

CONFERENCE ON DISARMAMENT

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**LETTER DATED 1 OCTOBER 2003 FROM THE PERMANENT REPRESENTATIVE
OF THE NETHERLANDS TO THE CONFERENCE ON DISARMAMENT
ADDRESSED TO THE SECRETARY-GENERAL OF THE CONFERENCE ON
DISARMAMENT TRANSMITTING A SUMMARY OF THE FIFTH OPEN-ENDED
INFORMAL MEETING IN THE FRAMEWORK OF THE NETHERLANDS' FMCT-
EXERCISE, ON A TREATY BANNING THE PRODUCTION OF FISSILE MATERIAL
FOR NUCLEAR WEAPONS AND OTHER NUCLEAR EXPLOSIVE DEVICES, HELD
IN GENEVA ON 26 SEPTEMBER 2003**

I have the honor to forward to you a summary of the fifth open-ended informal meeting in the framework of the Netherlands' FMCT-Exercise on the issue of banning the production of fissile material for nuclear weapons and other nuclear explosive devices (FMCT). This meeting was organised on Friday September 26, 2003, by the delegation of the Kingdom of the Netherlands to the Conference on Disarmament.

The topic of this fifth meeting was the non-weapon-use of fissile material: naval propulsion. At this meeting Dr. Marvin Miller, Research Affiliate, Center for International Studies, Department of Nuclear Engineering, Massachusetts Institute of Technology, and Dr. Tariq Rauf, in his personal capacity, gave introductions on this issue.

The total number of participants in this meeting was well over 100. Over 45 countries attended this meeting, some of them for the first time, demonstrating the growing interest in substantive debate on this issue.

I would be grateful, if you could issue this letter as well as the attachments to this letter as an official document of the Conference on Disarmament, and distribute it to all Member States of the Conference and non-members States participating in its work.

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Introduction

Dr. Miller, who emphasised to be speaking in a personal capacity, outlined the dangers of the diversion of HEU (Highly Enriched Uranium), particularly WGU (Weapon Grade Uranium) with regard to possible terrorist use to build a gun-type nuclear weapon. By means of examples (the widely spread HEU research reactors and nuclear powered submarines) Dr. Miller gave an overview of the difficulties in relation to a future FMCT and the present dangers of proliferation (see his presentation in attachment for more detailed information).

Dr. Rauf, who was also speaking in a personal capacity, gave a presentation on the problems arising from the use of fissile material as fuel for submarines in relation to non-proliferation implications. He especially drew the attention of the meeting to the lack of safeguards in this respect. He added that if a future FMCT would not cover naval propulsion, an important gap in the system of safeguards would remain (see his presentation in attachment for more detailed information).

Paragraph 14

Both Dr. Miller and Dr. Rauf drew attention to the problem that might be caused by invoking the 'escape' of paragraph 14 of INFCIRC/153, the NPT model safeguards agreement. Paragraph 14 creates a loophole in regard to comprehensive verification, since it allows states to make certain exceptions on the mandatory inspections.

Some participants argued that due to the highly classified nature of submarine operations and due to the fact that they operate most of the time out on the sea, it will be virtually impossible to develop a comprehensive safeguard-system. In this respect it was argued that the design of the submarine, reactor, composition of fuel, etc. are also highly classified information which parties would be very reluctant to make available for inspection.

It was also mentioned that under the NPT basically two categories of actions exist: allowed and prohibited activities. It was argued that it would pose difficulties to distinguish between those categories if an inspection, due to the classified nature of the reactor, submarine, etc. is limited to specific elements.

Role of the IAEA

Other participants argued that this is a loophole that should be mended. Dr. Miller replied that in his view the IAEA should investigate the possibilities and try to come to a solution. Dr. Rauf stated that if naval propulsion would be excluded from inspections by the IAEA this would leave an important gap in the system of safeguards. However, Dr. Rauf added that to a certain extent the loophole is already mended because the IAEA does investigate and keep track of non-declared stocks of HEU. The specific topic of naval propulsion though has not been subject of discussion within the IAEA. He furthermore added that the IAEA has developed a technique, which allows dismantling warheads, without revealing the composition of the used isotopes. This technique might be a solution for inspecting naval reactors. Remotely monitoring a reactor can prove difficult, because this might disclose its ships position.

Development of new techniques

Other participants emphasised the need for developing new techniques, which might simplify monitoring of non-described military use. The diplomatic community should no longer patiently wait and see what new techniques science is developing, instead diplomats should demand for the development of techniques that can be used to tackle the problems they are facing.

FMCT

Several participants stressed the importance of a Fissile Material Cut-off Treaty as a means of preventing proliferation of fissile material and prevention of non-conventional terrorism. Even the use of HEU for powering spacecraft was mentioned in this regard as a possible problem.

The readiness for starting negotiations on a FMCT was broadly acknowledged. By some it was argued that a FMCT would only relate to war materiel, not to the civilian or peaceful use of fissile material, although leaving the problem of verification of the latter unresolved. This issue should be dealt with after negotiations had commenced, it was argued.

(Signed):

Chris C. Sanders
Ambassador
Permanent Representative of the Netherlands
to the Conference on Disarmament

Annex I

***The Use of HEU in Naval Nuclear Reactors and
Its Implications for a Fissile Material Cutoff Treaty (FMCT)***

Marvin Miller
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Geneva, Switzerland September 26, 2003

1. As many of you know, the Bush administration's strategy paper, *National Strategy to Combat WMD*, issued in December 2002 supports the negotiation of an FMCT that "advances U.S. security interests". For some enlightenment on what this phrase means, I consulted a colleague at the U.S. State Dept. who told me that this document was an unclassified version of a classified Presidential Decision Directive that went into more details, but wasn't quotable at a public meeting. However, beyond noting that an FMCT wasn't high on the Bush administration's nonproliferation agenda, he said that the U.S. position was consonant with the views expressed in a recently published paper by William McCarthy and Andrew Barlow, "Verification of an FMCT". In particular, the U.S. government would only support a treaty that: applied to future production not existing stocks; took a focused approach to verification; and allowed the production of tritium and fissile material for civil purposes and non-explosive military applications, such as naval propulsion. Regarding the last, he commented, only half in jest, that the U.S. government would not allow "the FMCT tail to wag the Nuclear Navy dog." That is, the U.S. Navy would continue to use HEU, specifically weapons-grade uranium (WGU: 93.5% U-235), in its naval reactors, and would oppose intrusive verification of HEU in the naval fuel cycle.

2. On the other hand, the risk of diversion of HEU, particularly WGU, is, post 9/11, of growing international concern, particularly with regard to the possibility that a terrorist group could make a gun-type nuclear weapon from such material. This has motivated renewed emphasis in arms control circles on eliminating the use of HEU in both civilian land-based and naval reactors. Indeed, an effort to accomplish the former, the Reduced Enrichment Research and Training Reactor (RERTR) program has been underway since 1978 at the Argonne National Laboratory in the U.S. To date, 38 HEU-fueled research reactors in the U.S. and 19 other countries had been converted to the use of LEU, or are in the process of converting. In addition, 21 new research reactors have been built, are being built, or are planned with the new LEU fuels developed by the RERTR program. [For more information on the U.S. RERTR program, see their website: <http://www.td.anl.gov/Programs/RERTR/RERTR.htm>]

3. However, the task of eliminating the use of HEU in research reactors is far from complete. Although Russia launched its own RERTR program in parallel to the U.S., and succeeded in converting a significant number of WGU reactors it had exported to 36% enrichment, the program shut down in 1988 for lack of funding. In 1993, it restarted in cooperation with the US RERTR program with the goal of converting all US and Russian -designed research reactors to LEU by the end 2012. To this end, new and better LEU fuels - specifically fuels of higher uranium density to compensate for the reduction in enrichment - are needed to convert the most

demanding existing HEU reactors, e.g., the research reactor at MIT, and to encourage the use of LEU fuels in all future research reactors.

4. [The simple substitution of LEU for HEU in the reactor fuel elements without compensatory measures will reduce both the neutron intensity (flux) in the reactor and the lifetime of the fuel, and thus the reactor's potential utility as an experimental facility and its cost of operation, respectively. The major compensatory measure is to increase the amount (the loading or the density) of uranium in the fuel – either by increasing the proportion of uranium in an existing fuel type, e.g., a mixture of uranium and aluminum, or by the use of new fuels that have an inherently higher uranium density such as uranium silicides. The increase in density required may be decreased somewhat if it is possible to redesign the fuel element. For example, conversion of the 93.5% enriched MIT research reactor fuel to 20% would require uranium fuel densities of 8.6 g/cm³ and 7.6 g/cm³ for fuel of current and modified geometry, respectively. While the highest uranium density fuel currently licensed has a density of 4.8g/cm³, fuels with much higher density, e.g., so-called monolithic Uranium-Molybdenum (U-Mo) fuel with a density of 16g/cm³, are under development. (The existing MIT reactor fuel has a uranium density of 1.7g/cm³.)]

5. Thus, the prospects for LEU operation of all existing and future research reactors are good. However, there are still about 50 HEU-fueled research reactors with a power level of at least 1 MW for which no conversion to LEU is underway, and there are also a large number of officially shut-down, but not decommissioned research reactors, some of which may have significant quantities of poorly-secured HEU in inventory. The existing inventory of HEU for research reactors is estimated to be about 20 MT. [Also, a new 20 MW German reactor, the FRM-2, is scheduled to operate using HEU, but may be converted to LEU in the future if higher density fuels are developed.]

6. What about the prospects of converting HEU naval reactors to LEU? Currently, there are about 170 nuclear-powered vessels at sea; about 150 are submarines, and of these there are about 2X as many attack and cruise missile (SSN and SSGN) submarines combined as ballistic missile (SSBN) subs. [For a detailed breakdown, see Table 1 on p. 91 of the paper by Ma Chunyan & Frank von Hippel, "Ending the Production of HEU for Naval Reactors", *Nonproliferation Review*, 8 (2001), pp. 86-101.] Although the only states that currently have nuclear-powered vessels are the P-5, mostly in the US and Russia (~135), over the years several non-nuclear weapon states have indicated an interest in also acquiring SSNs. In fact, as most of you know, it was at the insistence of states such as Italy and Holland that wanted to retain an SSN option that the right to withdraw nuclear material from safeguards for such non-explosive military purposes was incorporated into paragraph 14 of INFCIRC/153, the NPT model safeguards agreement. [For a comprehensive analysis of the proliferation implications of invoking either paragraph 14 of INFCIRC/153 or Article III.2 of the NPT in order to utilize nuclear material in non-explosive military applications without safeguards, see Marie-France Desjardins and Tariq Rauf. See, e.g., "Opening Pandora's Box? Nuclear-Powered Submarines and the Spread of Nuclear Weapons" Aurora Papers 8 (Ottawa: The Canadian Centre for Arms Control and Disarmament, 1988)]

7. However, the paragraph 14 "loophole" was an academic issue until June 1987 when Canada announced plans to purchase a fleet of SSNs. At the time, I had recently returned from a leave of absence from MIT at the US Arms Control & Disarmament Agency (ACDA) where we had become aware of a secret Brazilian project to construct a centrifuge plant to produce enriched uranium to fuel a planned Brazilian SSN. The concern of the US government was that

if the fuel were weapons grade, as was the case for US and British subs, Brazil, at that time not a signatory of the NPT, would simultaneously acquire a nuclear weapons option. Since the admiral in charge of the Brazilian nuclear program and several of his associates were graduates of the MIT Nuclear Engineering Department (NED), while several of our senior professors had come from the US Nuclear Navy program, starting a research project at MIT on the feasibility of using LEU for naval propulsion seemed like a good idea.

8. [The challenge of converting existing HEU-fueled naval reactors, particularly submarine reactors, to the use of LEU fuel is more daunting than conversion of land-based research reactors. Space on ships, especially submarines, is very tight, and thus the option of enlarging the core volume as a means of maintaining the same reactor power and fuel lifetime in the absence of suitable higher uranium density fuels is not practical. Moreover, naval reactors must operate reliably for long periods of time, ideally for the life of the vessel, in a much more hostile and hazardous environment, e.g., in combat and underwater, and this may rule out the use of higher density fuels that are suitable for converting research reactors to LEU. However, as discussed below, it may be possible to design new nuclear-powered ships “from the ground up” to use LEU. See the following. Currently, the US and the UK use WGU to fuel their nuclear-powered subs and surface ships, Russia uses HEU up to 45% enrichment for its subs and up to 90% for its icebreakers, France uses both LEU and WGU for its existing subs, depending on the type, but future designs will use LEU, while China uses LEU. For details, see Ma Chunyan and Frank von Hippel, *op. cit.*, Table 2, p. 92.]

9. By the time of the Canadian announcement, such a project was already underway, but the competition between the UK and France to supply Canada with SSNs soon supplied us with an “existence proof” for the feasibility of an LEU-fueled submarine reactor. In a meeting in early 1988, with Yves Girard, a member of the French team that was promoting the sale of the French SSN, the *Rubis*, to Canada, I learned that the this submarine had been designed “from the bottom up” to use LEU instead of HEU. Specifically, the 50 MW *Rubis* reactor used fuel with three different enrichment levels, with an average enrichment of 7%. This required refueling every 10 years compared to 20 years for the larger US Los Angeles class SSNs. This in turn led to a decision to build hatches into the hull that in turn limited the diving depth to 350 meters. The other consequence of using 7% enrichment instead of the 97.3 % enrichment then used in US naval reactors was a significant increase in the volume of the reactor core, which was partially compensated for by using a compact “integral” reactor layout in which the steam generators are inside the pressure vessel instead of being outside as in a standard loop-type reactor layout. In sum, Girard said: “You must understand that we don’t have an unlimited budget. So our reasonable goal was not to make the best submarine in the world, but to get the best efficiency/cost ratio.”

10. The “existence proof” for the feasibility of an LEU-fueled sub provided by the *Rubis* was confirmed and extended by researchers in the MIT NED. They demonstrated that increasing the enrichment of the *Rubis* fuel from 7% to 20% permitted an extension of the core lifetime from 10 to 20 years, the same as that of the 97.3% enriched model reactor core that represented their best guess of the secret design of US naval reactor fuel. For reactors of the same power rating, the penalty for using 20 % enrichment was an increase in the core volume of about 2.5.

11. By the time the US Nuclear Navy got around to responding to the possibility of converting naval propulsion fuel from weapons-grade to LEU – in a June 1995 *Report on Use of Low Enriched Uranium in Naval Nuclear Propulsion* – the concern about SSN proliferation had

abated considerably. Canada had given up its SSN ambitions in 1990, primarily because of cost; nuclear subs are much more expensive to build and maintain than modern diesels. In addition, India had quietly returned the SSN it had leased from the Soviet Union amidst great fanfare in 1988 after a nuclear accident at sea, and Brazil had both scaled back its SSN program significantly, and pledged not to use fuel of >20% enrichment. Nonetheless, the report's bottom line - that the increase in core volume attendant in reducing the fuel enrichment from weapons grade to 20% was unacceptable to the U.S. Navy - has significant technical and political implications. The goal of the US Navy is to build the best nuclear-powered vessels in the world, and their fuel design has been optimized during an ongoing development program of more than 50 years to provide a rugged and reliable power source in the smallest possible volume that can respond to the need for rapid and frequent power changes to support tactical maneuvering, and last for the lifetime of the vessel. Their contention - that attempting to increase the uranium density of this fuel sufficiently to compensate for going to LEU without an increase in core volume would seriously compromise its performance - is both strongly held and impossible to verify without access to classified information.

12. Where does this leave us? The fact that the lifetime of the new US SSNs has been increased from 20 to 33 years indicates that some tweaking of their WGU fuel to increase the uranium density and/or that an increase in core volume *has* occurred. Could further changes in this direction permit the use of LEU? Perhaps. The good news from the perspective of the need to produce more HEU for naval propulsion is that both the U.S. and Russia are awash in stocks of HEU to fuel their nuclear-powered fleets for a long time without any further production. In particular, the U.S. Navy has stated that it has enough HEU stockpiled to fuel its nuclear ships at the current rate - estimated at ~2tons/year - for "many decades". During this time, the US could provide leadership by example by seriously investigating the potential for using new LEU fuels, possibly of the type being developed under the RERTR program to convert the remaining HEU research reactors, and also the possibility of non-intrusive but credible monitoring of the naval fuel cycle.

13. Re the former, I note that the high density U-Mo fuel previously mentioned is, unfortunately, not a suitable candidate for naval reactors primarily because of its poor metallurgical performance at the high temperatures characteristic of naval reactor operation. Re the latter, the need for credible, but non-intrusive verification in arms control agreements, e.g., the provisions for "managed access" to facilities in both the so-called "Additional Protocol" to IAEA safeguards agreements, INFCIRC/540, and in the Chemical Weapons Convention, is well recognized and accepted. Of course, "the devil is in the details", but it should be possible to devise credible nuclear naval safeguards procedures. For a detailed discussion, see the series of papers on the subject by Morten Bremer Maerli, the latest being "Timely Options for Increased Transparency and Non-Intrusive Verification on Highly Enriched Uranium Naval Fuel", *Journal of Nuclear Materials Management*, vol. XXXI, no. 4, Summer 2003.

Annex II

FMCT Exercise, Geneva: 25 September 2003

**THE CANADIAN NUCLEAR
SUBMARINE ACQUISITION
PROGRAMME OF 1987-1990**

by
Tariq Rauf

(Head, Verification and Security Policy Co-ordination
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PERSONAL COMMENTS

Disclaimer

During 1986-1995, Tariq Rauf worked at the Canadian Centre for Arms Control and Disarmament in Ottawa – an independent think-tank funded in part by External Affairs and International Trade Canada (EAITC), i.e. the Canadian foreign ministry -- and during that time he actively covered Canadian nuclear arms control and disarmament policy issues, including Canadian defence policy issues. During 1990-2001, he served as Non-Proliferation Expert / Advisor with Canada's delegations to NPT Review Conferences and their Preparatory Committees. The contents of this presentation derive from his publications and notes dating to 1987-1990, and do not in way reflect the views of any organization or entity – the views expressed are entirely personal and for purposes of facilitating discussion only.

**Canadian Nuclear Submarine Acquisition Programme:
1987-1990**

- June 1987: Canadian Defence White Paper identifies a requirement for the acquisition of 10-12 SSNs for the Canadian Navy
- Stated Mission Requirements: protection of SLOCs, GIUK gap, Defence of territorial waters
- Unstated Mission Requirements: assertion of Canadian territorial claims in the Arctic, including protection of the Northwest Passage and other Arctic sea-channels from foreign shipping
- Candidate SSN Suppliers: UK (*Trafalgar*) / France (*Rubis/Amethyste*)
- SSN Fuel: *Trafalgar* (HEU), *Rubis* (LEU)

**Canadian Nuclear Submarine Acquisition Programme:
Non-Proliferation Implications**

- NPT: no prohibition on acquisition of SSNs
- INFCIRC/164: Canadian CSA
- Paragraph 14, INFCIRC/164: Non-application of safeguards to nuclear material to be used in non-peaceful activities
- Model arrangement to implement para. 14 (?)
- Precedent for safeguards (?)
- Precedent for non-proliferation (?)

**Canadian Nuclear Submarine Acquisition Programme:
Non-Proliferation Implications**

- Key issue: exemption from safeguards of HEU/(LEU) used for nuclear submarine fuel ?
- *Trafalgar*: ship propulsion reactor (SP-5) licensed for production and use by the UK from the USA
- US-UK nuclear cooperation agreement does not allow retransfer or supply to third country, without specific prior permission from the US
- Isotopic composition of HEU-fuel, fabrication information, etc. remain highly classified
- Requirement for exemption of HEU-fuel from safeguards on the grounds of protection of classified information

**Canadian Nuclear Submarine Acquisition Programme:
Non-Proliferation Implications**

- Key issue: exemption from safeguards of HEU/(LEU) used for nuclear submarine fuel ?
- *Rubis*: ship propulsion reactor of indigenous French design burning LEU in pellet forms
- Isotopic composition of LEU-fuel, fabrication information, etc. remain highly classified (?)
- Requirement for exemption of LEU-fuel from safeguards on the grounds of protection of classified information (?)

**Canadian Nuclear Submarine Acquisition Programme:
Non-Proliferation Implications**

■ Paragraph 14, INFIIRC/153 (INFICRC/164)

Non-Application of Safeguards to Nuclear Material to be used in non-peaceful activities

14. The Agreement should provide that if the State intends to exercise its discretion to use *nuclear material* which is required to be safeguarded thereunder in a nuclear activity which does not require the application of safeguards under the Agreement, the following procedures will apply:

**Canadian Nuclear Submarine Acquisition Programme:
Non-Proliferation Implications**

Paragraph 14, INFIIRC/153 (INFICRC/164)

- a) The State shall inform the Agency of the activity, making it clear:
 - i. That the use of the nuclear material in a non-proscribed military activity will not be in conflict with an undertaking the State may have given and in respect of which Agency safeguards apply, that the nuclear material will be used only in a peaceful nuclear activity; and
 - ii. That during the period of non-application of safeguards the nuclear material will not be used for the production of nuclear weapons or other nuclear explosive devices;

**Canadian Nuclear Submarine Acquisition Programme:
Non-Proliferation Implications
Paragraph 14, INFIIRC/153 (INFICRC/164)**

- b) The Agency and the State shall make an arrangement so that only while the nuclear material is in such an activity, the safeguards provided for in this Agreement will not be applied. The arrangement shall identify, to the extent possible, the period or circumstances during which safeguards will not be applied.... The Agency shall be kept informed of the total quantity and composition of such unsafeguarded nuclear material in the State and of any exports of such material; and

**Canadian Nuclear Submarine Acquisition Programme:
Non-Proliferation Implications
Paragraph 14, INFIIRC/153 (INFICRC/164)**

- c) Each arrangement shall be made in agreement with the Agency...but shall not involve any approval or classified knowledge of the military activity or relate to the use of the nuclear material therein.

**Canadian Nuclear Submarine Acquisition Programme:
Non-Proliferation Implications**

- Central purpose of the Agency's safeguards system is to verify non-proliferation commitments (non-diversion of safeguarded nuclear material and absence of undeclared nuclear material & activities).
- In practice Agency safeguards apply to all nuclear material in a NPT NNWS.
- Exemption under para. 14 would affect verification of compliance and continuity of safeguards knowledge
- Practically impossible to create a "good precedent" for exemption under para. 14.

**Canadian Nuclear Submarine Acquisition Programme:
Non-Proliferation Implications**

- Para. 14 exemption was put in place during the negotiations on INFCIRC/153 (1970-1971), in deference to the wishes of certain advanced industrial States with advanced nuclear programmes
- Nuclear-powered civilian ships: *Otto Hahn* (German), and "*Mutsu*" (Japanese) – Soviet nuclear-powered ice-breaker fleet

**Canadian Nuclear Submarine Acquisition Programme:
Non-Proliferation Implications**

- Para. 14 exemption tried to limit the scope:
 - Non-proscribed military activity will not be in conflict with safeguards undertaking
 - Nuclear material will be used only in peaceful nuclear activity
 - During the period of non-application of safeguards, the nuclear material will not be used for the production of nuclear weapons or other nuclear explosive devices
 - The period / circumstances of non-application will be identified (to the extent possible)
 - The Agency shall be kept informed of the total quantity and composition of the nuclear material on which safeguards are not being applied
 - Approval / classified knowledge of non-proscribed military activity, or use of nuclear material therein, not required

**Canadian Nuclear Submarine Acquisition Programme:
Non-Proliferation Implications**

- Canada initiated discussions with the IAEA to negotiate a "model" paragraph 14 arrangement, with a view to: (a) ensuring the protection of classified information involving the ship-propulsion reactor, isotopic composition and fabrication of the nuclear fuel; (b) setting a "good precedent" to the extent possible by minimizing the break in safeguards; and (c) committing to the return to safeguards of the spent fuel (while protecting classified information relating to its composition).

**Canadian Nuclear Submarine Acquisition Programme:
Non-Proliferation Implications**

- Canadian critics of the SSN acquisition of the programme charged that, in practice, it would not be possible to set a “good precedent” in invoking the paragraph 14 exemption; that a Pandora’s Box could be opened leading other NPT NNWS to opt for exemptions thus leading to a weakening of the international safeguards system; that there was no internationally agreed definition of “non-proscribed military activity”; and that such action would break a “taboo” on the non-invocation of paragraph 14.

Canadian Nuclear Submarine Acquisition Programme

- In 1990, the Canadian government abandoned the SSN acquisition programme on the grounds of costs. A fleet of four diesel-powered submarines (SSKs) was eventually acquired from the UK in 2000-2002.