

“Australia’s future prosperity depends on our infrastructure systems.”

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Introduction and context

As a critical infrastructure in its own right, technology is becoming a more important part of the infrastructure discussion in developed and developing countries alike. But technology, especially the exploding array of networked communication and collaboration technologies that sit on top of the core network assets now as pervasive as roads, railways and energy – the network as a “fourth utility”, if you like – is a powerful and often disruptive source of innovation and renewal.

In that sense especially, the collision of technology and infrastructure is changing the way cities, regions and countries confront the daunting infrastructure challenges to which they have to find increasingly clever, affordable and sustainable answers.

This short paper contributes to the new infrastructure debate here in New South Wales. It explores how the pervasive use of connected technologies is changing the way infrastructure priorities are set, investments are made and performance is evaluated.

The paper stems from recent discussions with Infrastructure NSW (INSW), an expert body established by the new Government after the March 2011 election to write a 20-year infrastructure strategy for the State. Those discussions touched on the different ways in which technology is impacting the traditional debate about the provision of requisite infrastructure in a modern and rapidly changing society.

In particular, they started to explore how connected technologies substantially change the “terms of engagement” in the debate about how much to invest, in what sort of infrastructure, where and for what purpose.

The paper is a short “think piece” that introduces some new perspectives into the discussion about the best way to provision the infrastructure needs of NSW for the next 20 years.

It is not a detailed technical, financial or policy paper and doesn’t try and encompass all of the complexities of the infrastructure challenges which the State clearly faces. Rather, it sketches a point of view from which to look differently at the infrastructure challenges for NSW.

In summary

The basic argument goes something like this.

Too often, the infrastructure conversation focuses on the ‘what’ and the ‘how’, but doesn’t spend enough time thinking about the ‘why’. Being clearer about the wider economic and social impact that infrastructure investment is meant to achieve is a more sensible place to start.

Within that context, thinking about the potentially disruptive role of technology falls into three distinct but related categories.

- The first is the **role of technology in traditional or ‘hard’ infrastructure**. What is the impact of embedding sensors, for example, in bridges and roads and railways so that they can not only ‘talk back’ about their own condition but also provide information about changes in the physical context in which they operate?
- The second is the **role of technology as a critical infrastructure in its own right**. As more and more of the big social, economic and environmental challenges facing cities, regions and states are mediated through the digital domain, provisioning the underlying assets that enable robust connections, reliable communication and rich collaboration becomes a planning and investment priority in its own right.
- And the third category within which technology makes an impact could turn out to be the most important. It deals with **the way technology is disrupting patterns of mobility and engagement in cities and region** – in other words, the way we live and move around for work, leisure and learning. And not only are the new technologies of broadband-enabled distributed communication disrupting traditional patterns of movement, especially commuting in large cities. They are also introducing new options for work and play that have huge mobility, and therefore infrastructure implications.

Cisco’s CEO John Chambers summed it up aptly in a recent interview in which he reflected on the emergence of a new “intelligent network” with the potential not only to transform IT into business technology, but also “to catalyze new ways of being together; new ways of working together and boundless new opportunities for productivity and innovation.”

The broad trend was for IT and communications resources to become “more virtual, visual, social and mobile than anything we've seen to date.”¹

It's possible to see in these three distinct, but related categories three similarly connected models of change. The first is all about **automating** infrastructure, at least to the extent that it makes economic sense to do so with legacy assets and, increasingly, with new assets. This is all about making smarter use of technology, getting better value from existing and new assets and using data streams to know more and therefore to be able to make better judgements

The second, as technology becomes a critical ‘fourth utility’ and pervasive enabling or platform infrastructure in its own right, is about **integration**. More and more, technology assets can help to integrate diverse and distributed systems- traffic management, energy, environmental services – across a city or a region.

For example, a Department of Energy demonstration project in Washington State, using IBM technology, concluded that peak loads on utility grids could be trimmed by 15 percent. Nationally, such a reduction over a 20-year period would eliminate the need for the equivalent of 30 large coal-fired plants.²

And finally, as technology disrupts existing patterns of mobility and interaction, it helps to transform the way a city or a region works in the first place. New businesses emerge based on new business models that take advantage of cheaper and more effective ways to connect to suppliers, workers, customers and partners, new types of work evolve that need new skills and services, and a more connected and open relationship between people in their communities and with their governments and public leaders becomes the hallmark.

For government, the initial stages of the technology journey will impact directly on their capacity to provide and build, or commission, the assets and networks. As the new capabilities of “cloud” and massively distributed information and communication technologies start to spread, though, the role of government starts to shift. Some of those new “how” questions are only just beginning to emerge.

Technology and communications have long been a key infrastructure issue of course. But the advent of the Internet and the related growth of new social technology capabilities seem to have changed the nature of their collective and cumulative impact. They have become significant as critical assets in their own right and as part of the enabling layer of infrastructure that can make other assets more efficient and productive. In a way, technology has become another key factor of production along with the traditional factors of land, capital, labour and knowledge.

¹ http://articles.timesofindia.indiatimes.com/2011-12-31/strategy/30576194_1_business-technology-networked-innovation

² <http://www.nytimes.com/2009/04/30/business/energy-environment/30smart.html?pagewanted=all>

The argument then shifts beyond Sydney and the big urban centres to look at ways to provision the infrastructure assets necessary for regions and smaller settlements to remain relevant, robust and resilient.

The paper concludes with one warning and one suggestion.

The warning is that failure to embrace the implications of all three dimensions of technology’s potential impact risks ending up with an infrastructure investment strategy that hits the mark but misses the point.

Avoiding that outcome requires investing some time and effort at the front end to look, listen and learn. It involves taking time to understand the changing rhythms of people’s lives as they work, invest, learn and play. How do people actually move around the city and the regional spaces of the state?

What opportunities for new businesses, for innovation, for entertainment and for social and political engagement are they already starting to embrace, in the physical and especially the virtual world?

Answering those questions should take soundings from as wide a range and mix of people and organisations as possible so that the strategic model for NSW infrastructure that emerges is grounded, relevant and realistic.

2

Infrastructure: but why?

“I have said in the past that economists have difficulty describing in any detail the industrial structure that will maximise economic opportunity for Australians in the world of the future.

I can add today that our ability to be economically productive and competitive in the future depends heavily on having infrastructure systems that are well managed and can support industrial and societal evolution and innovation”

Dr Ken Henry

Traditional infrastructure discussions tend to start with the “what” question.

As soon as the interest in infrastructure is signalled, people quickly compile lists of potential projects that reflect their own favourites of assets to be built or refurbished. The discussion quickly moves to competing priorities and how to discriminate between spending limited resources on a new bridge or a school or upgrading roads and railways versus expanding port facilities. Cost benefit analyses and similar evaluation mechanisms are then wheeled out to help the process of selection and prioritisation.

As well as the ‘what’, infrastructure conversations are just as likely to be consumed early on with at least some aspects of the ‘how’ question.

Especially during periods of prolonged economic stress and financial constraint, the tricky business of how to fund, build and then maintain the assets is obviously critical.

Governments everywhere are experiencing an uncomfortable squeeze as rising demands for spending meet rapidly dwindling public investment funds. So the discussion inevitably moves to the merits or otherwise of direct funding by the public sector or the more likely approach these days of various forms of public-private partnerships and other similarly ‘mixed economy’ models of funding and investment.

Less frequently does the infrastructure conversation start out with some fundamental questions about ‘why’?

At one level, the contemporary answers to that question are becoming larger in their scope and ambition. Almost everything and anything that can be digitised is being digitised (via computers, cameras, sensors, tags, mobiles etc). As this happens, the cost of so many goods and services is going down often level tht are at or close to marginal cost ie zero (just think about what’s happening right now for things like books, movies, magazines, newspapers, games etc). The question is how to capitalise on this inexorable process of transformation or “creative destruction” to realise its opportunities as much as to mediate its risks. And the stakes are high. This is not just about provisioning the NSW economy or looking for a new foundation for investment, jobs and growth within the State. It’s just as much about provisioning the State’s capacity to take advantage of these opportunities in the wider Asia-Pacific region and beyond.

In that sense, the ‘why’ question is best answered in terms that reflect the blunt advice offered by Ken Henry quoted earlier in this paper.

The point of infrastructure is to “maximise economic opportunity for Australians in the world of the future,” or, in this case, for the people of New South Wales. And the quality and impact of the decisions we make about where to invest our dollars can only ultimately be judged by the extent to which the infrastructure systems that emerge are not only well managed but “support industrial and societal evolution and innovation.”

The role of technology is central to the task of making sure that infrastructure investment has something to do with the kind of society, and the kind of capabilities, we need to provision in order to combine the growth, sustainability, inclusion and innovation that the “world of the future” demands.

A recent study in the United Kingdom looked closely at the integration of different types of infrastructure investment with larger economic and social development goals. The study fed into the UK Government’s 2011 national infrastructure plan.

The study demonstrated how UK infrastructure systems are becoming increasingly interdependent. If appropriately accounted for in policy appraisal and decision making, the authors suggested that these interdependencies could offer:

- On-going opportunities, for example, lowering the economic costs of street works through well-targeted interventions to encourage them to be more efficient ;
- One-off opportunities, for example, by sharing infrastructure assets, such as tunnels, with other sectors, or by unlocking economic developments through better co-ordinated decision making; and
- Wider economic opportunities, such as positive impacts on the wider environment or attracting inward investment.³

Realising these opportunities requires consideration of infrastructure interdependency to sit at the heart of decision-making. In particular, the report suggested “it requires action to be taken to ensure interdependency is embedded both strategically and within policy frameworks”

One of the six case studies that formed the basis of the study looks at the interaction of smart grid and electric vehicles. It estimated that smart grid charging, which already assumes significant integration between electricity networks and ICT, could **save about 18% of the annual cost of charging the vehicles**, or something like £50 per car, per year. **Running low emission electric vehicles could save about £400 million a year relative to conventionally fuelled vehicles.**

Two recent examples from Cisco’s own experience reinforce both the strategic significance of infrastructure and the impact on larger social and economic outcomes.

After the 2005 devastation of **Hurricane Katrina** Cisco, in collaboration with national and international education partners and school districts in Mississippi and Louisiana, embarked on a journey to transform the education systems of eight districts in the Gulf Coast Region of the US.

As a result, each district articulated a vision and framework for a 21st century education system which guided the massive reconstruction process from the start. They invested not only in new buildings, but also in technology infrastructure that created the digital education assets for the future as well as programs of investment in curriculum and pedagogy, system reform and a change program built around leadership, people and culture. .

The key was to ensure that the urgent imperative to attend to the basics after the devastation of Katrina did not undermine the ability to prepare for the future.

Three years later, Cisco was heavily involved in the reconstruction process in the aftermath of the huge **earthquakes in Sichuan** in China in 2008. With a focus on both hospitals and schools, the same instinct was evident in the China context that drove the renewal of the post-Katrina education system.

When Cisco made the original commitment to contribute both money and people, we developed an MOU with the Sichuan provincial

³ <http://www.frontier-economics.com/europe/en/news/1249/>

government that set out the broad intent of the work, the levels of funding and timescales. At the various MoU related meetings, there was considerable discussion of what the Chinese described as a “build better, build for a new future” approach.

In both cases, the contribution from Cisco was primarily, but not exclusively, to the challenges of replacing ‘hard’ infrastructure or creating new assets altogether.

But it also touched on the skills, governance, management capabilities and the impact on the wider life of those communities – commerce, creativity and community – that represent similarly significant ‘soft’ infrastructure elements too.

Both these examples illustrate the need to focus on the future as much as to rapidly respond to the basic and urgent demand to repair the past.

At one level, that all seems very obvious. A program of road building is necessary to upgrade or improve poor quality road assets, or ports need to be expanded to accommodate rising demand and an often mounting backlogs of ships and cargo. You only have to look around and see the evidence...crumbling roads, inadequate transport systems, poor quality school buildings and old bridges need to be replaced.

But perhaps less easy, or at least less obvious, is the link between infrastructure investment and the larger social and economic ambitions which lie at the heart of the State’s longer-term development goals. And, more importantly, between infrastructure investment and the kind of society that we know NSW will have to be in order to succeed into the future.

NSW priorities

In the case of New South Wales, for example, the answer to at least some of the ‘why’ questions to which the INSW 20-year strategy might be offering some answers might include:

- Attracting investment and creating jobs.

A recent McKinsey Institute study on the impact of technology on jobs suggested that for every job that was lost due to the impact of technology, 2.4 new jobs emerged.⁴

⁴ http://www.mckinsey.com/Insights/MGI/Research/Technology_and_Innovation/Internet_matters

“The Internet’s impact on global growth is rising rapidly. The Internet accounted for 21 percent of GDP growth over the last five years among the developed countries MGI studied, a sharp acceleration from the 10 percent contribution over 15 years. Most of the economic value created by the Internet falls outside of the technology sector, with 75 percent of the benefits captured by companies in more traditional industries. The Internet is also a catalyst for job creation. Among 4,800 small and medium-size enterprises surveyed, the Internet created 2.6 jobs for each lost to technology-related efficiencies.”

A study by IBSG's Research and Economics team⁵ looked at exactly this issue of employment contraction and growth, recognising that some jobs are declining and some are growing, fuelled in both cases by the impact of technology. For example, in the last 10 years in the US, there were 44,000 fewer travel agents handling more complex bookings and requests. Over the same period, the IT sector has added about 600,000 jobs, with total IT sector employment standing at 3.2 million in 2010.

The paper notes that “while the majority of jobs in this area involve the direct operational support of computer systems, 900,000 of these jobs are in software application development or software system development. Based on long-term capital equipment expenditure trends in the United States, these software categories are likely to be among the fastest-growing.” The only certain way to avoid the inevitable technology-driven job displacement, the paper concludes, is to move from jobs that have grown up around information hoarding, low-value middleman functions and repetitive tasks to jobs that involve “learning new skills that deliver some sort of innovative service that cannot be automated, streamlined, or handled more efficiently by someone else, including service customers themselves.

There are significant opportunities for small (and large) businesses to exploit these transformations, especially to the extent the opportunities are cast in terms of not just jobs and investment for NSW but for NSW to capitalise on services and capabilities for the region and the world.

- Fuelling an innovation economy based on a virtuous circle between knowledge, skills, investment and creativity, with a particular focus on manufacturing, digital economy, professional services, international education and research , tourism and events (press release from Minister for Trade and Investment and Deputy Premier Andrew Stoner, September 2011)
- Making Sydney especially, and other major cities and towns, more liveable
- Creating assets and capabilities that turn NSW advantages in areas like health, education, finance and services, design and construction into rising export opportunities into the region and beyond
- Gradually lowering the carbon intensity of NSW economy
- Making regional centres and settlements more resilient and robust in terms of access to amenity and opportunities for growth and jobs, learning, culture and innovation
- Improving trust and service as the basis for effective public services and an improved relationship between citizens and governments.

⁵ *The Case for Upgrading Job Skills in the United States: How Not To Be Among the Next 2 Million Workers Displaced by Technology*, Douglas P. Handler, Cisco IBSG Research & Economics Practice, 2011

There are few of those areas in which technology's role and impact either in the provision of traditional infrastructure, or as a piece of critical infrastructure in its own right, will not be felt.

Take an example – employment and the growth of small and medium businesses. Small business accounts for almost half of all private sector employment in Australia and remains a major employer in NSW too.

Key to growing the capacity of these businesses to employ people is their ability to keep lifting productivity and growth. And both of those depend on innovation. In many cases, that combination of outcomes is dependent on the capacity to compete effectively with imports or produce goods and services that can be traded globally.

So the answer to one important 'why' question for the next wave of infrastructure investment in NSW is to create assets to help small and medium businesses to engage new sources of innovation and growth which fuels demand for high level skills and creates jobs.

And often, the infrastructure that is needed – for example, to support new service models for online retail or more traditional areas like manufacturing or building and construction - will create assets whose value will be as much about NSW's engagement with the Asia-Pacific region and beyond as they will be for economic activity within the State.

Take another example- exporting education and skills learning.

The Premier recently undertook a trade mission to India. A central part of the mission was about how the TAFE sector especially can step up to some of the huge skills and vocational learning opportunities that India's insatiable appetite for both is generating.

So if one of the demands for NSW success “in the world of the future” is to be outstandingly successful in the design and provision of world class vocational and skills education, anywhere and anytime, what are the infrastructure implications? How does the state privilege the mix of infrastructure assets, physical and digital, that are implied by its education and learning export ambitions, so it can meet not just current opportunities but create assets that can adapt and grow as those opportunities themselves grow and change over time?

Part of the answer to that question might be relatively traditional. NSW needs to provision the buildings, other physical assets and the teaching and management capabilities of a TAFE sector capable of training large numbers of Indian students.

But part of the infrastructure challenge that flows from the State's ambition to become a major force for vocational skills education and training in the region, and indeed the world (see, for example, the work NSW TAFE is already doing in technical education in Abu Dhabi) is digital.

How likely is it that the State's ability to service the emerging skills and VET needs in India will require, for example, high-quality video capabilities that

IN the mid-1990s, the Internet took off because its technological time had come. Years of steady progress in developing more powerful and less expensive computers, Web software and faster communications links finally came together.

A similar pattern is emerging today, experts say, for what is being called smart infrastructure — more efficient and environmentally friendlier systems for managing, among other things, commuter traffic, food distribution, electric grids and waterways. This time, the crucial technological ingredients include low-cost sensors and clever software for analytics and visualization, as well as computing firepower.

Wireless sensors can now collect and transmit information from almost any object — for instance, roads, food crates, utility lines and water pipes. And the improved software helps interpret the huge flow of information, so raw data becomes useful knowledge to monitor and optimize transport and other complex systems. The efficiency payoff, experts say, should translate into big reductions in energy used, greenhouse gases emitted and natural resources consumed.

A handful of big technology corporations, including I.B.M., Cisco and General Electric, have major initiatives under way...

Just how large the market will be and how quickly it will develop remain uncertain. The early smart-infrastructure ventures often seem like applied science projects, encouraging but small scale. It is not clear whether they will work outside the laboratory, where they must turn a profit or justify higher taxes or user fees. Much of the early Internet investment, after all, came to grief.

The smart infrastructure wave, analysts warn, could bring a similar cycle of enthusiasm and disappointment. Yet, like the Internet, they say, the technology will prevail in the long run.

"There will be a lot of hype and a lot of things that don't pan out," said Rosabeth Moss Kanter, a professor of business administration at the Harvard Business School. "But the direction is absolutely right. We've barely scratched the surface of how information technology can help control and conserve energy use."

<http://www.nytimes.com/2009/04/30/business/energy-environment/30smart.html?pagewanted=all>

provision new forms of distance and distributed learning? How will TAFE connect specialist teachers and skilled instructors with eager students in India, at scale and in an increasingly diverse pattern of times, locations and formats? And what about the associated capabilities in security and storage so that vast volumes of data and knowledge can be generated, stored, accessed and re-purposed with confidence and agility? In this space especially, technology's rising instincts to become ever more virtual, visual, social and mobile are powerful and exciting game-changers.

Both of these examples illustrate the power of the "why" question at the heart of INSW's strategic planning challenge. Lists of investment priorities and detailed discussions about potential funding models for the design, financing and construction of the assets are always going to be important. But a steady focus on the needs they are serving, the outcomes for the people of NSW they are supporting and the future for the State they are provisioning has to be persistent and pervasive.

3

Embedding technology in infrastructure

The first dimension of technology's impact on infrastructure is the potential transformation of the design and execution of traditional 'hard' infrastructure - roads, bridges, railway lines, hospitals and schools- when you embed 'smart' technology from the start.

A major study co-authored by The Climate Group about the role of technology in addressing issues arising from climate change found that ICT could improve existing infrastructure by 15%.⁶

The truth is that technology is often one of the most flexible and adaptable 'levers' that governments can pull to make a relatively quick

impact on infrastructure performance.

⁶ <http://www.smart2020.org/publications/>

Generally, it doesn't require too much physical disruption and the digital teams that are emerging in cities and regional and national governments have the task of identifying opportunities for technology-enabled infrastructure renewal.

As increasingly cheap and powerful sensor technologies emerge, and as they are connected to larger and more robust broadband networks, they are being used in different settings to essentially allow infrastructure to 'talk back'. The economic case for the investments necessary to make that happen will vary, especially in terms of legacy versus new assets. But the information flows about the quality of the assets themselves, the way they are being used and, in many cases, the health of the larger systems of which they are part⁷ have become as critical to their sustainability as the quality of the materials and construction of the physical assets in which they have become pervasive.

The University of Texas at Austin, for example, created wireless networks of sensors to monitor cracks in existing bridges where the failure of a single piece could bring down the entire structure. Because getting power to the sensors can be a problem, the group is studying how to use the vibrations of the bridge to generate electricity for the devices. It's also working on devices with enough computing power to analyze the stream of data and send alerts when potentially serious damage occurs.⁸

Similarly, in a trial with one of the nation's largest railroads, G.E. is using sensors on tracks, sidings and locomotives; sophisticated computer models; and optimization software to fine-tune the flow of traffic across the railway network. The outcome is that trains wait less and travel at higher speeds (an increase of 2 miles per hour on average). Although that seems a small incremental improvement, as it turns out each mile per hour improvement translates into \$100 million in efficiency gains including energy savings. And new locomotives effectively become "computers on rails", wirelessly downloading information on trips, traffic, terrain and loads, and making adjustments. That kind of automation can deliver energy savings of up to 13 percent.⁹

As these examples suggest, often relatively small investments in embedded technology (always easier and cheaper to do at the front of a project rather than paying to retrofit later) can have a big impact in terms of cost savings, efficiency and productivity.

These are just a few of the areas in which connected technologies have embedded information flows at the heart of effective and cost-efficient infrastructure.

⁷ The value of embedded sensors in a piece of freeway or a bridge is not just the information it can provide about the changing state of that asset, but also the information it can collect on things like traffic patterns and movements using that asset.

⁸ <http://online.wsj.com/article/SB123447510631779255.html>

⁹ <http://www.nytimes.com/2009/04/30/business/energy-environment/30smart.html?pagewanted=all>

There is growing evidence from across Australia and around the world that people, governments and business create real value by forming, and connecting to, effective human networks of innovation and creativity.

That is how they attract investment for new jobs, keep the environment clean and healthy, create better schools and more effective health systems, provision more efficient public transport systems and decongest cities and towns to make them more liveable.

Whatever the problem or opportunity, it's likely that better solutions will emerge more quickly if people can easily and safely connect to other people, to knowledge and ideas and to a mixture of 'hard' and digital or 'soft' assets.

Roads, bridges, schools, hospitals, ports, big public transport systems, new housing – all of these traditional assets are still important. But when an entrepreneur is looking for investors or partners to develop a great new product or service, when a teacher wants to connect her students to experts on the other side of the world or in the next town, when someone needs access to specialist health care or the care of a collaboration of family, medical experts and community support teams, they need to find people, connect and talk with them easily and often work together across large distances and over long periods of time.

In the increasingly digital and distributed future, whether we are trying to make our cities and towns easier to live in, to start new businesses and create new jobs, to keep our water clean and our energy sustainable, to make regional towns and rural communities more sustainable, we'll be "smarter, connected". What will matter most is not only the availability of expertise, insight and a willingness to help. What will matter is how quickly and effectively we can connect those pieces of the puzzle to get better answers quicker.

In particular, the human and technology fabric of the digital economy is becoming central to new demands for resilience and sustainability at the heart of policy for urban and regional growth and development.

The combination of rapidly spreading next generation broadband, an explosion of new services and applications are already changing the way people live, work, learn and play. The search for smart ways to "square the sustainability circle" of economic growth, social inclusion and environmental quality has put technology firmly at the centre. And good infrastructure planning is one of the ways to make that happen.

As well as the examples of roads, railways and bridges, schools and hospitals are being, literally, wired for new ways to teach and learn that assume the capacity to easily, quickly and safely connect teachers and students or doctors, patients and carers in new combinations across the school or hospital, between the institutions and home and with other people and institutions anywhere in the world.

Similarly, traffic and transport systems are incorporating new capabilities to 'talk' to passengers and those managing the system. Energy systems

are being wrapped in increasingly intelligent clouds of information and data so that people can be smarter in the amount of energy they use and therefore reduce costs and improve efficiency.

But just as important is the need to either replace existing or invest in new ‘soft’ infrastructure. Governments at state and local level are already experimenting with new ways to communicate with, and to listen to, citizens and communities. Policy discussions and key governance issues are now being aired in wider and more inclusive online and offline processes to make sure that good ideas can emerge and a sense of trust and legitimacy can grow.

As well, new models of innovation, including social innovation, are springing up as entrepreneurs, investors and often smaller, more nimble organisations use social media and new networks of collaboration to find good ideas, test them out, secure investment and then scale and spread them for success. And business and governments are experimenting with new ways to collect and analyse data and to turn that into knowledge that can fuel value-adding change.

4

Technology as a critical infrastructure

In a country investing so substantially in new national broadband assets, it’s perhaps not such a leap of logic to argue now that the physical and electronic assets of the digital economy – the ducts and fibre and wires and electronics – have become a “critical infrastructure” in their own right.

As more and more of the way we work, learn and play and the way we access and provide services as diverse as healthcare, shopping, border security, defence, transport, electricity and water is mediated through networked information and communication systems, their role in the infrastructure mix is well established.

Just imagine taking the Internet down for a day in Australia and the underlying communication systems on which it relies. These are now assets that have seeped deep into the structures and systems on which we rely to conduct pretty much every facet of our economic and social lives.

The concept of “critical infrastructure” has shifted considerably in recent times to reflect the changing role and significance of technology. One overview explains that “the systems and networks that make up the infrastructure of society are often taken for granted, yet a disruption to just one of those systems can have dire consequences across other sectors.”

The review goes on to take an example, a computer virus that disrupts the distribution of natural gas across a region. “This could lead to a consequential reduction in electrical power generation, which in turn leads to the forced shutdown of computerized controls and communications. Road traffic, air traffic, and rail transportation might then become

affected. Emergency services might also be hampered.”¹⁰ Major policy frameworks and significant defensive strategies are now emerging in most countries, including the US¹¹, Europe¹² and of course here in Australia¹³

In New South Wales, discussions are underway to rationalise access to, and use of, the mix of spectrum and fibre assets and capabilities owned by both the State Government and the Federal Government.

The focus is clear – the strategy will result in the best mix of technology and infrastructure capabilities for the State that lifts productivity, fuels economic growth and creates a platform for new businesses, public services such as emergency response and disaster recovery, education, health and transport as well as for innovation.

5

Technology and patterns of mobility

The city of Amsterdam undertook a survey recently to look at the impact of a decision by every employee in the city to work one day a week either from home or from a “third place” location like a smart work centre or a shared workspace “hub”. The study calculated that cost savings, in terms of time, expenditure on commuting and work travel for example, the likely savings would be about €15 million every year.

And as far back as 2006, some 30 million Americans, or about a fifth of the workforce, was estimated to be regularly spending significant work time not at home or in the office but in these third or intermediate spaces.¹⁴

The emerging dynamics between changing patterns and places of work and the way those patterns intersect with, and influence larger rhythms of life across a city, or indeed around a larger region, are profoundly impacted by, and shape, the social life of communities.¹⁵

In these changes, two things matter deeply.

One is the changing nature of work itself. Not for everyone and not all the time, it is true, but for increasingly large numbers of people and across increasingly diverse sectors and domains, work is becoming untethered from place. Fuelled by more reliable broadband networks with much greater capacity, people are using new broadband-enabled social and collaborative technologies, especially those based on video, to disrupt many aspects of traditional patterns of work.

¹⁰ http://en.wikipedia.org/wiki/Critical_infrastructure_protection

¹¹ <http://www.dhs.gov/files/programs/critical.shtm>

¹² http://ec.europa.eu/information_society/policy/nis/strategy/activities/ciip/index_en.htm

¹³ http://www.ag.gov.au/www/agd/agd.nsf/Page/OrganisationalStructure_CriticalInfrastructureProtectionBranch

¹⁴ http://www.usatoday.com/life/2006-10-04-third-space_x.htm

¹⁵ This section draws on a work-in-progress project on the “social life of cities” led by Cisco’s Internet Business Solutions Group. Associated research initiatives are being discussed with a range of partners, including The Young Foundation and NESTA in the UK.

The work-life debate has moved up several notches. Now it is about much more than bashing out a few emails and writing a report from your home study, and being able to pick up the kids from school at the end of the day (although there's nothing wrong with any of that, of course!).

It embraces, but is rapidly moving well beyond, some of the “telework” and “work from home” conversations of the past 30 years or so.

New patterns of productivity and creativity are emerging as people find ways to work at home or, increasingly, in the spaces between home and the traditional office, in quite different and surprising combinations that can be provisioned “anytime, anywhere”.

The other thing that matters sounds at first like a contradiction of that first trend. Work and place are increasingly untethered, it is true. More and more, work is something you do, not necessarily somewhere you go.

The old idea of a fixed office location to which you trek religiously everyday to spend a fixed amount of time before you leave and go to a place that is “not office” (home, restaurant, gym or whatever takes your fancy) is already fading.

But a new idea is emerging, reflecting the enduring human need for connection and collaboration. It turns out that we still need an “office”, but less and less of the sort that we've been used to for the last 50 years or more.

What we need is a different mix of cleverly designed places and spaces where we can congregate and connect for all sorts of work-related reasons. These are being conceived and provisioned with much more freedom and creativity and with a much greater insight into the importance of context and place.

People do like to work ‘anywhere, anytime’, but they also associated with the amenity and impact of the physical places in which their workspace is situated.

So the surrounding urban or community context of the place, its appeal and design, its facilities, risks and opportunities, all become a powerful element in the equation.

And evidence from leading cities and regions, like Amsterdam, Seoul, London, Paris, the innovation hubs springing up in east London or Birmingham for example, suggests a powerful collision of design, economics, property development, anthropology, science and technology is fuelling exciting experiments in new ‘office’ or collaborative work environments.

They go by a variety of names – hubs, incubators, shared work spaces, smart work centres – but they all obey a simple set of rules, including:

- Work where you need to, and want to, not where you have to
- Increase the chance of bumping into interesting people with unexpected opportunities to collaborate (learn to navigate and relish the emerging landscape of “systematic serendipity”)
- Make the design of the new “office” deeply appealing, flexible and therefore attractive

- Cater for pretty much every sort of working style you can think of – private, small group, large group, virtual – and build in as much ‘flex’ or “optionality’ as you can to cater for working styles that people are going to invent (but you don’t know what or when).
- Make it clean, green and smart...people need to be as busy as ever, if not busier (or at least, more productive, assuming those two things are not, alas, always the same). But they want, at the same time, to access new tools and locations that mean they are working smarter and with less impact on their environment

All of this points to the reality that we are changing, often quite dramatically, the way we move around cities and regions and towns, largely because of the role of technology and especially driven by new patterns of work and organisation.

Where once we travelled so we could find the information, knowledge and people we needed to do our work, more and more now the information, knowledge and people we need can find us, wherever we either want or need to be.

Many of these patterns are being driven by traditional demands of efficiency and cost reduction. More flexible work patterns tend to translate into lower demand for real estate and less wear and tear on roads and transport systems for example. On top of that has been loaded a new ‘green’ premium in which flexible work models play an important role as part of the mix of institutional, infrastructure and policy factors seeking reduced carbon footprints, lower waste and cleaner air for example.

But another and perhaps more important factor, over and above the benefit bundle of cost, convenience and carbon that flexible work can generate, is emerging.

Innovation, they say, is the “new black”. Organisations in business, government and civil society are obsessed, rightly, with the search for clever ideas to either incrementally improve or dramatically change their products, services and capabilities.

As the innovation imperative burns with new intensity, so has the realisation that, more and more, innovation can’t be done in isolation. People and organisations have to reach beyond their own boundaries to connect and make common cause with people, resources and expertise in other organisations.

The “open innovation” movement has risen powerfully to create new systems of innovation that depend for their success on the ease with which ideas and people can connect around the corner or across the world. New constellations of people and organisations are forming and evolving to capture the potential of new thinking and, in the process, shaping new practice.

At the heart of open innovation is an instinct for “systematic serendipity”, the ability to create and sustain unexpected connections between people who might otherwise not meet and collaborate.

If innovation is something that happens, at least in many cases, at the “collision of the unfamiliar”, then unexpected connections become critically important.

Many of the new models of working that are less focused on traditional organisational structures or office work spaces, and which pitch people into close proximity to others working in different, but perhaps complementary spheres of interest, are now being sustained by a desire to motivate innovation just as much as they are by the desire to save money or reduce carbon.

The broad narrative of change in the “work life” evolution is illustrated by the diagram below:



What the story suggests is a steady move away from a relatively simple replacement of traditional models of physical working with ‘distance’ or ‘virtual’ working towards new models of work altogether. In the terms of this narrative at least, “smart work is an act of production performed independent of time and place.” It is “results-oriented: it is often social and collaborative, and the result of a networked way of operating, with exchange, collaboration, and co-creation processes optimizing work and its output.”¹⁶

These trends are already having an impact in Australian cities as hubs and shared work spaces start to pop up and governments too start to think about better ways to provision more flexible working patterns for at least some of their workforce.

The drivers are the same – saving money and carbon, attracting a workforce whose demands for working environments are driven by the same instincts for deep, pervasive and increasingly internalised patterns of connection and collaboration they have grown up with.

¹⁶ *Work-Life Innovation: Smart Work Paradigm Shift Transforming How, Where, and When Work Gets Done*, Bas Boorsma and Shane Mitchell, IBSG, September 2011

It is a pretty sure bet that these same trends will dramatically disrupt the mobility patterns in Sydney as well as in towns and regions across New South Wales. Some early indicators are already emerging:¹⁷

- 20% of businesses in NSW are planning to change their employment model once the NBN enables remote teleworking (Impacts of Teleworking under the NBN, Access Economics, 2010)
- If 10% more Australians used teleworking, even half of the time, the productivity gains would be more than \$1.5 billion a year. (Australian Business Expectations for the National Broadband Network, Access Economics, 2010)
- If our teleworking performance matched the EU's rates of teleworking (9% telework fulltime and 6.2% 25% of the time), the benefits could be in the range of \$2.9-\$3.9 billion per year. (Access Economics, 2010).

These trends bring with them infrastructure demands of their own. And their impact will be felt in terms of changing demands for at least some components of traditional infrastructure – railways, roads, airports – which they will consume less of or at least in very different ways in 20 years time.

6

Making regions resilient and relevant

Amenity and access are the twin pillars on which effective regional policy and investment is based.

The point of good regional development strategy is to make available for those who live in regional cities and towns and in smaller settlements as full a mix of amenity, services and opportunities as possible for work, learning, social participation and entertainment.

And to the extent that outcome can be achieved, significant impact on wider aspirations will emerge, including for example:

- A more even and sustainable distribution of population that can reduce congestion in larger population centres and have marked impacts on liveability, lowering carbon intensity and lifting productivity
- Creating new economic opportunities for regions and smaller centres
- Reducing the need for people and businesses to relocate to larger centres to access markets and services that they need to be viable and on which to base growth
- Creating a better mix of ‘critical mass’ centres that can sustain a more evenly spread investment in infrastructure and assets across the State.

¹⁷ Taken from a draft submission to Infrastructure NSW by IBM

For the most part, what people seek when they make judgements about the amenity associated with where they live and work is access to people, access to information and ideas and access to services that support them in the different facets of their lives – learning, entertainment, business, and public services for example.

To the extent that more of that amenity is likely in the future to be brokered through the digital, NBN-enabled platforms to which more and more people will be connected, those platforms become vital infrastructure assets in their own right.

The telehealth dimension of the Far West NSW Digital Economy strategy is a good example of the potential for technology to become a critical regional transformative infrastructure.¹⁸ The strategy makes clear that, notwithstanding the current infrastructure frustrations, the Far West NSW region has an opportunity to become a leader in e-Health by building on the skills, expertise, processes and infrastructure already being put in place by some of the leading health providers in the region. The strategy gives some examples:

- NSW Health and its telehealth and e-Medical records program
- The Royal Flying Doctor Service and its skills, traditions and culture of innovation and adoption of the latest technologies
- The Broken Hill University Department of Rural Health (BHUDRH) and its community of care program
- Maari Ma Health Aboriginal Corporation

The strategy puts the story very clearly. “Technology should prevent development of the urban/rural health divide.” The ambition, which cannot be achieved without smart investment in digital and physical infrastructure and in services and skills too, is to “provide the same quality health care in the rural and remote locations as is provided in well populated metropolitan areas.”

These examples illustrate the impact technology is already having on access and amenity and therefore on the quality of life and the range and mix of opportunities to which regions can reasonably lay claim.

In the next 20 years, provisioning these new levels of regional amenity and access will be an important part of the State’s ability to be successful in the “world of the future”. Indeed, closing the amenity and access gap becomes, in its own right, one of the answers to the “why” question that animate the overall infrastructure strategy in NSW.

Getting this piece right will make it possible not just to compensate people for the distance they experience from larger urban centres in terms of services and amenities, but will to a large extent equalise them. It will, at its best, give regions and smaller centres new opportunities for regional-based innovation that can then be exported back to cities and other regions around the world.

¹⁸ <http://digitalfarwestnsw.com.au/health/>

7

Hitting the target, missing the point?

The first risk that INSW has to avoid is to create a perfectly sound and well balanced, responsibly costed 20-year infrastructure strategy that creates assets where they will not be needed or will not be used properly because patterns of investment, work, learning and leisure have changed.

In that sense, it's possible that the 20 year strategy could end up hitting the target...

...a carefully costed, well argued list of infrastructure priorities

but missing the point...

...creating assets that will help people and communities and businesses in NSW to be successful in the world of the future.

The other risk the strategy has to avoid is under investing in the digital and associated 'soft' infrastructure that people are likely to increasingly need and rely on to reach for the success to which they aspire.

In the absence of the right strategy or a strategy that is misaligned to the future, infrastructure investment will fail to support the "industrial and societal evolution and innovation" on which the State's future will be built.

8

Look, listen and learn

The infrastructure planning process in NSW should invest in a front-end process that looks carefully at the current and emerging patterns of economic and social life in cities and regions (including the rising impact of technology).

It should create simple and direct ways to listen and learn from the evidence and insights from a wide mix of people and organisations. It has to become familiar with the context in which infrastructure decisions will be made and what is shifting in that context – social, economic, political, technological – that will determine whether the final infrastructure investment decisions and priorities will make sense (or not).

Just think of these obvious and relatively simple examples.

With the introduction of **electric cars** and other vehicles, we can assume into the future a key infrastructure will be re-charging facilities both at home, at the places where people work and in other public and civic locations. It's not fanciful to assume that the investment priorities between replacing or adding roads and rolling out the infrastructure assets for rapidly rising use of electric vehicles will shift in the next 10 to 20 years.

Already we're seeing concerted efforts by health authorities, social entrepreneurs and NGOs to reduce the rate at which **older people** are forced to give up independent, community-based living and move to more expensive and socially disruptive nursing homes and other aged care facilities. Let's assume that trend is both inexorable and accelerating.

Two big asset or infrastructure questions arise. How many nursing homes and aged care facilities will we need in the next 20 or 30 years? Where do they need to be and how do they need to be constructed in terms of connectivity to services and communication?

And to the extent that people can stay in their homes longer, what kind of infrastructure will be necessary to make sure they can easily and reliably access services like

- Regular remote check-ups with nurses and other health workers
- Fitness classes where they don't have to leave their homes if they don't want to (or can't)
- A rapidly rising raft of new learning, social networking and family communication opportunities that keep them connected and in touch and therefore healthier and more independent?

That is a process of policy leadership. Investing some time and effort in this front-end invitation to look, listen and learn will, in large measure, provide the platform from which to then lead and, in the process, inoculate in large measure against the wrong outcomes or wasted resources.

A final thought on the “how” question

The 20-year infrastructure strategy should not only be deeply informed and influenced by the impact and emerging potential of technology, but should also be based on solid evidence and good advice about what's possible.

The gradual move from using infrastructure in existing and new traditional infrastructure assets, and using the disruptive potential of cloud-based, technology-enabled infrastructure services will not be without its challenges. This is especially true as the new opportunities to lift the performance and impact of infrastructure through wider use of technology meets resistance from current procurement systems and cultures.

The challenge here is in at least these areas:

- **Organization:** The nature of ICT delivered services is substantially different in that 1) it is both widely and privately distributed, and 2) as a result it is non-monopolistic and not easily marshaled into the usual procurement/delivery models of other government infrastructure.
- **Structure:** The need for a partnership model in the development and delivery of ICT enabled technology or “soft” infrastructure is substantially different from the vendor management approach – demand, command, and deploys - approach of most public sector agencies.

- **Approach:** There are a large number of innovative approaches available to government, but few that are available at scale or easily replicable across government procurement models. This is especially true as we look to drive demand and not just manage supply of access to services.

This is a key challenge for the “how” question and one that demands more thinking and development. But at its core, this is an issue that challenges the fundamental role of government in the sector and suggests a shift to better ensure deployment and equitable access to these technology enabled services.

To accomplish this, government agencies need to move from the provision and regulation of services through supply side models (provisioning for the services of doctors, building of hospitals, development of roads and bridges, supply of social workers, police forces, or jails) to the incentives that will ensure access to next-level services; services that will often largely be self-selected, personalized, and provided by a variety of private, public, non-profit, community, and individual service providers.

In many ways, it will require government to reconsider where its natural and appropriate dominion in service provision might lie and, more importantly, how to make that decision in a way that doesn’t further erode the social contract that is in place between citizens and government.

Integrating technology into the infrastructure investment process will also have an impact on governance and decision-making. It will test existing models of sensing trends, responding to and predicting emerging priorities and becoming more adept at calculating the savings that can accrue from better technology investment on consequent infrastructure investment. That implies changes of mindset and practice at different stages of the infrastructure planning and investment value chain.

Similarly, another big governance impact is the need to take many of the larger technology asset decisions on a whole-of-government basis. Many of these decisions and investments cannot be taken at an agency or cluster level. That’s not only because of their potential size and scope. It’s also because they will create capabilities that should be shared widely across agencies and functions – “build one, use many times” – to maximize the value and increase their productivity.

The emerging ICT and telecommunications strategies that are currently being developed by the State Government will be key opportunities to signal changes at this critical governance level.

Attachment

Some further examples

1. In 2006, Stockholm experimented with congestion pricing, charging cars up to \$4 to enter the downtown area, depending on the time of day. The cars were monitored with RFID cards and webcams that photographed license plate numbers. Drivers had to pay within two weeks or faced penalties, but IBM linked the driver data to 400 convenience stores in the city to make payment easier. Within a few weeks, the impact in Stockholm was evident, and it has proved permanent. Car traffic in downtown Stockholm has been reduced by 20 percent, carbon dioxide emissions have dropped 12 percent, and the city's public transport system has added 40,000 daily riders... The webcams accurately read license plates, even on snowy days, more than 95 percent of the time. So the RFID tags are no longer in use. After expenses, the smart traffic system generates \$80 million a year for the city.

<http://www.nytimes.com/2009/04/30/business/energy-environment/30smart.html?pagewanted=all>

2. The California Department of Transportation, or Caltrans, has installed radio receivers along several freeways in the San Francisco Bay area that read the electronic toll tags in passing cars. Using that information, Caltrans can track the speed of individual vehicles and determine the travel time from one point to another. Then those times are posted on electronic road signs. (Caltrans officials say they don't keep track of personally identifiable information from the tags, to protect privacy. Eventually, the data from the roadside sensors could help traffic controllers guide drivers to other travel alternatives: Is a bus or a train faster than the freeway? To that end, Caltrans and the Bay area's Metropolitan Transportation Commission are testing three electronic signs south of San Francisco. Along with freeway travel times, the signs show scheduled travel and arrival times on Caltrain. Drivers can see if they'd be better off getting out of heavy traffic, heading to a station and catching a train.
3. Enter a concept called vehicle infrastructure integration, or VII. These systems would let roads, traffic signals and vehicles talk to each other, and share crucial information automatically, by using a range of technologies -- GPS navigation, wireless communications, advanced sensors and onboard computers. For instance, a car in an accident could send out an automatic message about the time, location and severity of the crash to receivers along the roadside, which would then automatically dispatch emergency vehicles.

4. A smart grid would even be able to partly heal itself. Today, when a storm drops a tree branch on a power line, utilities typically have to rely on customer calls to locate the damage and assess the scope of the outage. CenterPoint is testing special sensors and switches that sit alongside power lines and detect sudden changes in the amount of current through the wire. The utility then can quickly route power around the break, restoring electricity within seconds to a large part of the blacked-out area and limiting the number of households affected.
5. Consider the bridge in Minneapolis that replaced the I-35 structure that collapsed in 2007. The new bridge holds more than 300 sensors that measure the effects of corrosion, temperature changes and winter de-icing. In addition to helping transportation officials monitor the health of the bridge, researchers at the University of Minnesota are analyzing the data to help design bridges better able to handle all the stresses.
6. Sensors from U.K. start-up Syrinix Ltd. can continuously monitor for leaks on major trunk lines used to carry water from reservoirs and water-treatment plants. The company's sensors measure subtle changes in sound waves through the water and the pipe itself. When they detect the sound of a small leak -- which can lead to bigger line failures -- the information is carried over high-speed phone lines, and the system automatically sends out an email or text-message alert. The system is currently deployed on about 16 miles of lines in London and Birmingham.
7. Another big area of research is protecting levees, particularly in the wake of Hurricane Katrina. As part of an initiative by the Dutch government to prepare for rising ocean levels and an increase in severe storms, a handful of government agencies and businesses created a test site with a smart levee -- one loaded with dozens of sensors that measure water levels, pressure changes, ground movements and the condition of the dike. When researchers intentionally caused the levee to fail, it produced a wealth of data that eventually could be used to predict a failure well before it occurs.

<http://online.wsj.com/article/SB123447510631779255.html>

8. IBES (Institute for a Broadband Enabled Society) http://broadband.unimelb.edu.au/main.php?pg=news&news_id=622... The *Ageing Well at Home* project is using Microsoft Kinect to trial an exercise program among older people in Brunswick via NBN. Led by the City of Moreland, one of the core aims of the project is to promote health and wellbeing among older people, enabling them to stay in their homes longer and promote social inclusion. "A reliable, high speed broadband network makes it possible to deliver interactive therapy to older Australians in their homes using engaging video gaming technologies." Said Mike Quigley, CEO of NBN Co.