Trident Replacement – overcoming obstacles

Armies often hang on to military forces that belong to a previous generation, but are inappropriate for their day. The French army started World War One wearing bright red trousers which only made it easier for them to be targeted. In 1939 Polish cavalry were no match for German tanks. At the end of the Second World War the Royal Navy acquired a new battleship, HMS Vanguard, just as such these behemoths became obsolete. About its only claim to fame was that it was used for a Royal Tour of South Africa. Today there is a new HMS Vanguard that is just as much of a military dinosaur. One aspect of Vanguard class submarines that is particularly obsolete is the tradition of having nuclear forces on a high state of alert. Maintaining this Cold War approach today brings only risks.

In considering the future of British nuclear forces, it is not simply a question of being on alert or not. There are a range of postures which could be adopted.

- At one extreme is having a submarine at missile state SQ1 – immediately ready to fire its missiles. With Polaris SQ1 could only be maintained for a limited period of time, possibly 24 hours.
- When Polaris submarines were in there designated patrol areas they were at SQ2, 15 minutes notice to fire and constantly able to receive incoming communications.
- Today Trident submarines are on an alert status (measured in days). It is not clear what this means, but it has been suggested that the lowered state involved a procedural rather than a technical change. It is probably similar to the "modified alert" of some US Trident submarine. The Defence White Paper on the renewal of Trident in December 2006 makes it clear that the MoD retains the ability to increase the alert state, either openly, or covertly, to a status which can be maintained throughout a patrol. This means that they could be secretly increased to SQ2, 15 minutes notice to fire, at any time, and maintained at this state for 3 months.
- It would be possible to stop continuous patrols, they could be replaced by occasional patrols, with submarines going on patrol from time to time, but not constantly.
- Or the submarines could end all patrols, only sailing on training and exercises. In either case they could remain fully armed.
- At a lower state yet the missiles and warheads could be removed from stored on-shore.
- At a further lower state of readiness all the nuclear weapons removed from service – but a capability to remanufacture them retained.
- And finally it would be possible to eliminate the nuclear weapon production capability.

These options produce a range of states of alert – from 1 minute at SQ1, to 15 minutes at SQ2, several days in the current state, a few more if armed but not on patrol, several months if the weapons are stored on shore, several years if the warheads are scrapped but not Aldermaston, and several decades if the production facility is dismantled. So there are a wide range of options.

Under the nuclear Non Proliferation Treaty and the 13 steps agreed at the NPT review conference in 2000, Britain, with other Nuclear Weapon States, is committed to getting rid of all its nuclear weapons. In January 2009 the Foreign Office produced a new report "lifting the nuclear shadow". This says that Britain should play a leading role promoting nuclear disarmament. It also said that the decision to renew Trident didn't mean that Britain had made an irreversible decision to keep nuclear weapons indefinitely.

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To fulfill its commitments to disarmament then Britain will at some point have to make the more substantial moves to reduce its nuclear posture – removing warheads from submarines and then dismantling them.

Alert state of several months

The practical implications of ending CASD can be illustrated by looking in more detail at one alternative posture - reducing the alert state to 1- 3 months.

There are currently two forms of nuclear weapons allocated to NATO. One is the British Trident force. The second is Dual Capable Aircraft, which can either use conventional weapons or the B61 nuclear bomb, around 350 of which are deployed at 7 airbases across Europe. Some B61s are allocated to aircraft from 5 European airforces and the remainder to USAF Europe. All the bombs are kept under US control in peacetime.

What is interesting is the way in which the alert status of these Dual Capable Aircraft with B61s has been reduced since the end of the Cold War. In 1981 5% of the aircraft were on minutes notice and the remainder on days or weeks notice. In 1995 half of the force was on weeks notice and the other half on months notice. In 2002 the whole force was reduced to months notice.

There has been considerable attention both within the US military and in Europe to these weapons. There are concerns, particularly from the US European Command, that in today's world these weapons are only a target for terrorists and are of no military value. In response the Pentagon argues that the weapons have an important political role.

Applying an alert status of several months to Trident would mean more than just ending CASD, it would also give time for "de-mating" - separating the nuclear warheads from the delivery system, the missiles. All the warheads could be taken off the submarines and stored on shore.

When Trident was being developed a massive new complex was built at the nuclear weapon store at Coulport above Loch Long. [RBM googleearth] Part of this is a facility called the Reentry Body Magazine (RBM). RBM contains four symmetrical buildings. Because of the planned submarine rotation where occasionally there are only two armed submarines, RBM has to be able to accommodate all the warheads from one submarine. When RBM was designed it was planned to arm each Trident submarines with around 96 warheads each. So the capacity of RBM is likely to be over 100 warheads, probably significantly more than 100.

The Government has said that the UK currently has up to 160 nuclear warheads which are operationally available. Normally, with three armed submarines, there will be 144 warheads deployed on submarines and 15 – 20 at Coulport. However if all the warheads were removed from submarines most, if not all, could be stored inside RBM. Depending on the exact capacity of the magazine it might be necessary to either expand RBM or, more likely dismantle a small proportion of warheads.

A major advantage of removing all warheads and storing them onshore would be that the UK would not present an immediate nuclear threat to any other country. The separation of warheads from submarines could also be easily verified.

There would be a safety argument for removing not only the nuclear warheads but also the missiles. Within Coulport there are 16 missile bunkers. [pic] The current number of missiles deployed on

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Trident submarines is not known. The Defence Minister recently acknowledged that Trident submarines are normally armed with less than their potential complement of 16 missiles. In 1994 HMS Vanguard was loaded with 16 missiles at the US base at Kings Bay in Georgia. However a year later HMS Victorious, the second Trident submarine, only picked up 12 missiles from Kings Bay, and the third HMS Vigilant collected 14. So in 1997 Britain only had sufficient missiles to have 14 on each submarine. It would not be possible to store all these missiles at Coulport. But it would be possible to store 16 – and that would be enough to arm 2 submarines with 8 missiles each. These 8 missiles could easily carry the current total of up to 48 nuclear warheads per submarine. If Trident was put back on alert then additional missiles could be uplifted from Kings Bay before a third submarine was operational.

Today HMS Vengeance is on patrol, HMS Vanguard is under repair following its collision with Le Triomphant and preparing to go back on patrol. Both these two submarines are armed with missiles and nuclear warheads. HMS Vigilant went into refit at Devonport in October 2008 and will be out of action for at least 3 years. It replaced HMS Victorious which finished its refit in July 2008. HMS Victorious is not yet operational and is only expected to be fully armed later in 2009.

With a lower alert state measured in months substantial changes could be made to the availability of submarines. If continuous patrols were ended then the demand on the vessels would be dramatically reduced. It should be possible to mothball one of the four submarines, probably the one under refit. There would be a need to maintain at least one submarine as a training vessel, with quite heavy use. The remaining two submarines could be used more lightly, allowing significant time for maintenance.

In order to understand how such a system might work it is necessary to consider what might happen in the unlikely event that it was decided to put submarines on alert. This could take a number of forms – either putting one submarine to sea, possibly with a limited number of missiles and nuclear warheads, in response to a particular scenario, or alternatively restoring continuous patrols.

Loading missiles and warheads takes place in the Explosives Handling Jetty at Coulport. It is a slow process. It would take several days to load 8 missiles then over a week to load 48 warheads. The whole task, at normal rates, could take 2 weeks. Although in an emergency the operation could be carried out a lot more quickly.

Currently a Trident submarine can have a preparation period of around 10 weeks between patrols. The first part of this normally concentrates on maintenance work on the submarine. Before it departs the vessel carries out an INDEX exercise when the crew are put through their paces during several days at sea. A submarine will sometimes visit the Explosives Handling Jetty to exchange a small number of nuclear warheads either just after coming off patrol, or just before the start of their next patrol.

If, as proposed, one submarine was kept in a fully functioning state as a training vessel, this could be armed, crewed and put to sea in several weeks for a limited nuclear deployment.

Restoring continuous patrols would mean having a second submarine fully operational within a further 3 months. Patrols could be maintained for a short period with one crew on each of two operational submarines, but sustaining this posture would mean restoring the double-crewing arrangement in due course.

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Safety

In 1990 Dr Sidney Drell produced a report for Congress on the safety of US nuclear weapons. This pointed out that the Trident system was potentially dangerous because the nuclear warheads are arranged in a circle around the third stage of the missile. Three years later a further report was written by John Harvey, now head of policy in the US ~~nuclear weapons establishment~~, NNSA, and Stephan Michalowski, now senior scientist at OECD. They pointed out that fragments from the detonation of the third state of a Trident missile could potentially cause a nuclear explosion. ~~15 years later~~ in 2008 Michalowski said: "the explosion of a boatload of missiles in a port would be an unimaginable catastrophe. It is a very, very scary thought".

Separating the missiles and warheads in peacetime would effectively remove the possibility of this kind of accident. The missile bunkers at Coulport are designed to contain the detonation of a missile and the warheads store is located at a safe distance from the missile bunkers.

Re-arming the submarine with missiles and warheads would reintroduce this hazard – and loading them in a hurry would be particularly dangerous. But if it was argued that it was necessary to have Trident at sea then the cost-benefit analysis in such a crisis would presumably be different.

Personnel

A recent parliamentary reply shows that as at 1 March there were just under 1,000 personnel assigned to Trident submarines, 114 officers and 883 ratings. This is equivalent to 142 in each of 7 crews, with 2 crews on 3 submarines and 1 on HMS Vigilant in Devonport. This figure is slightly higher than the nominal crew figure of 135.

With a low state of alert it would be possible to reduce the numbers assigned to Trident – possibly to three crews. However there would be a need to increase this if continuous patrols were restarted.

A key issue would be training. Not all training is done on submarines. The Trident Training Facility has a suite of simulators, including the ability to train in how to launch the missiles. In the US Trident fleet there are a wide range of computer simulators which are used not only on shore but also for training when at sea. Many routines and emergency drills can be practiced with the submarine moored at Faslane. So long as at least one Trident submarine was available for ~~training~~ exercises it would also be possible to conduct training at sea.

One problem would be how to generate a sufficient number of trained crew to recreate the numbers of crews which would be needed to restore continuous patrols over a long period. A solution is to look at the submarine fleet as a whole, including hunter-killer submarines, SSN – nuclear-powered but armed with conventional weapons.

If we consider the submarine fleet as a whole then the skills fall into three categories:

- Skills unique to Trident
- Skills unique to SSN
- Skills that are common to ~~Trident and SSN~~ both

Within the third category, in some cases the skills are identical, in others there are significant differences. It is normal for submariners to move between Trident and SSN during their careers. So long as there is a significant SSN fleet there will be a pool of trained submariners with many of the skills required for Trident. One area where the skills for Trident are unique is the missile system,

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however much of the missile training is done on simulators. The occasional test firing of missiles off Cape Canaveral need not be affected by taking Trident off patrol.

If CASD were restored from a low alert state then this would impose two pressures on the SSN fleet:

- There would be demands to shift key personnel, particularly senior staff, from the SSN fleet to Trident in order to reintroduce double crewing.
- Secondly the SSN themselves would be needed to provide protection to Trident.

This is a problem, but is not insurmountable. Currently the SSN fleet carries out several tasks – Strategic Intelligence, Support to the Strategic Deterrent, Integrity of UK, Op Telic and Op Calash (Gulf) and Falkland Islands Contingency.[1] If Trident was taken off patrol and put on a low state of alert, then SSN would be freer to carry out other functions. However if it was felt that the top priority was to restore ~~Trident~~ patrols, then some of the other tasks which are currently undertaken by SSN would have to be sacrificed. This illustrates the real nature of the question of whether to retain CASD – it is not an issue that can be considered in isolation from all other military tasks – there is a need to decide on priorities and to assign resources accordingly. It is hard to understand why Trident is given the priority that it is today.

The Navy argue that continuous patrols create an ethos and high morale. This is only partly true. Serving on Trident patrols brings particular problems for the personnel involved, especially for families. When on patrol submariners cannot send any messages to their families. Wives and families can ~~said~~ short messages to the submariners at sea – but these messages are censored. News which is likely to cause a problem, for example a close bereavement, is deliberately withheld until the submarine returns to port. Many service personnel in the Army, Air Force and Navy are forced to serve for months on end away from home. But for most there are good links with their families. When not on duty they are able to communicate with partners and children by phone or internet. This is not the case with Trident submarines on patrol. Moving to having Trident on a low state of alert would change the lives of those working in the submarine fleet and in many ways it would be a change for the better.

Keeping one submarine at sea at all times creates a high target for the personnel involved – achieving that target can bring a sense of achievement, but it ~~can~~ also bring costs. It distorts the prioritisation of work within the Navy and particularly within Faslane. Where society recognises that this is the first priority then the extra effort may be considered worthwhile. But in Britain in 2009 most people do not think that the first priority for the armed services is to keep a Trident submarine at sea.

Hull/reactor life

There are a two main factors that affect how long a submarine can remain in service – the reactor and hull.

- Reactor life is probably the main critical element. In their final years the Resolution class Polaris submarines were dogged with a series of problems. A fault was found on HMS Warspite in 1989 and the Navy soon realised that this was a generic defect that affected the whole fleet. In 2000 a second major defect was discovered when there was a radiation leak from the reactor on HMS Tireless in the Mediterranean.

[1] Written Answer by Bob Ainsworth 17 November 2008, Hansard

- Hull life was also a problem in the closing years of the Polaris submarines. It is largely related to the time the submarine spends at significant depth. Restrictions can be set on diving depth as a result of concerns about the state of the hull.

If Trident submarines were kept on a low state of alert then it should be possible to substantially extend the reactor and hull life. This would in turn mean that the Trident Replacement decision could be postponed.

Protecting forces

A range of military units from the army, navy and air force have been allocated to protecting Polaris and Trident. In 1978 the Chiefs of Staff produced a report on the UK's ability to withstand a conventional attack from the Soviet Union. This identified a number of major shortcomings in the countries defences. One of these was a shortage of minesweepers. The report said:

> "The Royal Navy's mine countermeasures vessels would have as their first priority keeping open the approaches to the nuclear submarine base at Faslane; after this, insufficient resources would remain to deal adequately with the tasks of clearing cross channel routes and providing safe access to our major ports".[2]

Prime Minister Jim Callaghan noted:

> "after securing the approaches to the nuclear submarine base at Faslane, we had insufficient resources to clear the cross-Channel routes and to provide safe access to our major ports"[3]

The table below shows the forces allocated to protecting Trident in 1998 and the smaller number assigned to this role in 2007.

	1998		**2007**	
	Committed	**Contingent**	**Committed**	**Contingent**
Attack Submarines	2	1	0	2
Destroyers & Frigates	1	2	0	1
Minewarfare vessels	1	3	1	3
RM Commando	0.5			
Royal Fleet Auxiliary Vessels	1		0	1
Infantry battalions		5		
Air Defence Aircraft		2		
Maritime & Reconnaissance Aircraft	4	8	0	8
Merlin ASW Helicopters (c)			0	5

[2] TNA PREM 16-1563 Response to the Soviet Threat to Targets in the UK, Chiefs of Staff 16 January 1978
[3] TNA PREM 16-1563 20 February 1978 Defence against the Soviet threat to the United Kingdom

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Survey vessels (c)			1	0

With regard to the "contingent" commitment of one frigate or destroyer today this allocation has been further clarified: "~~One nominated~~, at extremely high readiness and activated when required"[4] A recent example of the conflict between allocating forces to protecting Trident and other tasks is the deployment of minehunters based at Faslane. Two of Sandown class were deployed to the Gulf and returned to Faslane in early March.

Conceptual issues

To assess the value of CASD it is necessary to look behind the practical details to some of the fundamental questions of British nuclear weapons today.

Trident and Russia

The Duff-Mason report, which underpinned the decision to purchase Trident, considered whether the proposed nuclear weapon system had to be capable of dealing with a threat from any part of the world - and concluded that it did not. The decision to acquire Trident was based on an analysis which saw the only potential threat as being the Soviet Union. The specifications for the force and the nature of its deployment, including CASD, were drawn up with a view to tackling a threat from the Soviet Union. The invulnerability that was built into the Trident system was invulnerability from Russian forces. If you look at the strike capabilities of other potential opponents, then the degree of invulnerability is excessive.

In the late 1970s NATO was considering deploying new Long Range Theatre Nuclear Forces. The Ministry of Defence were contemplating hosting US forces, which is due course they did with the controversial deployment of Ground-Launched Cruise Missiles. Papers in the National Archive show that the initial proposals went beyond hosting American units. In 1978 the Chief of Defence Staff was discussing a plan to develop British Long Range Theatre Nuclear Forces, with the main candidate being Ground-Launched Cruise Missiles under British control with British nuclear warheads. This plan was dropped, but the papers describing it reveal some of the limitations of Polaris and Trident. The reports argued that any attack by Polaris would be seen as a strategic strike and would result in a massive response from the Soviet Union. The use of a limited number of Polaris missiles against carefully selected "theatre" targets would be misinterpreted in Moscow as an all-out nuclear attack. The CDS argued that there would be circumstances where a nuclear bomb dropped from a Tornado would be too small and a Polaris strike to big.

In the early 1990s Britain abandoned its plans to build TASM. Subsequently the country lost its air-launched tactical nuclear capability. This resulted not from any review of the requirement for such a capability, but from the lack of any practical affordable options. With no other options the MoD decided to allocate a second role to Trident and to develop the capability of deploying a small number of Trident missiles armed with single lower-yield warheads. At the time this was called "Sub-Strategic" Trident. However the feasibility of Sub-Strategic Trident has always been fundamentally flawed. As the discussions of British Cruise missiles in 1978 showed, any use of Trident against Russia was likely to be interpreted as a massive strike.

[4] Written Answer by Bob Ainsworth 17 November 2008 Hansard

Recent disclosures of the potential targeting of Polaris in the 1970s showed that Britain considered targeting Soviet Early Warning Radars and the ABM Battle Management Radar system. The flight time from British Trident patrol areas to the radar sites could be less than15 minutes. A single Trident missile launched from the patrol area is likely to be interpreted as a strike against the radar system and Russian Strategic Forces might well initiate a response before the trajectories had been properly analysed.

Using Trident, either Sub-Strategic, or the full force, against any country other than Russia is also fraught with difficulties. Any Trident launch could be interpreted against an attack against Russia, so what does London do ? Do they inform Moscow – "by the way in 12 hours time we are going to fire a Trident missile at Iran" ? This could well result in the Russian nuclear forces being put on a very high state of alert, either as a precaution or to restrain Britain from acting. Alternatively do they keep quiet, cross their fingers, and hope that Moscow won't misinterpret their attack.

It is perhaps conceivable that Trident could be used against a country other than Russia – but there would always be a "Russian" factor to any potential Trident strike.

The Independence of Trident

The United States and Russia each maintain a range of nuclear forces on different states of alert. One factor influencing whether or not it is necessary to retain CASD is whether British nuclear forces are seen as an independent capability – or if they are regarded as part of NATOs nuclear forces. If they are integrated into a wider US arsenal then why do they need to be on a higher alert state than NATO's Dual Capable Aircraft ?

The Duff-Mason report identified two reasons why it was important for Britain to have an independent force. The first is if US commitment to NATO were to erode over time. While this is a conceivable scenario, it is hard to imaging how the UK Trident force would remain effective if the US were to withdraw their backing. Polaris and Trident have both been heavily dependent on ongoing US support. If this were withdrawn then the capabilities of the system would progressively decline over months. It is questionable whether the UK could maintain an effective force for more than 6-12 months after the US withdrew its backing. Far from achieving greater independence the trend in recent years has been for increased co-operation, with warhead collaboration growing closer and renewed exchanges on submarine reactor design.

The second scenario in the Duff Mason report is where the US hesitates about using nuclear weapons in a crisis. The report recognised the weakness of assuming that Britain would be willing to act when the US had decided not to. If the United States, with its immense nuclear arsenal was not willing to push a conflict to the next level, how could it be credible for Britain, with its far smaller nuclear force, to threaten to do so ?

> "It cannot be assumed that (given our much greater vulnerability that the United States to nuclear attack) that a British Government would be readier than the United States President to engage in nuclear escalation that might provoke Soviet retaliation against our territory, even in circumstances in which British forces (like United States forces) might be facing defeat in combat"[5]

[5] Duff-Mason Part I para 23

The report argued that what was important was that the Soviet Union would not be able to rule out this possibility.

There are three basic scenarios when British nuclear weapons might be used:

- When the US supported it
- When the US was opposed it
- When the US was ambivalent about it

In the first case the British Trident force would be able to carry out its attack plan. The second scenario is the crucial one. The US-British nuclear arrangement is unique. Successive British Governments have repeated that the command and control system that is used to communicate the order to launch Trident systems in entirely in British hands. But that does not mean the missiles could be launched if the US was opposed to their use.

The US is so closely involved in the British Trident programme that they could probably take effective action to disrupt any plan to launch an independent strike – either by cyber warfare, jamming communications, or ultimately finding and destroying the submarine. The complex software in the Trident Fire Control system is almost all written in the US – and this provides a potential ability to restrict Britain's use of the system.

If the US was ambivalent about a British nuclear strike – then yes it probably could go ahead. But how likely is it that the US would not have a clear view of whether or not it was in their interest for Britain to engage in a nuclear war ?

Rationality of a British nuclear response against Russia

The Duff Mason report pointed out that, faced with the situation where the Soviet Union had launched a nuclear attack on Britain, there would be no logical reason for British nuclear weapons to be used in response -

> "In these circumstances the actual use of our strategic nuclear force in retaliation against the Soviet Union would represent an act of rage and revenge ... there can be no certainty that a Government would take a deliberate decision to launch this act involving the killing of large numbers of enemy civilians but serving no rational purpose".[6]

The credibility of the deterrent rested on the possibility that decision makers in Britain would cast reason and ethics aside –

> "Ultimate deterrence is perceived to work, because no nuclear weapons state (NWS) can feel confident enough to act on a judgement that an adversary, seeing the painful destruction of all that he most valued, would withhold retaliation on account of some cool calculation based on ethics and utility".[7]

Further evidence of the irrationality at the heart of British deterrence policy was provided in a series of interviews conducted by Peter Hennessey for the BBC. Denis Healey said that if the crunch came he would not have ordered the use of Polaris. Hennessey asked David Young, a former nuclear

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[6] Duff-Mason part I para 11
[7] Duff-Mason part I para 12

planner, what advice he would have given to Ministers if Russian missiles were heading towards Britain. Mr Young replied -

> "We've failed. It is absolutely pointless to retaliate. Keep your nuclear arsenal. Hope that it might be a bargaining chip with somebody. If need be put them under command of the Australians ... it's tragic, but it's pointless to retaliate".[8]

What the Duff Mason report and these statements show is that British nuclear deterrence rested on the remote possibility that the British Prime Minister and Chief of Defence Staff would act irrationally and unethically and launch a nuclear attack which would be in Lord Carver's words either suicide or a voice from the grave.

Cost Benefit of CASD

The issue of the vulnerability of Trident submarines should not be considered in isolation. It should be thought of within the context of a range of costs and benefits and of priorities.

Costs of CASD:

- Financial – higher running costs; need for a replacement sooner - with low state of alert Trident replacement could be postponed. High cost then has impact on other defence projects and wider public expenditure.
- A threat to others – Invulnerability is only one side of the coin – on the other is the constant potential to launch a devastating nuclear strike at short notice.
- Allocation of resources – requirement for dual crews, maintenance support and protection forces.

The potential value of CASD is very limited:

- Only for independent use of Trident
- Only really for use against Russia.
- An independent British nuclear attack on Russia would not be rational or ethical.

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[8] The Human Button BBC Radio 4 2 December 2008

Comparative state of alert of nuclear submarines – Fr, UK, US, Rus, Chi

A key justification for CASD is that without it British nuclear forces would be vulnerable. But the question has to be asked – vulnerable to an attack from whom and in what scenario? Which countries today have the capability of launching an effective attack on a Trident submarine at Faslane ? Only the US, France and Russia. China might have in future, but doesn't today. Assuming we can rule out the US and France then the concern about vulnerability only applies to Russia.

Iran does not today have either nuclear weapons or missiles with the 4,000 km range that would be needed to reach Britain.

Linked to the issue of vulnerab

Shift burden + default pts → to balance of [illegible]

Obstacles to early CASD →

Vulnerability → need E e-alert

→ Length [illegible]

→ [illegible] F.O.O.[illegible]

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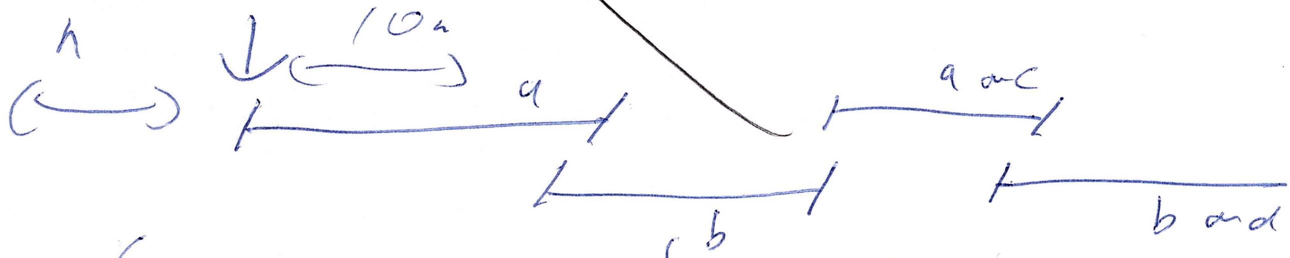

Crews

1 crew – n ~~[illegible]~~ 3 mths

2d crew – n + ~~10 mths~~ 2[illegible] 6–10 mths

3rd crew – n + ~~20 mth~~ 9–13 mths

4th crew – n + ~~[illegible]~~

5th crew – n+12 mths

6th crew – n+14 mths

Subs

1 – n

2 – n + ~~10 mths~~ 12 → 3 mths

3 – n + ~~[illegible]~~ 12 mths

60 days in [illegible]

→ ste 1 pln

If 3 crews

~~[illegible] 9 – 14 mths~~

Immune – 4 crews – 9+12 mths

5 " 12

6 " 15

Time on patrol	Op Subs	Op Crews
3 mths	1	1
10 mths	2	2
12	2	3

18 3 5

18 3 6