was, I would have been 9 or 10, and I think, initially, yes, it was, it was-it was quite difficult, erm, because as I say, before that, I think I was a bit of a softy and so, it-it was quite-quite, er, quite a lot to adjust and you developed a-a sort of a hard case where you would just sort of block out, you know, the-the difficulties. And in fact, I really didn't, I didn't much like parents coming and visiting because it sort of broke that shell if you like and-and-and it sort of re-awakened, you know, what one might call home-sickness I suppose. So, wh-whilest-whilest you were sort of busy and occupied with everything and-and doing

what you want, that was fine, and-and then, of course, the holidays came and that was good, erm, it was always a little bit tricky at the end of the holidays, to sort of recreate that-that shell. But it does definitely-it does definitely have an impact on you in that way.

[00:09:27]

Yes, in fact, I think, according to my notes, you actually started at that prep school at- in 1958, so, you must have been more like 7 or 8 years old, but erm.

[00:09:37]

Quite likely, yeah, I-I-I forget, er, er, probably, yeah probably nearer, yes, that's probably right.

[00:09:44]

Yeah, so, then you went to boarding-then you went to boarding schools, to senior, a senior boarding school, so, erm, was that a different... That was a presumably much more strictly regimented.

[00:09:54]

That was quite a shock because I went from a boarding school where, as I say, basically, you could do what you wanted as long as you didn't, you know, set fire to the place. Erm, and I went to Aldenham School, er, which actually, you know, I suppose that would have been in 1964 or somewhere like that. It was at the end of the- the time when public schools were, you know, behaving like public schools used to. It was just beginning to-to relax a little bit, but it was certainly the end of that era.

Erm, and so, that was a bit of shock to say the least, because I went from a, er, you know, a pretty well laissez-faire environment to one which was very regimented, although I realise now, compared to some other places, it was also relatively enlightened. [sniff]. And, so, I-I got into lots of trouble because you know, I could never remember that I should be going to do this or should be going to do that at a certain time. Er, and so, I-I found that I-I was forever, erm, having to do small penalties. I did get away without any... Being caught doing anything too terrible, but erm, I was forever missing various things that I should have been doing, and-and it

did take me a while to adjust. But I have to say, er, looking back, it was a much more enlightened public school than some of the others were perhaps at that time.

[00:11:15]

Yeah, and you did A-Levels in physics, chemistry, and maths, so, you obviously had that, er, technical-scientific brain, erm, and presumably, that was encouraged, I mean, were-were there inspirational teachers there who helped you decide on what you wanted to do next?

[00:11:33]

Again, it was a-a sort of curious thing, because actually, my best-performing subjects were English and Latin [coughs] and my w-w-worst was French and it was a very good example of-of how inspirational teachers are-are important because, at prep school, we had the inspirational Latin teacher and the most appalling French teacher. And so, my Latin was sort of pretty well fluent actually, my French was non-existent. And then when I went to-to Aldenham, it swapped round, we had a Latin teacher who-who, with due respect, was pretty hopeless, erm, and a French teacher who was inspirational. And so, yeah, my-my sort of linguistic ability completely swapped round and so, I was able before too long to-to be actually quite fluent in French.

So, my-my sort of best-performing subjects were actually English, French, and Latin but I... My interest was in physics, er, and, er, erm, in the broadest sense and so I did physics and chemistry, erm, and-and mathematics but unfortunately, I-I-I have a very poor memory for details, and chemistry was all about A plus B goes to C with smoke or whatever and I could never remember what those were so, I always had to work out chemistry from very first principles, sort of almost from the atomic level and work up, which meant that it took a long time. So, I eventually, I always got the answer, but, er, everybody else just remembered it and wrote it down whereas I had to go longhand. So, it was quite a... You know, going to physics and chemistry was quite a struggle, and mathematics, I-I never really got enthused by.

So, at the school, they were trying to direct me more towards the arts but I said, no, no, no, I really wanted to do physics. Erm, and physics clicked and I could do physics and did very well in physics, so, I stuck with that.

[00:13:38]

That's interesting, because of course, in the school today, they probably would be much better at enabling you to study a mixture of sciences and arts, but at that time, of course, it was very hard to do, wasn't it? It wasn't really contemplated.

[00:13:51]

No, I mean really, y-y-you did a certain subset of-of subjects and-and to have a mixture, really didn't work. So, I-I was very thankful actually at-at-at-O-Level, you had this broad mix, so, you could do languages as well as the sciences. Er, and when it came to A-Level, I managed to persuade them to let me do the physics, and the maths, and chemistry, erm, and although my, er, er, er, chemistry was not that highly rated, er, it was sufficient [laughs].

[00:14:26]

And er, were... Had you thought about IT, about computing at all at that stage given that you were doing maths as well?

[00:14:34]

Well, I mean, eh, er, computers at that stage, which would have been in 1968-ish I suppose, really didn't exist much and I did manage to er, and I forget how I did, but I somehow made some connections with City University in London who had a computer and they... I somehow managed to wangle myself in, although I had no connections with City University whatsoever, and I hadn't even gone to university at that point. But I managed to wangle my way in to be-to be able to use their computer to do some, er, er, some little experiments. Erm, but these were computers where you had to punch out holes in a card manually, feed the cards in, and then come back a day or two later to find out you had made a spelling mistake and had to do the whole thing again.

[00:15:21]

Mm-hmm.

[00:15:22]

So, you know, it wasn't IT by today's, you wouldn't recognise it by today's standards but-but it was the very, very beginning of that and it sort of, er, caught my imagination again.

[00:15:35]

So, you decided to do electrical and electronic engineering at Guildford?

[00:15:41]

Well, yes, but again, rather curiously, erm, I decided to electrical and electronic engineering and I applied to, erm, er, UMIST, erm, I'm forgetting what it is, er, University of Manchester Institute of Science and Technology, I think it was, which was sort of, The place for electronics in those days. Erm, but I had a schoolfriend, a good schoolfriend, who lived in Guildford, er, and during the summer holidays, after A-Levels and having accepted a position and got-got my accommodation and everything sorted out at UMIST, erm, I went down to... W-we had a week down in Guildford, er, you know, just to muck around and halfway through the week, we were a bit bored, er, and-and we didn't know quite what to do, it was in the summer and he said, "Well, they're just building a new university in town, shall we go and have a look at it?" and I thought, I don't know, that doesn't sound very interesting, but we couldn't find anything else to do so we-we did wander down there.

Erm, and the University of Surrey was just being built, I mean, it was really a building site, and we were wandering around this building site looking in the buildings and seeing what was being done. And somebody came out from a door and said, "Oh, what are you chaps doing?" and I explained that we were just wandering around, I was going up to UMIST and he said, "Oh, dear, you don't want to go there" he said, you know, er, I-I-I know this is, you know, it's not politically correct these days, but he said, "Oh, it's up north, and you know, it'll be cold and miserable. This is a new u-university, brand new, er, why don't you come here instead, it will be much more interesting?" And I looked around and I thought, well, actually there's a point, so, on the spur of the moment, I quit, I agreed, I said, "Yes, okay, I'll do it." and I quit from UMIST, and came to Surrey instead, and-and of course, at that point, as I say, they were really just building the buildings. And it is really interesting to look back because I think that decision which, goodness knows why I made it, but anyway, I

did. That decision was key because as a new university, it had no sort of history, it had no baggage.

And so, later on, as an undergraduate and then a post-graduate, when I wanted to do things, which were a little bit, unusual, shall we say for a university, yeah, they said, “Yeah, okay, no, yeah, let’s give it a go.” Now, had I gone to another more established university, they’d probably, as some of my other friends found, you know, they would say, “Oh, no, no, no, don’t, you know, we don’t do that sort of stuff, you know, get back to your studies.” [sniffs]

[00:18:00]

Mm-hmm. That’s very interesting, so, history might have been quite different if you had gone to Manchester?

[00:18:08]

Oh, I-I-I’m sure it would have done because I don’t think-I don’t think there would have been any chance from talking to some of my school friends who then went to univer... It wasn’t Manchester, but other similar types of universities, who found it very, very difficult to-to-to do anything extracurricular that was a little bit er, off the—out-out of the box, shall we say.

[00:18:31]

Yeah, and so, when you were-when you were using the, erm, er, the punch card, the-the computer in London, was that when you were still in the sixth form, that was before you went to Guildford presumably?

[00:18:42]

Yes, yes.

[00:18:44]

So-so-so, at Guildford, you-you obviously and decided and stayed on to do a PhD, so, what-what was your experience being at Guildford?

[00:18:53]

Well, I-I say, it was a very interesting new university, partly because it grew out of Battersea College of Technology, so, it was a-a-a quite a hands-on approach. Erm, they recruited a lot of new staff primarily from industry, and it prided itself on having very close industry links. But it also happened to have a very strong contingent of Polish technicians and lecturers because it had been the University of Free Poland during the war, erm, Battersea, or whatever. And-and there was this mixture of-of-of actually some very, very, gentlemanly, I can only put it that way, Polish lecturers, and technicians who were always willing to help and quite keen to do something new. Erm, academics who were coming largely from industry, and not a lot of sort of, erm, I-I hate to say it, not sort of er, er, I was going to say toffee-nosed academics, in the sense of, you know, er, academics who were saying, “Oh, no, no, no, no, yeah, we don’t do that just, er, you know, you don’t want to actually make anything, you know, let’s just think about it.” So, it was quite a-a really fertile environment, er, in order to have ideas.

So, when I was an undergraduate, I spent, to be honest, unfortunately, looking back, to be honest, I spent most of my time playing around with radios, radio transmitters, receivers, and tracking, erm, er, making up, er, a erm, satellite tracking equipment to be able to receive signals from the then soviet and American satellites. Now, we receive signals from the satellites every day now, we see them on the news and things like that. But a-at that time, you know, this wasn’t something that individuals actually did much, and erm, so, I spent a lot of time on that, which, you know, and my studies suffered accordingly. Erm, so, er, you know I did, I managed to get my degree but it wasn’t a terribly good one, because I spent all my time actually doing things that I was interested in.

Erm, but I was very, again, very fortunate, in that the head of department, who was a very fearsome character, clearly directly descended from Genghis Khan, erm, he-he-he actually terrified the staff, I mean it would have been completely unacceptable in today’s standards. Nevertheless, he sort of, I don’t know whether he recognised what I was trying to do or whatever, but he very quietly, without me knowing supported the work that we were doing and supported me when I wanted to go on and do research with a-a-a rather, erm, indifferent first degree. He-he stood up and said, “No, no, no,

you know, let's-let's make an exception here." Erm, and so, I was again, very fortunate in-in having somebody there who-who, er, supported me. Even though, I say, at the time, I didn't realise it, of course.

[00:21:45]

Yes. And that was when you had started to get interested in satellites, was it?

[00:21:49]

Yes. I-I guess I'm, you know, I was a child of the Apollo era, I watched you know, Neil Armstrong coming down the ladder when I was you know, just about at university, starting at university, erm, that got me fascinated. There was a film called 2001 A Space Odyssey, that came out around about that time, so, it was very much a-a you know, a space era in the-in the late 60s and early 70s. And so, my fascination with amateur radio, which had started at Aldenham School, erm, and had been actually very much, er, helped by the time I spent in the, er, er, cadet force. [sniffs] I was-I was really not very good at marching up and down and all that sort of stuff, but I-I really did enjoy and learned an awful lot with the military on radio communications. So, when I got to university, that sort of communications background, the space thing all came together, and so, that's when we started getting interested in-in space and satellites.

[00:22:49]

And of course, these... A new Sinclair type of personal computers had begun to appear, which, erm, you clearly saw that that was an opportunity in terms of er, being able to use, erm, much cheaper, widely available components.

[00:23:02]

Yes, it was... We started just before the sort of Sinclair ZX Spectrum type computers appeared, erm, but the very first microcomputer, or, er, yeah, microprocessors, they weren't really microcomputers quite then, er, appeared. And w-w-what that seemed to me was, I couldn't, I wanted to go into... I wanted to get involved in space, I couldn't be an astronaut, because astronauts tended to either come from the Soviet Union or from America and-and I couldn't see a way to do that. So, thought the next best thing would be to see if we could build a satellite, and this, these new

microelectronics, terribly crude by today's standards. I can remember being given a four-function calculator and thinking how wonderful that was. Erm, and these, this microelectronics, gave me the concept that you could build a satellite, using these components and make it much smaller, erm, much cheaper, erm, and yet, actually quite capable, again, by the standards of the day. And using the micro controls, the microprocessors, you could re... Potentially, reprogramme it in orbit and, er, you know, so, you could adjust as you went along, so to speak.

And so, it was-it was just at the very beginning when these consumer microelectronics were beginning to emerge, which allowed me to get into space on a budget and on-on a scale which was feasible in a university lab.

[00:24:31]

And that-that was the basis of your doctorate, was it, your PhD?

[00:24:36]

Oh, no, nothing to do with that. [laughs]

[00:24:39]

So, what-which came first then, how did-how did these-these things evolve?

[00:24:43]

Well, erm, because I've always been fascinated with radio, erm, and radio transmissions and being a radio amateur, you know, for a long time and then during the time I spent in the-with the signals, in-in, with the-with the army. Erm, I was really interested in how aerials, antennas worked, and so, I managed to get MEL at, er, which was then a part of Philips, to-to sponsor me to do a PhD studying, erm, er, very short aerials and how to make them work more efficiently because they were inherently very inefficient. So, that was my PhD, it had nothing to do whatsoever with space. In fact, it was very much the other end of-of the whole spectrum. Erm, but then whilst I was working on my PhD, I was then playing, if you like, in my spare time, on the satellite activity, so, these things happened in parallel and erm, you know, somehow, I did manage to complete the work that I needed for my PhD, erm, and-and also, we-we started the ideas of building the first satellite, and that was really

concurrent, although they were totally different; equally fascinating, I have to say, and I still do research on aerals now, erm, so, it's-it's been, er, you know a-a deep interest, but it had-there was no connect-not much connection between the two.

[sniffs]

[00:26:02]

Right, well, I mean, I suppose you need aerals to communicate with satellites or-or, I mean the two--

[00:26:07]

Yes, er, I mean, you're absolutely right, you do, but these were aerals in-in completely the other end, I-I mean, these were short-wave aerals, which were wire, erm, and at-at frequencies, er, very, very frequencies, compared to the satellites, which were very high frequencies. But, er, yes, it was all the same background technology I suppose and-and it was always something that was, you know, it was all communications. And-and anything to do with radio communications, fascinated me then and still does.

[00:26:39]

So, you went then to work for Marconi when, once you got your doctorate, is that right?

[00:26:45]

Er, again, no quite, erm, the sequence was a little different. Erm, as I mentioned, the University of Surrey, was, er, very-had a very strong industrial focus and part of that was the-they, er, sent undergraduates out in their third year of undergraduate, er, to spend a year in industry and then come back for a fourth final year. So, I spent my third year of undergraduate course, working for Marconi Space and Defence in-in, er, North London. Erm, and-and that year, er, er, preceded my-my then final year. But it was a-it was, sorry, it was an interesting experience because, erm, I-I started out working on underwater weapons, erm, and-and-and yeah, it was sort of interesting, erm, but I wasn't terribly good at it, to be honest, it was-it was very—not very exciting. And I got the opportunity after a few, I-I think about a third of the way through the year to change and work for the erm, satellite, er, communications part of

Marconi Space Defence, [sniffs] erm, and that was much more interesting. And-and again, it sort of started to-to-to sort of link together with the other satellite interests that I-I had, erm. One other important thing that it did teach me, nothing to do with the technology is that whilst I was at Marconi, and again, with great respect to all my colleagues around me, I saw people there who had been, who were very technically, absolutely superb, but they had been sitting in their job doing the same thing for like 30 years.

[00:28:22]

Mm-hmm.

[00:28:24]

And I felt somehow th-this was not really what I wanted to do; I didn't really want to... You know, I-I quite liked the work and so on, but it didn't really inspire me to-to go and work for a big company. Er, and again, I-I'm not sure I really thought it through quite like that at the time, but looking back, I think that was subconscious, quite a strong subconscious impact on me.

[00:28:50]

Okay, so, then Surrey Satellite Technology was t, er, ... How did that come about then, you were-you had got-you got your doctorate and then, presumably, you did have to think about a way to earn a living?

[00:29:02]

Well, erm, yes I got a doctorate, and it-I suppose, while I was doing my PhD, I had the idea of building a satellite. I went round and scrounged money and bits and pieces and so forth, to-to-to make it. And then, by the time I had finished my PhD, it was about the year before the launch of the satellite, and-and that was all built with basically volunteer labour. Erm, and, er, it-it was launched and it worked and then-then we said, well, yeah, that was really interesting and NASA came back after one day and said, "Oh, we've... By the way, you know, that-that was a-a success, erm, do you want to launch a second satellite?" and we thought, oh, absolutely. Erm, but the-the bad news they said was, that it had to be ready in-in-in I think it was six months. So, we had to work, again, with our volunteers night and day to-to build the second

satellite, and we did it and it launched and it worked. And then, everybody said, well, it's time to go and get a proper job and I thought, well, yes, but I didn't really fancy going back and working in industry. And in fact, I was offered a-a post at a very, then prestigious, er, government, erm, pseudo-government establishment to go and work for them. Erm, and I had the interview and they came back and said, "Yes, well, yeah, we've thought about it and-and we'll offer you a job." And I thought about it and said, "Well, actually, thank you very much, but no", and I'll, you know, I-I-I'll go and do something else. And I got a phone call from the-the head of that, er, organisation who-who berated me for about five minutes telling me how stupid I was to turn this down, that nobody in-in his... He had never experienced anybody who turned down this job. And I said, well, I'll-I'll give it a go, and if it doesn't work, I'll come back with my tail between my legs and-and, you know, see if he'll still talk to me.

I realised y-y-you can do something like building the satellites with volunteers and scrounged equipment and facilities and everybody's goodwill, you can-you can do it once, you can just about do it twice, but you can't keep on like that, you know, you-you have to sort of put it on a proper basis. And so, we had to try and find somebody who would actually pay for-for what we thought was going to be an interesting project. And then, you know, the university systems weren't really set up for that and so, we decided the best thing to do would be just to set up a company, primarily, in order that we could go out and buy things that we wanted and-and you know, have a sort of financial process which was different from the university financing system, which was, er, er, a bit impenetrable in those days. Erm, so, it was sort of set up in-in order to-to be able to carry on what was, I suppose some people would have considered a bit of a hobby. [sniffs].

[00:31:57]

Well, h-having persuaded satellite, er, NASA to take your satellite into space, not just once, but twice, I mean, that was a-a serious accomplishment, wasn't it? that must have gained you an-an enormous amount of credibility and-and useful contacts.

[00:32:13]

Yes, and-and we had very-very close links with the, erm, the American, er, er, organisation called AMSAT, the Amateur Satellite Corporation, and-and-and they provided the sort of introduction into NASA, er, and helped quite a lot along the way to-to sort of, er, you know. Because NA-NASA had just launched, you know, a man to the moon and then here is this, you know, UK student who comes along, never built a satellite before in his life, erm, and he wants-and wants to launch on one of their rockets, you know, without any money. And I think wh-what appealed to them, is after Apollo, they-they didn't really know what to do, they had had a lot of excitement, you know, Apollo had been a bit of the Wild West and they all suddenly got rather dreary and I-I think some of the personalities at NASA and the-the rocket company, McDonnell Douglas, were missing that excitement. And so, when I came along with what everybody would have considered a pretty hair-brained scheme, they thought, well, yeah, why not, this is something a little bit unusual and-and it will probably give them a bit of entertainment.

So, so, they were very, you know, very kind actually, and-and-and you know, would I have... If I had been in NASA, would I have allowed a student to put a satellite underneath one of my very expensive spacecraft and launch it when the guy didn't know much about satellites? [laughs], I doubt it, so—

[00:33:33]

It could have been quite risky, couldn't it, I mean it could have blown up and, er, er, caused a lot of problems.

[00:33:39]

I'd be hoping it wouldn't have blown up, but bits might have fallen off it or something and caused damage, but er, I mean, yes, er, really, they, yeah, they really took it on board, and, er, were very supportive, much to their cre-much to their credit, I have to say. But of course, what it did do, is it did-it-it did provide the credibility, it did provide contacts, both in the UK and overseas, and so, when, we then did start the company and started to see how to make money to-to pay for more satellites, erm, you know that obviously helped a great deal. I mean it-it-it... Start-ups happen every day, today, but it was a very different thing in-in 1985. Universities didn't have start-ups,

erm, there was no venture capitalist. In fact, when I did talk to venture capitalists I realised the one thing they, which was wrong in their vocabulary was the word venture, you know, er, they-they wanted dead-cert, er, they were dead-cert capitalists. So, we decided to avoid any investments and-and basically grow the company organically, by, er, putting in effort, getting contracts, reinvesting, you know, what small profits we made.

And the whole motivation was, to be honest, again, was not to make a lot of money, you know, my... The objective was to have enough money to eat and to, you know, survive and to build satellites, and you know, if we made a profit, then we used to that develop the next better satellite. Erm, and, you know, it might seem a bit naïve by today's start-up standards, but that was the motivation. So, the motivation at the beginning was not to make a fortune, the motivation was to be... To do something in space.

[00:35:21]

Yeah. So, it-it really was organic growth then was it? You didn't have, erm, you never had investment from, erm, the-the financial or indeed the-the technology community.

[00:35:32]

Er, that's correct, right. I mean, I suppose, we did-we did manage to secure through the university some research grants, er, in the early days, I mean they were very small, but they-they did help us get some of the sort of future ideas a bit. The rest of it was all organic, right the way up, and-and this is fast-forwarding a bit, but the only investor we-we then had, later on, was Elon Musk. Erm, but, er, up until that point, no, it was all organic. And of course, organic growth means you retain control and, but it's slow. And I think one of the things I realised when we did talk to-to some potential investors was that they would, the investors, er, quite understandably, would want us to focus on the things that would make money and return their investments, rather than the things that we thought were good ideas.

[00:36:23]

Mm-hmm.

[00:36:27]

So, that is why I opted for the organic growth so we had the freedom to do what we believed in and to make our own mistakes, and, you know, live or die by them, erm, but you know, the-the decisions were ours and if-and if it went wrong well, we couldn't blame anybody except us. Whereas, when we looked at potential investors, they were always going to constrain us into going down paths which generated, er, that time, you know, the return on their investment, understandably.

[00:36:52]

So, if the university had then had the kind of, erm, er, more entrepreneurial outlook that it has now, and-and would be-be more commercially astute, then, of course, it could have been very good news for the university, I suppose, it's perhaps a shame, that they-they weren't doing that sort of thing at that time.

[00:37:12]

Well, I think for-for Surrey, actually, it-it again, we're looking at it through today's lenses, and we have to sort of project ourselves back to the mid-1980s. There was a lot of criticism that we had, erm, some within the university and a lot of it outside, you know, from other universities was, oh, this sort of thing is not what academics should be doing, you know, this is-this is sort of a bit, you know a bit too hands-on, a bit grubby, you know, it's not real research, erm, you know, etc., etc., and-and so, it-it wasn't a-an easy environment. And I have to say that-that-that the management at the University of Surrey, didn't stick with that, they-they said, "No, okay, we'll support you, we'll continue, we think this is, you know, good, we'll-we will support you" both in terms, you know, financially in some senses, because they-they-they acted a little bit as a banker at times and things like this. So-so, er, Surrey was actually, I think, very entrepreneurial by the standards of the time and-and I think, er, much credit to the staff that did that.

[00:38:21]

So, what would you pick out as some of the key milestones in-in the way the company evolved?

[00:38:28]

Ahh, ooh, goodness me. Erm, I-I think, you know, clearly getting the first contract was-was [laughs] a good thing, erm, you know, small though they were, erm, and then we, er, I think our first major contract was to, er, do, er, a collaborative programme with South Korea, to help, er, to work together with a team from South Korea to build their first satellites. Erm, and what we did was to licence the know-how to them, erm, and they would come and spend time with us, a couple of years with us, design and build a satellite, which was then to be their first national South Korean satellite. That gave us, you know, we were then building spacecraft, we were being paid for it, and we could reinvest the profits back into new ideas and technology for the, er, for the next spacecraft.

And we always ran the commercial SSTL, Surrey Satellites, er, alongside the academic team, the Surrey Space Centre, and the academic team of researchers, who would be always looking at, you know, what's the new technology that's coming down the line, erm, what, er, opportunities might there be technologically in the five or ten years? And then sometimes, when the commercial projects ran into challenges, you know, we could use their academic experience to help us solve it. So, there was a very strong symbiotic relationship between the u-u-university academic research team and the company. And in fact, people and staff moved from one to the other, we had joint PhDs and so forth, it was a very intimate, er, intellectual relationship, it was completely separate financially, so, we kept the two separate financially, but intellectually, it was very close[sniffs] and I think that was the real trick.

So, the first contract we got with South Korea, a big contract with South Korea, was a major milestone. Erm, we then did a number of-a number of others working with China, with Thailand, with Malaysia, with the French MOD, which was an interesting experience, and, erm, and then later, we decided that our small satellites were not really capable enough, we needed a slightly bigger satellite. Er, and of course, erm, we wouldn't be able to, er, perhaps rely on NASA providing us with free launches after the first two satellites, and so, we had to then develop relationships with other rocket providers in-in Russia, India, and so on.

And so, you know, we... There were a number of sort of gear changes, the first contract, and then building our first, what we called mini satellite, something that was four or five times bigger, still small, four or five times bigger. And then, trying to find a rocket to launch it on, and persuading, er, finding, er, a Russian missile, er, an SS-18, er, i-i-i-intercontinental nuclear missile, which, er, was being decommissioned, er, making sure the warhead was not still on it and placing our satellite on it instead, erm, and then getting it reprogrammed so that it went up into orbit, rather coming back down again, of course. Erm, and launching-launching that from a-a silo in Russia, you know, absolutely, a wonderful experience, not least of all, you know, technically, very, very interesting, but also, of course, working with these international groups, whether it be Korea, Malaysia, Thailand, China, or Russia, was fascinating in itself. So, there was, I suppose you could call it almost a cultural ingredient in-in the fascination and alongside the technological.

[00:42:08]

Yes, because somewhere along the line, you picked up, erm, Mandarin, you speak Chinese, I think, is that right?

[00:42:14]

Well, not terribly well, but erm, because we-we, you know, we were working with countries who, erm, were not space powers. Again, going back, you know, at that time, you know, there was Russia, The US, the European Space Agency, then a couple of others, sort of in the background. A lot of nations had interest and recognised space as being valuable, erm, and wanted to do it, but they didn't have this huge budgets and th-that's what appealed to them about our work is that they could get a-a useful satellite into orbit, on a, you know, 100th of a budget that they would be spending if they were trying to do it the-the conventional way.

And so, erm, we worked with all these countries, and-and one of them, over a long time was-was China, erm, who had a very, very nascent space programme, which has developed out of all recognition since, of course. But at that time, you know, they really had a very, erm, underdeveloped, shall we put it, space programme. And so, working with Tsinghua University, that's their Oxford or Cambridge of China, and then subsequently with a Chinese, er, company 2118, this has been something that

lasted for, I guess, that started in, around about 1990. So, over the course of that period of time, travelling to China, er, as well as Russia and other countries very regularly, erm, and I always try, when you go to-to work with-with other countries, to learn a bit of the language. So, depending on how long the programmes lasted, my-my linguistic skills developed or not. Erm, but because, er, with-with China, it has been a programme that has lasted now, over 20 years, during that I've time I've slowly, learned Mandarin Chinese, although it's, er, it could do with a bit of polishing. [sniffs].

[00:44:07]

And how-how have the size of the satellites changed? Because the first ones, w-w-were they about the size of a washing machine or a fridge, does that [unclear 00:44:14]?

[00:44:17]

I think washing machine because I-I've seen some rather large fridges, erm, advertised. So, I think erm, yes, by comparison, the first satellites were roughly the size of a, er, a washing, er a normal washing machine. Erm, and in fact, they sort of developed in two ways, er, and interestingly, it really is rather like the mobile phone, if you remember, the very first mobile phones were sort of brick-size, and then they got smaller, and smaller, and smaller, and then people realised that actually, if they got so small, you couldn't see what you were doing and you had all the new apps and so, they started to grow again.

And the satellites have done a little bit of the same thing. So, we started out with a washing machine size, satellites, then our customers said, well, actually, you know, we want to get more pictures down from them, or we want to have more communications capacity and whatever, so, we need more power, so, make the satellite a bit bigger. So, the satellites grew from, let's say, the size of a-a washing machine to the-to the size of one of the, you know, the huge American-style fridges, erm, or possibly, er, erm about the size of a mini, a mini car. [coughs] And then, after that, er, miniaturisation in-in the last 10 years has obviously, advanced even further so, a new species of satellite sort of developed where we make them tinier and tinier, all the way down to something, you know, about the size of a football. Erm, and, you

know, that-that was really, really interesting but what we found was that the satellite the size of a football, could do some things but not a lot, it wasn't terribly useful. So, it was very good for experimenting, it was very good for research and demonstrating stuff, but when you wanted to provide a service, they just didn't have the power.

So, then the satellite sort of grew back up again, so, they-they sort of rather followed this, the-the similar development of a-of a mobile phone. So, now, we make satellites, everything from the size of a football, right the way to the size of a, erm, you know, Mini Clubman.

[00:46:07]

Right. Erm, and what about space junk then, and space debris, because that is becoming more and more of a problem, isn't it? and perhaps one could point the finger at companies like SST and say, well, it's your fault.

[00:46:20]

Yes, well, of course, everybody who launches anything, er, is potentially adding to space debris, the... And it is a real, it's a real problem, and in fact, one of our satellites which we built for the French MOD, back in 1996, was hit by a piece of space debris. And it was a very interesting, er, event because, erm, the satellite was hit, but it, it sort of hit one its arms, if you like, rather than its body and so, we lost, we lost one of the sort of the rudders. But the main spacecraft was still okay and we managed to recover it and work out what had happened, and-and were able to identify, it was a specifically, specific piece of, er, space debris that, er hit it. It turned out that actually, it was a bit of French space debris, so, the arguments over whose fault it was, [laughs] rather evaporated. But erm, that was the first, I believe recorded, er, collision in space where the satellite lived to tell the tale. And that sort of w-w-woke our woke us to the, to the real risk of space debris, which is present but not until recently, has not been something that happens very frequently.

But there is a huge... I mean, space is big, but there are millions of pieces of debris and much of this was caused by early, er, anti-satellite tests, sometimes by people not, in the early days, not bothering to-to what happened to bits and pieces of rockets and-and all the nuts and bolts and things like this, until they realised it was going to be a

problem. And then, more recently, of course, some fragmentation of, er, rocket bodies or spacecraft, when they get to the end of their life and the rocket fuels tend to eat through the-the pipings and things because they are rather corrosive and then they come into contact with each other, and then bang, you've got tens of thousands of pieces of satellite.

So, it's not the numbers of satellites that represent the risk, it's when they fragment, either deliberately or accidentally. And erm, of course, in recent years we've seen, erm, so-called mega-constellations, where now, you know, thousands of satellites are being launched, those by themselves, don't represent a big hazard, but should they fragment for any reason into, you know, er, thousands of parts, then it is a big risk. So, at the moment, erm, there is a lot of pressure to, first of all, make sure that your satellites don't fall to pieces, secondary, at the end of their useful life, make sure they come down and burn up in the atmosphere or get put out into a safe orbit, so, they don't represent a hazard to other users, and, er, to then, try to identify any hazardous pieces of space junk and remove it. And that is one of the projects we did, er, a couple of years ago now, which was to, er, launch a satellite, and to demonstrate how we could grapple a piece of space junk and bring it back down into the atmosphere and burn it up, so, that we can, you know, act as the sort of celestial dustmen.

Now, we're not going to be able to clean up the whole of space because there are literally millions of pieces less than the size of a golf ball whizzing around, but there, the, there are relatively small, er, few large objects, which might represent a hazard if they were to break up. And so, it is realistic to go and capture those and bring them down into orbit, so, you reduce the, you know, the addition to, er, the space junk field. I mean, to put it into perspective, our satellites, er, because of the radar tracking by the US and others, er, warn us when there is a piece of space junk coming close to our satellites and we will get a warning, you know, once a week, twice a week, that some piece of space junk is coming, you know, within 100 metres of our satellite. Erm, and then, I don't know, once every few months, we might have to think about making a manoeuvre to nudge ourselves out of the way, just to, you know, give a bit more space.

So, it's a real-it's a real threat and if we make it worse, it will become, er, an economic threat, er, particularly to the huge investments going into the mega-constellations, who can't possibly afford to, you know, to risk space debris damage.

[00:50:45]

Mm-hmm, er, you mean the er, the-the rockets which are-are going-going to go much further and might get damaged on the way out?

[00:50:55]

Well, no, not so much that, it, it, the-the space debris field, erm, is concentrated in a band between, about 700 kilometres and 1000 kilometres above the surface of the earth. But that's an area where we have the international space station, a little bit below that, but around about there. And then from, you know, 600 to 900 kilometres, that's the, you know, the-the sort of Goldilocks band, the really ideal place to put earth observation satellites, because any higher then, you know, the cameras get too big. Erm, and so, if you've got a lot of junk in there that's a real risk to-to-to those satellites.

But recently, in the last couple of years, there have been initiatives, by SpaceX with Starlink, by OneWeb, which has UK involvement, erm, with, erm, Amazon, er, er, er, with Kuiper, er, and so, to, erm, provide broadband communication services from space, rather like we have from fibre but from space, which makes it much more flexible. And these use satellites in the 600-to-1200-kilometre range, erm, in order to be able to get the low latency that you need so you don't get the delays. When you have a geostationary satellite, you get the rather irritating delay, down a satellite at 1000 kilometres, you don't get that delay, but you are now sitting in this-this band where there is an awful lot of space debris. And when you look at the numbers of satellites, where they're talking about, you know, tens of thousands of these space crafts being put into that orbit, and the huge investment that goes, the risk of collision, er, is much, much higher, and the economic impact, of course, is, is huge. So, there is a... This really had alerted everybody to the-the risks of space debris and what we would need to do to minimise it, both in good practice and also, you know, being celestial dustmen.

[00:52:54]

So, you mentioned, er, that you had, er, er, been, er, en-encountered Elon Musk then, in person. So, erm, what-what happened, what's-what's his involvement been?

[00:53:05]

Well, it goes—[sighs] it goes right back to the beginning of-of Elon's sort of i-interest. I first met him when he just emerged from, I think he had PayPal and-and PayZip, or ZipPay or something, and he was interested in space and he wanted to, er, er, to put a greenhouse on Mars and demonstrate that you know, this could be done on a different way and-and somebody somewhere said, well, you know, why don't you go and talk to-to me, because this is what we've been doing. And-and so, er, I remember having a breakfast with, er, er, Elon in-in when I was at a conference in-in Utah, and he-he came over. I think at that time, he owned a-a big jet, erm, and he flew that down and I was hoping he would give me a ride, but he never did. Erm, and erm, we had a chat and I said, "Well, yes, it's all possible, I would love to do this." Er, he went away and said, "Well, the problem is not so much the greenhouse, it's how do you get there?"

So, and I made, I gave him some suggestions and that time we had a good working relationship with our Russian rocket folk and he went over there, but he didn't really get on with that approach. So, he then decided to-to, er, start, er SpaceX, er, to provide affordable launches. Because he saw that clearly was going to be the-the bottleneck in the small satellite business. There is no point in building a satellite, you know, for a fraction of the cost if it costs you ten times as much to launch the thing. So, he-he needed to have a-a low-cost launch, and so, that is how it all kicked off. And erm, so, he then became an investor, later, after some years and getting SpaceX going, er, he then became an-an investor in SSTL for I think three years or thereabouts. Erm, while, er, whilst he was sort of thinking about first, his, er, first rockets and then the-the communication satellites.

So, I got-I got to know him, you know, pretty well and, er, he's a very interesting character, very driven, erm, and er, very, very focused, and extremely imaginative and exceptionally capable as well, technically. Er, so, a very, very interesting, er, guy, and, er, I was, you know, very fortunate that-that, er, we got on well and-and I had the

opportunity to, er, attend one of his weddings, and various birthday events that he had up in London. So, er, yeah, I, it-it was a very interesting experience. And-and what he's done since is absolutely amazing, actually, in terms of being able to create a total... You know, he has done for the launcher industry, er, he's made the biggest change in the launch industry that, er, you know, we've seen in-in 20 years, clearly, er, quite a revolution.

[00:55:46]

Mm-hmm. Are there, and who else would you, might you highlight? I mean, you've obviously met, er, presumably quite a lot of rather, erm, inspirational characters now over the years, erm, and potential mentors. Are there any others that you might, erm, er, focus on or mention who-who have really made you, er, helped to inspire you?

[00:56:08]

I think [sighs] it's-it's a difficult one, I-I-I've been asked that once or twice and I-I sort of struggle in the sense of, I'm not sure that, I mean, there were lots of people who helped along the way. Erm, you know, I went and sought advice, or-or-or whatever, and who were, you know who helped by being agreeable to providing resources or whatever it may be. Erm, I think that the people, that-that-that I was really interested in and-and who did have an impact, Elon was clearly one of them because he has a, he has a very-very clear focus and vision and-and-and, erm, really very imaginative. I don't always agree with him, by the way, erm, but, you know, a very, very imaginative an extremely capable, er, person. So, I think, he-he would be identified as one.

I did have the opportunity to meet Arthur Clarke, erm, and, er, and-and he was again, a very wide, clearly, a very wide-thinking, er, personality. Erm, I-I was brought up on his short stories in particular, as well as the film. Erm, but, er, yeah, and I found that his imagination really was stimulating, so, I-I think he would be another one who, sort of indirectly, er, infused my thought processes.

Erm, and then, there was a very interesting chap who used to work for GCHQ, who was one of the directors of GCHQ, er, Ralph Benjamin, who again, was a very deep thinker technically and extremely capable. In fact, it turns out subsequently that he-he was one of the-the first people who-who invented the computer mouse back in the

1950s or something. But of course, it wasn't able to be recognised because it was, er, within MOD.

And he was-was a visiting professor at Surrey, erm, and-and he would always, he would always listen to what you would say, and then he would sit there, silently for about five minutes, and I was wondering whether he had actually passed away. Er, and-and then, all of sudden he would come out and he'd computed the answer in his head, you know, in those five minutes and it was, you know, a complete solution.

And-and he was somebody that I-I-I really, er, sort of held up as a-as a, er, you know, somebody to aspire to. And it also turned out, he helped support, provide some very key support for our very first satellite, and when he put a little bit money into it, he's co-directors at-at the time, at GCHQ, said, "Oh, why are you doing this, this is money down the drain." And yet he said, "No, no, I think there is something in this, I will support it" and of course, you know, it turned out, that it-it-it was a-a key ingredient and something that changed the-the space industry. Erm, so, I think those are the three people that if, you know, if somebody said, who are the three people that I-I would sort of think about, those are the three.

[00:59:05]

Yeah, and erm, and yet you met, er, er, you presumably, you met Arthur Clarke when you were-when you were given the award in 2008?

[00:59:12]

No, no, no, I [sighs] I've got a feeling he might have passed away by then. No, I met him, erm, I forget when it was now, but it was, er, er, some years before that. Er, he was you know, fairly elder, yeah, clearly quite elderly by that point. But I remember having a discussion and-and he came up with some, you know, new ideas during that discussion, which I thought were really exciting. I don't recall what they were now, but I remember at the time thinking, wow, yes, that is a very different way to think about things. And I think that was... Again, if you go and look, if you read his short stories, like *Childhood's End* and some of the others, you know, they are actually really deep thinking.

[00:59:54]

Mm-hmm, so, what about, erm, er, your, erm, er, er, er, how society might have changed in the time that you've been, erm, developing this technology? Do you think it's had... I mean, obviously, it's had a-an enormous influence on how we communicate today and on so many different aspects of our lives. Erm, what do you see as being the real significant changes?

[01:00:17]

[sighs] Of course, it-it-it sort of, those changes moved around during the last couple of decades. I think initially, it was, when we started, of course, there was no internet, and s-some of the first projects we did was to provide electronic communications using these satellites in a sort of po-mailbox mode around the world allowing communities to-to communicate with each other. I remember one in particular where our satellite was providing electronic mail, if you like, erm, to remote, er, midwives in Africa and linking them to doctors in Europe. And I went out to meet these midwives [sniffs] erm, and-and, you know, I was actually staggered because the-the-these African midwives had actually a very clear grasp of orbital dynamics and how the satellites worked, far greater than I had any understanding of their business whatsoever, on midwifery, so, it was, er, rather a humbling experience.

But, yeah, that was one thing that made me realise that it-it shrank the world; satellite shrank the world, and of course, that's accelerated now with, you know, satellite broadband and everything else, but th-that was the beginning and over the next 20 years, it's brought everybody in touch, er, in-in a way that-that fundamentally has changed our perception of the world and-and how it-how it works.

The other side is that when we started, the ability to observe the earth was really rather scientific and-and fairly limited in-in its scope. Erm, and what we have now is whole ranges of-of multitudes of satellites that are observing the earth, our climate, the, er, er, urban development, erm, you know the, erm, er, er, forests and the tundra, the ice, and glaciers and-and just the whole climate change if-if you want to sum it up in one way. What we're doing to the earth, what-how we're affecting it, how we can extract useful things out of it in a sustainable way and also, hopefully, now, erm, as we start to-to look about how we-we're going to change our behaviour, we need to

monitor and see if our behavioural changes are actually working in the right direction. You know, we-we-we don't want to... We want to avoid any unintended consequences of what we think are good ideas now.

[01:02:49]

Mm-hmm.

[01:02:49]

So, I think it's in-in bringing the earth together, sorry, the peoples of the earth together in communications and also having visibility of the earth and-and what we're doing to it, those are the big societal shifts.

[01:03:01]

Yeah, yeah. Erm, and, I mean, it's-it's a bit of a sort of not very nice question, but I mean, would you do anything differently, how-how, what would you change perhaps if you could live your life again?

[01:03:11]

It's really interesting because I get asked that a couple of times, and it sort of sounds either, er, you know, lacking in inspiration or imagination or rather selfish, I think... I don't think there is anything that I would go back and say, hmm, I really would have rather done it differently, I think the only thing that, on the edges, that, you know, there is no doubt, and I-I think, I wouldn't want to say I share this with Elon Musk, but I think Elon has perhaps a more extreme experience on this is, you know, when-when you're this passionate and-and sort of committed and focused, erm, I-I think there is the-the risk that you can become a bit selfish in-in terms of, you know, your, er, outlook with other people. Because you're so focused and driven that-that I think there is that and I think there are a few things there that I-I-I would... I'm not sure whether I could do them differently, I'm not sure, maybe I couldn't do them differently and still do the same things. But you know, i-if I was to stop and I would say, yeah, I-maybe I should have thought a bit more about that and tried to find a way which was, erm, a little bit more sociably, er, you know, constructive.

Erm, I think from the point of view of the technology, and-and the business and career and everything else, no, I would do it all again, happily.

[01:04:29]

Yeah, so-so on the social side, being more socially constructive, do you mean on a personal basis or-or in terms of society as a whole and making-making the world a better place and in a different way?

[01:04:41]

No, I-I-on a personal basis, because I think, you know, there-there's no doubt that you know, family does take, er, er, er, does suffer from that. Er, I think for anybody, in any-any business whether it's space or anything else, you know, if your-if you have a-a passion and-and you are driven and you are trying to do something, which is, let's face it, not very easy, you know, you pay for it somewhere, you know, there is no-no doubt about it. I think on the-the wider social side, erm, [sighs], I-I-I wouldn't sort of overplay it, but we've, I-I-I've always felt that what we were doing hopefully, would be beneficial rather than detrimental to society.

And I-I wouldn't like to say that we were going to, you know, er, er, really try and, er, you know, change society for the better or anything like that, it-it wasn't in that way, but it, we always were looking at it and saying, you know, when we had a choice of projects, is this something that is going to be detrimental to society, er, or-or hopefully help. I suppose maybe the best way of doing that is that when we... We had done some work for-for, er, erm, let's say, the French MOD, the French military. Erm, you know we did and think very hard at the time, is this something that we wanted to do and how do we judge?

You know, there is a very thin line between civil and military activities, there is a lot of military-related work which is beneficial to the civilian world. Erm, but there is also stuff that-that one might not want to do and-and I think we always drew the line and said if it's anything that is going to harm anybody directly... Erm, you know, a computer can harm people so, y-y-y-that doesn't mean y-you're never going to use a PC, for example. But, you know, if-if the objective is to-to make life worse for somebody, then we wouldn't do it. If it's-if it's, erm, you know, working for

governments or the military where, as far as we can see, it doesn't have a direct, er, negative inter-, er, a negative impact on people, er, overtly, then-then that was the line. So, we-we, you know, we always went through that thought process and tried to work out what we should do. [sniffs]

[01:06:53]

What would your... Yes, what would your advice be to young people now, who are, er, thinking about which direction to-to move for their higher education or indeed for their careers; would you encourage them to, er, to go into space? And bearing in mind, this is really, erm, also, f-f-for people who are interested in IT, what-what-what's the sort of IT side of it all?

[01:07:14]

Er, again, er, I get asked quite a lot, you know, what-what would I advise young people? The-the one piece of advice I would say is, whatever you do, do it because you're interested in it. Erm, and, you know, the-the motivations of interest might be very different, er, you know, the-the science, the IT, or the-the space or whatever might be just really fascinating to you, that's great. It may be that you have a fascination in-in building businesses, er, or whatever.

Erm, but m-m-my advice is, you know, you're going to spend your-your life on something, if you have the opportunity to choose, and not everybody does, of course, but if you do have the opp- you know, if you're in the fortunate position of being able to choose what you want to do, whatever, it is, choose something that is fascinating to some extent, you know, really excites you; whatever it is. Because when it doesn't work, as it won't at times, and when things go hard and don't pan out if you have that underlying fascination and-and interest, you will see it through, and-and hopefully, it will be rewarding as well. And-and, you know, it doesn't matter what walk of life you're in actually, but—

[01:08:24]

So, when you look into your crystal ball, erm, and think about maybe the next sort of 10 years or so, erm, how do you see the world of-of satellite technology developing?

[01:08:37]

Well, my... And-and this is my sort of personal, er, take on things, erm, when you look at what's happened over the last two decades, microelectronics has transformed space. In the last, I suppose five years, maybe the last decade, er, micro, er, alongside microelectronics, we've seen some dramatic advances in materials, [coughs] and then bringing together microelectronics and these advanced materials, we know have a capability in robotics which we see... We already see on earth, so, to speak, which is, you know, quite amazing, if you, er, I mean, in fact, if you look at the sort of robots and what they can do now, it's what you would have seen in the science fiction movie, 20 years ago.

And this is developing very rapidly, so, in my view, er, we are g-we are already beginning to see the change of space from-from what is being called new space, which is the sort of microsatellite end to what I call next space, which is [sniffs] where, er, we will take advantage of robotics, and this will allow us to, first of all, assemble satellites in orbit, like Lego, we will, er, launch modules and then robotically assemble them into much bigger satellites than we can squeeze into a-into a rocket. We've just seen the launch of the James Webb Space Telescope, which is all folded up, squeezed into the biggest rocket envelope that we currently have; how are we going to build the next one, which is even bigger? The only way to do that is to assemble it in orbit, as I say, like Lego.

So, we now have the-the robots, or, er, robotic capability to do that and then the next step beyond that, is after, in-orbit assembly is in-orbit manufacture, where, I mean, again, if you want to think of it very simply, we-we launch a 3D printer and then you, with, you know, a heap of raw ingredients, and then you manufacture your satellite in orbit. And again, that allows you to build much larger satellites which gives you, you know, we can look more deeply into the universe, we can look more precision on earth, we can provide higher communications capability, possibly even, er, generate power in orbit, solar power in orbit and beam it down to the earth. These all require huge, er, structures and the robotics that we-we have now is just beginning to allow us to do that. Er, we also, of course, use robotics to-to help clean up, er, space, er, space debris.

And the implication of this is quite dramatic, I think because, if we look, [coughs], you know, I think by the end of this year, end of this decade, we will have in-orbit assembly as, er, of satellites and, you know, er, er, as sort of routine. And then in the next decade, we'll have in-orbit manufacture. When you do that, you don't then need to have all the facilities and test facilities and manufacturing facilities on earth. So, this is going to have a dramatic impact on the terrestrial space industry because it will- it will move from the earth out into orbit and-and that's going to be very, very different. And then from earth orbit, as we, er, go back to the moon and we have, you know prolonged human habitation on the moon, we will need robotic capability to, er, construct all the habitats in order, you know, rather like on the Antarctic, in order to- to, er, support human, er, presence on the moon. And so, robotics will allow us to do that safely.

And interestingly, that will then feedback into the terrestrial business where, let's say, in the construction business, if we have robots in space assembling the satellites and then on the moon assembling the habitats, we can then use robotics, that experience, to produce better robots on earth. Which will reduce the hazards that we see in the construction industry, which is, you know, terrestrial construction industry is a-is a messy and dangerous business and-and robots can be used to-to increase safety on earth. So, you know, I think there is going to be, er, space at the... In-in this time, you know, what is it, 2032, I think will be very, very different from where it is today.

[01:12:53]

So, er, one final question then. What, looking back over your career, your long and glittering career, and your many, many prizes, erm, what do you see as your proudest achievement?

[01:13:06]

Again, when I get asked that, I, to be honest, I tend not to dwell on those things. Erm, and-and I'm always very appreciative of, you know, the-the nice things people say or awards that are given and so forth. Erm, but yeah... And-and I don't want it sound trite, but, you know, that's not why I did it, I did it [laughs], er, I did because I was interested, and it's very kind that people think that's, you know, what's been done is

useful and helpful and-and I get the awards. So, yeah, I'm very grateful for them, I appreciate them, but I don't tend to sit and sort of dwell on them, or I don't have any of them pinned up on the wall, so to speak.

Erm, I think having said that, I think the, er [sighs], I think the-the one that stands out on that, was-was receiving a knighthood, which I think, was, er, special because it came from the industry, you know, er, from the space industry, recognising something which, when we started, was considered, at best a waste of time, erm, back in the, you know, the 1980s, when people said, you know, er, this is just, er, not going to work and-and it's a waste of time. And then, you know, 20 years later, recognised for the fact this act-actually has made a useful contribution. I think that was the thing that-that, you know if I had to pick out one thing I would say, yeah, that was the one that gave me the most satisfaction. I'm very appreciative of all the others, but as I say, I-I tend not to pon-you know, sit, and think about them a lot.

[01:14:42]

Well, Sir Martin Sweeting, thank you very much for sharing, er, your, all your experiences with us, it's been absolutely fascinating and a pleasure to meet you.

[01:14:51]

Well, thank you very much, Jane, it-it's always, it-it's not often that I sit and actually stop and think back in such a, er, a comprehensive way, so, thank you.

[01:15:02]

Great.

[End of Interview]