SAF5 Launch Speech – Draft V3

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Technology and society *co-create* one another.

We live, as Thomas Hughes' put it, in a "human built world" – a world built with, and of, technology. Understanding this world of technology creation and use is essential if we are to thrive.

- Technology is, to adopt Joel Mokyr's succinct phrase, *useful knowledge*. It is devoid of meaning *itself*, but we c*reate meaning in our lives* through technology – just think of your smart phone!
- Technology is so important to use as a society that we *define* ourselves in terms of the technologies of our time – as such, we are now in the "information age"
- While the *use of technology* is a source of great benefit, and provides solutions to many deep and important problems, it can also cause *severe harm*.
- Technology is multi-faceted, contradictory and complex. It is the *useful* and *equal* partner of science, with which it is inextricably intertwined.
- Any attempt to understand and forecast technology that ignores its messy complexity will fail.

Australia is a prosperous and technologically advanced country. But we cannot take this for granted. To secure Australia's future it is natural to ask questions such as:

- What impact will new technologies have on Australia society?
- What are the factors that affect their adoption?
- What can be predicted about future technologies?
- And what can be done about all of this, especially by governments?

Such questions motivated the report being launched today.

It is not technology *itself* that is daunting, or even worrying to some; but the use of *new* technologies or technological *change*. It is the use of *new technologies* that can make jobs redundant, or even make entire industries disappear. Technological change creates *new* threats and worries, but also contains *new* solutions to *old* problems, creates *new* and more interesting jobs, and creates entirely new industries.

Since identified by Robert Solow and Trevor Swan 60 years ago, it is now widely accepted that this *technological change* is *the* major driver of economic growth. If a nation wants to continue growing economically, it is hard to imagine how it can avoid continual technological change.

Technological change is complex because technology *evolves*, through the tangled intertwining of different components, reassembled in ever-new ways. This change progresses unevenly, through fits and starts, and the survival of any technological change is contingent upon the everything else.

Technology exhibits *inertia* and *lock-in*, arising often from interests heavily vested in the current technologies. Technological choices made in the past cast long shadows

into the future – we are still "locked into the car" as the design of our cities shows.

The *impacts* of technology are complex because multiple technologies contribute to a given effect, and a given technology has many separate effects. Even technologies such as radio, which we now take for granted, have interdependencies and influences that are impossible to fully fathom.

Technological impacts can be *positive* or *negative*, and vastly different for different groups of people. And what seems positive at first can end up being negative (e.g. the pesticide DDT). What seems negative at first (railways) ends up being viewed (largely) positively and part of the furniture of the world.

There are no natural categories of technology. As in biology, there is no one true taxonomy: is the use of GPS on a farm agriculture or ICT? Is the use of next generation sequencing and subsequent bioinformatics, data analytics or medicine? Such classificatory questions *matter* as history has shown repeatedly that radical change typically comes from *outside* the existing category – the ICT that will disrupt transportation in cities will not arise from "transport technology."

There are different levels of generality of categorisation. The more general taxa, helpfully called "general purpose technologies", include railways and electricity. More recently they include computers, and data analytics. These general

purpose technologies have impacts across all sectors of society and define successive industrial “revolutions”.

The rich complexity of how technology develops, evolves and is used, can not be ignored when considering the prediction and evaluation of technology, which Bob will now talk about.

Prediction

But what of *future* technologies? What can one predict?

Responding to a frenzied millennial burst of speculation, renowned economist of technology Nathan Rosenberg, said

> *Over the past year, with the turn of the new century – and Millennium – the media have been filled with speculations. You might call it the ‘Where is technology taking us?’ syndrome. I want to assert in the strongest possible terms what I regard as the only possible serious answer to that momentous question: We don’t know. In fact, I believe that we can’t know.*

Paradoxically, it *is* possible to predict quite precisely the evolution of key technical parameters, as Gordon Moore famously did with his prediction of the number of transistors on an integrated circuit. But that does *not* imply we can predict the resulting technological systems, let alone their impact.

The reason is two-fold.

1. Since new technological systems are assembled from parts, the whole is dependent on *all* the parts, and thus one would need to predict all of the parts.

2. Second, the *impact* and *adoption* of new technologies depends upon the entire economic and social system, not just the technology alone. Thus to predict adoption, one would need to predict society.

Evaluation

There are no "good" or "bad" technologies. Their value or virtue *always* depends on context. Furthermore, a given technology can be good for some people and bad for others.

The *evaluation* of technologies depends on the cost, but cost is not simple, and it depends upon cost to *whom*. Old technologies often have costs that are socialised and not properly accounted for (think of carbon pollution), which can make them appear cheaper than they really are. In evaluating new technologies, it is important to look at the full costs of the existing technologies that they may replace.

Meaning and imaginaries

Technologies mean different things to different people, and collectively these meanings define national "technological imaginaries," which permeate discourse about technology.

Australians celebrate the invention of the Victa rotary lawn mower, the Ford ute and the Hills hoist. They are promoted as proud examples of Australian technological inventiveness, and help to define a nation that celebrates innovation and adaptive re-use in a harsh (outback) environment.

The pervasive legend of a peculiarly inventive country used to be typified by the 'bush engineer' who invented the stump-jump plough and the Coolgardie meat-safe. Simon Jackson, traced the legend to the writings of historian C.E.W. Bean who wrote in 1909:

> *It is still a quality of the Australian that he can make something out of nothing...he has had to do without the best things, because they do not exist here. So he has made the next best do; and, even when these are not at hand he has manufactured them out of things which one would have thought it impossible to turn to any use at all. He has done it for so long that it has become much more than an art. It has long since become a part of his character, the most valuable part of it.*

Contemporary historian of technology Roy MacLeod concluded that

> *The 'legend of the bush', as represented from the 1890s, is now rightly regarded as an urban myth, a romantic construction of city-dwelling poets and novelists who inhabited one of the most urbanised countries on earth.*

As the 'bush engineer' myth fades, it is replaced sometimes by other parochial views of Australian technology. Wonderful as developments such as the cochlear implant or WiFi are, the Australian contribution to their creation is sometimes exaggerated.

Australia's technological imaginary can be put into context by comparing it to others. In the report we single out two other colonies – Canada and New Zealand, and we found the Australian peculiarity is not so peculiar after all.

While the tinkerer's attitude is essential (see later),

successful Australian technology development depended in the distant past, as it does now, on *advanced technological and scientific skills*. Australian historian of technology Ann Moyal has noted that

> *All successful migrant inventors came from backgrounds of strong technical education and expertise.*

Moyal draws lessons from 19th century Australia for the present day:

> *The most significant message is, undoubtedly, the pertinence of a strong, technically trained manpower to initiate, project and sustain technological invention and innovation; a wide distribution through the manufacturing system of engineering talent; and the presence of highly qualified entrepreneurial managers.*
>
> *The colonies exported not only Australian primary resources, but also high value-added goods. There was a clear absence of an attitude that has now become deep-rooted, that Australian innovation is fully recognised only when it has been exploited by industry abroad. Nineteenth century inventors and entrepreneurs demonstrated an assertive technological approach.*

Australia's future with new technologies will continue to be shaped by our national technological imaginary, but this needs *upgrading*. It is not enough to merely *import* and *adopt* new technologies. We to *invent*, *adapt* and *exapt* them for new uses.

Work and Jobs

New technologies change work. They change the type of work we do, and the jobs that are available. While new technologies destroy jobs, they also create them, so far, it

seems, in equal measure. Concerns about the "technological unemployment" so created are not new – from Keynes' first use of the term, through to worries about computerisation beginning in the 1960s and continuing to the present day.

Better described as "technological obsolescence" of jobs, one thing seems clear – attempting to freeze the advance of technology, as a means of preventing this obsolescence, will fail. Other countries will embrace the opportunities new technologies offer even if we don't, and we will thus fail to be competitive.

The solution appears to be to embrace new technologies, recognise there are *always* choices regarding *how* they are used, and ensure there are adequate measures to protect those who will suffer harm.

What is to be done?

The unpredictable, chaotic, evolutionary and stochastic nature of new technology should not be viewed as a *threat*, but as a *fabulous opportunity*.

Of the many new technologies that will impact Australia, from autonomous cars, to 3D printing; from next generation biological sequencing to nanofabrication; from new renewable sources of energy to new methods for waste disposal, the new technology with perhaps the greatest promise is *data analytics.*

Like all "new" technologies, it has a long and complex past, and its coming of age now results from the confluence of many seemingly unrelated events – from the discovery of

the giant-magneto-resistive effect (that underpins modern high capacity disk drives) to the algorithmic advances that enable computers to analyse such large amounts of data in short time. Data analytics stands to be the next general purpose technology, and is surely a harbinger of the next technological revolution. It can be applied to almost every sector of society and the economy. Its impacts will be complex and long lasting.

Such is the *promise,* but how are we to ensure it *comes to pass in Australia*?

Our report's longest and final chapter is on *interventions*: what can be done? I highlight a few now. Mike Keating will expand on this shortly.

Creativity and tinkering are essential

The *creation* of technology (engineering) is omitted from lists of "creative industries", but it is the source of many of mankind's greatest creative achievements.

Technology *is* a creative enterprise. Conveying the innate excitement of technology *creation* to our children can enthuse and motivate them to embrace the opportunity that new technologies offer. There are some great examples of schools around the world embracing the aptly named "maker movement" and augmenting the traditional *knowledge*-centered STEM curriculum with a greater emphasis on creative *skills* to *make* new technologies. Such an early emphasis on making could help Australia enormously.

History matters

A recurring theme we encountered is that many of the concerns and problems of technological change are not really new. A proper understanding of technological history could provide a better perspective to all Australians, and thus an obvious intervention is to ensure that all Australian students encounter our technological history in a rich and meaningful manner.

Education promoting adaptability to change

In the face of constant technological change, an education system that focuses on fundamentals as well as the skills needed to adapt and change is likely to be most helpful. Our sister report (SAF2) noted that

> *The Asian countries in the present study, all very successful in PISA and where disciplinary knowledge is held in high esteem, report a shift in focus towards nurturing generic skills of creativity, problem solving, collaboration and higher order thinking.*

Experimentation and dealing with failure

New technologies *always* fail. The only way humans *ever* build reliable technologies is to *learn* from the initial failures. This ethos of the scientist and engineer can be translated to the users and adopters of technologies. It simply requires a change of mind-set to one of *explicit* and *controlled experimentation*. That is hard to do, but as our report shows there are plenty of role-models. The key points are: *dispelling fear of failure* and *agility*.

Early stage R&D support because of lack of appropriability

New technologies do not arise by themselves. People *invent* them, and that invention is a long and complex process.

Crucially, the large long-term economic returns to such invention are difficult to *appropriate by the inventors*. This is *the* reason why governments around the world continue to make substantial long-term investments in early stage technological R&D – a nation benefits from this via indirect spill-overs. For-profit companies will not do it, *precisely because* of this lack of appropriability.

Hand over to Mike Keating

To further explore *how* governments can use the findings of our report, I hand over to my fellow working group member, Dr Michael Keating.

Australia has a choice

Technological change does not just happen. It does not march on without human control. It arises from *choices* that are made. The report being launched today is designed to guide those choices. As well as providing detailed answers to the questions posed when the report was commissioned, we have distilled our analysis into 18 succinct findings, which you can find at the front of the report.

Reflecting on our technological heritage, Roy MacLeod observed:

> *The myths of the 'bush engineer' assume a topical, if somewhat contradictory importance. Just as in the world wars - when 'colonial' and 'bush' qualities of versatility and ingenuity were required of Australian engineers mobilised overnight into intelligence, radar and aviation - so today, in a world of high technology, a mentalité that celebrates flexibility, innovativeness, and adaptability is essential.*

Ann Moyal has observed that

> *Contemporary attitudes would undoubtedly benefit from an injection of pioneering confidence to reduce Australia's prevailing stance of risk-aversion.*

Australia's prosperity rests upon shifting foundations. Australian economic historian Ian McLean concluded his book *Why Australia Prospered: The shifting sources of economic growth* by observing that

> *Australia has experienced both brief and prolonged periods of resource-based prosperity in the past; adjusting to their demise has invariably being wrenching. At the same time, [there is an] appreciation of the potential threat to longer-run prosperity posed by the current resource boom, and of the continuing [need] to creatively engage in the institutional innovation required to*

> *sustainably manage it.... Perhaps these are examples of Australians learning from their past.*

The lesson is not unique to Australia, but it is *especially important here* given our natural resource dependence. The transformations wrought by technological revolutions in the past have unleashed subsequent Golden Ages, but only when new technologies were embraced effectively.

As Malcolm Turnbull said last week as he became prime minister:

> *We have to recognise that the disruption that we see driven by technology, the volatility and change, is our friend ... if we are agile and smart enough to take advantage of it.*
> http://www.abc.net.au/news/2015-09-15/newly-elected-liberal-leader-malcolm-turnbull-to-be-sworn-in/6775962

Australia needs to *adapt* to its shifting foundations; to embrace *agility and experimentation*, and to exploit the *transformative* effects of new technologies.

It needs to change its strategy from focusing upon what worked well in the past, or business sectors that have been demonstrated to have strengths in the past.

Instead Australia should create and sustain the capacity, skills, culture and the will to invent, adopt, adapt, and develop its future source of prosperity and well-being: Australia's bright future can be envisaged, created and achieved through new technology.

Thank the team.