Defence FOI 140/21/22
Item 1, Serial 1

Australian Government

Department of Defence
Capability Development Group
Defence Materiel Organisation

MINUTE

SEA 1000/OUT/2021/

CCDG

ASPI PAPER: HOW TO BUILD A SUBMARINE – DEFINING AND BUILDING AUSTRALIA'S FUTURE FLEET

1. As requested, my response to the Australian Strategic Policy Institute (ASPI) paper regarding the acquisition of a future submarine capability for the ADF is provided for your consideration.

2. My point of contact on this issue is Director Future Submarine Capability Development, Captain Tim Brown, RAN, on (02) 6265 2262 or via e-mail timothy.brown@defence.gov.au.

R.C. MOFFITT AO
RADM, RAN
Head Future Submarine Program
R2-4-B092
Russell Offices, CANBERRA ACT 2600

Tel: (02) 6265 2251

Oct 21

Annex:
A. SEA 1000 Response to ASPI Paper: 'How To Build A Submarine – Defining And Building Australia's Future Fleet'.

Annex A to
SEA 1000 Minute
Dated 29 Jul 09

SEA 1000 RESPONSE TO ASPI PAPER – 'HOW TO BUILD A SUBMARINE – DEFINING AND BUILDING AUSTRALIA'S FUTURE FLEET'

General Comments

1. In general, this paper is a very good addition to the public debate and it is important that papers such as this are published. As a discussion paper, it is generally balanced and useful, and will serve to focus the proposed workshop on the right issues. It provides a valuable basis for a public discussion and it identifies several of the main challenges. That being said, we do not necessarily agree with everything that is written. That in itself is healthy – as it means that if people came together for the common purpose of analysing the ideas and suggestions laid out in the paper it might help crystallise ways to address the concerns as well as lay to rest some concerns. At the very least this should provide a mechanism to allow everyone to get a picture of what position particular actors take on the issues – which is always useful.

2. Of some concern, the paper leads the reader to assume that some of the issues raised within the paper have not been considered by the project. It is important that the authors understand that this is not the case. Indeed, in most instances the project has considered the suggested options and more and therefore has gained a better appreciation of what is needed now as we progress through the 'journey'. Furthermore, the paper is long on assertion, but rather short on justification. The paper infers that the skill sets required to build a submarine are similar to those of maintaining a submarine. In fact, they are significantly different as the USN have experienced with Electric Boat's venture into in-service support.

3. The thrust of the paper is generally aligned with SEA 1000 thinking. However, the authors have not recognised the current challenges effecting ASC to meet Collins support requirements nor the implications for the Collins program of anointing ASC in any way for SEA 1000 at this stage.

4. Overall the paper leans more in the capability/acquisition domain; however, with the Future Submarine (FSM) project in its infancy, the strategy/capability domain is perhaps more applicable in public discussion and lies at the core of the requirements for the FSM capability. In essence, capability requirements will fall from the strategic requirements and from this the project needs to devise suitable and acceptable acquisition strategies. If this is achieved then the risks across all domains can be better understood, prioritised and managed. During the current phases of the FSM project perhaps it is more appropriate for the public arena of FSM discussions to focus in the strategy/capability domain as it is this domain that will ultimately shape the acquisition strategy and ASC's role in it.

5. Some additional, more specific, comments are provided for consideration:

Capability Edge

6. The paper over plays the risk associated with the FSM capability timeline by asserting that there is a 'real prospect that our capability edge (around 2025) will have been eroded entirely'. The build programs in our region would suggest otherwise. We currently have an edge over the region and its unlikely those existing capabilities will erode this edge entirely when balanced with our upgrade program. The future submarine will simply re-establish a more defined capability advantage. (Further commentary on this is outside of the security limitations of this response).

7. The paper, associated workshop, and subsequent public paper could be quite useful as part of our strategic communications plan.

Acquisition Strategy

8. The paper rightly concludes that while the project is long term, there is much work to be done, and that the sooner we start, the better the likely outcome for Australia. The paper reinforces the relevance of the Kinnaird Review and the process DMO is following. However, this needs to be put in context and a ‘bespoke’ Australian design will bring new and different challenges that are not present in a MOTS project.

9. This paper is an insight to the debate that Defence should lead on. Defence should have its own views on how much indigenous shipbuilding and maintenance capability Defence would like and can afford. Including views on what model (wholly government owned, wholly private, or some degree of hybrid) best meets our needs (DMO lead). Which ever policy government chooses, this paper/workshop can help inform the strategic debate and communications plan.

Capability and Risk

10. The paper states that capabilities of FSM should be determined by the ‘harsh realities of financial, industrial and engineering constraints’. This is a poorly worded comment. The FSM must be designed and built to deliver the capabilities that deliver the Government its strategic effects. If this cannot be achieved due to financial, industrial of engineering constraints then the cost/capability trade-off part of the development process comes to the fore. The paper should strategically consider the need to identify and mould the environment needed in order to introduce FSM effectively. Subsequently, the risk can then be managed so that it is kept at an acceptable level. To imply that ‘it is all too hard now’ will ensure that FSM does not achieve the Governments objectives and, therefore, strategic risks that the paper infers will be realised and escalate.

11. There is considerable reference in the paper to plan for capability development in other areas should FSM not be able to achieve capability aspects required. The reality is that for the strategic effects to be delivered then FSM must be provided with the capability options required. There are no real alternatives to achieve the same. It is generally felt that the paper provides confusing commentary in this regard. In particular, the paper makes bold statements on necessary constraints and risks. However, there are several statements made that promote opposing arguments.

Australia's Unique Requirement:

12. The paper raises the possible option of a smaller type of submarine with spiral development based on existing design. This is outside the conclusions of the submarine options study and thereby the guidance provided for this project. Further comment derived from this 'option' is thereby not considered relevant and may be distracting.

13. The ASPI approach of a parallel fall-back track of a smaller European design if the Collins replacement design fails is not supported. This option would leave Nation with a capability that manifestly cannot meet our requirements – something may not be better than nothing as it will chew up resources, time etc and also not do the job we want.

14. The central issue of the future submarine project is that Australia needs a diesel-electric submarine with unique requirements compared with to the rest of the market. We need:

i. a fleet submarine;
ii. with oceanic range;
iii. using the latest combat system (weapons and sensors); and
iv. we want to assemble in South Australia.

15. The world market provides either:

i. smaller shorter-ranged coastal submarines with diesel-electric propulsion with the German Thyssen Marine Systems being the leading maker; or
ii. much larger nuclear-powered fleet submarines (US, UK and France).

16. The Government has currently ruled out a nuclear submarine capability as an option. Nuclear fleet submarines are operated by the major navies we see as our qualitative peers (USN, RN) and offer the range and submerged speed that would be desirable in our operating area. However, Australia's requirements describe a capability that attempts to merge the reach of a nuclear submarine with the unique attributes of a diesel-electric submarine.

17. This combination of requirements necessitates a bespoke design for Australia, whether it is designed domestically or overseas. The US and UK do not design diesel-electric boats anymore. However, this does not preclude their vital contributions in other aspects of design. The European designers (Germany, etc) do not commonly work on a scale suitable for Australia and, with the exception of Germany; all have a low rate production approach that ultimately limits design expertise.

18. There are also the unique and complex integration issues that need to be considered in any acquisition strategy, which this paper under-estimates.

19. Effectively the combination of our requirements and the limitations on design expertise means that we will be forced to develop unique solutions to our unique requirements OR accept a capability reduction. A capability reduction would be an unacceptable outcome and would fail to achieve the strategic outcome Government requires from the outset.

20. Some of the ASPI paper solutions (e.g. a spiral development of a smaller submarine) indicate a lack of understanding of the tightly coupled nature of submarine design where components and systems cannot be considered or altered in isolation. As such, a developmental approach of a smaller submarine would provide an unacceptably high-risk option.

Concluding Remark

21. Bottom line – we are where we are because our requirements (partly political, partly operational) are unique and that means if you don't want what the market makes, you have to make it yourself with all the risks that this involves.

22. The paper states that to reduce the risk to strategic effects, other force element options must be provided to mitigate against the capability requirements of FSM project proving unachievable. This exposes a fundamental flaw in the authors understanding of the submarine. That is, in almost all cases, the submarine is required because there is no other capability to achieve the strategic effect. Therefore, the project *has* to get it right and this means that the task is a difficult one—failure is not an option.

A937
17984

Requested
Schedule No.5585
Ref: OCCDG/OUT/2009/220

Australian Government
Department of Defence

Office of the Hon Sen. John Faulkner
26 AUG 2009
Minister for Defence

MINISTERIAL SUBMISSION

To: Senator Faulkner		Timing:	**Routine**
CC: Mr Combet		Required by:	08 SEP 2009
		Reason:	

Copies to: Secretary, CDF, FASMSPA, CEO DMO, CN, CDS, GMP, HSFP, DEPSEC S

Brief on Nuclear Power as an Option for Project SEA 1000

Recommendation:

That you **note** information relating to the matter of nuclear power as an option for Project SEA 1000, the Future Submarine Program.

NOTED / ~~PLEASE DISCUSS~~

Key Points:

1. In question time following your speech at ANZ SOG on 13 August 2009, you were asked if the ADF was considering nuclear propulsion for the future submarine force being acquired under SEA 1000. Specifically, you were asked about a Russian submarine design which uses a hybrid diesel electric/nuclear propulsion combination and if it would be suitable for Australian service. Question Time Brief 5.20 (copy attached) provided some background.

2. The Defence White Paper 2009 paragraph 9.5 states the Government policy ruling out nuclear propulsion for the Future Submarine. Australia has none of the necessary legal framework, regulatory system, monitoring and assurance industry elements, fuel management industry elements or infrastructure necessary to support such a capability. An International Atomic Energy Agency paper (Considerations to Launch a Nuclear Power Programme, 2007) explains that it takes 10 to15 years to develop a nuclear industry to the point from which it might be considered feasible to consider embarking on a nuclear submarine propulsion program. A nuclear submarine program would have a similarly lengthy lead time before an operational capability could be fielded although the two programs (national framework and submarine capability) could be undertaken in parallel. The supporting national framework would require the same component elements regardless of the number of submarines acquired and the size/output of their reactors. A nuclear powered submarine program would be likely to be roughly double the cost of a conventional submarine fleet of the same size (based on an informal comment from a senior US Navy source).

Sensitivity:

3. Medium. Sporadic media comment and interest group discussion of nuclear propulsion for Australia's submarine capability has surfaced occasionally for many years. The Defence White Paper 2009 has provided a catalyst for renewed discussion. The assessment is that without a significant increase in national interest in a domestic nuclear industry, the nuclear powered submarine debate is unlikely to achieve much traction.

Resources:

4. N/A

Attachments:

A. Question Time Brief 5.20

Approved By: **M. Tripovich** VADM, RAN Chief Capability Development Group Capability Development 24 Aug 2009	s22 [redacted]
Contact Officer Name: RADM Rowan Moffitt	Phone: s22 [redacted]

	s22 [redacted] .... **JOHN FAULKNER** 30 / 8 / 2009.

Attachment A

Subject :

SEA 1000

QTB No (Pac)

5.20 (TBA)

Session : **Spring 2009** Category : **CAPABILITY** Sort Order:

Action Area

Adviser :

Last modified in Minister's Office by

Response to Nuclear Submarine question relating to Future Submarine

- The Defence White Paper 2009 outlines Government's policy that nuclear power is not an option for Australia's Future Submarine.
- Russian Technology is not being considered in the acquisition of Future Submarine.
- Open press reporting in December 2007 indicated that Russia's Sevmash shipyard at the Arctic city of Severodvinsk had completed a hybrid submarine, powered by a diesel-electric plant and a small nuclear reactor. Designated B-90 and named Sarov, the submarine was apparently completed on 17 December 2007.

Factual Content Contact Officer	Position	Telephone No.
Captain Tim Brown	Director Future Submarine – Capability Development	02-6265 2262 Mob: s22

Factual Content Authorised by	Position
Rear Admiral Rowan Moffitt and	Head Future Submarine Program
Air Vice-Marshal Brian Plenty	Head Capability Systems

Background

After delivering a speech at ANZ SOG, the Minister for Defence was asked if the ADF was considering nuclear propulsion for the future submarine. He was apparently asked specifically whether there is a Russian submarine design which combines diesel electric and nuclear technologies and whether this might be suitable for Australian service. In addition, a response is required to an article in the Australian Financial Review by Geoffrey Barker (17 August 2009).

The SEA 1000 Project is not exploring the option to acquire nuclear submarines as the Government has specifically directed that nuclear submarines are not an option for the Future Submarine.

The reactor in a nuclear submarine is generally used to produce heat to generate steam to drive a turbine that propels the submarine. The steam is also used to generate the electricity needed to run equipment onboard. Nuclear powered submarines have an emergency back up diesel generator and battery system for use in the event the nuclear plant shuts down.

The Russians have apparently produced a submarine (Sarov) which uses a small nuclear reactor – known as a 'tea kettle' – that does not have sufficient power output to drive the submarine in the conventional sense but it can generate electricity to keep the battery charged. This is the same role the diesels fulfil - that is, like the diesel the 'tea kettle' is used to run a generator to provide electric power that is stored in the batteries.

A characteristic of the small nuclear powered generator is that it improves the submarine's underwater endurance on the relatively quiet electric propulsion. In effect, this is a nuclear form of Air-Independent Propulsion (AIP) system.

The "Sarov" is thought to be an experimental design, of which there is only one in existence.

Worth noting too in the context of this discussion is the question of relative quietness – an issue of critical importance in submarine operations. There is a common misconception that conventionally powered submarines are quieter than nuclear powered submarines. While this used to be generally true, it is no longer the case. Modern nuclear powered submarines can be as quiet at slow speed as the quietest conventional boat. The advantage today generally lies with the nuclear submarine in all operational respects because, compared with a conventional boat, the nuclear submarine has:

- No need to 'snort' to run diesels to charge the batteries, which compromises the stealth attributes of the submarine and offers detection opportunities to an adversary; and
- Significantly higher top speed, which can be sustained for long periods.

These two attributes also make a nuclear submarine able to be used in different ways and offer greater flexibility over conventional submarines.

The Australian Financial Review Article (17 August 2009)

Geoffrey Barker's article in the AFR is factually accurate. Nuclear submarines operated by western nations are generally superior to Western conventional submarines because they have better range, endurance, speed, lethality and survivability. They consequently offer a wider selection of response options compared with a conventional submarine.

Comment:

Action History:

Audit History: Created by Kirsten Busteed on 14/08/2009 13:45:53

AO 187
Revised Dec 2007

Australian Government
Department of Defence

Ministerial Tasking Sheet

Schedule number for this task: 5585

Due date for this task: 28 AUG 09

The Office of the Minister for Defence directions:

Ministerial Representation

Prepare reply for:

- [ ] Minister
- [ ] Chief of Staff
- [ ] Adviser
- [ ] Referral to
- [ ] Standard response
- [ ] For departmental action
- [ ] For information only

Ministerial Submission

- [ ] For approval
- [x] For noting
- [ ] Supplementary advice
- [ ] Event or visit brief
- [ ] Speech
- [ ] Meeting brief
- [ ] Ministerial talking points *(DGPA clearance required)*
  - [ ] MS Word document required
- [ ] Media release *(DGPA clearance required)*
  - [ ] MS Word document required
- [ ] For email advice only to:
  (cc to DMPLS MINDEF)

Directorate of Ministerial and Parliamentary Liaison Services (DMPLS) directions:

For action by: CCDG Date received: 17 AUG 09 Type: SB

Originator: DEFENCE - FAULKNER J SEN

Sponsor:

Subject: REQUEST FOR BRIEF ON WHETHER NUCLEAR SUBMARINES ARE AN OPTION UNDER SEA 1000

This tasking has been copied to: DNMC, CEO-DMO; CDS

Other instructions:

DMPLS Tasking Officer: Louise Connor Tel: x52518 or email DMPLS MINDEF

(Please call if you require any assistance)

Previous related papers are on *(Schedule/File)*: with

with

ASSISTANCE FOR YOU

http://intranet.defence.gov.au/oscdfweb/sites/dmpls

Contact the tasking officer **immediately** if you think this has been incorrectly tasked to you.

Contact the tasking officer **immediately** if you are unable to meet the due date above.

Assistance can also be obtained from your Group Coordinator Telephone:

The task is due to your Group Coordinator on

Berry, Joanne MRS

From:	Hawkins, Amy MISS
Sent:	Friday, 14 August 2009 13:11
To:	DMPLS MINDEF
Cc:	Wilson, Emily MS; Mellifont, Paul MR; Busteed, Kirsten MISS; DMPLS QTB; Hawkins, Amy MISS
Subject:	FW: New QTBs from ANSOG speech. ~~[SEC=IN-CONFIDENCE]~~
Categories:	~~IN-CONFIDENCE~~

~~IN-CONFIDENCE~~

DMPLS,

Please see below tasking. I will task for the QTB's separately but reference the request for a brief on whether nuclear submarines are an option under SEA 1000. Please task this formally with a two week turn around.

KB - heads up for the action areas on QTB's for Monday.

Amy

AMY HAWKINS
DEPARTMENTAL LIAISON OFFICER
OFFICE OF SENATOR THE HON JOHN FAULKNER
MINISTER FOR DEFENCE
M1-41 PARLIAMENT HOUSE
PH (02) 6277 7800 . FAX (02) 6273 4118 : MOBILE s22 [redacted]

From: Hamilton, Tom MR
Sent: Friday, 14 August 2009 11:06
To: Hawkins, Amy MISS
Cc: Wilson, Emily MS; Conroy, Pat MR
Subject: New QTBs from ANSOG speech. ~~[SEC=IN-CONFIDENCE]~~

~~IN-CONFIDENCE~~

Hi Amy

Could we please task new QTBs to cover off the ANZSOG speech:

s22 [redacted]

- Is the ADF considering Nuclear Submarines under project SEA 1000? (Please see briefing tasking below)

All QTBs referring to speech content should also be updated to ensure consistency, including:

s22 [redacted]

s22

Please check with other advisers that this list is all that is needed.

Additionally, could we please have a tasking for a brief to the minister on whether nuclear submarines are an option under SEA 1000? This is in response to a question the Minister was asked after the speech. He undertook to task a briefing. The brief is to specifically cover whether a Russian submarine design exists which comprises a 'hybrid diesal electric/nuclear propulsion combination' and if it would be suitable for Australian service. The questioner may have been referring to the Sarov.

Happy to discuss.

Cheers

TH

Tom Hamilton
Adviser
Office of Senator the Hon John Faulkner
Minister for Defence
(02) 6277 7800

Subject : QTB No (Pack):

FUTURE SUBMARINE PROGRAM 5.8 (A)

Session : Spring 2009 Category :CAPABILITY Sort Order:
Action Area: CCDG
Adviser : Andrew Witheford
Last modified in Minister's Office by Andrew Witheford

How can the Government justify a doubling of the submarine fleet?

- The 2009 Defence White Paper states that the principal task for the Australian Defence Force is to deter and defeat armed attacks on Australia.
- The Government is committed to providing the Defence Force with the right tools for this task, including a major boost to our maritime capabilities.
- The acquisition of 12 new Future Submarines, which will be more capable than the Collins-class, is a major element of this commitment.
- The expanded fleet of 12 submarines will sustain a force at sea large enough in a crisis or conflict to:
  - defend our approaches (including at considerable distance from Australia, if necessary);
  - protect and support other Australian Defence Force assets; and
  - undertake certain strategic missions where the stealth and other operating characteristics of highly capable advanced submarines would be crucial.
- Moreover, a larger submarine force would significantly increase the military planning challenges faced by any adversaries, and increase the size and capabilities of the force they would have to be prepared to commit to attack us directly, or coerce, intimidate or otherwise employ military power against us.

If asked: Is the Government considering nuclear submarines?

- The Defence White Paper 2009 outlines the Government's policy that nuclear power is not an option for Australia's future submarines.
- No nuclear technology, including recent Russian submarine-related nuclear developments, is being considered in the acquisition of future submarines.

If asked: Has the Government decided to design the submarines in Australia?

- No decision has been taken on the design strategy at this time.
- However, to ensure that Australia can sustain the Future Submarines once acquired, a number of support arrangements will be required in country including design capability.
- Defence has contracted the support of the US-based RAND corporation to assist in examining the nature of the required design capability, and how and when this might be able to be established.
- This process includes a study to examine the feasibility of establishing an indigenous design capability in Australia.
- The study builds on previous information gathered from Australia and overseas. The information it provides will inform Government's early consideration of capability and acquisition strategy issues.
- I repeat: no decisions have been made – we are currently gathering information to help shape the approach to the design of the next generation submarine.

If asked: What is the Government doing to ensure an appropriate submarine capability is delivered?

- A key defence election commitment for this Government was to ensure that preliminary work on Australia's next generation of submarines is carried out as a matter of priority.
- That is why the Government ~~initially~~ has approved initial development funding of $~~4.6~~15.4 million to conduct preliminary studies into the issues and technologies that will be relevant to these submarines.

- Currently, the Future Submarine Project team is assessing data from overseas and Australian industry in relation to feasible capabilities and relevant commercial matters.
- This process includes a study to examine the feasibility of establishing an indigenous design capability in Australia.
- The combination of White Paper and industry responses will allow the project to frame the requirements of the Future Submarine in a cohesive, achievable and cost effective manner.
- We will then make further decisions on what capabilities we require and what needs to be incorporated in the design of the submarines we might purchase.

If asked: If we can't crew our current submarines, how can we possibly crew the 12 submarines announced in the White Paper?

- Navy is very aware of submarine workforce and morale issues and has taken swift action to start addressing these concerns.
- The shortfall in the submarine workforce is an issue we take very seriously and we are absolutely determined to make lasting changes that benefit our submariners and their families rather than adopting short-term band-aid solutions.

- Last year, the Government commissioned a Submarine Workforce Sustainability Review. This review analysed the range of factors that were placing pressure on our submariners and impacting the Navy's ability to generate the required level of capability for the Submarine Force.
- The Chief of Navy has since received and agreed to the implementation of all of the reviews recommendations under the Submarine Sustainability Programme.

  - These recommendations will help build the foundations for rebuilding a sustainable submarine workforce, in conjunction with the New Generation Navy initiative, and lead to the successful maintenance and sustainability of the Future Submarine Force.
- The submarine workforce has now been stabilised and is expected to grow as reforms under the Submarine Sustainability Programme take effect.

If asked: Will the Government be conducting a Parliamentary Review of the Future Submarine Project? Why?

- There is no need for any review of the Future Submarine Project.
- Defence has commenced the project to fulfil Government’s direction as stated in the White Paper 2009.
- The project is in the initial stages of the defining the submarine capability requirements and assessing the overall project strategy, and no decisions have yet been made by the Government in respect of anything except exploratory work.
- The intention is for the Defence to seek Government’s initial consideration of the overall project strategy in early 2010 in order to enable the project to be progressed appropriately.

ADDITIONAL TALKING POINTS

If asked: Why is the Government insisting on building another submarine following the previous Collins submarine debacle? Why not go for an off-the-shelf design?

- Due to Australia's unique geography, and the need for a submarine with capabilities in excess of the Collins-class, it is most unlikely that any 'off the shelf' option will fill our future submarine requirements.
- Nonetheless, an off the shelf option will be retained as a risk mitigation strategy.
- The development of these new submarines require long term planning if it is to meet the current time frame of replacing the Collins class submarines from 2025 onward.
- The Government has directed Defence to commence preliminary technology studies and to start engaging with industry in order to develop proposals for the acquisition of future submarines.
- Government has allocated a total of $15.4 million in the early stages of the project to ensure the project is established in earnest from the outset.
- This is a highly complex project which is a priority for the Government and was first highlighted in Labor's 2007 Defence election policy.
- The Government remains committed to assembly and through-life support of the Future Submarine in Australia.
- It will however also be important to engage overseas expertise in the design of the submarines.

<u>If asked: Has the Government eliminated competition for this contract by promising that they will be built in Adelaide by ASC?</u>

- The Defence White Paper 2009 confirms the Government's intention to assemble the Future Submarines in South Australia.
- The role of ASC remains to be determined; for the present, it is expected that ASC will compete against international and Australian based companies for its project involvement.

BACKGROUND - NUCLEAR POWERED SUBMARINES

After delivering a speech at ANZSOG, the Minister for Defence was asked if the ADF was considering nuclear propulsion for the future submarine. Further, the Minister was asked specifically whether there is a Russian submarine design which combines diesel electric and nuclear technologies and whether this might be suitable for Australian service.

The SEA 1000 Project is not exploring the option to acquire nuclear submarines as the Government has specifically directed that nuclear submarines are not an option for the Future Submarine.

The Australian Financial Review Article (17 August 2009)

Nuclear submarines operated by western nations are generally superior to Western conventional submarines because they have better range, endurance, speed, lethality and survivability. They consequently offer a wider selection of response options compared with a conventional submarine.

Characteristics of Nuclear Submarines

The reactor in a nuclear submarine is generally used to produce heat to generate steam to drive a turbine that propels the submarine. The steam is also used to generate the electricity needed to run equipment onboard. Nuclear powered submarines have an emergency back up diesel generator and battery system for use in the event the nuclear plant shuts down.

The Russians have apparently produced a submarine (Sarov) which uses a small nuclear reactor – known as a ‘tea kettle’ – that does not have sufficient power output to drive the submarine in the conventional sense but it can generate electricity to keep the battery charged. This is the same role the diesels fulfil - that is, like the diesel the ‘tea kettle’ is used to run a generator to provide electric power that is stored in the batteries.

A characteristic of the small nuclear powered generator is that it improves the submarine’s underwater endurance on the relatively quiet electric propulsion. In effect, this is a nuclear form of Air-Independent Propulsion (AIP) system.

The "Sarov" is thought to be an experimental design, of which there is only one in existence.

Worth noting too in the context of this discussion is the question of relative quietness – an issue of critical importance in submarine operations. There is a common misconception that conventionally powered submarines are quieter than nuclear powered submarines. While this used to be generally true, it is no longer the case. Modern nuclear powered submarines can be as quiet at slow speed as the quietest conventional boat. The advantage today generally lies with the nuclear submarine in all operational respects because, compared with a conventional boat, the nuclear submarine has:

- No need to ‘snort’ to run diesels to charge the batteries, which compromises the stealth attributes of the submarine and offers detection opportunities to an adversary; and
- Significantly higher top speed, which can be sustained for long periods.

These two attributes also make a nuclear submarine able to be used in different ways and offer greater flexibility over conventional submarines.

Factual Content Contact Officer	Position	Telephone No.
Mr Mark Gairey	Future Submarine Project Director	02 6265 3519

Factual Content Authorised by	Position
Vice Admiral Matt Tripovich	

Attachments (Large Tables etc)

Comment:

Action History:

Audit History: Edited by Andrew Witheford on 12/11/2009 03:20:16 PM
Edited by Paul Mellifont on 12/11/2009 09:44:02
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Edited by Tom Hamilton on 08/09/2009 08:59:37 AM
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Edited by Tom Hamilton on 20/08/2009 09:29:57 AM
Edited by Pat Conroy on 17/08/2009 12:13:55 PM
Edited by Tom Hamilton on 17/08/2009 11:25:59 AM
Edited by Tom Hamilton on 17/08/2009 11:21:43 AM
Edited by Tom Hamilton on 07/08/2009 02:57:47 PM
Edited by Pat Conroy on 07/08/2009 02:25:19 PM
Edited by Tom Hamilton on 07/08/2009 01:40:21 PM
Edited by Tom Hamilton on 07/08/2009 11:58:21 AM
Edited by Kirsten Busteed on 07/08/2009 11:19:17
Created by Kirsten Busteed on 31/07/2009 15:58:42

Subject : QTB No (Pack):

FUTURE SUBMARINE PROGRAM 5.8 (A)

Session : Spring 2009 Category : CAPABILITY Sort Order:
Action Area: CCDG
Adviser : Andrew Witheford
Last modified in Minister's Office by Andrew Witheford

If asked: How can the Government justify a doubling of the submarine fleet?

- The 2009 Defence White Paper states that the principal task for the Australian Defence Force is to deter and defeat armed attacks on Australia.
- The Government is committed to providing the Defence Force with the right tools for this task, including a major boost to our maritime capabilities.
- The acquisition of 12 new Future Submarines, which will be more capable than the Collins-class, is a major element of this commitment.
- The expanded fleet of 12 submarines will sustain a force at sea large enough in a crisis or conflict to:
  - defend our approaches (including at considerable distance from Australia, if necessary);
  - protect and support other Australian Defence Force assets; and
  - undertake certain strategic missions where the stealth and other operating characteristics of highly capable advanced submarines would be crucial.
- Moreover, a larger submarine force would significantly increase the military planning challenges faced by any adversaries, and increase the size and capabilities of the force they would have to be prepared to commit to attack us directly, or coerce, intimidate or otherwise employ military power against us.

If asked: Is the Government planning on designing a unique submarine rather than buying an off-the-shelf design?

•<u>Due to the combination of Australia's geography and likely operational requirements, it is most unlikely that any 'off the shelf' option will fill our future submarine requirements.</u>

•<u>Nonetheless, off the shelf options are being examined in developing the project strategy.</u>

•<u>The level of capability to be acquired and the associated options will be considered by the Government later this year.</u>

<u>If asked: Is the Government considering nuclear submarines?</u>

- The Defence White Paper 2009 outlines the Government’s policy that nuclear power is not an option for Australia’s future submarines.
- No nuclear technology, including recent Russian submarine-related nuclear developments, is being considered in the acquisition of future submarines.

<u>If asked: Has the Government decided to design the submarines in Australia?</u>

- No decision has been taken on the design strategy at this time.
- However, to ensure that Australia can sustain the Future Submarines once acquired, a number of support arrangements will be required in country including design capability.
- Defence has contracted the support of the US-based RAND Corporation to assist in examining the nature of the required design capability, and how and when this might be able to be established.
- This process includes a study to examine the feasibility of establishing an ~~indigenous~~ design capability in Australia.
- The study builds on previous information gathered from Australia and overseas. The information it provides will inform Government's early consideration of capability and acquisition strategy issues.

- I repeat: no decisions have been made – we are currently gathering information to help shape the approach to the design of the next generation submarine.

If asked: What is the Government doing to ensure an appropriate submarine capability is delivered?

- A key defence election commitment for this Government was to ensure that preliminary work on Australia's next generation of submarines is carried out as a matter of priority.
- That is why the Government ~~initially~~ has approved initial development funding of $~~4.6~~15.4 million to conduct preliminary studies into the issues and technologies that will be relevant to these submarines and will assist in determining essential and desireable attributes.
- The issues and technologies to be investigated seek to inform the projects understanding of the cost and risk associated with various capability requirements, such as the feasibility of air independent propulsion.
- Currently, the Future Submarine Project team is assessing data from overseas and Australian industry in relation to feasible capabilities and relevant commercial matters.
- This process includes a study to examine the feasibility of establishing an ~~indigenous~~ design capability in Australia.
- The combination of White Paper and industry responses will allow the project to frame the requirements of the Future Submarine in a cohesive, achievable and cost effective manner.
- We will then make further decisions on what capabilities we require and what needs to be incorporated in the design of the submarines we might purchase.

If asked: If we can't crew our current submarines, how can we possibly crew the 12 submarines announced in the White Paper?

- Navy is very aware of submarine workforce and morale issues and has taken swift action to start addressing these concerns.
- The shortfall in the submarine workforce is an issue we take very seriously and we are absolutely determined to make lasting changes that benefit our submariners and their families rather than adopting short-term band-aid solutions.
- Last year, the Government commissioned a Submarine Workforce Sustainability Review. This review analysed the range of factors that were placing pressure on our submariners and impacting the Navy's ability to generate the required level of capability for the Submarine Force.
- The Chief of Navy has since received and agreed to the implementation of all of the reviews recommendations under the Submarine Sustainability Programme.
- These recommendations will help build the foundations for rebuilding a sustainable submarine workforce, in conjunction with the New Generation Navy initiative, and lead to the successful maintenance and sustainability of the Future Submarine Force.
- The submarine workforce has now been stabilised and is expected to grow as reforms under the Submarine Sustainability Programme take effect.

<u>If asked: Will the Government be conducting a Parliamentary Review of the Future Submarine Project? Why?</u>

- There is no need for any review of the Future Submarine Project.
- Defence has commenced the project to fulfil Government’s direction as stated in the White Paper 2009.
- The project is in the initial stages of the defining the submarine capability requirements and assessing the overall project strategy, and no decisions have yet been made by the Government in respect of anything except exploratory work.

- The intention is for the Defence to seek Government’s initial consideration of the overall project strategy in early 2010 in order to enable the project to be progressed appropriately.

ADDITIONAL TALKING POINTS

~~***If asked: Why is the Government insisting on building another submarine following the previous Collins submarine debacle? Why not go for an off the shelf design?***~~

- ~~Due to Australia's unique geography, and the need for a submarine with capabilities in excess of the Collins class, it is most unlikely that any 'off the shelf' option will fill our future submarine requirements.~~
- ~~Nonetheless, an off the shelf option will be retained as a risk mitigation strategy.~~
- ~~The development of these new submarines require long term planning if it is to meet the current time frame of replacing the Collins class submarines from 2025 onward.~~
- ~~The Government has directed Defence to commence preliminary technology studies and to start engaging with industry in order to develop proposals for the acquisition of future submarines.~~
- ~~Government has allocated a total of $15.4 million in the early stages of the project to ensure the project is established in earnest from the outset.~~
- ~~This is a highly complex project which is a priority for the Government and was first highlighted in Labor's 2007 Defence election policy.~~
- ~~The Government remains committed to assembly and through life support of the Future Submarine in Australia.~~
- ~~It will however also be important to engage overseas expertise in the design of the submarines.~~

If asked: Has the Government eliminated competition for this contract by promising that they will be built in Adelaide by ASC?

- The Defence White Paper 2009 confirms the Government's intention to assemble the Future Submarines in South Australia.
- The role of ASC remains to be determined; for the present, it is expected that ASC will compete against international and Australian based companies for its project involvement.

If asked: Given the continued difficulties with the Collins Class in regard to technical issues, how will this impact on the future submarine program.

- The Future Submarine project office is cognisant of these difficulties and has introduced a series of processes to reduce the risk of similar problems.
- A Science and Technology (S&T) plan has been prepared by the Defence Science and Technology Organisation (DSTO) and the project office to identify all of the technology issues to be addressed.
- DSTO is analysing current Collins Class issues to identify risk mitigation strategies that can be applied for the Future Submarine.
- Consideration is being given to the establishment of a Power and Energy Integration test-site that would allow all propulsion and energy storage systems to be proven before they are installed in a submarine.
- Implementation of the S&T plan will ensure that all equipment selected for inclusion in the Future Submarine has reached a sufficient level of technical maturity before it is selected.

BACKGROUND ~~– NUCLEAR POWERED SUBMARINES~~

NUCLEAR POWERED SUBMARINES

After delivering a speech at ANZSOG, the Minister for Defence was asked if the ADF was considering nuclear propulsion for the future submarine. Further, the Minister was asked specifically whether there is a Russian submarine design which combines diesel electric and nuclear technologies and whether this might be suitable for Australian service.

The SEA 1000 Project is not exploring the option to acquire nuclear submarines as the Government has specifically directed that nuclear submarines are not an option for the Future Submarine.

The Australian Financial Review Article (17 August 2009)

Nuclear submarines operated by western nations are generally superior to Western conventional submarines because they have better range, endurance, speed, lethality and survivability. They consequently offer a wider selection of response options compared with a conventional submarine.

Characteristics of Nuclear Submarines

The reactor in a nuclear submarine is generally used to produce heat to generate steam to drive a turbine that propels the submarine. The steam is also used to generate the electricity needed to run equipment onboard. Nuclear powered submarines have an emergency back up diesel generator and battery system for use in the event the nuclear plant shuts down.

The Russians have apparently produced a submarine (Sarov) which uses a small nuclear reactor – known as a ‘tea kettle’ – that does not have sufficient power output to drive the submarine in the conventional sense but it can generate electricity to keep the battery charged. This is the same role the diesels fulfil - that is, like the diesel the ‘tea kettle’ is used to run a generator to provide electric power that is stored in the batteries.

A characteristic of the small nuclear powered generator is that it improves the submarine’s underwater endurance on the relatively quiet electric propulsion. In effect, this is a nuclear form of Air-Independent Propulsion (AIP) system.

The "Sarov" is thought to be an experimental design, of which there is only one in existence.

Worth noting too in the context of this discussion is the question of relative quietness – an issue of critical importance in submarine operations. There is a common misconception that conventionally powered submarines are quieter than nuclear powered submarines. While this used to be generally true, it is no longer the case. Modern nuclear powered submarines can be as quiet at slow speed as the quietest conventional boat. The advantage today generally lies with the nuclear submarine in all operational respects because, compared with a conventional boat, the nuclear submarine has:

- No need to 'snort' to run diesels to charge the batteries, which compromises the stealth attributes of the submarine and offers detection opportunities to an adversary; and
- Significantly higher top speed, which can be sustained for long periods.

These two attributes also make a nuclear submarine able to be used in different ways and offer greater flexibility over conventional submarines.

AUSTRALIAN PACIFIC DEFENCE REPORTER ARTICLE "From SEA 1441 to SEA 1000 – will it work better this time?" January 2010

The article examines the likely capability requirements for the Future Submarine and questions the need for a unique design. It examines off-the-shelf submarine options (including nuclear powered) and on the basis of incorrect and / or misleading data suggests that a conventionally powered derivative of either the French Barracuda nuclear powered submarine or a derivative of the German Type 214 would be suitable. The article fails to recognise that the Collins class is in many ways superior to available off-the-shelf non-nuclear options or to appreciate the scope of design change necessary to modify a nuclear powered submarine.

Factual Content Contact Officer	Position	Telephone No.
Mr Mark Gairey	Future Submarine Project Director	02 6265 3519

Factual Content Authorised by	Position
Vice Admiral Matt Tripovich	

Attachments (Large Tables etc)

Comment:

Action History:

Audit History: Edited by Andrew Witheford on 12/11/2009 03:20:16 PM
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CDF AND MINDEF MEETINGS WITH FRENCH CGS

Desired Outcomes

Acknowledge the assistance and cooperation we have received from the French Government, French Navy and DGA so far and;
Convey to General Georgelin that no decision has yet been made on the acquisition strategy for the Future Submarine or regarding the involvement of overseas companies.

KEY ISSUES

- General Georgelin can be expected to reinforce French interest in being 'the' European partner with Australia in supplying a solution for SEA 1000 Future Submarine and will probably emphasise the credentials of French industry for this role. He is likely also to stress the French view of their ability to include US technology in a program for Australia and point to a number of examples from other programs where they have done so. The examples will not include any sensitive US technology however.

- Delegation General pour l'Armamente (DGA) is the French equivalent of DMO and DSTO. They have indicated strong support for French involvement in Australia's Future Submarine project.

- A number of French companies are interested in participating in Australia's Future Submarine project.
    - DCNS is the primary submarine designer in France and designs, builds, and delivers submarines for the French Navy as well as for international customers (Pakistan, Chile, India, Brazil).
    - Thales is a major provider of submarine technology particularly sonar and combat systems. Thales has two subsidiaries that may also seek to become involved in the project, Thales Australia and Thales UK.
    - Other possible French suppliers include:
        - Sagem – periscope and electro-optical equipment
        - Jeumont – propulsion equipment
        - SAFT – advanced battery technology

- DCNS recently announced a contract to supply Brazil with four Scorpene Submarines and assistance in the design and production of the platform elements of a nuclear powered submarine (based on the French Navy Barracuda SSN).

BRIEF AUTHORISED BY
Rowan Moffitt, RADM
Head Future Submarine Program
Tel: 02 6265 2251
Mobile: s22

CONTACT OFFICER
Mr Mark Gairey
Project Director
Tel: 02 6265 3519
Mobile: s22

Date: 13 Jan 2010

BACKGROUND

France no longer operates conventionally powered submarines. The nuclear powered submarines operated and under construction in France are smaller than those built by other countries and could provide a basis for Australia's Future Submarine. Very substantial design effort would be required. French industry designs and constructs conventionally powered submarines for the export market but these are much smaller than the type of submarine likely to be required by Australia. This export program helps to sustain the French industry skill base.

DCNS responded to the Request for Information issued by the Future Submarine project in late 2008 and has maintained regular engagement with the project office since.

The Future Submarine project believes that any technology developed for an Australian Submarine capability by France could subsequently be made available to other existing, or new, French submarine clients. Given the growing French submarine export portfolio, this potentially conflicts with maintenance of an Australian capability edge in the region. It may be possible to strike a commercial arrangement that would cede Intellectual Property control to Australia, but the indicative cost is high (c$A2 b).

The project office is concerned that French involvement as a major supplier to the Future Submarine could potentially impact upon Australia's ability to access sensitive technologies from other nations. s33(a)(iii) [redacted]

TALKING POINTS FOR NEWSPAPER ARTICLES FRIDAY 8 OCTOBER 2010

Issue

A number of articles and a letter to the Editor discuss the Government's plans to acquire 12 new submarines. The articles query the number of submarines necessary, the cost and the risks of pursuing unique design solutions.

TALKING POINTS

- The plan in the Defence White Paper 2009 to acquire twelve submarines is a result of the strategic assessment leading to where they are likely to be required to operate, for what purposes and for how long.
- Defence has a number of studies underway or planned to examine the full range of options that might meet the capability required. All options other than nuclear power are being considered. Studies include consideration of whole-of-life costing. Outcomes will be presented incrementally for Government consideration.
- Until such time as the exact level of capability to be acquired and the exact acquisition model are determined it would be premature to speculate on the likely cost of the submarines.
- The time required for maintenance and crew training, the nature of the operational task, the range at which operations are conducted and the time that submarines are required to operate completely unsupported results in only a small fraction of a submarine force ever being deployed at the same time. Globally, this ratio is considered to vary between 5:1 and 3:1 and is dependant more upon range of operation (and deployment length) than type

of submarine (nuclear or conventionally powered, both of which are highly complex vessels)

- The acquisition of 12 new future submarines, which will be more capable than the Collins class, is a major element of the 2009 Defence White Paper.
- The Future Submarine Program (Project SEA 1000) has been established to deliver this capability.
- The program office is conducting and / or planning a number of studies to explore the cost and capability options for both platform and combat system. This work includes whole-of-life costing and a review of the lessons learned from aspects of designing, building and operating Collins Class submarines.
- No option has been discounted to date other than nuclear power. All options ranging from existing off-the-shelf designs to a fully bespoke, Australian designed option will be carefully considered against Australia's future strategic defence requirements. Designs that fall between these will all be considered against capability requirements, cost, procurement timeframe, risks and the benefits to Australian industry.
- The future submarine is likely to incorporate technology from Europe, the US and Australia. Opportunities for collaboration with foreign governments and domestic/foreign industry are being explored.
- Defence plans to bring forward matters relating to SEA 1000 for Government consideration a number of times before second pass some time around 2016.

Cleared By: AIRMSHL John Harvey	**Prepared By: Mark Gairey**
Title: Chief Capability Development Group	**Title: Project Director Future Submarines**
Contact Number: 6265 2040	**Contact Number: 6265 3519**

Date: 5 Oct 10	**Date: 5 Oct 10**

Cleared By: Rod Dudfield
Title: Deputy Director General Public Affairs
Contact Number: 6127 1951
Date: 8 Oct 10

ACQUISITION OF NUCLEAR SUBMARINES

An article by Brendan Nicholson in the Australian Monday 7 February 2011 quotes a Kokoda Foundation report claiming that 10 US nuclear submarines would be a cheaper more effective military option for Australia than buying 12 large conventional submarines.

Is Australia considering nuclear powered submarines?

- As stated in the 2009 Defence White Paper, the Government is not considering nuclear powered submarines.

- Australia does not have the infrastructure to support nuclear powered submarines, such as the training facilities, medical support services, safety systems or fuel handling facilities.

- The cost of the necessary infrastructure would add significantly to the cost of submarines themselves.

- Additionally, nuclear powered submarines have much larger crews, about twice the size of a large conventional submarine.

SENATE ESTIMATES BRIEF

Capability
Secretary's and CDF's pack

BRIEF 30: SEA 1000 – FUTURE SUBMARINES

Key Facts

• Schedule to be determined in conjunction with Collins life evaluation • All options other than nuclear propulsion being examined • Future Submarines System Centre in Adelaide announced by the Minister for Defence 6 September 2012. • Lease for the Integrated Project Team office accommodation has been signed. Office is located in Dudley Park, Adelaide.	• The recent allocation of $214m covers design studies, technology evaluation, and capability analysis to inform future Government decisions • SPESIFy – Phase 2 (Requirements definition) of the study is underway – Babcock PTY LTD and Fraser Nash, following announcement by MINDEF on 12 December 2012 of research and development facility siting in Melbourne, integration facility in Adelaide and training facility in Western Australia.

Key Issues

- No option ruled out except nuclear propulsion (Government policy position).
- Options – all based on assembly in Adelaide:
  1. Military off the shelf (MOTS) modified only to comply with legislation
  2. Modified MOTS (with combat system of our choice)
  3. An evolved design that enhances the capabilities of existing MOTS, including the *Collins Class*, and
  4. A new design.
- Collins life of type is being evaluated; withdrawal will be managed with introduction of Future Submarines to avoid a capability gap.

CURRENT SITUATION

- Submarine Propulsion, Energy and Support Integration Facility (SPESIFy) – 1st Pass consideration March 2013.

- SPESIFy – is progressing with Babcock and Frazer Nash developing the capability definition documentation required for 1st Pass consideration.
- Integrated Project Team for new design – Office accommodation has been finalised. Work progressing towards a team start by end January 2013.
- IPT Team Leader selection interviews conducted 17 December 2012. Both team leader and deputy team leader have been selected.
- Combat System RFI – alternate combat systems being evaluated by end March 2013.
- MOTS Option 1 RFI – Assessment is ongoing. Holdups have occurred because of DCNS (France) and HDW (Germany) hesitation on entering into the Deed of Participation. Negotiation with both countries is ongoing. Navantia (Spain) data under evaluation by Systems Program Analysis (US).
- Strategic Business Advisor – A Request for Tender will be released in early 2013 to fill this role. A briefing was held with interested groups at Russell Offices in December 2012.

Planned Activities

- Workforce requirements study
- Australian compliant MOTS studies with European designers for Option 1.
- Combat System options business case to support Option 2.
- Updated Collins and other MOTS design studies for Option 3.
- Concept design, cost/capability trade off and cost driver studies (Australian industry) for Option 4 to begin in 2013.

If asked: Why isn't Australia examining nuclear propulsion instead of or in parallel to conventionally powered submarines?

- The Defence White Paper 2009 makes it clear that nuclear propulsion is not being considered for the future submarine.
- Australia does not have the infrastructure such as the training facilities, medical support services, regulatory or safety systems necessary for us to operate nuclear submarines.
- Nuclear submarines typically require twice the crew numbers of even a large conventional submarine. This, along with the cost of the necessary national infrastructure, would add significantly to the cost of the nuclear submarine option.
- There has been some debate in Australia on the issue of leasing or purchasing US Virginia Class submarines. The US has not made any such offer.
- The US has never exported nor leased a naval nuclear reactor.

- Notwithstanding the continuing interest and debate on nuclear power, both internationally and within Australia, the Government's position on nuclear propulsion for the Future Submarines is clear:
    - These submarines will be conventionally powered.
    - This was re-confirmed in the Prime Minister and Minister for Defence's media release of 3 May 2012.

If asked: Is the Government planning on designing a unique submarine rather than buying an off-the-shelf design?

- The Government has made no decisions yet on the design for the Future Submarines other than discounting nuclear propulsion.
- All options ranging from existing off-the-shelf designs to a new design are being considered against Australia's future strategic defence requirements.
- Even an off–the–shelf design would require some design effort to ensure compliance with Australian legislation.

If asked: Are we facing a capability gap between the retirement of the Collins Class submarines and the entry into service of the future submarines?

- The Government has no intention of allowing a gap in any capability that is so important to Australia's security.
- There is still a great deal of work to be done before a decision can be made on which of the existing range of options we will pursue to replace the Collins Class.
- Defence will shortly deliver for Government consideration a Collins Class Service Life Evaluation Program report that identifies:
    - the life achievable from the Collins Class, and
    - the work required in order to operate the submarines beyond their current planned life.
- Other navies have done similar assessments and successfully operated submarines beyond their original design life.
- Withdrawal of the Collins Class and introduction of the future submarines will be managed to avoid a capability gap.

If asked: How is Defence progressing with the Submarine Skilling Program Study?

- On 3 May 2012, the Government commissioned CEO DMO to prepare a Future Submarine Industry Skills Plan (FSISP). The Future Submarine

Industry Skills Plan will recommend actions to sustain and develop the skills required to successfully deliver Australia's future submarine project.

- The Plan has been developed by a team led by the Chief Executive Officer of the DMO, Mr Warren King and supported by an Expert Industry Panel headed by Mr David Mortimer, AO.
- Initial findings are:
    - the Australian shipbuilding industry is capable, but important white collar skills are spread thin;
    - while some Australian companies can reach back into their parent international organisations for design work, our indigenous design capability for submarine and surface ships is weak;
    - the current blue collar work force is limited, with production supervisors and electrical trades being the weakest skill areas; and
    - the key to building these skills is a continuous ship building plan with long term, predictable work.
    - The core group of skilled people needed for the future submarine project are those people who today are working on the Air Warfare Destroyer and Landing Helicopter Dock projects.
    - Skilled people need to be retained in the industry and we need to develop their skills and improve experience levels through work on other naval shipbuilding projects.
    - The Government will release the Plan shortly.

AUTHORISED BY:
MR DAVID GOULD
General Manager Submarines - DMO
Date: 23 January 2013

CONTACT OFFICER:
RADM ROWAN MOFFITT
RADM RAN
Head Future Submarines Program
Date: 23 January 2013

CONSULTED WITH:
Mr A. Cawley.
Future Submarine Industry Skills Team
CDRE G.J. Sammut
Director General Submarine Capability - Navy

BACKGROUND

Broad Project Schedule: For planning purposes, the current schedule assumes a traditional acquisition model and is based on the following key milestones. These are subject to review as further information is gathered.

2013/14	1st Pass.
2017	2nd Pass, decision to build sometime later.
After 2025	Initial Operational Release.

- Program office currently has 34 staff (includes four CDG personnel, three graduates and one Navy reservist), plus two embedded DSTO advisors.

Strategy

- No option ruled out except nuclear propulsion (Government policy position).
- Options:
    1. MOTS incorporating minimum modifications to comply with Australian Statutory legislation.
    2. Modified MOTS with Australia's choice of combat system, replacing the designers-provided system.
    3. Evolved MOTS options of European MOTS submarines, including Collins, with operational life through to 2050.
    4. New design large ocean going conventional submarine meeting Australia's requirements.
- All options will be analysed and evaluated, especially MOTS.
- Attention is being paid to lessons from Collins and other major Defence acquisitions, including AWD, JSF, AEW&C and Super Seasprite.
- Choice of combat system and weapons will have a significant influence.
- No existing or prospective MOTS option will meet the White Paper capability.

Transition from Collins Class

- Submarine Life Evaluation Program has been completed.
- Collins Class end of design life notionally 2025.
- Transition to FSM will be managed to maintain submarine capability.

Sea 1000 - Future Submarines – The Nuclear Option

Talking Points

The Government is currently considering all options for the Future Submarine project, other than nuclear propulsion, which the Government has ruled out.

The Government will not reconsider the option of acquiring nuclear powered submarines.

Acquiring nuclear powered submarines would involve outsourcing the construction, maintenance and sustainment of the submarines to another country, which the Government has ruled out.

If asked: **why Australia is not willing to consider the nuclear option?**

Not only would a nuclear submarine have to be built overseas, it would have to be fuelled, docked, de-fuelled and disposed of overseas, until Australia had built nuclear infrastructure able to undertake these tasks safely.

The cost of this alone would run into billions.

Safe operation of a nuclear powered boat will require commanders and especially chief engineers to be qualified and experienced operators of nuclear plant.

In short, unless or until Australia has the knowledge and skill to design and build a reactor, this will not run.

It is completely unachievable in the timescale of Collins replacement.

If asked: **about options for acquiring US nuclear submarines?**

As I have said in the past, the only option that we have ruled out is nuclear propulsion, and we rule out nuclear propulsion because we do not have a nuclear industry in Australia.

The Australian Government has not asked the US for access to nuclear submarine propulsion technology in any form and the US Government has not offered it. Note: The US Government has never leased or sold a naval nuclear reactor to any other country.

Commentators who propose nuclear submarines for Australia also consistently underestimate and understate the complexity and cost of even the most minimal supporting frameworks that would be needed before Australia could be able to operate them safely.

None of these essential and highly specialised arrangements, such as education and training, governance regulatory and supervisory structures and health services infrastructure exists sufficiently in Australia today.

Proponents of nuclear submarines also dismiss the very clear views of the Australian people on the nuclear issue.

***If asked:* Would the Minister like to see Tony Abbott declare his position on the nuclear option given the different positions noted last year?**

In a doorstop interview on 1 June 2012, Senator Johnston ruled out nuclear powered submarines.

Reports that senior Coalition leaders are now seeking to open the debate over the purchase of nuclear submarines to replace the Collins class is at odds with Senator Johnston's statements and the Opposition Leader needs to clarify his position on this issue.

Background

There was media coverage in 2012 suggesting that Australia should buy or lease Virginia class nuclear powered submarines from the USA, and public comments from both sides of politics suggesting that the debate on the nuclear option should be reopened.

Australia does not have the necessary infrastructure, expertise or experience in the nuclear industry or in nuclear power generation to introduce a nuclear submarine fleet at this time. In addition to the infrastructure requirements, the crew size of a nuclear powered submarine is twice that of a large conventionally powered submarine, which further detracts from this option. The US has not offered this capability to Australia and Australia has not approached the US for it.

We have confirmed through senior US Embassy defense staff that recent media articles interpreting comments by US Ambassador to Australia Jeffrey Bleich as a US offer of nuclear submarines misinterpret the facts. The US continues to offer Australia help and support with the Future Submarines Program but is not offering US nuclear technology in any form.

Opposition position on the nuclear option: In a doorstop interview on 1 June 2012, Senator Johnston ruled out nuclear powered submarines stating:

> "I have just come back from Plymouth in the United Kingdom where I was looking at the Trafalgar/Upholder Class sustainment which are both nuclear class submarines. The problem there is that before you even think about a nuclear submarine you need about $2 or $3 billion dollars worth of infrastructure. Now I don't think nuclear submarines are on the table… from my point of view I don't think nuclear submarines are on the agenda because of cost and because I don't think anyone is going to give us the technology in the short term."

There are reports that senior Coalition leaders are now seeking to open the debate over the purchase of nuclear submarines to replace the Collins class, which is at odds with Senator Johnston's statements.

Point of Contact:
RADM Rowan Moffitt, Head Future Submarines Program, (w) 6265 2251 (m) s22
David Gould, General Manager Submarines, (w) 6266 7756 (m) s22
Information valid as at: 11 February 2013

Johnston: MA14-003927
Reference: SEA 1000/OUT/2014/

Email Advice

Nuclear submarines – Talking Points to cover Australia's current ability to support a nuclear submarine capability.

Response:

- The Government is committed to ensuring Australia retains a regionally superior conventionally-powered submarine capability.
- A nuclear-powered option is not on the table.
- The Australian Government has not sought access to nuclear submarine propulsion technology, nor have foreign governments offered it.
- Any decision on the Future Submarine must balance cost and capability, ensuring that the capability acquired is sustainable into the future.
- It is important to ensure that all costs are considered, not just those related purely to the build of the submarines.
- We accept that there are inherent advantages in nuclear propulsion over conventional propulsion for submarines.
- The support costs for nuclear-powered submarines are particularly high and would significantly exceed the build costs.
- Australia currently lacks the infrastructure, training facilities, and regulatory or safety systems necessary to operate and maintain nuclear-powered submarines. These would add considerably to the cost of the Future Submarine Program, and would take a substantial period of time to develop.
- Australia also currently lacks the suitably qualified and experienced personnel within Navy and across industry to safely operate and sustain nuclear-powered submarines.

Drafted By:	Ms Lauren Benson	Tel: 02 626 55770 / s22	Date: 3 Dec 14
Cleared By:	RADM Greg Sammut	Tel: 02 626 52251 / s22	Date: 3 Dec 14

MEDIA RESPONSES **Expires:**

Inquiry Number:	002561
Subject:	NUCLEAR SUBMARINES FOR SEA 1000
Organisation:	THE MANUFACTURER
Contact Name:	s22
Tel: Mob:	 s22
Contact EMail:	s22
Time Received:	05:36 PM
Date Received:	06/01/2015
Due to DCAM:	07/01/2015 12:00 PM
Media Ops Officer:	SARAH ALLEN2 Team:
Media Ops Officer Notes:	

Year: **2015**
Group: **DMO, STRATEGY**
Action Area: **FIRST ASSISTANT SECRETARY - INTERNATIONAL POLICY**
Context:

SA 6/1/15 1736 - Email from journalist

Hi,

I'm contacting you from www.themanufacturer.com and wanted to ask a couple of quick questions regarding the ongoing submarines upgrade story.

1. Could you tell me whether the UK designed nuclear submarines are being considered at all?
2. And if not, whether there is likely to be any debate or discussion regarding the potential for nuclear powered subs to be deployed in Australia?
3. If you have any particular relevant information regarding Australia's stance/policy towards nuclear submarines, could you please send that over.
4. Lastly, I just wanted to try and confirm reports from the Mainichi newspaper in Japan, that Japan has submitted a proposal to jointly build a fleet of subs with Australia. I appreciate that you cannot comment on the level of interest in that proposal but could you confirm what you can of the specifics of that proposal.

Thanks.

Kind Regards,

s22

Questions and Responses:

1. Could you tell me whether the UK designed nuclear submarines are being considered at all?

2. And if not, whether there is likely to be any debate or discussion regarding the potential for nuclear powered subs to be deployed in Australia?

3. If you have any particular relevant information regarding Australia's stance/policy towards nuclear submarines, could you please send that over.

Draft response to Q1-3 (from DIB):

No decisions have yet been made on the design and build of the next generation of Australian submarines; however, a nuclear-powered option is not under consideration.

The Australian Government has not sought access to nuclear submarine propulsion technology, nor have foreign governments offered it.

4. Lastly, I just wanted to try and confirm reports from the Mainichi newspaper in Japan, that Japan has submitted a proposal to jointly build a fleet of subs with Australia. I appreciate that you cannot comment on the level of interest in that proposal but could you confirm what you can of the specifics of that proposal.

Draft response (from previous response):

Work is progressing to explore options for a conventionally powered Future Submarine, and Australia is discussing issues relating to submarines with a number of countries, including Japan.

The Government's decisions on the design and build of the next generation of Australian submarines will be based on reliable data evaluated against the Navy's requirements.

Clearances:

Clearance officers: please ensure both date and time are detailed

Drafted	Name	Appointment	Date and Time
TPs drafted by			

Clearance	Name	Appointment	Date and Time
Subject Matter Expert			
Group/Service 1 Star or above	*RADM Greg Sammut*	*PMFS*	*7/2/15*
	This information is consistent with advice provided to the Minister by other means (E.g. QTB, MinSub etc) (To be completed by 1 Star or above)		***Yes / No / Not Applicable*** *(Delete which ever is* ***not*** *applicable)*
Strategic Communications Adviser			
ASCAM or delegate			

Minister	Name	Appointment	Date and Time
Ministerial Action: *(To be completed by ASCAM)*			
Forward to/Cleared by			

For Information	Name	Appointment	Date and Time
Regional Manager Public Affairs			

Date Cleared:

From:	Clarke, John MR
To:	Sammut, Gregory RADM
Cc:	Pearse, Sophie MISS
Subject:	Fwd: FOR URGENT OMINDEF CLEARANCE/OMINDM INFO - Media enquiry - 004681 - Nuclear-powered submarines (Due Sunday 1 May) ~~[SEC=UNCLASSIFIED]~~
Date:	Saturday, 30 April 2016 3:03:22 PM

Greg, FYSA. Many thanks. Jc

Sent from my iPhone

Begin forwarded message:

From: "Clarke, John MR" <john.clarke@defence.gov.au>
Date: 30 April 2016 at 3:00:35 PM AEST
To: Media <Media@defence.gov.au>
Cc: "Pearse, Sophie MISS" <sophie.pearse@defence.gov.au>
Subject: Fwd: FOR URGENT OMINDEF CLEARANCE/OMINDM INFO - Media enquiry - 004681 - Nuclear-powered submarines (Due Sunday 1 May) ~~[SEC=UNCLASSIFIED]~~

Sarah, following a chat with RADM Sammut I can advise that he can only clear the words as proposed as he can only talk on behalf of what he knows to be true. We are not in a position to vouch for the rest of the Department as we simply don't know if the WP team, Navy or anyone else had discussions that we are not aware of. Jc

Sent from my iPhone

Begin forwarded message:

From: Media <Media@defence.gov.au>
Date: 30 April 2016 at 2:38:18 PM AEST
To: "Clarke, John MR" <john.clarke@defence.gov.au>, Media <Media@defence.gov.au>, "Pearse, Sophie MISS" <sophie.pearse@defence.gov.au>
Subject: Fw: FOR URGENT OMINDEF CLEARANCE/OMINDM INFO - Media enquiry - 004681 - Nuclear-powered submarines (Due Sunday 1 May) ~~[SEC=UNCLASSIFIED]~~

~~Classification: Unclassified~~

~~Classification: Unclassified~~

Hi John, Navy,

Please see Henry's email below and let me know if CASG and Navy are Ok with this. I will run it by SEC also.

s22 [redacted]

Sarah

IMPORTANT: This email remains the property of the Department of Defence and is subject to the jurisdiction of section 70 of the Crimes Act 1914. If you have received this email in error, you are requested to contact the sender and delete the email.

From: Budd, Henry MR
Sent: Saturday, April 30, 2016 02:26 PM
To: Media
Cc: Channer, Hayley MS; s22 [redacted]
s22 [redacted]
Subject: RE: FOR URGENT OMINDEF CLEARANCE/OMINDM INFO - Media enquiry - 004681 - Nuclear-powered submarines (Due Sunday 1 May) ~~[SEC=UNCLASSIFIED]~~

~~UNCLASSIFIED~~

Hi Media,

I would like the Minister to respond to this directly.

I've slightly amended the below statement. Can you please quickly factcheck to make sure I'm OK to refer to 'discussions with Defence' in the second paragraph rather than 'discussions with the Future Submarine Office'?

Thanks.
Henry

A nuclear-powered submarine capability is not being considered as an option for the Future Submarine.

The Government has not been involved in any discussions with Defence regarding switching from diesel to nuclear propulsion for the Future Submarine.

Australia lacks the qualified personnel, experience, infrastructure, training facilities and regulatory systems required to design, construct, operate and maintain a fleet of nuclear-powered submarines.

From: Media
Sent: Saturday, 30 April 2016 11:06 AM
To: Budd, Henry MR; Channer, Hayley MS; s22
Cc: Media
Subject: FOR URGENT OMINDEF CLEARANCE/OMINDM INFO - Media enquiry - 004681 - Nuclear-powered submarines (Due Sunday 1 May) ~~[SEC=UNCLASSIFIED]~~

~~UNCLASSIFIED~~

Good Morning Henry, Hayley,

Seeking OMINDEF clearance of the attached response.

The response has been cleared by Head Future Submarine Program, a/FASSP, and CN.

The journalist's deadline is Sunday 1 May, for an article in the Monday edition of the Australian Financial Review.

OMINDM - FOR YOUR INFO ONLY

Thank you,

Sarah Jackson
Public Affairs Officer
Defence Media
Department of Defence | Russell Offices PO Box 7909 Canberra BC ACT 2610
Phone: +61 2 6127 1999 | E-mail: media@defence.gov.au | Follow us on Twitter: @DeptDefence

Australia's Sovereign Submarine Capability – A Greybeard's Perspective

Peter Briggs - SIA CONFERENCE 15NOV16

Sovereign not Solitary

Defined as an Australian submarine capability in control of its own destiny, engaged with allied supporters:

- A new relationship with France and the Marine National to be developed, covering R&D and the design and operation of conventional and nuclear powered attack submarines.
- Complementing our primary strategic, operational and tactical relationship with the USA and USN.
- A revitalized R&D and operational relationship with the UK and RN would be beneficial given my final issue; preparing for a decision to commence an orderly transition to nuclear power.

Concept of Operations: [1]

- Forward deployed. [2]
- Exploiting stealth to gain access to key areas.
- Able to observe/strike as appropriate.

Australian Design Environment

Sovereignty requires that all detailed/production design and in service support performed in Australia by an Australian entity with DCNS support. [3]

- Build on ASCs and the very successful Submarine Enterprise supporting the rejuvenation of the Collins capability. [4]
- An AUSTEO environment will able to maximise protection of 3rd party IP.

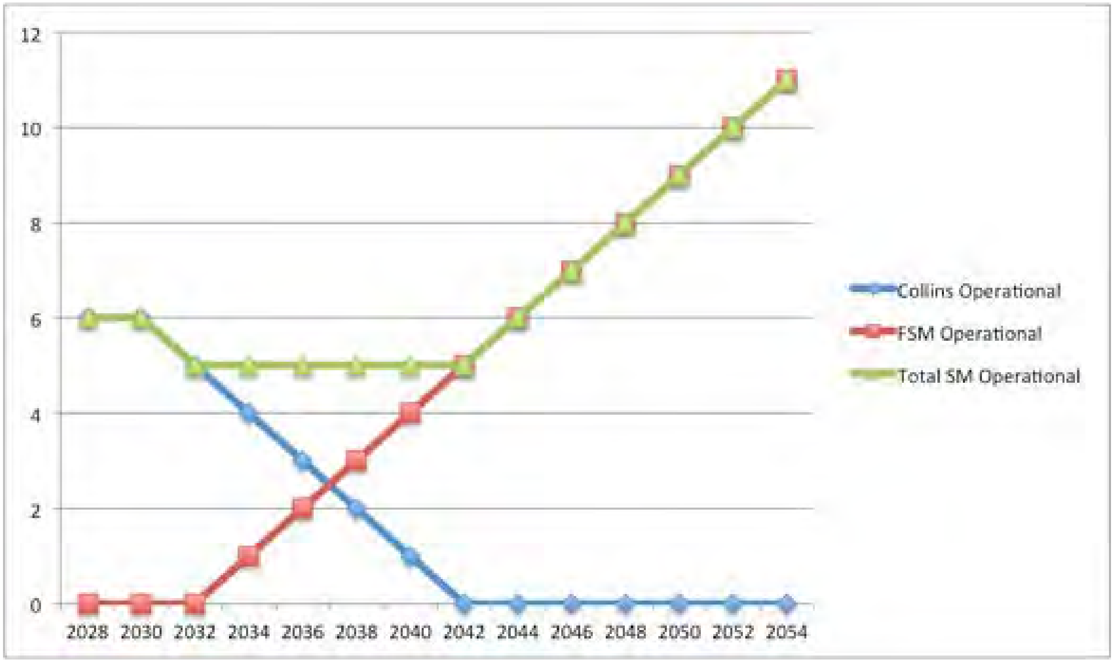
Sense of Urgency

---

[1] Why submarines for Australia, P Briggs, The Strategist, 22 February 2013.
[2] Mobility, endurance, and payload: lots of each for our submarines, P Briggs, The Strategist, 27 March 2013.
[3] Why Australia should build its own submarines Part 1 and 2), P Briggs, The Strategist, 21 January 2015
[4] The Trade – Newsletter for the deep thinker – Edition 2, 2016, Defence Publishing Service

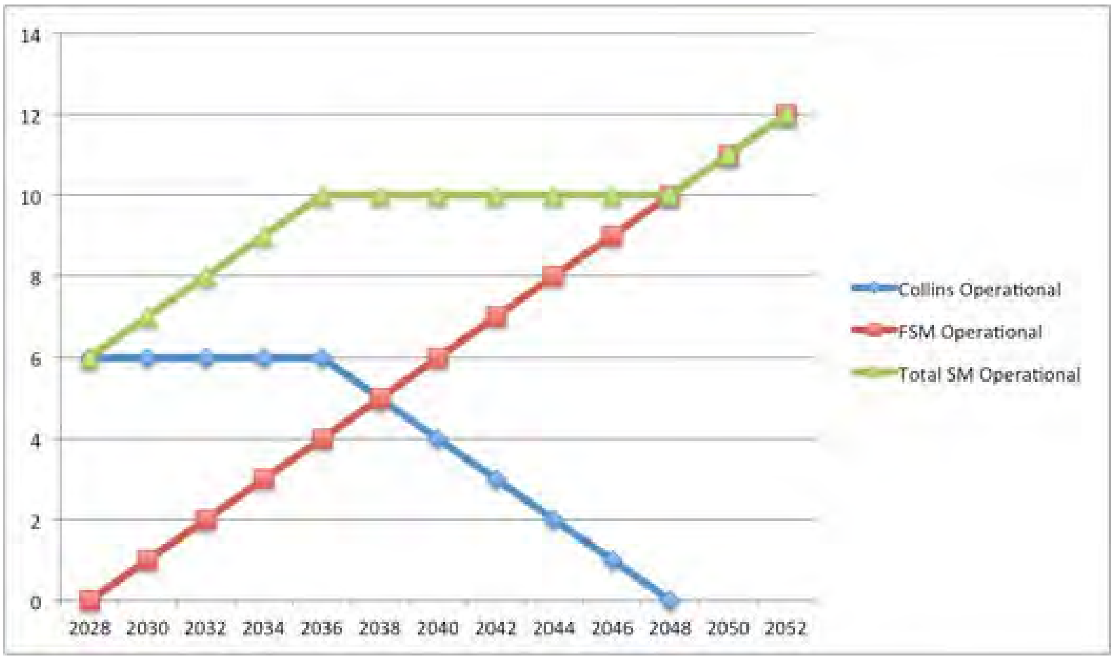
I believe we must build on Collins numbers to achieve at least 9 operational SM ASAP. [5]

- There is a wide range of options to achieve this, without being definitive; here are 2 examples to demonstrate the issues.
- They are based on the existing 10+2 cycles for Collins and construction drum beat for FSM of 2 years.



Graph 1 – The transition to avoid! FSM 01 commissioned in 2034 and only 3 Collins LOTE.

[5] How many submarines? (Part 1 & 2), P Briggs, The Strategist, 8 January 2014.



Graph 2 – Plan A? - FSM 01 2030, LOTE all Collins

This is a manpower issue first and a strategic one second.

- Without submarines at sea the RAN will not be able to generate the trained manpower to replace losses, cover the additional requirements of the transition and grow the number of crews.
- Six SM are at or below critical mass; witness our long struggle to finally get to 5 crews with a thinly manned shore balance. [6]
- This is a major lesson learnt from Collins – do not let submarine numbers drop during the transition.
- Strategically speaking where would you like to be in 2036; with a force of 10 SM (4 FSM and 6 Collins) or 5 (3 falling to 2 Collins and 2 rising to 3 FSM)?

We need to commit to a life extension for all Collins now – an early commitment will underpin the business case for investment:

- Collins should be updated to extend their mechanical and operational life.
- For example, operational updates could include an FSM like AIP section.

<u>Platform Issues</u>

Note these are the most difficult/expensive characteristics to alter in service.

[6] The Trade, edition 2 2016.

Sovereign control over signature in all spectrums:

- Snort signature will require indigenous R&D and investment.
- The transit is a design driver for the RAN CONOPS.

Mobility and Dived Endurance: [7] [8]

- Power train developed for the tropical operating environment.
- Lithium or lead acid batteries?
- AIP a key requirement for a challenging operating environment.

Shore based R&D facilities - required yesterday.

- Supported by test and treatment ranges.

Automation to support long mission requirements and reduce crew demands.

<u>Combat System</u>

Sovereign control over the Tactical Data Handling System aka Command Management System

- Re-establish the capability we had with the Oberon Submarine Warfare Systems Centre.
- A peer with USN counterparts.
- Mobilise, focus and drive Australian SME capabilities.

[7] SEA 1000: the importance of dived endurance (part1), P Briggs, The Strategist, 2 March 2016.
[8] SEA 1000: the importance of dived endurance (part2), P Briggs, The Strategist, 4 March 2016

Nuclear Propulsion

Efforts to transition to nuclear power must not divert us from critical need to establish a conventional FSM capability to replace Collins, build up to an SM Arm of at least 9 conventional SM and hence provide a viable basis for that transition.

An orderly transition to nuclear propulsion could be justified by:

- Australian geography.
- CONOPS.
- Surveillance/ASW capabilities in future operational environment.
- Improved mobility and stealth (ie no snorting) offered by nuclear power.

If a decision were made Australia would require the ability to ensure and oversee the safe operation of such a force.

- Skillsets significantly more demanding than a conventional SM crew.
- For example; double the number of Command Qualified officers, five times the number of Mechanical Engineering Officers!
- More demanding regimes of technical supervision, training and added auditing of processes.
- Need to comply with best practices.
- Very long lead-time for experienced nuclear engineers and technicians.

Manpower – the critical factor:

- This is not to belittle a number of other important factors
- But, if we can't man the capability the other factors are of no consequence!

I believe that it is impractical to proceed directly to nuclear power even if we wanted to, given the deadline we are facing with an ageing Collins force and ~ 600 submariners. The RAN will be unable to generate sufficient personnel for an orderly transition – we can't get there from here!

The starting point is to build up to 9 conventional SM, bulked up with additional mechanical engineering officers and technicians to provide the manpower base to undertake the transition.

Manpower lead-time requires a start on the process now to facilitate a final decision in 2030.

Platform lead-time 15 years could then see the 1st SSN commissioned 2046.

Conclusions

A sovereign submarine capability requires the design and construction of FSM in an Australian design environment.

We must maintain sovereign control over the signature in all spectra.

Given Australia's particular requirements a number of platform systems require urgent and significant R&D investment.

Australia should re-establish sovereign control over the Command Management System component of the combat system.

Given the long manpower lead-time we need to commence national preparations NOW to facilitate a decision for an orderly and competent decision on nuclear propulsion.

Achieving at least 9 conventional submarines as quickly as feasible remains the manning and strategic priority.

A formidable list indeed, however by building on the very successful foundations of the current Submarine Enterprise and engaging industry I am confident we will succeed.

Peter Briggs

23Sep16

QUESTION TIME BRIEF

Response to Nuclear Submarine question relating to Future Submarine

- The Defence White Paper 2009 outlines Government's policy that nuclear power is not an option for Australia's Future Submarine.
- Russian Technology is not being considered in the acquisition of Future Submarine.
- Open press reporting in December 2007 indicated that Russia's Sevmash shipyard at the Arctic city of Severodvinsk had completed a hybrid submarine, powered by a diesel-electric plant and a small nuclear reactor. Designated B-90 and named Sarov, the submarine was apparently completed on 17 December 2007.

Contact Officer	Position	Phone	Mobile
Captain Tim Brown	Director Future Submarine-Capability Development	02-6265 2262	s22 s22
Original Authorising Officer	Position		
Rear Admiral Rowan Moffitt	Head Future Submarine Program		

Background

After delivering a speech at ANZ SOG, the Minister for Defence was asked if the ADF was considering nuclear propulsion for the future submarine. He was apparently asked specifically whether there is a Russian submarine design which combines diesel electric and nuclear technologies and whether this might be suitable for Australian service. In addition, a response is required to an article in the Australian Financial Review by Geoffrey Barker (17 August 2009).

The SEA 1000 Project is not exploring the option to acquire nuclear submarines as the Government has specifically directed that nuclear submarines are not an option for Future Submarine.

The reactor in a nuclear submarine is generally used to produce heat to generate steam to drive a turbine that propels the submarine. The steam is also used to generate the electricity needed to run equipment onboard. Nuclear powered submarines have an emergency back up diesel generator and battery system for use in the event the nuclear plant fails.

The Russians have apparently produced a submarine which uses a small nuclear reactor – known as a 'tea kettle' – that does not have sufficient power output to drive the submarine in the conventional sense but it can generate electricity to keep the battery charged. This is the same role the diesels fulfil - that is, like the diesel the 'tea kettle'is used to run a generator to provide electric power that is stored in the batteries.

The advantage of the small nuclear powered generator is that it improves the submarine's underwater endurance on the relatively quiet electric propulsion. In effect, this is a nuclear form of Air-Independent Propulsion (AIP) system.

The "Sarov" is thought to be an experimental design, of which there is only one in existence.

Worth noting too in the context of this discussion is the question of relative quietness – an issue of critical importance in submarine operations. There is a common misconception that conventionally powered submarines are quieter than nuclear powered submarines. While this used to be generally true, it is no longer the case. Modern nuclear powered submarines can be as quiet at slow speed as the quietest conventional boat. The advantage today generally lies with the nuclear submarine in all operational respects because, compared with a conventional boat, the nuclear submarine has:

- No need to 'snort' at all (run diesels to charge the batteries, which compromises the stealth attributes of the submarine and offers detection opportunities to an adversary); and
- Significantly higher top speed, which can be sustained for long periods.

These two attributes also make a nuclear submarine able to be used in different ways and offer greater flexibility over conventional submarines.

The Australian Financial Review Article (17 August 2009)

Geoffrey Barker's article in the AFR is factually accurate. Nuclear submarines operated by western nations are generally superior to western conventional submarines because they have better range, endurance, speed, lethality and survivability. They consequently offer a wider selection of response options compared with a conventional submarine.

FUTURE SUBMARINE ANALYSIS OF ALTERNATIVES STUDY PLAN

INTRODUCTION

Background

1. This initial Analysis of Alternatives (AoA) Study Plan for Australia's Future Submarine capability has been developed prior to Government endorsement of Strategic Guidance or subsequent direction on the alternatives to be analysed.

2. Concensus on the alternatives and the scope of the analysis should be agreed with key decision makers prior to commiting significant resources to an AoA. This decision should be informed by information on the level of effort and resource requirments associated with the agreed scope.

- Reference Documents
  - Strategic Guidance
  - Top Level Requirement
- Capability Gap
  - Maintain an effective submarine operational capability to perform tasks in accordance with the CDF Preparedness Directive.
  - Maintain a submarine capability during the withdrawal of Collins platforms due to hull life issues.
  - Maintain a submarine capability during the withdrawal of Collins platforms due to system obsolescence issues.
  - Maintain a submarine capability during the withdrawal of Collins platforms due to erosion of the capability edge against potential regional adversaries.
  - Maintain a submarine capability during the erosion of Submarine capability due to workforce issues.
  - Grow and sustain an experienced and capable submarine design, build and support capability within Defence and industry.
- Prior Analysis Activities
  - SPA Scenario-Based Capability Analysis
  - EB Submarine Design Feasibility and Sensitivity Analysis
  - DSTO Operations Analysis
  - DSTO Combat Systems Options
  - SEA 1000 RFI – Submarine Designers' Responses to Exemplar Requirement
  - SEA 1000 RFI – Australian Industry Contributions

Purpose

- Analyse the alternatives for Australia's Future Submarine capability with respect to the following:

Q1. What is the operational effectiveness of each alternative[1] in meeting Strategic Guidance?[2]

Q2. What is the supportability of each alternative?

[1] Australia terminology for 'alternative', as per the Capability Development process is 'option'.
[2] Most cost-effective means precisely 'the option whose effectiveness meets the requirement at the lowest cost'.

Q3. What are the risks (technical, operational, programmatic) for each alternative?

Q4. When should the capability elements be acquired?[3]

Q5. What is the total cost of ownership for each alternative?

Q6. How do the alternatives compare against each other?

Q7. What is the level of uncertainty in the results for each of the questions?

Scope

– The Future Submarine capability is a complex and multi-faceted problem. To determine the total cost of ownership many alternatives need to be considered other than which submarine should be procured. Many of these alternatives are directly coupled to current submarine capability and therefore the interdependencies between the current and future capability need to be addressed. The alternatives to be considered include the following[4]:

  – Which submarines or mix of submarines and uninhabited systems alternatives will be included?

  – Will the Collins class undergo a service life extension and if so how many Collins submarines will be extended and for how long?

  – To what extent can existing Fundamental Inputs to Capability be utilised for Future Submarine capability, noting the likelihood for an extended transition during which both classes will need to be supported?

  – Will any strategic decisions be made that provide specific direction for elements of the solution, such as the adoption of US weapons and combat systems for a design to requirements solution?

  – To what extent will Future Submarine be capable of conducting the full range of tasks without extensive reconfiguration of the platform or the embarked payloads?

  – What are the objective and threshold effectiveness measures for each of the Future Submarine tasks and what is the role flexibility required without alongside reconfiguration of platform and payloads?

  – To what extent will Australian industry be involved in design, construction, in-service support and disposal?

  – To what extent will the Future Submarine need to comply with Australian and International standards?

  – To what extent will external asistance be sought to perform the role of Commonwealth assurance agent and in what areas?

GROUND RULES

Scenarios

– See OCD Section 3 and Annex A for scenario context and operating environments.

– Scenario-based capability analysis conducted under FMS to Systems Planning and Analysis (SPA) and Naval Undersea Warfare Center (NUWC) is aligned to a subset of the OCD scenarios, which were endorsed for use by CDF.

Threats

– See OCD Section 3 and Annex A.

[3] Answer is inter-related with question 1 as the option cost is determined by acquisition schedule.

[4] Defence White Paper 2009 directing that the Future Submarine capability will not be nuclear powered, and therefore all nuclear options have been excluded from consideration.

– Scenario-based capability analysis conducted under FMS to Systems Planning and Analysis (SPA) and Naval Undersea Warfare Center (NUWC) is aligned with OCD threats, which were developed with feedback from DIO.

Constraints and Assumptions[5]

Constraints are imposed limitations of a physical or programmatic nature that can be used to filter out alternatives. Assumptions are specific conditions that apply to the analysis. Constraints and assumptions must be clearly articulated as they will come under close scrutiny as they will strongly influence the outcomes and therefore will be critically evaluated.

Formal agreement on whether any of the statements within the Defence White Paper 2009 are to be treated as constraints should be achieved, as this will impact on the number of viable alternatives to be analysed.

– Future Submarine force structure comprises 12 future submarines.[6]
– Future Submarines will be assembled in South Australia.[7]
– Future Submarine will have greater range, longer endurance on patrol, and expanded capabilities compared to the curent Collins class.[8]
– Future Submarine will be equiped with very secure real-time communications and be able to carry different mission payloads such as uninhabited underwater vehicles.[9]
– Future Submarine will be capable tasks such as anti-ship and anti-submarine warfare; strategic strike; mine detection and ine-laying operations; intelligence collection; supporting special forces; and gathering battlespace data in support of operations **(constraint)**.[10]
– Future Submarine requires high levels of mobility and endurance to respond to short-notice contingencies in Australia's POE.[11]
– Future Submarine needs to be capable of undertaking prolonged covert patrols over the full distance of our strategic approaches and in operating areas.[12]
– Future Submarine requires low signatures across all spectrums, including at higher speeds.[13]
– Future Submarine shall not have nuclear propulsion **(constraint)**.[14]
– Future Submarine program will consider Australian industry involvement in design, development and construction phases **(constraint)**.[15]
– Future Submarine program will consider Australian industry involvement in the sustainment and maintenance life cycle, which will extend well into the 2050s and possibly beyond **(constraint)**.[16]
– Future Submarine program will consider basing and crewing issues **(constraint)**.[17]

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[5] Constraints are imposed limitations that will be used to filter the suitability of alternatives. Assumptions are conditions that apply for the analysis.
[6] DWP09 para 9.3.
[7] DWP09 para 9.3.
[8] DWP09 para 9.3.
[9] DWP09 para 9.3.
[10] DWP09 para 9.4.
[11] DWP09 para 9.5.
[12] DWP09 para 9.5.
[13] DWP09 para 9.5.
[14] DWP09 para 9.5.
[15] DWP09 para 9.6.
[16] DWP09 para 9.7.
[17] DWP09 para 9.7.

- Future Submarine program will engage overseas partners during the design and development phase.[18]
- Future Submarine program will continue to maintain very close Australia-US collaboration in undersea warfare capability, which will be crucial to the development and through life management of the capability.[19]
- The Future Submarine construction program will be designed to provide the option to continue building additional submarines in the 2030's and beyond, should strategic circumstances require it.[20]
- The Collins class submarines will receive incremental upgrades throughout the next decade, including new sonars, to ensure they remain highly effective through to their retirement.[21]
- The Collins class submarine will undergo a major reform program to improve the availability of the Collins class and ensure a solid foundation is laid for the expanded future submarine force.[22]
- DCP IOC/FOC dates??
- Operational interoperability with ADF and allied forces.
-

Timeframe

- The key **near-term** timeframe considerations for SEA 1000 are as follows:
  - Establish the project office and support network required to successfully deliver Future Submarine capability, using external assistance as required to supplement internal resource shortfalls for specialists.
  - Align Future Submarine and Collins fundemental inputs to capability, where practicable, to maximise opportunity for successful capability transition.
  - Obtain Government approval for project strategic guidance, program strategy and the options for further investigation.
  - Eliminate or minimise the capability gap that will occur when the Collins class are withdrawn from service.
- The key **far-term** timeframe considerations for SEA 1000 are as follows:
  - Facilitate a smooth transition from Collins to Future Submarine across all Fundemental Inputs to Capability.
  - Meet Initial and Final Operational Capability milestones.

Excursions

- The key planned analytical **excursions** for consideration during the AoA are as follows:
  - Vary threat levels with the scenarios.
  - Vary submarine presence and role effectiveness targets due to Allied force contribution to coalition operations, especially against a high threat adversary.
  - Vary submarine basing locations in Australia.

[18] DWP09 para 9.8.
[19] DWP09 para 9.8.
[20] DWP09 para 9.9.
[21] DWP09 para 9.9.
[22] DWP09 para 9.10.

– Vary availability of submarine replensihment ports in Australia and overseas.

– Vary submarine numbers required to achieve Strategic Guidance.

– Vary submarine operating concepts.

– Vary submarine sustainment concepts.

ALTERNATIVES

Description of Alternatives

– The following submarine procurement alternatives may be considered, ordered based in increasing level of Australian involvement:

A1. Overseas purchase of a single class of new operationally-proven MOTS submarines, such as DCNS Scorpene, HDW U212A, or HDW U214, with no changes to baseline configuration.

A2. Overseas purchase of a single class of new operationally-proven MOTS submarines, such as DCNS Scorpene, HDW U212A, or HDW U214, with modifications to meet Australian statuatory requirements and obsolescence issues.

A3. Australian build of a single class of new operationally-proven MOTS submarines, such as DCNS Scorpene, HDW U212A, HDW U214, or Kockums Collins, with no changes to baseline configuration.

A4. Australian build of a single class of new operationally-proven MOTS submarines, such as DCNS Scorpene, HDW U212A, HDW U214, or Kockums Collins, with modifications to meet Australian statuatory requirements and address obsolescence issues.

A5. Australian collaborative design and build a single class of new submarines that incorporate design changes to improve the operational effectiveness and/or sustainability of an existing MOTS submarine, such as DCNS Scorpene, HDW U212A, HDW U214, Kockums A-26, Kockums Collins, or Navantia S-80, with the assistance of an external independent design agent.

A6. Australian collaborative design and build a single class of new submarines designed to meet RAN requirements using a proven and capable submarine designer, such as DCNS, HDW, Kockums, Kawasaki/Mitsubishi, or Navantia, with the assistance of an external independent design agent.

A7. Australian collaborative design and build of **batches** of new submarines to incrementally build Australian industry and submarine force capability to meet RAN requirements, using a proven and capable submerine designer, such as DCNS, HDW, Kockums, Kawasaki/Mitsubishi, or Navantia, with the assistance of an external design and development support agent.

A8. Australian led design and build of a single class of new submarines, with the assistance of an external design and development support agent.

A9. Australian led design and build of **batches** of new submarines to incrementally build Australian industry and submarine force capability to meet RAN requirements, with the assistance of an external design and development support agent.

– The following modifications may be considered, in various combinations, with the previously listed alternatives:

Mod 1. Extend the life of some or all of the Collins submarines.

Mod 2. Extend the life and enhance the capability of some or all of the Collins submarines.

Mod 3. Supplement Future Submarine capability using uninhabited vehicles to enhance operational effectiveness in denied areas and improve Future Submarine survivability.

Mod 4. Utilise a submarine tender vessel to enhance operational effectiveness and supportability of Future Submarine capability during peacetime operations.

Nonviable Alternatives

– The following submarine procurement alternatives are considered to be nonviable alternatives:

A10. Overseas purchase of used highly capable submarines, due to lack of availability.

A11. Overseas purchase of nuclear submarines, as directed by Government, as per Government direction.

A12. Australian collaboration or involvment in the design or build of nuclear submarines, as per Government direction.

A13. Purchase of multiple submarine classes outside a batch build process, due to the significant increase in support costs.

A14. Purchase of a fleet of uninhabited vehicles to fulfil the full range of tasks outlined in the Defence White Paper, due to low system readiness level and communications requirement for non-autonomous operations.

A15. Purchase of surface or air platforms to fulfill the range of tasks outlined in the Defence White Paper, due to the existence of separate projects to address these alternatives.

Operations Concepts

– The following types of operations concepts are considered for each of the alternatives under peacetime, contingency and wartime employment:

s33(a)(ii) [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Sustainment Concepts

– The following support concepts should be considerd for each of the alternatives under peacetime, contingency and wartime employment:

SC1. Optimise the use of alongside training, using onboard or shorebased simulation and training of the appropriate level of fidelity based on the specific nature of the task.

SC2. Optimise the use of condition-based assessment to improve submarine reliability and maintainability.

SC3. Maximise the use of standardised and modular parts and software, where appropriate, to improve reliability and maintainability.

SC4. Optimise Fundamental Inputs to Capability to maximise cost-effectiveness of Futrue Submarine capability to meet CDF Preparedness Directive targets.

DETERMINATION OF MEASURES EFFECTIVENESS

Mission tasks (Solution Independent)

_ s33(a)(ii) [redacted]

– s33(a)(ii) [redacted]

– s33(a)(ii) [redacted]

– s33(a)(ii) [redacted]

Measures of Effectiveness (MOE)

– Each of Mission Tasks can be traced to one or more Measure of Effectiveness.

–

Measures of Performance (MOP)

EFFECTIVENESS ANALYSIS

Effectiveness Methodology

Models, Simulation, and Data

Effectiveness Sensitivity Analysis

COST ANALYSIS

Life-Cycle Cost Methodology

Additional Total Cost of Ownership Considerations

Fully Burdened Cost on Delivered Energy (if applicable)

Models and Data

Cost Sensitivity and Risk Analysis

COST-EFFECTIVENESS COMPARISONS

Cost-Effectiveness Methodology

Displays or Presentaton Formats

Criteria for Screening Alternatives

ORGANISATION AND MANAGEMENT

Study Team/Organisation

AoA Review Process

Schedule

Options

SEA 1000 THE FUTURE SUBMARINE

MINISTERIAL TALKING POINTS

- Manned submarines bring a decisive lethality to Maritime Defence, and are an effective weapon across the full spectrum of military operations, including asymmetric warfare.
- The Collins class submarines are a key element of Australia's Defence capability, and their contribution to real world operations is highly valued by our allies.
- They are scheduled for withdrawal from service in 2025. I have directed Defence to commence planning for new submarines for the ADF.
- Preliminary estimates for the cost of a fleet of large ocean-going submarines are around $20 billion.
- Government expects to consider First Pass for the project in 2011, at which time options such as size, numbers, design and production methods will be considered.
- The Government has yet to consider the future ownership of ASC, and the Company's role in the replacement program, but it is reasonable to say that ASC is likely to have a role in the acquisition of the future submarine.
- The Government will be keen for this project to leverage off Australian Industry's proven ability to manage submarine construction projects, support submarines in service, and bring innovative solutions to undersea warfare.

Clearance	**Name**	**Appointment**	**Date Time Group**
Cleared by: (Group/Service)	CDRE G. CHRISTIAN	**DGMD**	
Cleared by: (other Group/Service)		**** For cross-group clearance and input**	
Cleared by: (Public Affairs)		**** PA clearance is One Star or delegates (Deputy DGs)**	
Ministerial Action (tick one)	O For Clearance	O For Information O	No Action
Forwarded to / Cleared by:			

ANNEX A

QUESTION AND ANSWER BRIEF

Will nuclear power be considered as a propulsion option for the future SM?

Australia does not have the nuclear industry or infrastructure to support acquisition of a fleet of nuclear submarines in the required timescale. Nuclear propulsion will not therefore be considered.

Low output nuclear reactors have been suggested as a possible solution for an air independent propulsion system; will these be considered for the future SM?

DSTO have been keeping a watching brief on this technology, and will advise Defence on the feasibility, but given the other AIP options such as closed cycle diesels and fuel cells, it is unlikely that this would be an appropriate solution for Australian submarines.

Will the roles of the Future SM include land strike and mine warfare?

A submarine is one of several platforms in the ADF that could be used for land strike and offensive mining, although the necessary submarine weapons are not in the ADF inventory. Studies over the next few years will examine the best way to deliver these effects.

Do you expect more or fewer submarines than the Collins class?

The study into the Top Level requirement is underway, and this will indicate the broad capability solution, in terms of range, endurance and force mix, including numbers. Cost and capability trade-offs are integral to our acquisition system, and the future SM will no doubt be subject to this process.

Has ASC been selected as the preferred builder?

It is the Government's preference that construction takes place at the Common User Facility in South Australia, and it is probable that ASC will have a role in the project. However, the development of an acquisition strategy will take place between now and 2011, and I would not wish to pre-empt the outcome of that process.

What impact will the sale of ASC have on the project?

We are still assessing the implications of ASC ownership, but will ensure that any future arrangements will not prejudice the acquisition, or through life support, of the future SM.

Have you considered the low risk option of evolving the Collins class, rather than acquiring a new design?

Defence will study all options for this project, including an evolved Collins class. However, there are risks involved in updating a mid-1980s design, and we will be keen to ensure that whichever option is selected, it allows us to take maximum advantage of new technology.

In a resource-driven economy, the shipbuilding industry has to compete hard for its workforce; does Australia have the capacity to build new submarines, as well as destroyers and amphibious ships?

Workforce risks will be assessed in conjunction with Industry, and suitable strategies identified to ensure that our substantial prior investment in a submarine construction and support capability is not lost.

Will you look to support from the United States in designing and building the future SM?

Our relationship with the USN on submarine matters is very close, as illustrated by bilateral agreements still in force. I would anticipate that the exchange of technological information will continue, along with the existing close cooperation on submarine operational matters. It is too early to say what involvement there might be from US Industry.

Preceding the election, you were critical of DMO. Are you confident in their ability to effectively manage a project of this magnitude?

Given the fifteen year schedule for this project, there is ample opportunity for DMO to continue to develop their project management processes and expertise to support acquisition of the future SM.

Preface for Military.com: With Submarines, Size Does Matter

Too few Americans fully appreciate the continuing and emerging vital roles of U.S. Navy nuclear submarines, and that is most unfortunate because each one is so important to our national security. To achive the myriad missions our country demands of them and their crews in the 21st century, including various taskings of the sort that Joe Buff has discussed in his prolific writings for years, subs need to be relatively large and fast as undersea warships go, and consequently expensive. Some pundits have raised the issue of whether America should buy a larger number of cheaper diesel boats instead. A more robust response for America's unique global-reach strategic interests is the Tango Bravo feasibility study now underway, searching hard for "Technology Breakthroughs" (hence the name) that might make nuclear submarines be less costly to build and man, while they also become even more effective than now. Within this broader context, Joe Buff has carefully looked at the question of submarine size in isolation. He offers compelling observations, both technical and practical, to help demonstrate that -- everything else being equal -- smaller alone is often not better.

Joe's analysis was aided by his previous work in thinking about and writing of the world of submarining. His sources of information were in the public arena and it was his interest, ingenuity and common sense which has made him a knowledgeable commentator on issues of undersea science, strategy and operations. He has done that not only in his several novels but in the pages of *THE SUBMARINE REVIEW*, a professional magazine for the submarine community. As Editor of that magazine I have asked Joe to write about some subjects and his own initiative has led him to investigate and comment on other substantive issues. Our readership has responded positively to those efforts.

It is particularly appropriate that those interested in general military matters have the benefit of Joe Buff's insights.

Captain James C. Hay, USN (Ret.)
Editor, *THE SUBMARINE REVIEW*

Introduction

The extreme quiet of a diesel sub on batteries is well known, although according to some Silent Service practitioners the decibel difference relative to a modern nuclear submarine moving at quiet tactical speeds is somewhat overrated. Air independent propulsion (AIP) systems have been developed or proposed that would augment the diesel's traditional engine-generator-motor set and battery bank to enhance the "indiscretion ratio" of these boats, i.e. improve their non-snorkeling submerged endurance. In addition, the smaller size of diesel and diesel-AIP boats (here collectively denoted SSK) could be seen as an advantage in littoral (shallow water and/or near-shore) warfare vice a nuclear-powered fast attack sub (SSN).

This article will examine the relatively low displacement (weight and size) of representative modern SSKs compared to Western SSNs, and will help show that the smallness of "enemy" SSKs can be a significant weakness in real combat operations against the U.S., UK, and our allies. (Other reasons for the U.S. Navy to choose good SSN designs over cheaper SSKs will be discussed in later Parts of this multi-part article, including lessons to be learned from the **Royal Navy's budget-strapped decision to go from a mixed SSN/SSK fleet to an all-SSN fleet.**)

Note first one fundamental fact: Since all submarines while submerged (main ballast tanks flooded) are by their nature neutrally buoyant, anything that adds weight without reducing safe operating depth (i.e., thinning the pressure hull) forces the pressure-hull envelope to increase buoyancy in the only way that it can, by displacing more water -- it has to get bigger. Otherwise, once all variable ballast tanks were pumped or blown dry, the sub would sink like a stone until it either hit the bottom, or passed through crush depth and imploded, whichever came first. And a bigger hull, for the same propulsion-system power output, means a slower vessel, causing both strategic and tactical disadvantages. More propulsor power to solve these problems, in turn, means more (heavier) propulsion machinery and thus an even bigger hull -- **a vicious circle in which the SSN always beats the SSK**, because its nuclear reactor has much greater power density than any diesel-AIP could ever achieve.

The present writer will here, in part, take a view as futurist. Some of the following discussion would apply over the next ten to fifteen years, as advanced off-board sensors and remote combat vehicles become operational with our nuclear-powered SSN fleets, while other countries acquire more SSKs.

Surfaced Displacement Comparison

Consider the following data on surfaced displacement (weight) in tons:

SSK	SSN
Russian Improved Kilo 2,350(a)	USS Seawolf (SSN 21) 7,467
German Klasse 212A 1,370(b)	USS Miami (688-I) 6,300
Swedish Type A-19 1,384(c)	UK Astute Class(d) 6,690
Notes: (a) no AIP. (b) Fuel cell AIP. (c) Stirling cycle AIP. (d) in service 2006.	

The percentage of total displacement dedicated to combat sensors and systems, weapons loadout and other stores, plus crew habitability tends to be similar for both SSKs and SSNs: approximately 13% or 14% according to published references. Thus it can be said that **undersea warfighting payload** (defined here as the sum of these components of weight) may be, in absolute number of tons, 2.5 to 5 times as large for an SSN as for an SSK: between 185 and 320 tons for representative diesel or diesel-AIP boats, vice from 800 to 1000 tons for the SSNs. Furthermore, the reserve buoyancy (taken as submerged displacement minus surfaced displacement) of the SSN designs averages 2.3 times that of the SSKs. Why does any of this matter?

Warfighting Effectiveness

It seems inarguable that SSNs possess substantial advantages over SSKs (whether the latter are augmented with AIP systems or not), regarding a) rapid stealthy transit to and from the theater of operations, and b) continued rapid submerged movement during tactics in the OPAREA. The top quiet speeds of Seawolf and Virginia equal or exceed the absolute maximum speeds of any SSKs! But the following additional capabilities are also needed for a submarine to complete its assigned mission tasking successfully:

1. **Sensors and systems.** Active and passive sonars and signal processors and display consoles. Radio, radar, laser, acoustic, and other communications/connectivity equipment, and electronic support measures (ESM)

signals interception gear. Target motion analyzers, other weaponry controls, various computers and data storage capacity, and navigation systems.

2. **Weapons and Vehicles Loadout.** Torpedoes, missiles (anti-shipping, and land attack), and mines. Decoys and countermeasures. Unmanned undersea vehicles (UUVs), and unmanned aerial vehicles (UAVs). Remote-control combat vehicles (Manta?). Special operations minisubs (Advanced SEAL Delivery System) -- plus accomodation and physical fitness provided for commandos. Counter-mine reconnaissance and removal gear (LMRS prototype).

3. **Crew.** Battlestations and section watchstanders. Approach and Fire Control Coordination talent, command infrastructure. Operators of C4I consoles, remote vehicle control/downlink consoles, sensors, navigation, engineering, and weapons systems. Maintenance and damage control workers throughout the boat, including on-board data administrators and systems operators. Mess management/crew comfort personnel. Note that **increased automation to reduce crew size presents a serious conundrum:** there are more things requiring constant maintenance that might fail at a critical moment (the automation equipment itself) yet fewer skilled people (crew) available to perform preventive maintenance and make emergency repairs!

A submarine with smaller payload will perforce have less capacity in at least one, and almost certainly in all three of the above crucial areas.

Crew size determines and limits the boat's ability to sustain prolonged combat action in a complex high-threat environment. A diesel boat with a crew of two dozen (German, Swedish) or fifty (Russian, Chinese) may be less expensive to operate than a nuclear boat with a crew of well over one hundred, but during lengthy battlespace preparation and domination phases, a manpower advantage of up to five-to-one may prove decisive. The larger SSN crew will be able to "out-think and outfight the other guy," if only by being able to outlast him.

Firepower is crucial to deter or destroy a military opponent. Representative diesel torpedo-room loadouts are under 20 units. For SSNs, loadouts can range from 26 for Los Angeles-class boats through 38 for the Astute-class and the Virginias, to 50 for Seawolfs. (Late Los Angeles-class vessels, and the Virginias, also have a separate 12-weapon vertical launch system for Tomahawk cruise missiles.) In a fast-paced littoral melee, during which **anti-torpedo defenses** may come to play a significant role, **sustained rates of offensive fire** become important. The guy who runs low on ammo first, or who runs out altogether, is at a severe disadvantage. To the degree that UUVs and UAVs, mine countermeasures, and other off-board sensors and vehicles take up space and weight, there is less room for warshot torpedoes, missiles (including undersea-launched anti-aircraft missiles, e.g. Polyphem), and mines. Thus if SSN and SSK carry equal numbers of non-warhead-bearing devices that are launched through the torpedo tubes, the SSN's advantage in raw killing power is even greater than total loadout figures would suggest.

Target detection and situational awareness are vital warfighting attributes supported by good C4I, connectivity hardware, and sensor suites. Once more, a larger displacement is desirable. As computer systems become miniaturized, more and more tasks are found for computers to perform. Increasingly sophisticated sonar capabilities such as wide aperture array instant target ranging, and complicated navigation and ship-control aids such as high-resolution gravimeters and computer-assisted autopilots, take up space and weight. A boat with 2.5 to 5 times the payload for such equipment is 2.5 to 5 times as capable to win a battle, even one against multiple simultaneous threats. Furthermore, powerful active sonars require **large electrical supplies** that may drain a diesel's silent battery banks and fuel cells unacceptably -- an SSN has unlimited generator capacity, at the cost of (reportedly) only negligibly greater noise. And **sheer physical dimensions** matter, too. The larger beam and length of an SSN (X2 relative to SSKs is representative) provides a sonar bow sphere with four times the surface area, and a wide aperture array with twice the aperture. This can be especially critical at times such as littoral melees when towed arrays are not deployed.

Survivability

A successful submarine design must not only be able to put weapons repeatedly on target, it must be able to avoid or overcome damage due to enemy near misses and direct hits. A larger-displacement boat has the edge in several ways:

1. **Flooding:** A leak of a given cross sectional area at a given depth (pressure) will admit tons of seawater into the boat at a rate that cares nothing for displacement or reserve buoyancy. Clearly, a larger boat thus has more time, before the ability to surface is completely lost, during which to control and repair damage causing (and also resulting from) the flooding. In addition, a larger boat (SSN) can be subdivided more readily into watertight compartments. Internal pressure bulkheads are very heavy. The German Klasse 212A design, for instance, has no internal subdivision against flooding.

2. **Shock Isolation:** Shock isolation and quieting gear work hand in hand. They take up space and weight. Distancing from the outer hull is an important means to protect crew and sensitive equipment from blast concussion. A large boat has an advantage.

3. **Hull Thickness:** To withstand a given pressure, everything else being equal, the thickness of the hull must be proportional to the beam. Thus, obviously, a large SSN needs a thicker hull to withstand the same test depth as a small SSK. However, some warhead effects (including shaped-charge torpedo warheads and directed energy weapons) act locally, in which case a thicker hull gives added protection just like tank armor. By virtue of its smaller size/displacement, the SSK in fact is forced to carry a thinner, more vulnerable hull -- otherwise it would sink to the bottom and stay there.

4. **Volatile/Hazardous Substances:** An SSN's nuclear reactor contains dangerous materials. However, modern AIP designs do as well. Air independent systems, whether based on internal or external combustion or fuel cells, require on-board supplies of liquid oxygen, liquid hydrogen, and/or high-test peroxide. These are highly flammable and/or explosive. In addition, high-power-density batteries can operate at temperatures up to 1000 degrees centigrade, (vastly higher than an SSN reactor's core), presenting a significant fire hazard on a small boat.

Point 4 is worth elaboration. It has been argued that SSKs can be designed with the shielding and insulation needed for survivability, since nuclear submarines have been built (at least in some countries) with an outstanding record of reactor operating safety. However, three counter-arguments can be made:

1. **Shielding and insulation require considerable weight.** If an SSK design becomes weight-critical, safety may be compromised, perhaps unknowingly until the vessel enters battle or suffers a lethal accident at sea.

2. **Decades of experience and tradition may be required** to assure ongoing

safe handling of volatile substances in a combat or near combat (Cold War-like) environment. This culture exists in the U.S. and UK for SSNs (and SSBNs, and the new SSGN conversions). It is unclear whether Admiral Rickover's legacy of **quality control and personal accountability** can possibly be replicated by aggressor nations (actual or hypothetical) for their current or planned AIP-equipped SSK fleets.

3. **An oxygen or hydrogen or hydrogen peroxide fire/explosion may immediately kill the SSK and its entire crew.** In contrast, equipment and training exist to contain radiological hazards from a limited reactor accident -- shielding and redundancy are important components of the displacement of a nuclear submarine. If both SSK and SSN have casualties related to their air independent fuel systems, the SSN may be much better able to repair itself and keep on fighting.

Strategy Implications

An aggressor might seek to use its SSKs in one or more of several ways.

1. **Acts of terror or war** against Blue Force (U.S., UK, etc.) coastal population centers and military or industrial installations. (This would potentially involve an extremely lengthy transit, probably exceeding submerged AIP endurance, thus requiring snorkeling to run the noisy diesel engines and pull in fresh air for the crew.)

2. **Attacks against sea lines of communication** (SLOCs) in mid-ocean or at choke points, i.e. anti-shipping operations and commerce raiding or attacks upon warships. (This often requires a lengthy transit with high risk of detection via acoustic and advanced non-acoustic ASW sensors -- see below.)

3. **Defense of the aggressor's own local seaspace**, to prevent Blue Force amphibious operations and/or land strikes that would bring down the in-power "evil" political regime.

In these three missions, SSKs have two apparent advantages. First, they cost perhaps one fourth or one fifth as much as a nuclear attack sub, so an aggressor can purchase many more of them for the same money. Second, to ultimately defeat that aggressor nation, however/wherever hostilities begin, we must eventually dominate their littoral, the home waters of their SSKs -- and this is where their propulsion systems perform optimally, and where their difficulty of detection is at its best.

But if the arguments earlier in this discussion are accepted overall, then an SSN penetrating enemy waterspace has several counterbalancing strengths. Perhaps most critical is the classic one of **concentration of forces**. That is, a given amount of money invested in one extremely capable boat (SSN) is better militarily than the same amount invested in several separate less capable boats (SSKs). Besides the military concentration-of-forces edge, **the SSN also achieves a balance-sheet superiority**: Much "fixed-overhead expense" is saved since only one of everything is needed instead of lots of copies of everything to fit out the bigger squadron of smaller hulls.

The SSN, when equipped with UUVs and UAVs along with advanced mine and counter-mine capabilities and combatant minisubs, can indirectly reach into the shallowest waters to seek and destroy the enemy SSKs one by one. Clearly, a remotely controlled "probe" launched from an off-shore SSN is much smaller and quieter than even the best imagineable SSK design, and it is also much cheaper and more expendable than the diesel-AIP boat lurking in the littoral. The apparent four or five to one advantage in numbers of the SSK for the same money is turned on its head, to become an up to five to one advantage in concentrated fighting power (payload weight) for the SSN. This general observation is particularly true for "emerging nation" submarines, where close-combat coordination among a submerged flotilla is infamously difficult. However, for this perspective to continue to hold true as the number of SSKs in the world constantly increases, clearly **an adequately-sized SSN fleet is vital; otherwise, eventually, the SSKs can win by dint of sheer numbers.**

Once the aggressor's SSK fleet has been contained in its home waters, the enemy has at least three remaining options:
1. **Keep its SSKs in-harbor as a force-in-being**, representing a threat to any invasion by Blue Forces.

2. **Actively engage Blue Force SSNs** and their offboard fighting vehicles, in the littoral and out in deeper water, in hopes of inflicting sufficient losses to force a withdrawal or stalemate, at least politically/psychologically if not militarily.

3. **Sortie the SSKs but have them lurk in hiding as a threat and deterrent**, akin to SSBN tactics. Perhaps seek to refuel/reprovision them clandestinely at sea, or in harbors of nations friendly to the aggressor.

Tactics to counter these three options, respectively, would include:

1. **Mine enemy harbor mouths.** Also attack enemy SSKs at the dock with missiles, bombers, and/or special ops forces. (These are missions for which modern SSNs are ideal if not essential.)

2. As in 1, but also **use to the maximum the SSN's superior sensor capabilities, weapons loadout, and warfighting endurance in a battle of mobility.** Harass the SSKs constantly, and maintain a high rate of exchange of ordnance, non-reusable sensors, and expendable countermeasures. Do this by **network-centric warfare cooperation** with friendly airborne and surface weapons platforms, and their active and passive sonars. Also locate the enemy by LIDAR blue-green laser ASW detectors, LASH underwater color and shape anomaly detectors, portable/temporary SOSUS-like hydrophone grids, magnetic anomaly detection, and thermal, chemical, and wake anomaly effects. **Maintain connectivity** with UUVs by high-bits-per-second wireless underwater covert acoustic means, and do so from below periscope depth with surface and air units via sonobuoy-sized transceiver relay nodes and impending breathrough **"comms at depth and speed"** systems. Find bottomed SSKs using off-board probes, and prosecute them mercilessly.

3. As in 1 and 2, **seek out the SSKs wherever they may be.** Ideally, start by having SSNs in-theater before hostilities begin, and **trail each SSK from port as it sorties.** (Again, **a large enough SSN fleet is essential** to doing so with adequate effect.) Give the SSKs not a moment's peace. Deny them access to bases and tenders for replenishment, and sink or take down their milch cows. Deny the diesel crews their sleep and ruin their ability to think straight. **Make every SSK mission a one-way mission.** Localize, demoralize, and destroy.

The advent of **undersea photonics** (LIDAR, LASH, bioluminescence detection) and **advances in sonar signal processing** will make it harder and harder for a diesel or diesel-AIP to use one traditional infiltration tactic, namely hiding under or in the wake of a surface vessel. LIDAR scanners may permit "delousing" simply by looking under the keel. And the tonals generated by SSK diesel engines and/or near-surface screw cavitation can presumably be picked out of other noise by an alert escort's or helo's sonar watch, when properly equipped and trained. It can be expected than in any shooting war, or declared zone of exclusion, merchant ships upon which SSKs could ply this tactic will be scarce in any case.

One major threat presented by an SSK may be a weapons of mass destruction mission while "Allied" defenses are lulled in peacetime. Vigilance in undersea warfare by carrier battle groups on maneuvers, diligence in HUMINT and ELINT regarding enemy intentions and their SSK fleet readiness and movements, and constant acoustic and non-acoustic surveillance for suspicious diesel signatures on the high seas as well as in the friendly homeland littorals, will all give some protection. Once more, **numbers of SSNs on deployment are crucial.**

The WMD-laden SSK may be on a suicide mission as well. It is always wise for Blue Force commanders to assume enemy vessels are manned by determined opponents who will fight to the death in performance of their perceived duty. But for suicide forces, deterrence by the surety of mortal peril is simply not enough. A guaranteed hard kill is necessary, i.e. PK of virtually 100% for the defensive system overall. The discussion above about low displacement disadvantages and counter-tactics would still apply. **The SSK must be forced to do the impossible:** maneuver constantly while avoiding detection, fighting its way through a multi-layered active defense before reaching any high-value targets -- all while lacking sustained high-speed submerged endurance and without a large combat weapons/systems payload.

Conclusion

The small size of representative diesel-AIP submarine designs can be an important drawback to an aggressor nation dependent on such vessels. Tactics to exploit this weakness and deter/defeat aggression would include forcing a prolonged and continuous battle for seaspace dominance, in which the SSKs' fuels, weapons loadout, and crew are worked to exhaustion and their sources of replenishment are neutralized. Blue Force nuclear powered fast-attack subs, with their much larger payload capacity, unlimited high-speed cruising, infinite electrical supply, and enhanced survivability -- busily employing/deploying advanced combat sensors and systems, large special operations teams, and off-board littoral probes and fighting vehicles -- will help assure the "good guys" remain fully combat effective until, with the lowest possible casualties and least collateral damage, victory and peace are finally achieved. **The lower cost of an SSK compared to an SSN is thus a red herring: The several SSKs one can purchase for the price of one good SSN are fundamentally unable to make up in numbers for what they lack as a group in overall warfighting quality.**

PAPER NO.9.

NON-NUCLEAR SUBMARINES AND SOME ASPECTS OF THEIR DEVELOPMENT IN GERMANY

by H. Saeger, Howaldtswerke-Deutsche Werft AG.

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NON-NUCLEAR SUBMARINES AND SOME ASPECTS OF THEIR DEVELOPMENT IN GERMANY

Hans Saeger (Cdr., FGN Res.)

This paper considers submarine capabilities from an operational rather than technical viewpoint and comments on some aspects of the development of non-nuclear powered submarines.

While in no way disclaiming the tactical role of large, fast and nuclear-powered boats, there are convincing arguments supporting the attitude that conventionally or non-nuclear powered submarines still have a very valid part to play in modern navies. The navies of Western Europe alone dispose collectively of over 100 diesel-electrically powered submarines and only one navy shows the intention of operating only nuclear-powered attack boats. It should perhaps also be mentioned at this point that Admiral Gorschkov, far-seeing planner of Soviet fleet strength, has provided for a highly capable mixed fleet of diesel-electric and nuclear-powered submarines, strategically optimizing the Soviet force with respect to number of vessels, type of mission, total investment and life cycle costs. This has led Western nations to invest immense sums in building up and maintaining strong ASW forces, because number (in the case of submarines irrespective of whether they are powered from nuclear or non-nuclear energy sources) has a quality of its own.

After a brief discussion of some of the more salient developments in non-nuclear submarines in the last 40 years or so, the borderline between nuclear and non-nuclear powered ships and some advantages and disadvantages are discussed with respect to operational parameters and mission requirements. Finally, some recent issues and technological advances are outlined in relation to alternative non-nuclear power sources and their effect on the operational parameters of non-nuclear powered submarines.

The years between 1940 and 1980 saw radical changes in submarine design and operational characteristics. Operationally, the submarine as we know it today began its evolution towards the end of World War II in Germany, when first steps in the transition from submersible to submarine took place. Until then, these boats were essentially surface ships that could submerge for limited periods of time, to attack or evade the enemy. The transition from submersible to submarine is clearly reflected in speed and in underwater endurance. Whereas the diesel-electrically powered Type 7c, of which several hundred were built in Germany 1939-45, made 17 kn surfaced but only 7.6 kn submerged, the much larger Type 21 built in 1944-45 was the first operational submarine to sail faster submerged than surfaced: she had maximum speeds of about 16.8 kn submerged and 15.6 kn surfaced. When we consider also the advent of the snorkel in 1944, which still more drastically reduced the amount of time that had to be spent surfaced, it becomes clear that a whole new scope of operational possibilities was opening up for submarines at the end of the war.

The next major step must surely be seen as the harnessing of nuclear power. This enabled larger submarines to remain submerged for an almost indefinite period of time and made submerged speeds of over 30 kn attainable. There can be no question that nuclear power is the optimal energy source for large, fast-moving submarines; the relatively poor efficiency of the transfer of stored energy into propulsive or hotel power hardly matters in view of the vast amount of energy that is available. In spite of this, it seems likely that some rethinking with respect to nuclear-powered submarines is going to be necessary towards the end of the current decade, when sensors will be sensitive enough to measure even minimal thermal patterns on the surface of the sea. However, let us return for the moment to consideration of the development of non-nuclear submarines, which from the very beginning had to aim at highest possible efficiency of energy transformation and consumption due to the limited availability of energy on board, especially when submerged.

The most remarkable changes in the configuration of the diesel-electric propulsion system since 1940 have concerned the transmission of power to the propeller shaft and the weight of the batteries in proportion to the total displacement. Post-war designs no longer allow direct mechanical coupling of the diesel-engines to the propeller shaft (efficiency and noise), but the immediate source of propulsion power, even during a surfaced run, is the battery and electric motor. Even more important is the rise in battery weight relative to surface displacement as shown in Figure 1 for a number of German designs. The actual relative battery weight for any one design is influenced, of course, by customer requirements and depends on the scope of duties and type of mission the boat is intended for, but recent German designs have provided for over 20 % battery weight in relation to total surface displacement. If this figure is compared with well below 10 % in the early forties, it is clear that the potential for submerged cruise has risen remarkably in this time. Improvements in electrical energy stored on board have not only been effected with regard to quantity but also to quality, and battery performance has risen considerably. Figure 2 shows the increase in weight-specific and volume-specific performance of lead-acid batteries over the same period.

In addition to energy density, other battery parameters have been considerably increased, such as improved shock resistance and better inner conductivity to reduce losses and to shorten snorkeling periods. The battery today is keyed to maintenance-free operation during the maximum mission time and its guaranteed lifetime is well above 5 to 6 years - the normal main overhaul period. Hand in hand with these developments, the efficiency of consumers such as transformer and the electric propulsion motor itself has increased considerably. For the latter, efficiency rates of between 65 and 95 % over nearly the full range of possible rpm's may be considered standard today, so that the additional low power motor for silent submerged cruise frequently found in the forties is no longer installed. The sum total of improvements - which of course also includes hydrodynamic hull forms and other improved design parameters that are not considered in detail here - is clearly reflected in operational terms by the rise in battery-electric submerged cruising ranges: in 1940 a range of 80 - 130 nm submerged could be achieved, while modern German designs allow for 400 to over 600 nm today. This point will be taken up again later on.

The size of a submarine is determined today less by the battery capacity required to attain a given submerged range than by the kind and quantity of sensors and weapons to be carried, the type and duration of mission to be fulfilled and the amount of personnel needed on board to cope with operational, technical and maintenance tasks. It is clear that these parameters have an equal bearing on size considerations for nuclear-powered submarines. Probably the most drastic developments in submarine technology in the last forty years have concerned the sensor and weapon outfit, primarily of course due to the coming of electronics.

Today sensors covering nearly all mechanical and electromagnetic frequencies are integrated with the fire control system, primarily to fulfill four major functions:

- sensor data correlation
- target motion evaluation
- threat evaluation
- weapon control and guidance.

Submarine weapons have developed parallel to the extension in sensitivity and range of sensors. The straight-running short range torpedo of former days became a highly sophisticated, intelligent device with target discrimination and homing capabilities. Due to the two-core guidance wire the torpedo is used even as a "stand-off sensor", sending back detailed information such as bearing, distance and acoustic characteristics, and permitting constant target information updating and analysis on board.

Today, towed sonar arrays and refined ESM data processing cater for sensor ranges of 50 nm and more, providing not only an added safety factor for the submarine herself but also permitting the use of long range submarine-launched ship-ship missiles not dependent on target data received via data link or radio networks. In addition, cruise missiles may be submarine launched, either as tactical weapons against targets tracked with on-board means, or in a strategic role against predetermined targets or from target data received via external communication links. In the near future even air targets will be within the range of submarine-launched weapons, especially when more experience has been gained with infra-red sensors fitted on optronic masts in addition to or in place of optical periscopes. Possible targets will then include ASW units such as helicopters and marine patrol aircraft at ranges of 5 miles or even more.

The increasing sensitivity and range of acoustic and electromagnetic sensors also on the ASW units made it imperative that submarines be given the lowest possible profile:

- in noise radiation (thereby also improving detection capabilities of the submarine's own sonar)
- in magnetic signature (by using non-magnetic steel for hull and superstructure, by effective degaussing and compensation systems)
- and, finally, in thermal losses by ensuring highest possible efficiency in all the energy transformation processes at the lowest possible temperature level.

Analysis of these parameters and requirements shows that fulfilment can be reached more easily using non-nuclear platform designs; however, these then have the disadvantage of lower speed and total range.

It has already been mentioned that the size of a submarine depends largely on the sensors and weapon load, on mission time and profile, and on personnel requirements. Missions in coastal or shallow water are admirably fulfilled by small diesel-electric submarines displacing 400 - 500 tons, while ocean-going diesel-electric submarines today generally displace between 1000 t and 2500 t. Towards the upper end of this scale, the larger conventionally powered submarines are capable of ırrying the same weapons and sensors ; those found on nuclear-powered :tack boats.

rnis observation brings us to discussion of the borderline between diesel-electric and nuclear-powered submarines, in terms of operational capabilities and mission accomplishment.

First of all, some consideration should be given to operational data for a fairly large diesel-electric submarine. Taking cruising range performance of the HDW/IKL Type 2000 as an example, the parameters of range, speed of advance, endurance, patrol speed and fuel consumption are correlated in Figure 3. An example is given to illustrate total mission scope for a patrol mission with 60 days time on station at a patrol speed of 6 kn. Total endurance of the Type 2000 is 90 days.

During 60 days patrol at 6 kn, 40 % of fuel load is used (point 1 on Figure 3). It is assumed that a safety margin of 15 % fuel reserve on return to base is desired, which leaves a maximum of 45 % fuel for transit. The 45 % fuel consumption line is indicated by the dotted curve in Figure 3. The 90 days ship's endurance permit up to 30 days in transit. These conditions allow for mission parameters of

- maximum cruising range 6400 nm (i.e. 3200 nm from/to base) at 30 days transit at 8.7 kn speed of advance (point 2 on Figure 3);

or

- cruising range 4400 nm (i.e. 2200 nm from/to base) at 16.7 days transit at 11 kn speed of advance at mission endurance of 77 days (point 3 on Figure 3);

Alternatively, at the lower range of 4400 nm and slower speed of advance of only 6.1 kn, transit would take about 30 days but the ship would return to base with a total fuel reserve of 41 % instead of 15 % (point 4).
Any other speed of advance between points 3 and 4 will save either fuel or transit time. Similar examples for patrol at other speeds, transit distances, mission endurance etc. may be read from the figure to give a more complete picture of mission scope.

The mission endurance of a modern diesel-electric submarine, the presence and availability of her sensors and weapons in a critical area, is not really limited today by her fuel reserves. Even nuclear-powered submarines with their virtually unlimited power reserves are rarely exposed to missions lasting longer than about 60 days. The limiting factor that makes a maximum mission duration of about 60 - 90 days appear reasonable and sensible is the human element. The work to be done on board by the crew during operation and maintenance of the submarine, the psychological effect of being submerged for lengthy periods of time, have to be offset by a suitable degree of comfort. Maintenance and operation tasks can be facilitated by a high degree of automation but high standards of habitability are just as important as proper working conditions. While most people are familiar with the fact that the technologically less complex operational systems of diesel-electric ships require fewer highly specialized engineers and place lower demands on training and running maintenance, it may be less well known that habitability standards on diesel-electric submarines have easily kept pace with the rise in mission time and increase in submarine size, and are comparable today with those found on modern, large nuclear-powered ships. Taking free space volume per man as an indication of habitability, figure 4 shows that modern diesel-electric submarines have come a long way from the boats of the forties or the "hot bunk" of small coastal submarines.

In an effort to show how advanced modern diesel-electric submarines really are, particular emphasis has been given to certain areas. It has been mentioned that the larger conventionally powered submarines can carry the same weapon and sensor outfit and achieve the same mission endurance periods as their nuclear-powered counterparts, while their acoustic, magnetic and thermal signature is in many cases better than that of nuclear-powered ships. In spite of these very positive features, it is not my intention to gloss over two obvious disadvantages of diesel-electric submarines that must become apparent if they are compared with nuclear-powered ships. One such point concerns the much lower speed of advance of conventionally powered submarines. But, while admitting that a submarine under non-nuclear power has a considerably longer transit time, we must ask: does that really matter in the case of a barrier patrol mission or for coastal operation? Surely, consideration must be given to the fact that for half the cost, twice as many diesel-electric submarines can be put into operation on this kind of mission, where their abilities to fulfil mission requirements are at least as good as - and in some cases better than - those of a nuclear-powered ship? The naval force planners of the Western World are going to have to answer these questions. Modern designs for advanced diesel-electric submarines corresponding to these mission profiles are available now, and especially in post-war Germany a lot of design time has been invested in the continued improvement of cost-effective non-nuclear designs.

The second major disadvantage of diesel-electric propulsive power for submarines lies in their dependency on fresh air from outside the submarine in order to recharge the batteries. The snorkel head has to clear the surface of the water and in spite of the improvements that have been made in snorkel design, it is liable to be detected by radar or by unfriendly eyes; the diesel-powered generators raise the level of radiated noise to about that of an averagely fast moving nuclear-powered submarine, thus again raising the risk of detection and also slightly reducing the effectivity of the ship's own acoustic sensors. While snorkeling for short periods at night during transit to and from the operational area may be considered acceptable, having to snorkel during time on station or in a barrier area or in shallow coastal waters is certainly a very major disadvantage.

The almost unlimited energy at the disposal of a submerged nuclear-powered submarine has led the larger, more powerful navies of the world to consider the nuclear reactor as the ideal source of underwater energy. I should like to close my paper with some remarks on recent issues especially in Germany in the search for alternative energy sources. Other papers in the course of this symposium are concerned with the technical analysis of the problem, while the questions addressed here refer to operational parameters, in particular with respect to the submerged ranges that one may expect to reach with such an alternative, non-nuclear energy source. I should like to comment on some results of recent research into the use of fuel cells, in which the company I represent has been closely involved, together with the IKL design office in Lübeck.

The planning and development work that was begun some years ago aimed to retain the advantages of diesel-electric submarines but to introduce on board an energy source that was to be as cheap as possible while permitting a considerable increase in submerged range. The range that can be achieved depends on a number of parameters, notably ship displacement, and is shown for a fuel cell system in figure 5. A submarine powered purely by fuel cells has a number of disadvantages counteracting the increase in submerged range: the total range drops because of the loss of a diesel-powered generator and the extremely low running costs of a diesel-electric submarine in peace-time operation cannot be maintained. However, if only part of the battery is replaced by a fuel cell system (which is not overly serious in view of the high relative battery weight in modern designs, as shown in figure 1 earlier), then a successful compromise can be achieved, retaining the operational advantages of both the diesel-electric and fuel cell propulsion systems while keeping the running costs down, a factor of almost equal importance today. Figure 6 shows how submerged sprint capability - high speed for a short period of time - is covered by conventional power from the rechargeable battery while in addition the extremely low-noise fuel cell system allows medium to slow speeds submerged for a prolonged period. The submerged cruising range of this kind

5 Heavily
fuel cells

illustrated in figure 7, assuming that half the battery has been replaced by the fuel cell system. The calculated maximum performance permits a submerged speed of 8 kn at an extremely low noise level, allowing for optimal use of the submarine's own sensors. Performance is determined by maximum fuel cell output. The actual weighting of the two sources of energy, the amount of battery sacrificed to the fuel cell system, depends of course for an individual design on cooperation between the navy and the designer and takes operational duties and intended scope of mission into consideration.

As the topic at issue here is likely to give rise to some questions and some discussions, I should like to sum up with four statements:

- optimized diesel-electric platforms are a useful, cost-effective component in the submarine arsenal of the Western World, complementing rather than substituting nuclear-powered ships

- for some mission tasks, diesel-electric submarines are as good as nuclear powered ships, for some tasks even better

- additional alternative non-nuclear energy sources permit a considerable increase in the submerged range of conventionally powered submarines, without invalidating the advantages of relatively low investment and low life cycle costs of non-nuclear submarines

- research continues and we believe that alternative, quiet non-nuclear power sources in addition to advanced diesel-electric systems will play an important role in the next generation of submarines

Fig. 1: Battery Weight Relative to Surface Displacement

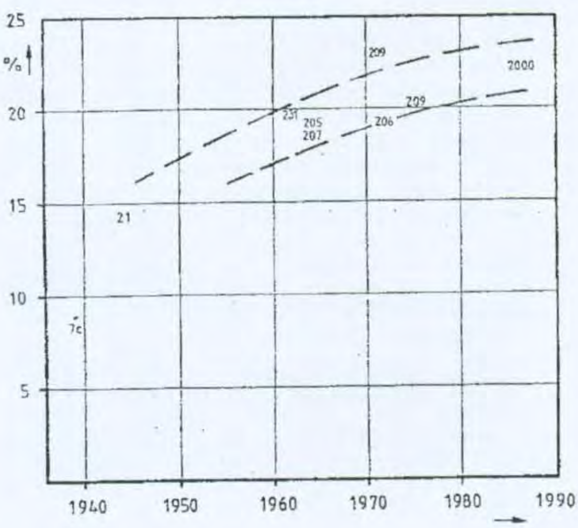


Fig. 2: Specific Energy Density

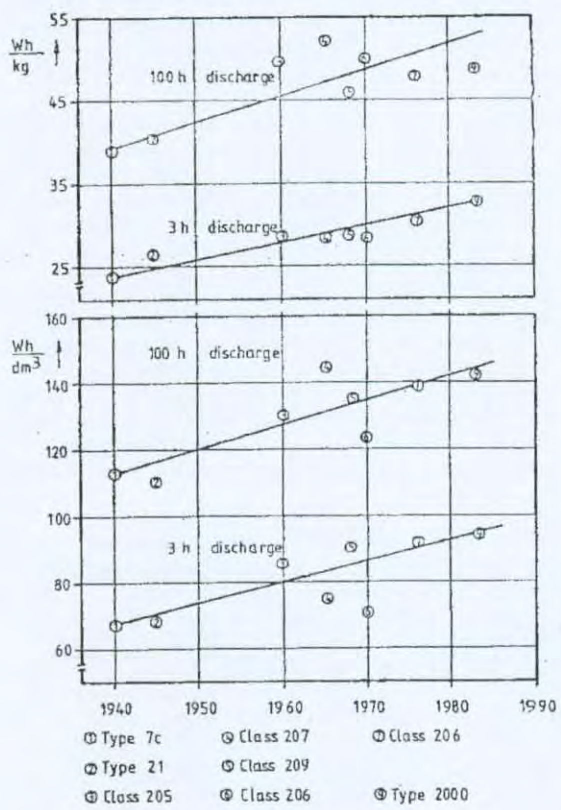


Fig.3: Example of Cruising Range Performance

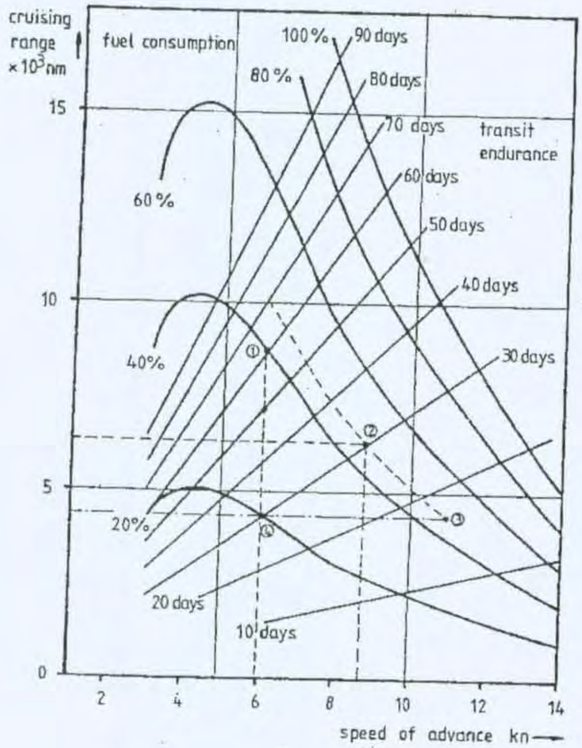
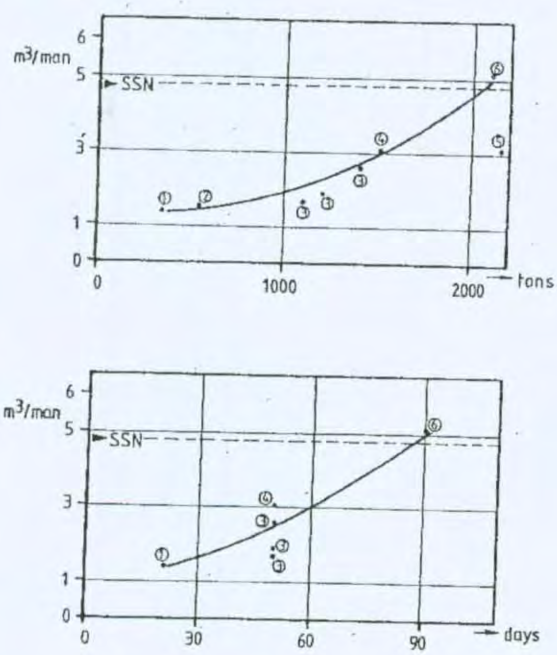


Fig. 4: Free Space Volume per Man in Relation to Displacement and Mission Time



① Class 206
② Type 7c
③ Class 209
④ Type 1500
⑤ Type 21
⑥ Type 2000

Fig. 5: Submerged Range Relative to Displacement

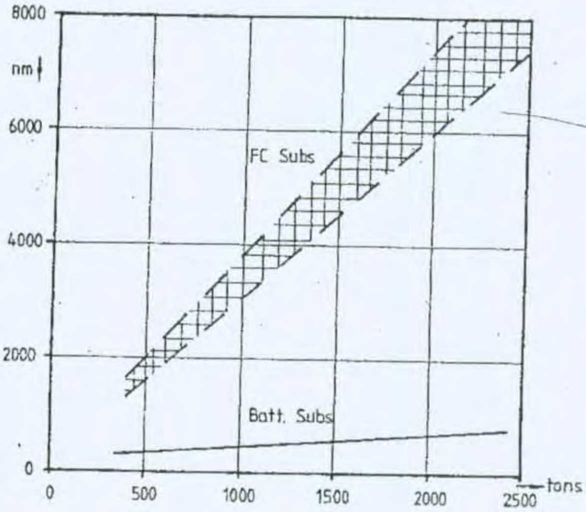


Fig. 6: Economical Energy Sources for Submerged Operation

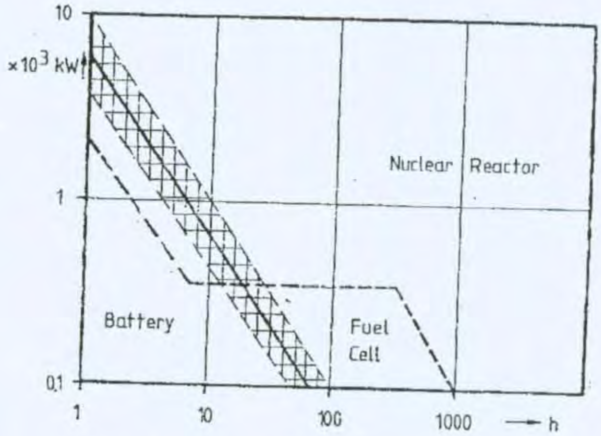
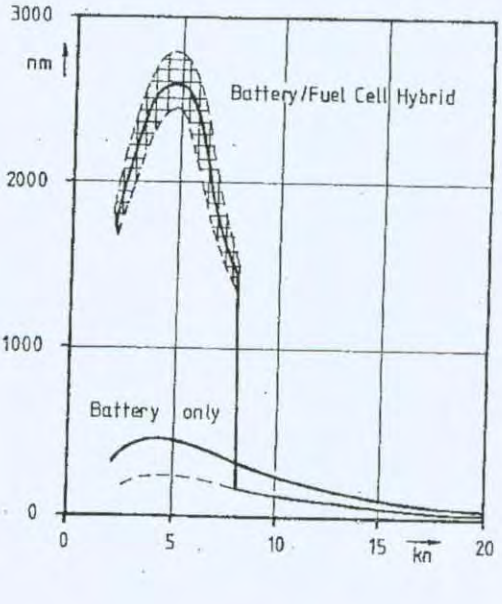


Fig. 7: Submerged Cruising Range



QUESTION TIME BRIEF

FUTURE SUBMARINE PROGRAM

How can the Government justify a doubling of the submarine fleet?

- The 2009 Defence White Paper states that the principal task for the Australian Defence Force is to deter and defeat armed attacks on Australia.
- The Government is committed to providing the Defence Force with the right tools for this task, including a major boost to our maritime capabilities.
- The acquisition of 12 new Future Submarines, which will be more capable than the Collins class, is a major element of this commitment.
- The expanded fleet of 12 submarines would sustain a force at sea large enough in a crisis or conflict to:
  - defend our approaches (including at considerable distance from Australia, if necessary);
  - protect and support other Australian Defence Force assets; and
  - undertake certain strategic missions where the stealth and other operating characteristics of highly capable advanced submarines would be crucial.
- Moreover, a larger submarine force would significantly increase the military planning challenges faced by potential adversaries, and increase the size and capabilities of the force they would have to be prepared to commit to attack us directly, or coerce, intimidate or otherwise employ military power against us.
- It should be noted that only a small fraction of a submarine force will ever be operationally deployed at the same time. This is due to the impacts of the time required for maintenance and crew training, the nature of the operational task, the range at which operations are conducted and the time that submarines are required to operate completely unsupported. Globally, this ratio is considered to vary between 5:1 and 3:1 and is dependant more upon range and duration of an operation than type of vessel. Both nuclear or conventionally powered submarines are highly complex platforms.

If asked: Is the Government planning on designing a unique submarine rather than buying an off-the-shelf design?

- Because of the combination of Australia's geography and likely operational requirements, it is possible that any 'off the shelf' option will not meet our future submarine requirements.

- However, no option has been discounted by the Future Submarine Program to date other than nuclear power. All options ranging from existing off-the-shelf designs to a fully bespoke, Australian designed option will be carefully considered against Australia's future strategic defence requirements. Designs that fall between these extremes will all be considered against capability requirements, cost, procurement timeframe, risks and the benefits to Australian industry.
- The level of capability to be acquired and the associated procurement options will be considered by the Government early in 2011.

<u>If asked: Has the Government decided to design the submarines in Australia?</u>

- No decision has been taken on the design strategy at this time.
- However, to ensure that Australia can sustain the Future Submarines once acquired, a number of support arrangements are likely to be required in country including design capability.
- Defence has contracted the support of the US-based RAND Corporation to assist in examining Australia's submarine design capability and capacity. Its analysis found that the majority of the core requirements exist, but that there are gaps and the capability that exists is, in part, shallow.
- The study builds on previous information gathered from Australia and overseas. The information it provides and further planned studies with industry on how an Australian design effort could be implemented will inform Government's early consideration of capability and acquisition strategy issues.
- I repeat: no decisions have been made - we are currently gathering information to help shape the approach to the design of the next generation submarine.

<u>If asked: What is the Government doing to ensure an appropriate submarine capability is delivered?</u>

- A key defence election commitment for this Government was to ensure that preliminary work on Australia's next generation of submarines is carried out as a matter of priority. The Government will never apologise for taking the appropriate time to get any complex and vital Defence project right.
- That is why the Government has approved initial development funding of $19.8 million to conduct preliminary studies into the issues and technologies that will be relevant to the future submarines. This is appropriate funding for the work that needs to be undertaken at this early stage of the project.

- Additional funding will continue to be made available, step by step, as the Government is satisfied that the necessary preliminary work for each stage of this large and complex undertaking has been done. This is consistent with good project management.
- Defence is investigating various issues and technologies to develop a better understanding of the cost and risk associated with various potential capability requirements.
- Currently, the Future Submarine Project team is assessing data from overseas and Australian industry in relation to feasible capabilities and relevant commercial matters.
- This process includes a study to examine the feasibility of establishing a domestic design capability in Australia.
- The combination of White Paper and industry responses will allow the project to frame the requirements of the Future Submarine in a cohesive, achievable and cost effective manner.
- The Government will then make further decisions on the capabilities it requires and what needs to be incorporated in the design of the submarines that might be acquired by SEA 1000.

<u>If asked: If we can't crew our current submarines, how can we possibly crew the 12 submarines announced in the White Paper?</u>

- Navy is very aware of submarine workforce issues and has taken rapid action to start addressing them.
- The shortfall in the submarine workforce is an issue we take very seriously and we are determined to make lasting changes that benefit our submariners and their families rather than adopting unsustainable quick fixes.
- In 2008, the Government commissioned a Submarine Workforce Sustainability Review. This review analysed the range of factors that were at the time placing pressure on our submariners and impacting the Navy's ability to generate the required level of capability for the Submarine Force.
- The Chief of Navy has since agreed to the implementation of all of the Review’s recommendations under the Submarine Sustainability Program.
    - Implementation of these recommendations will help build the foundations for rebuilding a sustainable submarine workforce, in conjunction with the New Generation Navy initiatives, and lead to the successful maintenance and sustainability of the Future Submarine Force.

- The submarine workforce has now been stabilised and is expected to grow as reforms under the Submarine Sustainability Program take effect.

<u>If asked: Has the Government eliminated competition for this contract by promising that they will be built in Adelaide by ASC?</u>

- The Defence White Paper 2009 confirms the Government's intention to assemble the Future Submarines in South Australia.
- The role of ASC remains to be determined. For the present, it is expected that ASC will compete against international and Australian based companies for its project involvement.

<u>If asked: Given the continued difficulties with the Collins Class in regard to technical issues how will this impact on the Future Submarine Program?</u>

- Defence is well aware of the difficulties facing the Collins Class and has introduced a series of processes to reduce the risk of similar problems in the Future Submarine Program. These processes have been informed, in part, by a review of the lessons learned from the experience of the design, construction and sustainment of the Collins Class.
- A Science and Technology plan is being prepared by the Defence Science and Technology Organisation and the Future Submarine project office to identify the technology issues to be examined.
- The Defence Science and Technology Organisation is analysing current Collins Class issues to identify risk mitigation strategies that can be applied for the Future Submarine.

<u>If asked: Is the Government on track to deliver the Future Submarines in the timeframe set in the white paper?</u>

- The initial activities planned for this project have been completed as foreshadowed in the Defence Capability Plan 2009-19.
- There is still much exploratory work to be done before we can start the early design work that will be necessary regardless of the submarine we acquire.
- Analysis of the acquisition options and capability requirements is being conducted so that a realistic options set can be developed, and assessed against a realistic capability requirement and acquisition timeline.
- These activities have commenced and will continue until early 2011. The project will not move into any design activity until Government is satisfied that it is appropriate to do so.

- The Government will ensure that regardless of the option chosen for the Future Submarine, the strategy will be to sustain a continuous and credible submarine capability as we transition from the Collins class.

If asked: Has sufficient funding been allocated to ensure appropriate progress for the Future Submarine Program.

- The Government has approved $19.8 for preliminary project activities. This has enabled Defence to conduct a comprehensive range of studies to gather information covering technology, design, commercial and broader program management matters. This information will enable Defence and Government to consider the various options and shape the procurement strategy in sufficient time for the matters to be explored before 1st pass.
- This funding is sufficient for the activities being undertaken.

If asked: How much will the Future Submarine Program cost?

- It is too early in the capability development process to focus on acquisition costs. The studies, cost and capability trade-off options and conceptual design activities that will be conducted between now and second pass around 2016 will inform decisions that the Government will make, and will determine the eventual cost of the Future Submarine. The program cost will need to take account of facilities, training, program management and other costs in addition to the cost of the submarines themselves.

If asked: Is the Government considering nuclear propulsion?

- As stated in the Defence White Paper 2009, nuclear propulsion is not being considered.

If Asked: Would it not be cheaper to buy submarines off-the-shelf from Europe rather than building them in Australia?

- In determining the best value for money outcome for Australia, it will be necessary to consider the whole of life costs for the Future Submarine, rather than the initial acquisition cost. The whole of life implications will be examined when Government considers acquisition options.

BACKGROUND

NUCLEAR POWERED SUBMARINES

After delivering a speech at Australia New Zealand School of Government (ANZSOG), the former Minister for Defence, Senator Faulkner, was asked if the ADF was considering nuclear propulsion for the future submarine. Further, the former Minister was asked specifically whether there is a Russian submarine design which combines diesel electric and nuclear technologies and whether this might be suitable for Australian service.

The SEA 1000 Project is not exploring the option to acquire nuclear submarines as the Government has specifically directed that nuclear submarines are not an option for the Future Submarine.

The Australian Financial Review Article (17 August 2009)

Nuclear submarines operated by western nations are generally superior to conventionally-powered submarines because they have better range, endurance, speed, lethality and survivability. They consequently offer a wider selection of response options compared with a conventional-powered submarine.

Characteristics of Nuclear Submarines

The reactor in a nuclear submarine is generally used to produce heat to generate steam to drive a turbine that propels the submarine. The steam is also used to generate the electricity needed to run equipment onboard. Nuclear powered submarines have an emergency back up diesel generator and battery system for use in the event the nuclear plant shuts down.

The Russians have apparently produced a submarine (Sarov) which uses a small nuclear reactor – known as a ‘tea kettle’ – that does not have sufficient power output to drive the submarine using steam turbines but can generate sufficient electricity to keep the battery charged via smaller steam generators. This is the same role the diesels fulfill - that is, like the diesel the ‘tea kettle’ is used to run a generator to provide electric power that is stored in the batteries.

A characteristic of the small nuclear powered generator is that it improves the submarine’s underwater endurance on the relatively quiet electric propulsion. In effect, this is a nuclear form of Air-Independent Propulsion (AIP) system.

The "Sarov" is thought to be an experimental design, of which there is only one in existence.

Worth noting too in the context of this discussion is the question of relative quietness – an issue of critical importance in submarine operations. There is a common misconception that conventionally-powered submarines are quieter than nuclear powered submarines. While this used to be generally true, it is no longer the case. Modern nuclear powered submarines can be as quiet at slow speed as the quietest conventional submarine. The advantage today generally lies with the nuclear submarine in all operational respects because, compared with a conventional boat, the nuclear submarine has:

- No need to ‘snort’ to run diesels to charge the batteries, which compromises the stealth attributes of the submarine and offers detection opportunities to an adversary; and
- Significantly higher top speed, which can be sustained for long periods.

These two attributes also make a nuclear submarine able to be used in different ways and offer greater flexibility over conventionally-powered submarines.

AUSTRALIAN PACIFIC DEFENCE REPORTER ARTICLE "From SEA 1441 to SEA 1000 – will it work better this time?" January 2010

The article examines the likely capability requirements for the Future Submarine and questions the need for a unique design. It examines off-the-shelf submarine options (including nuclear powered) and on the basis of incorrect and/or misleading data suggests that a conventionally-powered derivative of either the French Barracuda nuclear powered submarine or a derivative of the German Type 214 would be suitable. The article fails to recognise that the Collins class is in many ways superior to available off-the-shelf conventionally-powered options or to appreciate the scope of design change necessary to modify a nuclear powered submarine.

AUSTRALIAN FINANCIAL REVIEW, 7 June 2010, p11 – *Off-the-shelf subs on Defence's radar*

The article follows June senate estimates and analyses comments by Head Future Submarine Program (HFSP) on the 2009 Request for Information (RFI) from four potential off-the-shelf submarine suppliers. Article generally supports consideration of off-the-shelf options and cites Australian Strategic Policy Institute (ASPI) commentary on cost benefits of off-the-shelf options. The article further quotes Senator Johnston's comments on project progress and timelines, and closes with general reference to the range of studies that have been carried out.

Parliamentary Review of the Future Submarine Project

There is no need for a Parliamentary Review of the Future Submarine Project. Defence has commenced the project to fulfill Government's direction in the White Paper 2009.

The project is in the initial stages of the defining the submarine capability requirements and assessing the overall project strategy, and no decisions have yet been made by the Government in respect of anything except exploratory work. Sufficient funding, $19.8 million, has been allocated by the Government for this purpose.

The Government will consider the overall project strategy early in 2011 in order to enable the project to be progressed appropriately.

Contact Officer	Position	Phone/Mobile
Mr Mark Gairey	Future Submarine Project Director	02 6265 3519
Rear Admiral Rowan Moffitt	Head Future Submarine Program	02 6265 2251
Original Authorising Officer	Position	
Vice Admiral Matt Tripovich	Chief Capability Development Group	

NUCLEAR-POWERED SUBMARINES FOR AUSTRALIA

Three members of the Navy League, retired Rear Admirals Andrew Robertson, David Holthouse and Chris Wood (ex RN), gave a presentation in late November 2009 on the above subject to the Nuclear Panel of Engineers Australia (NSW Branch). They emphasised that in no way did they represent Defence or Navy views, but spoke as concerned citizens from their own experiences. They acknowledged that they were long retired and not up-to-date in technical advances but would address principles and information already available in the public domain.

The main address was given by Rear Admiral Wood, a former commander of several British submarines including the nuclear-powered attack boat HMS WARSPITE. He outlined, with many interesting slides, submarine developments since World War 2, including the six RAN OBERON class boats, showing :

- first, that until the end of the Second World War and for many years thereafter, submarines like these were powered by diesel-electric propulsion systems which were reliable and effective, but which were nevertheless limited operationally in terms of their range, speed, self-protection and counter-detectability by an enemy. Their primary tasks had been the destruction of enemy naval and merchant shipping carrying fuel, food, vital raw materials, troop reinforcements and armaments, all of it essential to any enemy's war effort;

- second, that the RAN of today is capable of operating modern submarines with panache, skill and technical ability. For all their current difficulties, the COLLINS Class submarines are at the peak of conventional submarine technical and operational achievement and the people who crew them are similarly endowed. If the necessary national investment in schooling, support and commercial cross-fertilisation to achieve adequate trained manpower was in place, the RAN's transition to nuclear-powered variants would in his view be perfectly feasible.

Rear Admiral Wood then outlined developments during the cold war with land and sea-based nuclear deterrents and nuclear propulsion being introduced.

The submarine's prime tasks now became surveillance and intelligence-gathering so as to enable threat assessment of the potential opposition, and ultimately to prepare for the destruction of its surface warships and submarines. In the latter case, the most effective counter to a modern, fast, stealthy and deep-diving opponent is another submarine which is capable of detecting, stalking and attacking from deep – and they need to be nuclear powered to be able to do that.

The first allied nuclear-powered submarine, the USS NAUTILUS, was commissioned in 1954 and with her later Westinghouse S5 WPWR nuclear reactor she had a range of 158,000 nautical miles!

Here at last, with its high speed and virtually unmanned totally submerged endurance, was the first true submarine. She had been developed by the Naval Reactors Branch of the US Atomic Energy Commission under the, then, Captain Hyman G Rickover whose fame and influence were to become legendary.

USS NAUTILUS went on to break all existing endurance and speed records and, in 1958, became the first vessel to reach the geographic North Pole en route to the UK, and in due course she went on to travel over 1800 nm under the ice – a major achievement, given the future importance of the Polar region for strategic ballistic missile submarine operations.

She also created the need for engineers and shipbuilders to adopt greatly improved quality control programmes for future design and construction – engineering disciplines which subsequently influenced and benefited marine shipbuilding standards across the board.

Later in 1960, the USS TRITON circumnavigated the world without once breaking surface, in a 3 month deployment. It was an astonishing achievement by any standard and one which initiated a full scale programme of building and improvement thereafter.

The first British nuclear-powered submarine, built with much co-operation from the US, was HMS DREADNOUGHT which commissioned in 1963. In most respects she was a direct copy of the US Navy's new SKIPJACK Class of attack submarine (or SSN) and was fitted with an advanced 2nd generation Westinghouse S5W PWR and a complete set of propulsion machinery driving through ahead and astern turbines to a single propeller.

Buying American enabled Britain to get her first nuclear to sea 3 years earlier than had been anticipated and importantly led to successful completion of a British shore-based prototype propulsion plant.

In addition to mastering the nuclear plant itself, new pressure-hull welding techniques to guarantee watertight integrity of the reactor compartment had to be learned, together with those for ventilation, air-conditioning, air purification, and waste disposal. A constant supply of pure air had to be provided by electrolysers extracting oxygen from seawater. High voltage precipitators were needed to keep dust out of the submarine's atmosphere which had itself also to be closely and continuously monitored for any radiation content. Other units were needed to remove CO_2 from the air. The learning curve was steep.

HMS DREADNOUGHT's distinctive whale-shaped hull gave reduced drag and emphasised speed rather than stealth in those early days. She was actually quite small – at 3000 tons, only a third bigger than contemporary diesel boats – but with a larger complement of 113 men.

One major impact of her introduction was the need for comprehensively re-organised recruitment, training and re-training necessary to prepare the crews and shore bases for the operation and support of these revolutionary new boats. Furthermore the unique qualities of life onboard required personnel of proven ability and leadership, capable of operating for long periods underwater.

The RN's second SSN, HMS VALIANT, had a British front half and part-British rear end. The third, HMS WARSPITE, was the first all-British nuclear submarine from one end to the other, and constructed with the first Rolls-Royce PWR1 reactor.

She was followed by a succession of evermore sophisticated and costly, but increasingly effective, hulls – initially an interim class of three Churchill Class, followed from 1973 onwards by the first of 14 larger and greatly improved and deeper diving SSNs of the SWIFTSURE and TRAFALGAR classes which bore the brunt of Cold War operations.

These boats would typically submerge as soon as they left their home base and, if necessary, remain dived for the duration of their operational patrol until surfacing outside that home base once again. Crews might go for weeks without seeing daylight or having any contact with the outside world. Most onboard would not have the slightest idea of their whereabouts, the time zone they were in, or even whether it was day or night.

Two or three month, and even longer, dived patrols were perfectly feasible so aspects of crew welfare became a priority in both selection and training. From early American experience, and as repeated in Britain, it was evident that prospective crews needed careful screening for temperament, intelligence and stamina, as well as operational competence. Social misfits in particular could not be countenanced and were rejected.

This, then, was the scene for the 30 years of Cold War operations during which, in close co-operation with our American allies, surveillance patrols were conducted against Soviet surface and underwater activity in the far reaches of the North Atlantic and elsewhere (including under the Arctic ice) so as to constantly monitor and assess the maritime threat.

Professionally they were valuable years which provided challenging technological and operational experience for crews, planners and analysts alike - but perhaps above all it was this eyeball to eyeball confrontation that confirmed the need for high sustainable power and lengthy dived endurance together with increasing stealth and reduced vulnerability to counter detection by an opponent, which defined the classic attributes offered by nuclear power.

Admiral Wood then went on to outline the British submarine involvement in the Falklands Campaign in 1982 which, until only a few years ago, had been kept under security wraps. He pointed out some significant problems which had to be faced, including :

- The 8000 miles separation between the UK and Port Stanley.
- The surface warship refuelling problem down to the South Atlantic, requiring the pre-placement of 40+ commercial tankers taken up from trade to act as petrol stations along the route.
- Ascension Island, the nominated Forward Logistics Support Base, was over 3000 miles from the Falkland Islands.
- South Georgia, where things started, was a long way from the Falklands.
- And finally, the worrying proximity of Argentinian shore-based air cover and aircraft equipped with anti-ship weapons sitting only a few hundred miles away on the mainland.

Six UK submarines, five of which were SSNs, were deployed in late March 1982, well before the developing crisis was generally acknowledged and broadcast to the British Nation. Two of these were of the fairly new SWIFTSURE Class (SPARTAN and SPLENDID), 2 middle-aged (CONQUEROR and COURAGEOUS), and an elderly SSN (HMS VALIANT).

In addition, one modern conventionally-powered diesel-electric submarine, HMS ONYX, was deployed for specialist shallow water and inshore operations.

Two of the nuclear boats were on station on surveillance patrol off Port Stanley and the Falklands Sound within a matter of days –and well before the Naval Commander in Chief in Britain needed to establish an Exclusion Zone around the islands.

The CinC's difficult task was to deliver an initial assault of about 7000 troops onto hostile shores 8000 miles away with only minimal air cover, and in increasingly foul weather. His only forward logistics support base was at distant Ascension Island.

For air cover, at least at the start, the only fixed wing aircraft capable of air defence and direct support of landing operations were the handful of Sea Harriers embarked in the two carriers HERMES and INVINCIBLE – whereas the Argentineans could deploy an airforce of considerable strength from safe shore bases on the mainland, and also from their own aircraft carrier the VIENTICINCO DE MAYO.

From the start, intelligence sources suggested that much of the Argentine fleet was at sea in the vicinity of South Georgia whilst other heavy units posed a direct threat to the Falklands from the west. But nothing was known of the whereabouts of their two small modern German-designed and very capable conventional submarines.

Early priority was given to establishing clandestine eyes and ears throughout the area, plus secure communications to and from UK and within Task Force ships, so the speedy SSNs became an obvious first choice for deploying those capabilities.

Emphasis upon their non-detectability and covertness was paramount and strictly maintained until circumstances in early May led to the incident which left the Argentines in no doubt whatsoever about the seriousness and determination of the UK response – namely the sinking of the elderly Argentine cruiser GENERAL BELGRANO.

CONQUEROR's attack on the GENERAL BELGRANO south of the Falklands was the first and only revelation of the presence of any of the British submarines, nuclear or otherwise, but it was not a demonstration to frighten off the opposition.

It resulted from the Battle Group Commander's assessment that his ships, and his 2 crucially important carriers in particular, were in jeopardy from threat of an Argentine Navy pincer movement by the aircraft-carrier DE MAYO Group on one edge of the declared Exclusion Zone and the BELGRANO Group on the other – with a further big question mark concerning their small, fast submarines which remained undetected and therefore a permanent threat.

The Battle Group Commander, Admiral Sandy Woodward's military (personally I prefer "naval", as in "naval and military") conviction was "Lose INVINCIBLE and the operation is severely jeopardised, lose HERMES and the operation is over".

Either way the tactical importance of the BELGRANO sinking was that it nipped in the bud any co-ordinated attack on the UK Battle Group, whilst the longer term strategic benefit was the withdrawal of all Argentine surface units to their home bases – never to emerge again for the duration of the conflict.

It was a significant military necessity clouded only by the failure to find and sink the aircraft carrier 25 DE MAYO instead. Her destruction would have removed many dangerous aircraft from the Argentine order of battle because later her brave pilots, operating from mainland bases, were to inflict heavy losses upon the British ships in the Falklands San Carlos amphibious landing area.

Separately from CONQUEROR, all the other four SSNs were employed covertly during the entire campaign. Their wide area surveillance and close contact monitoring ensured enforcement of the UK Exclusion Zone – and this was important because it not only established clear boundaries in fighting terms but it also created scope for further possible diplomatic options with continuing discussions at high level.

Next in importance came their constant tasks of locating, reporting and reconnaissance which revealed amongst other things, minelaying off Port Stanley (which was immediately surveyed and reported) and further attempted activity off South Georgia where the Argentineans were trying to decoy our forces off to the south east.

An obvious SSN role was to patrol and sanitise the entire sea area around the Falklands so as to protect and clear the way for the eventual British amphibious approach.

Another new role was the close inshore visual and electronic spotting identification and reporting of enemy aircraft as they took off from mainland airfields en route for the Islands. This early warning enabled the Landing Force to shorten its readiness time, prepare its defences and significantly reduce the potential for surprise attack.

The invisible presence of the British submarines (only ever guessed at by the Argentineans, and wrongly as it turned out because they assessed twice as many submarines were out there) – coupled with their later-revealed disbelief that the British would actually use such expensive assets as nuclears – meant that the deterrence effect worked successfully in two quite different but equally effective ways.

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The British Defence Review in November 2010 indicated that all the remaining TRAFALGAR Class SSNs will now be withdrawn from service. In their place the ordering of six (or maybe 7) of the very latest ASTUTE Class SSNs is confirmed. The first batch of these large submarines is estimated to cost £3.6bn – (ie £1.2bn – about $2bn per copy).

The ASTUTE Class has a dived displacement of over 8000 tonnes, length over 100m, a 50% greater weapon load than any previous SSN, a crew of only 98 (compared with TRAFALGAR's 118) and the latest Royce PWR2 reactor (Core H) which is designed to last for the full 25 year life of the submarine and thus obviate the need for any lengthy and expensive refuelling refits. Add to that a weapons and communications suite to surpass any other currently at sea, and she becomes the ultimate nuclear submarine for the Royal Navy.

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Following Admiral Wood's outline of some operational experiences with British nuclear-powered submarines in the Cold War and the Falklands War, Admiral Robertson gave his view of an Australian perspective in the case of a major war involving Australia.

He argued that of all world countries few would benefit more, in terms of national defence, from the possession of such submarines than would Australia. This was due to a number of factors – primarily our maritime geographical position, our vast distances and the fact that we are a democracy, slow to see a threat developing, and slow to react. So speed of deployment would be of considerable importance.

Any major threat to the survival of our nation itself must come from a powerful maritime nation, for armies cannot walk upon water and need huge support, particularly when deployed over great distances.

Arguably, noting our large island continent and small population, the best deterrent and defence capability we could possess would be an offensive capability which could be deployed indefinitely near an enemy's homeland. This would divert huge enemy resources into his local defence. The destruction of his shipping would have a major effect on any enemy's economy. Attack by submarines using accurate long-range weapons, such as the American Tomahawk, would pose a great threat to an enemy's centres of production, transport, command and Government, as was so vividly displayed on our TVs in the early stages of the Iraq War.

There seems a strong case that the most effective deterrent Australia could have would be some nuclear powered submarines armed with the latest conventional weapons, noting :

- Nuclear submarines can get to their operational areas submerged and stealthy in about one third of the time required by conventionally-powered boats.
- They can stay longer in the operational area than can conventional boats due to their high transit speed and endurance, limited only by food and crew fatigue. They can search out electronically vast areas of ocean, pursue, hunt and intercept targets much more effectively than can conventional boats.
- Operational areas can be changed swiftly.
- Refuelling would not be needed for the whole life of the latest boats, and there would be no call on maybe scarce oil supplies.
- They have almost unlimited power for propulsion and electricity generation.
- They can help in the escort of convoys and naval Task Forces (conventional submarines can't, due to lack of endurance at speed).
- Due to their stealth and speed, nuclear boats are probably more survivable.
- Australia having its own nuclear powered boats would greatly assist in the training of our own anti-submarine forces.

And the disadvantages?

- Larger and more skilled crews would be required (offset by the probability that fewer boats would be needed).
- Major training and considerable infrastructure would be needed (offset somewhat by the extra required for the projected future large conventional boats).
- Probable limitations in peacetime flag-showing cruises due to reluctance by some other countries to receive such visits.
- Depending on size and design, in some situations in shallow water small conventional submarines may be more effective than large nuclear-powered vessels.

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Admiral Holthouse, a naval engineer of over 40 years experience, trained in Britain in the mid 1960s at UKAEA Harwell, Winfrith Heath and Dounreay and at the Birmingham College of Advanced Technology. This was an indication of the RAN's vision for nuclear propulsion all those years ago.

He outlined further aspects of submarines emphasising that his nuclear expertise as a naval engineer was limited and much out of date. He stated that virtually the only work he did in the field after completion of his nuclear studies was to assess the likely fall-out from a hypothetical maximum credible accident occurring in a visiting nuclear powered warship in Sydney Harbour.

Interestingly, subject to selecting the right berth for the ship, the risk to the community was judged to be manageable.

The current Collins Class submarines, built in Australia, are as big as the French Rubis class nuclear attack submarines. Despite some much-publicised early problems the Collins Class are a fine achievement, one in which Australia should take pride, and he considered that they make perhaps the most important contribution to Australia's order of battle.

The announced eventual 12 replacements for the Collins Class, which will be very big boats, are the most significant element of the Rudd Government's Defence White Paper.

The size of these projected submarines is of importance not only because of the extra range, endurance, speed and payload that flow from size, but also, unfortunately, because Australia has nowhere to turn to but itself for expertise in designing and building such a large conventionally powered submarine. The US and the UK have no conventional submarines. Several European nations have them but they are too small to be extrapolated safely and economically.

The new submarine program has a high priority in the White Paper and enjoys bipartisan support. But it is a long way off, perhaps 10 years before the first steel is cut and 6 years later more before commissioning the first boat. The twelfth boat is probably 25 years beyond that, putting the last of them in the water in 2045.

As warships are complex and take a long time to build the usual practice is to build them in flights, taking advantage of technological and strategic developments over time. The last flight is therefore likely to be very different from the first in terms of capability, weapons fit, even mission,and of course propulsion.

So if we start conventional, can we finish nuclear? Anything is possible: after all the French Scorpene class is a conventionally powered design which it is rumoured may be redesigned for Brazil as a nuclear powered variant. The French offered Australia a conventional variant of the nuclear powered *Rubis* class as a *Collins* class option.

So it is possible but there has to be a will within government and there is presently none. Worse, in his view, is that there is simply no debate on the subject. One wouldn't expect Defence/Navy to take a different line from government about this but Admiral Holthouse expressed disappointment that the retired submarine community has apparently chosen to fall into line, too.

The publicly available reasoning for this stance includes :

Cost, covering both acquisition and through life costs. The generally accepted wisdom is that a nuclear submarine might cost between 1.5 and 2 times the cost of a conventional submarine and it is public knowledge that a USN VIRGINIA class attack submarine costs about US$2b in 2005 dollars.

Source. Only a handful of navies presently have nuclear submarines: US, UK, France, Russia, China, India, and perhaps Brazil and Argentina on the way. For our own practical purposes though, only the US, UK and France are relevant as potential sources. The USN and RN share information and technology, and in the past, access to the RN's nuclear submarine world was controlled by the US. Admiral Holthouse postulated that the RN's privileged access to USN technology might possibly be compromised were the RN to set itself up as a source of submarine nuclear propulsion technology independent from the US. Which would leave the USN and the French.

Admiral Holthouse had a largely unrestricted tour of USS NAUTILUS including the propulsion plant, during a visit to Pearl Harbour in 1958 but it was to be almost 30 years before he was able to look around another USN nuclear submarine, in Seattle in 1986 during an official visit to the USN by our own Chief of Navy.

He opined that times have changed and that the USN would not reject an overture from us out of hand today, were we to determine to source nuclear submarines from them next time around. He felt they would be very discouraging about the difficulties and cost of doing so and that for a range of reasons they would prefer us not to, but he did not think we would be rejected.

One difficulty would be that US submarines are very big. Our Collins Class boats displace about 3000 tonnes and the planned conventional replacements might displace about 5000 tonnes, as compared to the US nuclear-powered Virginia class of around 8000 tonnes and the Seawolf Class of over 9000 tonnes.

He considered that going elsewhere, to the French for example, was likely to be problematic. The USN might be concerned for permeability believing that an extended “family” including themselves, ourselves, the French and France’s other international customers would introduce just too many potential leakage paths for closely held information to be safe.

Industry infrastructure. Admiral Holthouse felt that the proposition that the Navy’s ability to own and operate nuclear submarines was governed by the availability of domestic nuclear infrastructure was often overstated. There were ways this perceived problem could be overcome.

During the RAN’s service with the US 7th Fleet in the Vietnam War, he had observed with amazement how reliant upon fly-in-fly-out commercial technical representatives the USN had become. The RAN does the same today and it works. 250,000 tonne merchant ships traverse the oceans with unmanned engine rooms and 18 souls on board, hooked up by radio link to monitoring stations ashore and the certainty of a technical response team meeting the ship at her next port of call in the event of a transducer somewhere in the system warning of an incipient problem.

He felt that were we to decide now that the next generation of submarine would be nuclear, entering service in 10 or 15 years’ time, we could handle it safely through a combination of immensely long refuelling cycles (minimum 20 years), return-to-builder for depot-level reactor and perhaps all primary circuit maintenance, and fly-in-fly-out technical representatives. The real issue for us would be whether the submarines would be alone in an otherwise still nuclear-free Australia or would the decision to acquire them provide the catalyst for other elements of a nuclear industry to emerge including ground-to-ground fuel cycling, nuclear waste processing and storage and even power generation in an era when fossil fuels are drying up and otherwise on the nose, and renewables are still an expensive luxury. He referred to the sometimes disputed Peak Oil element in the equation and made an interesting observation about how nuclear reactors in some commercial applications, for example as a power source in remote settlements and mining operations, are down-sizing. This opened up, he felt, the prospect of commonality between reactors for naval propulsion and civilian power generation.

National will. Conventional wisdom is that the Navy can do nothing about nuclear propulsion unless and until there is a domestic nuclear power industry to support it and that's a lot more than 10 years away. In his view it is a matter of how best to gain traction in a society which has become more willing than ever before to entertain the possibility of nuclear energy as a power source, since Prime Minister Howard floated it as a legitimate topic for discussion and since the community became more conscious of global warming and climate change.

What is needed is a champion, just as the then Defence Minister Kim Beasley was a champion for domestic building for the *Collins* class; and it may be easier to find a champion for nuclear propulsion for submarines than for a nuclear power generation industry ashore, in a timescale to suit the new submarine delivery.

The need is for a champion for nuclear propulsion this time, not for domestic building, which raises an interesting issue. Informed commentators have said that to build and support the new (conventionally powered) submarines would require a permanent workforce of 5000 and the involvement of 1000 Australian companies across the nation competing with the mining industry for critical engineering capacity and human resources. An overseas build would reduce the pressure on local industry and resources. However with a working population in excess of 12 million he felt that it has to be possible for Australia to find 5000 people for a submarine building industry, and the prospect of continuous work for decades.

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Admiral Holthouse then summarised his views. The presently planned conventional replacements for the Collins class will still be with us in the 2070s, by which time, surely, concerns for the availability of fossil fuels and their impact on global warming will have bitten hard.

If we are to design and build conventional replacements ourselves we may be faced with capacity problems. Were we to opt for nuclear propulsion and an offshore build these problems could be substantially reduced.

Nuclear powered submarines are steam ships. Towards the end of the steam era in the RAN its three remaining (high end) steam plants became orphans. There was no longer a steam nursery in which to train the operators and offshore training became the order of the day. We could obviously do it again.

The Government closed down any conventional versus nuclear debate by plumping for conventional from the outset. It did so pretty much because it believed the nuclear option to be unacceptable to the general public and that, anyway, Australia would need an established power generation industry and associated infrastructure to support nuclear powered and conventionally armed submarines.

Yet Australia mines uranium and sends it overseas, in the process dividing public opinion over the underlying moral principles. Some fresh impetus for ground-to-ground handling of the lifetime fuel cycle is needed to move this divisive debate forward. Australia's entry into the fuel cycle through the acquisition of nuclear powered submarines might just do it.

Options for the acquisition of nuclear powered submarines come down to probably two potential suppliers and both present difficulties. But just how serious these difficulties are will remain matters for conjecture until a champion emerges at the political level. Someone to carry the discussion overseas and to ask the question of potential supplier navies: what would it really take to persuade you to give us access to nuclear propulsion for our next generation of submarines?

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Admiral Robertson concluded the presentation by outlining some of the factors governing the practicability of introducing nuclear-powered submarines.

Costs. Assuming that one or other of our allies would be prepared to sell us such boats, how would costs probably compare with the local production of the proposed conventional boats? Admirals Wood and Holthouse had already given some rough costs of US submarines. The cost of a British Astute submarine (which does not have to be refuelled in its entire life and therefore considerably reduces running costs and increases operational availability) built in Britain has been quoted at about £1.2 billion. At present exchange rates this is about $A2 billion Australian dollars. Costs would seem to be similar for US boats built in the USA. The only known rough estimate of our proposed 12 future conventional submarines is $36 billion – about 3 billion each. Allowing for hidden costs, infrastructure etc the costs involved for conventional built here and nuclear built overseas would probably compare.

Crews. The problem may not be significant as, though individual crews would be greater for nuclear boats, less submarines may be required.

Training. Probably greater for nuclear-powered boats, though offset by less crews being needed for fewer boats.

Infrastructure. This will be considerable, but offset a little by the need for extra infrastructure for the currently proposed large conventional boats.

Can Australia introduce such submarines? It is still about 14 years before the first conventional boat is due to be completed. This would seem to be enough time to make the necessary arrangements. After all Australia in the past introduced :

- Aircraft Carriers in about 3 years from the decision to acquire without previous experience in carriers, though with much help from Britain.
- Submarines in about 5 years although it was some decades since we had last possessed such vessels.
- US Guided Missile Destroyers in about 5 years from decision, though this involved buying our first large American warships with entirely new equipment of all types including Australia's first large guided missiles, 3 dimensional radars and very high-pressure steam systems. This involved a huge recruiting, training, dockyard, infrastructure and logistic effort at the same time as submarines and other new ships and aircraft were being introduced into the RAN.

Political. This seems to be the main hurdle. A national debate on nuclear power and nuclear-powered submarines is needed to inform the Australian public. It should be remembered that the proposed conventional submarines will be in service from 14 years until about 50 or more years time in a very different world. Long-range decisions are required in the national interest, and unshackled by present perceived prejudices.

Four nations in our general area operate nuclear-powered boats today. Sixteen nations in our region have nuclear power stations. Australia is drifting behind in technology and in maritime defence and it would seem of importance for the nuclear option to become a national issue.

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In thanking the three Admirals for their presentation a representative of Engineers Australia confirmed that a new small reactor/engine system was under development and that this could be fitted in both small nuclear power stations and as the propulsion system for nuclear-powered submarines. Clearly this would have great potential advantages for countries such as ours.

The Navy League of Australia has for some years supported consideration of nuclear propulsion for at least a proportion of Australia's future submarines. Given the uncertainties of the strategic future as the balance of economic and military power moves slowly to East and South Asia it would seem in Australia's defence interest to consider seriously this form of propulsion for some, at least, of our future submarines.

Surely our brave youth, operating in this exacting and dangerous environment, so important to our national defence, should be equipped with the most effective, efficient, and survivable boats in the world. They deserve nothing less.

Andrew Robertson AO DSC
Rear Admiral RAN (Rtd)
Federal Vice President
Navy League of Australia

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Crewing Implications of Certain Options

Part 1

(CICO-1)

RADM P D Briggs AO CSC RAN Retired

This Paper examines the naval manpower implications of the acquisition of a force of nuclear powered attack submarines by Australia. Part 1 considers acquisition of US VIRGINIA or UK ASTUTE class SSNs.

It concludes that the manpower essential to safely operate and sustain these submarines s33(a)(ii) [redacted]

It recommends acquisition of a force of twelve conventional submarines as recommended in the 2009 Defence White Paper, as a pre requisite for any program to acquire this capability.

Crewing Implications for Certain Options

Table of Contents

Executive Summary

1. Following release of the Defence White Paper in May 2009 some commentators have suggested that Australia should acquire a force of nuclear powered attack submarines (SSN), in lieu of the recommended growth in Australia's conventionally powered submarine capability. [Section 1]

2. This paper considers only one of the many significant issues arising from this suggestion; the naval manpower required to operate and safely sustain such a force. It draws on the USA and UK experiences in setting up their SSN capability. [Section 2, 3, 4 and 5]

3. A series of manpower models, building from the crew numbers and skills used in the current US Navy and Royal Navy's SSN and the UK shore infrastructure has been used to develop an understanding of the numbers, skills and training involved. Allowances for attrition at the various stages of an individual's career is used to enable evaluation of the number of personnel required to enter the system each year to sustain the capability. [Section 6, 7, 8, 9 and 10]

4. It is assumed that Australia would wish to maintain a sovereign capability to ensure and oversee the safe operation of such a force. Establishing this capability prior to the arrival of the first SSN would entail additional capabilities in existing nuclear regulatory bodies and a major expansion of the Navy's technical oversight and training capabilities. [Section 5]

5. The UK and USA established their SSN capabilities under the national imperative of the Cold War, drawing upon a large force of conventionally powered submarines and a large but contracting force of steam powered surface ships. This situation assisted in providing the essential manpower and skills base; nonetheless the task was a serious challenge for each navy. Australia has none of these resources and will have to draw heavily on the supplier navy's training system and seagoing submarine force to train its personnel. The availability of the necessary level of support would be a major risk for an Australian SSN program and one that deserves early resolution. [Section 4]

6. The numbers and skillsets in an SSN crew are significantly different to that of a Collins crew. The training program would entail converting existing RAN submarine personnel and a substantial initial training program. Both would require long periods of training and overseas service to gain the necessary experience. Until Australia's SSN force reached sufficient operational submarines to undertake the at sea training of trainees, say at least 6 SSN, this training will have to be mainly conducted overseas. This number of SSN would be achieved approximately19 years after initiating the program. At this point RAN schools and a nuclear engineering faculty established within a selected Australian University could begin to take over this task. In the absence of any nuclear power generation industry in Australia, the cost of establishing and operating this training infrastructure would be borne by the SSN program. [Section 7]

7. The USN and RN experience indicates that the most critical personnel categories are likely to be Marine Engineer Officers, senior sailor Nuclear Technicians and command qualified Executive Officers. Under the RN model, Marine Engineers are likely to prove the most critical; the RAN would have to s33(a)(ii) [redacted] This is identified as a major risk for the SSN program. [Section 4]

8. Modelling indicates that at least 10 SSN would be required to generate sufficient numbers of these critical categories to man the crews and sustain the essential shore technical oversight. [Paragraph 5.14]

9. The effort required to man a force of 10 SSN and the essential shore infrastructure for safety, training and oversight would be a significant national undertaking involving a five-fold increase in the RAN's current Submarine Arm and a 22% increase in the size of the RAN unless offsets are provided from elsewhere in the Navy. The potential to recruit and sustain these numbers from available members of Australia's population is one of the fundamental issues raised by this proposal [Paragraph 13.3, 13.5].

10. An illustrative set of timings and manpower required to man the essential shore billets that must be in place and certified before the Australian Government assumes responsibility for the safe operation of SSN 01 and the crew for SSN01 with an allowance for attrition is set out in Annex G. The number of qualified submariners needed to achieve this is in the order of s33(a)(ii) [redacted], with a

s33(a)(ii) [redacted] also continuing to operate the Collins class submarines. [Paragraph 12.5]

11. It is concluded that this proposal is likely to be s33(a)(ii) [redacted] to operate the Collins force. [Paragraph 14.1]]

12. It is suggested that a more practical starting step to meet the 2009 Defence White Paper aspirations would be a double-crewed force of 12 large conventional submarines. This should be part of a deliberate plan to build up the number of crews and active measures to grow the number of marine engineers in the submarine force to facilitate a later decision to move to nuclear power. It would result in a submarine arm of 2,200 personnel by the early 2040s – this would be a 3-fold increase in the size of the RAN's submarine Arm. It would still require a further 50% increase in this larger submarine arm to man and support a force of 10 SSNs. [Paragraph 14.3]

13. The increase to a conventional submarine arm of ~ 2,200 personnel would also provide a good indication of the national capability to man such a force, prior to the significant national commitment to the larger and more technically demanding nuclear powered submarine force. The capacity to supply the necessary skilled and trained manpower as and when required to safely operate and maintain these submarines is fundamental to success. Embarking on such a program should not be contemplated without solving this challenge. To do otherwise would be a waste of significant resources and risk leaving Australia without an operational submarine capability during the transition; which could be at a time when it may need it most. [Section 15]

1 - Introduction

1.1 The Proposal

In his paper 'Australia's Strategic Edge in 2030', issued in February 2011 (Kokoda Paper #15), Dr Ross Babbage advocates the acquisition of nuclear powered attack submarines (SSN) to provide Australia with a greater asymmetric leverage in the uncertain strategic climate ahead. Professor Babbage suggests 10-12 Virginia class SSN be either leased or bought from the current United States Navy (USN) production line. Further, he suggests that by leasing, greater economy would be achieved for Australia by relying on the United States' Navy's support systems.

1.2 US Support

1.2.1 The suggestion to lease or buy 10-12 SSN has sparked significant commentary and interest within Australia. The US Ambassador to Australia, Mr Jeffrey Bleich has indicated that the USA will assist Australia in its future submarine program whether the submarine is conventional or nuclear powered. [1] Lacking the full context of these remarks it is difficult to draw any conclusions on the availability of the Virginia technology to Australia. In a statement on 11 November 2012 the ambassador qualified this support:

"It's an idea to speculate about, but it's so far away from being a serious policy consideration, ... It was up to Australia, not the United States, to start any conversation about looking into alternative nuclear technologies. But he said if Australia were to express interest in developing a nuclear program, the US would be open to dialogue." [2]

1.2.2 Early public comments have confirmed USN support for a non-nuclear Future Submarine (FSM) project, including by the media release following AUSMIN 2010:

'The United States welcomed Australia's program of capability development

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[1] Kerin, John, US Floats Nuclear Sub Option, AFR, 22 February, 2012

[2] Nuclear Subs 'out of Aussie reach' says US Ambassador, The Australian, 11 November 2012

outlined in the White Paper and Australia noted the importance of technology and materiel exchanges in meeting these capability goals.' [3]

1.2.3 Cooperation and technical support for a non-nuclear FSM program appear to have been discussed more directly in the Navy-Navy meetings that preceded AUSMIN as evidenced in the US Chief of Naval Operations, Admiral Garry Roughead's remarks as reported in an interview with John Kerin:

'The Chief of Operations with the United States Navy, Admiral Gary Roughead, has urged Australia to press ahead with a formidable generation of new submarines, warning that no country in the Asia-Pacific region can maintain an effective defence without them.

Admiral Roughead, who held talks in Canberra with Australia's Chief of Navy, Vice-Admiral Russ Crane, said the two had discussed ways to ensure their submarine forces worked more closely together, including co-operation on the new submarines.' [4]

From these exchanges it is apparent that the USA values Australia's contribution to the allied submarine capability in the region. What is not known is whether this interest would extend to the USA being willing to make its nuclear technology available to the RAN. Placing that issue aside, the proposal raises the immediate question of whether the RAN would have the capacity to man a nuclear submarine flotilla. It is that issue alone that this paper will address.

1.3 Aim

The aim of this paper is to consider the manning and training issues that arise from acquiring SSNs for the RAN. Estimates of the additional civilian personnel required are provided to ensure a complete picture of the manpower implications of the proposal.

The paper offers no commentary or judgement on the merits of the strategy. Nor will it comment on the significant public, political, financial, international or the Supplying Navy [5] issues which arise from the proposal.

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[3] AUSMIN 2010, media release 8Nov10

[4] *Kerin, John*, Subs In Deep Waters, Australian Financial Review, print edition, 8Oct10

[5] The navy of the country supplying the SSN.

1.4 Assumptions

In seeking to evaluate the manpower implications of the proposal a number of assumptions are made, each of which is stated in the body of the paper. As a general principle a minimalist approach is taken with the intention of not overstating the issues. In this way, it is hoped, a realistic but conservative model is derived which will demonstrate that the proposal cannot be addressed with less manpower and **may well require more**.

1.5 Acknowledgement

I am grateful for the wealth of detail freely provide by Captain Roger Turner BSc CEng FIMarEst RN, an experienced Royal Navy (RN) nuclear submarine marine engineer officer and submarine manpower planner. This paper has also benefitted from the peer review of a number of former nuclear submarine operators and engineers who have served in the RN and USN.

2 - What Is An SSN?

2.1 Description

2.1.1 There are two western navy SSN that provide an example of the type of vessel. The first is the RN's SSN, HMS ASTUTE. The first of class entered service in 2012 and a further 6 sister ships are intended. The second submarine is the USN's Virginia class. The crew size/skills and the propulsion arrangements of both submarines are similar. The crew structure for the Virginia class (Annex A) will form the basis for crew numbers and skill sets in this paper.

2.1.2 Virginia is a development from the Seawolf program; the latter was the last of the USN's cold war SSNs. Although intended as a less expensive platform than Seawolf, the Virginia class is a large and formidably capable, power projection and sea denial submarine. The following technical details are drawn from publicly available information[6]. USS Virginia displaces 7,900t, has a length of 115m and a pressure hull diameter of 10m. The submarine's reactor does not require refuelling during its 25-30 years life; hence range and endurance of operations are limited only by food, onboard logistics and crew effectiveness.

2.1.3 The Virginia class has a formidable strike capability. The early variants are fitted with twelve external, vertical launch tubes for Tomahawk Land Attack

6 http://www.navy.mil/navydata/fact_display.asp?cid=4100&tid=100&ct=4

Missiles (TLAM), 4x533mm torpedo tubes, with internal stowage capacity for thirty-eight torpedoes or missiles. In the current, Block III variant, the vertical launch tubes have been replaced by two Multiple All-Up Canisters (MAC) tubes to give the same capacity of twelve vertically launched TLAM missiles.

2.1.4 With the commissioning of the USS Mississippi in June 2012 the USN has nine Virginia class SM in service, with a total force of thirty planned. It is currently building two Virginia per year, sharing construction between two shipyards.

2.2 Build Time

The timeline for a Virginia class submarine build is illustrated by that of the latest Block III, USS Mississippi for which the key events were:

- Feb 2007 - Commence build
- Jun 2010 - Module assembly (laid down)
- Oct 2011 - Launched
- Dec 2011 - Christened
- Apr 2012 - Commenced Sea Trials
- Jun 2012 - Completion of sea trials and commissioning. [7]

2.3 The Lead Time for New Orders.

Whilst the actual construction of the submarine takes approximately five years, reactor and steam plant components are ordered two years prior to starting the build, leading to a construction period of seven years. In order to have appropriately qualified manpower a lead-time of nine years from placing the order to commissioning for the RAN's first of class is assumed in modelling manpower build up rates. The reactor is the most complex system and probably determines the critical path and time taken to construct a new SSN. Successive submarines would follow at a selected interval, say 2 years.

2.4 Manpower Implications for a Shift to Nuclear Power

In recent history the RAN has operated conventionally powered submarines since the late 1960s; however the step up to operating nuclear powered submarines will require major changes in approach. The first will be to develop an ethos of nuclear safety and with that an internationally credible core of expert and experienced nuclear power plant operators. This will demand a significant change in the balance of skill sets of the crew and some major new skills in

7 http://en.wikipedia.org/wiki/USS_Mississippi_(SSN-782)

recognition of the significantly more complex and demanding technical, engineering machinery and safety standards involved. Secondly, compared with conventional submarines such as the Collins class, SSN operations demand a significantly greater onboard technical and logistics capability to rectify defects. Finally, the supporting infrastructure for maintaining the boats and the training pipeline must be robust and dependable.

3 - How many SSN?

3.1 The Minimum Critical Mass For A Sustainable Manpower Base?

3.1.1 There is a significant amount of RAN experience that suggests that s33(a)(ii) [redacted] s33(a)(ii) [redacted] There is a natural turn over as submarine personnel move up the career ladder, leave the submarine arm or become unfit or too old for sea service. s33(a)(ii) [redacted]

3.1.2 The Royal Navy's experience provides a useful indication of the implications of operating nuclear powered submarines. In 2012 they had seven SSN and four SSBN requiring a total of thirteen crews generated from a total of 4,500 qualified SM personnel[8].

3.1.3 The RN is currently experiencing difficulty with some aspects of maintaining these crews, as evidenced by publication of so-called 'pinch point categories' where shortfalls exist and the payment of generous financial incentives both to attract and retain those with key skills. [9] More recently, the headlines *'Navy*

[8] Naval Service Monthly Personnel Situation Report dated 1 February 2012

[9] Ministry of Defence (UK) Annual Report and Accounts 2010-11 - Defence Committee, 18 January 2012, para 67.

Running Out of Sailors To Man Submarines' tells the same story, with a predicted 15% shortfall of engineers and weapons electrical officers. [10]

3.1.4 This paper will endeavour to quantify the minimum seagoing numbers needed to sustain the critical SM qualified manpower ashore to safely operate an SSN force. This would be an important consideration to inform the decision as to how many SSN Australia would have to operate to be self-sustaining in generating sufficient manpower.

3.1.5 Strategic and operational factors are likely to play the major role in selecting the number of SSN to procure. The Kokoda Paper 15 that prompted this paper does not consider these factors in detail. It is worth doing so before settling on a number for the purposes of this paper.

3.2 Operational Considerations

3.2.1 Submarines operate to a structured operating cycle the shape of which is largely dictated by mandatory periods of maintenance and material assessment/certification – not unlike aircraft. From a force of six SSN it would be reasonable to expect that 3 and sometimes 4 would be available for operations and of these one could be deployed on patrol at any one time.

3.2.2 A force of ten SSN would result in up to six being operational, with two deployable at any one time. Two deployed submarines would appear to be the minimum to meet the strategic objectives set out in Kokoda Paper 15. This paper will examine the number of SSNs required to provide a sustainable manpower base to support those objectives.

3.3 RN Operational Availability Experience

Anecdotally it is understood that the RN typically has achieved around 50-55% SSN availability over the life cycle. However, allowance must be made for the fact that this figure derives from earlier SSN which required routine nuclear refueling during service; something that the Astute and Virginia Class are designed to avoid. Thus we can assume that a modern design would achieve something better than 55% operational availability. This supports the assumption that a squadron of ten SSN could expect to make six available to the Navy for operations at any one time.

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10 *Thomas Harding*, The Daily Telegraph, 20 August 2012. http://www.telegraph.co.uk/news/uknews/defence/9486226/Navy-running-out-of-sailors-to-man-submarine

3.4 Assume A Force of Ten SSN

3.4.1 To allow a comparison between these numbers it is intended to model a force of six, ten and twelve SSN noting that ten would be the minimum number needed to meet the operational objective. Further, it is assumed that up to ten SSN could be managed by one suitably staffed Submarine Squadron. As described at Paragraph 5.7 on the role of the Squadron staff, this staff would have to be larger than Australia's current submarine Squadron.

3.4.2 The structure of the Squadron is based on an assumption that all SSN are operated from one homeport that is collocated with the Squadron. The Squadron staff would be unable to exercise the degree of oversight and provide the necessary level of support for submarines homeported elsewhere. Should it be considered a requirement to operate a number of the SSN from a separate homeport an additional Squadron would be required. This would entail a significant increase in the number of specialist, experienced submarine operators and engineers required.

4 - Selecting A Manning Model

4.1 The USN Model

4.1.1 Introduction of Nuclear Power to the USN. Congress authorized the construction of the USN's first nuclear powered submarine, the USS NAUTILUS in the FY 1951 shipbuilding program. The project was driven by the single-minded Captain Hyman Rickover serving simultaneously in two positions; the Head of Nuclear Propulsion in the Bureau of Ships and Head of Naval Nuclear Propulsion in the civilian Atomic Energy Commission (AEC). NAUTILUS was launched in January 1954 and proceeded to sea on nuclear power a year later. [11] In 1956 the USN made the decision to cease construction of conventional, diesel powered submarines.

By the time NAUTILUS was decommissioned in 1979 the USN had 113 nuclear powered submarines in service. This included 41 SSBN that were part of an extraordinary program that began operations in November 1960 when the USS

[11] *Thomas B Allen and Norman Polmar,* Rickover – Father of The Nuclear Navy, Potomac Books, Washington DC, 2007.

GEORGE WASHINGTON (SSBN 598) commenced the first Polaris equipped missile patrol.[12]

4.1.2 Introduction of Nuclear Power for Electricity Generation. The then Captain Rickover, acting in his AEC capacity also played a leading role in the construction of the USA's first nuclear power station which began operations in May 1958. The station used a pressurized water reactor design originally developed to power an aircraft carrier. In 2008 the USA had 104 commercial reactors in operation providing 20% of the nation's electricity. [13] The nuclear powered submarines therefore preceded establishment of the nuclear power stations.

4.1.3 The USN's Manning Model

4.1.3.1 The Role and Impact of Admiral Rickover. An extract from the inscription on Admiral Rickover's tombstone in Arlington National cemetery sums up his extraordinary career, contribution and impact on the USN's nuclear propulsion program – '*63 years active duty* and *the Father of the Nuclear Navy*'. Rickover pursued an unrelenting focus on quality and safety. His acerbic, irascible personality and strong self-belief often placed him in conflict with the hierarchy of Defence and the Navy. He survived numerous attempts to remove him by exploiting his dual positions in the Navy and AEC, defended by a strong support base in Congress. The Naval Reactors Branch and organization for managing the USN's nuclear matters that he created continues to reflect these origins. The Presidential Executive Order promulgating the duty statement for the Director, Naval Nuclear Propulsion, issued upon the forced retirement of Admiral Rickover is at Annex J.

4.1.3.2 Naval Nuclear Reactors Branch. The Naval Nuclear Propulsion Program is a joint Department of Energy and Department of Navy organization responsible for all aspects of the Navy's nuclear propulsion, including research, design, construction, testing, operation, maintenance and ultimate disposition of naval nuclear propulsion plants. The program's responsibility includes all related facilities, radiological controls, environmental safety and health matters, as well as the selection, training, and assignment of personnel. Naval Nuclear Reactors

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[12] Ibid.

[13] Ibid

Branch (NR), maintains an outstanding record of over 150 million miles safely steamed on nuclear power. In November 2012 the program operated 104 reactors and had accumulated 6400 reactor-years of operation. [14] NR directs all aspects of the naval nuclear power program including personnel selection, training, technical design and oversight. Some examples of NR's functions with respect to training and qualification are as follows:

- Administers uniformed and contracted instructors to manage entry level training for both officers and enlisted men, exercising on-site oversight of the contractors involved.
- Sits on the final qualification boards of all officers and most enlisted operators.
- Has the final say with regards qualification or disqualification of an officer or enlisted operator.
- Is the screening authority for officers qualifying as Ship's Engineer, usually in the officer's third year on board a submarine.

4.1.3.3 The Officer Manning Model. All USN submarine line officers must qualify as the Engineer of a submarine (the RAN equivalent of a charge qualified Marine Engineer). Although the Engineer is given considerable autonomy and authority, he has the backup of the submarine's XO and CO who have previously earned the same engineering qualification as the Engineer. The CO will additionally have completed a three-month intensive course at NR headquarters, taught largely by the staff subject matter experts. This latter course not only covers the details of the design of the reactor system, but also covers the tactical aspects of reactor operation. If a line officer is unable to meet the standards required to qualify as Engineer, his submarine career will be terminated.

4.1.3.4 The Training Model. NR oversees the training of all officers and enlisted personnel, exercising tight control of curriculum and instruction to ensure a quality output. The curriculum while very comprehensive is focused on the specifics of naval reactors and not generic or commercial configurations. The course is taught at two levels: officer and enlisted and lasts six months for each. Following that each group proceeds to six months of practical application training using training reactors where the principles taught at the school are consolidated.

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[14] Tom Dougan, *Navy Gets New Nuclear Propulsion Boss,* Naval Nuclear Propulsion Program Public Affairs, 2Nov12

Basic watch keeping skills are also taught and evaluated. Three enlisted categories undergo nuclear training; Electrician Mates to become Electrical Operators, Electronic Technicians become Reactor Operators and Machinist Mates to become Mechanical Operators. Specialist skills such as chemical and radiological control technicians and nuclear welders are also taught as a subset of these skills.

4.1.3.5 At Sea Training. After completion of nuclear power training, both officer and enlisted personnel are assigned to an operational submarine. They are given aggressive qualification deadlines to qualify to keep watch on the propulsion plant. The guidelines for the amount of time spent in these pipelines and for the qualification timeframes for initial watch station qualification are specified by NR. As a result USN ships routinely deploy with many trainees who are not qualified in their senior watch station. For instance, plant operators will qualify at 2-3 watch stations before reaching their senior station; electricians typically have one junior watch station, as do the reactor electronics technicians. The initial qualification period is measured in months for both officers and enlisted men.

4.1.4 Use Of Live Reactors For Training. The USN has a strong preference for using live reactors and propulsion plants for training and all prospective plant-operators must spend time running an actual plant before going to sea. These personnel must therefore pass through either the land-based trainers or the moored training ships before being deemed ready for their first sea appointment. To support this requirement, the USN has two moored training submarines. These are ex-ballistic missile submarines, moored on the surface and specially adapted for training. [15]

4.1.5 Supervision of Operations. The Submarine Squadron and ship's staff undertakes oversight of day-to-day submarine operations and maintenance. However, to provide an external oversight and ensure a consistency of standards across the fleet, the Operational Reactor Safeguards Examinations (ORSE) of the submarines' reactor operations are conducted at the Fleet level, two echelons higher than the Squadron. Part of the reason for this is that the inspection team inspects both submarines and nuclear powered aircraft carriers with the Fleet Commander being responsible for both. Importantly, this responsibility forces the higher-level staff to remain involved in reactor operations

15 http://www.globalsecurity.org/military/systems/ship/mts.htm

and oversight. If standards on board a ship or submarine become unacceptable, NR deals direct with the Fleet Commander to rectify the situation; not with the Type Commander, [16] Squadron, or the vessel itself.

4.1.6 SUBSAFE Program. The USN has a comprehensive and very robust SUBSAFE program administered by Naval Sea Systems Command (NAVSEA). The program reaches into every aspect of the USN submarine operations and involves personnel, materiel, training and practices. It has authority over the uniformed Navy, civilian shipyards, supporting industry and all suppliers of materials and services. The program also has a substantial shore-side infrastructure obligation. There are specialized organizations that routinely conduct crew, facility and industry inspections and material certifications. The program's prime focus is watertight integrity, preventing a flooding casualty and recovering from one should it occur. The reactor plant has a limited number of SUBSAFE components.

4.1.7 Operational Reactor Safeguards Examinations. Operational Reactor Safeguards Examinations (ORSE) are designed to ensure the safe operation of the reactor. They are administered by a board, headed by a post-command Captain (usually a submariner, but it could be an officer who has served as a Reactor Officer on a nuclear powered aircraft carrier and then subsequently held command of a non-nuclear surface ship). The members on the board are all officers with very high levels of nuclear experience and professional ratings. Their chain of command is to the Fleet Commander but NR is closely involved in everything they do. They review engineering department record keeping, especially dosimetry and radiological controls records, maintenance records, observe maintenance actions, special procedures and overall engineering department operations, conduct oral exams and administer written exams. They also conduct a series of drills with all watch sections. The entire exam takes a week. Qualitative grades are given to subsections of the exam and to the exam overall. An unsatisfactory assessment can result in decertification of the crew. Overall unsatisfactory or below average assessments result in formal corrective action plans and a re-examination in short order, three to six months. Most ORSE are scheduled well in advance and the crew has a workup period to prepare, but every once in a while a ship gets to experience a random, unscheduled, surprise ORSE. The ORSE Board also conducts examinations tailored for Fleet shore maintenance facilities and tenders, but the exam is called a Radiological Controls Practices Examination (RCPE). Ships completing extended maintenance periods also receive ORSEs. NR undertakes

[16] An example of a Type Commander is the Commander Submarine Forces Pacific (COMSUBPAC).

examinations for the four naval shipyards where nuclear repair work is undertaken.

4.2 The Royal Navy Model

4.2.1 The Transition of the RN Submarine Force To Nuclear Power.

4.2.1.1 The RN's first nuclear powered SM, HMS DREADNOUGHT, was launched in 1960 and commissioned in 1963. She was fitted with a Westinghouse S5W reactor provided by the USA under the 1958 US-UK Mutual Defence Agreement. The RN's second (and first all-British designed and built) SSN, HMS VALIANT was commissioned in 1966, followed by her sister ship, HMS WARSPITE in 1967. The first SSBN, HMS RESOLUTION was commissioned in 1968 and continuous at sea deterrent patrols have been maintained ever since. [17]

4.2.1.2 The introduction of nuclear submarines to the RN in the 1960's coincided with a period of significant down sizing of a substantial and largely steam turbine powered surface fleet. This provided a large corps of experienced steam engineers and technicians to provide an experienced work force in the Navy and the dockyards for the shift to steam powered SSN.

4.2.1.3 At the time that it began the transition from conventional to nuclear-powered submarines the RN was operating around thirty conventional submarines, in five squadrons. This force was also being reduced as the nuclear submarines were being manned up, thus making a large pool of submarine qualified manpower available to be cross trained into the nuclear squadrons. The RN's last conventional submarines, the UPHOLDER Class paid off in the early 1990's. Of note, the fledgling RAN and Canadian submarine arms training programs effectively provided trainees and manpower to support the RN's conventional submarine Squadrons during the 1960s and 1970s.

4.2.2 The Political Background for the Transition

4.2.2.1 In 1965 the UK had a population of 54 million, a strong naval tradition and a Navy held in high regard by the general population. WW2 was a recent memory and the Cold War was at its height. SSBN operated by the Soviet Navy together with the Soviet Union's stated aim to spread communism 'by all

[17] http://en.wikipedia.org/wiki/Royal_Navy_Submarine_Service

means' constituted a real and perceived threat to the UK mainland which demanded an independent nuclear deterrent and fuelled the desire for the RN to operate its own SSBN.

4.2.2.2 In support of that principal strategy, Anti Submarine Warfare (ASW) operations intended to mitigate the Soviet SSBN threat were a major challenge that called for investment in sophisticated weaponry in the form of the SSN.

4.2.2.3 Ownership of this capability also supported the UK's higher political aim of sustaining credibility as a holder of a permanent seat on the UN Security Council. This added to the strategic factors pressing for a nuclear armed UK and the nuclear powered submarines required to carry and defend the nuclear deterrent.

4.2.2.4 Against that strategic and political background, the UK's first civilian nuclear reactor began generating in 1956 leading to a steady increase in nuclear power generating capacity up to its peak in 1997 when 26% of the UK's power was generated from nuclear energy. As of 2012 the UK still operates 19 nuclear power stations. Thus the transition to operating SSBN/SSN was conducted against the background of a strongly growing nuclear power industry [18]. Particularly in the early days, there was much 'cross-pollination' between the military and civilian nuclear programs and the RN formed an early and strong association with the United Kingdom Atomic Energy Authority. Whilst the two programs proceeded in parallel and it would be inaccurate to conclude that one was a pre-requisite for the other, the relationship did undoubtedly lend strong credibility to the RN's subsequent manning and training program.

4.2.3 Shore support infrastructure

4.2.3.1 The RN, at the start of the transition was supported by four major dockyards; three of these were each to develop a nuclear refit capability able to handle two submarine refits in parallel. This total has now reduced to three dockyards of which one now retains a nuclear refit capability.

4.2.3.2 At the start of the transition the UK had three major shipbuilding yards capable of SM and steam-plant fabrication; this has now reduced to one.

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18 http://en.wikipedia.org/wiki/Nuclear_power_in_the_United_Kingdom

4.2.3.3 Today the RN's shore mechanical engineering technician training is concentrated in HMS SULTAN. A brief description can be found at:

http://www.royalnavy.mod.uk/The-Fleet/Shore-Establishments/HMS-Sultan/Nuclear-Department

The submarine School is sited at HMAS RALEIGH, further details are available here:

www.royalnavy.mod.uk/the-fleet/shore-establishments/hms-raleigh

4.2.4 Current RN SM Force

4.2.4.1 As the nuclear submarine capability developed the RN operated with around thirty submarine crews for over two decades. This comprised a mix of SSBN, SSN and SSK. The plans to continue the expansion slowed following the collapse of the Soviet Union and the numbers then went into decline.

4.2.4.2 The RN currently operates six, TRAFALGAR Class SSN. These are planned to be replaced with seven, ASTUTE Class SSN of which the first is now in commission. Each SSN has one crew of 130 that remains much the same whether the submarine is in Fleet or dockyard hands thus seven crews are needed to maintain the capability.

4.2.4.3 The RN operates four, VANGUARD Class SSBN to maintain the continuous at sea deterrent which has remained unbroken since 1968. The standard crew is 135; s33(a)(iii) [redacted].

4.2.4.4 From this the total RN SM seagoing requirement is therefore 13 crews, or 1698 seagoing personnel. These are maintained from a total corps of SM qualified personnel which number 4,500 [19] to give a 'crewing ratio' of approximately 2.6 people in the Submarine Arm for every member at sea. The breakdown of these numbers is discussed at paragraph 9.1.3. Anecdotally there are a further 500-1000 submarine qualified personnel still serving in the RN who

[19] Naval Service Monthly Personnel Situation Report dated 1 February 2012

have moved on in their careers and are either too senior or too old to serve in submarine billets.

4.2.5 Current RN Manpower Management

4.2.5.1 Category Structures. Operating comparatively small numbers of submarines with specialist branches of training has always presented challenges to maintain stable branch structures. Sometimes even a minor perturbation can lead to a shortfall that if left unaddressed would have serious longer-term consequences. An insight into current RN manpower shortfalls can be gained from the so-called 'Pinch Point Tables' published in the 2011 Annual MOD (UK) report to Parliament [20]. This reveals, inter alia, the key shortage categories which the RN submarine service was then experiencing. For the purposes of this paper, the key positions of concern are those of Command Qualified Executive Officers, Category A2 and Category B Nuclear Watch keepers. [21]The significance of these shortfalls will be discussed in greater detail at paragraph 7.3.

4.2.5.2 Financial Bonuses. To help attract and retain submariners a system of financial incentives has long been used. Today a 'Golden Hello' of £5,000 ($7,342) is paid to all personnel on their initial SM qualification. In addition to standard scale pay for their rank, submariners are paid an increment of SM pay which starts at £4,219 ($6,195) pa rising to £7,384 ($10,834) for as long as they remain liable for submarine service.

In addition to these incentives given to all submariners, to help attract and retain those who are qualified in the Pinch Point Categories further retention bonuses are paid. Bonuses have been paid to Warfare and Engineering officers and sailors. As an example, a Category A2 qualified nuclear reactor watch keeper (WO/CPO) receives £25,000 ($36,713) for four years return of service obligation and a Category B watch keeper (CPO/PO) receives £20,000 ($29,370) also for

[20] Ministry of Defence (UK) Annual Report and Accounts 2010-11 - Defence Committee, 18 January 2012, para 67.

[21] The RN categorises the ME Department watch keeping skills and experience levels; personnel progress from the lower level of the spectrum category D, basic watch keepers who have completed the requisite training, through category C and B to the Engineer Officer of the Watch and Nuclear Chief of the Watch at the upper level who are category A watch keepers. Further details are at paragraph 7.3.2. Table E-4 in Annex E provides an illustrative make up of an ME watch at sea in an SSN.

four years ROSO. The USN also uses a generous system of entry, qualification and retention bonuses both for officers and enlisted personnel.

4.3 A Comparison of The RN and USN Manning Models

4.3.1 Summary of the Two Models. There is a significant difference between the RN and USN crewing and training models. The RN favours a 'Specialist Officer' model in which officers are specialised in the four disciplines of Warfare, Marine Engineering, Weapons Engineering and Logistics. Warfare officers do not hold the engineering qualifications needed of a nuclear power plant operator as, equally, engineers cannot qualify for command. The USN favours a 'Line Officer' model in which a line officer can only qualify for command if he has first qualified formally as an Engineering Officer of the Watch (EOOW) and Ship's Engineer. While each model contains the same (or similar) elements of training, the way in which they are applied differs greatly between the two models and a choice should be made prior to designing an RAN SSN manning and training model

4.3.2 Safety Record. Both models are based on similar principles of training, regulation and oversight; both have an unblemished safety record regarding nuclear reactor accidents per se. The USN has lost two SSN; both losses were believed to have been caused by non-nuclear system failures. Thus either model would appear to satisfy the nuclear safety criteria.

4.3.3 RAN Practice. The RAN currently operates using a specialist model derived from that of the RN. This reflects the long association between the two navies and the Oberon Class of submarine genesis for the RAN's modern submarine arm. Adoption of the USN's model would involve significant change to the RAN's SM crewing paradigm, manpower structures and basic training.

4.4 Choice of Manning Model.

4.4.1 The choice of the Specialist Model by the RN and RAN has been well proven in war. The specialist tactician (or Warfare Officer) can accumulate sufficient experience and qualification to be ready for SSN command in his mid-thirties and thus be of an age to have the vigour and stamina to maintain an aggressive patrol posture for what may be months of a submarine patrol. The success of such a patrol will often derive from a firm belief that tactical decisions should be made for tactical reasons and not for engineering reasons. The Warfare Branch commanding officer will, for engineering advice, depend upon his specialist ME and WE officers. They will be of similar age to the CO and able to provide for all the appropriate nuclear (and other safety) considerations but ultimately the CO will make the tactical decision. It is upon this that the success of the mission depends.

4.4.2 The USN has over many years, derived and successfully operated on the Line Officer model. In this the CO is himself a specialist nuclear plant operator. It can be argued that this gives him intimate knowledge of the plant, allowing him to use it to its maximum capability, giving him a tactical advantage at a critical moment. However, the price for this is the time that it takes for him to become a specialist in both plant operations and tactics. Some would argue that the depth of tactical knowledge is greater under the RN's specialist model. From a limited survey undertaken in 2012, it appears that a US submarine commander may be older than his RN counterpart. [22]

4.4.3 Given that both models have their pros and cons, a decision should be made which reflects Australia's own preference. A strong consideration is that the RAN and its submarine service currently employs (and has a century long history of employing) the Specialist Officer model. For it to change to a Line Officer model would require a complete re-build of the RAN officer corps. There would need to be a strong reason for this change to be contemplated.

4.4.4 For these reasons, this paper will assume that the RAN retains a Specialist Officer model for manning the SSN force. There will be some economy in this approach as the training and career pipelines will be shorter. Consequently the manpower totals given in this paper should be considered the minimum.

5 - Manning An Australian Supervisory/Regulatory Structure

5.1 Nuclear Safety – A National Responsibility.

5.1.1 To guarantee that nuclear safety always remains paramount it is essential that a robust framework of supervision and regulation is in place with clear lines of responsibility which run from the bottom to the top of the organisation. For Australia to meet this requirement it is assumed that an Australian regulatory and technical capacity will be obliged to become competent, with the capacity to provide practical safety oversight, enable the Australian Government to maintain

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[22] A survey in April 2012 using publicly available information reveals that the average age of the USN's 5 Virginia class submarines was 44.2 years. A similar analysis of the RN's 5 Trafalgar Class is 37.3 years. All CO's in the survey were undertaking their first command.

sovereignty and to discharge its responsibility for the safety of all RAN operated nuclear reactors.

5.1.2 This responsibility cannot be contracted out, nor could an overseas system extend its coverage or foreign personnel undertake this in Australia without compromising Australia's sovereignty. The Australian public (and no doubt the international community) would expect the highest standards of safety and supervision, exercised under national control, ultimately by an elected official, ie the Minister for Defence.

5.2 Regulatory Infrastructure

5.2.1 It is therefore assumed that all nuclear related infrastructure in Australia would be modeled on those used in the USN and RN. This would include upgrading Australia's existing reactor safeguards system to match the standards used for SSN in these navies, such as the ORSE Board discussed at paragraph 4.1.7 above. Close modeling on these systems would provide legitimacy and credibility to operations in the early stages. Regardless of the model, to be credible the RAN would be obliged to ensure that its own infrastructure included the appropriate expertise and experience such as to ensure safety standards were met at all levels. To ensure that these standards are met, there is a need for a parallel expert organisation with powers to audit the process and ensure that regulations are fully complied with. Using UK terminology this paper has given that organisation the name Nuclear Safety and Reliability Directorate (NSRD).

5.2.2 In Australia the expertise needed to man the NSRD is probably best positioned in the Australian Nuclear Science and Technology Organisation (ANSTO). ANSTO role is described as "a public research organisation responsible for delivering specialised advice, scientific services and products to government, industry, academia and other research organisations"[23]. ANSTO is responsible to the Minister of Innovation, Industry, Science and Research thus being independent of the RAN's line of authority, ensuring a plurality and independence of oversight to the nuclear safety reporting chain.

5.2.3 Whilst ANSTO would have to generate the expertise to oversee the safety case generation, site licensing and regulation compliance arrangements they

[23] http://www.ansto.gov.au

would probably need support from experienced plant operators, many probably drawn from ex RAN technicians and officers. An allowance of 18 personnel for that latter function is made in Annex A, table A7.

5.3 Nuclear Site Licensing and Nuclear Safety Responsibility

5.3.1 Safety Case Analysis for Sites. To ensure that all operations are conducted safely, the nuclear related functions to be conducted at any site must be subjected to a safety case analysis from which a site licence will be generated detailing the regulations relevant to a specific site together with any preconditions or restrictions. This is a complex business and should not be underestimated. It is assumed that it is a function which ANSTO and NSRD will be able to address but being a largely civilian function no allowance for the personnel needed is made in the manning model.

5.3.2 UK Licensing Procedures. The nuclear site licensing process used by the UK Health and Safety Executive (HSE) provides a helpful indication of the complexity of the task. The details of that process were most recently published in the HSE's Licence Condition Handbook (October 2011)[24].

5.4 The Academic Training Structure

For nuclear power plant operators to have a full understanding of the submarine reactor they will be obliged to undergo a high level of both education and training. This is described in greater detail in Section 8. Delivery of the education could be made by a university derived academic body with due accreditation, acting under contract to the RAN, or by experienced nuclear trained officers and senior sailors as is done in the US. For efficiency the courses should be delivered at HMAS CERBERUS, site of the RAN's Engineering Training School, hence any university engaged would be asked to establish an independent faculty at that site. While the manpower required to establish and operate such a faculty has not been detailed in this paper, it is estimated at six personnel specialized in reactor design, physics and accident studies who, being collocated with the operator training could also draw on current operating expertise. The cost to establish and sustain it would have to be factored into any acquisition plan.

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24 http://www.hse.gov.uk/nuclear/silicon.pdf

5.5 The Naval Training Infrastructure

The Naval Training infrastructure developed to train the engineers and technicians needed to operate a nuclear power plant will require (at least at the outset) external accreditation and operate with the oversight and audit of the Supplier's Navy. This paper includes an allowance for the additional 19 naval instruction and administration personnel to deliver this training at Annex A, table A6.

5.6 Line of Responsibility for Nuclear Safety

5.6.1 Nuclear safety relies on an inculcation of safety ethos in all personnel from the most junior sailor working on the reactor through those in charge of operating the reactors, to those who direct the operations and finally to the responsible government minister. This chain defines the direct line of responsibility for nuclear safety that includes the training and qualification of the plant operators.

5.6.2 Alongside that chain there should exist a parallel but independent chain of inspectors with powers to scrutinise any aspect of the chain. In practice this would be divided allocating responsibility for oversight of the training and qualification to senior RAN operators while maintaining the NSRD with powers to scrutinise the material aspects of the program. Allowance is made for these positions in the Manning Model and estimates are provided for the extensive civilian functions. In both cases the buck stops with the relevant Minister and he must be provided with suitably qualified staff to assist him in discharging this responsibility.

5.6.3 While this paper follows the UK model for maintenance and oversight of nuclear safety a comparison with the USN equivalent is relevant. There, a plurality of operation and oversight is maintained by having a chain of command for the operations passing up to the Chief of Naval Operations. Meanwhile oversight and regulation compliance is ensured by the Director, Naval Nuclear Propulsion; an independent 4* officer with direct access to Congress, who also holds a senior position in the Department of Energy, with direct access to the Secretary of Energy. This plurality of oversight is well proven for use with the reactors currently in service with the USN that number some 70 SSN/SSBN and 11 aircraft carriers. However, it is suggested that a parallel organisation on that scale would be too great for the needs of the ten SSN envisaged by this paper.

5.7 The Role of the Submarine Squadron

5.7.1 In both the RN and USN models, the Submarine Squadron organisation provides a key oversight and safety role, supervising the operation and maintenance of the submarines together with the training, evaluation and certification of their crews. Accordingly, the Squadron is a key component in the nuclear safety chain, providing oversight of the onboard qualification process undertaken at every step in the individual and team training process. The squadron conducts many of the assessment boards, has oversight of training standards and conducts the operational readiness assessments of each crew prior to certifying the submarine ready for operational deployment.

5.7.2 In the RN a squadron comprises typically six to seven SSN or four SSBN while in the USN a squadron may have up to ten SSN. Whilst this allocation is not a rigid figure it is considered likely that more than ten SSN may require the establishment of a second Squadron. This paper works on the assumption that ten SSN can be overseen by one suitably staffed Squadron and that the RAN has one homeport for operating its SSN force.

5.7.3 Whilst this paper includes an estimate of Squadron size appropriate to this scale of numbers this may prove to be an underestimate.

5.7.4 A detailed breakdown of Squadron staff is included in the Shore Manning Scheme of Complement at Annex A, table A1. This shows a total requirement for s33(a)(ii) [redacted] personnel compared with the current Collins class Squadron manning.

5.7.5 Sea Training Group. The Submarine Sea Training Group is a key component of the Squadron, providing at-sea supervision of individual submarine crews, undertaking their operational readiness assessment and thus ultimately certifying that a submarine is adequately prepared and safe for operations. For a larger submarine Flotilla with more than one Squadron, this function would be carried out by an independent training organisation. For our purposes we can assume that it will come under the Squadron organisation.

5.8 Radiological Protection and Incident Response Team

5.8.1 Monitoring and protecting the health of the nuclear power plant operators and ensuring that there is no risk to the general public of exposure to harmful ionizing radiation is a part of the safety ethos associated with ownership of a nuclear power plant. To meet this function there will need to be an RAN responsible radiological protection team linked to an appropriate nuclear medical institution. Australia already has an established organisation charged with protecting the public from the harmful effects of radiation; the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). Australia would need to extend its current civilian and naval medical capacity to provide this supporting framework and establish the appropriate capability. The full extent of this augmented civilian role will require closer definition and costing.

5.8.2 The RAN Radiological Protection and Incident Response Team (RP and IR Team) will undertake the routine radiation monitoring function, maintaining records of the radiation dose received by classified watch keepers and workers to ensure that no individual is put at risk.

5.8.3 The RP and IR Team must have the expertise to respond to any nuclear incident, monitoring radiation levels and hazards to the public. Whilst it is to be hoped that this expertise will never be applied in earnest it requires skills that must be both maintained and exercised and the capability publicly demonstrated. This would require appropriate resourcing, secure from budgetary whims.

5.8.4 The Shore Manning structure at Annex A, table A5 provides 36 personnel for three uniformed incident response teams to be provided permanently at the RAN's homeport, providing a round the clock capability, albeit with reduced manning outside working hours. These teams would be supplemented by manpower drawn from the Squadron, Nuclear Repair Facility and Submarine School collocated at the Operational base. The Team would have a mobile function to cover other port visits. Australia will also need to develop a nuclear submarine repair facility at a remote dockyard, a second team should be provided at the facility that handles these major overhauls and repairs. It is probable that this would be considered a civilian function in that location but training and certification is likely to be of the same origin and the team of similar size, ie 36 people.

5.8.5 The details of the RP and IR Team are given in the Shore Manning Scheme of Complement at Annex A, table A5 but it should be noted that the category of s33(a)(ii) [redacted].

5.8.6 To give an idea of the scale of this capability in the USN, one USN commentator gave an insight into the USN arrangements in New London:

s33(a)(iii) [redacted]

5.9 Nuclear Safety & Reliability Directorate

5.9.1 The Nuclear Safety and Reliability Directorate (NSRD

The NSRD is a new function to be established to support the Government in discharging its responsibility for material nuclear safety. In the UK it is civilian manned, located in the Office for Nuclear Regulation a directorate of the Health and Safety Executive which is responsible to the Minister of Employment. It is comprised of experienced, senior civilian nuclear engineers or former RN reactor operators. In the absence of a nuclear power industry the equivalent of this group would have to be developed from Australia's existing ANSTO and ARPANSA structures recruiting additionally from overseas, or developed from within the RAN training program.

5.9.2 Whilst the UK model would sit well to develop Australia's nuclear site licensing capability, there are a number of options for how the military aspects of this function could be developed. While there is much to be said for having a system which reports to the Minister of Defence, it is preferable to maintain the plurality of the system by having an independent NSRD which reports to a different Minister for nuclear safety. The Manning Model allows for the uniformed personnel who would advise that reporting chain but it would be an early decision for Government as to just where the NSRD would sit.

5.9.3 As a policy Directorate it would be appropriate for NRSD to be sited in Canberra, established so that it is organizationally independent from the RAN, with outpost units at the operating base and the major repair base. A team of eighteen, headed by a Captain or public servant equivalent is allowed for in the Shore Manning Scheme of Complement at Annex A, table A7.

5.9.4 The Officer In Charge of NSRD should enjoy direct access to the appropriate Minister and unfettered access to all nuclear plant activities in the RAN.

5.9.5 It is anticipated that this capability would require certification from the nuclear technology supplier as an ongoing requirement of the lease or sale agreement.

5.10 Naval Nuclear Training & Safety Panel

5.10.1 The Naval Nuclear Training and Safety Panel should be a Canberra based policy RAN Directorate, headed by an experienced s33(a)(ii) .

5.10.2 Role. His role is to support the Minister of Defence in discharging his responsibility for ensuring that the standards of training and qualification of nuclear power plant operators are maintained. This should entail oversight of the training delivered by the RAN or any other training provider. For this he has access to all aspects of the training pipeline both for scrutiny and assessment. A team of twenty is allowed for in the Shore Manning Scheme of Complement at Annex A, table A2.

5.11 Assumption of Responsibility by the Australian Government

5.11.1 It is assumed that the Australian Government will take responsibility for the safe operation of each submarine and its nuclear power plant at handover of the SSN on successful completion of Sea Acceptance Trials and the subsequent defect rectification period in the building yard. This is the logical point for a handover from the builder to the RAN. Prior to this event the submarine would operate under the standard system of the technology supplier (the Supplier), with supervision of the RAN crew and the standard Supplier navy safety and control systems in place. Ultimately, the Supplier Government would exercise responsibility for its safe operation during the period prior to handover. This complex division of national responsibilities would require careful delineation as an early matter.

5.11.2 It is assumed that the Australian shore based personnel exercising regulatory and safety oversight are in place at least two years prior to the assumption of these responsibilities to enable procedures and policies to be developed and tested. These personnel would require licensing and regular re-certification, most probably by the appropriate Supplier Navy's authority.

5.11.3 It is assumed that the safety teams at the operational base and Nuclear Repair Facilities (NRF) are established at least six months prior to the arrival of the first SSN in Australian waters. These personnel would also require licensing and regular re-certification. Initially the appropriate Supplier Navy's authority would undertake this certification activity.

5.11.4 The key startup shore billets requiring nuclear experience and qualifications are identified in Annex A, table A9.

5.12 Design Authority Liaison Team

5.12.1 It is assumed that the Submarine Design Authority, which also has responsibility for nuclear safety within the design, remains with the Supplier Navy and its Design Authority for the SSN. The Design Authority Liaison Team provides an RAN interface with the Supplier Design Authority and a conduit to the RAN and its major maintenance facilities, with qualified personnel in the Supplier Navy Design Authority and Australia.

5.12.2 The Team also provides a capability to analyze any incidents and provide instructions to prevent repetition, e.g. changes in personnel skills, training, operating procedures, materials or design.

5.12.3 A team of twenty-five mixed uniform and civilian professionals is included in the Shore Manning Scheme of Complement at Annex A, table A4 to address this function. It is likely that a major repair facility would also be required to establish a design authority liaison capability. An allowance of twenty people has been made for this purpose and included in the numbers for NRF #2.

5.13 Submarine Capability Branch

5.1.3.1 Function and Roles. The Head of the Submarine Capability Branch is responsible to the Chief of Navy for the safe and effective delivery of the agreed level of submarine capability, within allocated resources. Operating in a matrix management structure reaching across the Defence and Navy organizations, he should have authority over all the Defence elements contributing to this outcome.

5.13.2 Manning. A proposed manning structure is set out in Annex A, table A3.

5.13.3 Submarine Capability Branch is suggested as the best organization to oversee the application of the Operational Reactor Safeguards Examination program discussed at paragraph 4.1.7, including orchestrating the unannounced drills and inspections required across the entire SSN program to ensure that this critical safety system is functioning correctly, a further 20 personnel are included in the total numbers of 123 at Annex A, table A3 for this purpose.

5.14 Minimum Number of SSN to Sustain Essential Safety & Technical Positions

5.14.1 Given the length of the training pipeline, providing the number of experienced s33(a)(ii) [redacted]. These positions are identified in the Shore Manning Scheme of Complement at Annex A and to a large extent they lead the requirements for the rest of the shore-manning scheme of complement.

s33(a)(ii)

[redacted]

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[25] The + symbol indicates that the officer is qualified to be in charge of a Mechanical Engineering Department of an SSN.

5.14.3 Notwithstanding these additional management measures to ensure the structure can be sustained, the model demonstrates that a force s33(a)(ii) [redacted] sustainable and should provide sufficient experienced personnel provided only one Squadron staff was being supported.

5.14.4 s33(a)(ii) [redacted]

5.14.5 Thereafter the smaller numbers of s33(a)(ii) [redacted] can be met from the outputs of the pipeline with scope to offer broadening appointments to the small number of officers surplus to the immediate nuclear requirement.

6 - Scheme of Complement for An SSN

6.1 Category Structures.

6.1.1 The Scheme of Complement (SOC) is based on that for a Virginia Class SSN (an ASTUTE class submarine has a roughly similar sized crew). Details are set out at Annex B; it consists of s33(a)(iii) [redacted]

6.1.2 The SOC has been derived from s33(a)(iii), s33(a)(ii) [redacted]

6.1.3 As with all modern submarines, the manning structure is s33(a)(ii) [redacted] This creates

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26 Mess men are sailors who assist in the serving of meals and maintaining cleanliness in the communal areas.

s33(a)(ii) [redacted]

6.1.4 The SOC allows for s33(a)(ii) [redacted] accommodated in the basic fashion traditional in such cases. A capacity for the submarine to carry a total s33(a)(ii) [redacted] has been assumed in the modeling.

6.1.5 Operating an SSN such as the Virginia or ASTUTE classes, propelled by steam turbines driving through reduction gearing will require a number of new skills and specializations for the RAN. s33(a)(ii) [redacted] A significant investment in shore training infrastructure would be required to regenerate the depth of experience in managing these potentially lethal systems.

6.1.6 In addition it is noteworthy that compared with a conventional submarine, the SSN carries a greater depth of skills, spares and onboard inventory management to enable the crew to conduct at-sea repairs. To a large extent this skill set comes with the level of expertise expected of the senior nuclear power plant operators who are likely to spend their shore time within the nuclear repair facilities. A retired SSN commanding officer commenting on this paper observed that whilst SSNs are rugged and generally highly reliable, when defects do occur, rectification can be significantly more difficult, time consuming and expensive. This is a function of the complexity and range of safety issues attaching to nuclear propulsion.

7 - The Manning and Training Model

7.1 Assumptions

7.1.1 Manpower Assistance From The Supplier Navy. It is assumed that the Supplier Navy will provide significant initial manpower with the necessary experience and skills to provide the critical oversight and monitoring capacity either by facilitating direct RAN recruitment or on loan as part of the sale/lease. This arrangement will, however come at a cost and the RAN would expect to move to a self-sustaining RAN model at the first opportunity.

7.1.2 Access to Supplier Navy Training Schools.

7.1.2.1 It is assumed that the RAN will be given the requisite access to the Supplier Navy training schools until it has established sufficient capacity in Australia to man and operate its own naval training system. It is probable that acceptance of the sixth SSN would be the earliest that this should be contemplated, typically some nineteen years from initiation and 6-8 years after the commissioning of the first SSN. Access on this scale to the Supplier Navy training system would be a significant undertaking for the Supplier Navy and cannot be presumed.

7.1.2.2 The author's experience with using an overseas navy's training system demonstrates that it would entail a significant financial cost and raise a substantial manpower management challenge for the RAN both in Australia and the overseas country. The training pipeline models used in Annex C include an allowance for pipeline inefficiencies, for example the time lost between courses and student attrition through failure or disenchantment. These latter effects tend to be elevated by the range of social factors arising from protracted overseas training. The model makes a conservative allowance for this effect.

7.1.3 It is assumed that the Supplier Navy will provide access to their submarines for at-sea training. This is one of the most problematic assumptions. At-sea training billets are always in high demand for the parent navy, to then add the load of conversion and ab initio training required for the RAN would be a significant imposition even without considering security and the range of national issues that would arise. This would be an issue requiring early resolution to establish the viability of the whole proposal.

7.1.4 As discussed above, establishing the Australian personnel structure without the benefit of a nuclear power industry or any nuclear higher educational faculty [27] would entail recruiting skilled and experienced nuclear plant operators,

[27] The ANU and University of Sydney have Nuclear Physics Departments for postgraduate and postdoctoral training over a wide range of research, from basic to applied.

technicians and academics. This expertise could also be obtained by Supplier Navy loans and exchanges. The possibility of recruiting suitably experienced personnel from friendly Navies operating SSNs should also be investigated. In order to preserve their cooperation this type of program cannot be undertaken without the consent of the source countries. It is likely that any leasing agreement would define the ground rules for these activities to satisfy the Supplier Navy that it was not adding to its own manpower challenges!

7.2 Officers

7.2.1.1 s33(a)(ii) [redacted]

7.2.1.2 s33(a)(ii) [redacted]

7.2.1.3 The MEOSM Training/Career Pipeline is modeled at Annex C. This model is greatly simplified and the results should be taken as illustrative, not a precise process. The model is sensitive to the failure rates used; these have been set based on the author's judgement to provide a basis for the initial modeling exercise.

7.2.1.4 s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

7.2.1.5 s33(a)(ii) [redacted]

7.2.1.6 s33(a)(ii) [redacted]

7.2.1.7 After providing an allowance for attrition at each stage of this pipeline the model at Annex C Table C1 demonstrates that each year the RAN would have to s33(a)(ii) [redacted].

7.2.1.8 s33(a)(ii) [redacted] The model assumes that this will not be required [redacted].

7.2.2 Warfare Branch Officers

7.2.2.1 Command Qualification. s33(a)(ii) [redacted]

7.2.2.2 COQC Venue. s33(a)(ii) [redacted]

7.2.2.3 The XOSM+ Training/Career Pipeline is modeled at Annex C. This model is greatly simplified and the results should be taken as illustrative, not a precise process. Warfare Officers undertake the standard submarine training pipeline with the addition of a four-month Nuclear General Course.

7.2.2.4 The Warfare Officer's career and training pipeline, following initial submarine qualification, involves completion s33(a)(ii) [redacted]

7.2.2.5 s33(a)(ii) [redacted].

7.2.2.6 After providing an allowance for attrition at each stage of this pipeline the model at Annex C, Table C2 demonstrates that s33(a)(ii) [redacted].

7.2.2.7 s33(a)(ii) [redacted] Allowing for attrition, the model at Annex C, table C4 demonstrates that s33(a)(ii) [redacted].

7.2.3 Weapons Engineer Officer

7.2.3.1 The Weapons Engineer Officer (WEOSM) training pipeline is modeled at Annex C. This model is greatly simplified and the results should be taken as illustrative, not a precise process. WE officers undertake the standard submarine training pipeline with the addition of a four-month Nuclear General Course

7.2.3.2 After providing an allowance for attrition at each stage of this pipeline the model at Annex C Table C3 demonstrates that s33(a)(ii) [redacted].

7.3 Senior Technical Sailors

7.3.1 s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

s33(a)(iii) [redacted]

7.3.3 s33(a)(ii) [redacted] and greatly respected. The sailor will hold the military rank of Warrant Officer or Chief Petty Officer. Sadly the man's reward for the endeavour needed to attain the position is then a succession of sea (two year) and shore (one year) jobs that are all very similar. This can easily lead to disenchantment causing the both intelligent and resourceful characters to seek alternative options within the industry. The retention difficulties for these categories leads to them being on the RN's 'Pinch Point' list as described at paragraphs 3.1.2 and 4.2.5.2.

7.3.4 To reduce the attrition rate from these Pinch Point categories, the Royal Navy has frequently resorted to the use of bounty payments. These have usually involved payment of a lump sum in return for a waiver of the right to give notice to leave the service. The most recent Royal Navy scheme is enumerated at

Paragraph 4.2.5. The USN also offers generous financial incentives to retain these categories of specialists.

7.3.5 The complexity of the various branches which can lead to the s33(a)(ii) [redacted] qualification is deserving of modeling in its own right but at the same time too complex to be considered for the purposes of this paper. Suffice to say that the numbers included in the manning model are estimates. For the RAN sustaining a s33(a)(ii) [redacted] It should be assumed that it will require a determined recruiting program, attentive management and proactive use of bonus schemes. Even given these there will probably still be a need to recruit from among former RN and USN personnel hence the financial incentives used will have to equate to or exceed those in use in those navies.

8 - The Training Course Hierarchy

8.1 Nuclear Reactor Course

8.1.1 Purpose. The Nuclear Reactor Course (NRC) is a one-year post-graduate course covering the technology, theory, physics and operation of submarine nuclear reactors. Taught in two parts it comprises six months of reactor theory followed by six months of plant operator training. It is mandatory for MEOSM seeking the Engineer Officer of the Watch qualification. In the RN the theory section must be delivered by a suitably accredited university faculty operating under contract and able to award course graduates with a post-graduate diploma. [28]The course requires the use of a reactor simulator that is used to model the live reactor; a live reactor is not required as such, avoiding any safety issues arising from placing a reactor in a shore training facility. The second part of the course will comprise largely plant operation training for which a Manoeuvring Room Team Trainer will be needed. This models both the primary and secondary plant and hence can be used to simulate both standard and emergency operating procedures. Experienced plant operators teach this element of the course. This one-year package equates directly to the USN 'Nuclear Theory and Prototype' package.

8.1.2 Given the author's previous experience of the high attrition rates suffered when naval officers undertake a university education on a civilian campus this course will best be conducted in a naval training environment, delivered by attached, resident University staff.

28 In the USN serving personnel deliver this training.

8.1.3 A throughput of 24-31 trainees per year is estimated to be needed for a force of ten SSN.

8.1.4 Overseas Training. Provided excess capacity existed overseas and the reactor technology was appropriate, the initial batch of training to prepare instructors and the crew for the first SSN could be undertaken at a suitable overseas Navy training facility. Thereafter economics, its synergy with the Nuclear General Course discussed below and need for self-sufficiency would dictate that it be repatriated.

8.2 Nuclear General Course

8.2.1 Purpose. The Nuclear General Course (NGC) provides training in nuclear technology at a level suitable for Warfare Branch, Weapons Engineer and Supply officers.

8.2.2 Delivery. This four-month course must be delivered by a suitably accredited university faculty. It requires the use of a reactor simulator; a live reactor is not required. There is significant commonality in staffing between the NRC and NGC, such that in the interests of efficiency the two courses should be collocated preferably at a naval training site and delivered by resident staff from a suitably accredited university.

8.2.3 Throughput. A throughput of 46-70 trainees per year is estimated for a force of ten SSN.

8.2.4 Overseas Training. Provided excess capacity existed overseas and the reactor technology was appropriate, the initial batch of training to prepare instructors and the crew for the first SSN could be undertaken at a suitable overseas Navy training facility. Thereafter economics, its synergy with the Nuclear Reactor Course discussed above and need for self-sufficiency would dictate that it be repatriated.

8.3 Nuclear Advanced Course

8.3.1 The Nuclear Advanced Course (NAC) is a one year MSc in nuclear engineering. It is not part of the mandatory nuclear training pipeline, but provides a desirable retention option for those with the intellect and interest in further study. In the RN most of these courses are done after the AMEO or DMEO posting, hence assisting in retention prior to the final MEOSM+ sea posting, prepares officers for the more senior staff engineering postings and provides enhanced credibility to the Navy's standing in the nuclear engineering policy environment. The NAC can also be used to explore technical options for plant modifications, future design or other associated technology.

8.3.2 All postgraduate nuclear engineering education must be delivered by a suitably accredited University. Currently Australia has postgraduate nuclear physics faculties located at the Australian National University, Canberra and the University of Sydney. However, neither delivers this type of course at the moment and given the small number of students, the RAN is likely to benefit from an overseas delivery. This should also add to the inducement value and external status of the qualification.

8.4 Nuclear Technician Long Course

8.4.1 Purpose. The 8-month Nuclear Technician Long Course (NTLC) is used to prepare qualified and experienced nuclear watch keepers to oversee reactor technicians and to certify them as Category B and subsequently Category A2 watch keepers.

8.4.2 Delivery. It is undertaken within the naval training system, not a university environment. There is benefit in collocating it with the NRC and NGC since these courses all make use of the same Manoeuvring Room Team Training simulators.

8.4.3 Simulators. The course is predominately focused on Nuclear Power Plant operations for which it will require access to a Maneuvering Room Team Trainer (MRTT).

8.4.4 Throughput. A throughput of 25 trainees per year is estimated to be needed to sustain a force of ten SSN. This figure is based on the throughput needed to sustain the force of ten SSN and Squadron functions with an expectation of two postings for a Category B before he leaves the Submarine Arm or applies to become a Category A watchkeeper with an attrition rate of 20%.

8.5 Nuclear Technician Short Course

8.5.1 Purpose. The 4-month Nuclear Technician Short Course (NTSC) is used to train nuclear reactor technicians and qualify them as Category C Reactor Watch-keepers.

8.5.2 Delivery. It is undertaken within the naval training system, not a university environment. There is benefit in collocating the NTSC with the NRC, NGC and

NTLC since these courses all make use of the same Manoeuvring Room Team Trainer simulators.

8.5.3 Simulators. The course is predominately focused on Nuclear Power Plant operations for which it will require access to a Maneuvering Room Team Trainer (MRTT).

8.5.4 Throughput. A throughput of 30 trainees per year is estimated to be needed to sustain a force of ten SSN. This figure is based on the throughput needed to sustain the force of ten SSN and Squadron with an expectation of two postings for a Category C watchkeeper before he leaves the Submarine Arm or applies to complete the NTLC to become a Category B watchkeeper plus a 40% attrition.

8.6 Basic Submarine Training Model

8.6.1 Training Model. Basic submarine training follows a similar sequence to current RAN submarine training, although the content may vary somewhat dependent on the candidates' rank and specialisation. All personnel undertake this training; there are separate courses, with different content for officers and sailors.

8.6.2 Part I - SM Training. This course teaches submarine principles and is undertaken by all submarine personnel. The course is delivered in a dedicated submarine training school operated as part of the naval training system and takes three months. Officers and sailors undertake different Part I training courses but a common element of both is Submarine Escape Tank Training (SETT). It is currently customary to make completion of SETT the landmark for commencement of submarine pay.

8.6.2.1 Officers' Throughput. The pipeline models for officers at Annex C illustrates the likely annual training loads for officer's Part 1 training as s33(a)(ii) officers, a significant increase over the current throughput of s33(a)(ii) officers per year.

8.6.2.2 Sailors' Throughput. The pipeline models for sailors at Annex C illustrates the likely annual training loads for sailors' Part 1 training as s33(a)(ii); a significant increase over the current throughput of s33(a)(ii) sailors per year.

8.6.3 Part II - Technical Category Training. The Part II course trains officers and sailors in particular technical aspects of their duties on a submarine. The courses are delivered in a dedicated submarine training school operated as part of the naval training system. Content varies according to the officer's specialization or a sailor's category; an allowance of three months is used in the modelling. The ME Part II includes an introduction to nuclear principles to enable these personnel to serve as Category D watch keepers after they qualify.

8.6.4 Part III – At-Sea Qualification.

8.6.4.1 Purpose. The Part III at-sea training and assessment is the final step of the submarine initial training pipeline.

8.6.4.2 A Choke Point. The Part III training represents a 'choke point' in the training pipeline and demands careful management. It requires bunk space in a sea-going submarine with a suitable program to undertake basic training as well as give experience of routine submarine operations. A dedicated training submarine has been tried and found lacking in imparting the necessary real world experience. Efforts to shorten this process by greater use of shore simulators are worthwhile, however these have been found to reach a practical boundary – the familiarity, confidence and trust required to become an effective submarine crewmember can only be achieved with sea time. Passing a final practical assessment board, conducted by the senior sailors and officers of the submarine where the candidate will probably then serve is an important 'rite of passage' for the trainee and importantly can be the final weeding process for candidates who do not fit in psychologically.

8.6.4.3 Limitations. The accommodation and escape equipment capacity provide finite limits to the number of personnel that can be carried. The ability for the submarine's crew to undertake the training and supervise the trainees must also be considered. The crew of a submarine undertaking an operational mission is generally heavily loaded, which limits their capacity to oversee training, further, if the mission requires the carriage of additional, specialist teams then there must be a reduction in the number of Part III trainees carried. The regime of Sea Acceptance Trials on completion of build is also unsuitable for the carriage of trainees as an experienced team is needed to operate the systems under what are often degraded conditions; no trainees should be programmed to be carried until after commissioning. The scheme of complement for a Virginia class submarine includes sixteen billets for trainees. It is likely that a further ten could be carried in spartan accommodation but maintenance of an effective training program for this total of twenty six trainees would be demanding for a submarine whose priority is to meet its operational tasks.

8.7 Pre-Joining Training.

8.7.1 A significant amount of equipment specific pre-joining training (PJT) to fit a submarine qualified sailor for a particular posting will also be required. This must be tailored to the individual's skills and experience and the new equipments he will be dealing with in his next posting. An arbitrary allowance of one month is allocated in the Manning Models at Annex E and F

8.8 Training Quotient.

A manpower planning allowance must be made for the provision of short-term relief for those obliged to leave their submarine for professional training courses. Conventionally it is assumed that an absence greater than 1 week will require a formal relief although this requires close management in order that the relief is suitably qualified which may require movement of the candidates through other submarines of the squadron.

8.9 Recertification for Returning Nuclear Power Plant Operators

8.9.1 Purpose. Nuclear power plant operators are required to be current in their watchkeeping position qualification prior to being left unsupervised in that position on a critical reactor. If they do not keep a watch in that position for six months (for example due to being appointed to a shore job or training course) they are obliged to undertake a requalification process. This regulation, whilst essential to the safety of the operations, places a heavy burden on the ME department management to ensure that the minimum numbers needed to operate the reactors (both shut down and critical) are sustained.

8.9.2 If a submarine is out of operation for a period in excess of six months (due to a defect or other constraint) programs for simulator training and assessment must be established or alternatively, personnel can be sent to sea in sister submarines to maintain their qualification. Requalification requires 3-4 months training, followed by a practical assessment identical to the initial qualification.

8.10 Pipeline Allowance.

An allowance has been added to the length of the training pipelines to allow for time delays caused by mismatches in course programming and other delays.

8.11 Overseas Training Allowance.

If, as is expected particularly in the early days, the RAN uses an overseas based University or Training School, two months should be added to the pipeline time for travel and settling in/out.

9 - Current RAN Manning

9.1 Crewing Ratios.

9.1.1 Rationale. The 'crewing ratio' is the ratio of how many qualified submariners are in the Navy to provide the seagoing submarine crews. This is a useful ratio for developing the gross manpower numbers.

9.1.2 RAN Current Crewing Ratios. Giving evidence to the Senate Estimates Committee in October 2011, the Chief Of Navy advised that the RAN had three submarine crews of 58 at sea and was attempting to form a fourth. There were a total of 559 qualified submariners compared with the 699 allowed in RAN manpower numbers. Assuming the RAN has 3.5 - 3.8 crews of 58, this gives a crewing ratio of 3.1 - 2.5. Alternatively, assuming that the RAN is theoretically manned to provide 4 crews of 58 from 699 personnel allowed for the SM Arm, this is a 'crewing ratio' of 3.3.

9.1.3 RN Crewing Ratios. It is understood that the RN currently successfully operates thirteen crews with a crewing ratio of 2.64 broken up as follows.

s33(a)(iii)

[redacted]

s33(a)(iii) [redacted]

Table 1 – RN Submarine Manning April 2012

9.1.4 Comparing The RN and RAN Crewing Ratios. s33(a)(ii) [redacted]

9.1.5 Selection of A Crewing Ratio For The RAN SSN Force. The manpower model used to illustrate the total numbers needed for ten SSN uses a crewing ratio of 2.8. This has been arbitrarily selected to be between the RN and RAN examples as a reasonable compromise between s33(a)(ii) [redacted])

9.2 Training Pipeline Status.

CN also advised (October 2011) that the RAN training pipeline was busy, with 149 trainees in the system (27% of the qualified SM arm) and working well, having just increased submarine numbers by a record 40% in the past year.

9.3 Formation of Crews.

It was also stated that the RAN could not achieve its goal of establishing four crews by the end of 2011 without stripping qualified submariners from the shore support positions. This practice has been tried in the past and inevitably leads to a systemic breakdown in manning numbers; CN advised that the RAN would not be repeating it. CN advised that the fourth crew had started to be formed but was some way off yet. Since overall numbers seem quite high, the inability to complete the fourth crew would appear to be the result of insufficient numbers of key technical or specialist officers and/or sailors. This was confirmed in 2013, updating the Senate Estimates Committee on 13 February 2013, CN indicated that despite net growth of 27 qualified submariners in 2009/10, 36 in 2010/11 and 9 in 2011/12, the RAN was unable to form the fourth crew due to the loss of experienced technical personnel, principally to the mining industry in Western Australia.[29]

9.4 Issues Arising.

These statements are evidence of two problems.

9.4.1 Firstly, it would appear that there is no difficulty in attracting recruits - trainee numbers are strong. Rather, it is the loss of experienced personnel that has prevented the formation of the fourth crew. This problem with experience retention in the COLLINS Class would only be magnified in the much larger submarine arm that would be needed to man ten SSN that are dependent for safe operation on personnel of a higher overall rank and longer experience. Recruiting of experienced personnel from overseas and extraordinary retention measures such as financial bonuses can assist, but the underlying requirement is for seagoing submarines undertaking real world operations. There is also a tension between growing basic numbers and lifting experience levels; submarines deployed on real world operations where their experience is honed, have a reduced capacity to carry basic trainees and a restricted ability to supervise and undertake their training. Adding to the tension between training and the real world operations; these operations are also a factor in generating a high morale/esprit de corps, a major factor in retaining experienced personnel.

9.4.2 Secondly, the at-sea training capacity is a major restriction on throughput; in this case s33(a)(ii) [redacted]

9.5 RAN Payment of Bonuses

At the Senate Estimates hearing on 13 February 2013 CN confirmed that the RAN had commenced paying individual bonuses to retain key categories of

[29] Hansard, Foreign Affairs, Defence and Trade Estimates, 13 February 2013

submarine personnel. Marine Technicians were being offered $20-40K per annum for two years in return for their service; Marine Engineer Officers were being offered $50K per year for two years under the scheme. [30]

9.6 Growth Plans for the COLLINS Class replacement

The RAN has not made any public announcements of its plans to develop the number of submarine crews required by the Government's Defence White paper released in May 2009, setting a goal to increase the force to twelve conventional submarines. A typical crew build-up plan and the details underpinning it are discussed in a paper written by the author. [31]

9.7 Lessons From The Past.

Any plans to increase the size of the RAN's submarine arm, be it for conventional or nuclear powered submarines, must develop a practical and achievable manpower plan. In the same paper on the implications of the Future Submarine Project [32] and its growth to twelve submarines it is argued that the experience with the Oberon class and ongoing experience with the COLLINS Class demonstrates the need to:

- Sustain the highest at-sea tempo possible during the build up and the transition phase,
- Initiate a long term steady development of the number of crews by multi-crewing these platforms, and
- Avoid a reduction in the number of operational submarines, during the transition; that is replace the old platforms with new submarines.

9.8 Growing Pains.

Meeting these criteria would be particularly challenging during a transition from a COLLINS Class submarine force to an SSN force when each crew is more than double the size. Nor, in simply making the numbers will two COLLINS crews provide the right balance of skills for one SSN crew. Surpluses in one area, e.g. an excess of Warfare officers will be offset by shortages in others, e.g. two Lieutenants Marine Engineering against a requirement for four Lieutenants (ME)

30 Ibid.

31 ***Briggs, Peter,*** Future Submarine – A Growth In Australia's Navy's Capability -Some Implications For The RAN, ANI Journal Headmark, March, 2011

32 **Ibid.**

and one Lieutenant Commander (ME) for each SSN crew. The imbalance would be most notable in technical sailors manning the propulsion plant, where the numbers, mix and skills are significantly different. Rectifying the imbalance will not be easy or quick; the lengthy training undertaken by officers and that of sailors is summarized at Annex C.

9.9 RAN Requirements For Engineering Graduates.

9.9.1 RAN Current Requirement. s33(a)(ii) [redacted]:

s33(a)(ii)

[redacted]

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s33(a)(ii) [redacted]

Table 2 – Estimate of RAN's Current Marine Engineering Requirement For Ships & Submarines

s33(a)(ii) [redacted]

9.9.3 The model developed for the SSN MEOSM+ requirement at Annex C Table C1 indicates that s33(a)(ii) [redacted] the current Fleet recruiting requirement. Let us now consider the RAN's current recruiting and training situation for mechanical engineering graduates.

9.9.4 Undergraduate Students Commencing Training. Data provided by the RAN for the number of students commencing a four-year Bachelor of Mechanical Engineering degree over the last five years indicates an average of s33(a)(ii) [redacted] students commenced each year. The data is very variable, with s33(a)(ii) [redacted] – perhaps reflecting uncertainty from the global financial crisis. Entry data is not a direct indicator of graduation numbers in four year's time as some completing students come with credit from previous studies and therefore have advanced standing; others take five years to complete the course.

9.9.5 Graduates For the purposes of this paper s33(a)(ii) [redacted] Not only is this graduation rate s33(a)(ii) [redacted] required to achieve the numbers estimated for the current surface ship Fleet plus a force of ten SSNs.

10 - Facilities and Their Manning Implications

10.1 Academic Educational Facility.

10.1.1 The need for an accredited University to deliver the academic courses in nuclear technology and engineering has been discussed in the training section above. The academic staff to conduct the training and administration would be supplied largely by the University, with a leavening of experienced RAN operators to provide a practical input to the courses including the operator and MANEUVERING ROOM TEAM TRAINER elements of the courses.

10.1.2 Given the interrelationship with the technical training for reactor operators there would be useful synergy in collocating the two types of instruction, both could then access the expensive Manoeuvring Room Team Training simulators required for training watch-keepers. Previous experience demonstrates that this training is best conducted at a naval training establishment, with access to a suitable university from which to draw its academic staff, rather than a university campus to avoid the abundant distractions of the latter. It will be necessary to provide suitable buildings to house an out-posted university faculty. The cost of this facility should be included in the project's costs, manning has not been included in the shore estimate.

10.2 Naval Technical Training School.

10.2.1 The various courses needed to prepare officers and technicians as nuclear power plant operators are discussed in the training section above. These are best conducted at a naval training environment. It is suggested that the existing marine technical propulsion training school at HMAS CERBERUS would make best use of the synergies available for existing infrastructure and therefore may determine where the academic faculty is also established.

10.3 Training Simulators.

10.3.1 As mentioned with regards the training, the courses will require a number of specialized (and expensive) training equipments. The fundamental difference between the RN's use of simulators and the USN's strong preference for live plant for training, discussed briefly in paragraph 4.1.4 would be a significant factor in deciding on the design of these training facilities. The RN model has been selected for this paper and is described below.

10.3.1.1 Reactor Simulator. A reactor simulator provides a high fidelity simulation of the reactor to enable watch-keepers to be educated in reactor theory, physics and reaction principles. This is largely to generate an understanding of reactor design principles rather than to teach principles of operation. It is an essential part of the ME officers' education (NRC) and a complementary part of the Nuclear Technicians Long Course.

10.3.1.2 One Reactor Simulator with a suitable level of support to ensure a high level of availability should suffice. It is assumed that the company supplying the simulator would provide the in-service support under a suitable maintenance contract.

10.3.2.1 Manoeuvring Room Simulator. On board a nuclear submarine, the reactor and its associated secondary steam plant are controlled from the Manoeuvring Room. This is manned at all times when the reactor is critical [33] by s33(a)(iii) [redacted] All operations (standard and emergency) are controlled from the Manoeuvring Room. In order to be able to train it is essential to provide the candidate watchkeepers with experience and the most effective way to do this is by use of a Manoeuvring Room Team Trainer (MRTT). The Maneuvering Room Team Trainer simulates the reactor and steam plant control and enables both individual and team training to be undertaken. This would be conducted at the training facility as part of the nuclear courses in order to prepare the candidates for their first sea appointment and later as they seek to move into the positions of higher authority. It is assumed that the company supplying the simulator would provide the in-service support under a suitable maintenance contract.

10.3.2.2 Continuation Nuclear Training. In order to qualify as manoeuvring room watchkeepers personnel undergo extensive emergency operating procedure training. This will take place on the Maneuvering Room Team Trainerlocated at the training establishment and as part of the Nuclear Reactor Course and Nuclear Technician Short and Long Courses. Those skills must be kept current but of course only limited emergency procedures can be exercised on a live plant. To maintain currency the operators are obliged to undergo continuation training, usually during maintenance periods for which a Maneuvering Room Team Trainer similar to that installed at the training facility will also be required at the operating base.

[33] A different level of manning is maintained when the reactor is shut down.

10.3.2.3 In addition to training, the Maneuvering Room Team Trainer will be needed for assessing and qualifying the watchkeepers. This is a continuous process that takes up much simulator time.

10.3.2.4 Finally, the Maneuvering Room Team Trainers are used to qualify and retain the currency of the shutdown watchkeepers. These are the manoeuvring room operators who man the reactor when it is shut down who must remain current in the shut down emergency procedures.

10.4 Nuclear Repair Facility and Nuclear Berths

10.4.1 Purpose. The Nuclear Repair Facility (NRF) is a licensed intermediate level [34] technical facility for routine maintenance and defect rectification on reactor systems. This is an essential intermediate level facility to maintain the safe operation of the reactor and its associated systems.

10.4.2 Siting.

10.4.2.1 Rationale. A NRF facility must be readily accessible to the operational submarines and those undergoing deeper refit or repair at the major dockyard facility. Two sites would be required for supporting ten SSN; one adjacent to or collocated with the operational base and the second at the dockyard. Both sites require the ability to dock an SSN.

10.4.2.2 RN Practice. By way of a comparison, the UK has had nuclear refuel/repair capabilities at Barrow, Chatham, Devonport and Rosyth and nuclear repair facilities at Portsmouth and Faslane - all within a few miles of major population centers. A number of other berths (usually within major ports, e.g. Liverpool, Cardiff) are licensed for visits and on occasions, limited nuclear repairs.

10.4.2.3 Classification of Nuclear Berths. Each berth to be used by a nuclear powered vessel is subjected to a risk assessment and given a category that defines the level of nuclear activity that may be undertaken. The category will restrict what can be done, at what plant state (pressure and temperature) and

34 The RAN has previously defined 3 levels of maintenance capability. *Organizational*, ie onboard the SSN, *Intermediate* available from a suitably equipped submarine base and *Depot level*, available from a suitable equipped civilian dockyard. Following recommendations in The Rizzo Report a return to this arrangement is anticipated.

for what period of time. The key in each case will be maintenance of primary, secondary and sometimes tertiary containment boundaries all with the purpose of limiting risk to the general public of exposure to radiation. Restrictions will also sometimes be placed on the extent (time and routine) of critical operations and call for the presence of an accident response team.

10.4.2.4 Australia's Requirements. Australia would have a reduced requirement, with no refueling requirement but inevitably will require nuclear repairs that call for a breach of the primary containment boundary. To permit that, restrictions would be placed on plant state, conduct of the repair, maintenance of secondary (and tertiary) boundaries and the time it is expected to take. This would be a significant public relations issue, requiring transparency and careful handling.

10.4.3 Manning. Allowance has been made in the shore based manning model at Annex A for the uniformed manning of the NRFs. The NRF adjacent to the Homeport is wholly uniform manning. To spread the manning loads, the model assumes that the second NRF is not manned until later in the build program, timed for the commissioning of SSN 09. Secondly, it is assumed that this NRF will make use of some civilian dockyard workforce manning and therefore needs fewer uniformed technicians. This accords with RN practice and experience.

10.4.4 RN Experience With Mixed Civilian and Naval Manning. s33(a)(iii) [redacted]

10.4 s33(a)(iii) [redacted]

10.4.6 Capabilities. The uniformed NRF structure is similar in concept to the RAN's Fleet Intermediate Maintenance Authorities (FIMAs) of yesteryear. The uniformed NRF must have the capacity to engage contractors to undertake specific work. They would also be resourced and equipped to provide a 'fly away' maintenance team capability. The uniformed NRFs would be manned by submarine technicians. This allows their operator experience to be applied in the repair and maintenance environment while also providing a particularly valuable, on the job training opportunity; essential to develop experienced uniformed organizational level maintainers (ie crew members of the submarines). This arrangement will also create shore jobs for uniformed nuclear technicians in the operating base and thus stability for those families who live in that area.

10.4.7 Nuclear Repair. The requirement to direct, conduct and certify repairs to nuclear plant is a highly disciplined process calling for deep expertise, rigorous execution and reliable audit procedures. Even the simplest of repairs will call for procedures to be designed, authorised and audited. Those procedures will call for expertise to be applied including for example, experts trained and qualified in nuclear system welding, plant instrumentation, chemistry, radiology, etc, It is not the purpose of this paper to identify how the civilian function of the NRF will be manned and trained but the extent of that task when Australia does not have a nuclear power industry background should not be underestimated.

10.4.8 Repairs Procedure Approval. All repairs or maintenance that have a nuclear safety implication (which includes breaches of the containment boundary e.g. the hull) can only be started if there is a written Nuclear Procedure authorised by an independent officer of appropriate qualification. This officer will chair a Procedure Authorisation Group (PAG) comprised members representing all those who will take part in the procedure – e.g. Repair Authority, Ship, Squadron, Base, Nuclear Repair Facility (NRF), contractors, etc. The Nuclear Procedure will detail the pre-requisites, special tools, isolation (Tag Out) boundary, precautions and then step by step the procedure itself which is then signed off as it progresses by those doing it and their supervising authority – usually MEO or duty engineer. The process is very rigorous and while a Nuclear Procedure could be a 2-page document authorised in 5 minutes it could also comprise several volumes reviewed daily while the job is in progress. It may include a range of external consideration, e.g. shore power supplies and possible effects on other submarines in harbour. The PAG Chairman will usually be an experienced former MEOSM+ assisted by a DPAG Chair usually a recent ship DMEOSM. They would have a staff of 2-4 CPO Technicians plus a Leading Writer to manage the library. Often a procedure can be drawn from the library but it must be authorised specifically for the ship and circumstances concerned. Manpower for these functions is included in the NRF manning at Annex A.

10.4.9 Nuclear Waste. Both the operating base NRF and the dockyard NRF will require mechanisms for the disposal of low-level nuclear waste. This would be in the form of (for example) used cleaning and irradiated materials. There would also be a need for a facility to purify discharged primary coolant that will have radiological implications. While in engineering terms this issue is not a major challenge, there is much emotion attached to the notion of nuclear waste disposal thus public relations issues would be an inevitability.

10.5 Radiological Protection and Reactor Incident Response Teams.

10.5.1 The training and manning of the RP and IR Teams is discussed above at Paragraph 5.8. In summary there will be a need for a uniformed RP and IR Team located primarily at the Operational Base but with a 'fly away' capability in order to support the submarines during port visits. A second RP and IR Team (probably civilian manned) will be required at the dockyard Nuclear Repair Facility.

10.5.2 While the skill specializations of this team are new to the RAN they are not new to the ADF. The Australian Army's Special Operations Engineer Regiment is skilled (inter alia) in specialist operations in radiological protection and is well practised in managing the requirements arising from radiation hazards[35]. This

[35] http://www.army.gov.au/Who-we-are/Divisions-and-Brigades/Special-Operations-Command/Special-Operations-Engineer-Regiment

expertise could be developed for the RAN probably in partnership with the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) and a relationship with a nearby a civilian hospital.

10.5.3 Manning. Allowance has been made in the shore based manning model at Annex A, table A5 for the uniformed manning of the RP and IR Team which may possibly be a mix of Navy and Army personnel. No allowance has been made for the civilian hospital function.

10.6 High Pressure/High Temperature Steam Training Facility.

10.6.1 Purpose. The Steam Training facility is intended to train operators and maintainers on the secondary steam plant including steam turbines, turbo generators and associated auxiliary equipment.

10.6.2 Facilities. The facilities would use a conventionally fired boiler together with generic steam turbines, etc. The facility would be used to train the operators in all aspects of operating the secondary systems and their components together with faultfinding and defect rectification. A secondary steam plant from a recently decommissioned submarine similar to the moored training ship concept in the USN would be an alternative.

10.6.3 Site. Given that there is no other steam turbine powered unit in the RAN this facility will be key to generating the basic knowledge needed in this discipline and should be located at the naval technical training school.

10.7 The Submarine School.

10.7.1 Purpose. The purpose of the Submarine School is to provide the specialist submarine training to new entry sailors, pre-joining training and career training to already qualified submariners. This is discussed further in the training section above.

10.7.2 Site. For practical reasons in the management of the at-sea Part III training, synergy with the Sea Training Group and in order to provide a useful source of shore billets to balance seagoing billets, the School should be under Submarine Squadron control and collocated at the Operational Base.

10.7.3 Facilities. The Submarine School will make extensive use of simulators, modern computer-based training systems, models and land based, single task trainers. Accordingly it will require extensive, custom designed facilities. These equipments will need to be maintained and upgraded in order to remain current with the technology that they are being used to teach.

10.7.4 Specialized Training Simulators. There are a number of specialized onboard equipments required for shore based maintainer and operator training to reduce the time taken to train onboard. Systems should include:

- The Manoeuvring Room Team Trainer.
- Ship control simulator that should be dynamically mounted to provide ship control team training under realistic conditions.
- The onboard emergency diesel generator and associated battery bank

10.7.5 Differences in the Use of Simulators. It is USN policy not to use simulators but wherever possible to use live reactors and steam test facilities for training purposes. The RN on the other hand makes extensive use of simulators. This practice is likely to be more appropriate to the RAN also, where in the longer term the use of simulators would be inevitable. In the event of a US supplied SSN this difference in policy may be significant and would need to be exposed and resolved early in the proceedings.

10.8 Shore Test Facility.

10.8 It is customary during submarine construction to assemble the principal secondary plant components at a shore test facility. The purpose is primarily to ensure that all the components are functioning correctly and in concert prior to them being installed in the submarine hull. This facility doubles as a training facility allowing ship's staff to become familiar with the equipment and its operation. In this case it would be expected that this facility would be located in the building country and consideration will have to be give as to the relative efficiency of gaining access to that facility or of developing a similar arrangement in Australia.

10.9 Submarine Command Team Trainer.

10.9.1 Purpose. The Submarine Command Team Trainer (SCTT) is used to provide individual operator, maintainer and pre-joining training in the command system. These facilities also provide an excellent tool for tactical development and post patrol analysis; both important capabilities to sustain a world class submarine capability.

10.9.2 Facilities. The SCTT makes extensive use of computer-based simulation of all the sensors, tactical displays and weapons. It is in high demand and in RN practice, frequently works in two shifts. Part task trainers for training individual operators, small teams and basic Part II trainees are also required. It is likely that the workload needed to support ten SSN would justify two complete and independent SCTT control rooms.

10.9.3 Site. The SCTT should be collocated with and managed by the Submarine School collocated at the operational base.

10.9.4 Manning. Manning for the SCTT is included in the shore numbers for the Submarine School, SCTT and Tactical Development Cell at Annex A, table A8.

10.10 Operational Base

10.10.1 Specialized Base Requirements. Submarines require specialized bases providing a range of dedicated support services, protected from extreme weather or sea states, with workshops, a docking capability and other facilities for intermediate level maintenance, training, armament depots and facilities for crew rest and recreation. The RAN's current Submarine base at HMAS STIRLING in WA has limited facilities to accommodate a visiting SSN alongside; the only such facility in Australia.

10.10.2 These facilities would require substantial upgrade and expansion to serve as an operational base for a squadron of ten SSN. Such additional facilities would include ability for handling and disposal of low level nuclear waste, purification and disposal of primary coolant (reactor water), etc. A further requirement is for the provision of shore supply electricity. For reactor safety purposes this must be guaranteed and hence available from two independent supplies. For submarines in port, there is typically one shore power source from the local grid. The quality of the power is important, minimum harmonics and fluctuations. The submarine has two internal sources of power, a battery and an emergency diesel generator. During docking operations when there is no shore power and the ship's installed diesel is not operable due to lack of seawater for cooling, a portable diesel is installed topside. The cardinal rule is that the ship must **always** have two independent sources of power. While not an issue this may (because of the distances involved) require some management or additional facilities. This paper will not develop details of these technical requirements; simply to note that they will be a significant component of the infrastructure costs associated with the project.

10.10.2 Manning. Manning for one operational base and its facilities is included in the Squadron numbers and general allowance of shore billets to offset the sea-going crew numbers. Should a second operational base be established on the east coast then additional personnel would be required. These could generally be provided from the surplus of submarine shore billets required to offset the seagoing billets, without an overall increase in the size of the submarine arm with one exception; s33(a)(ii) [redacted]

11 - The Sales Regime

11.1 Construction and Sea trials Arrangements

11.1.1 Responsibility for Safety and Build Standards. It is judged that it would be impractical to establish a separate Australian technical oversight capability in the Supplier nation's building yard. The entire program would therefore be undertaken using Supplier nation personnel and procedures for the construction phase – a similar process as for an off the shelf item of military equipment.

11.1.2 Supplier Nation's Responsibility For Safety and Build Performance. It is assumed therefore that the Supplier nation will provide suitably experienced personnel and the procedures necessary in order for the Supplier nation's Government to discharge responsibility for safety and build performance until completion of Sea Acceptance Trials and the post trials docking/maintenance availability that follows. Delivery of the submarine to the RAN will occur on completion of this availability/docking. This is a major load on the Supplier nation and will no doubt be a significant cost factor in any lease/sale arrangement.

11.1.3 RAN Crew Joining. The build period is an excellent preparation and training opportunity for the Australian crews. The manning model assumes that the crew joins at the normal timing for Supplier nation practice and provides the manpower to operate the submarine for trials, etc under Supplier nation control and supervision, reducing the need to provide a Supplier nation crew and also providing the benefit of the training opportunity for the RAN crews. Although this will raise some issues of licensing and certification, a senior commentator experienced in the construction of nuclear submarines has judged it to be 'do-able' given the will of both parties to make it happen. A broadly similar process to this was followed for the construction of the RAN Oberon class submarines in the UK in the 1960/70s.

11.2 Joining Sequence

11.2.1 On The Job Certification and Currency Training. Having completed conversion of previously qualified conventional submariners or initial submarine training in the Supplier nation's training system, the RAN crew should be well prepared for their role as crew for the SSN during build. However, there will be a range of training, certification and training required to demonstrate currency in key systems. It is assumed that the Supplier nation's training and certification system would meet these requirements.

11.2.2 System Assembly and Testing, Initial Criticality and Power Range Testing IC/PRT. s33(a)(ii) [redacted]

11.2.3 Marine engineering Department Joining Timings. The following joining routine is proposed:

s33(a)(ii) [redacted]

s33(a)(ii) [redacted].

11.2.4 The Weapons Engineering Department. s33(a)(ii) [redacted].

11.2.5 Executive and Supply Departments. s33(a)(ii) [redacted].

[redacted]

[redacted] rt [redacted].

11.2.6 Commanding Officer. s33(a)(ii) [redacted].

11.3 Operating & Overhaul Regimes

11.3.1 Principals of A Submarine Operating Cycle.

11.3.1.1 s33(a)(ii) [redacted]

11.3.1.2 s33(a)(ii) [redacted]

s33(a)(ii) [redacted].

11.3.2 s33(a)(ii) [redacted].

11.3.3 s33(a)(ii) [redacted].

11.3.4 s33(a)(ii) [redacted].

11.3.5 Refit Cycles.

11.3.5.1 s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

11.3.5.2 s33(a)(ii) [redacted]

11.3.6 s33(a)(ii) [redacted]

11.3.7 s33(a)(ii) [redacted]

11.4 Delivery Process.

11.4.1 s33(a)(ii) [redacted]

11.4.2 s33(a)(ii) [redacted]

11.4.3 s33(a)(ii) [redacted]

11.5 Shut Down Operations

11.5.1 Once a reactor has been taken critical for the first time it begins to develop a fission product inventory and hence constitutes a potential hazard if not monitored and controlled appropriately. The safety systems are designed to mitigate the risks associated with that and the training and qualifications of the crew are a significant part of that mitigation. s33(a)(ii) [redacted]

11.5.2 s33(a)(ii) [redacted]. No allowance has been made for this in the manning model on an assumption that appropriately qualified personnel can be found within the NRF and the Squadron but it should be recognized that additional personnel might be required to sustain a ten SSN squadron.

11.5.3 s33(a)(ii) [redacted]

11.6 The Handback Process

11.6.1 Manning Implications. It is assumed that the lease or purchase arrangements will provide for the SSN to be returned to the Supplier nation at the end of life, for decommissioning and spent reactor fuel storage or recycling. Whilst this will obviously be a significant task and no doubt attract appropriate costs, it is assumed that there are no manpower implications for the RAN once the SSN are delivered to the Supplier nation at their end of life.

12 - Program Timings

12.1 Manning Implications for Building the SSN.

12.1.1 RAN Crew. s33(a)(ii) [redacted]

12.1.2 Crew Joining Sequence. The details of the crew joining sequence are discussed at section 11.2

12.2 Establishing Australian Regulatory/Safety Oversight Capabilities.

12.2.1 It is essential that an adequate shore oversight and regulatory infrastructure is established prior to the assumption of responsibility for the nuclear safety of SSN01. Depending on the expertise and experience required for the position these could be drawn from a number of sources:

- s33(a)(ii) [redacted]

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s33(a)(ii) [redacted]

12.2.2 s33(a)(ii) [redacted]

12.2.3 s33(a)(ii) [redacted]

12.3 s33(a)(ii) [redacted]

12.4 Managing The Training Pipeline

12.4.1 s33(a)(ii) [redacted]

12.4.2 Planning Proportions. s33(a)(ii) [redacted] The annual training targets to achieve this and provide some growth in the shore support infrastructure are discussed below.

12.4.3 Annual Manpower Training Numbers s33(a)(ii) [redacted]

- s33(a)(ii) [redacted].

[redacted].

12.4.4 Supplier Nation's Training System capacity. One of the key issues in assessing the practicality of this plan is the Supplier nation's capacity to provide this level of assistance both for the shore training courses but critically, for the at-sea training.

12.4.5 Suitability of RAN Submariners for Conversion. A further factor will be the suitability and personal preferences of the existing Collins workforce; not every member will be willing or able to complete the conversion training. Additional academic preparation will be required to enable personnel to undertake this training with a better chance of success.

12.4.6 Balancing Categories. The conversion and ab initio training pipelines need to be loaded with the right balance of specializations (Warfare, Marine Engineering, Weapons Engineer or Supply specialisations) and ranks, based on the proportions of the breakdown of the Scheme Of Complement per Annex B.

12.5 Combined Impact of Manning Essential Shore Billets and SSN01

12.5.1 An illustrative set of timings and manpower required to man the essential shore billets that must be in place and certified before the Australian Government assumes responsibility for the safe operation of SSN 01 (Shore Phase I in Annex A) and the crew for SSN01 with an allowance for attrition is set out in Annex G. s33(a)(ii) [redacted]

SSN01 Table G3 provides a breakdown of the s33(a)(ii) [redacted]

12.6 An Alternative Approach

12.6.1 It would appear that the RAN will need to increase the size of its submarine arm manpower substantially to meet this requirement. One option for doing so would entail enlarging the RAN submarine Arm along the lines envisaged in the 2009 Defence White paper with the construction of 12 modern conventional submarines, larger and more capable, to replace the Collins class. This appears to be one of the few practical solutions to this problem and an essential step on the path to introducing a force of SSN. Assuming a crew of 50 in the replacement submarine, (Collins has a seagoing crew of ~ 45) and an availability of 66%, this would result in 8 operational submarines from a force of 12. Deliberately increasing submarine arm manning to provide a reservoir of trained personnel would appear to be an essential part of the manpower strategy; multi crewing [36] or double crewing [37] would lead to a sea going force of 600 – 800 personnel. Applying a crewing ratio of 2.8 (the same as developed for the SSN program), this would entail a submarine arm of 1680-2240 qualified personnel.

12.6.2 Given this significantly larger trained force of personnel, this initial surge would still entail committing 20-27% of the trained force to this task. It seems likely that the RAN would also have to allocate the SSN training requirements priority for manpower and divert experienced personnel from the surface navy to submarine training in order to meet this need.

13 - Summarising Manning Outcomes from Models

13.1 Caution!

The manning models have been compiled to outline the scale of the management problem and identify where possible the key issues that will be encountered. Whilst every attempt has been made to apply available experience it should be recognized that there might be further unforeseen issues. The

36 Three crews for each of 2 operational submarines, ie12 crews.

37 Two crews for each operational submarine, ie 16 crews.

manning model is at this stage quite crude and whilst it may be used to illustrate the points raised in the paper it would need refining in much greater detail before it can considered an accurate way to estimate the precise requirements for the manpower associated with the proposal.

13.2 Minimum Number of SSN for A Sustainable Manpower Base

From the manning model it is assessed that the minimum number of SSN for a sustainable manpower base is ten. This number is necessary to ensure that sufficient MEOSM+ officers are generated to bring the right experience to the senior posts in the essential shore safety and supervisory billets. If less than ten SSN are operated, shortages can be expected to develop in the Marine Engineering category. It may be possible temporarily to sustain fewer than ten SSN by recruiting additional experience from overseas, but this is unlikely to be a viable long-term strategy. If, however, six or fewer SSN are operated it is probable that shortages will develop in the s33(a)(ii) branches, after which crisis management measures will need to be taken and ultimately the hulls will be laid up for want of qualified crews.

13.3 Overall SM Arm Numbers.

13.3.1 The manning model demonstrates that the total number of uniformed submarine officers and men needed to man ten SSN sustainably is circa s33(a)(ii) qualified submariners, using a 'crewing ratio' of 2.8. Allowing for an additional s33 in the training pipeline, a total manpower allowance of approximately s33(a)(ii) would be required. This ratio has been selected between the s33(a)(ii) , the current RN and RAN submarine manning experience (see Paragraph 9.1) provide a helpful sanity check and some 'collateral' evidence that the manning model is giving results that are in the right order of magnitude.

13.3.2 The figure of s33(a)(ii) qualified personnel represents approximately a s33 growth in the RAN's current SM Arm of s33 qualified positions. The increase of the Submarine Arm's manpower current allowance of s33 qualified and say, s33 trainees to s33(a)(ii) qualified plus s33 trainees, ie from s33(a)(ii)

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personnel would represent an increase of circa s33(a)(ii) [redacted] in the size of the RAN [38] (unless offsets are provided as suggested by Professor Babbage). [39]

13.4 s33(a)(ii) [redacted]

14 - Conclusions

[Paragraph numbers bracketed in each paragraph refer to the appropriate paragraph or section in the paper]

14.1 Key Issues

14.1.1 Impact Of A Nuclear Power industry. Both the UK and USA initiated significant nuclear powered electrical generation programs in parallel with their introduction of nuclear powered submarines, spreading the costs of the underpinning academic infrastructure; a downside to this arrangement was the resulting competition for trained personnel. Such a parallel program seems an unlikely event in Australia.

14.1.2 Uncounted Cost of Manpower. Whilst Australia does have a framework of nuclear safety regulation, some nuclear engineering and academic competencies and an incident response capability, these would require expanded regulation and substantial new naval and academic infrastructure to support the proposal. These are generally identified in Section 10 of this paper. Where the manpower requirement is not included the fact is noted in this paper. These missing capabilities are generally highly specialized and would require substantial lead-times to address [Sections 5 and 10].

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[38] RAN permanent manpower strength 14,215 http://en.wikipedia.org/wiki/Royal_Australian_Navy

[39] *Babbage Ross*, Australia's Strategic Edge in 2030, Kokoda Paper #15, February 2011, p92, Options 2, 3 and 4

14.1.3 Australia's Sovereign Responsibility for Safety. A democracy such as Australia would not wish to outsource responsibility to a foreign government for the safety of RAN submarines operated in Australia by RAN crews. The paper assumes that the Minister for Defence as an elected representative and member of the Government assumes ultimate responsibility for nuclear safety, with an independent auditing process overseen by a second Minister. It is likely that ongoing Supplying Navy monitoring will be a condition of any sale/lease, to ensure that these processes remain adequate for safe operation. The paper estimates the structures the shore support infrastructure and manning required accordingly [5.1]. The integration of the new capabilities with Australia's existing nuclear regulatory and advisory bodies described in Section 5 would be important to the smooth functioning of the program and warrants early consideration.

14.1.4 Criticality of Supplier Nation's Support. None the less, Australia would have to lean heavily on the Supplier nation's navy while establishing this oversight capability, drawing on their advice and recruiting some of the key experience required to establish this at the program start up. The entire program would require substantial access and support from the Supplier nation's navy and academic training systems and access to Supplier nation's seagoing submarine force to convert Collins class submariners and undertake ab-initio training.

14.1.5 Impact of Overseas Training. Engineering personnel undertaking training prior to standing by an SSN being built would face a protracted period of absence from Australia; in some cases up to seven years. The overall impact of this combination of issues would pose significant capacity, security and social issues for the RAN and Supplier nation's navy and would be an early issue for agreement in developing such a program. Administration of this effort would require additional personnel and expenditure; estimates for the administrative manpower involved are not included in this paper. **Given the likely real world restrictions on the Supplier nation's capacity and possibly, their willingness to render this support, this issue is flagged as a major risk for the program.**

14.1.6 Start Up Costs. Given the absence of a civilian nuclear power generation industry, the nuclear submarine program would have to bear the cost of establishing additional Australian regulatory, SUBSAFE [4.1.6, 5.12.4], industry and academic capabilities to provide the essential oversight, maintenance and training capacities. The manpower required for the non-naval academic and all the industry capabilities is not included in this paper. [Sections 5 and 10]

14.1.7 Marine Engineers. The recruitment, training and retention of Marine Engineers is likely to be one of the most critical manpower challenges. There is already a shortage of engineers in Australia – generating a Senate inquiry into the matter at the time of writing this paper. It is estimated that the SSN program would require the annual graduation of fifteen recruits from a four-year bachelor's degree in mechanical engineering in order to sustain ten SSN. Over the past four years the RAN has graduated an s33(a)(ii) [redacted]

[7.2.1.7, 9.10]

14.1.8 Manning Model? The choice between a Specialised Officer or Line Officer manning and training model will need to be made at an early stage. This is not a trivial decision and would s33(a)(ii) [redacted].

14.1.9 Use Of Simulators Vice Reactors For Shore Training. The RN's use of simulators, rather than a live training plant ashore is also a significant point of difference between the two training systems. Simulators would obviously be significantly easier to install in Australia than a training reactor and have been assumed in the manning allocated for shore training. It may be, however that any arrangement for transferring nuclear technology from the Supplier nation may attract an obligation to adopt their model [4.3, 4.4].

14.1.10 Commanding Officer's Qualifying Course. s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

14.1.12 Sustaining Submarine Numbers During The Transition. There will be a need to sustain the conventional submarine capability during the transition to avoid a dip in hull numbers, leading to the production of qualified submariners or a cessation of submarine operations. This is a major lesson drawn from the Oberon-Collins transition.

s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

14.1.15 Minimum Number of SSN Required to Maintain a Sustainable Manning Structure. Given sufficient quantities of recruits of the right quality, the number of SSN purchased or leased is a key issue, determining the capacity to train personnel and generate the experienced personnel needed to man the essential, critical positions at sea and ashore. Ten SSN is judged as the minimum to generate the key Marine Engineering personnel to man the essential shore infrastructure providing technical support and safety oversight. s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

14.1.18 Building Up From A Small Submarine Manpower Base. The USN and RN transitioned to nuclear powered submarines from large but shrinking forces of conventional submarines. Both navies had a substantial but shrinking number of steam turbine powered surface ships. This combination of circumstances made available the manpower, particularly engineering officers and senior sailors with experience appropriate to a nuclear submarine program. In both cases the transition was a significant challenge albeit driven by the tangible threats posed by the cold war. s33(a)(ii) [redacted] The four years prior to commissioning SSN01 will be particularly challenging.

s33(a)(ii) [redacted]

14.2 Decision Timings to Avoid a Submarine Capability Gap.

14.2.1 Setting aside the major risk issues identified in paragraphs 14.1 above, there remains the issue of avoiding a gap in Australia's submarine capability. The first Collins is due to pay off at the end of its planned life in 2025. Whilst a life extension program is feasible, this will divert financial and technical resources and the operational capability obtained will be problematic; as one would expect from an effort to extend 1980s technology into the 2030s. The most optimistic schedule to initiate and negotiate arrangements and a nine year construction period, with a decision to embark upon this program in 2014 would result in commissioning SSN01 in January 2029, this is illustrated at Annex G. It has been concluded that this timetable is not possible given the manpower required to achieve it and the current state of submarine manpower. Finally, achieving the necessary decisions within this timeframe would appear improbable.

14.3 Risk Mitigation.

14.3.1 s33(a)(ii) [redacted].

14.3.2 s33(a)(ii) [redacted].

14.3.4 s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

14.3.5 s33(a)(ii) [redacted]

15 - Recommendations

15.1 Ensure An Adequate Supply of Manpower.

There are many critical aspects to successfully establishing an SSN capability for the RAN. The capacity to supply the necessary skilled and trained manpower as and when required to safely operate and maintain these submarines is fundamental to success. Embarking on such a program should not be contemplated without solving this challenge. To do otherwise would be a waste of significant resources and leave Australia without an operational submarine capability at a time when it may need it most.

15.2 Grow The Conventional Submarine Force First.

Accordingly, Australia should proceed with a replacement submarine program for 12 capable conventionally powered submarines as foreseen in the 2009 Defence White Paper. The opportunity should be taken to ensure that this program is undertaken in a manner that will facilitate a decision to move to nuclear powered submarines at a later date, should that be the national decision.

P Briggs AO CSC

RADM RAN Rtd

23 February 2013

Annexes:

A. Shore Manning Scheme of Complement.

B. SSN Scheme of Complement.

C. MEO, XO and WEOSM Training Pipelines.

D. RN Officers Training Courses.

E. RN Sailors Training Courses

F. At Sea Training Throughput.

G. Illustrative Timings SSN01

Attachment:

1. Head of Nuclear Reactors Duty Statement

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Head Nuclear Reactors Duty Statement

1. The Executive Order setting out the position description created to perpetuate the Head of Nuclear Reactors when Admiral Rickover was retired was later enshrined in law. It read:

Executive Order 12344--Naval Nuclear Propulsion Program

Source: The provisions of Executive Order 12344 of Feb. 1, 1982, appear at 47 FR 4979, 3 CFR, 1982 Comp., p. 128, unless otherwise noted.

By the authority vested in me as President and as Commander in Chief of the Armed Forces of the United States of America, with recognition of the crucial importance to national security of the Naval Nuclear Propulsion Program, and for the purpose of preserving the basic structure, policies, and practices developed for this Program in the past and assuring that the Program will continue to function with excellence, it is hereby ordered as follows:

Section 1. The Naval Nuclear Propulsion Program is an integrated program carried out by two organizational units, one in the Department of Energy and the other in the Department of the Navy.

Sec. 2. Both organizational units shall be headed by the same individual so that the activities of each may continue in practice under common management. This individual shall direct the Naval Nuclear Propulsion Program in both departments. The director shall be qualified by reason of technical background and experience in naval nuclear propulsion. The director may be either a civilian or an officer of the United States Navy, active or retired.

Sec. 3. The Secretary of the Navy (through the Secretary of Defense) and the Secretary of Energy shall obtain the approval of the President to appoint the director of the Naval Nuclear Propulsion Program for their respective Departments. The director shall be appointed to serve a term of eight years, except that the Secretary of Energy and the Secretary of the Navy may, with mutual concurrence, terminate or extend the term of the respective appointments.

Sec. 4. An officer of the United States Navy appointed as director shall be nominated for the grade of Admiral. A civilian serving as director shall be compensated at a rate to be specified at the time of appointment.

Sec. 5. Within the Department of Energy, the Secretary of Energy shall assign to the director the responsibility of performing the functions of the Division of Naval Reactors transferred to the Department of Energy by Section 309(a) of the Department of Energy Organization Act (42 U.S.C. 7158), including assigned civilian power reactor programs, and any naval nuclear propulsion functions of the Department of Energy, including:
(a) direct supervision over the Bettis and Knolls Atomic Power Laboratories, the Expended Core Facility and naval reactor prototype plants;
(b) research, development, design, acquisition, specification, construction, inspection, installation, certification, testing, overhaul, refueling, operating practices and procedures, maintenance, supply support, and ultimate disposition, of naval nuclear propulsion plants, including components thereof, and any special maintenance and service facilities related thereto;
(c) the safety of reactors and associated naval nuclear propulsion plants, and control of radiation and radioactivity associated with naval nuclear propulsion activities, including prescribing and enforcing standards and regulations for these areas as they affect the environment and the safety and health of workers, operators, and the general public;
(d) training, including training conducted at the naval prototype reactors of the Department of Energy, and assistance and concurrence in the selection, training, qualification, and assignment of personnel reporting to the director and of personnel who supervise, operate, or maintain naval nuclear propulsion plants; and
(e) administration of the Naval Nuclear Propulsion Program, including oversight of program support in areas such as security, nuclear safeguards and transportation, public information, procurement, logistics, and fiscal management.

Sec. 6. Within the Department of Energy, the director shall report to the Secretary of Energy, through the Assistant Secretary assigned nuclear energy functions and shall serve as a Deputy Assistant Secretary. The director shall have direct access to the Secretary of Energy and other senior officials in the Department of Energy concerning naval nuclear propulsion matters, and to all other personnel who supervise, operate or maintain naval nuclear propulsion plants and support facilities for the Department of Energy.

Sec. 7. Within the Department of the Navy, the Secretary of the Navy shall assign to the director responsibility to supervise all technical aspects of the Navy's nuclear propulsion work, including:
(a) research, development, design, procurement, specification, construction, inspection, installation, certification, testing, overhaul, refueling, operating practices and procedures, maintenance, supply support, and ultimate disposition,

of naval nuclear propulsion plants, including components thereof, and any special maintenance and service facilities related thereto; and
(b) training programs, including Nuclear Power Schools of the Navy, and assistance and concurrence in the selection, training, qualification, and assignment of personnel reporting to the director and of Government personnel who supervise, operate, or maintain naval nuclear propulsion plants.

Sec. 8. Within the Department of the Navy, the Secretary of the Navy shall assign to the director responsibility within the Navy for:
(a) the safety of reactors and associated naval nuclear propulsion plants, and control of radiation and radioactivity associated with naval nuclear propulsion activities, including prescribing and enforcing standards and regulations for these areas as they affect the environment and the safety and health of workers, operators, and the general public.
(b) administration of the Naval Nuclear Propulsion Program, including oversight of program support in areas such as security, nuclear safeguards and transportation, public information, procurement, logistics, and fiscal management.

Sec. 9. In addition to any other organizational assignments within the Department of the Navy, the director shall report directly to the Chief of Naval Operations. The director shall have direct access to the Secretary of the Navy and other senior officials in the Department of the Navy concerning naval nuclear propulsion matters, and to all other Government personnel who supervise, operate, or maintain naval nuclear propulsion plants and support facilities.

Sec. 10. This Order is effective on February 1, 1982.

Ronald Reagan

Attachment 1

Extract from
Public Law 106-65
106th Congress

SEC. 3216. DEPUTY <<NOTE: 50 USC 2406.>> ADMINISTRATOR FOR NAVAL
REACTORS.

(a) In General.--(1) There is in the Administration a Deputy Administrator for Naval Reactors. The director of the Naval Nuclear Propulsion Program provided for under the Naval Nuclear Propulsion Executive Order shall serve as the Deputy Administrator for Naval Reactors.

(2) Within the Department of Energy, the Deputy Administrator shall report to the Secretary of Energy through the Administrator and shall have direct access to the Secretary and other senior officials in the Department.

(b) Duties.--The Deputy Administrator shall be assigned the responsibilities, authorities, and accountability for all functions of the Office of Naval Reactors under the Naval Nuclear Propulsion Executive Order.

(c) Effect on Executive Order.--Except as otherwise specified in this section and notwithstanding any other provision of this title, the provisions of the Naval Nuclear Propulsion Executive Order remain in full force and effect until changed by law.

(d) Naval Nuclear Propulsion Executive Order.--As used in this section, the Naval Nuclear Propulsion Executive Order is Executive Order No. 12344, dated February 1, 1982 (42 U.S.C. 7158 note) (as in force pursuant to section 1634 of the Department of Defense Authorization Act, 1985 (Public Law 98-525; 42 U.S.C. 7158 note)).

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Crewing Implications of Certain Options

Part II

(CICO – II)

RADM P D Briggs AO CSC RAN Retired

This Paper examines the naval manpower implications of the acquisition of a force of nuclear powered attack submarines by Australia. Part I considers acquisition of US VIRGINIA or UK ASTUTE class, Part II the French Barracuda class SSN.

Regardless of the propulsion technology used the author believes that the size of the RAN's submarine arm must be increased to manage the transition to a new class of submarine; expanding to 6-7 Collins crews, effectively doubling its size.

This starting point, when combined with the direct recruiting of experienced nuclear personnel from overseas and an initial training pipeline utilising the French Navy's submarine training system, with sufficient lead time prior to the commissioning SSN 01 should provide sufficient manpower to undertake the program.

This is not a simple or easily achieved target; it would require national commitment and Navy dedication.

There are a number of outstanding and significant questions to be resolved; eg Australia's capacity to generate the required number of high quality young officers and sailors needed and the French Navy's training system's capacity to train them.

The major conclusion is that given a positive answer to these questions and this level of national commitment Australia could man a force of 10 Barracuda class SSN. The relatively small crew size of 60 (comparable to that of a Collins and less than half the size of the larger SSN) is what makes this proposition possible.

Table of Contents

Executive Summary

1. Following release of the Defence White Paper in May 2009 some commentators have suggested that Australia should acquire a force of nuclear powered attack submarines (SSN), in lieu of the recommended growth in Australia's conventionally powered submarine capability. [Section 1]

2. Part I of this paper considered the options of acquiring a force of Virginia or Astute class SSN currently in operation with the USN and RN respectively. Part II of this paper considers the option of acquiring a force of Barracuda class SSN currently being built for the French Navy, the Marine Nationale (MN). The first of these submarines is due to be commissioned in 2017.

3. Both parts of this paper consider only one of the many significant issues arising from this suggestion; the naval manpower required to operate and safely sustain such a force. The papers draw on the USA, UK and French experiences in setting up their SSN capability. [Section 2, 3, 4 and 5]

4. A series of manpower models, based on the crew numbers and skills used in the current USN, RN and MN SSN and the UK/French shore infrastructure has been used to develop an understanding of the numbers, skills and training involved. Allowance for attrition at the various stages of an individual's career is used to enable evaluation of the number of personnel required to enter the system each year to sustain the capability. [Section 6, 7, 9 and 10]

5. It is assumed that Australia would wish to maintain a sovereign capability to ensure and oversee the safe operation of such a force. Establishing this capability prior to the arrival of the first SSN would entail additional capabilities in Australia's existing nuclear regulatory bodies and a major expansion of the Navy's technical oversight and training capabilities. [Section 5]

6. The UK, USA and France established their SSN capabilities under the national imperative of the Cold War, drawing upon a large force of conventionally powered submarines and a large but contracting force of steam powered surface ships. This situation assisted in providing the essential manpower and skills base; nonetheless the task was a serious challenge for each navy. Australia has none of these resources and would have to draw heavily on the supplier navy's training system and seagoing submarine force to train its personnel. The availability of the

necessary level of support would be a major risk for an Australian SSN program and one that deserves early resolution. [Section 4]

7. The numbers and skillsets in an SSN crew are significantly different to that of a Collins crew. Though the crew of a Barracuda would be similar size to of a Collins or a future large conventional powered submarine the demands of operating a complex platform such as an SSN with a crew of 60 (less than half that of a Virginia or Astute class SSN) only serves to accentuate the need for the required crew skills. The training program would entail converting existing RAN submarine personnel and a substantial initial training program. Both would require long periods of training and overseas service to gain the necessary experience.

8. This Paper assumes that until Australia's SSN force reached sufficient operational submarines to undertake the at sea training of trainees, say at least 6 SSN, this training would have to be mainly conducted overseas. Depending on the build interval, this number of SSN would be achieved approximately 16-19 years after initiating the program. At this point RAN schools and a nuclear engineering faculty established with a selected Australian University could begin to take over this task. In the absence of any nuclear power generation industry in Australia, the cost of establishing and operating this training infrastructure would be borne by the SSN program. The alternative of a hybrid French/Australian training system using Australian facilities with mixed staffing could enable a reduction of the time required overseas and warrants further examination. [Paragraph 7.3]

9. Apart from the cost implication of academic faculties dedicated to the RAN's SSN program, the absence of a nuclear power industry is not seen as a serious obstacle. [Section 7]

10. The USN, RN and MN experience indicates that the most critical personnel categories are likely to be Marine Engineer Officers, senior sailor Nuclear Technicians and command qualified Executive Officers. The RN and MN use professional mechanical engineers (similar to the current RAN officer model). Under this model, Marine Engineers the RAN would have to s33(a)(ii) [redacted] This is identified as a major risk for the SSN program. [Section 4 and 9]

11. Modelling indicates that at least 10 SSN would be required to generate sufficient sea days to create numbers of these critical categories to man the crews and sustain the essential shore technical oversight. [Paragraph 5.14]

12. The MN intends to continue their current practice and double crew the Barracuda in order to provide attractive conditions of service – essential to sustaining their manning and achieve a cost effective return on the investment. If the RAN followed this model this would lift the sea going manpower numbers to 1,080 and an overall submarine arm qualified manpower allowance of 2,900 personnel. This would be over 4 times the current allowance of 704. The conclusion arrived at Part I stands – growth of sufficient personnel to man an SSN program of this size is s33(a)(ii) [redacted] s33(a)(ii) [redacted] continue to operate the Collins force. [Paragraph 14.1].

13. A single crewed program would require s33(a)(ii) [redacted] the current allowance. [Paragraph 9.1.4]

14. An illustrative set of timings and manpower required to man the essential shore billets that must be in place and certified before the Australian Government assumes responsibility for the safe operation of SSN 01 and the crew for SSN01 with an allowance for attrition is set out in Annex B.

15. It is proposed to increase the size of the RAN Submarine Arm by s33(a)(ii) [redacted] personnel required to man a force of 10 single crewed Barracuda over the 19-20 years of an SSN program would be demanding but should be achievable. [Paragraph 12.5.3]

16. There are a number of significant questions to be resolved in developing a full understanding of the manpower issues and the feasibility of this program:

a) The crew skills and balance entailed in the MN manning model for Barracuda. [Paragraph 6.4]

b) The range of training issues identified in Section 7, including the feasibility of a hybrid French/Australian training system.

c) The refitting strategy; are these to be carried in Australia or France? [Paragraph 10.3]

d) Is a shore based training reactor required? [Paragraph 4.1.5, 10.11]

e) There are a number of assumptions regarding the construction and Sea Trials model at paragraph 11.2.

f) Does the MN have the training capacity to support an RAN program as postulated? [Paragraph 12.4.4]

g) Is a hybrid French/Australian training system feasible, reducing the periods spent in France for training?

17. These and the many other issues likely to be raised by consideration of this proposal can only be resolved by French/Australian Government sponsored formal discussions with the MN and DCNS.

18. It is recommended that a third option be added to the current Department of Defence considerations to provide Government with First Pass options for achieving the Future Submarine; the feasibility of undertaking a program to acquire a force of 10, single crewed Barracuda class SSN. A decision made by January 2016 could reduce or avoid the financial and operational impact of a life extension program for the Collins Class.

1 - Introduction

1.1 The Proposal

In his paper Australia's Strategic Edge in 2030 (Kokoda Paper #15) written in February 2011, Dr Ross Babbage AM suggested the lease or purchase of 10-12 VIRGINIA class nuclear powered attack submarines (SSN). The first part of this paper examined the manpower implications of Australia leasing or purchasing Virginia or Astute class SSNs. These SSNs require a crew of 121 submarine qualified personnel, as concluded in the first part of this paper; this is a major and perhaps a decisive factor against the feasibility of this proposal.

1.2 The Objectives of This Paper

The second part of this paper will examine the manpower required to man a force of 10 smaller SSNs of the French Barracuda class currently under construction for the French Navy.

This Paper will focus solely on the manning issues. It will draw on the work of the first part where appropriate to avoid repetition.

As in the first part the very real public policy, political, strategic and finance issues are not considered.

Where assumptions are made these are stated, general a minimalist approach is followed, i.e. the result is a conservative answer; the capability cannot be achieved with less manpower and may well require more.

1.3 Acknowledgements

I wish to acknowledge the assistance of the experienced French submarine specialists/industrialists and my ex RAN and RN colleagues in developing this paper.

2 - The French Barracuda Class Submarine

2.1 Description

2.1.1 Barracuda Construction Program. Six Barracuda nuclear-powered attack submarines are under construction for the French Marine Nationale (MN). The Barracuda Class is being introduced to replace the existing force of four Rubis submarines which entered service from 1983 to 1988 and the two Amethyste Class submarines which entered service in 1992 and 1993. All SSN except RUBIS have now been upgraded to the Amethyste combat system standard. Six SSN have found to be the minimum number to generate the required number of experienced Commanding Officers for the SSBN force (successful command of an SSN is a pre-requisite for command of an SSBN).

2.1.2 Rubis and Amethyste Class Submarines. The Rubis and Amethyste classes of submarines replaced a force of 20 conventional submarines operating in 2 Squadrons. The first Barracuda class SSN; the Suffren is due to go to sea in 2016 and commission in 2017.

2.1.3 Sources of Technical Details. The technical details used in this paper are based on published information.

2.1.4 MN SSN Missions. The primary mission of the MN submarine force is anti submarine warfare, in particular to protect the deployment of the French SSBN's and the nuclear powered aircraft carrier, Charles de Gaulle. However, the SSN are a multi role platform and carry the torpedoes, mines or missiles necessary to undertake anti surface ship operations and land strike using cruise missiles. Provision has been made to carry special forces and an external shelter can be fitted to house their equipment. [1]

2.1.5 Design Precedents. The submarines are a development from the Rubis and Amethyste classes though they are substantially larger, displacing 5,300 tonnes submerged, with a length of 99.4m and a pressure hull diameter of 8.8.m. [2] One of

[1] http://en.wikipedia.org/wiki/French_Barracuda-class_submarine

[2] en.wikipedia.org/wiki/Rubis-class_submarine

the lessons learnt from the earlier classes is the need to provide better access for maintenance; as a result a substantial reduction in the cost to operate these submarines is anticipated. Many of the technologies developed by DCNS for the Le Triomphant Class nuclear powered, nuclear capable, ballistic missile submarines (SSBN) and by Izar and DCNS for the Scorpene Class SSKs are being integrated into the design of the Barracuda and reflect an ongoing development of the nuclear security rules.

2.1.6 Endurance. The high level of automation integrated into the submarine's operational and mission systems will allow it to operate for 70 days with a complement of 60 compared to 78 in the Rubis and Amethyst Classes. The operational cost is expected to be reduced by 30% compared to that of the Rubis Class. The Barracuda incorporates a range of diving, safety and damage control technologies and an Integrated Platform Management System (IPMS).

2.1.7 Signature. The design incorporates a range of stealth technologies to minimise the acoustic, magnetic, radar and visual signatures. The Barracuda is designed to provide a high silent running speed and good manoeuvrability for the anti-submarine role.

2.1.8 Atmospheric Life Support Systems. EADS Astrium is supplying the life support system for the submarine, which will be based on the carbon dioxide regenerative technology Astrium has developed for human spaceflight.

2.1.9 The Combat System

2.1.9.1 The SYCOBS (système de combat pour Barracuda et SSBN) combat management system is being developed by DCN and Thales. SYCOBS will also be fitted on the final SSBN submarine, Le Terrible, being built for the French Navy. The combat system integrates active and passive sensors, electronic, optronic and optical sensors and data processing, signal processing of downloaded external tactical data, the launch and control of torpedoes, missiles and countermeasures, external communications and navigation. The communications suite includes satellite and extra-low-frequency acoustic links.

2.1.9.2 Sagem Défense Sécurité has been contracted to supply the DAS surface detection system which comprises one radar mast and two optronic masts and integrates a passive electromagnetic detection sensor.

2.1.9.3 Thales Underwater Systems has been selected as prime contractor for the sonar suite. The submarine is fitted with bow sonar, wide-aperture flank sonar and towed sonar arrays.

2.1.9.4 The submarine has four 533mm Nato-standard torpedo tubes with water ram weapon discharge and accommodates 20 reload torpedo and missiles in a mixed load. It will carry new heavyweight torpedoes; the Black Shark torpedo developed by DCN and Whitehead Alenia Sistemi Subaquei (WASS). Black Shark is a dual-purpose, wire-guided torpedo which is fitted with Astra active / passive acoustic head and a multi-target guidance and control unit incorporating a counter-countermeasures system.

2.1.9.5 The Barracuda's anti-surface missile is an upgraded version of the SM39 Exocet missile that is launched from a torpedo tube. The new naval land-attack cruise missile, Naval Scalp, developed by MBDA, is also fired from a torpedo tube. The missile has long-range precision attack capability against targets at ranges up to 1,000km. Scalp has inertial guidance that is continuously updated in flight with digital terrain matching and GPS (global positioning system). An imaging infrared seeker and automatic target recognition provide terminal guidance.

2.1.9.6 The Barracuda will be configured to enable future back-fitting of unmanned underwater vehicles (UUVs), although there are no current operational requirements for the installation of a UUV. [3]

2.1.10 Propulsion Systems.

2.1.10.1 The submarine utilizes a 50 Mw Pressurised Water Reactor (PWR), similar in design to the K15 design used in the French Navy's SSBN and the aircraft carrier, *Charles de Gaulle*. The fuel has a similar level of enrichment to that used in French nuclear power stations, mitigating concerns regarding proliferation arising from higher levels of enrichment, reducing costs substantially and providing a lifetime of 10 years between refueling. Refueling is accomplished in parallel with a 12 month refit of the hull and mechanical systems, undertaken as part of the usage upkeep cycle.

2.1.10.2 The reactor provides low-pressure, saturated steam for use in powering 2x 10 Mw Turbo generators and a propulsion steam turbine. At low speeds the submarine is powered by one or both of two electric motors using electricity generated by the turbo generators or provided from two large battery banks. The electric motors drive the single shaft through a reduction gearbox. This configuration is different to the SSBN or Rubis class and is intended to provide an improved low speed acoustic signature and a level of redundancy via two electric

[3] http://www.naval-technology.com/projects/barracuda/

motors. At higher speeds a single propulsion steam turbine is also used to increase the power available, driving through the same gearbox.

2.1.10.3 The submarine has a publicized maximum speed of 25 kn.

2.1.11 Complement. The Barracuda class is designed to operate with a crew of 12 officers, 44 'Petty Officers' and 4 sailors. It is able to carry an additional 12 personnel, eg specialist teams, trainees or special forces. All operational submarines (ie all those not in refit or build) will have two crews, to obtain optimium use of the platform and provide for crew rest and training requirements. The submarine has a planned endurance of 70 days, with sufficient food, habitability and other supplies.

2.2 Construction Program

2.2.1 Design Process. In 1998 the French Ministry of Defence put in place the Barracuda integrated project team (BIPT) with team members Délégation Générale pour l'Armament (DGA); DCN, with responsibility as the platform design authority and ship building prime contractor; Technicatome, which has responsibility for the nuclear power system; and the Commissariat à l'Énergie Atomique (CEA), the French nuclear regulatory authority. The feasibility study for the Barracuda Class was successfully completed in 2002 and the programme entered the design definition phase in late 2002.

2.2.2 Construction Timings and Costs. The French Defence Procurement Agency (DGA) awarded DCN and Areva TA (prime contractor for the nuclear power plant) the contract for the design, development and production of the first of class vessel, with options on the remaining five, in December 2006, at a unit cost of approximately €1.45B. The entire cost of the Barracuda construction programme has been estimated at €8.7B. AREVA TA also provides training for naval crews and will be able to draw on operating feedback from the test reactor built at Cadarache. The contract to AREVA TA represents around 15% of the total value of the program that is € 1.2B over a twenty-year period. [4] [5] The submarines are scheduled to be

[4] http://www.areva.com/EN/operations-1556/index.html

[5] http://www.areva.com/EN/operations-1664/propulsion-and-research-reactors-nuclear-reactors-for-naval-propulsion.html

delivered at two-year intervals starting in 2017, with the final submarine delivered in 2027. [6] The construction program was confirmed in May 2013. [7]

2.2.3 Build Time. The submarines are under construction at DCNS's Cherbourg shipyard supported by DCNS centres around the country. Construction time appears to have been tailored to provide a steady/economical level of work for the shipyard whilst meeting the end of life dates for the existing force of SSNs. Currently three SSN are under construction.

2.2.4 Maintenance. The existing SSN force is maintained by a DCNS dockyard workforce and serving personnel at the SSN base at Toulon. Maintenance operations are conducted by DCNS, controlled by the crews.

2.3 Manpower implications.

2.3.1 Collins Compared To Barracuda. Although the overall number in a Barracuda crew will be similar to a Collins the balance skillsets in crew members will be different, with a greater proportion of mechanical engineering officers (5 compared with 1), mechanical technicians and no weapons electrical officer or dedicated electrical technicians as the MN follows a user/maintainer philosophy for its electronic sensors and equipment. The skillsets required of a crew of 60 operating an SSN are likely to be critical to success, it would be prudent to study these in greater depth to ensure an RAN crew provided a matching capability.

3 - How Many SSN

3.1 Critical Mass For A Sustainable manpower Base. The discussion on the critical mass for sustainable manpower in the first part of this paper remains valid for the smaller Barracuda crew; the key challenges are to produce enough command qualified Executive Officers, Mechanical Engineering Officers ('Chief Engineers') and their mechanical technician senior sailors to sustain the submarine force and its

[6] http://www.naval-technology.com/features/featureastute-arihant-ohio-worlds-top-nuclear-submarines

[7] http://rpdefense.over-blog.com/french-minister-of-defence-confirms-11-fremm-frigates-and-6-barracuda-submarines-will-be-built

essential shore supervision. As discussed in detail in the first part of this paper and at section 5 below, the process of training and qualifying a 'Chief Engineer' is likely to remain the critical manpower and training challenge. The fundamental consideration, is that a force of less than 10 will not provide sufficient sea days and is likely to struggle to generate a critical mass of personnel sufficient to sustain the essential manpower base, in particular experienced mechanical engineers and reactor technicians. By comparison the MN operates 16 crews spread across its SSN and SSBN forces to achieve this.

3.2 Operational Considerations. This paper does not seek to justify the number of SSN on the basis of an operational or strategic argument.

3.3 French Availability Over The Life Cycle. The Barracuda usage upkeep plan from which its availability can be calculated is not available. It is understood that it will be similar to that used for the SSBN, this is discussed in section 11. An overall sea going availability of 58% would be achieved by this plan.

3.4 Assumption on RAN Force Size. For the purposes of this paper a force of 10 SSN is assumed.

4 - MN Submarine Manpower

4.1 Manpower Distribution and Recruiting

4.1.1 Submarine Manpower Distribution. The submarine forces of France (Forces sous-marines or FSM) is the submarine component of the French Navy. It is a self-sufficient command - providing the support of its own vessels, served by ~ 3,824 personnel and made up of two components:

- The force océanique stratégique (FOST), made up of four ballistic missile submarines, based at île Longue with an SSBN squadron, an operation centre and a training center in Brest.

- The escadrille des sous-marins nucléaires d'attaque (ESNA), the nuclear attack submarines squadron made up of 6 SSNs, a training center and an acoustic intelligence center (CIRA) based at the Toulon naval base.

4.1.2 FOST. The commander of FOST (ALFOST) is also in overall command of the whole submarine force:

a) Operations are conducted under the authority of the Chief of the Joint Staff for operations.

b) Submarine technical and support matters under the authority of the Chief of Staff of The Marine National (chef d'état-major de la marine).
c) ALFOST has operational control of the SSBN force and the essential shore facilities to sustain the deterrent force.
d) He is responsible for the operational qualification of all submarine crews, oversees the safe operations of all submarines.
e) He is supported by the maintenance service "Service de Soutien de la Flotte" charged with maintaining the submarine force under the authority of the Chief of the Navy and in charge of the relations with industries.
f) SSN are usually under the operational control of the area operational command where they are employed.
g) Should difficulties occur in these command relationships and the occasion demands, ALFOST has direct access to the President of the French Republic.

4.1.3 Distribution. Current Submarine Manpower is typically distributed as follows:

s33(a)(iii) [redacted]

[redacted] This manpower is not included in the submarine manpower work force calculations in this paper.

4.1.4 MN Submarine Recruiting Practice.

4.1.4.1 The MN submarine service usually operates an active promotion and recruiting campaign within the navy and from the French population at large, mainly in the cities that have special relationships with the submarines ('villes marraines'). Submarine recruiting teams actively visit schools and colleges to promote service in submarines. Personnel recruited in this way are identified as submarine personnel on entry into the MN and commence submarine training as soon as their initial recruit and technical training is completed. The MN does not currently allow females to serve onboard submarines.

4.1.4.2 Petty Officers typically leave after about 17 years of submarine service, with an entitlement for their military pension and generally are at the most senior rank they can achieve. Submarine service is attractive because one year aboard a submarine with a minimum of 1000 hours diving is equivalent to 3 years of service. So when combined with shore and at sea periods, they can leave at about 37 years age and pursue another career. Selected nuclear petty officer technicians (numbers range from 0-4 each year), with a special professional accomplishment are offered a commission as officers, with the opportunity to become the Chief Engineer aboard an SSN. This is an alternative route used for those who are unable to enter as an officer via navy school.

4.1.4.3 Manpower is a permanent issue and the MN is invariably under pressure to provide sufficient qualified and experienced submarine personnel. The MN provides individual career management to its qualified submarine personnel; arrangements are based on a mutual understanding and often, a moral/individual contract with the more senior Petty Officers.

<u>4.1.5 Impact of Nuclear Power Generation.</u> France has a large nuclear power industry with 59 nuclear reactors supplying 79% of its electrical power. The industry designs and builds reactors and France is one of the few countries in the world recycling spent fuel. [8] [9] The existence of such an extensive nuclear industry is a mixed blessing, but overall a net positive benefit for the MN's nuclear power program. The nuclear power industry serves as a competitor in the recruiting of engineers and attracts many submarine personnel, causing them to discharge from the navy. On the other hand it broadens the academic base for training, for provision of experienced personnel in the independent supervisory organisations and provides an attractive career for those who may choose to start their careers in the Navy with the intention of moving into the civilian power industry later. The active competition for the recruitment and retention of experienced naval technicians necessitates attractive conditions of service and competitive remuneration, including retention bonuses for key personnel.

[8] http://en.wikipedia.org/wiki/Nuclear_power_in_France

[9] http://www.world-nuclear.org/info/Country-Profiles/Countries-A-F/France/#.Ubc29BZC-fQ

4.1.6 The MN Manning Model.

4.1.6.1 Role of Supervisory Authority. An independent supervisory authority oversees nuclear training and practices, in a similar fashion to the USN an RN models discussed in the first part of this paper. This is discussed further in section 5 below.

4.1.6.2 The Officer Manning Model. French submarine officers are drawn from the Navy, having completed initial training in the navy school. In the case of Warfare Branch Officers this includes approximately 2 years service in a surface ship to obtain a bridge watch-keeping certificate. Mechanical engineering officers complete a university degree and must qualify at sea in submarines, serving as the non nuclear qualified assistant engineering officer for about a year before undertaking the nuclear engineering course of about 2 years duration at the nuclear facility in Cherbourg (EAMEA école des applications militaires de l'énergie atomique). The MN does not utilize specialist Electrical Engineers in its submarines.

4.1.6.3 Training Model. The MN requires that:

a) Individual submariners revalidate their different qualifications annually.

b) A crew has to complete a Sea Training Group evaluation to obtain an operational qualification.

c) There are 2 levels of operational qualifications; 'elementary' (dive and sail in safety) and 'standard' (anti submarine warfare, anti surface ships warfare, coastal operations, special forces operations).

d) On occasions, a crew will be required to obtain a specific qualification, eg for crews who are testing new tactical procedures

During the Sea Training Group managed training period the crew would normally spend 6 weeks for individual knowledge using simulators and evaluated by quizzes. This is important to refresh individual knowledge after a leave break and to manage the typical turn over of one third of the crew. The second part of the training period is for used for team training and administered by the Sea Training Group. The level of the crew is evaluated after 2 weeks and any concerns are referred to the Squadron Commander.

4.1.6.4 At Sea Training. The MN's approach to sea training is very similar to the RAN's with regular operational assessments undertaken by a Sea Training Group based in the Submarine Squadron (see 4.1.6 below). The Squadron Commanding Officer declares the operational status of an SSN 18 days after a maintenance period. The sea training period is typically divide as follows:

s33(a)(ii) [redacted].

[redacted].

4.1.7 Use of Training Simulators. The MN makes extensive use of simulators for individual and team training. A prototype of the K15 naval Pressurised Water Reactor, operated by the manufacturer, AREVA is used for training naval reactor operators. Hands on training, using a live reactor is considered essential by the MN. The construction of shore based training reactor would be an early issue for resolution in establishing a naval training regime for RAN technicians in Australia.

4.1.8 Supervision of Operations. Within the MN the SSN force is operated by a single Squadron based in Toulon, providing training and supervision for individual crewmembers, team training and training and assessment of the crew to issue a licence for the deployment of each SSN. It is considered important that each crew undergoes an annual assessment in order to sustain a safe and operationally effective submarine force.

4.2 Comparison With Current RAN Manning Model

4.2.1 Summary of The Models. Both models make use of specialist warfare officers (Executive Branch) to operate the submarine and specialist engineering officers providing hull, watertight integrity and operating the propulsion and other ship support systems.

The first difference of arises from the absence of weapons electrical engineering officers combined with the operator /maintainer training of sailors operating the electronic equipment onboard the submarine. This demands appropriately designed equipment, logistic support/training systems and would entail changes from the RAN's current practices. A detailed examination of the skillsets required in the crew would be essential to ensure that an RAN crew provided the necessary skillsets.

4.2.2 Females. Females are not permitted to serve onboard French submarines. It is understood that this is a practical management issue due to concern over possible complications arising from a pregnant female onboard a deployed submarine and the additional expenses of employing females arising from increased training costs from the higher turnover rates of female personnel in the MN. The employment of females onboard RAN SSN would require further investigation. At initial glance the problems are not considered insurmountable, though they would require specific policies, supervision and habitability arrangements to be established. The USN and RN have recently introduced female personnel into their nuclear powered submarines.[10][11]

4.2.3 Electrical Engineering Personnel. The relative merit of converting one of the executive branch Lieutenant billets to enable Weapons Electrical Engineering Officers to continue to serve in RAN SSN should be evaluated. The impact of the loss of a Warfare Branch officer billet to provide a junior officer opportunity for development as a future Executive/Commanding Officer would be an important factor in this assessment. Existing Petty Officer electronic technicians should be able to convert to user maintainers should they choose to do so.

4.3 Choice of Manning Model.

For the purposes of this paper it is assumed that the RAN adopts the French Navy's manning structures as part of an 'off the shelf' acquisition of the Barracuda class SSN.

[10] http://www.navy.mil/submit/display.asp?story_id=70940

[11] http://www.dailymail.co.uk/news/article-2076210/Royal-Navy-spend-3m-converting-submarines-women.html

5.Manning An Australian Supervisory/Regulatory Structure

5.1 Nuclear Safety -- A National Responsibility.

As discussed in the first part of this paper, it is assumed that in country regulatory and technical capacity must be sufficient to provide practical safety oversight, enabling the Australian Government to maintain sovereignty and discharge its responsibility to the Australian public and internationally for safety

5.2 French Regulatory Infrastructure.

5.2.1 National Nuclear Safety. The Nuclear Safety Authority, (L'Autorité de sûreté nucléaire) (ASN) is an independent administrative authority set up by law 2006-686 on 13 June 2006 concerning nuclear transparency and safety. It is tasked, on behalf of the State, with regulating nuclear safety and radiation protection in order to protect workers, patients, the public and the environment from the risks involved in nuclear activities. It also contributes to informing the citizens. This law improved and clarified the status of ASN with regard to nuclear safety and radiation protection, increased its independence and legitimacy with respect to those in charge of promoting, developing and carrying out nuclear activities. It enjoys a legal foundation and a status comparable to that of its counterparts in other industrialised nations. It also has enhanced powers enabling it to penalise violations and take all necessary urgent measures. The new status consolidates ASN's goal, which is to provide nuclear supervision that is efficient, impartial, legitimate and credible, that is recognised by the citizens and that constitutes an international benchmark for good practice. ASN checks compliance with the rules and specifications applicable to the installations and activities within its field of competence. Inspection is one of the primary means of verification available to ASN, which also has appropriate powers of enforcement and punishment. [12] At the national level ASN supports the Minister of industry in his role overseeing nuclear safety matters.

[12] http://www.french-nuclear-safety.fr/index.php/English-version/About-ASN

5.2.2 Defence Nuclear Safety. As part of this day-to-day process, the Ministry of Defence Acts jointly with the Nuclear Safety Authority for Defence-related facilities and activities. (ASND). This ensures total independence from reactor operators and is in accordance with its objective of transparency in public information. The Délégué à la Sûreté Nucléaire et à la Radioprotection pour les Activités Intéressant la Défense (Delegate for Nuclear Safety and Radiation Protection for National Defence Installations and Activities) (DSND) is the representative in charge of Nuclear Safety and Radiation Protection for Defence-related Activities and Facilities and is a key player in the regulation of nuclear safety, providing a link between the Minister of Defence, the Minister of Industry and the Government. Advised by the Nuclear Safety Authority for Defence-related facilities and activities, the Ministry of Defence assesses the health impact of a potential release of radioactive elements. In addition to providing information on expected reactions in case of incident or accident, the Ministry of Defence is directly involved in the organisation of government crisis management at national and local levels. Ministry crisis management is based on a concentric division of responsibility plan. To test its precautionary and planning guidelines, the Ministry of Defence conducts regular nuclear security exercises involving government professionals, as well as those employed by operators. 13

5.3 Safety

5.3.1 French Navy Safety Record. There have been no losses of French nuclear submarines nor are any nuclear radiation incidents known to have occurred. The most significant accident was aboard of SSN Emeraude, when ten submariners died in the turbine room after being scalded by the steam during an inspection; this was not a nuclear accident but the result of human error.

5.3.2 Existing Australian Nuclear Regulatory & Safety Arrangements. The existing Australian nuclear regulatory and safety arrangements are discussed in the first part of this paper. The suggestions made therein to expand Australia's existing regulatory authorities appear to remain appropriate should a force of French Barracuda class SSN be acquired.

5.3.3 French Submarine Repair Procedure Approval. The MN uses a similar process to independently check and verify the repair process for defects or routine

[13] http://www.defense.gouv.fr/english/portail-defense/defence-and-you/nuclear-security/nuclear-security

maintenance before authorizing work to commence or activation of the reactor. After a maintenance periods there are a series of checks and technical controls for the nuclear reactor and its controlling system, the steam turbine and all the systems in relation with the nuclear power system. These controls are performed by the crewmembers of the submarine with the appropriate qualification and who have satisfactorily completed the annual assessment, supervised by the Submarine Squadron. The submarine Commanding Officer is required to report the situation to the Squadron Commanding Officer who will then give the clearance for the nuclear reactor to be activated. If there has been an issue with the nuclear reactor or its control systems, approval has to be granted by the Service de Soutien de la Flotte (SSF nuclear division) and approved by the Chief of the Navy who has a Rear Admiral in charge of nuclear power and weapons oversight.

5.4 The Academic Training Structure

Remarks in the first part of this paper remain germane.

5.5 The Naval Training Infrastructure

The remarks made in the first part of this paper regarding the accreditation and external audit of the RAN's nuclear training infrastructure remain germane. In this case oversight by the appropriate MN authorities could be sought as part of any acquisition project. This requirement could be reviewed once the SSN capability was established and stable.

5.6 Line of Responsibility

Remarks regarding the need to inculcate a safety ethos, with clear lines of responsibility from sailor reactor technicians all the way to the Minister of Defence remain germane.

5.7 The role of the SM Squadron

5.7.1 MN Practice. The MN practice appears to be substantially the same as that followed by the USN and RN. The Submarine Squadron has a key role in the nuclear safety chain, conducting operational readiness assessments, overseeing onboard qualification boards and training standards.

5.7.2 An Expanded Squadron. The MN's Squadron organisation is geared to support 6 SSN. The manpower estimated in this paper is intended to allow for the additional workload and responsibilities of a Squadron of 10 SSN. This includes the manpower to provide an enlarged Sea Training Group to undertake at sea training, assessment and licensing. These roles are similar to current RAN practice.

5.7.3 Assumption. This paper assumes there will be one, augmented Submarine Squadron.

5.8 Radiation Protection, Incident Response Team.

The discussion in the first part of this paper regarding the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), need for an RAN team linked to the Institute of Naval Medicine and their role in routine monitoring and managing an emergency is germane.

5.9 Nuclear Safety & Reliability Directorate and Nuclear Training & Safety Panel.

The discussion in Part I of this paper remain germane. In the French case, to preserve an independent perspective, ASND is a high level civilian engineer with two deputies; one is a civilian engineer named by the Minister of Industry, the second is an MN officer named by the Minister of Defence

5.10 Assumption of Responsibility for Safe Operation of SSN By The Australian Government

It is assumed that the Australian Government would take on responsibility at handover after completion of the post building Sea Acceptance Trials and the associated docking/maintenance availability undertaken by the shipbuilder as part of the construction contract. This leads to the following assumptions:

a) Nominated Australian based Oversight/Regulatory personnel need to be in place 2 years prior to Commissioning SSN 01 to ensure the procedures and processes are established, tested and certified prior to the assumption of responsibility.
b) Australian based safety teams need to be in place 6m before arrival of SSN 01 in Australia, typically 6m after commissioning.

5.11 Australian Design Authority Liaison Team

It is assumed that the Design Authority (DA) (which has responsibility for nuclear safety within the design) would remain with the French DA, vested in the company DCNS and the MN organisation overseeing the DCNS design support, a combination I will term as the 'Class authority'. This leads to the following arrangements and assumptions:

a) Whilst the DA function remains with the French 'Class Authority', the Australian Design Authority Liaison Team is a conduit to the RAN - with qualified Australian personnel from the Australian Design Authority Liaison Team serving in France and with RAN SM Force Commander.
b) The Australian based capability is responsible for analysing any RAN incidents and providing instructions to manage any hazard, including changes in personnel, training, operating procedures, or referring any suggestions for design changes back to the French Class Authority.
c) The French based members are intended to facilitate efficient communications between both countries on safety and other design matters.

5.12 Submarine Capability Branch

The functions, roles and manning developed in the first part of this paper remain germane.

5.13 Minimum Number of SSNs to Sustain the essential Safety and Technical Positions

The modeling undertaken in the first part of this paper demonstrates that the production of experienced s33(a)(ii) [redacted] remains valid. This criticality is closely followed by the production of sufficient command qualified s33(a)(ii) [redacted] as the next most challenging categories. Although the scheme of complement for the Barracuda is less than half that of the larger Virginia or Astute classes, the numbers of s33(a)(ii) [redacted] required of these critical categories in each crew are the same. Although the Virginia and Astute are single crewed they currently achieve similar or greater at sea availability – sea time is the key to producing these experienced personnel. On balance therefore it is suggested that the analysis would also hold for a force of Australian manned Barracuda class SSN;

s33(a)(ii) [redacted] are required to achieve a sustainable production of these key personnel, s33(a)(ii) [redacted] provides a more sustainable force and allows a buffer for unanticipated drops in sea going availability.

6. Scheme of Complement for a Barracuda Class SSN

6.1 Scheme of Complement

A full descriptive breakdown of the anticipated category structures for a Barracuda class SSN is not available. This analysis is based on an extension of the structures used in previous classes of French SSNs, modified for the reduced numbers and knowledge of the areas where automation has been employed to reduce the crew size. Publicly available descriptions of the submarine indicate that the Barracuda Class is designed to have a complement of 60 made up as follows; 12 officers, 44 Petty Officers and 4 Seamen. This is a reduction of 10 from that of its predecessors. It is achieved by a greater level of automation in the operation of the submarine.

6.2 SOC Structure

6.2.1 Officers. The 12 officers are divided as follows:

a) The Commanding Officer, a command qualified Warfare Branch specialist, qualified in nuclear power with the equivalent rank of Commander.
b) The Executive Officer, a command qualified Warfare Branch specialist, qualified in nuclear power with the equivalent rank Lieutenant Commander.
c) Four Warfare Branch Lieutenants qualified in nuclear power as control room watch keepers and overseeing the specialist areas of Sensors, Communications & Electronic Surveillance, Navigation and Weapons. The senior Lieutenant is known as the 'Chief of Operations'.
d) The Engineering Officer (the 'Chief Engineer'), a 'charge qualified' [14] mechanical engineer, equivalent rank Lieutenant Commander.

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[14] Assessed by individual assessment by a Board formed by the Submarine Squadron to be fit to take charge of a submarine's Mechanical Engineering Department

e) Four Engineer Officers, all Mechanical engineers; 1 Deputy Engineer and 3 Assistant Engineer Officers, equivalent rank Lieutenant.

The Executive Officer works as a relief to the Commanding Officer when the operational situation does not require the presence of the Commanding Officer in the control room.

The four Warfare Branch control room watch keepers normally operate in two watches. During a low threat transit this may be relaxed to one in three watches.

The 'Chief Engineer' is a non watch keeping, head of Department. The Deputy Engineer Officer and two Assistant Engineers are reactor plant watch keepers. The fourth (and most junior) Assistant Engineer, is normally a newly trained engineering officer who has yet to undergo nuclear training. He is responsible for the non-propulsion platform systems.

6.2.2 Sailors

6.2.2.1 The 44 Petty Officer and 4 sailor billets are divided equally between the Operations and Engineering Departments.

6.2.2.2 The 24 Operations Department NCO and seamen billets are typically allocated as follows:

a) Three personnel are dedicated to managing food, feeding the crew and domestic functions.
b) Three non watch keeping Senior Sailors are in charge of Sonar, Electronic Surveillance/Communications and Combat System sections and available on call depending on the operational situation.
c) The balance of 18 billets is divided across the sonar, electronic surveillance, communications and combat system functions.
d) All personnel are trained as user/maintainers.
e) A number of these Petty Officers are electronic technician specialists trained as operators, providing a greater depth of experience in electronic systems
f) These personnel normally operate in two watches of 9. This may be relaxed to three watches where the operational scenario allows it.

6.2.2.3 The Engineering Department operates in 3 watches, regardless of the operational situation. Three senior sailors are non-watch keepers. The Barracuda is designed to situate all watch keepers in the control room with roving personnel checking in the machinery spaces. This is yet to be proven in sea trials. The proposed arrangements for the remaining 21 personnel would be employed as follows:

a) Two are employed in the control room operating the integrated ship control/management system, including the non propulsion platform systems and atmosphere control systems.
b) Three are reactor and propulsion control watch keepers, also in the control room.
c) Two are a roving machinery space watch keepers.

6.3 Trainees

Following submarine training ashore varying from 4-8 months depending on the specialization of the sailor, final training and qualification is undertaken at sea. Each SSN has capacity to carry up to 12 trainees.

6.4 New Specialisations/skills for the RAN

6.4.1 Sailor Skillsets. Operating a submarine platform as complex as an SSN with a crew of 60 requires a high level of integration of the individuals and total crew skills with the platform. This may require adaption of the skills balance for many RAN sailor categories and deserves detailed study to ensure the RAN has the necessary skill sets onboard.

6.4.2 s33(a)(ii) [redacted]

6.5 Organisational Maintenance Capability

It is not apparent how capable the Barracuda's onboard repair capability would be; the ability to conduct at sea repairs is probably reduced compared to the SSN with twice this scheme of complement. Nonetheless in order to achieve a 70-day mission, equipment design, spares support, redundancy and onboard repair capability must be integrated and adequate. In Barracuda's case this remains to be proven at sea.

[redacted]

7. Manning and Training Model

7.1 Assumptions

A number of assumptions are set out below as questions to provide a starting point for further discussion should this concept to be further developed.

7.1.1 MN Manpower Assistance. Would some initial MN manpower with the necessary experience and skills will be provided by as part of the sale/lease to fill the critical shore supervisory billets?

7.1.2 Access To MN Training. Would access to MN training schools be available until the RAN had established a self sufficient training system, say on commissioning SSN 06? How would the numbers of trainees (approximately 50% increase in MN basic SM training) be accommodated?

7.1.3 Access to MN SSNs for At Sea Training. Would training places be available in MN SSNs to undertake RAN conversion and initial training?

7.1.4 Recruiting Skilled/Experienced Nuclear Plant Operators. Will the RAN be able to enlist assistance from experienced nuclear plant operators to man the senior supervisory shore billets using MN loans and exchanges? Or, by mutual agreement, to recruit from MN retirees?

7.2 Currency of Nuclear Experience.

An officer or Petty Officer with reactor responsibilities must qualify and then demonstrate an annual proficiency. The results are maintained in a personal logbook.

7.3 An Australian/French Hybrid Training System Alternative?

An alternative training system, aimed at reducing the impact of the Australian requirements on the MN training system and also reducing the lengthy postings in France for trainees and their families should be investigated. This would entail establishing a training system is Australia at the current submarine school in HMAS STIRLING, fitted with suitable simulators and other training equipments and staffed by experienced MN trainers. The at sea component of training would still require access to MN SSN and French language proficiency, but it may be possible to provide this in a more concentrated period that reduces its impact on both student and the MN SSN force.

7.4 Flexibility In Ranks.

The prolonged preparation and training required is likely to introduce a career delay to those involved. These personnel should not be disadvantaged for promotion, particularly relevant given that the RAN would be attempting to attract some of its best quality personnel to enter the force. This may require some flexibility on the rank of personnel filling various positions in the SSN.

8. Training Courses

8.1 USN/RN Training Models Used.

Given the lack of detail on the MN's training system the models developed for the USN/RN training system in Part I of this paper have been used to model the generation of key qualified personnel. Since Barracuda has the same number of mechanical engineering officers these would continue to constitute the critical category.

9. Current RAN Manning

9.1 Crewing Ratios

9.1.1 Rationale. The first part of this paper developed the concept of a 'crewing ratio', that being the ratio between the total submarine manpower and the number of personnel in seagoing crews as a measure of the relative efficiency of the manpower model and to calculate the total manpower required.

9.1.2 Current Crewing Ratios. The RAN manning numbers have been updated to 12 September 2013 when the RAN had s33(a)(ii) [redacted] An RAN crewing ratio of 2.8 was used in the first part of this paper. The RN by comparison has 13 crews and a crewing ratio of 2.6.

9.1.3 MN Crewing Ratio. Given that it has 1470 seagoing personnel in its SSBN and SSN force from a total submarine manpower of 3,824, the MN also has a crewing ratio of 2.6.

9.1.4 Selection of An RAN Crewing Ratio for A Force of Ten Barracuda SSN.

9.1.4.1 An RAN force of 10 Barracuda class SSN employing a similar double crew model to the MN would require s33(a)(ii) [redacted] g [redacted] of the size of the MN's seagoing workforce. To allow for some loss of efficiency arising from the reduced scale and provide a conservative estimate of total submarine manpower a crewing ratio of 2.7 is assumed for this paper. s33(a)(ii) [redacted]

9.1.4.2 If a single crewing model was used with a seagoing workforce s33(a)(ii) [redacted]

9.1.4.3 Ten crews of 60 requiring a submarine arm of s33(a)(ii) [redacted] qualified personnel appears to be the most achievable of the options and will be used in drawing conclusions in this paper.

9.2 Engineering Personnel.

The first part of this paper discussed a range of issues surrounding the RAN's current submarine manpower situation and particularly the training of engineering graduates. Since a Barracuda SSN has a similar requirement for graduate mechanical engineers, these remain germane.

10. Facilities and The Manpower Implications

10.1 Training Facilities.

The first part of this paper discussed the requirements for academic and naval training facilities. These discussions remains germane.

10.2 Nuclear Repair Facility & Nuclear Berths

10.2.1 Purpose. These berths have been certified as suitable to accommodate an SSN with its reactor shut down, ie two independent sources of power are provided to ensure cooling and safe operation of the reactor at all times.

10.2.2 Siting

10.2.2.1 Rationale. The MN force of 6 SSN operates from one base situated in Toulon. The base is adjacent to a dockyard operated by DCNS that provides 3 dry docks able to accommodate an SSN. Assisted maintenance periods are normally undertaken in dock.

10.2.2.2 Australia's Requirements. Australia's requirements were discussed in the first part of this paper. It is assumed that the force of 10 SSN would be operated s33(a)(ii) [redacted]. This base has access to a ship lift and a number of associated dry berths to undertake routine dockings and mid cycle surveys able to accommodate s33(a)(ii). Nuclear certified berths would also have to be provided at a selected east coast deployment base for s33(a)(ii) to meet an exigency that required deployment of SSN from the east coast. The facilities at s33(a)(ii) would be available for refits, unscheduled repairs, provision of s33(a)(ii) is suggested. All berths would have to comply with the nuclear safety distances from civil infrastructure and dwellings. s33(a)(ii) are known to have this certification currently.

<u>10.2.3 Manning.</u> The manning proposed for these facilities in the first part of this paper remains germane.

<u>10.2.4 MN Experience With Mixed Civilian and Naval Manning for Maintenance.</u> Both MN crews are used to undertake work during the assisted maintenance periods and work in conjunction with industry's dockyard workforce. The oncoming crew, in conjunction with the dockyard undertakes the planning. The dockyard is paid to deliver availability and penalized for failing to meet its targets.

<u>10.2.5 The Need To Be Able to Undertake Nuclear Repairs.</u> Discussion of the capabilities and ability to undertake nuclear repairs, including the handling of nuclear waste in the first part of this paper remain germane.

<u>10.3 Reactor Refueling.</u>

The Barracuda reactor utilize a lower level of uranium enrichment than Virginia or Astute and requires refueling every 10 years, coincident with a 12 month refit of the hull and other systems. Judging by refueling refits of earlier SSNs this appears an ambitious target – for example the earlier USN Los Angeles class SSN required 24 months to refuel. [15] This period might be reduced by a design arrangement that allowed an exchange of the old reactor with a refueled reactor. The practicality of undertaking a refit and refueling/reactor exchange in Australia would require a detailed study. The outcome could have a significant impact on the nuclear repair facilities and manning levels.

<u>10.4 Radiation Protection Capability.</u>

The requirement for nuclear accident response teams in the first part of this paper remains germane.

<u>10.5 High Pressure/Temperature Steam Training Facility.</u>

[15] http://www.globalsecurity.org/military/systems/ship/ssn-688-ero.htm

The requirement for a shore based steam-training plant using a non-nuclear boiler/steam plant to supply steam to a turbo-generator and propulsion turbine discussed in the first part of this paper remains germane.

10.6 Submarine School

The requirement for a Submarine School discussed in the first part of this paper remains germane.

10.7 Shore Test Facility.

The requirements for a shore test facility for the ships systems, including the integrated ship control system and its associated simulator remain germane.

10.8 Submarine Command Team Trainer.

The requirements for a command team trainer discussed in the first part of this paper remain germane.

10.9 Operational Base.

The requirements of an operational base discussed in the first part of this paper remain germane.

10.10 Shore Based Training Reactor.

The MN makes use of the prototype K15 reactor for shore training reactor plant operators and considers it to be an essential facility. The requirement for a similar shore based facility to support RAN training would be an issue for early resolution. Although the establishment of a shore based nuclear reactor facility is a major political and practical issue it is unlikely to have an impact on the total number of personnel required in the submarine force.

10.11 Use Of Reactor Simulators.

The MN use one simulator for training and operational crews but it is heavily booked and technical failures cause great difficulties. For a squadron of 10 SSN a second simulator would be essential. The MN continues to debate the value/reliance on simulators. All agree that simulators remain invaluable for verifying modifications to the reactor and to ensure that crews are well trained and tested with a valid representation of the reactor, without having to undertake a risky procedure on a live reactor. Some believe that shore based training on a live reactor is also an essential requirement.

10.12 Facilities To Support A Hybrid Training Model

Should the hybrid French/Australian training model discussed at paragraph 7.3 above prove practicable then many of the shore training facilities, particularly those of the Submarine School would be established as an early priority to provide facilities for initial training of all Australian personnel.

11. The Leasing or Sales Regime

11.1 Lead Time for New Orders.

11.1.1 Lead Time Assumption. Given the existence of construction line with 2-3 completed SSN prior to receipt of an RAN order, a lead-time for the first of class of 9 years is assumed from placing an order to the commissioning of the first RAN SSN. This is probably overly conservative; the first batch of 3 RAN SSN would be batch 3 submarines, with the benefit of a substantial learning curve in the construction yard.

11.1.2 DCNS Capacity. Information is not available on DCNS's capacity, however, it is apparent that considerable industrial capacity exists across the Group's facilities with a demonstrated capacity to simultaneously construct conventional and nuclear powered submarines and different classes of surface ships. Given that a Barracuda production line exists, for the purpose of this paper, it is assumed that additional submarines could be available with a hull construction lead-time of 8 years. It may be possible to advance this date to avoid any requirement to extend the Collins class; regardless of the technical feasibility of this proposal, the impact on the training program would require careful consideration. An RAN order in 2020 for delivery in 2029 would fit neatly into the current production schedule as the last of the MN's 6 Barracuda Class SSN is due for delivery in 2027. A delivery interval of 1 year as used in this Paper's manpower modelling would be an increased tempo compared to the current construction program's 2 year interval.

11.1.3 Reactor Fabrication the Critical Path? Details are not available on the construction capacity available at AREVA Technicatome (AREVA TA) the designer and manufacturer of French nuclear propulsion reactors. The company is a substantial conglomerate with a wide breadth of experience and capacity. [16] The assumption used in the first part of this paper of an 8 yr lead time first order of a new reactor and thereafter a lead time of 6 yrs should suffice for this examination of the manpower requirements. Public information advises that commissioning of the nuclear reactor for the first Barracuda is scheduled for 2015, the submarine will undergo sea trials in 2016 and commission in 2017. (See also paragraph 11.2.3, 11.2.4 below)

[16] http://www.areva.com/EN/operations-1664/propulsion-and-research-reactors-nuclear-reactors-for-naval-propulsion.html

11.2 Construction and Sea Trials Model

11.2.1 Responsibility for Safety and Build Standards. It is assumed that the contract would entail the French Government assuming responsibility for the safety of the submarine(s) under construction until they are handed over to the Australian Government at commissioning of the submarine following the post sea trials docking. Australian personnel and the RAN crew would be present during the construction to fulfill the roles normally attributed to the crew and operate the submarine under supervision and a license issued by the MN's normal licensing processes. An alternative model has also been suggested; that Australia assumes this responsibility from the installation of the reactor and is supported in discharging these responsibilities by France. The model to be adopted is an issue for mutual agreement and would have a significant impact on training and recruiting time lines.

11.2.2 On The Job Certification and Currency Training. Having completed conversion of previously qualified conventional submariners or initial submarine training in the MN's training system, the RAN crew should be well prepared for their role as crew for the SSN during build. However, there will be a range of training, certification and assessment required to demonstrate currency in key systems. It is assumed that the MN's training and certification system would meet these requirements.

11.2.3 System Assembly and Testing, Initial Criticality and Power Range Testing (IC/PRT). s33(a)(ii) [redacted]

11.2.4 Marine Engineering Department Joining Timings. Unlike the RN/USN practice of undertaking critical range testing of the reactor 18-24 months prior to commissioning, the MN installs the reactor 12 months prior to commissioning. At this point the reactor systems have to be completely installed. An adaption of the process used in the RN is shown below to provide a starting point for considerations:

s33(a)(ii) [redacted]

s33(a)(ii) [redacted] - [redacted] r, [redacted]. [redacted]. [redacted] t [redacted]

e) Annex B provides an illustrative sequence of allocating these personnel for training.

11.2.5 Executive Department. The RN manning model adapted for the smaller crew size is used here s33(a)(ii) [redacted]

[redacted]

11.2.6 Commanding Officer. s33(a)(ii) [redacted]

11.3 Operating Cycle.

11.3.1 Overall Cycle. s33(a)(ii) [redacted]:

[redacted]

s33(a)(ii) [redacted]

11.3.2 Assumption On usage/Upkeep Cycle. It is assumed that the MN's usage/upkeep cycle will be adopted by the RAN.

11.3.3 Assumption On Maintenance Periods. It is assumed that the Assisted Maintenance Periods are undertaken at the s33(a)(ii) [redacted]. These will need a limited nuclear repair facility and reactor instrumentation certification capability. This is a significant technical project that would demand separate considerations in assessing the feasibility of the proposal.

11.3.4 Refit Cycles.

11.3.4.1 One of the significant differences between a Barracuda class SSN and the Virginia or Astute classes is the need to refuel at 10 year intervals. This work is undertaken during a programmed refit. One option would be to steam the SSN back to metropolitan France for refit and refueling. It is 7,686 nm from Fremantle to Toulon, requiring 23-25 days to complete the passage through the Suez Canal. Time is one of the simplest factors in assessing the viability of this solution however, the ongoing strategic dependency on France for refits, restrictions on Australian Industry's participation and manpower implications of ongoing deployment of RAN crews to stand by refitting submarines in France are of greater consequence. As discussed at paragraph 10.3 above this would require detailed study before deciding on the solution.

11.3.4.2 One option to avoid the strategic, industrial and manpower consequences and simplify the manpower issues could be to build sufficient (one or two) spare reactors to form a rotatable pool, enabling a reactor to be changed out during the refit in Australia. This solution if practicable could provide a better balance the various competing factors. s33(a)(ii) [redacted].

11.4 Delivery Process.

11.4.1 Delivery. s33(a)(ii) [redacted].

11.4.2 Pre Arrival AMPs. s33(a)(ii) [redacted]

11.4.3 s33(a)(ii) [redacted]

11.5 Shutdown Operations

11.5.1 Shutdown Watchkeeping. The discussion of shutdown operations in Part I remains germane. Once a reactor has been taken critical for the first time it begins to develop a fission product inventory and hence constitutes a potential hazard if not monitored and controlled appropriately. The safety systems are designed to mitigate the risks associated with that and the training and qualifications of the crew are a significant part of that mitigation. s33(a)(ii) [redacted]

12. Program Timings

12.1 Manning Implications for Building the SSNs

12.1.1 RAN Crew. s33(a)(ii) [redacted]

12.1.2 Crew Joining Sequence. The details of the crew joining sequence are discussed at section 11.2

12.2 Establishing the Regulatory, Safety and Oversight Capabilities

12.2.1 Manning The Oversight Billets. It is essential that an adequate shore oversight and regulatory infrastructure is established prior to the assumption of responsibility for the nuclear safety of SSN01. This date is assumed to be the commissioning of SSN 01 (timed to follow post construction Sea Trials and a docking to rectify any defects). Depending on the expertise and experience required for the position these could be drawn from a number of sources:

s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

12.2.2 Manning Timing. s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

<u>12.2.3 Manning Sequence.</u> s33(a)(ii) [redacted]

<u>12.2.3 Planning Proportions For Manning Essential Shore Billets.</u> s33(a)(ii) [redacted] This is an ambitious assumption that warrants early confirmation in developing the program. It serves to highlight the order of challenge in establishing this part of the program.

<u>12.3 Initial Training.</u>

<u>12.3.1 Role of An Initial Training Program.</u> Although of similar size Collins crew (58) and the SSN crew (60) the initial training of RAN personnel in MN's training system to qualify them in an SSN will still have an important role in building up the numbers of qualified nuclear submariners and providing a spread of seniority with sufficient junior members entering the submarine arm. If possible it would be

s33(a)(ii) [redacted]

12.4 Managing The Training Pipeline

12.4.1 Balance Between Initial and Conversion Training. The balance between initial nuclear training and conversion training for qualified Collins submariners will be an important, dynamic man-management decision as the program is implemented. Sufficient initial trainees must be entered to fill out the base of the manning structures. There are several factors to be balanced in reaching the decision on how many of each type of trainee to recruit in any particular year:

a) The MN's training and seagoing capacity to absorb initial recruits – the conversion trainees should be quicker to qualify and could be expected to suffer a lower attrition rate.
b) The need to sustain the RAN's sea going submarine capability during the transition – an important lesson learnt from the Oberon-Collins transition is the need to preserve the number of sea going hulls be they old or new submarines as these are the source of new trainees to sustain and grow the qualified manpower base.
c) The ability to recruit suitably talented trainees.
d) The efficiency of the initial pipeline, particularly an overseas pipeline.
e) The timings for manning the RAN's SSN force on build and then sustaining it in service.

12.4.2 Planning Proportions. s33(a)(ii) [redacted] The annual training targets to achieve this and provide some growth in the shore support infrastructure are discussed below.

12.4.3 Annual Manpower Training Numbers. s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

[redacted]

12.4.4 MN's Training System Capacity. One of the key issues in assessing the practicality of this plan is the MN's capacity to provide this level of assistance both for the shore training courses but critically, for the at-sea training.

12.4.5 Suitability of RAN Submariners for Conversion. A further factor will be the suitability and personal preferences of the existing Collins workforce; not every member will be willing or able to complete the conversion training. Preparatory academic instruction will be required to enable most personnel to undertake this training with a better chance of success. s33(a)(ii) [redacted]

12.4.6 Balancing Categories. The conversion and initial training pipelines need to be provided with the right balance of specializations (Warfare, Marine Engineering specialisations) and ranks, based on the proportions of the breakdown of the Scheme Of Complement. The balance between initial and conversion training will also be a dynamic one, an initial ratio of 30% initial and 70% conversion training has been used as a starting point in the models.

12.5 The Combined impact of Manning Essential Shore Billets and SSN 01.

12.5.1 Timings. An illustrative set of timings and manpower required to man the essential shore billets that must be in place and certified before the Australian Government assumes responsibility for the safe operation at the commissioning of SSN 01 and the crew for SSN01 with an allowance for attrition is set out in Annex B. Table B3 provides a timeline for the s33(a)(ii) [redacted].

12.5.2 Direct Recruitment. It is suggested that the RAN directly recruit s33(a)(ii) [redacted] personnel with appropriate nuclear experience from France, UK and USA to provide an experienced core for establishing the RAN's nuclear regulatory capability prior to assuming responsibility for SSN 01. Security clearances and ITAR issues would be a factor in the viability of this approach.

12.5.3 RAN Personnel. The s33(a)(ii) [redacted] should be achieved by converting existing RAN submarine personnel. s33(a)(ii) [redacted] qualified submariners would be required to commence conversion training to achieve this target along with a further s33(a)(ii) [redacted]. This training occurs over s33(a)(ii) [redacted] period, with a series of peaks of s33(a)(ii) [redacted] each year prior to commissioning SSN01. Table B2 in Annex B of this Paper provides a breakdown of the s33(a)(ii) [redacted]

12.5.4 Enlarging The RAN SM Arm.

12.5.4.1 The RAN currently has 4 crews in 4 operational Collins class submarines. The recently agreed usage upkeep program aims to provide a steady state of 3 operational submarines with an occasional 4th from its force of 6 submarines. A deliberate policy to increase the size of the RAN's manpower would need to be undertaken to provide a workforce large enough to handle the transition period from Collins to SSN.

12.5.4.2 This could be undertaken, by s33(a)(ii) [redacted] leading to a submarine manpower of s33(a)(ii) [redacted] This would not be easy to achieve, adding crews is difficult and slow. It would require a single-minded focus and Navy wide priority to direct manpower into the submarine training system.

12.5.4.3 Having just achieved a fourth crew the RAN has not yet announced any plans to increase the number of submarine crews further. In the author's opinion this should be an early priority regardless of whether the future submarine is an SSN or a new conventional submarine.

12.5.5 Manning From An Enlarged Submarine Arm. From a manpower base of s33(a)(ii) [redacted] submarine personnel, it would require s33(a)(ii) [redacted] personnel to man a force of 10 Barracuda SSN and the essential shore infrastructure and supervisory personnel positions. This growth of s33(a)(ii) [redacted] of the acquisition program.

13. Summarising Outcomes From The Models

13.1 Caution!

The manning models have been compiled to outline the scale of the management problem and identify where possible the key issues that will be encountered. Whilst every attempt has been made to apply available experience it should be recognized that unforeseen issues are likely. The manning model is at this stage quite crude and whilst it may be used to illustrate the points raised in the paper it would need refining in much greater detail before it can considered an accurate way to estimate the precise requirements for the manpower associated with the proposal.

13.2 Minimum Number of SSN for a Sustainable Manpower Base.

From the manning model it is assessed that the minimum number of SSN for a sustainable manpower base is 10. This number is necessary to ensure that sufficient MEOSM+ officers are generated to bring the right experience to the senior posts in the essential shore safety and supervisory billets. If less than 10 SSN are operated, shortages can be expected to develop in the Marine Engineering category. It may be possible temporarily to sustain fewer than 10 SSN by recruiting additional experience from overseas, but this is unlikely to be a viable long-term strategy. If, however, six or fewer SSN are operated it is probable that shortages will develop in the s33(a)(ii) [redacted] branch also, after which crisis management measures will need to be taken and ultimately hulls will be laid up for want of qualified crews.

13.3 Overall SM Arm Numbers.

The manning model demonstrates that the total number of uniformed submarine officers and men needed to man 10 Barracuda SSN with single crews sustainably is circa s33(a)(ii) qualified submariners, using a 'crewing ratio' of 2.8. Allowing for a personnel turnover of s33(a)(ii) newly trained submariners would be required annually to sustain the submarine arm. Assuming a s33 failure rate in initial training, s33 trainees would be required to achieve this number of new qualifications. Hence, a total manpower allowance of approximately s33(a)(ii) personnel would be required. Compared to the current allowance of s33(a)(ii) this would be an increase of s33 times the current manpower allowance. Comparing an enlarged Collins submarine arm of s33(a)(ii) qualified personnel discussed at paragraph 12.5.4.2 above, the s33(a)(ii) qualified personnel required to crew a force of 10 Barracuda SSN would represent an increase of s33(a)(ii)

13.4 The Most demanding Pipelines.

The categories of nuclear submariner that can be expected to prove the most challenging are those of the Marine Engineering Officer and the senior nuclear technical sailors. The RN has also experienced some difficulties with maintaining sufficient qualified Executive Officers. In each case the branch structures can be bolstered by recruiting from overseas or by introducing financial incentives; however, it must be recognized that such measures will introduce perhaps significant additional costs and are not a reliable long term strategy.

14. Conclusions

14.1 Key Issues

14.1.1 Impact of A Nuclear Power Industry. The UK, USA and France initiated significant nuclear powered electrical generation programs in parallel with their introduction of nuclear powered submarines, spreading the costs of the underpinning academic infrastructure; a downside to this arrangement was the resulting competition for trained personnel. Such a parallel program seems an unlikely event in Australia. However this history also demonstrates that it is not necessary to have a nuclear power industry in order to introduce nuclear powered submarines.

14.1.2 Uncounted Costs of Manpower. Whilst Australia does have a framework of nuclear safety regulation, some nuclear engineering and academic competencies and an incident response capability, these would require expanded regulation and substantial new naval and academic infrastructure to support the proposal. These are generally identified in Section 10 of this paper. Where the manpower requirement is not included the fact is noted in this paper. These missing capabilities are generally highly specialized and would require substantial lead-times to address [Sections 5 and 10].

14.1.3 Australia's Sovereign Responsibility for Safety. A democracy such as Australia would not wish to outsource responsibility to a foreign government for the safety of RAN submarines operated in Australia by RAN crews. The paper assumes that the Minister for Defence as an elected representative and member of the Government assumes ultimate responsibility for nuclear safety, with an independent auditing process overseen by a second Minister. It would be sensible to invite ongoing MN monitoring, to ensure that these processes remain adequate for safe operation. The paper estimates the structures the shore support infrastructure and manning required accordingly [5.1]. The integration of the new capabilities with Australia's existing nuclear regulatory and advisory bodies described in Section 5 would be important to the smooth functioning of the program and warrants early consideration.

14.1.4 Criticality of MN Support. Australia would have to depend heavily on the MN while establishing this oversight capability, drawing on their advice and recruiting some of the key experience required to establish this at the program start up. The entire program would require substantial access and support from the MN and

France's academic training systems. In addition access to the MN's seagoing submarine force to convert Collins class submariners and undertake initial training is a key component of the manning strategy advanced.

14.1.5 Impact of Overseas Training. Engineering personnel undertaking training prior to standing by an SSN being built would face a protracted period of absence from Australia; in some cases up to 9 years for MEOs undergoing initial training with the MN. The overall impact of this combination of issues would pose significant capacity, security and social issues for the RAN and MN and should be an early issue for agreement in developing such a program. Administration of this effort would require additional personnel in France and Australia and expenditure; estimates for the administrative manpower involved are not included in this paper. s33(a)(iii) [redacted]. This impact may be ameliorated by adopting a hybrid French/Australian training model should this prove feasible. [Paragraph 7.3, 10.12]

14.1.6 Start Up Costs. Given the absence of a civilian nuclear power generation industry, the nuclear submarine program would have to bear the cost of establishing additional Australian regulatory, SUBSAFE [4.1.6, 5.12.4], industry and academic capabilities to provide the essential oversight, maintenance and training capacities. The manpower required for the non-naval academic and all the industry capabilities is not included in this paper. [Sections 5 and 10]

14.1.7 Mechanical Engineers. The recruitment, training and retention of Marine Engineers is likely to be one of the most critical manpower challenges. There is already a shortage of engineers in Australia – generating a Senate inquiry into the matter in 2012. It is estimated that the SSN program would require the annual graduation of s33(a)(ii) [redacted] [Part I paragraphs 7.2.1.7, 9.10 refer]

14.1.8 Manning Model? The operation of a 5,300 tonne SSN with a crew of 60 is at the forefront of world practice. It would be prudent to study the MN manpower and training model carefully and to follow it scrupulously. Any deviation should be taken only after careful consideration and actual experience with operating the submarine.

14.1.9 Use Of Simulators Vice Reactors For Shore Training. The French debate over the necessity of a live training plant ashore even when high fidelity simulators are available requires early resolution. Simulators would obviously be significantly easier to install in Australia than a training reactor and have been assumed in the manning allocated for shore training.

14.1.10 Commanding Officer's Qualifying Course. This is second order but important decision. A choice will have to be made on venue of the Commanding Officer's Qualifying Course (COQC). This is a critical course in maintaining safety and operational standards. It is possible that some combination of the RN and MN courses would provide the optimum outcome to maintain RAN standards and access to the tactical thinking of both navies. However the author has no details or knowledge of the MN's course.

s33(a)(ii)
[redacted]

14.1.11 Sustaining Submarine Numbers During The Transition. There will be a need to sustain the conventional submarine capability during the transition to avoid a dip in hull numbers, leading to a drop in the production of qualified submariners to replace wastage or a cessation of submarine operations. This is a major lesson drawn from the Oberon-Collins transition.

s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

14.1.14 Minimum Number of SSN Required to Maintain a Sustainable Manning Structure. Given sufficient quantities of recruits of the right quality, the number of SSN purchased or leased is a key issue, determining the capacity to train personnel and generate the experienced personnel needed to man the essential, critical positions at sea and ashore. Ten SSN is judged as the minimum to generate the key Marine Engineering personnel to man the essential shore infrastructure providing technical support and safety oversight. s33(a)(ii) [redacted] [Part I paragraph 5.13.2, 13.2 refer]

s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

s33(a)(ii) [redacted]

14.1.18 Building Up from A Small Submarine manpower Base. The MN transitioned to nuclear powered submarines from large but shrinking forces of conventional submarines and a substantial but shrinking number of steam turbine powered surface ships. This combination of circumstances made available the manpower, particularly engineering officers and senior sailors with experience appropriate to a nuclear submarine program. The transition was a significant challenge albeit driven by the tangible threats posed by the cold war. s33(a)(ii) [redacted].

The 14 year period commencing 4 years prior to commissioning SSN01 until the transition to Australian training at SSN 06 will be particularly challenging.

14.2 Decision Timings to Avoid a Capability Gap.

14.2.1 Collins Life Extension. The first Collins is due to pay off at the end of its planned life in 2025. Whilst a life extension program has been assessed as feasible, this will divert scarce financial and technical resources. Perhaps the most important implication; the operational capability obtained will be problematic, as one would expect from an effort to extend 1980s technology into the 2030s. The optimistic schedule to initiate and negotiate arrangements and a nine year construction period set out in Annex B, with a decision to embark upon this program in 2016 would result in commissioning SSN01 in January 2029 (Annex B table B1 refers). A life extension for some of the Collins class may be required to avoid a dip in SM numbers and provide some hedge against delays in the SSN program. Most of the impact on the RAN's operational capability of a full life extension program should be avoided and Australia would have the benefit of a rapid increase in operational submarine capability arising from the growing SSN capability.

14.3 Comparison Between Virginia/ASTUTE and Barracuda Manning

14.3.1 Virginia/ASTUTE Manning. The number of qualified personnel needed to man 10 of these SSN sustainably is circa 3,400 qualified submariners, using a 'crewing ratio' of 2.8. Allowing for an additional 500 in the training pipeline, a total manpower allowance of approximately 3,900 would be required. The figure of 3,400 qualified personnel represents approximately a five-fold growth in the RAN's current SM Arm and would represent an increase of circa 22% in the size of the RAN. [Part I Section 13.3] s33(a)(ii)

[redacted]

14.3.3 Barracuda. The total number of qualified personnel needed to man 10 Barracuda class SSN with single crews sustainably is circa 1,680 qualified submariners, using a 'crewing ratio' of 2.8. Allowing for 180 trainees a total manpower allowance of approximately 1,860 personnel would be required. Compared to the current allowance of 704 qualified this would be an increase of 2.3 times the current manpower allowance. If Collins manpower was increased to 6-7 crews in a submarine arm of 1,140 qualified personnel, the increase of 540 personnel to the 1,680 qualified personnel required to man a force of 10 Barracuda represents a 47% growth over the 20 year period of the program.

14.3.4 It Is Possible! The major conclusion from this paper is that given satisfactory resolution of the outstanding manpower issues identified in this paper, it could be possible for Australia to man a force of 10 Barracuda Class SSN. There are two important provisos to this forecast; the project would have to be tackled as national priority and the RAN must use the short time remaining to build up the numbers of qualified personnel by double crewing the Collins Class force with 6-7 crews.

15 - Recommendations

15.1 Ensure An Adequate Supply of Manpower.

There are many critical aspects to successfully establishing an SSN capability for the RAN. The capacity to supply the necessary skilled and trained manpower as and when required to safely operate and maintain these submarines is fundamental to success. Embarking on such a program should not be contemplated without solving this challenge. To do otherwise would be a waste of significant resources and leave Australia without an operational submarine capability at a time when it may need it most. The RAN should immediately initiate a high priority program to grow the RAN submarine Arm to 6-7 crews. This step is the starting point for any future submarine program transition; be it conventional or nuclear powered.

15.2 Prepare A Barracuda Option.

A study should be initiated with the objective of providing a third option for the Future Submarine (FSM) First Pass decision; that of a 10 Barracuda Class SSNs. Finally, a suggestion on the timing of this decision; the First Pass decision on which of the 3 options to select must occur no later than January 2016 if the operational and financial impacts of a Collins Class lifer extension program are to be mitigated or avoided.

Annexes:

A. Essential Shore Manning

B. Illustrative Manning Timings

Website/Social Media Video

Audience	Current/Future Navy workforce, family
Platform	Navy intranet, YouTube, CN/Navy social media channels (including IGTV)
Film Location	Canberra – OCN, Russell
Creator	Kon Velanis
Editor	Digital Media
Word Count	989
Total Time	08:36

Script – Chief of Navy, VADM Michael Noonan, AO, RAN

The 2020 Defence Strategic Update (DSU) highlighted a rapidly deteriorating strategic environment in our near region.

The Indo Pacific is now at the epicentre of strategic competition, and the risks of miscalculation are increasing.

The Government remains committed to protecting Australia and its national interests, and that of our partner nations, in a rapidly changing global environment.

In the Indo-Pacific, military modernisation is occurring at an unprecedented rate.

Capabilities are rapidly advancing and their reach expanding.

The technological edge enjoyed by Australia and our partners is narrowing.

There is no doubt that we are operating in complex, and uncertain times.

It is important, now more than ever, that Our Navy is prepared and able to deter and respond to current and future challenges in our region.

To do this, we must invest in the right military technologies. These capabilities will enable us to continue to defend Australia and its national interests.

Today, on the 16th of September, the Prime Minister announced an Enhanced Trilateral Security Partnership between Australia, the United Kingdom and the United States – to be known as AUKUS.

This partnership is based on a shared vision for a stable, secure and prosperous Indo-Pacific, building on our already-rich relationships.

AUKUS will allow Defence to enhance our joint capabilities and interoperability, with an initial focus on cyber capabilities, artificial intelligence, quantum technologies and additional undersea capabilities.

The first major initiative under AUKUS is the acquisition of a nuclear-powered submarine capability for our Navy.

This is the single most consequential capability decision - certainly in my lifetime - and it will shape the direction of our Navy for ever more.

It heralds a new era for our Navy and will no doubt change the shape of our Nation.

I welcome this announcement and the decision by Government to ensure that our People have the capabilities that we need to fight, and win, at sea.

The pace of change means that in the future, a conventional submarine, no matter how advanced, will be unable to undertake the full range of required activities across the region.

Nuclear-powered submarines have superior characteristics of stealth, speed, manoeuvrability, survivability, and almost limitless endurance, when compared to conventional submarines.

They can deploy unmanned underwater vehicles and can also carry more advanced and a greater number of weapons.

These abilities allow nuclear-powered submarines to operate in contested areas with a lower risk of detection and deter actions against Australia’s interests.

Most importantly to me, this approach will give our People the very best available capability to fight and win at sea.

Over the next 18 months, we will work with our UK and US counterparts to determine the optimal pathway to achieve this capability, and address elements such as nuclear stewardship, regulation, training and our workforce.

This work will be primarily undertaken by a dedicated task force, led by Vice Admiral Jonathan Mead, with various levels of support from across Defence and the whole of Government.

In parallel, Our Navy will work with the Task Force and other stakeholders to develop a Submarine Capability Transition Plan, to work through the complex changes that will be required to successfully deliver this capability into service, while continuing to sustain the Collins class submarines.

In order to focus the resources where they are most needed, the Prime Minister has also announced that our Government is not proceeding with the Attack class program.

While this is a necessary step, there will be many of our People working on the Attack class program that will be affected by this news.

To that end, I want to take time to acknowledge those working in the Attack Class Program, and their extraordinary efforts, over a long period of time. Thank you.

And now more than ever, your expertise is essential to our future success.

For those of you thinking, ‘what does this mean for me?’

It is important to note that the Navy, and Defence more broadly, has an important job to do, today, ensuring forces are ready now to defend Australia and our National interests, while concurrently delivering and transitioning to future capabilities.

Apart from contributing to Government directed operations and activities, over the coming decades, the National Naval Shipbuilding Program will see the delivery of:

- 9 Hunter class frigates
- 10 Arafura class offshore patrol vessels
- 6 evolved Cape class patrol boats
- up to 8 new mine countermeasure and military survey vessels
- an ice-rated replacement for our Ocean Protector, and
- a new large forward support vessel.

The Government has also announced an investment in the enhancement of our long-range strike capability, with our Hobart class destroyers equipped with Tomahawk Cruise Missiles

These capabilities, coupled with our planned life-of-type extension of our Collins class submarines—which remains one of the most capable conventional submarines in the world—will enhance our ability to deter and respond to potential security challenges during the transition to a fleet of nuclear-powered submarines.

This is a critically important time for Our Navy, and we need all hands on deck.

Some of you will be intimately involved in the development and eventual operation of this capability - our nuclear-powered submarine fleet.

Many though, are yet to even enlist in Our Navy

The next generation will bring with them a new generation of thinking, skill and mastery, contributing to ideas and outcomes never before seen in Our Navy’s history.

Together, we will forge a new legacy.

To those currently serving, I want to thank you all for your service, your efforts and your dedication. To our Future Navy, I want to thank you for all that you will do.

There is hard work ahead, and the consultation period over the next 18 months will help us chart a course. I am confident that there is nothing we cannot achieve, together.

We will build upon our highly capable force – a thinking, fighting and Australian Navy, that will be ready to meet whatever challenges may come.

Now and into the future.

// ENDS

Australian Government
Department of Defence

SERVICE
COURAGE
RESPECT
INTEGRITY
EXCELLENCE

A message from the Secretary and the Chief of the Defence Force

16 September 2021
Colleagues,

Today, Prime Minister Morrison, together with Prime Minister Johnson and President Biden, announced, an historic advance in Australia's strategic ties with the United Kingdom and the United States.

This enhanced trilateral security partnership, known as AUKUS, will deepen collaboration on a range of security and defence capabilities.

Australia's commitment to this goal has required the Government to reassess its capability needs so that our ADF can continue to protect Australia and its national interests for decades to come.

The first major initiative under AUKUS will be Australia's acquisition of a nuclear-powered submarine fleet, for operation by the Royal Australian Navy.

Defence is not seeking the acquisition of nuclear weapons. We are fully committed to our obligations under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), and to upholding other agreements, including with the International Atomic Energy Agency.

A Nuclear Powered Submarine Task Force, led by Vice Admiral Jonathan Mead AO, will work over the next 18 months to extensively examine the requirements that underpin nuclear stewardship, including safety, disposal, regulation, environmental protection, training facilities, basing, workforce, and force structure.

This decision means Australia will not proceed with the Attack class program, and was not made lightly. The decision was made by Government, based on advice from Defence, following a review into future strategic requirements.

We would like to acknowledge and thank all of the staff - ADF personnel, public servants and contractors - who have worked tirelessly on the SEA 1000 project to date. Many of you have worked on this project for a number of years. Please know that we, along with Government, are committed to finding roles for all personnel affected by this announcement.

While this is a pivot in our future submarine program, we still have a job to do in delivering our continuous naval shipbuilding program.

The Prime Minister also announced that Australia will invest in the enhancement of our long-range strike capability, including:

- Tomahawk Cruise Missiles, to be fielded on Navy's Hobart class destroyers; and
- Joint Air to Surface Standoff Missiles (Extended Range) for our Air Force.

Additionally, through AUKUS, the three nations will collaborate on joint capabilities and interoperability, initially focusing on cyber capabilities, artificial intelligence, quantum technologies and additional undersea capabilities.

These decisions will enhance Australia's ability to deter and respond to potential security challenges during the transition to a fleet of nuclear-powered submarines.

We encourage you to watch the Prime Minister's speech, available here.

We understand these decisions may cause some staff stress and uncertainty. There are a number of support mechanisms available to you if you feel you need assistance. The All-Hours support line (1800 628 036), the Employee Assistance Program (1300 687 327 [1300 OUR EAP]), and the ADF's mental health and psychology services are available to promote positive mental health for all Defence members.

Thank you

Greg Moriarty	Angus J Campbell, AO, DSC
Secretary	**General**
Department of Defence	**Chief of the Defence Force**

From CN AUSTRAL A

DTG: 160300Z SEP 2021

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Pr or ty

AUKUS ENHANCED TRILATERAL SECURITY PARTNERSHIP AND NUCLEAR-POWERED SUBMARINES FOR AUSTRALIA Z4P

A. SECRETARY AND CDF MESSAGE 16 SEPTEMBER 21
B. 2020 DEFENCE STRATEG C UPDATE-DSU20
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1. PURPOSE. TH S S GNA PROV DES MY N T A GU DANCE FO OW NG THE S GN F CANT GOVERNMENT DEC S ONS ANNOUNCED BY THE PR ME M N STER TODAY, AND SUMMAR SED BE OW:
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A. ESTAB SHMENT OF QUOTE AUKUS UNQUOTE, AN ENHANCED TR ATERA SECUR TY PARTNERSH P BETWEEN AUSTRA A, THE UN TED K NGDOM AND THE UN TED STATES, WH CH W NC UDE DEEPER COOPERAT ON ACROSS A NUMBER OF CAPAB TY SYSTEMS.
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B. ESTAB SHMENT OF A WHO E OF GOVERNMENT TASK FORCE TO DETERM NE THE PATHWAY FOR DE VERY OF NUC EAR-POWERED SUBMAR NES FOR AUSTRA A SUPPORTED THROUGH AUKUS. TH S W NC UDE NOT PROCEED NG W TH THE ATTACK C ASS PROGRAM.
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C. THE DE VERY OF AN ENHANCED ONG-RANGE STR KE CAPAB TY, W TH THE ACQU S T ON OF TOMAHAWK CRU SE M SS ES FOR THE HOBART C ASS DDG AND JO NT A R-TO-SURFACE STANDOFF M SS ES (EXTENDED RANGE) FOR THE RAAF.
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2. WHY. THE 2020 DEFENCE STRATEG C UPDATE (DSU) AT REF B, H GH GHTED THAT AUSTRA A'S STRATEG C ENV RONMENT HAD DETER ORATED MORE RAP D Y THAN EXPECTED AND FORESAW THAT ADJUSTMENTS TO PO CY, CAPAB TY AND FORCE STRUCTURE SHOU D BE MADE. AS A RESU T, A SER ES OF STUD ES WERE CONDUCTED TO ASSESS THE EFF CACY OF THE FUTURE FORCE, AGA NST THE GOVERNMENTS RESO VE TO PROJECT M TARY POWER AND DETER ACT ONS AGA NST US N A S GN F CANT Y MORE CHA ENG NG AND CONTESTED ENV RONMENT. THE ANNOUNCEMENTS ABOVE REF ECT THE CAPAB TY REQU RED TO ACH EVE THAT M SS ON. N THE CASE OF SUBMAR NES:
-
A. BASED ON THE ACCE ERATED M TARY MODERN SAT ON, T WAS FOUND THAT A CONVENT ONA SUBMAR NE, EVEN THE MOST ADVANCED BOAT, WOU D BE UNAB E TO UNDERTAKE THE FU RANGE OF REQU RED ACT V T ES N THE DES GNATED OPERAT NG ENV RONMENT.
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B.NUC EAR-POWERED SUBMAR NES HAVE SUPER OR CHARACTER ST CS OF SPEED, MANOEUVRAB TY, SURV VAB TY AND A MOST M T ESS ENDURANCE, WHEN COMPARED TO CONVENT ONA SUBMAR NES. THEY CAN DEP OY UNMANNED UNDERWATER VEH C ES AND CAN A SO CARRY MORE ADVANCED AND A GREATER NUMBER OF WEAPONS. THESE AB T ES A OW NUC EAR-POWERED SUBMAR NES TO OPERATE N CONTESTED AREAS W TH A OWER R SK OF DETECT ON AND DETER ACT ONS AGA NST AUSTRA A'S NTERESTS.
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3. WHAT TH S MEANS FOR OUR NAVY. TH S S A S GN F CANT ANNOUNCEMENT, AND HERA DS A NEW ERA FOR OUR NAVY. THERE ARE VERY FEW NAV ES THAT PUT NUC EAR-POWERED SUBMAR NES TO SEA, POSSESS FORM DAB E ONG RANGE STR KE CAPAB T ES AND BENEF T FROM DEEPENED COOPERAT ON ACROSS A RANGE OF EMERG NG SECUR TY AND DEFENCE TECHNO OG ES. OUR NAVY W BE ONE OF THEM.
--
4. WHAT NEED FROM OUR NAVY. SOME OF YOU W HAVE A PART TO P AY N DEF N NG THESE CAPAB T ES, NTRODUC NG THEM NTO SERV CE, AND U T MATE Y OPERAT NG THEM, POTENT A Y N CONTESTED ENV RONMENTS. HOWEVER, FOR THE MAJOR TY OF OUR NAVY R GHT NOW, WE NEED TO REMA N FOCUSSED ON OUR CURRENT HEADMARK SO THAT OUR NAVY S READY TO CONDUCT SUSTA NED COMBAT OPERAT ONS AS PART OF THE JO NT FORCE. THROUGH BUSHF RES, PANDEM CS AND CONT NUED OPERAT ONA DEP OYMENTS, OUR NAVY HAS DE VERED ON TS COMM TMENT TO OUR NAT ON, AND WE MUST CONT NUE TO DO SO N THE MONTHS AND YEARS AHEAD, WH E CONCURRENT Y

P ANN NG FOR OUR FUTURE MAR T ME SYSTEMS.
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5. WHAT NEXT. APART FROM OOK NG AFTER OUR PEOP E, AND SUPPORT NG REA WOR D OPERAT ONS AND GOVERNMENT D RECTED ACT V T ES, OUR H GHEST PR OR TY S ENSUR NG THAT WE HAVE ADEQUATE RESOURCES AND THE R GHT PEOP E EMP OYED TO ENAB E THE NUC EAR-POWERED SUBMAR NE AND THE ENHANCED ONG-RANGE STR KE PROGRAMS, WH E A SO CONT NU NG TO P AN AND DE VER THE EX ST NG H GH Y COMP EX SH PBU D NG AND MAR T ME DOMA N PROGRAMS. N RE AT ON TO NUC EAR-POWERED SUBMAR NES, MY NTENT OVER THE COM NG MONTHS S BASED ON THREE PR MARY NES OF EFFORT:
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A. STAB SE. THE GOVERNMENT'S DEC S ON TO PURSUE NUC EAR-POWERED SUBMAR NES MEANS WE W NOT BE PROCEED NG W TH THE ATTACK C ASS. HAVE NO DOUBT THE ATTACK C ASS SUBMAR NE WOU D HAVE BEEN A WOR D- EAD NG CONVENT ONA SUBMAR NE, AND THAT THE PARTNERSH P W TH NAVA GROUP WOU D HAVE DE VERED THE CAPAB TY AS ENV SAGED. THE WORK DONE BY A ACROSS THE ATTACK C ASS PROGRAM FROM DEFENCE AND NDUSTRY ACROSS FRANCE AND AUSTRA A HAS BEEN EXTRAORD NARY. MY MMED ATE FOCUS S ON RECOGN S NG THESE EFFORTS, AND OOK NG AFTER OUR PEOP E AT HOME AND ABROAD.
-
B. COMMUN CATE. T S MPERAT VE THAT WE ARE AB E TO COMMUN CATE THESE DEVE OPMENTS C EAR Y AND CONC SE Y TO A KEY STAKEHO DERS, NC UD NG OUR PEOP E. N THE SHORT TERM, THERE W BE VAR OUS NES OF COMMUN CAT ONS TO EXP A N THE DEC S ON, THE CAPAB T ES SOUGHT, AND THE PATH AHEAD. WH E W BE THE S NG E PUB C SPOKESPERSON FOR NAVY, WE W A NEED TO BE A GNED N OUR MESSAG NG TO ENGAGE W TH FAM Y, FR ENDS AND CO EAGUES ON THE BAS C E EMENTS OF THESE DEC S ONS.
-
C. P AN FOR THE FUTURE. THE GOVERNMENT HAS COMM TTED TO AN 18 MONTH PER OD OF NTENSE WORK W TH THE US AND UK TO DENT FY THE OPT MA PATHWAY TO DE VER A NUC EAR-POWERED SUBMAR NE CAPAB TY. A DED CATED MU T -AGENCY TASK FORCE, ED BY VADM MEAD, HAS BEEN ESTAB SHED TO UNDERTAKE TH S WORK. N PARA E , NAVY W WORK C OSE Y W TH THE TASK FORCE TO DEVE OP A SUBMAR NE CAPAB TY TRANS T ON P AN WH CH W ADDRESS MMED ATE ASPECTS SUCH AS PEOP E, ORGAN SAT ON, COMMAND AND MANAGEMENT, TRA N NG AND FAC T ES.
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6. MY COMM TMENT TO OUR PEOP E. NAVY'S FUTURE S BR GHT AND AS A WAYS, T S THE MEN AND WOMEN OF OUR NAVY WHO W REA SE WHAT S TO COME. MANY OF YOU W NO DOUBT HAVE QUEST ONS, AND AM DEEP Y AWARE THAT OTHERS W BE D RECT Y AFFECTED BY THESE DEC S ONS. W CONT NUE BE NG TRANSPARENT W TH PROGRESS AND FUTURE DEC S ONS AND CAN CONF RM THAT NAVY, CASG AND DEFENCE BROAD Y S ABSO UTE Y FOCUSSED ON ENSUR NG THE CO ECT VE WE BE NG OF OUR PEOP E AND THE R FAM ES.
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7. FOR W DEST D SSEM NAT ON.
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8. CN SENDS

Australian Government

Defence FOI 140/21/22
Item 2, Serial 4

AUKUS: Trilateral security partnership

A step-change in our approach in regional security

'AUKUS' is an enhanced trilateral security partnership between Australia, the United Kingdom and the United States. AUKUS is based on our enduring ideals and a shared commitment of our three countries to a stable, secure and prosperous Indo-Pacific region.

AUKUS will deepen diplomatic, security and defence cooperation between Australia, the United Kingdom and the United States with a focus on joint capabilities and interoperability - initially focusing on cyber capabilities, artificial intelligence, quantum technologies and additional undersea capabilities.

For Australia, AUKUS is a step-change that will complement our efforts to build a network of international partnerships—such as with ASEAN, our Pacific family, Five Eyes partners and like-minded partners in the region, like the Quad.

Change in our strategic environment

The *2020 Defence Strategic Update* noted the strategic environment has deteriorated more rapidly than anticipated. The Indo-Pacific is now at the centre of strategic competition. We are seeing technological disruption and military modernisation occurring at an unprecedented rate.

This is a pivotal moment for Australia to become a more capable power in the 21st century, in line with our commitment to a global rules-based order. Through AUKUS, we will strengthen our ability to support shared security and defence interests. AUKUS will also foster deeper integration of defence-related science, technology, industrial bases and supply chains. It will enable us to deepen cooperation on a range of security and defence capabilities.

Nuclear-powered submarines

The first major initiative under AUKUS is a trilateral program to support Australia in acquiring at least eight nuclear-powered submarines for operation by the Royal Australian Navy. A submarine capability is essential to safeguard our maritime approaches, sea-lines of communication and to support a range of strategic effects that contribute to our national security.

Nuclear-powered submarines have superior characteristics of stealth, speed, manoeuvrability, survivability, and almost limitless endurance, when compared to conventional submarines. They can operate in contested areas with a lower risk of detection and deter actions against Australia's interests.

This is about nuclear-powered submarines. The Government has no intention to acquire nuclear weapons. Australia will remain a non-nuclear weapons state and will continue to meet its obligations under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and other relevant agreements, including with the International Atomic Energy Agency.

The Government intends to build Australia's nuclear-powered submarine fleet in South Australia, and we will actively work with industry to maximise Australian industry opportunities in this endeavour.

Australian Government

Investing in a capability edge

Australia's strategic environment

Australia's region is now in the midst of the most consequential strategic realignment since the Second World War. The *2020 Defence Strategic Update* and *2020 Force Structure Plan* reaffirmed the need to build a more potent, capable and agile defence force, including acquiring capabilities that enable Australia to hold adversary forces and infrastructure at risk further from Australia.

The Australian Government is delivering on a range of high-end capability enhancements within the next 10 years which will ensure the Australian Defence Force is better prepared to support a secure, stable and prosperous region.

Opportunities through AUKUS

The establishment of AUKUS demonstrates the shared commitment of Australia, the United Kingdom and the United States, to protect and promote prosperity in the Indo-Pacific region.

Through AUKUS, we will collaborate with the United Kingdom and United States on a nuclear-powered submarine capability for Australia as well as on cyber capabilities, artificial intelligence, quantum technologies and additional undersea capabilities.

AUKUS will also enable our three countries to better collaborate on defence science, research and education, technology, joint capabilities and industrial bases, building on Australia's existing defence investment.

Increasing our investment in strike capabilities

Throughout the 2020s, Australia will rapidly acquire long-range strike capabilities to enhance the ADF's ability to deliver strike effects across our air, land and maritime domains.

- **Tomahawk Cruise Missiles** will be fielded on our Hobart class destroyers, enabling our maritime assets to strike land targets at greater distances, with better precision.
- Australia will acquire **Long-Range Anti-Ship Missiles** (Extended Range) (LRASM) for the F/A-18F Super Hornet.
- **Joint Air-to-Surface Standoff Missiles (Extended Range)** will enable our F/A-18 A/B Hornets and in future, our F-35A Lightning II, to hit targets at a range of 900km.
- We are collaborating with the United States to develop **hypersonic missiles** for our air capabilities.
- We will acquire for our Land Forces, **precision strike guided missiles** which are capable of destroying, neutralising and supressing diverse targets from over 400km.
- We are accelerating $1 billion for a **sovereign guided weapons manufacturing enterprise** – which will enable us to create our own weapons on Australian soil.

$64-$86 billion*

Australia's naval and maritime forces are a vital element of our national defence. They must be able to protect force at range and operate across vast distances. We are investing in a sovereign and continuous naval shipbuilding industry in Australia with new ships and vessels entering service and being sustained to maintain our capability edge.

$65 billion**

Air combat power is critical to protecting Australia and deployed forces from adversary threats. Australia's air combat investments have delivered a deployable F-35A Lighting II, the most advanced multi-role stealth fighter in the world. We are also investing in hypersonic weapons for our aircraft, greater maritime surveillance and accelerating design and manufacture of remotely piloted and autonomous systems.

$7 billion**

This investment ensures Australia has access to space, space services and geospatial information. From 2022, Defence is establishing a Space Division to work with the Australian Space Agency and industry to transform the way the ADF operates in space and across the joint force. We will acquire sovereign satellite communications, intelligence and surveillance capabilities which are critical to Australia's warfighting effectiveness.

$55 billion**

Australia's immediate investment in land combat capabilities will increase the land force's combat power, and give Defence more options to deploy land forces. The ADF is acquiring land Precision Strike Missiles; Self-Propelled Howitzers, and investing in enhanced combat vehicles and battlefield aviation capabilities in order to deploy and operate in high-threat environments.

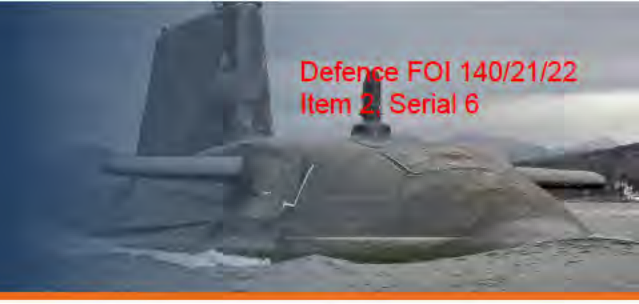
$15 billion**

Malicious activity and cyber threats have increased. Defence is funding the rapid expansion of offensive cyber capabilities, information warfare, and artificial intelligence. $1.35 billion will be invested over the next decade on the Cyber Enhanced Situational Awareness and Response package which will enable us to better identify more cyber threats to protect Australians and keep our critical services safe.

PLACEMAT

*Planned capability investments over the next decade as set out in the 2020 Force Structure Plan (PBS20-21). Cost-estimates for Australia's nuclear-powered submarines will be determined as part of the 18-month consultation with the UK and the US.
**Planned capability investments over the next decade as set out in the 2020 Force Structure Plan (PBS20-21).

Australian Government



Nuclear technology in Australia

Nuclear stewardship

Responsible nuclear stewardship is fundamental to Australia building, operating and sustaining a nuclear-powered submarine capability.

The United States and United Kingdom have set and maintained exemplary safety records in the operation of their submarine nuclear reactors for decades. Australia will look to replicate that safety record by leveraging their decades of experience as excellent stewards of this technology.

For more than 60 years, Australia has operated nuclear facilities and conducted nuclear science and technology activities, providing us experience in stewardship of nuclear facilities. The Australian Government will engage with the International Atomic Energy Agency (IAEA) throughout the program and maintain Australia's exemplary nuclear non-proliferation credentials. The Government has also directed the Department of Defence to ensure our national nuclear organisations are closely consulted at all stages.

Australia will maintain it's commitments to nuclear non-proliferation and the safe and responsible use of nuclear technology and materials. Australia's new submarines will **not** carry nuclear weapons.

Over the next 18 months, Australia will work with the United Kingdom and United States, to intensively examine the full suite of requirements that underpin nuclear stewardship, with a specific focus on safety, design, construction, operation, maintenance, disposal, regulation, training, environmental protection, installations and infrastructure, basing, workforce, and force structure.

The Australian Government **will**:

- maintain our exemplary nuclear non-proliferation credentials
- continue our longstanding history of safety and regulatory capability
- engage regularly with international and national nuclear regulators.

The Australian Government **will not**:

- have nuclear weapons on the submarines
- seek to build a civil nuclear power industry
- be required to refuel the submarines during their lifetime
- dispose of nuclear waste in an unsafe manner.

Australian Government

Nuclear-powered submarines

Australia's new submarine strategy

In response to a rapidly deteriorating strategic environment, Australia, with the support of AUKUS, will establish a pathway for the acquisition of at least eight nuclear-powered submarines.

Nuclear-powered submarines represent a significant capability enhancement, and will allow Australia to play a stronger role in contributing to stability and prosperity in our region. Submarines are an essential part of Australia's naval capability, providing advantages in terms of surveillance and protection of our maritime approaches. Australia's new submarines will not carry nuclear weapons.

Over the next 18 months, Australia will work with the United Kingdom and United States, to intensely examine the full suite of requirements that underpin nuclear stewardship, with a specific focus on safety, design, construction, operation, maintenance, disposal, regulation, training, environmental protection, installations and infrastructure, basing, workforce, and force structure.

Our acquisition of nuclear-powered submarines will form part of a suite of capabilities that will ensure Australia's ability to shape our strategic environment, deter actions against Australia's interests and respond with credible military force when required.

At least 8 nuclear-powered submarines

18 months to determine the optimal pathway

Intent to build at Osborne, sustain in Australia

Significant capability enhancement

Capability edge

Nuclear-powered submarines offer an enhanced capability when compared to conventional submarines. They are powered by a nuclear reactor instead of a diesel-electric engine, which means they can generate more power and are not required to resurface (snort) in order to recharge their batteries.

Nuclear-powered submarines have superior characteristics of stealth, speed, manoeuvrability, survivability, and almost limitless endurance, when compared to conventional submarines. They can deploy unmanned underwater vehicles and carry more advanced weapons. This enables them to operate in contested areas with a lower risk of detection and deter actions against Australia's interests.