Martyn Thomas CBE

Interviewed by

Jonathan Sinfield

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Welcome to the Archives of Information Technology. It's Wednesday 30th of May 2018, and we're in the Worshipful Company of Information Technologists Hall in London. I am Jonathan Sinfield, an interviewer for Archives of IT, and today I'll be talking to Professor of Information Technology, Professor Martyn Thomas.

Martyn is a world-renowned expert in software engineering and cybersecurity. He graduated from UCL in 1969 with a degree in biochemistry. On graduation, forsaking a career in law, he joined UCL's Computer Centre. Subsequent to work with South West Universities, he went on to form Praxis Systems in 1983, a company renowned for its commercial use of mathematically formal software development methods. Martyn has worked on many high-profile, critical systems throughout the world, including work with NATS, the UK leading provider of air traffic control services. In 2007 Martyn was awarded a CBE for services to software engineering. Today he remains an adviser to Government, university, and holds a number a non-exec directorships. In 2015 he was appointed the Inaugural Livery Company Professor of Information Technology at London's prestigious Gresham College. Good afternoon Martyn.

Good afternoon Jonathan.

[01:36]
Martyn, I wonder if you can take us back, well, to, and let our listeners, or advise our listeners, when you were born and where you were born.

I was born in Salisbury in the UK in 1948. My mother was a nurse, my father was a Government scientist. And, I grew up in Salisbury, and, and then went to Bishop Wordsworth's School, which was a grammar school in Salisbury.

[02:12]
And, what area of science did your father specialise in?

He was a spectroscopist.

Right.

So, he was a, an analyst at Porton Down, the chemical defence experimental establishment. And, he really specialised in the chemistry of organophosphorus compounds, the nerve gases, which of course have come into sharp focus as a result of other events in Salisbury extremely recently when somebody was poisoned with a, a modern nerve gas.

Ah, so that, that was your first, the first time you learnt about Porton Down was from your father then.

Absolutely.

Yes.

And, and then, in fact in a gap period between school and university I went to work there.

[03:06]
Mhm. And your, your schooling. You attended what, Uplands Primary School.

Yes.

And, and did your Eleven Plus there?

Indeed.

And, entered grammar school. And that was Bishop Wordsworth's Grammar School. That's a, that's in Salisbury itself.

That's the boys' grammar school in Salisbury, yes.

And, and what did you… You studied your O Levels and your A Levels at that school?

Yes. Yes I did. They had a rather strange scheme whereby, if you seem to be doing well, you did your O Levels in four years and went straight into the sixth form, and, and then did your A Levels. And as a consequence I was ridiculously young at the point where I actually passed my A Levels. And that was a problem, because it meant that, even though I took a year between school and university, I was still stupidly young and immature by the time I got to university.

[04:08]
Mhm. And what A Level subjects did you study at school?

I did maths, physics, chemistry and biology.

Mhm. So, very much on the science side.

Very much on the science side. Really influenced by my parents, by my parents, by my father in particular.

And did you, presumably you, you enjoyed science at that stage?

Oh enormously. Yes. I mean with hindsight, I wish I had done some arts subjects to a, to a high level, and, and really studied those, but, I was brought up to feel that science was supreme and that that was very definitely where I ought to be going.

[04:51]
And, if you think about your, I say, informative years, perhaps we should say we are, should be informative throughout our lives, but, were there any particular incidents or individuals who affected your post thinking, after you left school, or…?

[hesitates] It's… It's a long time ago of course. But, there was actually an English teacher who, who impressed me enormously, because he introduced us to a range of then very modern dramatists by, by reading parts of plays in English lessons.

Yup.

I remember a play called *Next Time I'll Sing To You*, which impressed me remarkably and gave me a, a lasting interest in the theatre, and I'm still very much a theatre-goer.

[05:48]
Right, OK. And as you said, you, you effectively did your, by, by UK standards, you did your A Levels at a, an early age. So, that presumably influenced you deciding to take a gap year.

Yes. Yes, that and the fact that I hadn't got particularly good A Levels, and, and so I, I thought I'd stay on and do S Levels, you know, essentially re-taking them at a, at a higher level.

Mhm.

But, for a variety of reasons, that turned out to be a fairly silly idea. I spent some, a couple of months at the school helping with an exhibition that was being put on, a science exhibition for, for parents. And, that they asked me if I would be interested in, in getting some people together to redecorate the old boys' room, and, unfortunately, it had a billiard table in it. And, the consequence was that, several of the teachers wanted to join in at least looking to see whether the redecoration really need to be done. And I spent a very large amount of time playing snooker, in particular with the French master.

[07:01]
Oh right. [laughs] Oh. But, when you left, left school, or, was in '65, 1965, you did spend a gap year at the Chemical Defence Experimental Establishment at Porton Down.

Yes, I got a job as a junior scientist, just, just for, a bit less than year, up at Porton Dow, working in, in one of the labs that was doing some biological experiments. And, and it was, it was really eye-opening to me. I mean this was practical science in a secret establishment, doing classified work to, to a high level of, of science, but also, with hindsight, doing work in a, in a way that was remarkably casual. I, I mean I suppose that it was the ethos of a government science laboratory at the time, mid-

Sixties. But, you know, I, I can remember that, that the, the standard way to, to clean contaminated glassware for example was through a, a reaction called the Hilditch reaction, which, which caused a particularly dramatic explosion, and, and cleaned the glassware absolutely perfectly, and, and used to be done on, on one of the, the mounds of earth that was behind the laboratory where we were working. It made a pleasant summer afternoon cleaning glassware.

Mhm. And, did you find it very methodical at Porton Down, or…?

Oh yes. The actual science was very rigorous.

Yes. Right.

And, and we were working with some, reasonably dangerous agents. I mean I remember that, you know, there were self-injection kits at the end of the lab just in case you contaminated yourself with a nerve agent for example, so that you could, you could stand some reasonable chance of, of recovering. It was, it was a, a fun environment for somebody who had really enjoyed doing experimental science at school, at a time when schools were allowed to do things that, that were dangerous, you know. We, we weren't dressed up in safety glasses and, and watching videos of, of people dropping sodium into water. We were doing what… We, we were making explosives and blowing them up in the bio lab garden, and we were, we were doing all kinds of, of syntheses of, of different things that happened to take our fancy that we thought we'd quite like to make. And, no inhibitions at all. I mean even the, even the young children had access to the concentrated acids that just stood in bottles on, on all the chemistry lab benches, and… And of course, you know, there were the occasional accidents caused by either children messing about or, [laughs] or by incompetent masters blowing something up that they shouldn't have done. But, you know, it, it was, it was a time that stimulated a, really a deep interest in science. It, it led me to believe that, that chemistry gave you a power over nature, a power over things, that, that I had never really imagined before, that you could make things that had never existed before.

Mhm.

And, and you could, you could try things out that, that you couldn't look up in the, in the books, because, you couldn't find anything in, in the books that told you what happened. And, you know, I fear that a lot of that's gone from science lessons now, because people are too protected, and, and schools can't afford to take the risks.

No. I, I should say, I'm… I'm sure you mean when you're talking about children and experiments, we're talking your school days rather than at Proton Down.

Yes.

Yes?

Yes. Yes, yes absolutely.

[11:04]
So, at school, was it at school that you decided to pursue biochemistry at university, or was it at Porton Down, or was it just a continuing…?

Well, as I said, I was, I was really too young to be making a, an informed decision on my own. I was under pressure from, from my father to pursue a science career. My mother really wanted me to be a doctor, and there was no way that with my background and my A Levels I was going to get into a medical school. And there was a potential route to becoming a doctor by doing a biochemistry degree first, and then converting to medicine. And that was what I told UCL I planned to do when I applied to go to UCL.

Mhm.

So, that was what led me into biochemistry. And with hindsight it was a dreadful choice.

Mhm. From, from what angle was it a dreadful choice?

Oh, it, it was, it was a bad decision because, it was too much biology and not enough chemistry, for my interests.

Mhm.

And because actually, with hindsight, I'd probably have done better academically if I had studied something completely different, maybe even one of the humanities. But, you know, these things happen. You, you go down a particular path and life happens to you.

I suppose that's a common experience, well, students today effectively going, entertaining the wrong course for them, and finding out a bit too late.

Yes. And, and of course, I was of that privileged generation that had free tuition, and a maintenance grant, and, and came out of university with no debts.

[12:52]
Mhm. So at your time at university, perhaps beyond biochemistry, what did you get involved with at…?

I played a lot of three-card brag.

Right, OK.

But… And, and quite a lot of bridge.

Right.

But beyond that I, I got involved with a student newspaper called *Pi*. And started off editing the "other universities'" news page that was called *Compass*. And because there wasn't a lot of particularly interesting news about other universities, I used to make it up. And, and was quite delighted to see how often actually other universities' newspapers then picked up our stories and, and reran them when they were completely false, and even, even on occasions I managed to get, get some stories into

the nationals that way. I invented the University of Pontefract, and, and peopled it with a, a number of my friends from school carrying out various functions. And, and illustrated it with, with a number of photographs that were typically things that had been sent in by advertisers for completely different purposes that we chose to insert to, to illustrate a particular story. It, it was enormous fun. And I then moved from that to, to taking all the photographs for, for the newspaper.

Mhm.

I found that in the basement of the building we were in there was a, an old darkroom that belonged to the physics department that nobody had been in for a long time, and I managed to get hold of a key to it and set up a darkroom down there. And so, I used to spend day after day going out and taking pictures of, of news events that the university was interested in, or, or just pictures around, around London. And, you know, I, I'd take pictures in the morning, I'd develop them over lunch, and print them. If I didn't like them, I'd go out and take them again in the afternoon. And so I actually became quite a decent photographer.

Mhm. So, I mean, and… So… So in the Sixties, we have fake news in the Sixties as well.

Absolutely we did, yes.

[laughs] Yes.

I, I can't claim to have invented fake news, it was around a long time before me.

[15:18]
No. And, that editorial side of things, did you come back to that in later life as well, or…?

No.

No.

No, I… I, I did have a, get interested in, in the printing processes. We, we used to get the newspaper printed in a, a linotype workshop and, and printers, that was in Dursley, in Gloucestershire. And so, once a fortnight we would, we would take the newspaper, which had been set up and, and printed in galleys and which we had cut up and pasted onto sheets to show the layout, and we'd take it across to, to Dursley, and see it set up in, in type and printed, and, and then, and then come back in the morning. So I, I used to get back to, to UCL at, seven o'clock in the morning and, and typically fall asleep in the newspaper office rather than making it to my nine o'clock lecture.

[16:21]
Oh right. You've written books on, on printing

And, that, that led me to an interest in, in typography, and, and layout and, and so on, yes. And in later life I got very interested in the seventeenth-century typefaces that were introduced to Oxford University Press by Bishop Fell, who was very much the founder of the Press. He needed type for the press of course. There was a, a stranglehold on the availability of type. The Stationers' Company held the ability to manufacture lead type at that time, because they had the matrices from which it was cast. And because type gets very battered, they, they had a constant stream of income, because, you'd use the type and it would wear, and then you'd have to buy some more from them. And so Bishop Fell decided that what he wanted was a range of typefaces that were owned by Oxford University Press, and in order to do that he sent messengers out round Europe to the greatest type founders and either bought matrices or, actually hired type founders to cut the punches that you drive to make the matrices that are then the moulds for the type, And so Oxford University Press owns a, a vast range of seventeenth-century typefaces for, for all the different languages that were in use in, in scholarly printing at the time.

Mhm.

And, some of them are absolutely beautiful, and came back into use towards the end of the nineteenth century, and I could, you know, I can bore for Britain on the subject

of, of how that happened and who the key people were in that process. But, I, I and a colleague, Martyn Ould, who was my technical director at Praxis, and we'll come to Praxis in due course, liked the typefaces and were interested in producing a, a list of the books that had been printed in those typefaces in the nineteenth and twentieth centuries, just for our own purposes as collectors. But in doing the research to, to find out which books had been printed in the archives of Oxford University Press, we came across so many fascinating stories, we ended up writing a book on the revival of the, the Fell types. And, and that then led me to an interest in the archivist, the, the key man at, at the archives of Oxford University Press in the 1950s, a man called Harry Carter.

Right, yeah.

Who, who was an extraordinary polymath, and, and a real scholar of the type. And, I wanted to find out more about his life, and, and discovered that there wasn't a biography written of him. And so, I thought he deserved one and wrote it, with, based on some materials that John A Lane, another typography scholar, currently in the Netherlands I think, who had already done some preliminary research. And I came across his, his paper in St Bride's Printing Library, and contacted him, and he agreed that I could, I could develop it into a full biography.

Mhm.

And, and a complete bibliography of his work as well. So I, I, you know, I got hooked on that and ended up writing stuff about, about the Fell types and, and about Harry Carter.

[20:08]
Mhm. Well thanks for sharing that with us. So you were at UCL '66-'69 studying. Any involvement with computing at that juncture in time?

[pause] Because I was, was not doing well at my biochemistry, I decided not to be a rebel and simply to do the courses that were recommended in my third year, and one of them was computing. It was, it was computing and numerical analysis, it was

being taught by the professor and the head of the computing centre there, Paul Samet. And, the introduction to that course, a requirement before you could go on the course, was that, in the very first week of January in your final year you did a, a one-week course in FORTRAN.

Mhm.

And I loved it. It was, it was completely magical, that you could, you could write something in, in a, a mathematically looking language, and, and instruct a, a £2 million computer to, to do calculations for you, and, and these would be run by, by the operators and, and the next day you would get back a, a listing of paper that, that showed what happened, and, and the outcome. And, the feeling of, of power, of being able to, to calculate things that it would have been hugely difficult to do by hand, and, and to do it very quickly and succinctly, I, I just fell in love with it.

Mhm.

I remember one of the first things I did was to work out all the odds for, for the different hands in three-card brag.

[laughs]

Using, using Monte Carlo methods to generate the hands. I mean it was, it was great fun.

Brilliant. [laughs] Yes, we'll have to do a sequel on gambling, I can see this. [both laugh]

[22:08]
So… So, three-year course. You graduated with a biochemistry degree. And, and then what did you do after that?

Well I… It was clear to me that I wasn't going to enjoy biochemistry. We, we had spent the, the final year, most afternoons of the week I seemed to be in the, in the

biochemistry laboratory carrying out astonishingly tedious experiments that required using the entrails of rats in order to, to perform some, some part of the experiment. And which always then started by having to cut the heads off live rats with blunt scissors. And I got really alienated by the fact that there were several of the people in my year who seemed to enjoy doing that, and indeed volunteered to do it for other people.

Mm.

And, and so, I had decided that I was going to do something else. And, I was, I was good friends with somebody who was studying law at UCL, and from talking to him got interested in the law, and I thought, perhaps I could take my knowledge of science and become a patent lawyer.

Mhm.

So I signed up to the Inns of Court School of Law to, to start doing some part-time studies in law. And also, registered as a student member of the Middle Temple, because, I, I saw myself going forward as a barrister. I had a, a completely naïve view that the law was sufficiently important that people who didn't have access to, to legal services ought to have free access to legal services, and that that was potentially something I might be able to provide as a, as a barrister. So for, for a while I was, I was dining in hall in, eating my dinners, which was a requirement, certainly at that time, of, of being a student member of, of one of the Inns of Court, and, and reading some, some law. But it became apparent that if I was going to pursue this after graduation I was going to need some income, and completely unexpectedly, the professor of computer science who had been teaching me asked me if I would be interested in a one-year job carrying out a research project for the National Computing Centre, which he had won and needed to staff. And of course I jumped at the chance. It gave me an opportunity to carry on using the computers in the university. And, after I had been working on the research project for, for six months, he offered me permanent job in the systems department in the computer centre, that being the group that looked after the mainframe computer, to make sure that the operating system was running effectively, and, and fixing problems. And, you know, these were the early

days of mainframe computing, and, and it was a big IBM 360 65, running OS/360. And, it crashed, often, sometimes several times a day, certainly several times a week. And, I was sufficiently interested that I went on an IBM course to learn about the internals of the operating system. Found that complexly fascinating, and took on the responsibility for finding the errors when, when the system crashed. So the operators were under an instruction to take a, a full dump of the memory, and, and to put the full listing on my desk. And I'd come in in the morning and, and find that there were two or three mountains of paper on my desk, and I would work through the day, finding out what had actually happened, and then looking at the source code of the operating system. We had a full microfiche set of the, of the source code. And trying to diagnose what the faults were in, in IBM's operating system so that we could, either instruct IBM to fix them or, or perhaps even patch them ourselves directly.

And this was when you were working for Paul Samet, yes?

I was working for Paul Samet in, in the computing centre, yes.

[26:50]
Yes. And did you get to the bottom of the, the issues, or improve reliability?

Oh yes. Yes, I… We managed to improve the, the reliability of the operating systems, and it was down to, to crashing once or twice a month rather than with the frequency previously. And, and then, Paul Samet had made an arrangement with the University of Delft, the Technische Hogeschool in Delft, to provide them with operating systems support for writing a new ALGOL 60 compiler. The, the IBM ALGOL F compiler was, was woefully slow, and quite difficult to use. And, the University of Delft had agreed with IBM that they would write a, a new compiler to replace it. And, and one of my colleagues in the computer centre had agreed that she would provide this support, that she would go over to, to Delft, and at the very last minute she decided to pull out. And I was asked, just, just one day, if, if the following week I would be prepared to take her place. And, I jumped at the chance, and on and off spent the next couple of years, between London and, and Delft, working on this ALGOL 60 compiler, and learning an awful lot about ALGOL 60, and an awful lot

about compilers, and, and a lot about IBM operating systems. It was, it was a very a interesting time.

[28:25]
Mhm. So you were with the UCL's computer centre for, what, four years, almost four years, '69 to '73.

Yes.

And then you chose to move on.

Yes. I had, I had really done the work that needed to be done, as far as I was concerned, at University College. There was more of the same around, but I, I was looking for other things to do, and, and more progress. And I had met a senior manager in Standard Telephones and Cables, a, a telephone subsidiary of, of the American company ITT. And, he was, was running a, an organisation in Cockfosters, and he said, 'Why don't you apply to, to join us?' And I applied, I applied to Logica, because of some, a friend from university days, Bean, was working in Logica, and he said, 'Why don't you come and work for the software house, Logica?' And I applied to Standard Telephones and Cables. And I was interviewed by both, and Logica turned me down flat on the… I understand that the woman who interviewed me got the sack shortly afterwards. And, STC offered me a, a job helping design their first generation of computer-controlled PABXs, private telephone switches. And so that was, that was what I did for a couple of years.

[30:05]
At this stage, or at what stage had you… I'm assuming at this stage you, you had chosen to continue your career effectively in information technology. When do you think that, the penny dropped on that, would you say, or…?

Oh, very early on, while I was working in, in the first year at UCL. It was obvious that, firstly, it fascinated me, and secondly, I was very good at it. I was really interested in the detail, and, and seemed to have a, a good grasp of, of the systems view of computing. And I think, probably, to, to give it credit, that was, was the

benefit that I got out of doing the biology and the biochemistry, which is a very systems view of, of human chemical systems, and their, their interrelationships. And I, I suppose I carried forward that perspective into the computing. So, I, yeah, I suppose I, I owe them a lot, despite the fact that with hindsight I would never have gone there. [laughs]

[31:20]
Mhm. So you spent two years at Standard Telephones and Cable. And, and then, went into another university computing centre.

Yes. What happened was that, the south-west universities, they had a, a regional network, the South West Universities Computer Network, that was providing the ability for, for people in the universities of Bath, Bristol, Exeter, Cardiff and the University of Wales Institute of Science and Technology, those, those five universities, could run program on each other's computers. They had a network of ICL System 4 computers, and they were able to, to pass messages around, and to, to share programs across the network. And they won the right to have a regional computer centre from the funding body that existed at the time, the Computer Board. And so, a decision was made that they were going to set up the South West Universities Regional Computer Centre. They chose the University of Bath as the location for that, partly I think because it wasn't the larger universities of, of Bristol, Exeter and Cardiff, and, and therefore seemed perhaps less of a threat to the people running the computer centres at those universities. And they were given by the Computer Board a brand new ICL 2980 computer, because that was what the Computer Board was buying, that was what the Government was subsidising, because ICL was, was a British company. And so there was a new computer centre being set up, and because I had been, critical I suppose of the way that University College Computer Centre was run, in the time I was there, I saw the advertisement for staff to, to set up this new computer centre and simply couldn't risk, couldn't, couldn't resist applying for a job.

Mhm.

I, you know, I, I've always felt that, if there's a, if there's a challenge to, to show you can do something better, then it's worth going for, and, and the opportunity to, to do that on an absolutely brand new computer was, was just too, too wonderful to, to resist. And by chance, it turned out that my friend from university, David Bean, saw the same advertisement and also applied for a job there. And we turned up for interview on, on the same day, only having discovered a couple of weeks before that we had both applied for, for jobs there. And we were both interviewed, and, we were both appointed, one to, to run the operating systems team, that was David, and one to run the compilers and utilities development and support team, and that was me. And it was only after they had appointed us that, that the, [laughs] the interview people realised that we knew each other. So it was a, a bit of a, a bit of a surprise to them. I, I had in fact, I, I had come to the interview from a holiday on David's narrowboat, which, which he had lent to me, and we, we, my wife and I were on the, the southern Oxford Canal at the time that I learnt, that I had, I had got an interview, and we parked up by the side of the canal and, and found our way to a station and I went to Bath.

Mhm. So you hadn't teamed up together at Logica, but you did…

Well we did… We did team up at…

Then you did team up at, at South West Universities. Yes.

At South West Universities, yes.

[35:25]
And you mention compilers. From a technical standpoint, what compiler were you, are we talking about in that regard?

Well, the, the most important thing to, to get going at, at the South West Universities Regional Computer Centre was, was FORTRAN, because that was the main language that, that people needed. But they, they were also big users of ALGOL W, a development of ALGOL 60 that Niklaus Wirth had developed. And, of course we couldn't, we couldn't run ALGOL W on, on the new ICL mainframe. In fact for the

first year and a half we couldn't run anything on the ICL mainframe, because, I mean, really didn't have any software. It was very early days. We… And indeed we, we didn't have a functioning computer for quite a while. We were having to use ICL's own machine at, at Bracknell, with a remote login from a, from a batch terminal that you had to nurse card decks through to the other side by having two telephones open at the same time, and…

Mhm.

It, it was, it was a real challenge doing the development work we needed. But, it, it was, it was successful, and, and we, we managed to get a, an initial service up. But then, quite rapidly we needed to solve the problem of how we were going to replace ALGOL W. And, the users said that, what they wanted was ALGOL 68, as, as the replacement language. And so, I looked around, how that might be possible. ICL didn't have a, an ALGOL 68 compiler, and talked to them at a senior level about it. They were interested in the potential of having an ALGOL 68 compiler. But what I discovered was that, the Royal Signals and Radar Establishment at Malvern had developed an ALGOL 68 compiler for the ICL 1900 series of computers, and had a, a front end to that compiler which was capable of generating an intermediate language so that it could be implemented on other computers. And that Oxford University was interested and had started a project to write a code generator for ALGOL 68. And so, I persuaded ICL to fund us to produce a real product quality ALGOL 68 compiler.

Mhm.

And, and they agreed to do it, on the condition that we, we wrote it entirely to the standards of their other compilers. So we had to use all the interface software, it had to be written in, in S3, the programming language for, for the, you know, the system programming language for the 2900 series, which incidentally and perhaps ironically was a derivative itself of ALGOL 68. And, it had to be provided with all the documentation, the standard manuals, the, the ordinary, you know, the, the same format of error messages, all the things that made it look like an ICL standard product and part of their language suite. And we took on a contract to do that.

Mhm.

And I ran the team that, I managed the, the diverse team of, of some, some people in, in the South West Universities Computer Centre in Bath, some in, some in Oxford, some in, in Malvern, to, to bring that together.

Mhm.

So I spent quite a lot of time over that period driving between, between Malvern and Oxford and, and Bath.

[39:18]
And ALGOL 68 is, has been used by the military for some years, hasn't it, or…

Oh, ALGOL 68 wasn't hugely widely used by anybody actually.

Oh right. Yes.

It, it… It's a super programming language in, in my opinion, but, I think widely disliked academically.

Right.

The, the people who had been advocating for further development of ALGOL 60 split into, into two warring factions and then really into three warring factions, and, and so they, you know, there were people who went down the Pascal route, there were people who supported ALGOL W, there were people who, who were interested in Modular, and there were some ALGOL 68 enthusiasts. But ALGOL 68 was, was seen as hard, and, and the defining document for the language was seen as impenetrably obscure. I mean personally I think it's, it's a stunningly beautiful document that is extraordinarily clever, and that the language itself is, is again, quite, quite beautiful. But, no, there was no, no great take-up of ALGOL 68.

Mm.

The University of Bristol had, had bought a Multics computer by this stage, and they asked if we would write them a, an ALGOL 68 compiler, so my team at Bath then developed an ALGOL 68 compiler for Multics, which was then used on the other Multics machines around the world. But, but apart from that, it didn't really get, get wide use.

Did I read somewhere that the Russians were using it as well?

You may have done.

Yes.

If I ever knew that, I've forgotten it.

[41:12]
Oh right, OK, yes. But, with… What… You're renowned for, of course, structured programming.

Yes.

Is that something that you had adopted at that stage, or, you were an ambassador if you like of that?

Yes. When I was at STC, I was introduced to a, a top-down graphical design method called structured programming, which then became called structured analysis and design technique. It had, it had been developed by a man called Doug Ross and was supported by his, his American consultancy company SofTech. And we had a, a SofTech consultant came and worked with us at, at STC, a man called Bob Monk, who, who was a terrific software engineer, and, and a great advocate for, for SADT, for, for structured programming. And I really liked the, the semi-formal, top-down, functional development style of developing software, and I became a, an advocate within the ITT group of companies for that, and I, and I taught it, and gave some lectures for commercial companies about using those techniques. And because I had

become interested in structured techniques, I started reading much more widely about them. I came across the dull Dijkstra and Hoare book, *Structured Programming*, and thought that, that the mathematical techniques that Dijkstra and Hoare were promoting were extraordinary and, and remarkably powerful. And so, really from there, wanted always to introduce as structured and then as formal methods as possible into any software team that I was involved with.

And the book you mention there, I mean, is still recognised today as…

Oh yes.

…as a, something we can all learn from.

It, it's a, it's a seminal text. It's, it's well worth anybody, anybody reading, reading that. It, it's eye-opening and, and quite foundational. It's, it's wonderful.

[43:42]
Mhm. You were there at South West Universities for about eight years. Would you… Perhaps you would like to share with us perhaps one, one challenge you had there, and how you, how you got over that. I'm sure you had many challenges, but, something that perhaps we can learn from.

I, I became, when the systems manager, the man who was the boss of, of David Bean, of, of me, and, and of the man who was running the, the networks group, when he decided to, to move on, I was appointed as a systems manager, and shortly afterwards I, I took on the role too of being deputy director of the Regional Computer Centre. And I had set up a group of people learning from, from the lessons really of the ALGOL 68 compilers. I had realised that there was an opportunity to build all kinds of software that the university needed, and to do without it costing the university any money. So, I started taking on commercial contracts on behalf of the university, and hiring people on short-term contracts to, to do that development work. And, it was, it was successful. You know, we had a team of half a dozen people there. David Ban had moved on, back into Logica at this time, and was, was running the office systems division of, of Logica in, Reading or Swindon, I can't remember which, Swindon I

think, called Logica VTS. And, I, I had this, this group of technical people, all of whom were on two-year contracts.
[45:33]
And then, there was a, a review of the funding of the Regional Computer Centre, and, as part of that review, I was instructed to close down the commercial work that we were doing. And, I've never fully understood why, but, certainly the feeling I had at the time, and, and I think the, the view shared by, by Jim Brookes, who was the director of the computer centre, was that it was political, that, that we were seen as, as a threat, because we were growing in staff numbers, through the commercial work, and, of course it kept raising the question of, why the other universities' computer centres around the region weren't also doing commercial work, and, and growing their staff numbers. It gave us perhaps too much independence, because we were able to use the commercial income for, for all kinds of other purposes that, that suited, suited us in the way that we wanted to develop the computer centre. And, so I was faced with the dilemma, that, I had been instructed to, to shut down an activity that I could see was, was the right thing for universities to be doing.

Mhm.

And I wrote to the Computer Board, and asked them whether they would be prepared to, to allow me to attempt to do this nationally, to, to run a commercial organisation that, that drew on staff from across all the university computer centres, in order to, to increase the funding to university computer centres. I didn't even get a reply to that letter. I asked the University of Bath if they would let me transfer the unit into the University of Bath Computer Centre, and they declined to do that, for their own reasons.

Mm.

But, you know, I had made a commitment to the people I had brought to Bath that I would guarantee their jobs, that although they were on two-year contracts, if they wanted to stay on, I would always renew them. And I had always managed to do that within the university. And now I was going, going to have to fail to do that.
[47:52]

And David Bean and I had always talked, because of his Logica experience, about the possibility one day of setting up our own software house. And this was the crunch really. I had got a team of people that could form the, the basis of a software house. I needed somehow to be able to continue to give them contracts. David Bean was feeling that, he had come to the end of what he wanted to do at Logica VTS. And so we agreed in principle that that was what we were going to do, and we started doing some planning for it. And then, David, as is his wont, precipitated action by telling me he had resigned [laughs] and we were starting two months later. And, and so off we went.

[48:40]
So this, this was in 1983.

This was 1983, and that was the birth of Praxis, yes. And we started by renting accommodation on the campus of the University of Bath.

Mm.

And we, and we started off by renting one office, and then two. And, and then gradually renting additional offices in, in the only corridor in, in building 1 West North that they had available for commercial rental. And, and finally we, we filled it up completely, and, and had to find our way to, to somewhere else, and moved into, into the middle of Bath.

[49:13]
Going back to the universities, what you are saying is, they didn't realise the commercial success within the computer centre was effectively funding other aspects where, where the universities themselves would benefit. Would that be true to say?

I think they really did recognise the commercial success, and didn't like it.

Oh right.

Because I think it was seen as politically threatening.

But they could see the benefit.

They could see the benefit, but, it was destabilising. You know, they were funded out of, out of limited university funds, and, and we were able to keep growing our staff numbers.

So it's not a question of they say, oh well, your priority's on the commercial side rather than the university side?

No. I mean, they may have said that; if, if they did, I don't, I don't remember it being said.

No no no. And so it's, it…

I, my feeling is that it, that it was a, a political decision, they, they just wanted to get control back over their regional computer centre.

Yes, it's difficult to understand, that's why I asked you, you know, the question. But, as you found it as well.

Yes.

But, as you found it as well.

It was, it was difficult for me to understand

[50:25]
So, Praxis was born. July '83, with David and yourself the first employees.

Yes. Yes, and, I think, five of the six people I had working for me in, in the university decided that they were prepared to take the risk and transfer to this start-up. And, we took with us the contracts that we had already won within the university. So

we, we started with… Because we, we couldn't leave the university saddled with a set of contracts that they now no longer had the wherewithal to, to deliver against, they were delighted to get rid of the contracts, and it gave us work to, to start up. And we were partway through developing a, a FORTRAN compiler for ICLs Distributed Array Processor, a, a very strange array calculating engine that was of particular interest to the military.

Mhm.

We were partway through developing and supporting a compiler for the electronic logic language, the VLSI designed language that the Ministry of Defence was using for developing computer chips, and which by that stage a number of the VLSI foundries in the UK, and there were, there were a number that had been set up under the, under the Alvey Programme some, around the, in the early 1980s, set up and, and had continual funding that way, that were using, using ELLA as well. So there was a, there was a market for, for ELLA. And, very, very early on, as part of the Alvey Programme, ICL won a contract to do quite a lot of research and development projects for the Alvey Programme, which they couldn't staff. And because of our relationship with ICL from the other things that we were doing, astonishingly, they gave us a, a five-year commitment to, to £2 million worth of work a year. And, and on the back of it, we just started hiring and growing. So, we, we immediately, on, on starting in July '83, took the decision that we were going to hire a bunch of new grads, and we, we hired them and brought them in, and started teaching them ALGOL 68 and, and structured programming techniques. And, we, we just carried on growing. So we, you know, we started off with, with very few people, and by the end of the first year I think we had got twenty-two or, twenty-four, and by the end of the next year we were up to forty-seven, and by the end of the year after that we were over seventy. So, yeah, we were, we were very ambitious in what we were doing, and we, and we kept recruiting into the growth that we could see ahead of us.

[53:41]
Yes, and normally I ask someone in a start-up situation, you know, how they funded that first step. But effectively what you're saying is, you, you already had that relationship with these clients, you in fact took them from, I say took them, with the

university's permission, from the university's computer centre, who didn't want, want to continue those contracts, and therefore you had the income to fund Praxis.

We had the income to, to make a business plan credible, but of course we needed start-up funding. Because, you know, we needed facilities, we needed, we needed desks and offices, we needed to be able to pay salaries ahead of being, of bringing money in and so on.

Oh right, OK, yes.

So, you know, there was, there was working capital. But, we put some, some money in, David and I put some money in. Jim Brookes, the director of the computer centre, put some money in. And, we took out a Government-backed loan. There was a, a Government-backed loan scheme then for start-up companies that reduced the risk to banks that, that provided start-up funding. And, we tried, tried to get Barclays. David had a good relationship with his bank manager at, I think Barclays in Oxford Street, who had been doing lots of these start-up loans, and agreed that they would give us one. I was banking at Coutts for some, some rather amusing reasons, which I'll tell you about it if you like.

Yes.

And, at the last minute, David's bank pulled out. They said that head office said that they had been doing too many of these things, and had forbidden them to do any more while they carried out an investigation as to how successful it was being.

Mm.

And so we, we er left high and dry. And I contacted Coutts to say, 'Look, this is the situation, this is where we've got to. You know, we've got the business plan.' And Coutts came back to me immediately and said, 'Well we've never done one of these before. Come and talk to us.' And a week later, the whole thing had gone through. I mean it was an astonishing piece of, of banking by, by Coutts, who simply decided that, that they liked the scheme, they, they liked us; they had never done anything like

this before, but it seemed like a good idea. They liked the business plan. And, and so, so Coutts did it. I, I've become a, a, a client of Coutts, again, just, just by chance. I, I was a, I had a bank account at the Co-Op.

A long way from Coutts then.

And, the Co-Op refused to give me a cheque guarantee card, because, you know, I was a student, and, and they weren't prepared to do that. And that was really awkward, because, you know, cheques were, were the main currency at that time, apart from, apart from cash. And I was moaning about this to, to a colleague, somebody else who was working in the, in the *Pi* office in the, in the university newspaper office, at the student bar one day. And he said, 'Oh I, I bank at Coutts. Why don't you get an account at Coutts? Nobody has bounced a Coutts… Coutts haven't bounced a cheque since, since the sixteenth century, and they're not about to bounce one now just because it's you.' And so nobody ever asks for a, for a guarantee card for a Coutts cheque.

Right, I didn't know that.

And I said, 'Well they wouldn't take me on.' He said, 'Well as it happens, they seem to be looking for customers at the moment.' So I contacted Coutts, and as a, as an impecunious student, they gave me a, a chequebook and, and a bank account. And it was absolutely true, nobody looked twice at… Well they looked twice at a, at a spotty student giving them a Coutts cheque, but they never refused one.

Mm. So from the Co-Op to the Queen's banker in…

From the Co-Op to the Queen's banker in, in one step. Yes, it was…

Brilliant.

It was… I mean, you know, things happen to you don't they, and when they do, you just grab the chance and run with it.

[58:07]
Mm. You were with Praxis for nine – well, nine years, and we'll come on to what happened at the end of the nine years. What would you say your proudest moment was during that time?

I'd… It's really hard to say. And we… We had the opportunity to, to acquire a group of people who were working in mathematically formal methods. We, we were good at structured methods and, and you know, high quality programming. I guess, the first really proud moment was when we became the, the first independent software house to, to win the quality standard, British Standard 5950. No, 5750…

5750, yeah.

…which became ISO9000, for, for all the work that we did. And, and we, we did that because, we had got a, a quality manager that we had hired, Chris Miller, who was extremely good at, at introducing and developing quality systems that were, were fit for purpose. And, and we really needed, you know, we saw ourselves as a, a high quality engineering-based software company, and, and therefore we needed to work to high quality standards. So, so being the first to, to, 5750, for everything that we did as an independent software company, was, was a, a big step.
[59:48]
And then, an organisation that was in the lead in, in total quality management in, in America, decided to run a major conference, and invited Texas Instruments to represent best practice in software development in America, and Praxis, as the representative of, of best quality software development in Europe. And, that was a proud moment, particularly, you know, we, we had to give a whole string of presentations, both us and Texas Instruments, and when we had finished our presentations, the Texas Instruments team came up onto the stage and, and said to the audience that, that they gave us best, that they thought that we were doing stuff that they could only admire, and that they would like to ask us in front of the audience if, if they could come over and do some benchmarking with us. So that was, that was a proud moment.

Mhm.

[1:00:53]
Winning the CDIS air traffic control system for, for National Air Traffic Services, was, was a, a very proud, and very scary, moment. We bet the company on that. That was a, a project that had a value that was, significantly more than our annual turnover. And, it was very brave of, of NATS to award a contract of that scale to, to a company, a company such as us. But again, you know, we, we knew them, and, and they had learnt to trust us, and, and we had… We had used mathematically formal methods in preparing our bid. So, in, in, before we had, had actually submitted our bid, we asked them over 200 detailed questions about their requirements that weren't in their specification that they had put out to contract. And I think that deeply impressed them. Because we, we had formalised their requirements, and we could see all the conflicts and, and omissions that were clearly evident in the, in the formal requirements that they had produced. So that was, that was a proud moment.

[1:02:07]
And, bringing, I say, to today, I mean we're, it seems every week we seem to get another so-called IT disaster, whether it be, well recently two banks have had serious issues.

Yes.

Two large national banks have had serious issues. We've had, probably, well from a different area, security with the NHS. Do you think that the industry as a whole has kind of, departed from a kind of, a rigorous approach to the development of software, or, or structured approach should I say?

No. I think the industry has never *had* a rigorous approach to the development of software. I think that it's been too easy to make money in the software industry, and that, software development has never matured as an engineering discipline. It, it has, has grasped the title of engineering, software engineering, without ever realising what it is that other engineering disciplines do that entitles them to call themselves engineers.

Mhm.

And so I think most programmers don't understand computer science, and don't use science-based methods. I mean two, two simple examples. You know, we've known at least since the mid-Sixties that you can't find most of the errors in software by testing it, no matter how much you test software. You just can't. Software systems are too complex. The state space that they occupy is too complex. You cannot possibly test them exhaustively. It just takes too long. And you think of a, you know, a simple… You, you can write a one-line program that would be an absolute nightmare to find an integer overflow in, simply because, because the number of states it would have to go through would, would be too many to be able to run a sensible test suite. And, and given that, that you can't therefore show the absence of defects by testing, and, and therefore you can't assure any particular level of quality by testing, you know that you must actually, not give up testing, but rely much more heavily on analysis, that, that it's, it's by analysing software, which is after all a mathematical object, even at the assembly code level, or at the binary level, it's a mathematical object. It's, it's got operational semantics, otherwise it couldn't be executed on a computer.

Mm.

And so, of all engineering artefacts, it is the one that you must be able to reason about, but you can't do it at, at the binary level, because the complexity is too high. So you, you have to do it by reasoning about, your specification, and then about your design, and then about your implementation, and by showing that, that there is a, a correlation, that, that the design does in fact implement the specification, and the implementation does in fact implement the design. And then by reasoning at these abstract levels, you can get a very high degree of assurance that your, your software is right. And then, obviously, you run some tests as a, as a safety net. But, but you ought, at the start of testing, you ought to be believing that you're not going to find any errors, and when you do it should come as a shock that tells you, something went wrong earlier in the process, and you'd better go back and fix it in the process. Because you should not be finding errors in something by the time you get through to, to actually having a, an artefact that you're, that you're building. So, unless you've

got that mindset, which is… You know, that's all bridge builders do. You know, they don't just chuck up a bridge and, and then test it to see if it falls down. You know, you're building something like the Shard, you don't, you don't build it and then do, do the testing to see whether you've, you've actually built it with enough strength to carry the floor loadings that are going to be needed when people move in. You, you do the maths. You, you use the science. You make sure that, that every stage of the process is built on sound science and engineering experience. So you expect it to work when, when you've actually built it.

Mhm.

[1:07:88]
And increase… You know, hardware, hardware manufacturers do exactly the same thing. They reason about, about the, the behaviour of their chips. And, it's only software where people think that, build it, test it and fix the bugs you find is an appropriate way of trying to develop product quality software. It's just rubbish. It's amateur. It's unprofessional. And it's, it's at the root of all the problems that we've got in, in for example, the, the current cybersecurity crisis. You know, almost all cybersecurity problems are software design defects, either at the implementation level or, or simply because we're, we're giving users tools and then telling, you know, that have been designed to work in a particular way, and then telling them, you know, 'Oh don't use this the way it's designed, you know, don't, don't open the attachments that we've said you ought to be able to send using these emails. Don't click on the links that we've said you can embed in the emails. It's not safe to do that.' Whereas, you know, obviously, we could build email clients that were sufficiently sandboxed that you *could* click on the link safely, and you *could* open the attachment safely. We, we choose not to give users tools that are fit for purpose, and then we blame the users for using them the way they were designed.
[1:08:10]
But, but at the deeper cybersecurity level, buffer overflows and, and cross site scripting, and these sorts of things, you know, these are type violations, if you look at them from a, a point of abstraction.

Mm.

A decent programming language wouldn't let you make most of those mistakes. What are people doing, wiring in a language that makes a buffer overflow even possible? We've known about strong typing since ALGOL 60.

Mhm.

Since ALGOL 58. So, what is it that causes people to say, 'Oh I can't cope with the constraints of strong typing. You know, I'm, I want to be able to define something as a text string, and then treat it as a numerical object, or a pointer'? [sighs] It's just stupid. It… As I say, it's amateur and unprofessional, and, and we really, really ought not to tolerate it. And companies who do that, ought to bear at least some of the liability for the consequences.

Mm.

[1:09:19]
Praxis gave guarantees.

Right.

When we wrote CDIS we, we gave them a ten-year warranty. We would, we would go back and, free, we would go back and fix defects that occurred free, serious defects, if they were defects in the implementation of the spec. If they had changed it, then, if they changed the requirement of the, the software, then, then the bets were off. And, and if they were doing something that wasn't in the requirement spec, the bets were off. But, but in terms of implementing what we had agreed to implement, we'd fix defects free. And I think they only ever called us back in once. What they did do was to ask us to come back in, several times over periods, to train their operators in how to start the system up. Because it hadn't failed, and they had forgotten how to reboot it if it did. And so we had to keep rerunning the, the training course for, for booting the system. You know, that's quality software.

[1:10:25]

With your knowledge today with, with the market, are there, are there other organisations out there that would give that type of guarantee these days?

I don't know of any that will give you those sort of warranties, other than, than the company that is the, the company that, that acquired the key part of the process.

Altran, yes.

Which is Altran UK.

Yes.

They're prepared to warrant software.

Right. OK.

Because, they're, they're still using those sorts of methods, you know, they, they use the, SPARK toolset, and, and produce proven software, and they expect their software to work first time and forever.

[1:11:07]
Mm. At Praxis, you also won the, the Queen's Award to industry as well.

Yes. Always regarded as a kiss of death. [laughs]

Oh right.

You know, most, most organisations that seem to get Queen's Awards run into, into some financial difficulties subsequently, I'm not quite sure why, why that is, but it was certainly well-known at the time. It was, it was almost as bad as appearing on *Tomorrow's World*, which would always, you know, the television programme…

Yes.

…that always seemed to be a, a way of predicting which companies were going to be disappearing over the next decade or so. But yes, we, we got a, we got a Queen's Award. I think it was actually for, for the work on ELLA. I think it was joint with RSRE Malvern, the Radar Establishment.

The VLSI designed…

Yes.

[1:12:00]
Yes, the… Yes. And, must have been an honour. But, after eight years, you decided to, to… You had taken the company public.

We, we took the… Well, I mean we didn't take the company public in the sense of floating any shares.

Right.

We, we converted formally, from being a limited company to being a plc.

Right, OK.

Because, we were in a building in, in Bath, in Manvers Street, where the head landlord required a bank guarantee on the, the rent that we were paying.

Mhm.

Which was costing us money. And, we had negotiated at the time that we took the lease that, if we ever became a plc then, we wouldn't need the bank guarantee any more. So, so we became a plc.

Yes.

And, and didn't need a bank guarantee any more. So that, that worked fine, that seemed straightforward. But… Yes, in, 1989 I guess, Touche Ross, as, as they were then called, came knocking on the door asking us, saying that they were, were looking to acquire a software company of around our size, and were we interested?

Mhm.

And, we had an open door policy basically, that if anybody approached us and said they would be interested in talking to us about acquiring us, we would always talk to them, because you always learn some stuff by doing that. And it turned out that what Touche Ross wanted was a company essentially to become the software division of, of Touche Ross, to take over the people who were currently doing software development in Touche Ross, and, and to grow significantly. And, and we were faced with the strategic decision, did we want to remain essentially a, a niche company, or, or did we want to take the opportunity to join a company that was doing work nationally and internationally, and which had the resources to really expand? And we saw it as an opportunity to, to take the message of proper software engineering into a very very much wider space. And so, we agreed to be taken over, to, to sell to, to Touche Ross, largely for those strategic reasons.

Mhm.

I mean we, the UK economy was running into some difficulties at that time, and we were running into some financial strains that meant we were probably going to be needing to make some people redundant, which we hadn't needed to do before. Except, when we, when we sold off the ELLA part of the business, but that's a separate issue. But… And, and so, you know, for, for those, those two reasons, because it, it removed any financial pressure and, and guaranteed the, the future of our staff, and, and because strategically it felt like the right thing to be doing as the next step of our, our growth as a, as a leading software company in the world, we, we agreed to continue negotiating and, and finally to, to actually go through with the, with the takeover. So we became the, the computing division of Touche Ross. And Touche Ross then managed to regain control over the Deloitte name, which, which they had lost as part of various partnership mergers that had gone on previously, and

they, they became Deloitte & Touche. And then, Deloitte &Touch internationally merged its consultancy practices to produce the Deloitte & Touch Consulting Group. And, and David and I became partners in the Deloitte & Touche Consulting Group. And then, because the consulting group was dominated by the American partners, we found that actually we weren't in a good place at all, because we didn't have any control over our own future. And we were part of an organisation now that didn't believe in the kind of software engineering that we believed in, and, and indeed, was terrified of the safety-critical work we were doing, and, and told me to close down the critical systems division that was doing all the safety work and where all the formal methods stuff was.

Mhm.

[1:16:57]
So, it turned out to be a mistake, going through that, that sale. With hindsight, I, I wish we hadn't done it. But, you know, it, it looked like the right thing to do at the time. And I suppose, what lesson do you learn? That, that you do of course lose strategic control when you go through a, a sale like that. However much it looks as though you've got control over your own future, as somebody else's subsidiary, you really don't, whatever promises they've made, whatever commitments it looks as though have been made. [pause] And, and that's a hard lesson to, to have learnt in, in a hard way. But I did manage to rescue the, the critical systems division by, by getting Deloitte's to agree that I could, I could sell it, rather than close it down, and, and running a, a sales process that, that sold it to Altran.

Right, yes.

Unfortunately, one of the conditions of that from the Deloitte side was that I didn't go with it.

Right.

So, that separated me from, from the Praxis critical systems people, and, and from what subsequently has happened within, within Altran UK.

[1:18:24]
Mhm. So, it was 1992 that Touche came in and, or, or you became a partner there, and you were…

Yes.

...there for about five years. You talked about the Americans effectively instructing the sale of the sector, critical development. Was that the… Oh yes, because, they just weren't prepared to take the risk, is that the…?

Yes. It, it's the liability, the, the thought that, you know, we were doing air traffic control systems, and, and if anything went wrong, they might get sued in, in American courts, and there might be some extremely high penalties. It just wasn't a risk worth taking from their perspective. And they didn't understand what we were doing anyway, so, and therefore didn't value it, and, and we were seen as very small compared with some of the software activities that they had got under way. So we, we weren't strategic, that group wasn't strategic, and, and they, you know, the easier thing to do, safe thing to do, was get rid of it.

[1:19:23]
Can you think of any… I mean, Praxis was a, a success, and, and its achievements. Can you think of any events that set it on the road to success that you could highlight?

Well it… It was our determination to be a high-quality software company, and to, to focus really on quality ahead of profit. I mean, we, we were very much an organisation that, that first and foremost believed in treating software development as an engineering process, and, and would not compromise on that, and, and hence, you know, we had our, our ISO9000 certification, we were trading heavily on that. We had, we acquired a, a formal methods group when, when it was, was falling out of, of another organisation that needed to close it down, and, and as a consequence had, had staff who were able to do mathematically formal software development. We had other staff who were very keen to get involved in doing that sort of software development. And so, we, we were on a, a path where, we saw ourselves as, as the

highest quality software developers in the UK, and, and in Europe perhaps. And, and that was, that was the root of our success, because, many companies around us saw us in that way as well, as, as exemplars, particularly of the mathematically formal methods. Because nobody was really doing that. I mean, Logica Cambridge was doing, using some mathematically formal methods, in some secure, cryptography and encryption work that they were doing for, for the military, or, or for the agencies, I don't know which. But, but nobody else was trying to use mathematically formal methods on ordinary commercial development contracts, and, and we were. And, and so, of course we talked about it, we talked about it at conferences, and, and we, we did lots of benchmarking with overseas companies who came over to see what, what we were doing. And, and so we had a very strong reputation, that was… It's that reputation that, that I think is what makes Praxis a, at very best, you know, a, a serious footnote in the history of software development.

[1:22:08]
Mhm. And, if you had your time over again, is there anything you would have done differently, and, and if so, what?

Well I wouldn't, wouldn't have sold the company.

Wouldn't have sold, yeah, I thought you might say that.

Yeah, I'd have, I'd have, I'd have found a way through, through the recession that we were facing, and, and kept going with, with hindsight. But, it, it was, it was a difficult decision to take, and, and you, you know, you, you take the decision that feels right at the time. [pause]
[1:22:35]
What else wouldn't I have done? What lessons have I really, really learnt from that? I'm sure there are, there are lots. We, we took in some funding and, and acquired a couple of non-exec directors. The non-execs were, were terrific actually, they were, they were really helpful. But having external investors was, a serious irritation in a number of ways. I think I, I would have thought harder to, to manage to find a way to stay organically funded, even if that reduced our rate of growth, with, with hindsight. We were commercially naïve. Profit felt like a, like a bit of a dirty word. And, and

building up financial reserves wasn't therefore… You know, it… Because it looks as though it was wealth that belonged to the shareholders, and because the major shareholders were the founders, it, it didn't look quite in accordance with the ethics of the company that we were running, which was a very open company. I… Everybody in the company was a shareholder. We, we, we gave people the opportunity to buy a number of shares, fifty quids' worth I think it was, on, on recruitment, and, and if they didn't have fifty quid, we would lend them the money, because we wanted everybody in the company to be a shareholder if they were willing to be a shareholder. And that, that had a big influence on, on the internal culture of the organisation. It meant that every staff meeting was a shareholder meeting.

Mhm.

I was doing monthly reports on the management accounts to my shareholders at staff meetings. That, that sort of, it empowers staff to ask very hard questions and to demand a say in, in strategic issues, and that was the kind of company that we were.

Mhm.

You know, we had endless debates about, about the sort of work we were willing to take on, whether we would, would do weapons work, and, and what we meant by weapons work, when we decided that we weren't prepared to do weapons work because we wanted to do things that were positive rather than design for killing people.
[1:25:16]
I remember Martyn Ould tried to write a taxonomy of what, what were weapons, and, and he got it up to about seven full pages of, of, you know, an individual structured taxonomy. And then somebody pointed out that in his experience in the Navy, the system that did the, the, that devised the, the menus for the, for the on-ship catering, was most certainly a weapon. [laughs] And at that point the whole just collapsed. It became… Somewhere I've probably still got that taxonomy, and if I haven't, I'm sure Martyn Ould has, because he keeps everything.

[1:25:56]

Mhm. So, take you back to '97. You sold the, the critical systems side of the business.

Yes.

You've already said that, because of contractual agreements you couldn't follow that, that side of the business. So you left Touche Ross, or, Deloitte's as they were then.

Yeah. I, I had become a, an international partner. I… I never really understood the politics of, of what was going on in the, in the consulting group. It went through some, some convulsions of its own, and, and started losing money, and, for a while I was the only partner whose group was making significant profit. And, and David Bean had left already. And, I think, perhaps they, they wanted to get rid of me, because I was seen as anomalous, but, I, I ended up as a, as an international partner responsible first for software engineering, advanced software engineering worldwide in the consulting group, which was a pretty notional thing, but, but meant that I got paraded in front of some customers, and in particular in front of, of Gartner Group when they were doing evaluations of various things.

Mhm.

But then they needed somebody to lead the year 2000 services for, for the consulting group. And I hadn't really realised just how serious a threat Y2K was, but, but got in, you know, once I realised, I became a, a very strong advocate for urgently sorting out the issues, because I could see how, how damaging it was going to be if, if the problems weren't solved. So I, I spent some, some time leading the, the consulting group's Y2K activities internationally.
[1:28:03]
But, the culture was so different from, from anything to do with software engineering as I understood it, and the culture within a… The partnership at that time felt to me to be, to be toxic. It, it was too money-focused, and, and there was a, a level of bullying that I, that I couldn't tolerate, that, that was happening. Not bullying me, but, you know, that I, that I was witnessing or, or told about. And I just decided, at, at a meeting of the, the service line partners in America, where I had tried to sell them the idea that the consulting group ought to take on as a, as a strategy, being the leading

consulting group worldwide that sold itself on the basis of adding measurable value to its clients' businesses, and that therefore each of the service line leaders ought to work on ways of, of coming up with metrics to measure the value that they were adding to, to their customers' businesses, and maybe even charging on the basis of, of just a percentage of the value that, that they added. And it was flatly rejected by, by the service line leaders. They didn't want to discuss it. And I came away from that meeting having told the head of the service line leaders that I was going back to England and that I would be resigning. And I went back and, and resigned.

[1:29:52]
Mhm. Since that, that time, in '97, you've been extremely busy, in, a non-executive director, you're a visiting professor in a number of universities, and involved with quite a number of government bodies.

Yes. Throughout my career I've, I've been on various government committees. It's always seemed to me that, you know, if you, if you've got a bit of a mission to try and, and improve the quality of software development, and to get software development recognised and becoming an engineering discipline, then, you, you look for the places where there might be some leverage. And so, when there are opportunities to get involved in government committees that look as though they might be influential, or, or where it might be possible to help the process of transferring technology from universities out into industry, I have been willing to put time in to, to try to achieve that. Because, you know, I'm helping the committee and, but at the same time I'm advancing an agenda that I think's important. And, and so, yeah, I must have served on, oh, a few dozen committees of various sorts for different government departments and for the European Commission over, over my career since, probably starting in the late Seventies.

[1:31:24]
Mhm. And… [pause] Martyn, I'm conscious you've had a, you have a number of non-executive roles. I wonder, perhaps you could talk us through your experience perhaps at, a couple of them, let's say leading off with SOCA, the Serious Organised Crime Agency.

Yes. Happily I… I was interested in, in doing the, the role. They, they were looking for somebody who could lead on science for, for the board of the Serious Organised Crime Agency, because the Chief Scientific Adviser in the Home Office wasn't able to, to put in a lot of time supporting the Serious Organised Crime Agency. He had much wider responsibilities. And so they, they needed a, a technical person who could, could help them with scientific aspects. And, it just looked absolutely fascinating. I mean the Serious Organised Crime Agency was, you know, it's, it's right at the pinnacle of, of dealing with, with serious organised crime, and, and consequently with, with some issues that, that as a member of the general public you, you just never, never get inside, you never get to see the kind of operations that are going on and the kind of, of ways in which serious organised crime is, is tackled, and how the intelligence is gathered, and, and how finally the convictions are, are obtained. And, there were two particular areas where the board needed somebody with, with strong technical skills. The first was, was that they were in the throes of an IT modernisation programme, that really needed board oversight because it was so critical to the operation of, of the entire organisation. And the second was the operational technology, the, the covert technology that, that is, is used in, in security operations. And, and so I was able to provide the, the technical support to the board that was, was needed in, in those areas, and, and I think, you know, delivered useful value to them, whilst at the same time finding it utterly fascinating myself to, to be privy to, to the, the way in which such an organisation operates.

[1:34:07]
And, one of the other areas, well, you've spent, what, the last four years involved with the Health and Safety Executive as well.

Yes. Science again. There was an opportunity to, firstly to, to join the board of the Health and Safety Laboratory, which at that time was a, an arm's length body that belonged to, to the Health and Safety Executive, which itself is, is part of the Department of Work and Pensions. But it's, it's one of the remaining, that laboratory is one of the remaining public sector research establishments in the UK. And from my earlier experience of working with the Royal Signals and Radar Establishment, and, and then to, to a degree with, with some of the other, the National Physical Laboratory and, and some of the other public sector research establishments, I

developed a, a real affection and respect for the work of Government scientists. And so, the opportunity to, to be on the board of, of the Health and Safety Laboratory was one that, that I jumped at. I knew it was going to be interesting, and indeed the, the range of capabilities that exist at, at that laboratory in, in Buxton, in Derbyshire, is quite extraordinary. I mean they, they, we, have, have the ability to, to do a remarkable range of the things that you, you need to be able to evaluate in order to do the fundamental research in the science that underpins both the policy work in health and safety, you know, the regulatory work in health and safety, and also the major accident investigations that, that go on when something dreadful happens, like Didcot for example. And they have the ability to, oh, to, crash vehicles, to create major fires, to reproduce the Buncefield fuel explosion, in order to really understand how it happened. To, to work with things as toxic as Ebola in order to be able to develop the appropriate protective equipment for, for the, the front line responders to, to the Ebola crisis. And to a huge range of, of other issues that, that, as I say, provide the, the strong science and engineering foundations on which it, it is possible both to regulate health and safety in the UK and to, to bring successful prosecutions when, when that's necessary, against, against the people who have allowed serious accidents to occur by failing in their duties to, to reduce risks.

Mhm.

[1:37:11]
And I then moved, at the… After the triennial review of the, of the Health and Safety Executive, which recommended merging the laboratory back into the centre of the Health and Safety Executive, I wanted to protect the science to make sure that it was properly understood and respected by the rest of the Health and Safety Executive, and so I applied to join the board of the Health and Safety Executive itself. And I'm, I'm still a member of that board, and in fact I chair the board subcommittee that oversees all of Science Division's work, and, and all the, the science, the engineering, and the evidence gathering that is, that is done within Science Division for, for the Health and Safety Executive to, to provide that, that fundamental support to all the other work.

[1:38:08]

And presumably the HSE get involved with public inquiries as well into tragedies and things like that.

They, they do give evidence to public inquiries, or, or will, will provide support where, where necessary. HSE has, has been providing some, some level of support after Grenfell for example.

Yes, I…

You know, I mean, in particular of course it was, it was very important to ensure the safety of the people who were dealing with the aftermath of, of the Grenfell fire, because, you know, a big fire like that, leaves a lot of toxic residues, and therefore you, as, as you, of necessity, have to, have to be sifting through the residues and dealing with them, it's extremely important to keep the people whose job it is to do that work safe as possible. So… And, and the structure of the building itself of course was, was a question for a while.

Mm.

And the safety of that. So, yes, HSE has, has provided support there, and in various other areas where, where the science needed to be, either explained or, or extended in some cases by, by doing particular experiments and testing.

[1:39:29]
I wonder if you would say a few words about how you see the state of cybersecurity today. I appreciate it's a massive subject, but I, I understand you, you actually reviewed the MOD's, Ministry of Defence, cybersecurity science capability, and assisted with the review of the cybersecurity strategy and implementation across security agencies. So, a very senior role with those organisations. What's your view on the state of play as regards cyber security at the current time?

I'm very worried about, about the state of software, and, and the growing and already high cybersecurity threat of course is the context within which I'm worried about, about the state of, of software. We've built a digital society on badly engineered

foundations, because, we have never properly engineered the software on which so much of our society depends. And a lot of the vulnerabilities that, a lot of the defects that are in the software, that, on which we depend, can be exploited as, as vulnerabilities for cyberattacks.

Mhm.

So we've got a lot of badly designed, difficult to use software. We've got a lot of software that is just badly implemented and, and consequently can be, can be penetrated and, and exploited in various ways. And there is no strategy to get us out of that mess. The, the work, the strategies that exist, the recommendations that are put forward at the moment, are, are reactive. They are, they're an attempt to try to minimise the consequences of the defects that exist in the software, rather than looking to the future and saying, how can we replace the software with software that does not contain exploitable defects, and how can we make sure that new software that is being put into critical areas doesn't contain exploitable defects? There's no strategy to do that, yet, and, and no real commercial motivation for commercial companies to do it, because they don't carry the consequences of, of their customers being cyberattacked, or of, of systems failing and, and causing societal damage through, through cyberattacks.

Mm.

So, it, it's… Somehow we… Our strategy seems to be to train more people to do penetration testing, when we know that testing can't find most of the defects that, that you're worried about anyway, so… It, it's a bit like saying, you know, we, we live below sea level and the dikes are failing, and we need to train more people to, to shove their fingers into the holes that are emerging in the dikes, rather than saying, we need to do something about building some new dikes.
[1:42:52]
And, and the other thing that we seem to want to do is to train people to write bad software. You know, the whole notion that, that it, it's really in, in the country's interests to train lots and lots and lots of students to write software as part of everything that they do in the hope that, that they will, you know, become the next

Facebook, when we're not teaching them to write secure software, we're just teaching them to write software in a, in an agile way, to, essentially to write prototypes that look as though they provide the functionality you want, and then to get them into the marketplace quickly and to win the market share, which is the commercial winning strategy, well it's also the strategy that leads to the world being full software that's riddled with security problems. And, it, it alarms me. I, I can't see this ending well. Unless the world can find a way to reduce the level of vulnerabilities that exist, we will see an ever-increasing range of, of exploitation of those vulnerabilities, firstly by criminals, secondly by, by activists for their own purposes, thirdly by terrorists, and fourthly by hostile nations.

Mhm.

And, and we're told by the security services, and, and by the National Cyber Security Centre, that the level of those threats is going up all the time. The, the head of Defence Intelligence said at a meeting just two or three weeks ago that, a full-scale cyberattack would cripple our country in minutes. And, and apparently later in his speech he went on to say that the UK should be willing to launch such a cyberattack. And, it… I, I've heard it suggested that a full-scale cyberattack is essentially as devastating as, as a nuclear attack. And, [sighs] and yet we, we don't have anything approaching the idea that, that we should have a, an offensive cyber non-proliferation treaty. Indeed, you know, last December the UK signed a, an accord with Poland I think it was that included as part of its text that the UK recognises the right of every country to have an offensive cyber programme. Now, you know, you slot nuclear in there instead of cyber, and, and that's a shocking statement. But, but if cyberattack can be as devastating as the head of Defence Intelligence says it can, what on earth are we doing saying that every country has the right to have that capability? This, this is not a sensible strategy for the future.

[1:45:55]
Mm. And, and, this goes back to the, the root, the way, effectively software is built, you know, people not adapting, or adopting I should say, rigorous software engineering.

Absolutely.

And… So…

I mean so many of the, of the ways in which people take over systems, are just buffer overflow attempts. I mean there are lots of other attacks you can use. But, but buffer overflows still seem to be a very fertile way of being able to, you know, break into the workings of a car through its radio systems for example.

[1:46:33]
Yes. I suppose that leads us on to, perhaps your work in, or current work, in academia. I mean, I know you've been in the past a visiting professor at Oxford, and I think you still are at Manchester and Bristol and Aberystwyth.

Yes, I've recently been appointed to, to a, a visiting professorship at, at Manchester in the, in the Thomas Ashton Institute, which is, an institute doing research in, in reducing risk and improving regulation of, in the safety, safety space. They're doing some, some really interesting work, really, as much as anything to, to learn from the vast experience that HSE has got in all the data that it's collected as a result of its accident investigations. Because, one of the great strengths of the science in, in HSE is that uniquely in the world, it brings together both fundamental science and, and a huge amount of empirical evidence from individual accident investigations.

Mm. And presumably the message is, your concerns, you deliver with your time at these universities, through lectures and papers et cetera.

I, I do what the universities would like me to do when I've got time available. I… I've worked with universities throughout my career, as much as anything because, it, it was a way of, of getting good technology into practice, and, the universities value the, the commercial experience, the opportunity to work on real commercial problems, and of course practice benefited from having access to, to really leading theoretical computer scientists, to, to be able to help us solve particular difficulties that we have. I remember when we were building CDIS, the air traffic control system, for NATS, for example, we had real difficulty in being able to show that the

dual token ring network that we were building couldn't deadlock. And we tried to, to work through the, the proofs, we had got them expressed in a formal language, and couldn't get the proofs to work. And, and finally we, we got the centre for, for the foundations of computer science in Scotland to work with us, and they were able to show us that actually, the reason we couldn't get the proofs out was because there was a deadlock capability in these, these protocols that, that, we were using some, some IBM technology, and, and the protocols were in fact capable of, of deadlocking. So, we were able to fix that problem, having, having found it through, through failure to be able to prove it didn't exist.

Mhm.

[1:49:38]
And, and it's those relationships that, that have led me to want to contribute back to universities all the time. I mean, throughout my career, when I've, I've had a, a challenge in computing where I, I needed some up-to-date information as to what the state of the art was in a particular area, I've been able to fire off a, an email to a world expert in the subject, and quite routinely, I've had back, you know, three paragraphs of, of information which, if I was a commercial organisation wanting to buy that expertise, would have cost me thousands of pounds, and, and would have taken months to get.

Mhm.

And, and that relationship has been enormously beneficial to me. And, and it seems right that I should, I should be doing my very best to, to repay that debt. And so I, you know, I have, I have worked on steering groups for research projects; I've, I've helped write proposals for research projects; I've, I've helped write reports that came out of research projects, and, and the books that, that come from there. I, I work with individual academics on, on papers that, that they write.

Mhm.

Always happy to, to review stuff and, and you know, make, make contributions where I can. Sometimes I get to talk to students. Sometimes I, I give public lectures, or, lectures to, to larger groups of people at, at the universities. Sometimes I just talk to academics and, and you know, talk in departmental seminars or, or something. But, you know, it, it depends what, what it looks as though I might be able to contribute. You know, I, I recognise, I'm no academic computer scientist, so, I, I don't expect to be able to make a big contribution there, but, I do have a, a very broad view of a lot of different technologies in different parts of science, and different parts of engineering, and, and how they interact. And because academics are driven these days to be more and more and more and more specialist, that breadth of view, the ability to say, that's, that very interesting, how, how does that relate to something that I know about over here, where what feels like the same sort of problem came up, and it had these manifestations. Those, just raising those sorts of questions, seems to be very highly valued by, by the people that I talk to. And I, I'm always pleased and surprised that, that the contributions that I make are considered, significant by, by people who I respect for their astonishing intellectual achievements, and, and academic abilities.

[1:52:41]
And in the last three years, from 2015 through to '18, you are the Inaugural Livery Company Professor of Information Technology at Gresham College.

Yes.

Perhaps you could tell us, perhaps you could tell our listeners a little bit about Gresham College and how that appointment came about.

Gresham College is an extraordinary institution. It was founded under the will of Sir Thomas Gresham, who was a financier back in Tudor times, who founded the Royal exchange in London. And, as you would expect of a man working in those areas at that level, he became personally very rich. He died without an heir, and left instructions in his will that the revenues from the Royal Exchange and, and his other wealth, should be used to found a college that would provide free public lectures of the highest academic standard for the citizens of London. And, that institution was, was set up, and the, in, in the first and early days, professors actually had private

accommodation in the City of London that was given to them free. They gave lectures on, on a daily basis, and the lectures were, were delivered first in English and, and then in Latin, in the afternoons. Luckily we've dropped the requirement to deliver the lectures in Latin. But, but Gresham College has been providing public lectures of high academic standard free to the public since Tudor times, and continues to do so on a, on a regular basis, and we're moving into the twenty-first century by streaming those lectures live on YouTube now, and we have a, a big digital archive of previous lectures that are freely available. And every one of the lectures is accompanied by a written paper of, of high, high standard, that is, is labelled as a transcript but is usually much more than a, a verbatim transcript of the lecture. [1:55:09]

And the IT Livery Company, the Worshipful Company of Information Technologists, decided that they were willing to sponsor, the very first time, a chair in information technology in Gresham College, and Gresham College advertised that vacancy, and I applied for it, because it gave me access, potentially, to an audience that I have not had the ability to address before, the, the public of Gresham College, and to be able then to have those lectures preserved really forever on a prestigious website that can be used by, by anybody who wants to, to download and use either the video materials or, or the transcript papers worldwide. And, and I have thoroughly enjoyed the three years that I have spent giving those lectures, and, and preparing the, the papers that go with them. I hadn't appreciated for a moment when I, when I applied, how big a task it would be. Because, writing papers that warrant having the Gresham College name attached to them, and which you know are going to be around in an organisation that's already lasted over 400 years, going to be around probably for another 400 years, is, is a challenge that, that forces you to do the research properly and to write papers of, of a good standard. And I've found that actually, it's been a half-time job for three years.

Mhm.

Which is much more work than I realised I was taking on when I applied for it. But the interaction with the public audiences in the Museum of London where I've been giving lectures for Gresham College, and, and discussions with people online as a consequence of them, have been extremely rewarding, and I hope has helped me get

the message of the importance of rigorous software engineering across to a much wider group of people than I've manged to reach before.

Mhm.

So I'm very grateful to the, the IT Livery Company for the opportunity to do that, and very pleased that they're continuing the sponsorship and that I will have a successor.

[1:57:33]
Mhm. And, as part of that three-year commitment, you know, I think, what, delivered eighteen lectures so far and more to go or something.

I, I've delivered eighteen so far, and, and my, my final lecture on computers and the future is in two weeks' time.

Yes. And there was a theme to your, your series of lectures?

Yes. I, I called it 'Living in a Cyber-Enabled World', a rather clumsy title, but I, I wanted to capture the fact that the thread that ran through all the lectures was that, we do live in a digital society, in a world that, that has been empowered and, and created to a large extent by the developments that have spun out of the invention of modern computing. You know, the, the very first modern stored program computer ran its very first program just seventy years ago, in Manchester, on June the 21st, a little after eleven o'clock in the morning. And, and from there, has developed the, the entire digitally-based society that we now live in. It's an astounding transformation for, for a discipline to have brought about in the world, and yet we're only in, in the early stages of, of the industrial and social revolution that that invention has caused. So I, I wanted really to, to capture the lessons that I've learnt from working in, in the industry for, for fifty of those seventy years, in the hope that the lessons that I've learnt might, might help people not to make the same errors in the future, and, and to be able to perhaps really take advantage of, of the enormous opportunities that we've got from, from autonomy, from robotics, from artificial intelligence, and, and from software engineering, to, to make the world a better place to live in, and, and a more prosperous and a more secure place, if, if we only do things right.

[2:00:01]
And I think at the, at the outset, after your appointment, your, your objective, which you, you have suggested, is that we, we need to, to do, what we need, what we, we're exploring is, how to shore up the foundations of a digital society, which you describe as being increasingly built on sand.

Yes. And, and an interesting choice of, choice of words, because of course, you know, it's the, it's the cliché phrase of, of, built on sand meaning insecure foundations.

Yes.

But of course, you know, the, the silicon-based economy is essentially a sand-based economy chemically. So, it's, it's a, it's an interesting juxtaposition in, in that phrase. But, but I do feel, you know, we, we have built this, this astonishing society on, as I said earlier, foundations that, that really have not been well engineered.

Mm.

And yet we continue to build higher and higher and higher on those foundations. And that doesn't feel as though it ends well.

Mhm. And, and you're happy with the areas that you've covered to get that message across in those, in those, that series of lectures?

Yes.

Yes.

Yes, I've, I've, I've covered I think enough of the fundamentals to enable people to see why the messages that I wanted then to across in, in the particular areas of cybersecurity or artificial intelligence, actually make sense. Because, it's, it's very easy to, to look at software and to think that, you know, kids do it, they, they, you

know, children become, become millionaires writing apps in their spare time, in their bedrooms, or, or they have the, the capability to break into the Pentagon, and, you know, the use of computing must be easy because children can do it.

Mhm.

And, and the answer is that, yes, you know, it's like, children can build models out of Meccano too. Well probably they can't any more, but they used to be able to. But you wouldn't want them building a major bridge or, or viaduct or, or a major engineering construction of any sort. And there is an enormous difference between being able to produce some powerful functionality, and being able to produce that powerful functionality to a product quality that makes it fit for purpose in a critical application. And that difference is engineering.

Mhm.

And we're not teaching it.

[2:02:53]
That was going to be, actually, my question. I mean, I appreciate you're visiting professor at a number of universities. My question was going to be, is that message coming across in the actual lectures that most students will be attending, or the tutoring, or…?

No, it, it doesn't. And, and for very good reasons. That the Government has chosen to make the universities commercial organisations, and to make the customers for those commercial organisations the students. Whereas actually, universities ought not to be. Universities are, are agents of, of social development, and the real customer is, is the societies in which they operate. But we have chosen to move away from that model and to say that, that they are commercial and that, that the students are, are the customers and need to get value for money, and need to have a, a choice about what they get taught. The students, because they come out with debts, want to be taught what will give them a job and a high, highly paid job if at all possible. And, and yet, the universities are embedded in an industry which wants functionality and rapid

software development, not high quality engineering. And so the universities teach what the students want, and the students want what their employers want, and their employers are not demanding the ability to develop highly engineered, highly secure, software, because that's not how you make money in the software industry.

Mm.

So the universities are doing the job that the Government has set them up to do, and it's a disaster.

[2:04:34]
Mhm. And no doubt, I mean, I know one of your other areas of expertise is a, well, you often appear as an expert witness throughout the world, and…

Yes. I, I've given up doing that, because it, now, because it, it's just too intense, but I have done a number of roles in major litigations around the world as an expert looking at projects that have failed and helping the court to understand whose, whose fault it is. And, I mean it is an enormous task. I mean you, the kind of litigations I've been involved in, I've had, oh, upwards of three-quarters of a million documents to, to become familiar with in, in order to be able to look at the real history of a project and to determine exactly why it is that that project ended up where it, where it ended up.

Mhm.

And of course you, you do it with a, a team of, of paralegals who are organising documents and providing electronic access to them and search capabilities and all those kind of things. But, but to be able to master the, the complete project well enough to be able to stand up in a court and be cross-examined about it in front of a judge, for days at a time potentially, requires a level of concentration and, and focus and, and sheer hard work, that frankly I don't want to do any longer at the age of seventy. So…

But you did return to the law after, after many years' absence in one way or another.

Yes, at, at that level. And, and I've developed enormous respect for the judges that hear these cases, who, who seem to be paying no attention whatsoever, but, you know, you look at them and you think they're doing Sudoku or something. But, but then at, at the end of some lengthy examination by a barrister, they, they look up and ask the probing question that, that you, you really wish you had, had been in a position to ask. And probably they come up with another one that you hadn't thought of. And, and it is immensely impressive, the, the skill of forensic lawyers is quite remarkable.

[2:06:52]
Mhm. Thank you for sharing that. Martyn, you've already spoken about current challenges. Normally at this stage of the interview, as we're drawing to a close, I ask the interviewee about the biggest challenges and opportunities. I do appreciate that you've covered, certainly the, the challenges of today. I don't know whether you see anything in particular that hasn't been prevalent on the horizon as well. But, if you would like to, to make any comment on the challenges, opportunities for the next ten years, it would be appreciated.

Yes. I think, the, the big challenge is, is going to be exploiting the, the enormous opportunities that, that exist, particularly with, with artificial intelligence and, and autonomous systems of various sorts, in a way that is robust against the, the now really threatening cyber environment, the, the offensive cyberattacks. You, you just have to expect that every credible system will now be subject to attack, and, and that's, because it's part of the context, the industry has to recognise that that's the case. And so, how we manage to exploit the opportunities for example for increasingly autonomous cars in a, in the context of an environment where you can expect that any vulnerabilities will be exploited, that's a real challenge.

Mhm.

And if we can't solve those problems, we're, we will run into difficulties where we can't take the benefits that society demands from, from the increased use of these technologies. And, and the, the increasing use of, of artificial intelligence in medicine for example, it's going to be enormously important, again, to make sure that we, we have good mechanisms for doing validation to a very high degree of, of the

functionality and the safety of such systems. So, better engineering is obviously imperative, that's the theme I've been banging away at all my life and throughout this interview.

Mhm.

But it is the big enabler for, for being able to exploit the opportunities that lie ahead of us. And there are enormous opportunities.

[2:09:20]
Where do you think someone would, where are best placed to, to learn about these good practices? You've commented that some universities at least are not really adopting that approach.

Where, where would you, where would you go to learn about how, how to do things well?

Mm.

It, it's really hard to, to learn to use good technology unless you are using it on the job. I mean it's fine, fine to read about it, and by all means, you know, I would strongly encourage people to, to rad the, the seminal papers and, and the books that exist about strong software engineering. But the best thing you can do is to find companies that are building really critical systems to very high standards, and of course the, the leading one that I know of is Altran UK, because, you know, that's, that's where my colleagues from, from Praxis have gone and, and continue to build extremely high quality processes and, and to do stuff which I have been admiring from afar from, for, for the decades since, since they, we moved apart. So, that's the best way to learn I think, is, is to learn from, from people who are doing things well. Because if you, if you go into an organisation that has got an established technical culture, you will have to adopt that established technical culture; you can't hope to, to change the way that, that another organisation works.

Mhm.

[2:11:01]
And, I, I think a new graduate faces the dilemma, considering which, which part of the software industry they want to go into, because, the parts that are really making a difference to society in a positive way are not typically the parts that are going to be making money rapidly. And when you graduate with a lot of debt, I can really understand that what you want to do is to make money, and so, you know, the temptation of going into the City, going into, if you've got good mathematical skills, going and becoming a, a quantitative analyst for, for a big hedge fund or something like that, and making very high salaries, is, is very tempting. And, and you know, all strength to you, but, but once you've, you've got the money and you've paid off the debts, use your skills for, for social benefits, and, and start finding ways to help people to build the systems that society depends on, to a standard that really warrants the trust that is being placed in those systems. Because that's hugely important.

Well Martyn, that brings us to the end of our interview today. First of all, may I thank you for your, your insight into your career, and the very sound advice you have given our listeners and myself. And, Martyn mentioned that his lectures at Gresham College are, are available online as are papers. Gresham.ac.uk I believe is the…

Yes.

…Web address for, for that. Fascinating, a variety of subjects there as well that I think anyone who's interested in information technology, it would be a, a sound use of some time to take a look at what Martyn has been speaking about over the last three years. So, thank you very much Martyn for your time.

Well thank you for, for the opportunity to be, to be interviewed for the archive, and, and to give me access therefore to yet another audience. Thank you very much.

Thank you.

[End of Interview]