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29 April – 1 May 2019
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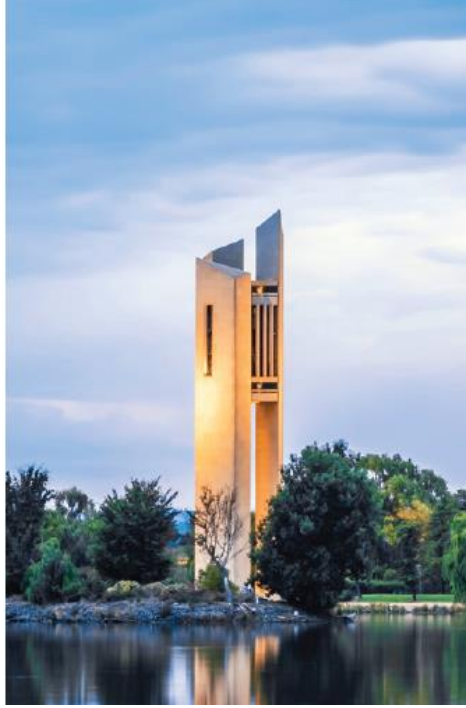

NUCLEAR PROPULSION ROADMAP FOR AUSTRALIA® - A SYSTEMS ENGINEERING APPROACH

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Nuclear Propulsion Roadmap for Australia ®			
	A. Impact on Legislation	B. Fuel cycle for SSN	C. Reactor sourcing
1. Rationale			
2. Consulting			
3. Design			
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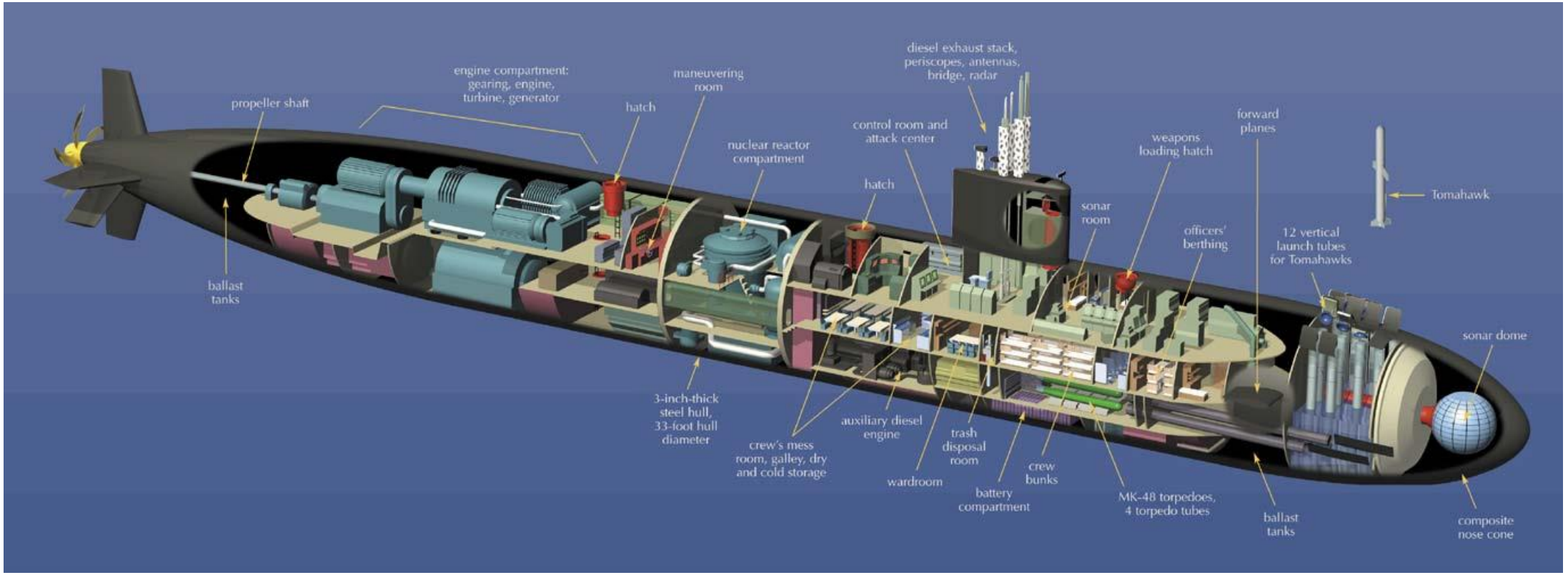
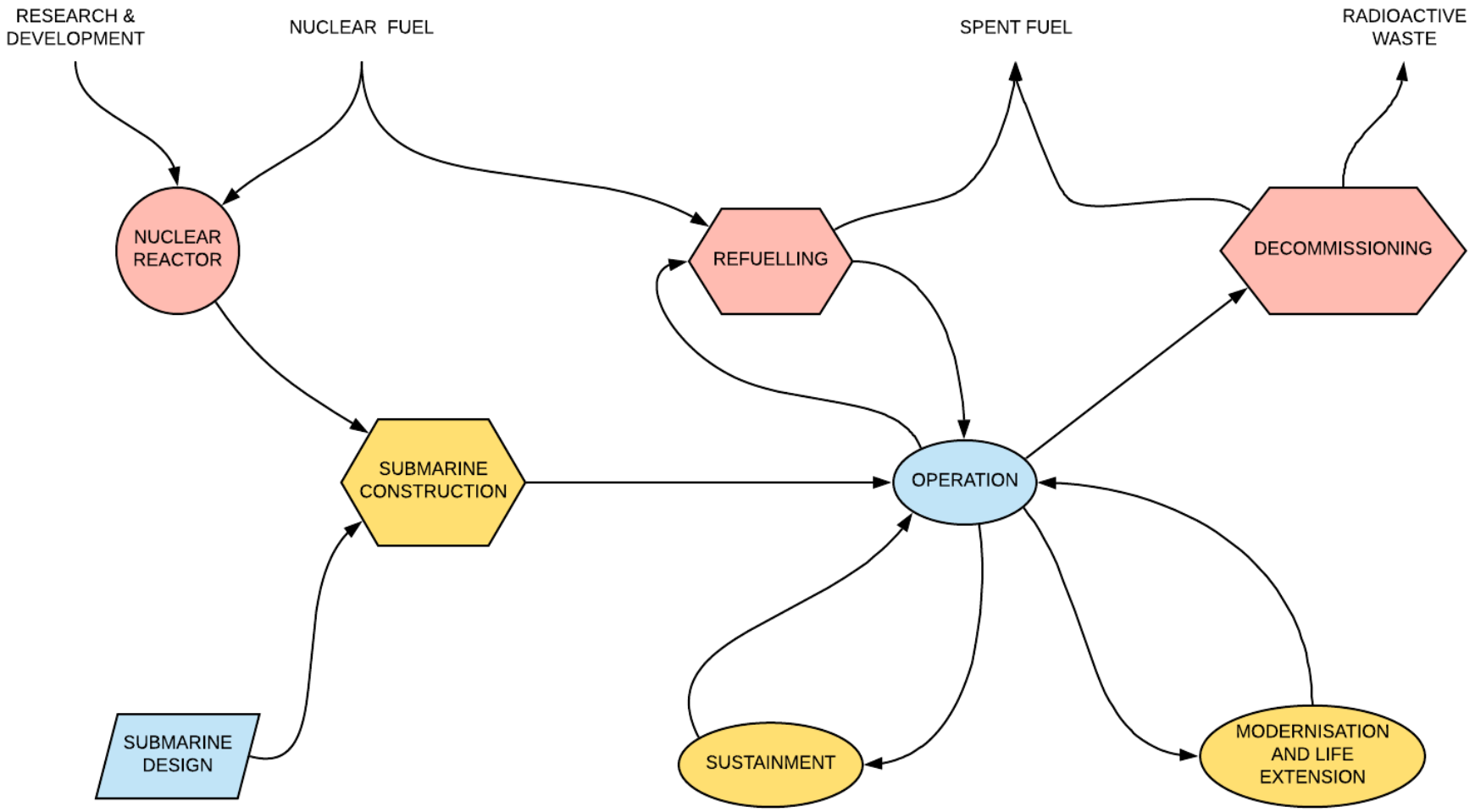
NPRM4A – A nuclear submarine illustration



NPRM4A – Nuclear Submarine Life Cycle



NPRM4A - Introduction

- A frequently raised question is why wasn't nuclear propulsion adopted for the new Future Submarine Program [FSP] to design and build the ATTACK class conventionally powered submarines in Australia
- The customary response is that Australia lacks a nuclear power industry, which is implied to be essential to provide the rigour and scope of nuclear science, technology and engineering for submarine propulsion, even for sustainment and refuelling, let alone for construction

Is there a need for nuclear industry?

Snowy Hydro's Tumut 3 power station, where Snowy 2.0 will be built if it goes ahead. PHOTO: AAP

Garnaut has energy superpower vision

29 APR 2019

AFR

Exclusive

Ben Potter

Australia needs three key reforms – including splitting Snowy Hydro into two state-owned companies – to regain its place as an energy superpower with globally competitive power in regions and cities as the world shifts to renewable energy, top energy economist Ross Garnaut says.

Professor Garnaut, economics professor at the University of Melbourne and architect of the last Labor government's never-implemented carbon trading scheme, says he has no doubt Australia can have secure reliable electricity at much lower prices that would underpin expansion of minerals processing and other heavy industry if it adopts his plan.

The first step is to split federal government-owned Snowy Hydro's existing and proposed pumped hydro assets from its baseload generation. The second is to tweak the Australian Competition and Consumer Commission's recommendation for the federal government to underwrite some firm energy generation. The third is more transmission to allow renewable energy to move more easily from generation sites to demand centres.

"After a dozen years living closely with the Australian and global energy transitions, I now have no doubt that intermittent renewables could meet 100 per cent of Australia's electricity requirements by the 2030s, with high degrees of security and reliability, and at wholesale prices much lower than any experienced in Australia over the past decade," Professor Garnaut says in the third of a series of lectures.

His optimism stands in stark contrast to the election campaign debate in which the Morrison government has slammed Labor's 50 per cent renewable energy by 2030 and 45 per cent economy-wide carbon emissions reduction targets as economically reckless.

Professor Garnaut says Australia's unique clean energy resources – in solar, wind and pumped hydro storage – mean it can contribute its fair share to global efforts to limit industrial era temperature increases to 1.5°C. It can also – with good policy – supply "firm power in globally transformative quantities ... to industrial locations in each state at globally competitive prices" of around $45 to $50 per megawatt hour. "No other developed country has a comparable opportunity," he says. But it will take many years to restore Australia's edge and the economic opportunities will be lost "if we wait until our slow-moving business institutions and policy move to correct the errors of the past".

Professor Garnaut says "fleet of foot" businesses and regional governments can get on with it without waiting for national policy, but his reforms will boost the prospects of a strong outcome. He says it is necessary to split Snowy Hydro into two because the ACCC had found in its Retail Electricity report that Snowy Hydro would have 60 per cent of the market for peaking power in NSW and Victoria if it built its proposed $5.1 billion, 2000 MW Snowy 2.0 pumped hydro expansion. He would call the pumped hydro company Snowy Energy Guarantee or "SNEG" and charge it with keeping peaking power cheap by intervening – using existing pumped hydro assets and Snowy 2.0 if it stacks up – whenever prices get out of line.

He would extend the ACCC's proposed firm generation underwriting scheme from five years to 10 and separate the process from the Clean Energy Finance Corporation to fully take advantage of the federal government's low borrowing costs.

With these tweaks to "Recommendation 4" of the Retail Electricity report, he says globally competitive power supply is feasible now in major industrial sites outside capital cities – "including Collie, Bunbury in WA, the Upper Spencer Gulf in SA, the Latrobe Valley and Portland in Victoria, Newcastle and Port Kembla in NSW, and Gladstone and adjacent inland regions and perhaps other industrial ports in Queensland".

Finally, the grid won't accommodate more than about 50 per cent renewable energy without more transmission. Professor Garnaut says this can be facilitated by reforms allowing a stronger public sector role in transmission planning, less of a role for network companies, and "reward for private unregulated investment that adds public value to the network", rigorously supervised by the Australian Energy Regulator.

- Professor Ross Garnaut says:

'… I now have no doubt that intermittent renewables could meet 100 per cent of Australia's electricity requirements by the 2030s, with high degrees of security and reliability, and at wholesale prices much lower than any experienced in Australia over the past decade.'

('Garnaut has energy superpower vision' Ben Potter, Australian Financial Review 2019-04-29)

NPRM4A – why develop a Roadmap?

- The chicken and egg dilemma of the need for a nuclear industry for nuclear propulsion and on the other hand the legislative prohibition on Australian engagement in nuclear power development within the *Environmental Protection and Biodiversity Protection Act 1999*

- A Roadmap is proposed to examine all the options in moving forward so that the way ahead can be perceived and pursued in the light of all the known factors and options applicable

NPRM4A – A Systems Engineering Approach

- Systems Engineering, and even more so, System of Systems Engineering deal with the real-world environment in which complex systems must be designed and implemented
- The U.S. Under Secretary of Defence for Acquisition, Technology & Logistics published 'System of Systems System Engineering Guide…' in 2008
- The field of complex systems was proposed as a discrete field for research and development by Mo Jamshidi in 2009
- Charles B. Keating et al articulated the requirements for governance of complex systems (Keating & Katina 2015)
- In 2018 Keating et al published 'A Method for Identification, Representation and Assessment of Complex Systems Pathologies in Acquisition Programs.'
- The Roadmap sets out to apply these conceptual frameworks to the way ahead for Nuclear Propulsion in Australia

NPRM4A – Nuclear Propulsion as a Complex Systems Domain

Concern	System of Systems	Applicability to Nuclear Propulsion
Stakeholder involvement	Added levels of complexity; stakeholders at differing levels have competing interests and priorities	Applicable in absence of central management authority such as the Office of Naval Reactors in the USN
Governance	May have funding and management lines of responsibility at the SoS level and also at the level of individual systems	As above
Operational Focus	SoS must meet operational objectives using systems for which their individual objects are not aligned	A significant challenge that must be addressed by the overall design authority
Acquisition, Testing and Validation	No established process for these essential processes to be completed comprehensively. Differing life cycles for component systems makes this more difficult	Again a central authority must ensure that all component systems are considered and competing criteria are reconciled and integrated
Boundaries and Interfaces	Focus is on identifying the systems that contribute to the SoS, and enabling the flow of data, control and functionality of the SoS within the various constraints	Very applicable
Performance & Behaviour	Ensure end-to-end performance of the SoS, within the context and constraints of all the systems	Very applicable again

NPRM4A – Roadmap Table of Contents

The proposed Roadmap Structure is based on six proposed major work areas as follows:

1. Rationale and business case development, consultation and publication
2. Communications and consultation with community, media, government, academia
3. Design and integration; lifecycle approach, especially decommissioning
4. Source of reactor and reactor fuel cycle
5. Safety and regulatory requirements; legislative framework
6. Workforce for design, safety assurance, installation, commissioning, operation, sustainment, refuelling, decommissioning, waste recycling and disposal.

NPRM4A – Case Study: Canadian Submarines

- In 1987 Canada decided it needed 10 to 12 nuclear powered submarines to properly secure its national security interests, especially in the Arctic Ocean where nuclear propulsion was necessary for under-ice operations
- The Canadian Submarine Acquisition Program [CASAP] was to be based on British or French submarine design but was eventually cancelled due *"very high costs required to create and maintain the hard and soft infrastructure to operate and maintain a fleet of SSN's"* (Insight Economics 2017)
- The Canadian Small Modular Reactor (SMR) Roadmap in 2018 stated *'Canada is a tier 1 nuclear nation, with a full spectrum industry…'*
- Canada is currently considering the acquisition of 12 modern non-nuclear submarines using air-independent-propulsion [AIP] for under-ice operation (Dunlop 2018)(Pugliese 2017)

NPRM4A – Role for SESA, INCOSE, ITEA

- For the Roadmap to be accepted within Australia, the full scope of professional insight from learned societies such as the three institutions conducting this Systems Engineering, Test & Evaluation [SETE] Conference are essential for comprehensive consideration
- This applies just as much to the negative case for nuclear propulsion as it does for its advocacy
- The main thing is to establish the accuracy and traceability of the arguments and options presented
- The timeframe for all of this is whatever it takes to do the job effectively
- As the Canadian case shows, there are other factors besides the existence of a nuclear power industry.

Recent Contributions

May we go nuclear in the future? If so we have some work to do first, including:

- Gain political and social acceptance
- Negotiate a deal with the US, UK or France for nuclear technology transfer.
- Establish a Naval Nuclear Regulatory framework for Australia.
- Decide a procurement strategy – import complete or part-build in Australia.
- Decide on a location for submarine bases & complete environmental and security assessments.
- Define the nuclear specific facilities required
- Achieve local acceptance of a nuclear presence at these locations.
- Establish a training programme for civilian and naval nuclear engineers.

If we are to switch to nuclear powered submarines, we need to be starting this work now.

'A Century of Submarine Development' John JEREMY AM, The NAVY Vol.81 No.2 Apr-Jun 2019

- Plan for decommissioning, defueling, fuel disposal and hull break-up and disposal

Private communication from former submariner Ian Noble

Disposal of Old Nuclear Submarines

THE NATIONAL INTEREST

Published on The National Interest (https://nationalinterest.org)

Home > The Royal Navy Can't Seem to Figure Out How to Dispose of Old Nuclear Submarines

The Royal Navy Can't Seem to Figure Out How to Dispose of Old Nuclear Submarines

April 27, 2019 *Topic:* Security *Region:* Europe *Blog Brand:* The Buzz
Tags: United Kingdom, Royal Navy, Nuclear Submarines, U.S. Navy, Nuclear Waste

Not an easy problem to solve.

by Michael Peck

- However a knowledgeable correspondent tells me that it is normal practice to place decommissioned reactor materials where the residual radiation can decay sufficiently to reduce the exposure of crews that will later dispose of the materials into a permanent site
- The US Navy buries its old reactors in a dedicated site

NPRM4A – Concluding Remarks

- Nuclear Propulsion confers significant operational advantages on submarine operations
- There are significant costs involved in developing the infrastructure and operational and sustainment frameworks essential for nuclear propulsion
- The lack of a nuclear power industry in Australia is not the only nor even perhaps the most important challenge to the introduction of nuclear propulsion for Australian submarines
- Assuming all the challenges can be overcome, the timeframe for introduction of nuclear propulsion is significant and will not be less than 15 or 20 years
- However to achieve even this timeframe requires sensible thinking now

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Questions and Comments

Nuclear Propulsion Roadmap for Australia®
- A Systems Engineering Approach

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