UNITED KINGDOM: NUCLEAR WEAPON COMMAND, CONTROL, AND COMMUNICATIONS

Recommended Citation

John Gower, "UNITED KINGDOM: NUCLEAR WEAPON COMMAND, CONTROL, AND COMMUNICATIONS", NAPSNet Special Reports, September 12, 2019, https://nautilus.org/napsnet/napsnet-special-reports/united-kingdom-nuclear-weapon-command-control-and-communications/

JOHN GOWER

SEPTEMBER 12, 2019

I. INTRODUCTION

In this essay, John Gower states that the UK Nuclear Weapon Command Control and Communications (UK NC3) architecture is designed and operated to support SSBN strategic nuclear deterrence in all foreseeable circumstances from peacetime to nuclear conflict. **"**Through multiple paths and frequencies, fall-back and alternative systems and with dedicated and unique encryption and processes it delivers continuous availability for the Prime Minister should a decision to launch be made."

A podcast with John Gower, Peter Hayes, and Philip Reiner on UK NC3 is found **here**.

Formerly commander of two submarines, Rear Admiral John Gower was Assistant Chief of Defence Staff (Nuclear & Chemical, Biological) in the UK Ministry of Defence. He served as the senior MoD policy officer for the UK NC3 reporting its status to the Nuclear Deterrence Policy Committee, and the Cabinet Office for the Prime Minister. He is now an independent consultant on global nuclear policy issues.

Acknowledgments: The workshop was funded by the John D. and Catherine T. MacArthur Foundation.

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II. NAPSNET SPECIAL REPORT BY JOHN GOWER

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Summary

The UK Nuclear Weapon Command Control and Communications (UK NC3) architecture is designed and operated to wholly support the single mission of SSBN strategic nuclear deterrence in all

foreseeable circumstances from peacetime to nuclear conflict. It has evolved through 66 years of being a nuclear armed state, from aerial bombs alone to combinations of bombs and Submarine Launched Ballistic Missiles (SLBM) to SLBM alone. Through multiple paths and frequencies, fall-back and alternative systems and with dedicated and unique encryption and processes it delivers continuous availability for the Prime Minister should a decision to launch be made.

Introduction

The United Kingdom formally became a nuclear weapon state in 1952, with operational systems from 1955. From then until 1968, the strategic element of its deterrent was borne principally by the Royal Air Force and, thereafter, by the Royal Navy. Although less than strategic weapons came and went over this period, they had permanently disappeared from the UK capability by 1994 and are extremely unlikely to return. This paper deals predominantly, therefore, with the NC3 brought into service and refined for the now sole submarine-launched ballistic missile (SLBM) system; other systems are of historic interest only.

Nuclear weapon system information, particularly the detail of national command, control and associated communications systems and protocols, are among the most tightly guarded and classified secrets of any nation. The UK is no exception to this and until the decision to release some of the protocols and procedures as part of the Cabinet Office co-operation with a BBC Radio programme, "The Human Button", first broadcast on 7 Dec 2008, every facet of current national arrangements was classified. The author of this paper was closely involved in the operation, policy and management of UK NC3 between 2008 and 2014 and desiring not to spend the remainder of his current post Royal Navy life detained at Her Majesty's pleasure has restricted the use of his knowledge in compiling it to that information which is publicly available.

A Short History of the Pre-SSBN Era

Until the UK strategic nuclear deterrent became vested in the SSBN force in 1968, with continuous patrols established from 1969, command and control of the UK's nuclear deterrent was complex and multi-layered, although initial authority to release has always remained with the Prime Minister (PM), nominated Ministerial Deputies or in extremis the Royal Air Force (RAF) Commander of the then RAF Strike Command. Indeed, the only wartime employment of nuclear weapons, against Hiroshima and Nagasaki in August 1945, required the parallel approval of the UK Prime Minister in

accordance with the protocols of the 1943 Quebec agreement which saw the merger of the nascent UK and US nuclear weapons development programmes under the US-led Manhattan Project.

With the introduction of the WE177 gravity bomb in 1966 and its expansion to the Royal Navy strike aircraft and helicopters in 1971, command and control arrangements expanded to include the operational and tactical employment of nuclear weapons in conflict with the Warsaw Pact. Under NATO's doctrine of flexible response, whilst initial allocation of the UK's nuclear weapons to NATO remained a political decision owned by the Prime Minister, once the UK had acceded to such a request, some aspects of tactical nuclear release authority could be delegated to NATO operational commanders. Over this period therefore, NC3 was integrated with conventional C2 networks.

Throughout the period between 1954[1] and 2006, the UK also hosted US nuclear weapons, first by providing forward bases for USAF Strategic Air Command (SAC) nuclear bombers, then a forward base for US Polaris SSBN in Holy Loch in Scotland from March 1961. In addition, US THOR ballistic missiles were based in the UK, operated by the RAF under dual-key control from 1958 until 1963. Following the introduction into service of longer range nuclear bombers, capable of conducting missions from the continental US, and US-based InterContinental Ballistic Missiles (ICBM), the last SAC aircraft left the UK in 1964. To meet late 1970s NATO nuclear doctrine, US Ground Launched Cruise Missiles (GLCM) were based in the UK from the early 1980s. As a result of the now near-moribund Intermediate Nuclear Forces (INF) Treaty in 1987 these GLCMs left the UK in 1991. The Holy Loch base closed in 1992 as the longer range of US Trident SLBM made a forward SSBN operating base redundant. US tactical nuclear bombs for USAF NATO Dual Capable Aircraft (DCA) remained in storage in USAF bases in the UK until 2006. Throughout this period, the UK Prime Minister had a role in authorising US nuclear strikes originating from UK bases and territory. The NC3, therefore, had additional layers of complexity with consultation links between the UK and the US at every level from the Prime Minister to the operational units involved. These consultation layers no longer form essential elements of the UK NC3.

Since the withdrawal of all US weapons from the UK, and the concentration of the UK deterrent (since 1994) in the SLBM system, the need for these additional complexities of the NC3 systems has evaporated and the current system is therefore designed and focused exclusively on the purely national need to exercise C2 over the SSBN force in all circumstances from peacetime to nuclear conflict.

Some of the history of the thought processes behind the upper echelons of NC3 in the UK is contained in the meticulously-researched and highly readable book by Peter (now Lord) Hennessey, "**The Secret State**", the second edition of which was published in 2003. I commend it to interested readers. Within the historic data contained in this summary of official papers made available to the author and his researchers can be found the seeds, and first examples, of elements of the NC3 which are maintained today, from the first concept of the "last resort" to the complex and often strangely humorous and perhaps uniquely British solutions found to the need to connect the Prime Minister to the nuclear command and control under all circumstances in the pre-computer and pre-handheld mobile communications world.

UK NC3 in the SSBN Era

UK Documentation

The UK's requirements for its nuclear deterrent systems and the integral NC3 are not laid out in detail in publicly available legislation or documentation. The authority for the UK to own, operate and manage its nuclear deterrent is held within the Prime Minister's Nuclear Directive, which is supported by the UK Nuclear Deterrence Policy, owned by the Cabinet Office. From these key and

highly classified documents are spawned a hierarchy of equally highly classified directives and requirements documents, operating procedures and protocols. None of these documents is currently or is ever likely to be made available to the public.

Launch Authority and Last Resort

Authority to launch the UK's nuclear weapons rests solely with the Prime Minister, as the National Command Authority (NCA). In times of crisis, the PM may nominate formal Nuclear Deputies who can take nuclear release decisions upon the death of the Prime Minister, thus negating the intended paralysing effect of a decapitation strike or targeted assassination of the PM as part of an extreme crisis. The Prime Minister is advised by a small group of key ministers and officials. The UK is significantly different from all other nuclear weapon states in that the military has no formal role in the advice or decision upon whether to launch UK SLBM (save detailed expert advice on whether the options for consideration are capable of being executed as the political leadership might desire).

The UK is a relatively small nation, vulnerable to an overwhelming strike in the most extreme circumstances. Therefore, since the first adoption of the SLBM strategic deterrent, "last resort" protocols, made formally public only in 2008, have been an integral part of the deterrent. Each Prime Minister, shortly after taking office, receives an options briefing from Cabinet Office staff on the UK "last resort" protocols. Under these protocols, designed to provide additional deterrence by denying a potential adversary the option of seeking, through a devastating strike, to destroy not only the NCA (the PM and Deputies) but also enough of the NC3 infrastructure to place a firing order in doubt, the PM writes a dormant directive letter to each of the SSBN Commanding Officers. In that letter, the contents of which are known only to the sitting PM, is the final directive in the event of such a devastating strike. An adversary cannot discount that the PM has directed a retaliatory strike, whatever the PM has written. This possibility exerts UK nuclear deterrence against even the most extreme alternatives open to an adversary. That letter is only opened after a most complex and exhaustive process which the SSBN Commanding Officer must complete (taking a considerable time and involving many steps and stages) should he determine that such a devastating strike may have occurred whilst he is on patrol.

The UK Deterrent as it drives NC3

Before examining the detail of the NC3 and how it operates in peacetime and in crisis or conflict, it is necessary to understand the nature of the UK's deterrent which has shaped it and binds future developments.

The UK operates a submarine based strategic deterrent through a force of four SSBN. These operate in such a way to retain a single SSBN at sea on strategic patrol in the deep ocean, relatively undetectable and invulnerable. This mission, now termed Operation RELENTLESS, has been maintained since 1968 and continuously since 1969. From the early Polaris SSBN days and until relatively recently, the SSBNs were held at high readiness to launch, requiring them to maintain the ability to receive communications from the UK continuously to meet that requirement.

Today, their Trident D5 SLBM are at several days' notice to fire and, since 1994, are not targeted. If the strategic situation dictates, and at the direction of the Prime Minister, the missiles will be targeted from information onboard the SSBN, or from information signalled to the SSBN during its patrol. In addition, the SSBN can be ordered to operate at higher readiness to match the crisis. The ability to shorten or extend the SSBN response times to match the strategic circumstances without such action escalating a crisis is one of the significant strengths of a continuous patrolling sea-based deterrent and allows the UK, and NATO, to make appropriate deterrent messages from the strength of knowing the surety of the inferred or explicit response options within those messages. The robust

and survivable NC3 architecture is therefore a significant contributor to the deterrent effect of the system in peacetime and crisis.

Owing to the nature of the UK's “last resort” policy there are no Permissive Action Links (PALs) in the system, either physical or electronic. It can be deduced from the concept of last resort, therefore, that each SSBN sails with all the information onboard necessary to conduct a strategic missile launch, when so ordered, against a wide range of potential adversaries.

An SSBN operates passively. While this used to be the case for all submarine operations, the increasing integration of non-nuclear armed submarines in coordinated operations has increased the capability and practice of submarines transmitting whilst on operations. An SSBN, however, would only break transmission silence in circumstances where it could no longer be relied upon for its primary deterrent role. The SSBN's greatest strength is its undetectability and therefore no system requiring a positive transmitted response from it could be tolerated within the NC3.

UK declaratory policy also makes it clear that the UK considers its nuclear deterrent to be capable of a range of responses dependent upon the strategic circumstances. From these statements can be inferred that the UK NC3 can transmit all the necessary elements of information and direction for a range of nuclear response options to an SSBN in a developing crisis.

Each submarine carries the Trident II D5 submarine-launched ballistic missile system that fields the UK's nuclear deterrent. Developed and manufactured by Lockheed Martin in the United States, Trident entered service with the Royal Navy in 1994 with the Vanguard class, 14 years after it was selected as the replacement for the previous submarine-launched Polaris missile carried by the Resolution class SSBN. It was designed to be more sophisticated than its US predecessor, Trident I C4, and has a greater payload capacity.

The missile is 13 metres long, weighs 58.5 tonnes, has a range of 12,000 kilometres (7,500 mi), a top speed of over 21,600 km/h (13,400 mph - Mach 17.4) and a proven accuracy of warhead delivery to within "a few feet". It navigates using an inertial guidance system combined with star-sighting and is not dependent on the American-run Global Positioning System (GPS). All three stages of the Trident II D-5 are made of graphite epoxy, which made the missile much lighter than its predecessor and increased both its range and accuracy.

Following the decisions in the SDSRs of 2010 and 2015, the UK now deploys 8 Trident missiles on each operational Vanguard-class submarine. The UK has title to 58 missile bodies within the US inventory, which are held in a communal pool at the Strategic Weapons Facility at the Kings Bay Submarine Base in Georgia, USA. Maintenance and in-service support of the missiles is undertaken at Kings Bay at periodic intervals.

Each Trident missile was originally designed to carry up to 12 nuclear warheads, but the 2010 Strategic Defence and Security Review imposed a limit of 40 warheads per operational submarine. The destructive power of each of the warheads is not made public but has been estimated at up to the equivalent of eight to ten Hiroshima weapons. All the UK's warheads are built and maintained at the Atomic Weapons Establishment in Aldermaston and nearby Burghfield in Berkshire and transported when required by secure convoy to the armament depot at Coulport, adjacent to Faslane, for mating with the missiles aboard an operational SSBN. They will remain mated with the missiles for the duration of the submarine’s commission (around 10 years per commission).

UK NC3 in Peacetime, Crisis and Conflict

Submarines require a complex suite of communications to operate far from their base over a

spectrum of activity, from fully integrated Joint Force Operations to solo patrols in support of national objectives. For Royal Navy submarines today, this requires global coverage and the capacity to handle both the shortest low data messages and very high data load demanded by modern internet protocol communications networks.

This complex requirement drives both national, bilateral and multinational allied and NATO capabilities across the radio spectrum using land- and space-based communications to transmit to, and receive from, globally deployed submarines.

SSBN usually operate at the solo deployed end of this spectrum, but they are fitted with a full suite of communications equipment. In peacetime, therefore, they will benefit from national use of the high-capacity bandwidth systems, many of them multinational, to manage the amount of data necessary for normal operations. For their primary role, however, the core UK NC3 exists to give an assured exclusively national data path under all foreseeable circumstances for the messages necessary to change their readiness, receive necessary targeting information and, most importantly, a correctly authenticated UK national firing control message from the NCA.

Elements of UK NC3

For the UK NC3, in common with all strategic NC3, the requirements are designed to meet the four essential elements of such a system:

- The correct, unambiguous and authenticated identification of the NCA, a correctly formatted and authenticated firing message, with authenticated verification of both elements at every human interaction within the communications chain between the NCA and the SSBN command;
- A system architecture beneath the NCA which has no single point of failure, nor any possibility of a firing message being generated by any other than the NCA. Invulnerable and specific encryption of the necessary signals is an important element of this;
- A system which has multiple possible, and preferably simultaneous, transmission paths across the radio spectrum. This multiplicity of paths and frequencies is sufficient to achieve transmission and reception in the presence of all foreseeable threats, physical and electronic. All elements of the system with the necessary physical and electronic protection appropriate to the strategic situation;
- The NC3 must be capable of operating in the most hostile environment foreseeable. In order to deter, the system must be capable of achieving its mission after a major nuclear strike, with attendant electromagnetic pulse (EMP) and destructive effect.

The architecture of the resultant system, its locations and fall-back modes and the associated readiness levels are beyond the classification of this paper.

Operation of the NC3 from Decision to Detonation

As previously explained, the responsibility to order a launch of the UK’s nuclear deterrent rests solely with the Prime Minister. The UK’s nuclear policy makes it clear that such a launch would only be contemplated in extreme circumstances of self-defence, including the defence of our NATO Allies. UK nuclear weapons support the collective security of NATO, together with those of the US and France, and the North Atlantic Council can request that its three nuclear weapon state members launch weapons in support of that security. The decision whether to accede to that request and launch remains with the respective PM and Presidents.

While the SSBN on patrol is normally at several days’ notice to fire in peacetime with its missiles

untargeted, in crisis the PM will undoubtedly wish to ensure that the SSBN is readied appropriately as part of the measures to deter nuclear weapon launch by an adversary. This could include reducing its notice to fire and passing appropriate additional target information to the patrolling submarine via the NC3. Any of these measures would be conducted in the utmost secrecy, the continuous nature of SSBN operations allowing the PM options without inflaming or escalating the crisis itself through precautionary activity.

Should the PM decide that it is necessary to consider launching missiles from the SSBN, he or she will receive detailed briefings depending upon the circumstances which took him/her to that decision. That briefing will explain the options available for employment of the deterrent, whether within a purely national or a NATO context. Should a decision be made to launch missiles then the target package decided upon will have unique designators which identify it to the weapon system onboard. These designators form the core of the Nuclear Firing Control Message which will be drafted for the PM, based on that decision. The message also contains the ordered date and time to launch as well as any other specific launch instructions or constraints.

In order to initiate the process, the PM communicates that decision to the MoD from one of several secure sites in and around London where the communications capability exists to pass the PM's order to the SSBN. The primary of these is the Nuclear Operations and Targeting Centre (NOTC) within the PINDAR complex deep beneath the Ministry of Defence Main Building in Whitehall. This complex, designed to survive all foreseeable means of attack for enough time to execute a response, is perhaps the most protected space in Whitehall. This starting point for a nuclear firing message lies deep underground and is secured against the electromagnetic effects of a nuclear attack on London.

The message is authenticated by the PM and encoded, and from the moment it leaves the PM's hand it is handled at all stages by two nuclear-authenticated operators following strict protocols. The order is transmitted to the patrolling SSBN through several communication paths appropriate to the crisis; at least one of these can survive even a devastating nuclear attack upon the UK. On arrival onboard the SSBN, the message is authenticated by two officers (neither of whom is the Commanding Officer) and decoded using two separate cryptography sets (and matching the two sets of cryptography used by the original officers in the presence of the PM) and the submarine follows the instructions regarding the targeting of the missiles and ordered launch time, manoeuvring to remain undetected and secure to a position from which it can conduct the launch unmolested and undetected until the directed launch time.

Launch, Ballistic Flight and Detonation

Onboard the SSBN, the missiles are carried upright in vertical launch tubes in a missile compartment abaft the submarine fin. The submarine places itself at launch depth and prepares for the ordered launch time. The following sequence occurs for each missile which has been ordered by the PM to launch. Submarine inertial navigation systems pass a very accurate position to the missile guidance in the tube and the necessary countdown takes place. At launch, rapidly expanding gas is introduced into the tube, the pressure of which is used to eject the missile out of the submarine and out of the ocean surface where the missile senses it has cleared the water and ignites the solid fuel in the first of three stage motors, commencing the initial powered portion of the flight. At the same time, an aerospike designed to reduce drag by around 50% extends from the tip of the missile. The missile burns successively through its three stage motors to accelerate to the velocity required to leave the atmosphere and give enough speed to reach its target. Within approximately two minutes from launch the missile is travelling at over 20,000ft (6,100 metres) a second. On completion of each stage, like the original Apollo 3-stage rocket, the stages separate and fall to earth, the majority of which burns up in the atmosphere. Once the missile reaches space, its guidance system takes a

navigation update from the stars to confirm the inertial guidance determination of the missile's position and makes any adjustments necessary to the pre-programmed route to its target area. The forward section of the missile containing the warhead(s) then continues in a ballistic trajectory towards the predetermined points in space where it will release the warhead(s).

Once in the vicinity of its targets, the guidance system on the forward section takes another star reading to confirm its position to the required accuracy. Small thruster rockets then manoeuvre the section, so each warhead can be individually released in the right place in space to freefall through the atmosphere at very high speed to the individual aim points, where each will detonate according to one of several pre-set fuse options.

Unique Aspects of Ballistic Missiles

From an NC3 perspective, the most important fact is that, once the missile has launched, there is no facility to interact with it. It cannot be re-directed away from its target or destroyed from the ground. It will continue directly, reliably and accurately to its commanded aim point and detonate. It is upon this implacable surety of response under all conditions which rests the bulk of the deterrent effect of the continuously patrolling SSBN.

This also means that, unlike decisions involving air-breathing pilots, the PM would know that a decision to launch is a decision to detonate. Unless the launch time is a significant time after the firing message is received by the SSBN, there is no certainty of any message cancelling the strike being received before the then-irrevocable launch. The briefing officers would make certain the political advisers and the PM were aware of this fundamental nature of SSBN operations and invariably they would advise that if there is any decisional doubt, a firing message should be withheld until the last safe moment. The PM would be briefed that it is better to issue a last safe moment launch order than to issue one in advance and trust to a further message being transmitted and received if the circumstances or the PM’s mind were to change. The CRIMSON TIDE of Hollywood this would not be.

Exercise, Test, Analysis and Confidence

Essential to the credibility of a national nuclear deterrent are three central pillars: a PM who will make the decision to launch when considered necessary, a system which will deliver a warhead to the chosen target which detonates when ordered (and obviously doesn’t at **any** time unless ordered), and a NC3 capability which can connect the two with predictable precision and infallibility.

Clearly, the system is never exercised in its completion and against the most testing environment: after a nuclear attack from an adversary. Live missiles aren’t launched, and the PM doesn’t exercise the decision against live adversaries in peacetime. Therefore, two of the credibility pillars are constructed by the declaratory policies and public statements of the government (and the PM in particular) and by sub-system tests and regular and observable test missile firings. The fundamental enabling nature of the NC3 is so important, however, that the main elements of it are assessed and tested almost continuously. Fall-back elements of the architecture are exercised and tested sufficiently often to ensure proficiency and confidence in these.

As the main components of the NC3 also bear routine communications during each patrol, a significant amount of data is collated to assess its reliability and effectiveness in all the geographic areas of a patrol. In peacetime the Commanding Officer will be encouraged to patrol widely to maintain confidence that there are no patrol areas where the reliable receipt is diminished. In addition to this routine assessment of the various radio bearers and equipment which make up the NC3, each SSBN patrol will be exercised relatively frequently with firing drills initiated from the UK.

In these, which use entirely separate encryption and specific dummy information to ensure they can never be confused with a genuine PM firing message, the entire firing chain and NC3 architecture is tested under realistic conditions. Some of these require the SSBN to take the process all the way to simulated missile launch; some complete when the dummy firing message is received and authenticated. Finally, while the SSBNs are, as previously indicated, at several days' notice to fire, each patrolling submarine will be ordered for a portion of the patrol to assume very high readiness and to practice continuous reception of the communications broadcast. This both allows more detailed analysis of reception data and ensures crew proficiency in this most demanding of operational disciplines for an SSBN.

Every SSBN patrol is subject to detailed analysis by an independent (of the command and responsibility chain) organisation in the MoD. Records are kept from every patrol from the first in 1968 to the latest this year. The percentage availability of NC3 onboard the SSBN and at the transmitting stations is recorded and analysed.

Conclusion

The UK NC3 architecture which exists today is much leaner and focused than at the height of the Cold War where there was a greater variety in, and missions for, the UK's nuclear weapons. Designed and operated specifically to support the posture of SLBM Continuous At Sea Deterrence with one of four SSBN always at sea, it is capable of supporting that mission in peacetime, in crisis and in nuclear conflict with assurance and predictability. It delivers an availability and surety that would be the envy of every other government output, if privy to its detail. Over the 50 plus years that UK SSBNs have been patrolling the waters of the North Atlantic and contiguous oceans, it has never failed to deliver a test firing message to the SSBN when demanded and has provided very high levels of percentage availability of the various bearers which collectively, considering redundancy, delivers effective 100% availability to the PM. Whilst all who have and will design, maintain, protect and operate the multiple component systems of the UK NC3 hope fervently it will only ever be required to transmit dummy test firing messages, the surety which it delivers is one of the strongest pillars of the UK's strategic nuclear deterrent.

III. ENDNOTES

[1] Although the SAC bombers themselves first deployed in 1949, and the bomb assemblies from 1950, the weapons cores were not authorised for deployment to the UK until April 1954.

IV. NAUTILUS INVITES YOUR RESPONSE

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Nautilus Institute
2342 Shattuck Ave. #300, Berkeley, CA 94704 | Phone: (510) 423-0372 | Email: nautilus@nautilus.org