





Royal United Services Institute for Defence and Security Studies

The 2018 UK PONI Papers

Edited by Cristina Varriale





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October 2018



Royal United Services Institute for Defence and Security Studies



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Editor's Note

At the 2018 UK Project on Nuclear Issues (UK PONI) Annual Conference, held at RUSI in June 2018, emerging experts gave presentions on contemporary civil and military nuclear issues. These presentations were then adapted by the experts for this publication. The information contained in the publication is current at the time of writing in July 2018. The views expressed are the authors' own, and do not necessarily reflect those of the authors' institutions, UK PONI or RUSI.

I. Deterrence Planning Through Artificial Intelligence

Damon Jones

RTIFICIAL INTELLIGENCE (AI) has become increasingly prevalent in the past decade and continues to be at the forefront of technology-related news. This increasing prevalence can be attributed to advancements in processing power and new ways of processing larger amounts of data than previously possible, such as neural networks. On an almost correlative path with the introduction of AI, the way we test our software has also become more automated. The core concepts are similar – humans tend to get tired, bored and make mistakes. Autonomous systems, however, have the capability to work 24 hours a day, seven days a week doing the same tasks repeatedly and, assuming the system is programmed correctly, without mistakes. In this paper, I will discuss possible military applications of AI, specifically as part of the UK's nuclear deterrent, and outline some of the legal, political and moral questions of using such systems.

Al can be defined as '[the automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning' and '[t]he study of the computations that make it possible to perceive, reason, and act'.¹ Al has many uses that typically improve our lives. Examples of these include earlier detection of cancer during screenings,² autonomous or 'self-driving' cars sought out by companies like Waymo and Uber,³ stock market prediction,⁴ and robotics. Emphasising the topic of robotics offers examples of the application of Al, engineering and robotics from a military perspective, such as the discontinued 'BigDog' from Boston Dynamics and drones used for missile strikes, reconnaissance and more.⁵

So far, military applications of robotics and AI have been developed with safety in mind; militaries no longer need to carry heavy loads or send reconnaissance units, for instance, and instead let these systems do the job for them, leaving humans free and unhindered to carry out other important tasks.

2. Cade Metz, 'Using AI to Detect Cancer, Not Just Cats', Wired, 11 May 2017.

^{1.} Richard Bellman (1978) and Patrick H Winston (1992), quoted in Stuart Russell and Peter Norvig, Artificial Intelligence – A Modern Approach, Third Edition (London: Pearson, 2016), p. 2.

^{3.} Aarian Marshall, 'The Never-Ending Self-Driving Car Project', Wired, 8 April 2018.

^{4.} Jacob Saphir, 'Deep Learning Stock Prediction: Artificial Intelligence Expanding Applications', *IKnowFirst*, 27 March 2017.

^{5.} Stewart Smith, 'Military and Civilian Drone Use (UAV, UAS): The Future of Unmanned Aerial Vehicles', *TheBalanceCareers.com*, 6 April 2018.

Al could play a role in the future of the UK's nuclear deterrent. This could cover a range of areas such as logistical optimisation planning and stockpile management – for example, the transportation of warheads, and optimising their decommissioning and disposal. These could easily be implemented as part of the deterrent programme, perhaps even using commercial off-the-shelf products (COTS) that can be tailored to the unique processes involved with deterrence. We know Trident is governed by two-person control over the 'red button'.⁶ Applying Al to this system would probably use two or more autonomous systems communicating with each other, possibly through voting principles to determine outcomes.

Another application for AI in the UK's nuclear deterrent could be autonomous targeting. It can be assumed that software is being used to determine the trajectory and target of warheads in launch scenarios. We can also assume the task is being performed and checked by humans, who are, as discussed earlier, susceptible to fatigue, boredom and making mistakes. From a solely non-political perspective, warhead targeting, in theory, is simply data entry and verification. AI is particularly good at data analysis and could be used to carry out analysis on warhead launch and targeting data.

Before integrating AI in the UK's nuclear deterrent, there are legal, political and ethical implications to be considered. There are two challenges for policymaking in this area. The first is the Convention on Certain Conventional Weapons (CCW),⁷ which began in 1980 and over the past decade has fuelled discussions regarding lethal autonomous weapons systems (LAWS).⁸ In April 2018, both the UK and the US rejected negotiating new international laws on fully autonomous weapons at the CCW, but all states involved that spoke during the week stressed the need to retain human control over weapons systems and the use of force.⁹

The second concern is the possibility of violations of international humanitarian law with regard to the 'principle of distinction' governing the legal use of force in armed conflict, whereby belligerents must distinguish between combatants and civilians.¹⁰ There are questions over whether AI differentiates between civilian and military targets. In short, it would be very difficult for AI to make this distinction, unless the target was a base far away from towns and cities.

Before integrating AI, it would also be necessary to consider the risks and responses of relying on this capability for nuclear deterrence. If software were to go wrong, there are prominent

- 7. United Nations Convention on Certain Conventional Weapons, Geneva, 10 October 1980.
- Regina Surber, 'Artificial Intelligence: Autonomous Technology (AT), Lethal Autonomous Weapons Systems (LAWS) and Peace Time Threats', ICT4Peace Foundation and the Zurich Hub for Ethics and Technology (ZHET), 28 February 2018.
- Campaign to Stop Killer Robots, 'Convergence on Retaining Human Control of Weapons Systems', 13 April 2018, https://www.stopkillerrobots.org/2018/04/convergence/, accessed 17 July 2018.
- 10. Asa Kasher, 'The Principle of Distinction', *Journal of Military Ethics* (Vol. 6, No. 2, 2007), pp. 152–67.

^{6.} Douglas C Waller, *Big Red: Three Months on Board a Trident Nuclear Submarine* (New York, NY: HarperCollins, 2001); Douglas C Waller, 'Practicing for Doomsday', *Time*, 4 March 2001.

examples in history that demonstrate how this could play out. One example is the Russian false alarm incident, where the late Stanislav Petrov prevented almost certain nuclear war by taking faith that a missile alert on a Soviet detection system was a false alarm.¹¹ In a scenario unlike this, where human intervention fails to prevent catastrophe, questions over where the blame should lie would be raised. Politically, those in power would likely face a backlash as the ones responsible for allowing such a system to be used. From a safety-critical software perspective, the writers of the software tend to take financial blame,¹² but in cases such as this, the forces personnel signing off the data would also likely face repercussions.

Questions of ethics and morality would also need to be considered. Introducing AI raises the question of whether AI can be programmed to understand morality in its calculations. In essence, morality is a set of rules constructed by society, and computers, generally, are very good at following rules. It could be argued that a system such as this may be almost *too* moral when compared to a human equivalent,¹³ with AI being limited to following the rules it is given and not using contextual judgement.

These systems and their integration into the UK's nuclear deterrent will not become a reality within the next decade or so. However, given the broader trends in the development and use of AI, their integration could be a possibility in future. Before this can happen, policymakers and operators of the UK nuclear system will need to consider how these capabilities could be used and the political, legal and ethical questions of doing so.

^{11.} Madeline Bradshaw, '1983 Nuclear False Alarm', submitted as coursework for PH241, Stanford University, 9 November 2017.

^{12.} William Yeager et al., 'Safety-Critical Systems', Google Introduction to CIS, <https://sites.google. com/site/cis115textbook/safety-critical-systems>, accessed 28 June 2018.

^{13.} John McCarthy and Patrick J Hayes, 'Some Philosophical Problems from the Standpoint of Artificial Intelligence', Stanford University Computer Science Department, 1969.

II. Self-Driving Cars? Why Not a Self-Driving Nuclear Power Station? The Role of Artificial Intelligence in Civil Nuclear Power Stations

Oliver Dawkins

RTIFICIAL INTELLIGENCE (AI) is fast becoming ubiquitous in the modern world. From cancer diagnoses¹ to fully self-driving cars,² AI is taking on roles in society that had previously been solely in the human domain. With the advent of AI in such a wide-ranging set of industries, the nuclear sector seems to be languishing outside the growing AI bubble. This paper focuses on future potential applications for AI within the civil nuclear industry and examines some of the challenges that would need to be overcome to incorporate it. AI in its broadest sense is the capability of a machine to imitate intelligent human behaviour. Currently, the most successful AI programmes are those that use machine learning.

One of the key tools within the machine learning toolbox is neural networks. Neural networks are ensembles of interconnected units, each of which perform a calculation before passing the result on to the next connected layer. Although it sounds simplistic, neural networks allow for successful predictions of non-linear processes. It is only in the last decade or so, thanks to the introduction of more powerful graphics-processing units and more specialised tensor-processing units,³ that there has been enough processing power available to train these networks with the required amount of data to feasible timescales.

An example of how effective neural networks are at tackling real-life challenges is seen in technology company DeepMind's flagship AI, AlphaGo Zero.⁴ Designed to play and win games of Go, a board game, it learns by playing games against itself and training its corresponding neural network. Currently, it is arguably the highest-ranked Go player in the world. This is a prime

^{1.} Andre Esteva et al., 'Dermatologist-Level Classification of Skin Cancer with Deep Neural Networks', *Nature* (Vol. 542, February 2017), pp. 115–18.

^{2.} Bruce Brown, 'Tesla Fully Self-Driving Autopilot Package Coming in August, Musk Says', *Digital Trends*, 13 June 2018.

^{3.} Matthew Lynley, 'Google Announces a New Generation for its TPU Machine Learning Hardware', *TechCrunch*, 8 May 2018.

^{4.} David Silver et al., 'AlphaGo Zero: Learning from Scratch', *DeepMind*, 18 October 2017.

example of how AI can infer and capitalise on complex patterns that perhaps have no obvious empirical relationship.

During the operation of a civil nuclear power station, a vast amount of data is produced from the various plant inputs. Due to the sheer number of operational parameters, there is a large degree of non-linearity between the disparate elements, making it exceedingly difficult to predict the resultant change caused by an individual parameter. In the case of safety-critical decisions, there can be short timescales in which to decide on the best course of action to take. In this combined arena, it seems likely that AI-backed systems would not only be able to provide greater forewarning to impending issues, but also to monitor and decipher complex relationships within the underlying plant.

Generally, performance and safety of a nuclear power station move in opposite directions, with the sacrifice of one being required for an improvement in the other. With the onset of AI, however, methods to acquire improvements in both may be on the horizon.

While there is a large amount of complexity within power stations, it should be possible to predict the outcome of a transient based solely on the readings received. If a plant is operating in a steady state condition, the set of readings it receives produces a unique 'image' of what that state is. If a normal or an abnormal transient occurs, it should be possible for AI to classify what has caused the change and predict the state which the plant will finish in. Indeed, a recently published paper performs a similar analysis on a test reactor at Oregon State University and shows the accuracy of the predictions produced by a neural network.⁵ The advantage of this kind of transient identification is that it can provide increased forewarning to an operator about what has caused the transient and how likely issues are to arise from it. It could also help to provide differentiation between transients that produce a similar plant response, giving the operator further clarity.

To provide an increase in thermal performance, a neural network could be used to monitor the departure from nuclear boiling ratio (DNBR), a metric that describes how much additional heat and therefore power can be extracted from a nuclear power station for a given set of conditions. Previous work has looked at using neural networks to map a set of plant variables to the DNBR as calculated by a piece of software called COBRA,⁶ allowing a real-time investigation of how much additional power can be extracted from the plant. For reference, for each additional megawatt electrical (MWe) output produced, a surplus revenue of \$150,000 was generated.

As with any new technology, there are risks that must be overcome before implementation. In this case, one of the key risks comes from the data that is used to train the AI. If biased or faulty data is used during the training stage, then the predictions in a new scenario with

^{5.} Mario Gomez Fernandez et al., 'Nuclear Energy System's Behavior and Decision Making Using Machine Learning', *Nuclear Engineering and Design* (Vol. 324, September 2017), pp. 27–34.

^{6.} Robert E Uhrig, J Wesley Hines and William R Nelson, 'Integration of Artificial Intelligence Systems for Nuclear Power Plant Surveillance and Diagnostics', 1998.

unbiased data may also be skewed, producing a result that may potentially endanger the plant. In addition to this, an avenue of risk to consider would be in the case of faulty operation of the plant. If incorrect or incomplete data was received, for example if a temperature sensor was damaged, how would the AI react and how would it predict the best course of action given incomplete information?

In addition to incomplete information, nuclear power stations managed by AI could be at risk of adversarial attacks. A fairly recent area of interest, adversarial attacks on neural networks are designed to cause a neural network to misclassify an input, creating a targeted output. For an image classifier, this might mean misclassifying an animal, but for a power station it may cause far more serious damage.⁷

In conclusion, although AI use in a real-time nuclear station is far off, there exists a broad environment in which AI could be brought to bear. AI in the civil nuclear industry has the potential to increase safety levels while improving performance. Continuing to overcome the challenges presented, especially in relation to training AI to correctly read scenarios, is necessary before reaching a stage of implementation, but should not result in the dismissal of further exploration of these applications to the civil nuclear industry.

^{7.} OpenAI, 'Attacking Machine Learning with Adversarial Examples', 24 February 2017, <https://blog. openai.com/adversarial-example-research/>, accessed 22 June 2018.

III. Could a State Cyber Attack Result in Nuclear Retaliation?

Guy Bishop

S INCE THE 1940S the threat of a nuclear strike has concerned many states around the world. In the past decade or more a new threat has emerged: cyber attacks. With an increasing reliance on technology, the threat of a cyber attack has gained more prominence. This has given rise to a debate over whether a state cyber attack could result in nuclear retaliation. This paper specifically explores the criteria for nuclear use in the UK and the US and assesses whether or not a cyber attack could meet them. Based on the policies for nuclear use set out by the UK and the US, this paper argues that it seems implausible for these states to use nuclear weapons in retaliation to a cyber attack.

What are the Criteria for Nuclear Use?

The UK and the US have nuclear policies of calculated ambiguity and apply negative security assurances to non-nuclear weapon states (NNWS). They both state that they will only use nuclear weapons in extreme circumstances and have a commitment not to use them against NNWS which are party to the Non-Proliferation Treaty and in compliance with their nuclear non-proliferation obligations.¹

These individual pledges, however, contain caveats. In 2010 the US Nuclear Posture Review (NPR) suggested that nuclear weapons still play a role in deterring biological and chemical weapon attacks on the US or its allies and partners.² Furthermore, it stated that it may revise its assurance to reflect potential developments in biological warfare technology. The UK applied similar language in its 2015 Strategic Defence and Security Review.³

In the 2018 NPR, the US expanded this caveat from biological weapons to include any significant non-nuclear strategic attacks, which could include attacks on US, allied or partner civilian populations, or infrastructure and on US or allied nuclear forces.⁴

The UK is more ambiguous in its policy and maintains that it will deter the most extreme threats against it. It also states, like the US, that its assurance does not apply to those 'in material breach

US Department of Defense, 'Nuclear Posture Review 2010', US Government, April 2010, p. 15; HM Government, 'National Security Strategy and Strategic Defence and Security Review 2015', Cm 9161, November 2015, p. 35.

^{2.} US Department of Defense, 'Nuclear Posture Review 2010', pp. viii, 16, 47.

^{3.} HM Government, 'National Security Strategy and Strategic Defence and Security Review 2015'.

^{4.} US Department of Defense, 'Nuclear Posture Review 2018', US Government, February 2018, p. 21.

of those non-proliferation obligations'.⁵ Interestingly, both countries state that they reserve the right to change this assurance should future threats develop.

What Damage Could a Cyber Attack Do?

In the context of UK and US policy, for a cyber attack to be an extreme threat and meet the nuclear threat threshold, it would have to cause extreme damage possibly equivalent to a nuclear strike.

The US and the UK have stated that Russia and China⁶ have increasingly strong cyber capabilities and pose a great threat.⁷ With these capabilities, potential extreme cyber attacks could be made on:

- Critical National Infrastructure (CNI).
- Nuclear, command, control and communications (NC3).

What Would a Cyber Attack on Critical National Infrastructure Look Like?

An attack on CNI could impact the health sector, power and water, and/or financial sector, among others, and would cause severe, sustained damage (including loss of life). Lloyd's Insurance has estimated that an extreme attack could cost a country more than \$120 billion.⁸ Cyber attacks on CNI have been seen in the WannaCry⁹ and the NotPetya attacks.¹⁰ The ability of these attacks to disable a country's CNI draws parallels with the disruption caused by the electromagnetic pulse of a nuclear strike, as well as its speed to disable the fundamental workings of a country.

What Would an Attack on Nuclear Command, Control and Communications Look Like?

A few widely publicised reports¹¹ have suggested that an attack on NC3 could take many forms, the worst of which are that it could create a false alert of an incoming nuclear attack or cause an inadvertent launch.

- 5. HM Government, 'National Security Strategy and Strategic Defence and Security Review 2015'.
- 6. National Security Cyber Centre, 'ZTE: NCSC Advice to Select Telecommunications Operator with National Security Concerns', 16 April 2018.
- 7. National Security Cyber Centre and FBI, 'Russian State-Sponsored Cyber Actors Targeting Network Infrastructure Devices', 16 April 2018; US Department of Defense, 'Nuclear Posture Review 2018'.
- 8. Julia Kollewe, 'Lloyd's Says Cyber-Attack Could Cost \$120bn, Same as Hurricane Katrina', *The Guardian*, 17 July 2017.
- 9. BBC News, 'Cyber-Attack: US and UK Blame North Korea for WannaCry', 19 December 2017.
- 10. Sarah Marsh, 'US Joins UK in Blaming Russia for NotPetya Cyber-Attack', *The Guardian*, 15 February 2018.
- 11. Beyza Unal and Patricia Lewis, 'Cybersecurity of Nuclear Weapons Systems: Threats, Vulnerabilities and Consequences', Chatham House, 11 January 2018; Andrew Futter, 'Cyber Threats and Nuclear

For a cyber attack to be made on NC3 it would have to be very sophisticated. Examples of such capabilities are not publicly known, but a few reported examples have seen cyber attacks on nuclear facilities. In 2007 Israel was able to attack a Syrian nuclear facility by purportedly disabling the air-defence system through a sophisticated cyber operation.¹² Furthermore, the Stuxnet virus demonstrated a US/Israel cyber capability to infiltrate a secure nuclear facility.¹³

A recurring theme in the US NPR is the threat to the US NC3. Coupled with the stated cyber threat from Russia and China, it could be perceived that a severe cyber attack on NC3 could legitimise a nuclear response, or even cause one. Furthermore, Russia and China are not covered by the negative security assurances from the US or the UK as they possess nuclear weapons.

Overall these examples show that a severe cyber attack on CNI or NC3 would be devastating for a country. Whether they would constitute a significant non-nuclear strategic attack according to the US NPR and therefore warrant nuclear retaliation is debatable. The capability of a cyber attack to cause the equivalent amount of damage to a nuclear one is hard to justify. Past examples of cyber attacks have not caused the same amount of devastation as a nuclear strike, suggesting that the capability is not there yet. The US NPR seems to imply this by stating that it reserves the right to change its assurance should there be future developments in non-nuclear weapons technology.

A severe cyber attack on NC3 might cause a nuclear strike. However, such an attack would have to be highly sophisticated and it would be hard to trace back to a specific country. Second, there are more options to defend against a cyber attack than a nuclear attack. The US and the UK's cyber security are among the best in the world, suggesting that their NC3s would have excellent cyber security. Furthermore, other means exist for retaliation, such as sanctions, offensive cyber and conventional weapons.

Although a cyber attack can pose a severe threat to a country, the capability for it to cause the same amount of damage as a nuclear strike does not exist yet. Within US criteria, an attack on NC3 might warrant a nuclear response but it would have to be highly sophisticated and hence hard to trace back to a country. With currently known capabilities, cyber attacks do not pose a credible threat for nuclear retaliation.

Weapons: New Questions for Command and Control, Security and Strategy', RUSI Occasional Paper, July 2016.

Kim Zetter, 'Mossad Hacked Syrian Official's Computer Before Bombing Mysterious Facility,' Wired, 3 November 2009; David Fulghum and Douglas Barrie, 'Israel Used Electronic Attack in Air Strike Against Syrian Mystery Target', ABC News, 8 October 2007.

^{13.} Michael Kelley, 'The Stuxnet Attack on Iran's Nuclear Plant was Far More Dangerous Than Previously Thought', *Business Insider*, 20 November 2013.

IV. Securing Operational Technology: Nuclear Critical National Infrastructure

Kirsty Nixon

PERATIONAL TECHNOLOGY (OT) is used all around us and enables many aspects of everyday life, operating across many sectors of Critical National Infrastructure (CNI). OT is any combination of hardware or software that controls or monitors the operation of a physical process.¹ It can range from the systems that monitor and control an environment within a nuclear power plant to the sensors and weapons systems on a nuclear submarine. This short paper advocates a collaborative approach to risk assessment and management, encouraging both civil and defence enterprises to engage more with their stakeholders, as well as threat intelligence professionals, to improve the identification and management of risks to their OT through cyber attack.

As industries across all sectors continue to face greater economic pressure, many seek ways of improving the efficiency and performance of their operations. Our continually advancing technical capability often provides us with the solution to that challenge, and as a result we are now seeing more interconnected and outward-facing OT than ever before. These new connections can improve the performance of systems, enable remote viewing and, where applicable, permit remote control.

While technical capability continues to progress, so does the world's offensive cyber capability. A large proportion of OT has been in service for many years and was never designed to be secure from the type of threats we are seeing today. We are only beginning to see how cyber threat actors are developing their offensive capabilities to exploit OT weaknesses. This means that any connections to OT must be assessed to ensure that a route is not being created to allow malicious code to interact with systems. In 2018, the CEO of the UK's National Cyber Security Centre (NCSC) stated that a serious cyber attack on the UK is no longer a matter of if but when,² so we must be prepared and strengthen systems as best we can now.

Although targeted attacks are still few, this does not mean that systems would not suffer collateral damage from exposure to indiscriminate malicious code. As well as preventing a way

Gartner, 'Operational Technology (OT)', <https://www.gartner.com/it-glossary/operationaltechnology-ot/>, accessed 19 May 2018.

Ciaran Martin, 'Protecting the UK from the Increasing Cyber Threat – the Next Steps', National Cyber Security Centre, 22 April 2018, https://www.ncsc.gov.uk/news/protecting-uk-increasing-cyber-threat-next-steps, accessed 19 May 2018.

in, we also need to be sure we are not enabling a route out for data exfiltration; intelligencegathering operations may target operational data to reverse-engineer systems and procedures. Even if no new connections are made, physical support to OT should also be reviewed. This will include scrutiny of both the supply chain and repair and commissioning equipment in case they could enable a compromise.

To better assess the risk, more than solely technical vulnerabilities must be considered. Systems do not operate in a vacuum: they exist in the real world to fulfil a specific purpose. When assessing an OT system there must be an understanding of who would want to compromise it, and some determination of whether or not they can. It is this judgement of the capability and intent of threat actors that allows a true assessment of the extent of the threat they pose and an appreciation of the risks that exist.

While the impact of compromising OT can be very physical, it is only achieved by maliciously targeting the information or operational data contained on the equipment, and it is important that this information should have an owner. By taking ownership of the information, the foundation of the risk-mitigation strategy can be built. It would be sensible to consider the information owner within the nuclear sector to be the licence holder for civil applications and the UK government for defence. The information owners can determine what the information is worth because they have brought the system into being and have defined its purpose. They should understand the impact if information on those systems becomes compromised, for example the consequences if information lost its integrity, became unavailable or if unauthorised persons were to gain access or steal the information held on their OT.

Although the owner alone can initially decide the value of the information, they cannot identify risks and their associated mitigations alone. They will require the cooperation of stakeholders who play a part in managing the OT through its life-cycle. They will require support, knowledge and expertise from designers, manufacturers, operators and maintainers, as well as an understanding of the threat landscape. Only by working together and creating this joint enterprise will a balanced and objective risk assessment be made.

The cyber threat is evolving, and the techniques and tactics of threat actors change regularly; and while no organisation relishes the idea of owning and managing such risk, it is unfortunately necessary in today's rapidly changing cyber environment. Both civil and defence should reach out to their respective enterprise to bring together their stakeholders and improve this communication. Although there are challenges to the collaborative assessment of OT risk, the benefits are greater; this cooperation and collaboration will help to avoid preconceptions and bias and encourage a more objective risk assessment. It will also allow the enterprise to respond in a more dynamic way when risks are identified. While technical solutions can take time to design and test, the enterprise can strengthen its operational procedures to compensate until the technical solution is ready. OT vulnerabilities are still not fully understood and offensive capabilities are still in their teenage years. We are learning all the time, and by working together best practice can be shared, not only strengthening each stakeholder but resulting in a more robust and resilient enterprise as a whole.

V. An Argument for Capability Retention in the Event of Multilateral Disarmament

Brogen Dawkins

N THE EVENT of global nuclear disarmament, the question of how to manage legacy capabilities such as the handling of fissile material, knowledge and skill sets within the nuclear industry would be raised. There has been much consideration on the prohibition of nuclear weapons and what this future would look like, but less consideration has been given to what capabilities stand to be lost alongside the nuclear deterrent. Three main areas should be considered: managing public perception of nuclear issues; the importance of the field of nuclear forensics in terms of national security; and the benefits afforded by the current capabilities held within the nuclear industry.

It is important to be mindful of public impact and the influence of groups that help drive the narrative on disarmament issues. To prevent the danger of forgetting the many roles within the nuclear industry, more effort needs to be made to dissociate the word 'nuclear' from negativity in the public domain. Whether intentional or not, in some cases the lack of distinction in dialogue with the public can perpetuate a cycle of misunderstanding, leading to fear. Whether we are talking about weapons, power stations or national security, there is a stigma associated with anything nuclear. To diminish this negative view, it is vital that the gap in public perceptions on nuclear issues and their associated risks and the perceptions of experts within the industry be taken into consideration in an effort to improve understanding, due to the significant role it plays in the future of the industry.¹ A demonstration of this is in the energy sector with regard to potential development at sites with no history of nuclear operations. Without community support and good communication, the siting of new operations would be very difficult in the face of opposition.² Securing an informed understanding of public perception and awareness of nuclear risk will encourage and improve policy and decision-making processes.

At present, anti-nuclear campaigns advocating for disarmament are designed to strengthen these negative attitudes. For example, the Campaign for Nuclear Disarmament (CND) website includes information on campaigns calling for the abolition of not only nuclear weapons, but

^{1.} James Carr and Geeta K Devgun, 'Safety of the Nuclear Industry: A Case Study of Public Awareness and Perceptions', Symposium Series No. 156, IChemE 2011, p. 375.

House of Commons Energy and Climate Change Committee, 'Building New Nuclear: The Challenges Ahead', HC 117, Sixth Report of Session 2012–13, 4 March 2013, EV 127, para. 11; EV 128, para. 20–23.

also nuclear power.³ If an informative dialogue to increase understanding could be established, and parties involved were more receptive to discussion, issues and misinterpretation around the topic could be resolved, thereby reducing public fear.

One of the key areas that would still be an essential capability to maintain without the production of nuclear weapons would be nuclear forensics, the analysis of intercepted illicit nuclear material and any associated material to provide evidence for nuclear attribution. As said by Nancy Jo Nicholas in her previous role as Associate Director for Threat Identification and Response at Los Alamos National Laboratory, 'it takes a nuclear weapons lab to find a nuclear weapons lab'.⁴ It is likely that non-state actors would continue to be willing to capitalise on available stockpiles of material, or divert by-products from civil endeavours, for extremist purposes. As such, nuclear analysis to identify forensic indicators in interdicted nuclear and radiological samples, in order to assess their origins, would remain essential.

Specialist facilities and detailed knowledge are required to analyse and assess the material. Facilities best equipped to handle nuclear material for the role of disarmament and interdiction, safely and securely, are those which historically have done so, such as weapon facilities. When discussing the irreversible conversion of facilities in the event of multilateral disarmament, in some cases the facilities required to perform continuing adequate nuclear forensic analysis would look very similar to those required to produce weapons.

The infrastructure and instrumentation that would be required to continue nuclear forensic endeavours to provide support to national security efforts is already in place. Specialist facilities such as the Conventional Forensics Analysis Capability (CFAC) available at the Atomic Weapons Establishment (AWE) can recover fingerprints, fibres, DNA and other traditional trace forensics markers from materials that have been contaminated with radiological, nuclear or explosive materials.⁵ Again this is a unique capability that we could ill afford to lose, or indeed replace.

National security incidents such as the theft, trafficking and diversion of material are well documented. In an update of International Atomic Energy Agency (IAEA) trafficking statistics issued in 2017, it was shown that in 2016 alone there had been 189 confirmed incidents involving nuclear and other radioactive materials. In addition, a total of 1,174 confirmed or suspected incidents of trafficking or malicious use have been recorded since 1993. Of that number, 18 incidents involved the trafficking of highly enriched uranium and plutonium.⁶ Take the well-

- 5. James Brokenshire, 'How Nuclear Forensics Can Help Us Tackle Nuclear Terrorism', speech given at the Global Initiative to Combat Nuclear Terrorism, 7 January 2014.
- IAEA Incident and Trafficking Database (ITDB), 'Incidents of Nuclear and Other Radioactive Material out of Regulatory Control 2017 Fact Sheet', 2017, https://www.iaea.org/sites/default/files/17/12/itdb-factsheet-2017.pdf>, accessed 31 May 2018.

Campaign for Nuclear Disarmament, 'Campaigns', <http://cnduk.org/campaigns/>, accessed 14 May 2018.

^{4.} Nancy Jo Nicholas, 'It Takes a Nuclear Weapons Lab to Find a Nuclear Weapons Lab', *Defense One*, 21 November 2017.

known case of Alexander Litvinenko. It was possible to provide the expertise and analysis needed to manage the event safely owing to the training, experience and instrumentation afforded by a branch of research provided by the nuclear weapons industry.⁷

In addition to the need to maintain a nuclear forensics capability, it is important to consider what other current capabilities may also be required. An obvious but critical point is that without a detailed knowledge and understanding of warheads, safely disassembling nuclear weapons in a move towards disarmament would not be possible.

There are many different types and forms of material that have been produced in the past specifically for weapons use that can be very different to civil material. The processing and demilitarisation of material would be required in this case. Other problems would be presented such as the requirement for a long-term storage system for these materials and assessing the issues that this would pose, such as design, environmental factors and criticality assessments, among others.

An excellent example of where the retention of knowledge and skills has been of great benefit in the absence of a capability to produce is the recent Novichok incident handled by the Defence Science and Technology Laboratory (DSTL) at Porton Down. Despite the production of chemical and biological weapons ceasing in the UK in the 1950s, DSTL remains the only licensed site for the receipt, storage, breakdown and disposal of chemical weapons in the UK.⁸ More than 20 years after the entry into force of the Chemical Weapons Convention⁹ and more than 50 years after the UK stopped production,⁸ cases such as the recent incident in Salisbury highlight the need to maintain the facilities where these weapons were produced in order to be at the forefront of developments to prevent the spread and use of such weapons.

This capability would also be vital to monitor and verify treaties, becoming increasingly more important in a post-disarmament world. There is an abundance of data and information available in the public domain and this has led to potentially viable weapon designs in the past. In an experiment conducted by Lawrence Livermore National Laboratory, three PhD students with no previous experience in the nuclear weapons industry were asked to design an explosive weapon with a significant yield.¹⁰ After only two and a half years they had designed an implosion device through open-source information. In the mid-1970s, John Aristotle Phillips, a student at

^{7.} Robert Owen, 'The Litvinenko Inquiry: Report into the Death of Alexander Litvinenko', HC 695, 21 January 2016, p. 39.

Defence Science and Technology Laboratory, 'The Truth About Porton Down,' 27 June 2016, https://www.gov.uk/government/news/the-truth-about-porton-down, accessed 14 May 2018.

^{9.} Arms Control Association, 'The Chemical Weapons Convention (CWC) at a Glance,' updated 22 June 2018, https://www.armscontrol.org/factsheets/cwcglance, accessed 17 May 2018.

^{10.} W J Frank, 'Summary Report of the Nth Country Experiment', Lawrence Radiation Laboratory, University of California, Livermore, March 1967, pp. 7–8.

Princeton University, achieved a similar aim using publicly available books and papers to write a term paper.¹¹

Given that we cannot remove this information from the public domain, and with greater access to data than ever before, ensuring a capability to maintain and verify non-proliferation and disarmament agreements will be vital. Without a detailed understanding of the materials, possible contaminants and signatures that these materials provide, identification and attribution would be impossible. Without a working knowledge of weapons manufacturing facilities, over time it would be increasingly difficult to offer the required expert advice provided to weapons inspectors. This experience is critical to be able to identify key indicators of proliferation and to ensure treaty compliance.

Looking beyond the nuclear industry, it is important to note the skills, benefits and instrumentation available and the applicability outside this sphere. We have the capability to move forward cutting-edge scientific research using the equipment and skills available, such as the use of the Orion laser facility in the education sector, that not only provide benefit for the reasons already discussed, but also for industries that rely upon valuable research.

The skills and capabilities available in the nuclear industry include more than is often considered. Fostering discussion and strengthening public knowledge will highlight these important areas. This will prevent the loss of key resources currently available in support of nuclear forensics and treaty verification. Therefore, a more considered and realistic approach to the issue that encompasses the need for continued national security and the maintenance of essential capabilities would be required in the event of multilateral disarmament.

VI. An Examination of the Potential Effects on Nuclear Safeguards of the UK Leaving the EU

Patrick Ferns

N 23 JUNE 2016 the UK, via referendum, took the decision to leave the EU.¹ Subsequently the British government invoked Article 50 of the Treaty of Lisbon, beginning the process of the UK's withdrawing from the EU.² It was determined by both governing bodies that this also triggered withdrawal from the European Atomic Energy Community (EURATOM) due to a link in legislation.³ In addition, this initiated a nominal period of two years to process the withdrawal, which was later extended to include a 'transition period' up to 31 December 2020. The UK has several key challenges to overcome in a short timescale to maintain an acceptable level of nuclear safeguards by the end of the transition period, including: renegotiation of agreements; personnel challenges; and infrastructure availability.

EURATOM, of which the UK has been a member since 1973, was founded with the resolve of 'creating the necessary condition for speedy establishment and growth of nuclear industries'.⁴ In order to perform this task, the EURATOM treaty states that it shall 'ensure that all users in the Community receive a regular and equitable supply of ores and nuclear fuels', and that it shall also 'make certain ... that nuclear materials are not diverted'.⁵ This is undertaken by the implementation of a nuclear safeguards regime, including performing inspections and materials accountancy.

^{1.} The Electoral Commission, 'EU Referendum Results', <https://www.electoralcommission.org.uk/ find-information-by-subject/elections-and-referendums/past-elections-and-referendums/eureferendum/electorate-and-count-information>, accessed 22 June 2018.

Theresa May, 'Prime Minister's Commons Statement on Triggering Article 50', House of Commons, London, 29 March 2017, https://www.gov.uk/government/speeches/prime-ministers-commonsstatement-on-triggering-article-50>, accessed 22 June 2018.

^{3.} European Union, 'European Union (Amendment) Act 2008', <https://www.legislation.gov.uk/ ukpga/2008/7/pdfs/ukpga_20080007_en.pdf>, accessed 22 June 2018.

^{4.} European Union, 'Consolidated Version of the Treaty Establishing the European Atomic Energy Community', October 2012, p. 5.

^{5.} *Ibid.,* p. 5.

Nuclear safeguards are measures by which a country seeks to assure the international community that they are compliant with the Treaty on the Non-Proliferation of Nuclear Weapons.⁶ As a nuclear weapons state (NWS), the UK provides assurance of a separation between military and civilian uses of nuclear material through a voluntary offer agreement, allowing application of International Atomic Energy Agency (IAEA) safeguards on its civil nuclear industry, and an additional protocol, enhancing IAEA investigative powers.⁷

Until recently, the UK's nuclear safeguards regime has been provided through trilateral agreement with EURATOM and the IAEA. This was replaced by a bilateral agreement with the IAEA on 7 June 2018. Other trilateral agreements that the UK currently holds, notably Nuclear Cooperation Agreements (NCA), which enable trade of nuclear materials, will also require re-agreement as bilateral treaties.⁸ Four have been identified as key by the government, to be in place by the end of the transition period; these are with the US, Canada, Australia and Japan. All of these NCAs require ratification, with only the agreement with the US currently having been signed;⁹ this 'relies on an enormous groundswell of good will from the global nuclear community' to implement.¹⁰

For these agreements to be viable, the UK must implement a robust domestic nuclear safeguards regime; the government intends to ensure the implementation of this through the passing of the Nuclear Safeguards Bill 2017–19. This allows for the creation of the conditions required to implement a nuclear safeguards regime by creating the required legal framework; placing the Office for Nuclear Regulation (ONR) in charge of delivering the safeguards regime; and providing the secretary of state powers to amend and create nuclear safeguards legislation.¹¹ This will then be used to implement two subsequent pieces of legislation: 'The Nuclear Safeguards Regulations $20'^{12}$ and 'The Nuclear Safeguards (Civil Activities, Fissionable Material and Relevant International Agreements) Regulations $20''^{13}$

- 6. Office for Nuclear Regulation, 'What are Nuclear Safeguards?', 14 July 2017, <https://www.onr.org. uk/safeguards/what.htm>, accessed 22 June 2018.
- 7. Office for Nuclear Regulation, 'What are Nuclear Safeguards?'
- 8. Suzanna Hinson, 'The Nuclear Safeguards Bill 2017–19', Briefing Paper, Number 8107, House of Commons Library, 2018.
- 9. UK Government, 'UK Meeting Milestones for Euratom Exit', press release, 7 June 2018, <https:// www.gov.uk/government/news/uk-meeting-milestones-for-euratom-exit>, accessed 22 June 2018.
- 10. *Hansard,* House of Lords, 'Nuclear Safeguards Bill', Second Reading, Column 2033, 7 February 2018.
- 11. *Ibid.*
- 12. UK Government, 'The Nuclear Safeguards Regulations 20—', <https://assets.publishing.service. gov.uk/government/uploads/system/uploads/attachment_data/file/723305/2018-07-09_Draft_ Nuclear_Safeguards_Regulations_2_.pdf>, accessed 22 June 2018.
- 13. UK Government, 'The Nuclear Safeguards (Civil Activities, Fissionable Material and Relevant International Agreements) Regulations 20—', <https://assets.publishing.service.gov.uk/ government/uploads/system/uploads/attachment_data/file/675200/nuclear-safeguards-civilregulations-pre-consultation-draft.pdf>, accessed 22 June 2018.

Key challenges need to be addressed to provide the UK with this nuclear safeguards regime and for 'business as usual' to occur after the end of the transition period.

The government has stated that its aim is to maintain EURATOM standards. The challenge with this is that EURATOM staff engaged in 1,000-person days of inspections in 2014; to provide this level of resources it is estimated that the ONR will require 20 additional safeguards inspectors.¹⁴ The trade union Prospect states that it takes a number of years for a nuclear safeguards inspector to be fully able to do the job.¹⁵ There is a shortage of subject-matter expertise¹⁶ and as such these staff will all require training, with the ONR stating that '[i]t is fair to say that this is unprecedented territory ... and ... that we will not be able to replicate EURATOM standards on day one'.¹⁷ According to a leaked version of the risk register, the recruitment of staff to fill these new roles is currently regarded as a high-level risk for the ONR.¹⁸

The second challenge to be overcome is the provision of equipment, including a new IT system, which was previously owned by EURATOM; this is required to continue operating a safeguards regime. The government has stated that the funds for this will be provided; however, the IT system is another of the items considered high risk on the same risk register. The deadline for this essential IT system has been described in the risk register as 'irretrievably lost'.¹⁹

When the UK ceases its membership of EURATOM and is no longer able to take advantage of the safeguards regime, this presents the challenge of international perception. Perception towards UK safeguards may change as this represents a shift from a regime provided by an independent international body to a domestic government-run enterprise. Safeguards are reliant on the perception and confidence of the international community; this change in regime may erode this confidence, which, due to the UK's status as an NWS, could adversely affect international reputation.

In conclusion, the UK has a number of key challenges to overcome in a short timescale to maintain an acceptable level of nuclear safeguards by the end of the transition period. This would be a complex task in the easiest of political climates with no time limit; in a period of decreasing budgets, and in light of all the other Brexit negotiations with the deadline of December 2020, this represents a mountain to climb. However, the government has scaled some of the hurdles and a safeguards regime will be in place.²⁰ But ultimately, on 1 January 2021 the UK nuclear safeguards regime is likely to be considered less robust than the one currently provided.

^{14.} Hinson, 'The Nuclear Safeguards Bill 2017–19', p. 26.

^{15.} *Ibid.,* p. 26.

^{16.} *Hansard,* House of Lords, 'Nuclear Safeguards Bill', Second Sitting, Column 35, 31 October 2017. Reference to remarks by Mina Golshan.

^{17.} Hansard, 'Nuclear Safeguards Bill', Second Reading.

^{18.} *Ibid.*

^{19.} Faisal Islam, 'Red Warnings for UK's Post-Brexit Nuclear Safeguards,' Sky News, 16 May 2018.

^{20.} Office for Nuclear Regulation, 'What are Nuclear Safeguards?'

VII. The Non-Proliferation and Disarmament Impacts of US Leadership on Arms Control

Jennifer Schofield

S THE FIRST state to possess nuclear weapons, the US and its actions in the area of arms control are of particular interest. This paper asks whether US action on arms control encourages others to follow. I argue that US leadership in support of arms control has contributed to non-proliferation efforts. However, the US's refusal to endorse some current international arms control efforts has the potential to run contrary to efforts towards disarmament.

The most recent Nuclear Posture Review shows US arms control concentrating on bilateral strategic stability.¹ However, US arms control policy has certainly involved more multilateral efforts in the past. One of these is the Joint Comprehensive Plan of Action (JCPOA), negotiated between Iran and the E3/EU+3 (US, China, Russia, UK, France and Germany) in 2015, after two years of negotiation and 'secret' talks between the US and Iran. However, not all engagement by the US is in support of arms control, such as its refusal to sign the recent 2017 Treaty on the Prohibition of Nuclear Weapons (TPNW).

This paper focuses on whether US action encourages others to pursue, or continue, arms control to the ends of disarmament or non-proliferation. In order to examine the importance of a strong US lead in forming arms control agreements, two case studies are analysed: the negotiation of the JCPOA as an example of the change that US commitment can make on the actions of states; and the TPNW as an example of an effort that does not follow 'traditional' arms control actions and, it could be argued, undermines disarmament efforts.

Here arms control is broadly defined and intersects with disarmament. Arms control can be seen as 'all the forms of military cooperation ... in the interest of reducing the likelihood of war, its scope ... and the political and economic costs'.² In addition, this definition includes unilateral, plurilateral or normative actions seeking a limit on the use of nuclear weapons.³ Arms control does not have to include disarmament and, thus defined, is broader than disarmament, encompassing more than 'simple reductions in military force, military manpower,

^{1.} US Department of Defense, 'Nuclear Posture Review 2018', US Government, 2018.

^{2.} Thomas C Schelling and Morton H Halperin, *Strategy and Arms Control* (Mansfield Center, CT: Martino Publishing, 2014), p. 2.

^{3.} Stuart Croft, *Strategies of Arms Control: A History and Typology* (Manchester: Manchester University Press, 1996), p. 12.

military budgets, [and] aggregate explosive power'.⁴ Non-proliferation can be defined as the prevention of the spread of nuclear weapons and nuclear weapon technology.

The JCPOA negotiation is clearly arms control; action for the negotiation of the JCPOA was partly taken to reduce the risk of conflict in the region.⁵ The JCPOA as an arms control agreement is not disarmament, as Iran does not possess nuclear weapons. The agreement does aid non-proliferation and limits the risk of Iran 'breaking out' and acquiring nuclear weapons. There are limitations on many aspects of the fuel cycle, including a limit to 5,060 operating centrifuges (with 13,000 dismantled) and requirements on conversion of the Fordow and Arak reactors to an isotope production reactor and a power plant producing less weapons-grade material respectively.⁶

US engagement was key to the successful negotiation of this treaty. The JCPOA is not a bilateral agreement between Iran and the US, and some have argued that European partners (the UK, France, Germany and the EU) were instrumental as an intermediary in the negotiation of the JCPOA.⁷ However, the EU had been attempting negotiations with Iran since 2003, with relatively little success. The opening of back channel talks between the US and Iran in March 2013 is regarded as the start of a successful agreement.⁸ There is also evidence that even European strategists view the US as leading this interaction, with numerous examples of the US being described as the lead in the negotiations.⁹ Although European partners can be credited with initiating engagement with Iran, the role of the US in taking this forward to reach the conclusion of the JCPOA was vital.

The second case study, the TPNW, negotiated in 2017, has been ratified to date by 14 non-nuclear weapons states.¹⁰ This treaty seeks to strengthen norms of behaviour against possession and use of nuclear weapons. The TPNW originates from frustrations towards perceived limited action on the Treaty on the Non-Proliferation of Nuclear Weapons' (NPT) disarmament commitments by nuclear weapon states. One important group in creating the TPNW was the humanitarian initiative, a group of non-nuclear weapon states who led a series of conferences considered to be precursors to the TPNW negotiations. This treaty must also be described as arms control, as

- David Albright and Andrea Stricker, 'Iran's Nuclear Program', 2015, <http://iranprimer.usip.org/ sites/default/files/Nuclear_Albright%20and%20Stricker_Nuclear%20Program%202015.pdf>, accessed 16 November 2017.
- 9. Bruno Tertrais, 'Iran: An Experiment in Strategic Risk-Taking', *Survival* (Vol. 57, No. 5, 2015), p. 72.
- Paul Meyer, 'The Nuclear Nonproliferation Treaty: Fin de Regime?', Arms Control Association, April 2017, <https://www.armscontrol.org/act/2017-04/features/nuclear-nonproliferation-treaty-fin-deregime>, accessed 7 November 2017.

^{4.} Schelling and Halperin, *Strategy and Arms Control*, p. 2.

^{5.} Kenneth Katzman, 'Iran: Politics, Human Rights, and US Policy', *Congressional Research Service*, CRS Report 7-5700, 2017, p. 24.

^{6.} UN Security Council Resolution 2231, 20 July 2015, LS/RES/2231.

^{7.} Steven Blockmans and Astrid Viaud, 'EU Diplomacy and the Iran Nuclear Deal: Staying Power?', Policy Insights, Centre for European Policy Studies, No. 2017-28, 14 July 2017, p. 3.

it is an agreement taken with the clear hope by its negotiators to '[enhance] global and regional peace and security'.¹¹

The US has not acted in support of this treaty negotiation and has clearly influenced other states' decisions. It is unlikely that any nuclear weapon-possessing state will ever sign the TPNW. The UK, France and the US have collectively stated that '[they] do not intend to sign, ratify or ever become party to it'.¹² It is not just nuclear weapons' possessors that have objected; NATO members and those with close ties have not signed. This could be seen as a result of the US and other nuclear weapon states' lobbying of these signatories, particularly in countries such as Sweden where there has been strong discouragement by the US.¹³ Aside from US leadership there is also concern over the prohibition of extended deterrence. The TPNW states 'never ... [to a]llow any stationing, installation or deployment of any nuclear weapons or other nuclear explosive devices in its territory or at any place under its jurisdiction or control'.¹⁴ As many NATO members see extended deterrence as vital to protecting their security interests, this also affects states' decisions to follow the US lead.¹⁵

The effects of this arms control effort on disarmament and non-proliferation are uncertain. The treaty is not currently encouraging nuclear weapon possessors to disarm. The non-proliferation aims in the treaty are clear; however, there are concerns over the effect. In fact, it has been suggested that this treaty might harm the NPT, which would also be detrimental and possibly counterproductive to the aims of arms control agreements.¹⁶

US engagement encourages others to follow. Some suggest that the US nuclear weapons policy has no effect on the actions of other states engaging in arms control.¹⁷ However, their argument often concentrates on numbers and does not consider the effect of US engagement. This wider US nuclear posture may include aspects such as statements, talks or decisions on deterrence posture and is shown well by the successful negotiation of the JCPOA. It is still important to understand that US engagement in arms control will not be the only factor in the success of arms control efforts to aid non-proliferation and disarmament. For example, Iran's decision to successfully conclude negotiations was affected by sanctions. There were also

- 13. Emil Dall, 'Sweden's Choice: NATO or the Nuclear Ban?', RUSI Commentary, 22 September 2017.
- 14. 'The Treaty on the Prohibition of Nuclear Weapons', Article 1, para. g.
- 15. Aaron Mehta, 'Mattis Reportedly Threatens Swedish Defense Cooperation Over Nuclear Treaty', *Defence News*, 1 September 2017.
- 16. Adam Mount and Richard Nephew, 'A Nuclear Weapons Ban Should First Do No Harm to the NPT', *Bulletin of the Atomic Scientists*, 7 March 2017.
- 17. Matthew Kroenig, 'US Nuclear Weapons and Non-Proliferation: Is There a Link?', *Journal of Peace Research* (Vol. 53, No. 2, 2016), p. 169.

^{11. &#}x27;The Treaty on the Prohibition of Nuclear Weapons', 2017, p. 3.

^{12.} United States Mission to the United Nations, 'Joint Press Statement from the Permanent Representatives to the United Nations of the United States, United Kingdom, and France Following the Adoption of a Treaty Banning Nuclear Weapons', 7 July 2017, https://usun.state.gov/ remarks/7892, accessed 14 November 2017.

domestic considerations, for example the election of Iran's President Hassan Rouhani in 2013, leading to warmer international relations.

A perceived failure of the US to back an arms control effort can lead to measures which could be counterproductive to disarmament or non-proliferation. This has been seen most clearly in the TPNW. The US lead in lobbying against the treaty has been followed by many, including those in NATO and other countries.

When looking at both these case studies together, where there is a strong US commitment, others have taken cues on arms control from the US. Both case studies examined here are currently in a state of flux and future events, such as the collapse of the JCPOA or the entry into force of the TPNW, may affect the conclusion of the impact of US engagement.

VIII. Bridging the Transatlantic Divide: Assessing the Implications of Changes to US Declaratory Policy for European Allies

Maxwell Downman

N 2 FEBRUARY 2018, the Trump administration released its nuclear weapons policy with the US Nuclear Posture Review (NPR) 2018. US policymakers have sought to present the review as entailing more continuity than change, yet changes to US declaratory policy expand US nuclear deterrence to new scenarios, increase ambiguity in nuclear signalling and arguably increase the saliency of nuclear weapons.¹ European responses to these trends have been relatively muted; nevertheless such changes challenge European assumptions about the role of nuclear weapons in defending the NATO Alliance and could present new challenges for European capitals and knock-on effects for NATO cohesion.

Continuity and Change in US Declaratory Policy

The NPR 2018 provides a snapshot of current US thinking, and comparing it with the Obama administration's 2010 review can highlight areas of continuity and change. Broadly, the review describes a deteriorating international strategic context characterised by a return to great power competition and complicated by emerging threats, in which nuclear weapons are given increased saliency.² The most notable threat is Russia and its suggested willingness to engage in a limited nuclear first strike or a supposed "escalate to de-escalate" doctrine'.³

Consequently, the US sees a need to bolster deterrence and make changes to its declaratory policy. Principally, the review signals US willingness to engage in a limited nuclear retaliatory strike to counter Russia, and plans to augment the capabilities for this mission by upgrading its existing non-strategic forward-deployed nuclear weapons and developing a new sea-launched cruise missile (SLCM) and low-yield submarine-launched ballistic missile (SLBM).⁴ A common

^{1.} John R Harvey et al., 'Continuity and Change in US Nuclear Policy', *RealClear Defense*, 7 February 2918.

US Department of Defense, 'Nuclear Posture Review 2018', US Government, February 2018, pp. 6–14.

^{3.} Ibid., p. 30.

^{4.} *Ibid.*, p. 54.

criticism of this change is that it lowers the nuclear threshold by expressing a willingness to resort to nuclear use earlier in a conflict.⁵

There are other areas of both continuity and change in formal US declaratory policy. Both the 2010 and 2018 reviews reject a no first-use policy and sole purpose doctrine – that nuclear weapons are only intended to deter nuclear threats.⁶ However, the 2010 NPR explicitly identified 'sole purpose' as a near-term objective and there were indications at the end of his presidency that Obama was reconsidering his position.⁷

Similar to the 2010 review, the NPR 2018 states that the US would only consider using nuclear weapons 'in extreme circumstances to defend the vital interests of the United States, its allies, and partners'.⁸ However, it expands this definition to include 'significant non-nuclear strategic attacks ... [against] the U.S., allied, or partner civilian population or infrastructure, and attacks on U.S. or allied nuclear forces, their command and control, or warning and attack assessment capabilities'.⁹

This language of 'significant non-nuclear strategic attacks' moves away from the previous administration's claims that it would use nuclear weapons against nuclear threats and 'a narrow range of contingencies' against conventional, chemical and biological threats from nuclear armed states.¹⁰ For example, these 'non-nuclear strategic attacks' could include a broader range of conventional, chemical, biological and emerging technologies, such as cyber, from nuclear- and non-nuclear weapon states.

This has raised questions over the strength of US negative security assurances (NSAs) to not threaten non-nuclear weapon states with nuclear weapons. While the NPR 2018 reiterates that the US will 'not use or threaten to use nuclear weapons against non-nuclear weapons states that are party to the NPT and in compliance with their nuclear non-proliferation obligations', this is caveated in a number of new ways: first, by the language about 'significant non-nuclear strategic attacks'; and second, by the NPR's claim that 'the United States reserves the right to make any adjustment in the [negative security] assurance that may be warranted by the

- 8. US Department of Defense, 'Nuclear Posture Review 2018', p. 21 and 'Nuclear Posture Review 2010', p. 16.
- 9. US Department of Defense, 'Nuclear Posture Review 2018', p. 21.
- 10. US Department of Defense, 'Nuclear Posture Review 2010', p. 16.

See, for example, Arms Control Association, 'The New US Nuclear Strategy is Flawed and Dangerous. Here's Why', Arms Control Association Issue Brief (Vol. 10, No. 2, February 2018), <https://www.armscontrol.org/issue-briefs/2018-02/new-us-nuclear-strategy-flawed-dangerousheres-why>, accessed 29 June 2018.

^{6.} US Department of Defense, 'Nuclear Posture Review 2018', p. 21; US Department of Defense, 'Nuclear Posture Review 2010', US Government, April 2010.

^{7.} Josh Rogin, 'Obama Plans Major Nuclear Policy Changes in His Final Months,' *Washington Post*, 10 July 2016.

evolution and proliferation of non-nuclear strategic attack technologies and U.S. capabilities to counter that threat'.¹¹

The retention of a 'right' to apply nuclear deterrence to a range of unforeseeable future circumstances could cast doubt on the US's willingness to disarm in the eyes of some.

The NPR proposes new nuclear options to signal US resolve to engage in a limited nuclear strike and expands nuclear deterrence to cover broader conventional, chemical, biological and emerging threats with a strategic effect. It attempts to clarify some circumstances in which the US could consider using nuclear weapons, but obscures whether and how Washington might use them in specific circumstances to avoid the commitment trap.

It thus increases ambiguity, and its sometimes contradictory caveats may have unintended consequences for US messaging. The Trump administration denies that these changes expand the circumstances of nuclear use, lower the nuclear threshold or increase the saliency of nuclear weapons. On the contrary, they claim, the 2018 NPR raises the threshold for nuclear use by reducing the potential for adversary miscalculation.¹² But it could equally have perverse effects by confusing signalling. Certainly, it communicates the value the administration attaches to its nuclear arsenal and calls into question any intention to engage in efforts to reduce nuclear saliency.

Impacts for European Allies

Following Russia's illegal annexation of Crimea in 2014, NATO has refocused on deterrence and defence. Nevertheless, the Alliance has been reluctant to reopen controversial debates on nuclear weapons, and the hard-negotiated 2010 Strategic Concept and 2012 Deterrence and Defence Posture Review (DDPR) still outline NATO's posture.¹³

However, changes to US declaratory policy raise questions over NATO policy in two ways. First, the declared willingness to engage in limited nuclear strikes potentially contradicts the DDPR's claim that the 'Alliance's nuclear force posture currently meets the criteria for an effective deterrence and defence posture', by signalling that the previous posture lacked credibility.¹⁴ Second, expanding the circumstances of nuclear deterrence may undermine NATO statements that 'nuclear weapons are unique' and would 'fundamentally alter the nature of a conflict' by appearing to put nuclear weapons in the same category as other weapons.¹⁵ Former US official

^{11.} US Department of Defense, 'Nuclear Posture Review 2018', p. 21.

^{12.} Ibid., p. 54.

NATO, 'Strategic Concept for the Defence and Security of the Members of the North Atlantic Treaty Organisation' (Strategic Concept), 19 November 201, pp. 14–18; NATO, 'Deterrence and Defence Posture Review', 20 May 2012, pp. 8–12.

^{14.} NATO, 'Deterrence and Defence Posture Review', p. 8.

^{15.} NATO, 'Warsaw Summit Communique', 9 July 2016, p. 54.

Frank Rose, who has broadly welcomed the review, has called the NPR's language on 'non-nuclear strategic attacks' a 'self-inflicted wound that will likely fester for some time'.¹⁶

While Europeans assess changes in US policy, it is important to note that European opinion is not homogenous. Undeniably, the NPR is an effort to bolster assurance to European allies, and many Eastern European states, who feel most threatened by Russia, have quietly welcomed it.¹⁷ Yet, for other European states, especially those with strong domestic anti-nuclear sentiment, increasing dependence on nuclear weapons is troubling. For example, Germany's foreign minister has said the review 'shows that the spiral of a new nuclear arms race has already been set in motion'.¹⁸ In attempting to justify their defence policies, European governments will have to both rationalise deterrence thinking and reconcile pro-disarmament public opinion with Trump's perceived lack of restraint. An example of this is German and Dutch attempts to strengthen NSAs.¹⁹ Here, the NPR's position on declaratory policy could be seen to close down avenues for progress.

Finally, there are questions over what these changes mean for France and the UK. Could changes to US declaratory policy inadvertently limit French and British decisions over their declaratory policies? Significant departures could be seen as a criticism of the US or an opportunity for Russia to divide the Alliance. On the other hand, both states must take into account the need to reassure other NATO allies concerned with moderating declaratory policy in the interests of wider non-proliferation affairs.

Differences in Approach

Perhaps changes to US declaratory policy are representative of a difference between a broadly 'European' and an 'American' approach to dealing with Russia. The 2018 NPR puts faith in a policy largely reliant on threat, the assumption that the US must stand up to an aggressive Russia and keep 'all options on the table'. In Europe there is some distrust towards a policy that

- Artur Kacprzyk, 'Results of the US Nuclear Posture Review', *Polish Institute of International Affairs Bulletin* (Vol. 29, No. 1100, February 2018), p. 2; Lukasz Kulesa, 'The 2018 US Nuclear Posture Review: A Headache for Europe', *European Leadership Network*, 6 February 2018.
- Sigmar Gabriel, 'Foreign Minister Sigmar Gabriel on the Publication of the US Nuclear Posture Review', German Federal Foreign Office, press release, 4 February 2018, https://www.auswaertiges-amt.de/en/Newsroom/bm-veroeffentlichung-us-nuklearstrategie/1433732, accessed 22 August 2018.
- Michael Biontino, 'German Statement on Cluster 1: Nuclear Disarmament and Security Assurances', speech given at NPT PrepCom, Geneva, 26 April 2018, http://statements.unmeetings.org/media2/18559478/germany-printer_20180426_104255.pdf>, accessed 29 June 2018; Robbert Gabriëlse, 'Statement of the Netherlands: General Statement', speech given at NPT PrepCom, Geneva, 23 April 2018, http://reachingcriticalwill.org/images/documents/Disarmament-fora/npt/prepcom18/statements/23April_Netherlands.pdf>, accessed 29 June 2018.

^{16.} Frank A Rose, 'Is the 2018 Nuclear Posture Review as Bad as the Critics Claim it is?', Brookings Policy Brief, April 2018.

signals a return to dependence on nuclear weapons and closes off avenues for cooperation and reconciliation. Declaratory policy is only one element of a wider transatlantic discussion on a shared approach to deterrence, non-proliferation, arms control and disarmament. Yet this discussion will become ever-more pressing in the context of the current crisis in arms control. While there has been discomfort in some European capitals on the direction of US declaratory policy and nuclear strategy, Europeans need to more clearly articulate a vision for reducing nuclear risks.

IX. China's Response to the US Nuclear Posture Review

Rose Tenyotkina

N FEBRUARY 2018, the Trump administration released the 2018 Nuclear Posture Review (NPR) that, along with the National Security Strategy (NSS) and the National Defense Strategy (NDS), takes an aggressive stance toward China and highlights the US's perception of China as a threat to its security.¹ In particular, the NPR paints China as a hostile state with language that harks back to Cold War-era rhetoric. It claims that China's lack of transparency and modernisation has the goal to 'challeng[e] traditional U.S. military superiority in the Western Pacific'.² China is portrayed as a rival, a strategic competitor and a revisionist power. There is concern among China analysts that this language will ignite another nuclear arms race.³

The language used to refer to China and its strategic relationship with the US is important as it can impact the nature of the relationship. It is vital to global strategic stability that the West correctly understands China's strategic intentions and objectively analyses their response. Without this understanding, the US cannot develop a well-informed and appropriate policy towards China. Key to establishing a deterrence relationship is maintaining clear communication with mature, well-defined language, and this currently represents a true deficit between the US and China. This paper specifically considers China's response to the labelling of rival, strategic competitor and revisionist power, and considers how this will impact on the China–US strategic relationship.

Rival

Among the terms 'rival', 'strategic competitor' and 'revisionist power', the term 'rival' is seen as being particularly problematic due to it being more difficult to translate. In both Chinese and English, the terms 'rival' and 'adversary' are often used interchangeably, while 'enemy' has a stronger negative connotation. The two most commonly used terms in Chinese are 'duishou', meaning 'rival', and 'dírén', which best translates as 'enemy' and is more combative in tone. In Chinese, however, although both are historically quite negative terms and rarely used in official government statements, the term 'enemy' is more suited for wartime. In the Chinese translations of the NPR, and in statements regarding the NPR, the more negative of the two, 'dírén', is used. This perceived bellicose rhetoric elicited a critical response from the Chinese government.

^{1.} Executive Office, 'The National Security Strategy', US Government, December 2017, pp. 8, 25.

^{2.} US Department of Defense, 'Nuclear Posture Review 2018', US Government, February 2018, p. 1.

^{3.} Stephen Chen, 'China Steps Up Pace in New Nuclear Arms Race with US and Russia as Experts Warn of Rising Risk of Conflict', *Politico*, 28 May 2018.

The Chinese government immediately stated that the antagonistic language used in the NPR illustrates that the US is adhering to obsolete concepts, such as a Cold War mentality and 'zero-sum' game thinking.⁴ The official statement further argued that the US has undermined the international nuclear disarmament process because the NPR reduces the threshold for the use of nuclear weapons. Furthermore, as expected, the Chinese government reiterated their long-standing commitment to a no first-use policy and promised that China will reduce the role of nuclear weapons in national security and take concrete actions to maintain international peace and stability.⁵

Strategic Competitor

Prior to describing the current international security environment, the NPR quotes Admiral John Richardson, Chief of Naval Operations: 'For the first time in 25 years, the United States is facing a return to great power competition. Russia and China both have advanced their military capabilities to act as global powers'.⁶ Beijing routinely requests that the US abandon what it regards as a 'Cold War mentality'. The 2018 NPR, by emphasising the great power competition and identifying China as a strategic competitor, validates China's concern that the US is pursuing this mentality.

However, there is a shifting attitude among Chinese youth as they perceive the label of 'competitor' – a term that China itself has never used to describe the US – in a positive light.⁷ They believe that this validates China's presence in the international arena and justifies China's modernisation efforts.⁸

In the eyes of Chinese academics and analysts alike, in addition to the new rhetoric being rife with undertones of Cold War-era mentality, nuclear weapons have once again become a tool for global hegemony.⁹ In response to what is viewed as the US fight for hegemony, Beijing academics

- 4. Zhang Hongzhou, 'Guófáng bù xīnwén fāyán rén rènguó qiáng jiù měi gōngbù "hé tàishì shěnyì bàogào" fābiǎo tánhuà' ['Defense Ministry Spokesperson Ren Guoqiang's Speech on the US Announcement of the Nuclear Posture Review'], Ministry of National Defense of the People's Republic of China, 4 February 2018, <http://www.mod.gov.cn/info/2018-02/04/content_4804130. htm>, accessed 23 September 2018.
- 5. Ibid.
- 6. US Department of Defense, 'Nuclear Posture Review 2018', p. 5.
- Hu Zezhen, 'Měiguó yīdàn luòshí duì huá duìkàng xìng zhànlüè zhōng huì xiàng xiànshí dītóu' ['After the United States Implements its Confrontational Strategy Towards China, it Will Eventually Bow to Reality'], Huánqiú [Global Times], 1 March 2018.
- 8. Da Wei and Bonnie Glaser, 'Growing Friction in US-China Relations: A Conversation with Da Wei', *Season ChinaPower Podcast*, 2018.
- 9. Hua Yunang, 'Měi hé tàishì pínggū xīn yǔhuì: Cóng yī mǎ tōng chī dào liáng shēn dìngzuò' ['New Vocabulary for US Nuclear Situation Assessment: From One Fit Solution to Tailored Response'], Xīnlàng [Sina], 8 February 2018; Yuan Zheng, 'Yuán zhēng: Chénzhuó lěngjìng yìngduì zhōng měi guānxì xīn biànhuà' ['Yuan Zheng: Responding Calming to New Changes in Sino-US Relations'],

have argued that China's hands are tied; China must continue to enhance the survivability and penetration prevention capabilities of their nuclear weapons to increase the effectiveness of their nuclear deterrent capability.¹⁰ Additionally, Chinese experts argue it is necessary to continue to emphasise that China has no intention of contending for hegemony or using nuclear weapons for hegemony.¹¹ Nor will China participate in any form of nuclear arms race, and it will continue to support a no first-use policy.

Revisionist Power

The term 'revisionist power', as Da Wei, a professor at the University of International Relations in Beijing, discussed in an interview, is problematic because the Chinese simply do not understand it. He stated that this term was used by China to describe the Soviet Union, thus when they hear it, they relate it to the Cold War era.¹²

From *PLA Daily* and *Xinhua News* articles to the work of Chinese academics, the uniting theme in contemporary Chinese publications is calling for China to strengthen and expand its nuclear deterrence capabilities. This is in line with current plans well underway in response to Chinese concerns regarding advances in US intelligence, surveillance, reconnaissance (ISR) and missile defence capabilities. None of these advances are a direct response to the 2018 NPR, but rather a continuation of Chinese policy.¹³ This is clearly seen in the 2013 edition of *The Science of Military Strategy*, which underscored the importance of responding to the US's ability to influence China's nuclear retaliatory capabilities and outlined the necessity of strengthening China's nuclear deterrent capabilities.¹⁴ However, Chinese strategists will likely interpret the NPR as validating China's concerns and providing further evidence to adhere to their existing nuclear policy and strategy.¹⁵ Hence, China will have an unwavering desire to increase the survivability of its nuclear weapons and counter US missile defence systems.¹⁶

Xīnlàng [*Sina*], 5 May 2018; Jia Xiudong, 'Hǎiwài bǎn wànghǎi lóu: Bào chí "zhōngguó wēixié lùn" de gāi huàn huàn nǎojīnle"' ['Overseas Office at Wanghailou: Be Willing to have a Change of Mind on the "China Threat Theory"'], *Nánchāng xīnwén* [*NanChang*], News, 2 February 2018.

- 10. Xiudong, 'Hǎiwài bǎn wànghǎi lóu' ['Overseas Office at Wanghailou'].
- 11. Bin Li, 'Will US Nuclear Posture Review See a Return to Hegemony?', *Global Times*, 24 January 2018.
- 12. Wei and Glaser, 'Growing Friction in US-China Relations'.
- 13. Michael S Chase, 'Chinese Views on the 2018 Nuclear Posture Review, and Their Implications', *China Brief*, 12 March 2018.
- 14. Guangqian Peng and Youzhi Yao, *The Science of Military Strategy*, 3rd Edition (Beijing: Military Science Press, 2013).
- Lora Saalman, 'How Chinese Analysts View Arms Control, Disarmament, and Nuclear Deterrence After the Cold War', in Cristina Hansell and William C Potter (eds), *Engaging China and Russia on Nuclear Disarmament* (Washington, DC: Center for Nonproliferation Studies, March 2009), pp. 47–71.
- 16. Zhao Xiaozhuo, 'Měiguó xīnbăn "hé tàishì pínggū" bàogào chūlú, hé zhànlüè yǒu năxiē tiáozhěng?'
 ['What is the Adjustment of the Nuclear Strategy in the New US Nuclear Posture Review?'],

Last, by the US using such aggressive rhetoric while simultaneously pulling out of the international arena, China could potentially occupy the moral high ground, advocate for international cooperation and actively participate in global governance structures. China has historically rejected verdicts handed down from global governance structures, such as the ruling in the South China Sea, and how Beijing responds to future international arbitration will be critical. While US soft power is eroding, China is building up its diplomatic system and soft power through its Belt and Road initiative. Because actual power underpins such hostile language, the US needs to be wary of labelling China as a revisionist country.

Conclusion

Viewing the US–China relationship in a Cold War framework is inappropriate and misleading.¹⁷ By referring to China as a rival (enemy), strategic competitor and revisionist power, the US is misunderstanding Chinese policy. At best, it is not a useful conceptualisation because the US–China relationship is drastically different from the US–Soviet one, thus diverting efforts to create an effective strategy to deal with China. At worst, it is detrimental because it can become a self-fulfilling prophecy.

In sum, China is not very concerned with the US NPR 2018, and actually benefits from it. The problem is that the US remains unable to define its relationship with China.¹⁸ The many terms, from 'strategic partners' to 'rival' to 'strategic competitors', used to categorise and describe US–China strategic relations over the years point to this very fact.¹⁹ Viewing the US–China relationship through a Cold War lens is problematic and must be abandoned.

Jiěfàngjūn bào [PLA Daily], 1 March 2018.

^{17.} For an illuminating discussion of the implications of viewing the US–China relationship in a Cold War framework, see Iskander Rehman et al., 'Policy Roundtable: Are the United States and China in a New Cold War?', *Texas National Security Review*, 15 May 2018.

^{18.} Jūnshì dà shìjiè [Military World], 'Měi zhuānjiā: Měi duì huá zhànlüè quēfá tóunǎo zhōngguó bùshì rìběn dìguó' ['American Experts: The United States Lacks a Cohesive Strategy on China; China is Not the Japanese Empire'], 21 May 2018.

^{19.} Lora Saalman, 'Placing a Renminbi Sign on Strategic Stability and Nuclear Reductions', *Strategic Stability: Contending Interpretations*, 5 February 2013, pp. 343–70.

X. Anti-Satellite Technology and US–China Nuclear Deterrence Stability

Cameron Hunter

HE COLD WAR debate over the destabilising effect of anti-satellite (ASAT) technologies to nuclear deterrence relationships has been rekindled in contemporary US–China relations.¹ Despite the anticipated catastrophic outcomes of deterrence failure in a future crisis, the disruptive potential of ASAT has been understudied. Where these risks are mentioned, implicit allusions are more common than explicit analysis. Too often, the dangers supposedly posed by ASAT are taken for granted and the hypothetical scenarios in which they might be used are light on details.² The purpose of this paper is to begin to unpack some of the assumptions about the nuclear risks around ASAT in the US–China case to facilitate analysis of these factors.³ After even this relatively cursory analysis, it is clear that ASAT is not 'causing' instability, but rather is contingent on wider US–China politics. Understanding the political significance of ASAT is a difficult task due to the complexity of this relationship. Despite these difficulties, analysis of both the technical and political context shows that ASAT technology is not inevitably causing one set of (catastrophic) outcomes. Simultaneously, however, such an analysis also shows that miscalculation after ASAT remains possible.

ASAT refers broadly to any technology which can damage or disable a satellite. This could be done kinetically, as exemplified by the ground-based Chinese SC-19 that is designed to destroy its target by colliding with it.⁴ Equally, a variety of non-kinetic options may be possible, such as 'dazzling' a satellite's sensors with a laser, hacking or jamming some portion of its system, or

- Publicly available information on US Air Force wargames indicates a high propensity for escalation after ASAT use, but scenario details are restricted. See Laura Grego, 'Limiting the Use of Antisatellite Weapons in Space', New York Times, 9 July 2015.
- 3. This paper defines 'deterrence stability' narrowly as the reduced probability of crisis escalating to (accidental) nuclear war.
- 4. Brian Weeden, 'Anti-Satellite Tests in Space the Case of China', *Secure World Foundation*, 16 August 2013.

For a recent discussion of ASAT and deterrence stability, see Bharath Gopalaswamy, Wu Chunsi and Nancy Gallagher, 'Space Weapons and the Risk of Nuclear Exchanges', *Bulletin of the Atomic Scientists*, 30 July 2015. For a Cold War example, see Joseph S Nye (ed.), *Seeking Stability in Space: Anti-Satellite Weapons and the Evolving Space Regime* (Washington, DC: Aspen Strategy Group, 1987).

even more esoteric methods.⁵ Disabling and destroying enough satellites with these methods could effectively 'blind' satellite systems, and by extension also 'blind' the owners reliant on their data.

The most concrete scenario elaborated by US observers of Chinese ASAT use in a future crisis pertains to the Taiwan Strait.⁶ It is worth first providing some context and detail around this imagined scenario, which this paper terms a 'Taiwan contingency'. Maintaining Taiwanese independence while limiting the risk of escalation with the communist mainland has not always been easy, with the most recent of three major crises culminating in the deployment of a US carrier group to the Strait.⁷ Relatedly, the Chinese deployment of 'carrier-killer' anti-ship ballistic missiles has alarmed some US observers.⁸ In a Taiwan contingency, to hide their launch from US early warning – so the implied narrative goes – Chinese ASAT strikes would blind a host of space-based assets, up to and including the global positioning system (GPS). In its blinded state, the US might then fear an imminent Chinese nuclear first strike intended to exploit this weakness, or make a variety of other miscalculations.

Many assumptions underpin this scenario, however, and unpacking them illuminates how hypothetical future conflicts with China are being imagined in the US. More importantly, it provides a basis from which to assess the credibility of the concerns over ASAT and deterrence instability.

The US is heavily dependent on space-based technologies for capabilities across the spectrum of Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR), particularly for nuclear missions. The Space-Based Infrared System (SBIRS) is a constellation of satellites which can detect missile launches almost anywhere on the Earth's surface within minutes of launch.⁹ Only one SBIRS satellite is permanently tasked with observing Asia, meaning it could only take one ASAT strike to blind the US to missile launches across almost one-third of the Earth's surface.¹⁰

- 6. This paper deals only with US perspectives.
- See Andrew Scobell, 'Show of Force: Chinese Soldiers, Statesmen, and the 1995–1996 Taiwan Strait Crisis', *Political Science Quarterly* (Vol. 115, No. 2, 2000), p. 238; Vasilis Trigkas, 'Aircraft Carriers in the Taiwan Strait', *The Diplomat*, 29 December 2014.
- 8. See Andrew Erickson, *Chinese Anti-Ship Ballistic Missile (ASBM) Development: Drivers, Trajectories and Strategic Implications* (Washington, DC: Jamestown Foundation, 2016).
- Jeffrey Lewis, 'Is Launch Under Attack Feasible?', Nuclear Threat Initiative, 24 August 2017. See also US Air Force Space Command, 'Space Based Infrared System', 22 March 2017, http://www.afspc.af.mil/About-Us/Fact-Sheets/Display/Article/1012596/space-based-infrared-system/, accessed 30 June 2018.
- Jeffrey Richelson, America's Space Sentinels: DSP Satellites and National Security (Lawrence, KS: University Press of Kansas, 1999), p. 70. See also Justin Ray, 'Preview: Advanced Missile Detection Satellite for Early-Warning Alerts Awaits Liftoff', Spaceflight Now, 16 January 2017.

^{5.} Yousaf Butt, 'Effects of Chinese Laser Ranging on Imaging Satellites', *Science and Global Security* (Vol. 17, No. 1, 2009), pp. 20–35.

Another small constellation, the Advanced Extremely High Frequency system, provides hardened nuclear command and control (NC2) for the National Command Authority.¹¹ GPS also provides support for guidance, but perhaps more importantly has a nuclear detonation sensor package which provides a battle damage assessment (BDA) capability during a nuclear war.¹² If Chinese ASAT attacks were to somehow disable these capabilities, US leaders would find it harder to remain in control of their nuclear arsenal or to confirm Chinese nuclear use during a crisis.

While none of these capabilities are mirrored exactly on non-space-based platforms, the US is not solely reliant on space systems for nuclear purposes. Terrestrial radar could pick up ballistic missiles somewhat later than SBIRS. For NC2, the US maintains redundant systems such as the very low frequency (VLF) system used to communicate with ballistic missile submarines. VLF is both ground- and air-based, providing a highly survivable capability to communicate with the US second-strike force even during a nuclear war.¹³ Finally, there are a variety of fixed-wing assets which could undertake limited BDA if GPS was disabled.¹⁴

Without space-based assets, then, the US is slower and less precise. But it is not helpless. For a Taiwan contingency scenario to go nuclear, one has to assume that US leaders are so attached to their space-based systems that they feel extremely exposed without them and begin to miscalculate. For example, the Chinese nuclear arsenal is too small to disarm the US, meaning that a first strike against the US would result in US retaliation.¹⁵ For the scenario to work, one must assume that US decision-makers would believe that China would attack the US without regard to the consequences. Effectively, US decision-makers would have to assume that China is not deterrable in a Taiwan crisis, even by the Trident submarines which could retaliate against Chinese targets from the Mediterranean Sea (presumably entirely safe from Chinese antisubmarine efforts).¹⁶ Many of these assumptions seem rather far-fetched, but we must recall that US observers have relatively consistently portrayed China as reckless and irresponsible

- US Air Force Space Command, 'Advanced Extremely High Frequency System', 22 March 2017, http://www.afspc.af.mil/About-Us/Fact-Sheets/Display/Article/249024/advanced-extremely-high-frequency-system/, accessed 30 June 2018.
- US Air Force, '[Unclassified Appropriation for NUDET Package]', PE 0305913F: NUDET Detection System (Space), February 2012, http://www.dtic.mil/descriptivesum/Y2013/AirForce/ stamped/0305913F_7_PB_2013.pdf>, accessed 30 June 2018.
- Federation of American Scientists, 'Very Low Frequency (VLF)', 29 April 1998, <https://fas.org/ nuke/guide/usa/c3i/vlf.htm>, accessed 30 June 2018.
- 14. For example, the USAF has a variety of long-range reconnaissance aircraft such as the U-2. See US Air Force, 'U-2S/TU-2S', 23 September 2015, http://www.af.mil/About-Us/Fact-Sheets/Display/Article/104560/u-2stu-2s/, accessed 30 June 2018.
- US ICBMs outnumber Chinese warheads in range, even without considering other US delivery vehicles. See Hans Kristensen and Robert Norris, 'United States Nuclear Forces, 2018', *Bulletin* of the Atomic Scientists (Vol. 74, No. 2, 2018), pp. 120–31; Hans Kristensen and Robert Norris, 'Chinese Nuclear Forces, 2018', *Bulletin of the Atomic Scientists* (Vol. 74, No. 4, 2018), pp. 289–95.
- 16. Based on Trident range of 7,360 km; see Federation of American Scientists, 'Trident II D-5 Fleet Ballistic Missile', 1 May 1998, https://fas.org/nuke/guide/usa/slbm/d-5.htm>, accessed 30 June

over the past six decades,¹⁷ and the extent to which these perceptions are earnestly held by US decision-makers is unknown.

A second major assumption is that Chinese ASAT capabilities are fearsome. Yet, how feasible is a significant Chinese 'blinding' of US C4ISR? ASAT capabilities are not wonder weapons. They are constrained by the laws of physics and thus have advantages and disadvantages. In 2013 China probably demonstrated a capability to destroy satellites in geostationary orbit, the orbital ring 36,000 km above the Earth where many of the most crucial military satellites are placed.¹⁸ Yet, flying this distance even at sub-orbital speeds takes time, and SBIRS would easily identify the launch. In this time, some avoidance might be possible, and certainly a degree of political or military response. Likewise, disabling sufficient numbers of GPS satellites to cause a serious drop in coverage would take dozens of attacks taking place over several hours as the US satellites progressively flew over China.¹⁹ For the scenario outlined earlier to make sense, China must be assumed to have a huge and capable arsenal of ASAT technologies, and the will to use them.

Overall, we are left with a picture of an accidental war scenario in which the technical factors are better understood than the political factors. Based on the assessment of technical factors in this paper, ASAT capabilities are not inevitably causing a deterioration of nuclear deterrence stability between the US and China. These technological developments are themselves products of politics, and interaction in outer space and in the nuclear arena are merely two important areas in a much larger relationship. It would be a mistake to assume that issues around space or nuclear technologies are drivers of the relationship. Accidental nuclear war after ASAT use in a future US–China crisis is therefore not inevitable, but that is not to say that it is impossible.

2018. Trajectory calculated using MISSILEMAP, see Alex Wellerstein, 'MissileMap 1.0', https://nuclearsecrecy.com/missilemap/, accessed 30 June 2018.

- Repeated calls by the US for China to 'become' a 'responsible stakeholder' inevitably imply that China is currently irresponsible. For an indicative example, see Robert Zoelick, 'Whither China: From Membership to Responsibility?', US Department of State Archive, 21 September 2005, <https://2001-2009.state.gov/s/d/former/zoellick/rem/53682.htm>, accessed 17 July 2018.
- 18. Weeden, 'Anti-Satellite Tests in Space the Case of China', p. 2.
- 19. Jaganath Sankaran, 'Limits of the Chinese Antisatellite Threat to the United States', *Strategic Studies Quarterly* (Vol. 8, No. 4, Winter 2014), pp. 19–46.

XI. The Future of Fast Attack Submarines in the UK: Nuclear Relevance, Cost Cutting and Enrichment

James Bauld

S OF 2018, the UK has six attack submarines in service: three *Trafalgar*-class, designed during the 1960s, built throughout the 1980s; and three *Astute*-class, built throughout the 2000s and 2010s. The *Astute*-class submarines, however, are based on propulsion technology developed for the *Vanguard* class of ballistic missile submarines, which were designed in the 1980s.

The *Astute*-class submarine build is halfway through the build process of the seven boats ordered, with one more planned to enter service in 2018. However, due to the long timescales required to design and build submarines, the replacement of the *Astute* class is already being considered.

Since the late 1960s, the UK has transitioned from a submarine fleet consisting of approximately 30 vessels, both conventional and nuclear powered, to a handful of only nuclear-powered vessels (SSNs) with an increased demand of their capability.

Since the decision was last made to make SSNs,¹ the available options to perform the role of an underwater force have changed significantly. This is reflected in the government and Royal Navy naming the *Astute*-class replacement the Maritime Underwater Future Capability (MUFC), with no direct mention of a submarine at all.

Specifically, unmanned underwater vehicles (UUVs) have gained attention over the last two decades, due to the success of their air-based counterparts and their ability to remove sailors from harm's way. However, the design and application of UUVs have struggled to overcome issues with underwater communications and propulsion endurance.² It may be that this type of technology is best deployed from another vessel to reduce the scales of UUV operation, while still offering a global reach.

^{1.} John F Schank et al., *Learning from Experience Vol. III: Lessons from the United Kingdom's* Astute *Submarine Program* (Santa Monica, CA: National Defence Research Institute, 2011).

^{2.} Robert W Button et al., *A Survey of Missions for Unmanned Undersea Vehicles* (Santa Monica, CA: National Defence Research Institute, 2009).

As such, there is a strong possibility that there will be a need to develop a submarine replacement, but the recent development of conventional submarine propulsion systems may challenge the UK's current stance of an all SSN fleet. From 2005 to 2007 the US Navy was loaned the Swedish HSwMS *Gotland* submarine.³ During this time, the air-independent propulsion (AIP) submarine was able to best the US Navy's fleet several times. Its success was attributed to its relative stealth and size compared to a nuclear counterpart.

Added to the proven success of an AIP submarine, the cost compared to an SSN is significantly smaller – in the wake of the large costs associated with the *Dreadnought* and *Astute* classes of submarines, it is argued that an AIP might be a cheaper alternative.

However, the UK's use of attack submarines is beyond the capability of AIPs. With a submerged record of only 18 days at slow speeds,⁴ the capability of an AIP option is best suited to coastal defence and not the far-reaching global deployment for which UK SSNs are intended.⁵ Furthermore, the decision to not pursue a nuclear-powered vessel may have significant consequences for the viability of replacing the *Dreadnought* class in several decades.⁶

Although a significant challenge for the viability of a SSN is the capital cost, which is partly due to their generally large vessel size, it could be considered that the major benefit is the extreme submerged time and the relatively high speeds. However, a smaller vessel design which retains the unique qualities of a traditional nuclear vessel may have a more palatable cost.

In addition, there is a perceived – and very real – complexity associated with the design of a nuclear-powered submarine. This can be credited to a number of bespoke and long lead components which in turn limit the supply chain and their competitive costs. Parallels can be drawn to the equally complex space industry, where the subject of cost saving has seen recent success. It may be that the UK submarine industry could learn from companies like SpaceX – whose innovative thinking, combined with a more commercial approach to supply and investments in advanced manufacture, has led to savings which have undercut competitors by an order of magnitude.⁷

From a political perspective, another major downside to the pursuit of a UK SSN is the use of highly enriched uranium (HEU) fuel. Although currently the UK faces no legal sanction from its

- 5. HM Government, 'National Security Strategy and Strategic Defence and Security Review 2015', Cm 9161, November 2015.
- 6. John F Schank et al., *Sustaining Design and Production Resources* (Santa Monica, CA: National Defence Research Institute, 2005).
- 7. John Matson, 'NASA Figures Show That Commercial Rocket Costs Less Than Half as Much as Government-Run Effort Would', *Scientific American*, 28 September 2011.

^{3.} Sebastien Roblin, 'Sweden's Super Stealth Submarines are So Lethal They "Sank" a US Aircraft Carrier', *National Interest*, 13 November 2016.

^{4.} Sebastien Roblin, 'Why Germany's New Super Stealth Submarines Could Take on Any Navy', *National Interest*, 6 June 2017.

continued use of HEU, it may be challenged on its use of weapons-grade material, especially given that other countries' forces, including the French navy, have vessels powered by low enriched uranium (LEU) fuel that cannot be used for nuclear weapons. It is unlikely that any technical benefits would promote LEU use,⁸ and the feasibility of developing a sovereign LEU fuel in timescales to support MUFC, while reducing programme cost, is extremely challenging.

In summary, for the *Astute*-class replacement, SSNs are not the only credible option, but they have a highly versatile capability and suitability for adapting to emerging UUV technology, for which there is currently no comparable alternative. Long-term political issues, such as enrichment, should be addressed irrespective of whether change is pursued. For the SSNs, a step change is required to ensure that the option is cost effective and takes lessons from other ground-breaking industries.

^{8.} Office of Naval Reactors, 'Report on Low Enriched Uranium for Naval Rector Cores', Report to Congress, United States Department of Energy, January 2014.

XII. Over the Horizon Nuclear Technologies: The Rise of Hypersonic Defence

Martin Everett

YPERSONIC WEAPONS ARE grabbing headlines as a nuclear arms race is seemingly building between the US, Russia and China on the development of these capabilities. The focus has been on offensive hypersonic platforms,¹ with much less focus given to hypersonic defences and how they may further complicate this arms race.

The US, Russia and China are all developing hypersonic weapons and have performed tests of their capabilities. A natural response to an emerging weapon is whether it can be defended against – and some states are already pursuing this question.

The three questions to be addressed when approaching this problem are:

- What hypersonic defences are being considered?
- How would hypersonic defences impact strategic stability?
- How should we respond to hypersonic defence?

Hypersonic weapons are those that travel above Mach 5 and, broadly speaking, they exist in two distinct forms: hypersonic glide vehicles and hypersonic cruise missiles. Hypersonic glide vehicles are carried in space on a ballistic missile and then released, picking up velocity on re-entering the atmosphere and gliding to their destination. Hypersonic cruise missiles use advanced air-breathing supersonic combustion ramjet (scramjet) engines to reach hypersonic speeds.²

Hypersonic weapons possess the twin problems of target ambiguity and shortening the target's reaction time. Target ambiguity refers to the ability of hypersonic weapons to fly low and fast. A ballistic missile follows a ballistic trajectory, and thus their destinations are relatively predictable. A hypersonic weapon, however, is in flight, which means it can alter course, perform evasive manoeuvres and change destination – all at over Mach 5. A target whose early warning system is dependent on ground-based radars may not be able to detect a hypersonic weapon until it is

^{1.} See for example Rob Crilly, 'US Awards \$1bn Contract for Hypersonic Missile as it Falls Behind Russia and China in New Arms Race', *Daily Telegraph*, 19 April 2018.

Missile Defense Advocacy Alliance, 'Hypersonic Weapon Basics', 30 May 2018, http://missiledefenseadvocacy.org/missile-threat-and-proliferation/missile-basics/hypersonic-missiles/, accessed 18 July 2018.

almost on top of the target, as the weapon can fly low and approach over the horizon, giving the target less time to react.³ These challenges are driving a desire for hypersonic defence.

Hypersonic defences do not necessarily require the building of entirely new systems. Existing ballistic missile defence systems can be adapted to target faster platforms. Lockheed Martin's Extended Range upgrade to the Terminal High Altitude Area Defense (THAAD) missile defence system is intended to defeat hypersonic weapons, essentially adding a second rocket stage to the interceptor, permitting it to travel faster and intercept faster targets such as hypersonic weapons.⁴ Other hypersonic defences include directed energy weapons (DEWs). DEWs are radiation beams such as lasers, which would be used instead of projectiles to destroy hypersonic weapons.⁵ Nothing travels faster than light, so this would be the fastest vector for destroying a target. However, work is required to get output power levels to benchmarks needed to be a serious threat to ballistic missiles (approximately 100 kW). Last year, Lockheed Martin produced a system capable of emitting a 58 kW beam.⁶ DEWs may also be countered by reflective or ablative coatings to disperse the beam's energy.

Space will likely become an increasingly important theatre for hypersonic defence, if satellites are able to assist in tracking hypersonic weapons. With ballistic missiles, satellites to date tend to search for infrared signals indicative of a launch. General John Hyten, head of US Strategic Command (STRATCOM), believes an affordable space-based mid-course sensor system for tracking hypersonic weapons is both feasible and necessary.⁷

More concerningly, there may be a temptation to return to a 'Star Wars'⁸ space-based missile defence platform – this has been earmarked in the FY2018 National Defense Authorization Act.⁹ Under Secretary of Defense for Research and Engineering Michael Griffin stated recently in the US Congress that he wanted 'by the latter part of the next decade ... a megawatt-class

- Jeff Hecht, 'Fiber Lasers Mean Ray Guns Are Coming', *IEEE Spectrum*, 27 March 2018; Patrick Tucker, 'Pentagon Requesting \$66M for Laser Drones to Shoot Down North Korean Missiles', *Defense One*, 12 February 2018.
- Lockheed Martin, 'Lockheed Martin to Deliver World Record-Setting 60kW Laser to US Army', 16 March 2017, https://news.lockheedmartin.com/2017-03-16-Lockheed-Martin-to-Deliver-World-Record-Setting-60kW-Laser-to-U-S-Army, accessed 18 July 2018.
- 7. Sydney J Freedberg Jr, 'STRATCOM Wants Space-Based Midcourse Tracking Vs Missiles: Hyten', *Breaking Defense*, 28 February 2018.
- 8. Robert Farley, 'May the Force (Not) be With You: Missile Defense and the Legacy of SDI', *National Interest*, 10 November 2014, https://nationalinterest.org/feature/may-the-force-not-be-you-missile-defense-the-legacy-sdi-11638>, accessed 19 July 2018.
- 9. 'H.R. 2810: National Defense Authorization Act for Fiscal Year 2018 (US)'.

^{3.} Richard H Speier et al., *Hypersonic Missile Nonproliferation: Hindering the Spread of a New Class of Weapons* (Santa Monica, CA: RAND Corporation, 2017).

^{4.} Howard Bromberg, 'Integrating Air & Missile Defense', Lockheed Martin Corporation, presentation given at RUSI Missile Defence Conference, London, 12–13 April 2016.

device that can go in space and protect us against enemy strategic missiles'.¹⁰ Not only might such a system be perceived as a serious existential threat to nuclear-armed states if it were to blunt the effect of a survivable second strike, but feasibility challenges also exist. Many of the concerns and challenges inherent to such a system – such as the need to maintain a large enough constellation of satellites to produce a reliable defence – will still exist now as they did in the 1980s. However, hypersonic weapons, DEWs, and many of the new nuclear weapons platforms we are seeing emerge were once considered implausible and fanciful, making currently unlikely space-based missile defence a possible future development.

Assuming these technologies are viable, how would hypersonic defences impact strategic stability? As is well documented, missile defence systems play a large role in strategic stability. In 2002, the George W Bush administration withdrew the US from the Anti-Ballistic Missile Treaty (ABMT), to Russia's chagrin. The ABMT limited the amount of ballistic missile interceptors either state could deploy and defined their scope as being only within their own borders. To counter the threat of limited nuclear strikes from rogue states, the US deployed more ballistic missile defence (BMD) assets worldwide. The US withdrawal from the ABMT was cited by Russian President Vladimir Putin in March 2018 as motivation for developing new weapons platforms – ones that could defeat American BMD.¹¹ China also disapproved of the US decision, strongly dislikes being left behind technologically,¹² and is also working on hypersonic weapons.

If the US or Russia develop hypersonic defence capabilities, China will likely seek to also develop them to avoid a technological disparity between itself and a major competitor. It also may be that Russia and China feel they can restore a mutual vulnerability aspect of nuclear deterrence that they believe is threatened by American BMD. The big three drivers of hypersonic weapons production clearly all feel threatened strategically by each other, hence the security dilemma-driven arms race of new nuclear weapons platforms.

While the arms control regime is under threat¹³ and seen as unfair to non-nuclear weapons states,¹⁴ progress in this area will not be made until these three states feel secure with respect to each other. Paradoxically, hypersonic weapons may serve as a means of restoring a sense of mutual security and strategic stability.

- House Armed Services Committee, 'Defense Department Drones Budget Request', C-SPAN, 17 April 2018, <https://www.c-span.org/video/?444170-1/defense-department-officials-testify-dronesbudget-request&start=2179>, accessed 18 July 2018.
- President of Russia, 'Presidential Address to the Federal Assembly', 1 March 2018, http://en.kremlin.ru/events/president/news/56957>, accessed 28 March 2018.
- 12. Bin Li, 'Differences Between Chinese and US Nuclear Thinking and Their Origins', in Li Bin and Tong Zhao (eds), *Understanding Chinese Nuclear Thinking* (Washington, DC: Carnegie Endowment for International Peace, 2016), pp. 6–7.
- 13. Steven Pifer and Oliver Meier, 'Are We Nearing the End of the INF Treaty?', Arms Control Today, 10 January 2018.
- 14. Ray Acheson, 'The Nuclear Weapons Ban and the NPT', *Bulletin of the Atomic Scientists*, 15 June 2017.

The flaw of relying on hypersonic weapons to restore mutual vulnerability is their inherent crisis instability, at least with respect to current detection and early-warning capabilities. The dangerous scenario is one with hypersonic weapons and hypersonic interceptors. Interceptor-based hypersonic defence will only make a challenging situation worse. Ballistic missile interceptors were an important motivator for development of Russian hypersonic weapons, and hypersonic weapons will certainly be desirable in a post-ABMT world. Repeating the same cycle again will only spawn further arms racing. Instead, policymakers – especially those in states developing hypersonic weapons – must encourage the development of improved radar and satellites, to provide increased early warning of any possible hypersonic nuclear weapon launches.

The importance of space-based observation platforms in providing a stable solution to this problem cannot be understated either and this means space will become an increasingly important theatre in the future. All must be vigilant also against attempts to deploy hypersonic interceptors in space, and the case must be made to limit anti-satellite weapons use to preserve mutual investment in satellite early-warning and tracking systems.

The safer scenario is one with hypersonic weapons and improved early-warning systems, updated radars and satellites. In this arrangement, the broad strategic stability concerns of the US, Russia and China are satisfied. The US gets to retain its 'classic' BMD to defend against limited early-generation ballistic missile strikes from rogue states. Russia can preserve nuclear vulnerability with respect to the US, and with its Avangard glide vehicles and Kinzhal hypersonic missiles it can retain a level of nuclear capability at both the strategic and tactical levels. China can also preserve nuclear vulnerability and retain technological parity with its next-nearest competitors.

The appetite for arms control, including in relation to hypersonics, is low. Progress on arms control is unlikely to resume until major inventors of new weapons feel more secure. The US will be unwilling to consider a renewed ABM treaty until its security concerns are addressed, yet American BMD is a security concern of Russia and China, hence their desire for hypersonic weapons. Additionally, China desires hypersonic weapons so as not to be left behind. Ultimately, if these states decide it is in their best interests to acquire these weapons, they will acquire them. They are en route to achieving that goal. Without a shift in strategic pressures and concerns, hypersonic weaponry might have to be accepted as a new technological and strategic reality.

Clearly, this is not an ideal scenario. However, there will be even less progress on international arms control until these states feel secure enough to start discussing arms control again. The US, Russia and China are developing hypersonic weapons to address their strategic stability concerns, or fear of being left behind technologically, and this drive is now bleeding out into development of hypersonic interceptors. Some of these systems are adaptations of existing platforms (BMD, space-based interceptors) that have led to the aggravation of security concerns driving the proliferation of hypersonics in the first place. A possible way forward may be to accept the reality of hypersonic offensive weapons while improving early-warning space-based sensor layers and limiting hypersonic interceptors. In this way, broad strategic concerns of the

primary drivers of hypersonic technology may be addressed without falling prey to some of the destabilising features of these systems. Reinforcing each state's sense of strategic stability may then permit an increase of mutual trust and a return to discussions on arms control.

XIII. The United States Sale of Trident to the United Kingdom, 1977–1982

Suzanne Doyle

HE US WILL play a pivotal role in the replacement of the British Trident nuclear system. The UK is technically dependent upon the US for the supply of its nuclear delivery systems. Despite this, contemporary discussion on the replacement of Trident often overlooks, or obscures, the role of the US.¹ There are many reasons for this. It is difficult for British politicians to discuss the technical dependency of the 'independent nuclear deterrent'². In addition, while current public discussion on Trident replacement is more open than British nuclear policy of the past, the secretive nature of nuclear diplomacy means that the UK government's contemporary conversations with Washington remain classified.

With the declassification of government documents, on both sides of the Atlantic, it is now possible to analyse the UK's original purchase of the Trident missile system from the US in the early 1980s. In July 1980, the UK and the US reached agreement on the sale of US Trident C4 missiles to the UK. In 1981, then US President Ronald Reagan's decision to replace the Trident C4 missile with the Trident D5 system earlier than originally planned reopened the British decision on the C4. Subsequently, in March 1982, the UK and US governments signed the Trident D5 agreement. This paper briefly analyses and compares the respective approaches of the administrations of past US presidents Jimmy Carter and Reagan towards the sale of Trident. Given the secrecy of US–UK negotiations on the supply of US delivery systems, such analysis is of historical and contemporary importance, and provides valuable insights into the impact of the UK's technical dependency on British decision-making.

In December 1977, a British Cabinet committee met to discuss the replacement of the existing Polaris nuclear system.³ The committee assessed that they should rule out a truly independent British ballistic missile due to 'capability and cost'.⁴ Subsequently, in February 1978, the Jim Callaghan Labour government commissioned a study, commonly referred to as the Duff-Mason report, that would consider the 'principal options' for the replacement of Polaris.⁵ The British

^{1.} See, for example, *Hansard*, House of Commons, 'UK's Nuclear Deterrent', Debates, 18 July 2016.

^{2.} HM Government, National Security Strategy and Strategic Defence and Security Review 2015: A Secure and Prosperous United Kingdom, CM9161 (London: Stationery Office, 2015), p. 34.

^{3.} Note of meeting, 1 Dec. 1977, PREM 16/1564, The National Archives, United Kingdom (TNA).

^{4.} Ibid.

^{5. &#}x27;Terms of Reference for a Study of Factors Relating to Further Consideration of the Future of the United Kingdom Nuclear Deterrent', December 1978, DEFE 19/275, TNA; Hunt to Callaghan, 7

government wished for insight on the ideal replacement to more effectively lobby the US not to close off their preferred option in the ongoing Strategic Arms Limitation Talks (SALT) between the US and the Soviet Union.⁶ The final Duff-Mason report recommended, rather conclusively, the US Trident C4 system.⁷

In 1979, Callaghan, and then Margaret Thatcher after her election in May 1979, approached the Carter White House to enquire about the possible supply of the Trident C4 system. The Carter administration was broadly supportive of assisting the British with the replacement of Polaris, but at the same time US officials were concerned about the possible political impact of the supply on wider US foreign policy. The administration was concerned that the supply of Trident C4 would provoke a reaction from the Soviet Union that could undermine the delicate SALT II ratification process in the US Senate. US officials were additionally worried that the supply could undermine efforts to achieve NATO consensus on the 'dual-track' decision by further unnerving some Allies about selling publicly the commitment to deploy new theatre nuclear forces (TNF) in Europe.

As such, in October 1979 the Carter administration decided to postpone formal negotiations on the supply of Trident C4 until after Senate ratification of SALT II and the NATO agreement on TNF deployment in Europe. This delay created angst in Downing Street about whether the British would secure agreement on the purchase of Trident C4 before the end of Carter's term.⁸ Fortuitously for the British, in March 1980 the US decided to proceed with formal negotiations on the supply of Trident due partly to their fears of a damaging leak from the British if there was further delay, as well as a shift in Carter's foreign policy priorities following the Soviet invasion of Afghanistan.⁹

The approach of US officials in the formal negotiations that then began surprised the British. The Carter administration demanded a British commitment to use the 'savings' from US–UK nuclear cooperation on their conventional forces, to provide offsets for any reduction in the research and development levy, and to agree to the US government's plans to extend US facilities on Diego Garcia.¹⁰ Thatcher scribbled her dislike on the briefing she received: 'I have read these papers with dismay. We should never have trusted the assurances we were given. I am not prepared to negotiate on this basis'.¹¹

December 1978, DEFE 19/275, TNA.

- 7. 'Duff-Mason Report', December 1978, DEFE 19/275, TNA.
- 8. See Suzanne Doyle, 'Preserving the Global Nuclear Order: The Trident Agreements and the Arms Control Debate, 1977–1982', *International History Review* (Vol. 40, No. 5, 2018), pp. 1174–90.
- 9. Brzezinski to Carter, 18 March 1980, NLC-SAFE 17 D-26 32-11-7, Jimmy Carter Library, United States (JCL).
- 10. See Suzanne Doyle, 'The United States Sale of Trident to Britain, 1977–1982: Deal Making in the Anglo-American Nuclear Relationship', *Diplomacy & Statecraft* (Vol. 28, No. 3, 2017), pp. 477–93.
- 11. Armstrong to Thatcher, 'Polaris Replacement', 28 March 1980, PREM 19/159, TNA.

^{6.} Hunt to Callaghan, 'The Timing of Further Consideration of the Future of the Deterrent', 28 November 1977, PREM 16/1564, TNA.

After protracted negotiations the British agreed to a watered-down commitment on conventional force spending, to pay a 5% R&D levy in addition to operating US Rapier systems in Britain, and to the US plans for Diego Garcia.¹² These demands were not onerous to the British in real terms, particularly due to the savings the purchase of Trident afforded compared to the other options for the replacement of Polaris. However, Washington expected certain returns for Trident and officials used the supply to influence British defence and foreign policy. Indeed, US officials openly discussed using Trident as 'leverage'.¹³ The Carter administration treated the US–UK nuclear relationship as coolly transactional.

The election of Reagan in November 1980 reopened the UK's decision on the replacement of Polaris. The new president campaigned on a platform of strategic modernisation. Subsequently, in August 1981, the Reagan administration decided that the US would replace the Trident C4 missile with the more advanced Trident D5 missile by 1989.¹⁴ Following this decision, the White House informed Downing Street that it was prepared to sell the D5, but did not provide reassurances that it would supply the advanced missile on the same terms as the C4.¹⁵ The expense of the independent Chevaline project had highlighted to the British the potential costs of losing commonality with the US.¹⁶ Yet uncertainty about the price of the D5 created deep concern in Downing Street over whether the UK could afford the advanced system, and even if the UK could remain a nuclear weapons power.¹⁷ After hesitation within the Cabinet Committee over two long meetings, British officials decided to go ahead with negotiations on the sale of Trident D5.¹⁸ Here the UK political elites' belief in the necessity of a British bomb prevailed.

Despite the supposed friendliness of the Reagan and Thatcher relationship, the Reagan administration took a similar approach to Carter's on negotiating the terms of supply of Trident. It similarly sought quid pro quos in return for the supply of the Trident D5 system, despite their broad support for the supply of D5 and Britain's nuclear programme. They sought UK commitments on defence spending and adjustments to Britain's conventional defence programme in geostrategic areas of concern for the US. After protracted negotiations the US secured a series of 'quids' that both sides were happy with.¹⁹

15. Weinberger to Thatcher, 24 August 1981, PREM 19/417, TNA.

17. Armstrong to Thatcher, 'The United Kingdom Strategic Deterrent MISC 7 (81)', 11 Jan. 1982, PREM 19/694, TNA.

^{12.} Doyle, 'The United States Sale of Trident to Britain, 1977–1982'.

 ^{&#}x27;Agenda Paper: Meeting of the PD-46 Steering Committee, Strategic Nuclear Cooperation with Britain and France', 29 May 1980, Meetings – Muskie/Brown/Brzezinski 5/80 – 6/80, Box 23, Subject File, Brzezinski Collection, JCL.

^{14.} Thomas to Gillmore, 'The Trident D-5 Decision', 25 August 1981, FCO 46/2751, TNA.

Duff Mason Report, Dec. 1978, DEFE 19//275, TNA; 'Most Confidential Record to MISC 7 (81) 1st meeting', 24 Nov. 1981, CAB 130/1222, TNA.

^{18.} Suzanne Doyle, 'A Foregone Conclusion? The United States, Britain and the Trident D5 Agreement', *Journal of Strategic Studies* (Vol. 40, No. 6, 2017), pp. 867–94.

^{19.} *Ibid.*

This brief analysis demonstrates that British dependency on the US in the original Trident sale led to far greater US influence over British decision-making than is often acknowledged in contemporary debates. British reliance on the US for the supply of a delivery system created angst over when, and indeed if, a deal would be finalised. In addition, the UK worried about whether the US would provide Trident at a price the British could realistically afford. In turn, the US used British dependency to influence and shape wider British policy, despite Washington's broad support for the UK's nuclear programme. Both administrations sought commitments in return for Trident that would benefit US wider foreign and domestic policy aims but not financially harm the British. In this way, the original purchase of Trident highlights that the current replacement of the nuclear system is, at least in part, contingent on the dynamics of US politics and deal-making, and that this aspect is important to discuss in contemporary debate.

XIV. Generational Analysis for the Recruitment and Retention of Talent Within the Nuclear Industry: A Summary

Ben Percy and Victoria Murtland

STUDY BY THE UK government in 2015 predicted that by 2021, almost 100,000 full-time employees would be required to support the UK nuclear sector: an increase of almost 20,000 employees compared with 2018.¹

The nuclear sector rapidly grew in the 1960s. However, the lifestyles and childhoods of that workforce differ significantly from those of individuals growing up in the current technological era. To address the workforce deficit, the Young Nuclear Safety Professionals' Forum (YNSPF) launched a study on generational theory to identify how this theory could be used to increase recruitment and retention of skilled workers in the sector.

Generational Theory

Generational theory states that a population can be split into specific groups or 'generations', based on the era in which its members were born, with each group exhibiting distinct psychological and sociological traits.²

By 2020, Generation Y (born between 1977 and 1995) will represent 50% of the UK's workforce.³ Literature across industry sectors characterises Generation Y with traits such as changing companies regularly and favouring development opportunities over job security.⁴

- 3. PWC, 'Millennials at Work: Reshaping the Workplace', 2011, <https://www.pwc.de/de/ prozessoptimierung/assets/millennials-at-work-2011.pdf>, accessed 22 August 2018.
- 4. Robert P Coffey, 'A Phenomenological Study of Leadership and Millennial Employees in the Nuclear Industry', dissertation, University of Phoenix, 2013.

^{1.} HM Government, 'Sustaining our Nuclear Skills', Nuclear Sector Skills Strategy: Government and Industry in Partnership, 2015.

^{2.} Simon Biggs, 'Thinking About Generations: Conceptual Positions and Policy Implications', *Journal of Social Issues* (Vol. 63, No. 4, 2007).

To understand if this literature was also representative of Generation Y in the nuclear sector, the YNSPF surveyed civil and defence nuclear organisations and ran workshops to elicit recommendations to aid recruitment and retention of Generation Y in the nuclear sector.

For comparison with Generation Y, this study also analysed Generation X and Baby boomers, who were born between the years 1965 and 1976 and 1946 and 1964, respectively.

Significant Results

Attraction to the Nuclear Sector

As presented in Figure 1, the study showed that only 22% of Generation Y respondents had exposure to the nuclear sector prior to university-level education. Although 47.8% of respondents had a positive perception of the sector prior to joining, the majority of remaining workforce members with a negative perception were either uninformed of the sector or had been influenced by the media portrayal (Figure 2).



Figure 1: Stage in Life of First Exposure to the Nuclear Sector, by Generation

Source: Ben Percy et al., 'Generational Analysis for the Recruitment and Retention of Talent Within the Nuclear Industry', Young Nuclear Safety Professionals' Forum, 4 March 2018.



Figure 2: Perceived Source of Negative Opinions of the Nuclear Sector, by Generation

Source: Ben Percy et al., 'Generational Analysis for the Recruitment and Retention of Talent Within the Nuclear Industry', Young Nuclear Safety Professionals' Forum, 4 March 2018.

Company Versus Sector Retention

To understand current retention rates, the study questioned current employees' future aspirations and whether they intended to remain with their current employers (Figure 3) and/ or in the nuclear sector (Figure 4).

This study found that 47% of Generation Y planned to stay with their current employers for the foreseeable future. In comparison, recent surveys by Deloitte and PWC on how long Generation Y will stay with their current employer across a range of industries had much lower results. Deloitte quoted that 31% of Generation Y respondents who were questioned planned to stay with their employer for more than five years.⁵ PWC stated that only 18% planned to stay with their current employers for the long term.⁶ Despite this and the results showing a high proportion

Deloitte, 'The 2017 Deloitte Millennial Survey: Apprehensive Millennials Seeking Stability and Opportunities in an Uncertain World', 2017, https://www2.deloitte.com/content/dam/Deloitte/ us/Documents/about-deloitte/deloitte-millennial-survey-2017-executive-summary.pdf>, accessed 22 August 2018.

^{6.} PWC, 'Millennials at Work'.

of Generation Y planning to stay in the nuclear sector as a whole, development and training schemes should account for over half of Generation Y wishing to change organisations regularly.

Figure 3: Likelihood of Remaining With Current Employer for the Foreseeable Future, by Generation



Source: Ben Percy et al., 'Generational Analysis for the Recruitment and Retention of Talent Within the Nuclear Industry', Young Nuclear Safety Professionals' Forum, 4 March 2018.

Figure 4: Likelihood of Remaining Within Nuclear Sector for the Foreseeable Future, by Generation



Source: Ben Percy et al., 'Generational Analysis for the Recruitment and Retention of Talent Within the Nuclear Industry', Young Nuclear Safety Professionals' Forum, 4 March 2018.

Motivation at Recruitment

The study also investigated factors attracting employees to the nuclear sector and compared them with current motivators in employees' roles.

The results (Figure 5) highlighted that pay and location are key factors for joining the nuclear sector; however, younger generations place a larger importance on career development than their older peers. This does not appear to be limited to the nuclear sector, though, as this was also highlighted in PWC's study.⁷



Figure 5: Motivations for Joining the Nuclear Sector, by Generation

Source: Ben Percy et al., 'Generational Analysis for the Recruitment and Retention of Talent Within the Nuclear Industry', Young Nuclear Safety Professionals' Forum, 4 March 2018.

Recommendations

The nuclear sector should increase recruitment for the future by simplifying its complexities to audiences that are as young as possible. To improve its public perception in the imminent future, the sector should publicise more success stories and ensure that mass media is not the main source of information about the sector.

To facilitate the movement of Generation Y across the sector, organisations should be open to sharing resources between companies, either through temporary placements or job exchanges. Training and development should also be adapted for this movement through industry recognised and standardised qualifications.

When attempting to attract Generation Y, the nuclear sector must maximise the potential of the local workforce as well as keeping salary and other pay benefits competitive. When specifically targeting Generation Y, the sector must prioritise the advertisement of development programmes over job security.

Summary

The trends described in the generational theory literature appear to hold true for the nuclear sector, but to a lesser extent. These trends must be understood because the demand for skilled and educated individuals in the sector will increase to support civil nuclear new build and defence project growth.

These results and recommendations should be the starting point from which organisations within the sector can conduct their own research to find specific answers to their recruitment and retention questions. The full report on this topic can be found at the YNSPF website.⁸

This paper is based on research conducted with James Atkinson, Rowan Barton, Charlotte Burman, Daniel Burnett, James Craven, Neepa Paul, John Shoyode and Jessica Taylor.

^{8.} Ben Percy et al., 'Generational Analysis for the Recruitment and Retention of Talent Within the Nuclear Industry', Young Nuclear Safety Professionals' Forum, 4 March 2018, <https://www.nuclearinst.com/YNSPF>, accessed 22 August 2018.

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