Australian Government
Chief Scientist

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Cresting the Wave: The Voyage of Science and Innovation

******* CHECK AGAINST DELIVERY *******

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Thank you Chris…

Assistant Minister Karen Andrews, Secretary Glenys Beauchamp, my wife Elizabeth, friends from the Science Meets Parliament event including president Professor Jim Piper, ladies and gentlemen.

Lessons from a lost ship

Let me start with a story about a small nation with middle-power ambitions.

It's a nation in transition. Its population is growing. Its commodity-based economy is booming, on metals and minerals and grain.

That growth is supported by a strong financial sector and a sizeable migrant workforce.

It is underpinned by landmark tax reform bedded down a few decades ago.

But this small nation is well aware of its uncertain place in a strategic region at a volatile time.

So it embarks on a bold exercise in next generation defence procurement: a flagship for its navy and a statement about its place in the world.

The construction and financing is a public-private partnership.

The work is outsourced to a foreign company. That company subcontracts in turn to an international consortium of SMEs.

And then they head into an old-growth forest to source the materials.

A forest – because this ship will be built of oak.

The setting is Sweden, four hundred year ago, in 1625.

Big dreams, epic failure

Now this was no ordinary ship that the Swedes contracted the Dutch, who subcontracted the Germans, Danes and Finns, to build.

This was something that no-one in Sweden had ever attempted before: a 135 foot warship with two decks, each bearing 36 cannons.

And it had to be built on the keel of the 110 foot, one-deck warship the contractors were initially instructed to build.

That ship was half done when the King changed his mind – inspired by the thought of an extra deck, with extra cannons.

So the builders set to work, and they did their best to adapt the keel, while the King went off to fight his war with Poland.

By August 1628 the ship was ready.

All of Stockholm gathered at the harbour for the launch of this mighty symbol of Swedish pride.

And all of Stockholm was still there when, twenty minutes after the launch, tilted by the gentle nudge of a light sea breeze, it sank – less than one nautical mile from dock.

This ship – the *Vasa* – has sailed into business school history: as the textbook case in innovation done wrong.[i]

- Project specifications that changed at political whim.
- A workforce of 400 people, the largest workforce ever engaged in a single project in Sweden, split up into five autonomous project silos.
- No evidence of design plans.
- No prototype before the full-scale model was built.
- No appetite for frank and fearless advice – the giving *or* the receiving of it.
- No testing until the very last stage – and then no courage to halt the launch when the tests confirmed the outcome would be catastrophic.
- Money squandered on vanity projects – including 20 busts of Roman emperors facing off against some ornamental mermaids.
- And above all – not enough science.

The ship and 53 lives were lost as a result.

When investors say they are risk-averse, here's the reason:

No-one wants to go down with the two-deck ship.

Learning to innovate - intelligently

You might say it's risky to start a speech with failure. But I've never been afraid of risk.

And I can tell you that no modern engineering team would build the *Vasa* today.

I'm assuming, of course, that at least one member of the team would have come within spitting distance of Newton's Laws of physics in the course of their training.

But the *Vasa* was about six decades too early for Isaac Newton.

The shipmasters did not know about force vectors and how they sum, or the significance of the centre of gravity.

So they were effectively blind, where modern science gives us the power to see.

The more we know – thanks to science – the more we can achieve through innovation. And the more efficient the path we take to get there.

Elizabeth and I visited the Vasa museum in Stockholm in January. When I heard the story, I immediately knew that I would have to include it in my maiden voyage as Chief Scientist at the National Press Club.

The first thing that the story of the *Vasa* says to me is this: if we want bold solutions in this century then we need science – and plenty of it.

As important as it is, though, science is not enough. We need to think about interactions, unexpected consequences and the management of risk.

If we were to build nothing new before we were absolutely certain we knew the best way to do it, that would be the end of progress.

And even if we did figure out the quantum world tomorrow – even if we did have a grip on the fantastical complexity of the human brain – even if we did crack nuclear fusion…

There would still be questions about the practical ways our knowledge might be applied.

Take self-driving cars.

Now I'm not drawing a direct parallel here to the *Vasa* – I know which of the two I'd rather travel in, and it's not the one with ornamental mermaids.

But I will put it to you that we are *in our own way* launching an untested craft into unknown waters, with consequences that we can only foresee in part.

There are plenty of benefits: mobility for the elderly, fewer accidents, freedom to talk on your mobile phone …

But is it that simple?

- Say you're in the city to attend a meeting. Do you pay for the car to park – or do you just send it round and round the block for the duration of your meeting? Congestion would skyrocket.

- Say it's 8:00 AM on a school day. Do you carpool – or pack the kids off and wait for the car to return… again, and again? More congestion!

But the harder questions for government only proceed from there.

- How do we deter people who think like me from adding to traffic congestion?

- Who do we allow to own or direct these cars?

- What happens to all the people who today drive things like trucks and taxis for a living?

- Who builds, and then who takes responsibility, for the sophisticated networks of sensors to support the cars?

- And given that orderly traffic flow depends on the interconnections between the cars and the traffic management software, what happens when a car hits an internet blackspot? Potential catastrophe.

These are but a fraction of the issues attached to one technology in the immediately foreseeable future.

To solve them, we need not just science, but *research*. Where research is the investigatory collaboration between science, technology, sociology, economics and the like.

In all of the complex challenges that technology will bring, the humanities, arts and social sciences are critical to our research endeavour and we neglect them at our cost.

Combine these research elements, and we will reap the benefits:

Gridlock – gone. Crashes – avoided. Carparks – repurposed. Designated drivers – extinct. Backseat drivers – forever silenced.

And if you can imagine that self-driving car – then you can also imagine a low-emissions electricity grid supplying electric vehicles.

Connected to fantastic arrays of solar panels in the outback.

Travelling through an ever more exciting world.

Perhaps by then we've made progress towards bionic eyes for the vision impaired. Or launched trips into space for tourists.

We could be living in an Electric Planet. A zero emissions world.

How much progress could your lifetime contain?

We decide – and not just by the scope of our ambition but by the breadth of our research, the quality of our planning and the calibre of our leadership.

So science is vital; and innovation takes hard work – two lessons that a shipwreck can teach.

Learn them, and we will prosper in our own remarkable times.

With great science we will create great research outcomes.

With clever innovation we will turn those research outcomes into societal and economic benefit.

With great science and clever innovation combined, we can discover how truly remarkable we might be.

Applying the lesson to public policy: the vision and the path

As a student, researcher, innovator and investor, I've always tried to keep the doors of opportunity open.

I've reflected a great deal recently on what chasing opportunity means for public policy.

After all, Australia has embarked on one of the most ambitious public sector innovation projects we have ever attempted.

Its aim is set out in the National Innovation and Science Agenda.

We are seeking the design specifications for a very different sort of country: a country with the scientific potential, the industrial capacity and the startup culture to thrive in the decades ahead.

Above all, it's about thinking and operating at scale.

If you recognize a problem is big, you will be more likely to develop appropriately large-scale solutions.

For example, although Australia has the largest rate of rooftop solar installations in the world[ii], the total contribution to our electricity needs is just 2.1%.[iii] Electricity itself only represents about a fifth of our total energy consumption, so the contribution of solar today is still tiny.

We've done wonders with solar from a virtual standing start in 2010, but to get to where we want to be we need to move faster, with bigger ambitions.

Operating at scale is not just about distributing money. The goal has to be to create an environment that encourages success.

Take red tape. It's the gift-wrap for opportunity.

For example, our existing regulations make it easier to test unmanned aerial drones in Australia than it is for developers to test them in the United States.

So we have an opportunity to be a leader rather than a follower in the use of drones for media, mining, retail and sport.

Our regulations also support an efficient, world class clinical trials industry, a national asset we ought to celebrate.

Every year, around 1000 new clinical trials commence in Australia, capturing a $1 billion dollar investment.[iv]

But we don't create the same supportive environment for manufacturers of medical devices. Why not aim to win on all fronts, in the interests of consumers as well as workers and investors?

Beyond regulation, we need a highly educated workforce, and tax regimes that are simple, reasonable and fair.

We need to ensure that the Government's contribution to the innovation system is not too complex.

And when designing an environment to encourage innovation we need to declare in advance how we will measure success.

We are capable of creating this environment; and where we succeed, good things happen.

Let me give you some examples from my first month on the job. I do *not* take credit – but I do take note, as should we all.

In basic science, we've observed gravitational waves. Easy to say – but so difficult to do that Einstein himself thought we'd never crack it.

To me, this was the most exciting announcement in physics in my lifetime.

It rounded out Einstein's theory of general relativity.

The event was observed by an instrument, to which Australia made important contributions, that is the most sensitive combination of physics and engineering ever contemplated.

Most important, we now have a whole new way to observe the universe.

More than 400 years ago Galileo improved the optical telescope so that he could use it to prove that the Earth revolves around the Sun.

In the 1930s, the radio telescope was invented and eventually used to discover pulsars, quasars and the cosmic microwave background radiation.

Now, the optical telescope and the radio telescope have been joined by a gravitational telescope.

With it, we will discover things we never imagined.[v]

Back on earth, in the marketplace, we've seen Australian science in translation, in the form of a $730 million licensing deal in which the pharmaceutical giant Merck acquired rights to a new drug to treat lymphoma, sickle cell anaemia, lung cancer, breast cancer and colon cancer.[vi]

And then Atlassian powers on, after sparking the dreams of a million ambitious young people when it listed on the US stock exchange and reached 5.8 billion US dollars overnight.[vii]

It's a classic story of two Sydney science and IT students who developed planning tools for software developers, a product that was so good that it sold itself without a sales force.

Good news. Good news across the spectrum from scientific discovery to commercial success. Good news that stimulates the imagination.

And if you think we've exhausted the tank, if you think we've optimized the policy settings, it you think this is as good as we can get – you're wrong.

How many women give up on promising careers in science, technology, engineering and mathematics? Women comprise more than half of science PhD graduates and early career researchers, but by their mid-30s a serious gender gap starts to appear. We are improving – but we have a long way to go.[viii]

And how many businesses don't engage with universities or research agencies? Enough to rank us at the bottom of the OECD for cross-sector collaboration.[ix]

How many researchers were never encouraged to think about working in industry or creating a startup in the course of their training? Too many – because we still set PhD students' sights on academic careers, even if for the majority we can't possibly satisfy the expectations we create.

And how many good ideas might be waiting to be turned into products or processes in our research facilities? We've got great universities – but none in the Thomson Reuters list of the Top 100 University Innovators.[x]

We rank 9th in the Global Innovation Index for the calibre of our science institutions – but 72nd for innovation output.[xi]

I'm telling you all this bad news because there's a silver lining. Just think what this country might achieve if we address these issues.

Then Australians can get on with bringing the future into the present.

Linking to my agenda

"So what are you doing about it, Alan?" you might ask. "Lots", is the short answer. "Enough to weigh down a speech like 36 cannons on a seventeenth century ship", is the longer one.

So let me signpost some of the work to expect from my office in the year ahead.

First, there's my role at Innovation and Science Australia under chairman Bill Ferris, to help lead the development of a 15 year plan for investment in science, research and innovation. It's the strategic plan for the country; and it will be critical to coordinate the many moving parts in play.

Second, Bill and I will be joined by John Fraser to undertake a review of the R&D Tax Incentive.

Yes, it's been reviewed several times. But as we gather more data from the operation of the program there is an opportunity to further refine the incentive to ensure that it is effective at encouraging R&D that would not otherwise take place.

Third, I will be leading the development of a roadmap for our future national research infrastructure.

This term “research infrastructure” is a little clunky because when we hear ‘infrastructure’ we usually think of the everyday things – the bridges, ports or railways we know so well.

We don’t think of the infrastructure that maps the cosmos, images the brain, explores the oceans, and archives our history and stories.

But we should – because it enlarges our capacity to reach for the future.

If endorsed, the proposed new infrastructure identified in the road mapping exercise will power Australian research in coming decades. And if history is our guide, powering science translates to fuelling industry, and putting Australian innovations out to the world.

Fourth, there’s the work of the Commonwealth Science Council, for which I am the Executive Officer.

We will measure progress against the nine National Science and Research Priorities, so we can answer to the expectations of Australians.[xii]

We will identify our most transformational research; and we will scope the big future opportunities for Australia.

Finally, a word about education. I came to this role with the experience of creating three ongoing education programs, two in schools and one for early career researchers.

So it makes sense that, building on the Office of the Chief Scientist’s existing capability, I intend to present the data that will help to elevate our ambition for Australian schools.

We must reverse the slipping rankings of our students in international tests.

In 2007 we were ranked at around 10th in the world. By 2011, these numbers had deteriorated and Australian students were *significantly* outperformed by 18 countries in science and 17 countries in maths.[xiii]

Being out of the top ten is bad enough, but being on a downward trajectory is even worse.

What can we do to reverse this trend? Numerous concerned individuals, institutions and companies have created extracurricular activities to try to stimulate interest in science.

My Office has just published a listing of the extracurricular STEM initiatives around the country and during the course of this year we will work to make it available as a dynamic database accessible to all teachers, students and parents.[xiv]

But this will not be enough. The scale of the challenge is huge.

We need to enhance our in-curriculum teaching capacity.

We need to ensure that students learn deep content, not just how to learn.

And we need to challenge our students and support them to meet those challenges.

* * *

All up, a three year term as Chief Scientists doesn't seem quite long enough. But as a travelling engineer I have learned to pack efficiently.

Conclusion

I began with the *Vasa* gunship. I'll end with its postscript.

It sat on the bottom of the harbor for 333 years. Then it was raised in 1961 – almost perfectly preserved, ornamental mermaids and all. Raising it was a phenomenal feat of ingenuity and engineering.

It was installed in a purpose-built museum, where more than a million people every year line up to see it.

To Sweden, the Vasa is now a great source of national pride.

Because Sweden didn't give up on building ships. They built two-deck gunships. They built *three*-deck gunships. Gunships that became the pride of the Swedish military for the next thirty years.

They helped to usher in the age the Swedes call *stormaktstiden* – the Great Power Period.

Failure – repurposed as a symbol of success.

But we don't have to get there from the bottom of the harbour.

Let's take the direct path to our own stormaktstiden, our Great Power Period.

Thank you

[i] R. Fairley, "Why The Vasa Sank: 10 Lessons Learned" (University of Portland), http://faculty.up.edu/lulay/failure/vasacasestudy.pdf

[ii] Samantha Donovan, "Australia leads world in household solar panel installations" (Australian Broadcasting Corporation, The World Today, 29 September 2015), http://www.abc.net.au/news/2015-09-29/australia-leads-world-in-installation-of-household-solar-panels/6813532

[iii] Clean Energy Council, "Clean Energy Australia Report" (2014), https://www.cleanenergycouncil.org.au/policy-advocacy/reports.html

[iv] Austrade, "Australian Clinical Trials Capability Report" (2015), https://www.austrade.gov.au/ArticleDocuments/2814/Clincal-Trials-Capability-Report.pdf.aspx

[v] Office of the Chief Scientist, "Gravitational Waves Announcement" (12 February 2016), http://www.chiefscientist.gov.au/2016/02/speech-gravitational-waves-announcement/

[vi] Cancer Therapeutics CRC, "Cancer Therapeutics CRC to benefit from a multimillion dollar licensing deal" (28 January 2016), http://www.cancercrc.com/wp-content/uploads/2016/01/PRMT5_-PressRelease.pdf

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[viii] Office of the Chief Scientist, Analysis of 2011 Australian Census data, in publication

[ix] Office of the Chief Economist, "Innovation Systems Report 2015", http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Pages/Australian-Innovation-System-Report-2015.aspx.

[x] Reuters, "The world's most innovative universities", (2015), http://reuters.com/most-innovative-universities

[xi] Cornell University, INSEAD and WIPO, "The Global Innovation Index 2015: Effective Policies for Development" (Ithaca, Geneva, 2015), https://www.globalinnovationindex.org/content/page/GII-Home

[xii] Department of Industry, Innovation and Science, "Science and Research Priorities", http://www.science.gov.au/scienceGov/ScienceAndResearchPriorities/Pages/default.aspx

[xiii] S.Thomson, et al., "Monitoring Australian Year 4 student achievement internationally: TIMMS and PIRLS 2011" (ACER, 2015), http://research.acer.edu.au/timss_pirls_2011/3/

[xiv] Office of the Chief Scientist, "STEM Programme Index 2016", http://www.chiefscientist.gov.au/2016/01/spi-2016-stem-programme-index-2016-2/