WHAT CAN INFORMATICS DO FOR SCOTLAND?

January 2009

1. RATIONALE

We are surrounded by a fast-moving revolution in information and communications technology (ICT) that is profoundly changing the way we live, work and play. Policymakers in particular need to understand the scientific and engineering basis of this revolution in order to anticipate its effects, take advantage its opportunities and prepare for its threats.

Developments in digital computation and chip technology are creating exponential growth in the speed and storage capacity of computers and a similar decrease in their size and price. Computers have become pervasive: embedded in many products such as cars, washing machines, mobile phones, hi-fi, etc. Typical PCs or laptops are now greatly outnumbered by small, embedded computers invisibly distributed all around us, making products smarter, more efficient and able to communicate with each other. This trend to create an “intelligent environment” will continue.

Computers have revolutionised communication. Linking them to wireless transmission, geostationary satellites, cameras on a chip and optical cable has developed a global flux of information and intelligent systems. The world of mobile phones, the internet, email, CCTV, blogs, digital television, robots, remote monitoring, music downloads, electronic games, etc., is just the beginning. But we also live in a world of computer viruses, phishing, spam, identity fraud, online porn, dotcom busts, etc.

Both opportunities and threats are rapidly changing. They cannot be predicted in detail, but greater understanding by policymakers of the underlying science and technology is crucial if their potential is to be realised and if we are to respond efficiently to unexpected developments through generic rather than piecemeal responses. Chance favours the prepared mind.

2. SEMINAR PROGRAMME

09.20- 09.30	Introduction – Geoffrey Boulton
09.30-10.00	Informatics: the underlying science and technology. – Alan Bundy
10.00-10.30	The current status of ICT: what is currently possible? – Alan Pollard
10.30-11.00	The dream: what might be next? – Colin Adams
11.00-11.20	Coffee
11.20-12.10	The nightmare, and avoiding snatching defeat from the jaws of victory - Jim Norton
12.10-12.40	Information for the benefit of citizens & society. - Richard Susskind.
12.40-13.50	Lunch and animated discussion.
13.50-14.20	Strategies for government: procuring on time and in budget? - Martyn Thomas
14.20-14.40	How to seize economic value for Scotland. Stimulating high development of high growth ICT companies. Ian Ritchie.
14.40-15.00	How Government should place bets on technology - Ian Halliday .
15.00-16.00	Panel discussion. Chaired by Sir John Elvidge

3. KEY MESSAGES FOR THE SCOTTISH GOVERNMENT

The Past and Present

1. Scottish/British scientists and engineers have played an important role in the development of the modern computer.
2. Cheap computers are now ubiquitous. Only 1% are in conventional computers. The rest are in cars, phones, washing machines, televisions, credit cards, etc. On average, every family has

100. The UK company ARM is the world's largest designer of these devices.

3. Lay discussion of computers tends to focus on the electronic hardware. But hardware only provides the substrate for the software. It is the software that determines what the computer will actually *do.* As yet, we have massively under-utilised its potential applications.

4. Computing enables researchers and society to ask new kinds of questions, including those that require the processing of huge amounts of data or the use of models too complex for manual manipulation. Informatics is setting the intellectual agenda of the 21st Century. It is one of Scotland's greatest research strengths.

5. The informatics infrastructure has three principal components:

   a. Telecommunications systems – the means whereby information is transmitted. The network mesh, with routers that switch information along optimal routes towards its destination, such that local failures do not stop transmission, ensures high resilience. Its vulnerability comes from: anything that impedes power supply to large areas of the network; from the major "internet exchanges", whose failure would cripple the internet in that region; and the role of GPS (controlled by the US Dept of Defence) in providing the timing (the heartbeat) of the internet.

   b. Applications architecture – the software systems that are the "recipes" that determine how information is used.

   c. Information architecture – the locations in cyberspace and in data archives where information is kept and the form in which it is encoded. The mining of information is replacing the mining of raw materials as an economic driver. Google has an increasingly dominant position. Much UK data is archived offshore. We do not know where much information is stored, and cannot guarantee either access or provenance.

Future Trends and Benefits

6. The massive impact of ICT over recent decades has been driven by Moore's law describing the doubling of transistor capacity every 18 months. Further dramatic growth could be driven by the possible advent of Quantum Computing. Future developments will be driven by the growth of user-generated information, increasing by ten times every 5 years.

7. This will be allied to wider access to this information. In 5 years time we will have at least 2 billion users of the Internet and 3 billion mobile phone users. It is changing the geography of where actions are carried out, travel patterns, health diagnosis, definition of community and where economic benefit may be derived – or taxed.

8. This data comes from many sources - from records held by government, companies, individual citizens, researchers, sensors of many types such as RFID tags, image and video generated by individuals or security monitoring equipment. Much of the data is unstructured and thus difficult to search. Much is stored in large centralised data centres, accessible (with permission) from anywhere on the globe.

9. Properly used, these trends can bring benefits: developing new drugs and health treatments; providing more and better remote health and social care; improving security; optimising the use, cost and efficiency of use of transport, energy, resources and goods and reducing environmental impacts; improving the delivery of continuing education and the operation of research; empowering individuals and changing the way government interacts, provides services for and responds to citizens.

The down-side

10. There are major problems. How accurate is this information? The cost of inaccurate data is $600 billion pa to the US economy alone. Where do we store this information; centrally or at the personal level? Who has access under what circumstances to the various levels of data? Can we close a yawning 'digital divide' in society? The storage and retrieval of such large bodies of data has an environmental impact similar to that of the airline industry at about 2% of carbon emissions.

11. ICT now underpins the operation of most components of national infrastructure such as transport, water supply, sewerage, oil, gas, electricity etc. It is the means of system control and information storage, and the means by which control and information are communicated across the system. Its efficient, reliable, secure and resilient operation are crucial to the operation of national infrastructure. Failure in significant parts of the ICT system could trigger cascading infrastructural failures. Failure of key elements of infrastructure, such as communications or power, as a result of freak weather, human error or deliberate act could lead to a devastating cascade of failure. Such failures have been growing in frequency, and unless steps are taken to ensure resilience, are likely to become more frequent and more damaging. Common views of relative infrastructure fragility tend be misconceived.

12. Resilience of the system is reduced because of :

    Increased coupling. There has been policy and economic drivers (just in time manufacturing, removal of warehousing, “running lean”) that have pushed towards centralisation and economies of scale. Serial dependability provided by parallel, uncoupled backup systems, has been lost. The trend towards unification of telephony, data and television onto single networks will increase vulnerability and is a major cause of concern.

    Low software dependability. The science that permits the creation of dependable software exists. It is not applied. Typically there are 1 to 30 errors per 1000 lines of source program in commercial software. Testing software, which is a sampling procedure, cannot identify all errors. Current procedures build vulnerability into national infrastructure.

13. The global Internet offers massive scope for the e-crimes of fraud, deception and sabotage. Power is migrating to the gaps between States. New multi-lateral approaches and bodies are required to address these challenges.

14. Centralising tendencies in private or public sector bureaucracies ICT tend to exploit the unparalleled opportunities to collect data on the day to day activities of citizens, through huge databases, almost continuous video surveillance, and the egregious collection of data and voice traffic information and financial transactions. There is a need for far wider debate on the human rights impacts of current developments. There can be benefits to citizens in certain limited public sector data sharing, but the case has yet to be made and key protections are often lacking. Many current databases may be illegal under European law.

Assimilating benefits and minimising costs

15. This exponential growth in capability has tended to outpace the more linear rate of assimilation into Society and our understanding of how best, responsibly, to build consensus around the use of these new tools and capabilities. Technology is neutral and can be used for good or ill. How best to reap the remarkable benefits without harming to society or individual human rights. The projects most likely to lead to such disasters are frequently proposed with the best of intentions.

16. We need more systematically to maximise benefit in areas such as optimising use, cost and efficiency of use of transport, energy, resources and goods; and maximising health, safety and security benefits must be balanced against threats to privacy, civil liberties and financial security. The current approach tends to be unthinkingly risk averse. We need better social means of agreeing the balance. It is also vital that the substantive law keeps apace with wider developments and IT and so supports rather than hinders its safe and productive exploitation.

17. The great benefit of IT in Government lies not simply in *automating* current practices and processes, but in *innovating* – using IT to allow government to undertake work and deliver services that previously were not possible.

18. The internet is increasingly becoming the first port of call for citizens, for example in medical self diagnosis, and in its potential to increase access to law and justice.

19. A challenge for Government is to develop both as a reactive open government, one that responds favourably to requests for access, and as a proactive open government making available to citizens the information that is created in the process of governing. Government should develop well-conceived public sector information policies that seize new opportunities for its creative use to the benefit of citizens, whilst avoiding the many pitfalls.

Effective procurement

20. IT systems are vital to public and private sectors, but in both, not simply the public sector, procurement tends to be highly inefficient. Roughly a fifth of projects are cancelled before delivery and over half of the rest overrun, typically by over 100%, and most are significantly over budget.

21. This arises primarily because customers do not precisely define their requirements. Major software companies encourage this, arguing that this can be done later. They bid at a price designed to obtain the contract in the confidence that profits will come from subsequent revisions. Engineering projects, in contrast, have an architect, who precisely defines the need and the design required to satisfy it, before passing this on to an engineering contractor to build the design.

22. A two-step procurement process that would avoid these problems should be adopted by the Government in procuring major software systems, and should be coupled with science-based dependability procedures. If Government would require an architect to design the software requirement to fulfil the clients needs, and the software company required to build to the design, it would cut costs, reduce the paranoia that increasingly infects people when the idea of a major software requirement is broached and greatly improve the efficiency and reliability of the ICT infrastructure.

23. If this were coupled with use of science-based development methods that can greatly reduce or eliminate the defects and vulnerabilities that are currently delivered into service, it would increase system security and dependability and reduce the incidence of defects which could lead to system failure, cause loss of data, or compromise security.

Seizing economic value for Scotland

24. The low rate of take up of science-based development methods by industry is a market failure that justifies Government action to break the deadlock. The growing demand for dependable systems creates an opportunity for Scotland to win a substantial share of the market for the next generation of IT systems.

25. For example, if the Scottish Govenrment were to require the two-step procurement process described in paragraph 22, it could have the by-product of encouraging development of a new ICT SME sector, which the skills base in Scotland would be well placed to respond to. It could make Scotland a major centre for efficient and cost effective production of dependable software, with considerable overseas earnings potential.

26. It is important to recognise that Scotland is one of the global centres of ICT research and to analyse in depth the mechanisms that would permit this strength to be utilised for economic benefit through the growth of new companies. Such mechanisms are suggested, including the vital need for a major new Scottish investment fund.

27. A major means of promoting exploitation of its strengths is to place long-term, sustained bets on forward looking areas of technology where Scotland has world leading strengths, and where major areas of intellectual property can be captured.

4. PRESENTATIONS

1 Alan Bundy - Informatics: the Underlying Science and Technology

Throughout history, visionary thinkers, such as Gottfried Leibniz and Charles Babbage, have dreamed of automated reasoning machines. Babbage partially realised such machines with his clockwork Difference and Analytical Engines. His collaborator, Ada Lovelace, was the world's first computer programmer. These dreams were only fully implemented, however, via a combination of more appropriate technology and military imperative in WWII. The technology came in the form of electronics, with first the thermionic valve, quickly replaced by the transistor and integrated circuits. The military imperative came, for instance, from the code-breaking work at Bletchley Park and the requirement to predict accurately and quickly the trajectories of projectiles.

This work initially yielded a diverse array of special-purpose calculating and reasoning machines. Soon, though, Babbage’s dream of a stored-program, general-purpose computer was realised by treating the computer program as data, which could be input to the computer, possibly modified and then used to direct the computer’s operations. Alan Turing developed the mathematical theory of the general-purpose computer. John von Neumann devised its architecture, which has survived, more or less intact, in today’s computers. There are many competing claims to have built the first general-purpose computer, for instance, Manchester University’s 1948 Manchester Baby.

In 1965, Gordon Moore, founder of Intel, first observed that the number of transistors on an integrated circuit was doubling in number every two years, then predicted that this would continue to happen. This prediction is known as Moore’s Law. It has held ever since. The consequence has been an exponential increase in speed and memory capacity, and a corresponding decrease in price and size. This has had a profound effect on the uptake and application of computer technology across society. It has encouraged the representation of all sorts of information in digital form, in which it can be automatically processed and transmitted. Information technologies have converged with telecommunications, leading to new kinds of product, such as the Internet, mobile phones and digital television.

Cheap computers are embedded in very many domestic and industrial products to make them smarter, more efficient and able to communicate readily with other products. It has been estimated that most UK families own about 100 computers, embedded in their cars, phones, washing machines, televisions, credit cards, etc. The UK company ARM is the largest manufacturer of these computers by volume: 10 billion supplied by the end of 2007, currently increasing at the rate of 10 million per day. In contrast, there are only about 100 million laptops and desktops shipped per year. Most users remain blissfully unaware of this hidden iceberg of embedded computers all around them.

Lay discussions of computers tend to focus on the hardware – the electronics the computers are composed of. But hardware only provides the substrate for the software, and it is the software that determines what the computer will actually do. Think of the hardware as providing a well-equipped kitchen and the software as the recipes for the dishes you can then cook. Software tends to be ignored because, despite being of central importance, it is invisible and intangible. There are an infinite number of possible computer programs, defining a more diverse and numerous collection of ‘mental’ machines than the physical machines that emerged from the industrial revolution. Thanks to the work of Turing and other theoreticians, we are able to structure this collection as generated by a ‘grammar’ of easily understood, basic programming instructions. We also have a theory of algorithms and their complexities, which informs an appropriate choice of programs for each task. Increasingly, new programs are built from powerful, general-purpose components, which are recycled and extended as their full range of application is explored. We are only in the foothills of exploring this collection and, thereby, discovering what computers can and can’t do. We are also still developing ‘software engineering’ methodologies to ensure that dependable ICT products are built on time and on budget.

Computational thinking is influencing research in nearly all disciplines, both in the sciences and the humanities. Researchers are using computational metaphors to enrich theories as diverse as proteomics and the mind-body problem. Computing has enabled researchers to ask new kinds of questions and to accept new kinds of answers, for instance, questions that require the processing of huge amounts of data or using models too complex for manual manipulation. Informatics is, thereby, setting the intellectual agenda of the 21st Century.

Alan Bundy FREng FRSE, is Professor of Automated Reasoning in the School of Informatics at the University of Edinburgh.

2 Alan Pollard - The current status of ICT: what is currently possible?

In the past 25 years we have seen dramatic growth in the capacity of technology and the ubiquity of information. We tend to underestimate and under-use what is currently at our disposal. Currently we can link and share information globally, perform mind-boggling calculations in fractions of a second, access a vast array of information while we are walking about, driving and juggling several tasks at once. We can join computers together to multiply their collective power, locate people and things by wireless means and, by with our ability to manipulate images, disprove the age-old adage that a camera never lies.

Pessimists point to the threats that these capabilities bring in their train: loss of personal identity; dangers of fraud and other crimes; exploitation by terrorists; exposure of the vulnerable in society to those who would take advantage of them, be they children or adults; and the ever-present media dramatise every perceived failing of IT.

One of the principal barriers to our willingness to exploit what we already have at our disposal, whether as individuals or as public or private sector enterprises, is our natural aversion to risk and our desire to avoid it and be called publicly to account for endangering life, reputation, wealth and health. The potential benefits of the use of a unique identity or the capability to track people, products, vehicles and documents in real time and with pinpoint accuracy, for example, are often overshadowed by concerns about threats to liberty, privacy and personal possessions. The real social potential of distance learning; electronic access to and by the citizen; optimisation of our use of transport, energy, resources and goods; and the preservation of health, safety and security: are all benefits to be grasped but we often hold back from them.

ICT is a Pandora's Box of possibilities good and bad. All over the world there are millions of people experimenting with technology. The volume of data is inconceivably large, but is meaningless without structure and interpretation, but it can be put together in countless combinations to become information. From the chance combination of items of information, made possible by on-line collaboration and ever more powerful means of deriving meaning and semantics from data, can emerge hitherto unexpected results and the identification of unforeseen trends of behaviour and activity. Once we have assembled that information we can manipulate and transmit it. Properly handled, ICT is today able to achieve much more than it is currently used for. Tomorrow's potentials, discussed by the next speaker, will be even greater.

Before we arrive in that future, emerging capabilities include: new ways of storing information that do not rely on mechanical devices and that use less power; faster processors; new means of inputting data that don't depend on traditional keyboards and mice; and even the ability to charge batteries and mobile phones without cables. Many are being developed in Britain and Scotland. We must not let fear of the unknown hold us back, but judiciously avoiding the potential downside and boldly exploiting the benefits.

Alan Pollard is the President of the British Computer Society.

3 Colin Adams - The Dream: what might be next?

The vision of the future I would like you to consider is one in which there is massive growth in data and information. Over the last 50 years, technology, economic and societal advances have been underpinned by Moore's Law and the advances in underlying manufacturing technology providing access to computational power by a growing proportion of the population. Future developments will be increasingly driven by a growth in information generated by users – individuals, organisations and governments rather than technology itself. The digital information universe is increasing by an order of magnitude roughly every 5 years. The mining of information is replacing the mining of raw materials as an economic driver.

Allied to the Information growth is the dramatically growing pervasiveness of communication technologies, enabling an even wider scale of access to this information and pushing to new level of globalisation. In 5 years time we will have at least 2 billion users of the Internet and 3 billion mobile phone users. This will change the geography of where actions are carried out, travel patterns, definition of community and where economic benefit may be derived – or taxed.

This data comes from many sources - from records held by government and companies, sensors of many types such as RFID tags, image and video generated by individuals or security monitoring equipment. Much of the data is unstructured and thus difficult to search. Much is stored in large centralised data centres, accessible (with permission) from anywhere on the globe.

Information is Power. It has great economic value because it allows individuals to make choices that yield higher expected payoffs than they would without that information. Properly used, these trends can bring benefits to all elements of our life and society: dramatically changing the way we discover and bring on stream new drugs and health treatments; how we provide more and better remote health and social care for an aging population; improving the way we provide security to our population; understanding and reducing the impact of our consumption and production on the environment; improving the way we deliver continuous education and the way we do research; empowering individuals and changing the way government interacts with and responds to the electorate.

The Science and Technology driving this area is very broad, offering many future avenues of development. Fundamental research explores how we handle complexity in very many domains of human concern, and how we efficiently process the vast and growing corpus of information now available through the study of "Algorithmics".

Realising these potentials also requires us to solve difficult barriers to progress. How accurate is this information? Current estimates put the cost of inaccurate or dirty data at $600 billion pa to the US economy alone. Where do we store this information; centrally or at the personal level? Who has access under what circumstances to the various levels of data? The benefits of the Digital Dream can only be derived by those connected to the digital world. Can we close a yawning 'digital divide' in society? Last but not least the storage and retrieval of such large bodies of data has an environmental impact currently about the same as the airline industry at about 2% of carbon emissions.

Colin Adams was Vice President for R&D in Europe and the US for Cadence Design Systems and is now Director of Commercialisation in the School of Informatics at Edinburgh University.

4 Jim Norton - The nightmare, and avoiding snatching defeat from the jaws of victory

The exponential growth in performance per unit cost of all the underlying Information and Communications Technologies (ICT) was arguably one of defining developments of the second half of the 20th Century. This exponential growth has continued unabated into the 21st Century and can be extrapolated for at least the next eight years based on developments already being engineered today. It would be foolish not to expect further developments, in more esoteric areas such as Quantum Computing, to extend the run still further. We also see dramatic impacts where ICT acts as a catalyst in areas such as biotechnology, where it has created entirely new capabilities such as Synthetic Biology. This exponential growth in capability has tended to outpace the more linear rate of assimilation into Society and our understanding of how best, responsibly, to build concensus around the use of these new tools and capabilities.

Technology is neutral and can be used for good or ill with equal efficacy. This presentation addresses the issue of how best to reap the remarkable benefits flowing from ICT without harming society or individual human rights. It is notable that the projects most likely to lead to such disasters are frequently proposed with the very best of intentions.

The advances in ICT have allowed us to develop a complex and highly interconnected/interdependent society. There are real risks that failure of some element of our basic infrastructure, such as communications or power, could lead to a devastating cascade of failure. Such failure could as easily be from freak weather or human error as from deliberate act of terrorism. In the summer of 2007 flooding in Gloucestershire and Worcestershire demonstrated that we could be only hours away from fighting in the streets for access to water. This presentation will outline what steps might be taken (and some already being taken) to strengthen the infrastructure and limit the potential for such cascades.

There are no new crimes, merely old crimes using new tools. The global Internet offers ample scope for the e-crime equivalents of fraud, deception and sabotage. The 21st Century is witnessing the decline of purely national power and the impotence of many existing international bodies. Power is migrating to the gaps between States. New multi-lateral approaches and bodies are required to address these challenges.

There are centralising and controlling instincts at the base of most bureaucracies. ICT developments give unparalleled opportunities to collect data on the day to day activities of citizens, whether through huge (though often thankfully impractical and poorly designed) databases, almost continuous video surveillance, and the egregious collection of data and voice traffic information and financial transactions. This presentation will suggest the need for far wider debate on the human rights impacts of current developments. It recognises that there can be benefits to citizens in certain (limited) public sector data sharing, but suggests that the proper case has yet to be made and that key protections are often lacking.

Jim Norton is an independent policy adviser and Visiting Professor of Electronic Engineering at Sheffield University.

5 Richard Susskind - Information for the benefit of citizens & society

Thinking about the future of IT in government requires a new mind-set. Its great potential lies not simply in *automating* current practices and processes, but in *innovating* – using IT to allow government to undertake work and deliver services that previously were not possible. Planning for the future is difficult because IT itself is developing at a remarkable rate. New techniques, such as social networking and mass collaboration, can change the landscape in a small number of years. Nonetheless, experience suggests that broad trends can be predicted, even if it is rarely possible to anticipate the particular enabling technologies that will be transformational.

The administration of law, regulation, and justice is gradually becoming streamlined and improved through IT. Lessons from other jurisdictions suggest that much more can yet be achieved. In the past, citizens and businesses generally had to consult human lawyers if they sought advice on most legal or regulatory problems. Today, non-lawyers can secure legal help on a wide range of legal issues from websites developed and maintained, amongst others, by government bodies and consumer associations. While the counsel provided by these sites may be less tailored and rigorous than that offered by traditional lawyers, they can provide useful briefings for people before they seek professional advice. And where it is not feasible for citizens to obtain formal help directly, these websites are generally far more useful than having no legal guidance at all. Meanwhile, court-rooms can be equipped with IT, including systems for the display of documents and exhibits, large monitors and wall screens, computer assisted real-time transcription, and video-linking for remote evidence. More ambitious is the idea of online dispute resolution – some people are challenging the assumption that court work requires parties to congregate in one physical space and they are developing systems to allow litigants to present arguments and evidence through online systems.

Looking beyond the law, public sector bodies in the course of their everyday work create and capture huge quantities of information. This includes advice, analysis, and research, as held in letters, reports, documents, filing cabinets, and databases. There has been growing recognition that this information (for example, geographical, meteorological, and statistical information) constitutes a resource of great potential value; that public information is an asset, an intellectual asset, that should not be seen as usable for one purpose only. Instead, it is argued, this information can and should be made available for re-use (a recycling of sorts). Public sector information can be re-used by other public bodies, by citizens, by businesses, and by not-for-profit organisations. Re-use of public information should be distinguished from two related challenges – that of securing, preserving, and archiving public information; and that of providing ready access to information under the freedom of information regime.

The emergence of new information technologies raises pressing legal questions – for example, about privacy and data protection, copyright and intellectual property, freedom of information and security, and more. It is vital that the substantive law keeps apace with wider developments and IT and so supports rather than hinders its safe and productive exploitation.

Richard Susskind OBE FRSE is an independent policy adviser and Honorary Professor of Law at Gresham College.

6 Martyn Thomas - Strategies for Government: procuring on time and in budget?

IT Systems are important to Government for four main reasons: their use adds value to almost every economic activity; the manufacture of IT systems is a large and growing market sector; IT-based systems are widespread in the critical national infrastructure; most Government policy initiatives require new IT systems to support them.

The benefits of IT systems are frequently reduced because development projects are late and over budget: roughly a fifth of projects are cancelled before delivery and over half of the rest overrun – typically by over 100%. Most systems that are put into service contain thousands of defects, many of which could lead to system failure, cause loss of data, or compromise security.

These problems, though widespread, are avoidable. An experiment by the US National Security Agency has shown that near-zero-defect software can be developed with no increase in cost over current methods. A change to a two-step procurement strategy, starting with the engagement of a systems architect to develop a rigorous and analysable statement of the system requirements, could eliminate a high proportion of the misunderstandings and changes to requirements that lead to project delays and cost escalation. Greater use of science-based development methods can greatly reduce the number of defects and vulnerabilities that are currently delivered into service, increasing system security and dependability.

The growing demand for dependable systems creates an opportunity for Scotland to win a substantial share of the market for the next generation of IT systems, because the current market leaders are encumbered by the need to support the users of their existing and not dependable, legacy software.

A new generation of dependable software will need appropriate methods, tools and system components but there is little incentive for product vendors to invest in developing these tools and components as the early investors in the market will lose money because of the lack of compatible components. The low rate of take up of science-based development methods by industry is a market failure that justifies Government action to break the deadlock that exists.

Martyn Thomas CBE FREng, is a consultant software engineer and Visiting Professor at the Oxford University Computer Laboratory.

7 Ian Ritchie - Seizing economic value for Scotland: exploding the myths about start-up companies

A news story from 2020: *"Scotland now has the eighth highest gross national product per head in the world, alongside Switzerland and the USA and is ninth in the league of fastest growing economies in the world alongside China, India and Brazil. It is home to 70 of the world's leading niche technology companies in bio-medicine, genomics, environmental technology and informatics. These businesses, along with investment management, are now the economic powerhouses of this amazingly innovative country. Scotland, with its world class renewable energy technologies has reduced its carbon footprint to 80% of the level produced in 1990, some 18 years ahead of target. Its universities research ratings are ranked as one of the best in the world – with less than 0.01% of the world's population, it creates over 1% of the world's new knowledge."*

This is just a dream, except for the very last bit. With less than 0.01% of the world's population, Scotland, today, does actually create over 1% of the world's new knowledge; a remarkable achievement. But although we have one of the most creative and productive scientific research communities in the world, we still have one of the most sluggish economies with relative poor rates of new company formation, low levels of growth and very low levels of innovation.

Why is it that other regions such as Silicon Valley and Cambridge can regularly generate new globally competitive, large-scale technology businesses, such as Google, Cisco, and ARM; companies which, although under 30 years old, now make a huge economic contribution. Geography needn't be a key factor either: before Microsoft, Seattle was not a high-tech centre. Before Nokia, neither was Finland.

There are a number of reasons for this under-performance in Scotland:-

- Lack of ambition among Scots and relative lack of immigrants (immigrants being disproportionately entrepreneurial).
- Lack of good role models. Successful Scottish entrepreneurs have traditionally succeeded in property, retail or transportation, not technology.

- Chronic lack of early-stage funding. Early stage funding is very high risk and historically has performed quite badly.
- Scotland's financial community largely ignores the early-stage sector.
- Venture capital, when it is acquired, mostly comes in closed end 10 year funds, early trade sales are therefore encouraged - rather than building companies of scale.
- Lack of good mentoring by globally ambitious market-aware individuals. California and Cambridge have an excellent pool of experienced non-executive directors.
- Universities tend to maximise their research performance and are not strongly motivated to encourage the creation of new enterprises
- HE 'Knowledge Transfer' schemes still aims to 'push' technology which is not an effective strategy for successful company creation.
- Over 50% of the Scottish economy is in the public sector, which is not a 'risk taker' and therefore does not provide a good market for innovative companies.

The source of risk capital that has been available in the past is now severely depleted. Business angels do not have the capital gains to invest, nor the tax to shelter, and Venture Capital firms now find it impossible to raise new funds. Banks are reluctant to provide any financial support to early stage businesses.

So is the chance of realising our 2020 dream news story highly unlikely? Not necessarily, but to realise it would require targeted actions to correct our deficiencies. It could be done, but would require bold action.

Ian Ritchie CBE FREng FRSE, is a serial entrepreneur and Past-President of the British Computer Society.

8 Ian Halliday - Seizing economic value for Scotland: how should Government place bets on technology?

I bring three strands of experience to this seminar: a physics-oriented user of computers since the days of valves and paper tape; and organiser of scientific communities so that they play to their strengths in order to gain competitive advantage through innovative IT systems; and as a prime mover as CEO of one of the Research Councils for the UK e-science programme. CERN and the World Wide Web development was part of this.

As in so many areas of research there are two extreme approaches to technology advance. Ask for ideas and fund the blue-sky research; or apply real pressure to deliver solutions to hard problems. A classic example is academic computer research pre WW 2 and computers in WW 2.

First Question: Do we (UK, CERN, Genome Project, NHS, Scotland) want to design and implement computing systems to satisfy our needs?

Second Question: If the answer is yes what means are necessary?

Third Question: To what ends?

To question one, of course we do, since efficiency gains are possible. But "design" and "needs" are trickier, covering a multitude of problems. Who designs? Is it our suppliers or us as users? What does design mean? Who fixes the needs and balances these against the costs?

Question two receives different answers depending on the environment. At one level it is a cash question. At another level it is a process question. Are you an intelligent customer? Do you, as customer, know what is deliverable easily and what might be deliverable after an intense R&D programme?

The third question is the most interesting and demanding. Is the absolute priority the solution of the immediate problem? Do you want to own the IPR and sell it on to other users? Can costs be shared with others? Do you want to retain flexibility and potential costs for ongoing improvement? Is an end of the programme to develop IPR, local skills or local businesses? Is this agreed?

Two examples to illustrate what might be possible. The European Space Agency has a policy of growing technical capability. This includes software for space missions. LOGICA is a company that was grown and nurtured on ESA contracts before branching out into the big world. CERN and DESY (the major German accelerator lab) grow and nurture European high tech companies and capability to the benefit of particle physics and the companies. This uses pooled UK money. Similar attempts to use UK Research Council money typically hit state aid barriers.

The BIG message from this engagement with companies is that both sides gain IPR to mutual benefit. It is not simply aid to the company. This primacy of IPR is a concept with which Europe struggles. In other words buying R&D and the results of R&D as opposed to buying things is a procurement like any other.

What should Scotland attempt to do? I am an unashamed believer in picking winners. Since the alternative is usually to do nothing. So, in software development, where are the big lucrative challenges? What software, properly implemented would revolutionise banking risk, health care, nuclear safety, or whatever? In the USA, in defence areas, this task is delegated to DARPA staff members. These are not bland or trivial foresight exercises in the hands of committees, but visionaries who are given resource, responsibility and intent. They expect many failures.

In conclusion: Scotland needs to be an intelligent customer in procurement and probably expand its desired ends to include company engagement and growth. It needs to pick winners and invest; nothing comes cheap in this world. Computing is far too important to be left to the computer scientists.

Ian Halliday CBE FRSE, is the CEO of the Scottish Universities Physics Alliance (SUPA) and President of the European Science Foundation.