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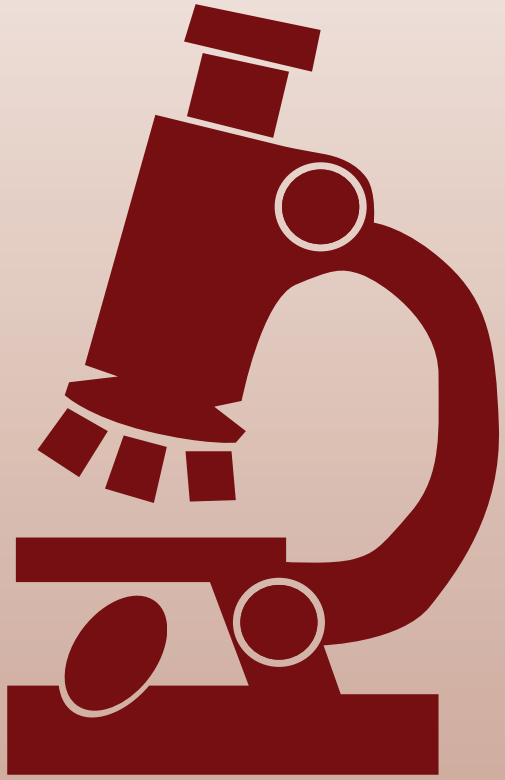




UK nuclear weapons:

a catastrophe in the making?

Philip Webber and Stuart Parkinson



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Philip Webber and Stuart Parkinson, Scientists for Global Responsibility

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Executive Summary

The UK government is due to make a decision in 2016 on whether to approve a like-for-like replacement of its submarine-based Trident nuclear weapons system. Both the main political parties currently support replacement, although they disagree about some relatively minor technical aspects. Hence there has been little public debate on whether replacement is a good idea – beyond the vague questions of whether we can afford it during times of austerity or whether we might need it as insurance in 'an uncertain world'.

The purpose of this briefing is to challenge this narrow debate – by highlighting the latest scientific and technical information about the risks posed by the continued deployment of Britain's weapons of mass destruction.

In particular, we focus on the following.

- If used, the nuclear weapons carried by just one Trident submarine could cause such huge climatic disruption that global food supplies would be at risk and the survival of human civilisation itself would be threatened.
- If used, the nuclear weapons carried by just one Trident submarine could directly cause more than 10 million civilian casualties.
- Intentional use of the UK's nuclear weapons would therefore be both genocidal and suicidal.
- The probability of unintentional use of the UK's nuclear weapons – whether through accident or miscalculation during a crisis – is not negligible. There have been numerous known cases across the world of 'near nuclear use' over the past 60 years, despite much nuclear history being clouded in secrecy. It is therefore only a matter of time before our luck runs out. The UK's round-the-clock nuclear patrols – and the desire to continue these indefinitely – add significantly to this risk.
- The UK is one of a very small number of states actively deploying nuclear weapons, creating a completely unacceptable risk of catastrophe for human society. Processes set up under international treaties to further nuclear disarmament are stalling. Whilst there is widespread agreement that other weapons of mass destruction such as chemical weapons are completely unacceptable and are therefore banned by international treaties, the nuclear armed states continue to argue to case *for* the nuclear weapons that *they* possess but oppose any other state acquiring them. This situation has been likened to apartheid – one rule for the nuclear armed states – another rule for everyone else. A large number of non-nuclear armed states have now pledged to make nuclear weapons illegal and plan to commence a new treaty process to bring this about.

The report argues that to reduce the nuclear risk, the UK should take Trident off continuous patrol at sea and place our nuclear warheads in storage. Trident replacement should be cancelled enabling active support of current international discussions to ban nuclear weapons in a similar process to other weapons of mass destruction such as chemical and biological weapons.

The evidence in support of these points is set out in the following sections.

1. The extremely destructive effects of nuclear weapons

News bulletins from a series of recent conflicts - for example in Iraq and Syria - regularly portray scenes of devastated urban areas - the result of conventional air strikes, artillery and mortar fire. But terrible as these scenes are, they are the consequence of months and years of conflict. But one or a very small number of nuclear weapons could create even worse destruction in a matter of a few seconds with huge loss of life. There would be no time for anyone to escape.

On top of their immediate destructive power, nuclear weapons cause a whole range of additional impacts. Table 1 lists the impacts in the order they happen, with some idea of scale given for a single Trident nuclear warhead with the standard explosive power equivalent to 100,000 tonnes (100 kilotonnes = 100kT) of TNT.

With the exception of the electro-magnetic pulse, all these effects[1] [2] cause fatalities and horrific injuries including radiation sickness. Radiation sickness can cause death over a period of up to two weeks after detonation.

The Hiroshima bomb, which was dropped without warning over a very densely populated Japanese city centre in 1945, killed about 140,000 people[3] - both immediately and within the following few months. The casualties resulting have been very carefully analysed over many years and, along with information from numerous nuclear tests, have enabled mathematical models to be developed to estimate deaths and injuries at various distances from the explosion and fireball for a range of different sized nuclear weapons. This is carried out for a set of concentric blast and fire zones centred around the point of detonation and complex fallout contours downwind. For each zone of blast, fire and radiation, the numbers of people resident are worked out using census figures, and the numbers killed and injured can thus be calculated.

Table 1 **General impacts of a 100kT nuclear weapon**

Time period	Effect	Distance
Immediately	Intense electro-magnetic pulse (EMP) wrecks electronic systems	hundreds of miles
	Fierce burst of nuclear radiation	within 1.5km
	Blinding light flash	tens of km
	Intense fireball – severe burns, widespread fires or firestorms	3 – 4 km
In a few seconds	Supersonic blast wave destroys buildings and kills people	4 – 5 km
In a few hours	Long lasting radioactive fallout – years to decay	tens of km downwind
Over hours to days	Strike on nuclear reactor – very long lasting fallout – decades to decay	hundreds of km
Over weeks to years	Various kinds of cancer and genetic mutations	hundreds of km
Over years	In case of a weapon exploding at or near ground level – dangerous levels of background radiation	within 1.5km

Table 2. Casualty estimates for a 100kT nuclear weapon exploded in central Manchester[4]

Zone	Distance (km)	Deaths	Injuries	Uninjured (by blast)	
Complete destruction	Up to 1.8	39,000	0		
Severe destruction	1.8 – 3	34,000	27,000	7,000	Severe fires
Heavy damage	3 – 5	9,000	85,000	94,000	Third degree burns
Damage	5 – 8	0	100,000	300,000	Second degree burns
Totals		**82,000**	**212,000**	**401,000**	

A recent study[4] examined the impacts of a single 100kT warhead detonated over Manchester in the UK. Its findings are summarised in Table 2. Greater Manchester has a population of 2.68 million people and is typical in area and population density of a medium sized western conurbation.

In the Manchester case, 695,000 people live within these impact zones, whilst most of the population is on the periphery. 82,000 would be killed immediately or as a result of serious or multiple injuries. 212,000 would be injured and require a range of medical attention.

Burns injuries could increase the numbers killed significantly – depending on the numbers of people in the open or near windows. This could add a further 10,000 deaths to those already injured and a further 10,000 serious burns injuries to those uninjured by blast. Extensive fires would be started which would cause further casualties, and during a normal working day, population numbers would be higher due to workers commuting into the city. In the case of a warhead detonated at ground level, it is estimated that 40,000 people could die from radiation exposure over a period of two weeks or more (but blast deaths would reduce by roughly the same amount). Around 695,000 people would be in housing with complete or severe destruction. 40% of hospital capacity would have been lost and electricity, water, gas and electronic communications would be severely disrupted.

Despite the fact that this 100kT warhead is eight times more powerful than the one that devastated Hiroshima, the overall estimated casualties are much lower, simply because there are far fewer people resident in the areas of destruction. Hiroshima and Nagasaki had very much higher population densities at the end of World War II in smaller areas which were almost completely encompassed by the areas of destruction.

Thus, a conservative estimate is that one Trident-sized warhead, would kill at least 80,000 people if detonated over a modern city and would injure at least 200,000 more.[5] According to the Red Cross and other medical professionals, even the use of one nuclear warhead would overwhelm any rescue and health services.[6]

Each UK Trident submarine carries 40 nuclear warheads on eight missiles (making four million tonnes of explosive power in total or equivalent to 320 times that of the Hiroshima bomb). This is an enormous destructive power. The firepower of one Trident submarine is greater than the entire estimated explosive power of bombs dropped in World War II including the two atomic bombs exploded over Hiroshima and Nagasaki in Japan.[7]

The Trident missiles and warheads were designed at the height of the Cold War to evade possible anti-missile defences surrounding Moscow, and to kill at least 40% of the inhabitants of Moscow (ie at least 4 million civilians) as well as devastating several other large Russian cities. War planners called this ‘The Moscow Criterion’.[8]

Our estimates, which are supported by other studies, predict that one Trident submarine with forty 100kT warheads could cause at least 10 million casualties and as many as 20 million in 10-20 large cities and hit a further 20 military targets such as bases and command bunkers.[9] Trident missiles have a range of 7,000 miles. This, combined with the submarine's ability to sail into any ocean area, enables it to strike targets anywhere across the globe within around 30 minutes of launch.[10]

This is far more than any 'minimum' level, as is often claimed by UK ministers.

2. Could Trident cause a nuclear winter?

What is rarely discussed, or even widely known among the general public, is how vulnerable our global climate system and the wider environment would be to the use of even what are considered small nuclear arsenals, or how vulnerable human society across the globe is to such effects.

International studies by US and Russian scientists, using the latest climate models, have modelled the effects of a range of scenarios, from small 'regional' nuclear conflicts to all out nuclear war between the USA and Russia.[11] A climatic impact – commonly known as a 'nuclear winter' – arises because of the intense fireballs that nuclear weapons create. Unlike a fire from conventional weapons, even intense fire-bombing such as in Dresden in World War II, the nuclear fireball would carry huge volumes of small sooty particles far into the stratosphere, high above normal weather patterns. These high altitude particles would reflect much of the incoming solar radiation causing shorter growing seasons, major changes in rainfall and global disruption of weather patterns. It would take years for these particles to disperse. Such effects have been observed on a smaller scale following huge volcanic eruptions, and have been used to help calibrate current climate models. Other impacts such as long term damage to the ozone layer are predicted.

The studies predict that as few as 100 Hiroshima sized weapons – about one third of the nuclear firepower of one Trident submarine[12] and less than 0.1% of world-wide nuclear stockpiles – detonating over highly flammable cities, would likely cause severe weather disruption across the globe for 7-10 years[13] leading to severe food shortages. Critical food growing areas would be badly hit and monsoon rainfall disrupted, leading to dramatic shortages of wheat and rice – key staple foods. As current global food stocks would last less than 100 days,[14] very severe consequences would follow. Recent estimates put the number threatened with starvation well outside the target zones at about 2 billion of the most vulnerable people[15] – for example, those living in Africa and other poverty-stricken parts of the world.

The conclusion from this information is that Trident would cause very severe longer term and catastrophic harm to the entire northern hemisphere – including the UK – as well as to its targets.

The extremely severe environmental and societal implications of the use of nuclear weapons have been recently picked-up by some security analysts. They suggest that the implication is that nuclear deterrence (assuming that it works at all) cannot work beyond the deployment of about 50 Hiroshima-sized weapons world-wide (that is less than 0.1% of the current global nuclear arsenal) – *shared across all the nuclear armed states!* They have coined the term 'Winter-safe deterrence' to describe this means of avoiding a global nuclear Doomsday.[16]

At present the nuclear firepower of *each one* of the 9 states possessing nuclear weapons, ironically with the exception of North Korea, already exceed this firepower.

Table 3. Estimated numbers of nuclear warheads by country [17] [18] [19]

Country	Warheads deployed	Warheads in reserve
Russia	1,780 [a]	2,720 [b]
United States	2,080 [a]	2,620 [b]
France	290	10
China	0	250
United Kingdom	150	65
Israel	0	80
Pakistan	0	100-120
India	0	90-110
North Korea	0	<10
Total:	**4,300**	**6,000**

(a) About 900 each of the weapons in Russia and the USA are ready to fire at very short notice at actual or mistaken warning of attack. The US figure includes 180 drop bombs deployed in Europe in Belgium, Germany, Italy, Netherlands and Turkey.

(b) In addition, there are also about 5,400 warheads held in stockpiles by the USA and Russia awaiting dismantlement.

At least 100 Hiroshima-sized nuclear weapons are available in the India-Pakistan nuclear confrontation, so a nuclear conflict in this region would not only be completely disastrous there and cause huge casualties in the tens of millions in the large urban populations that are targeted but would also have disastrous climatic and food supply consequences for the whole world.

The detonation of the 1,800 ready-to-fire ('launch-on-warning') nuclear weapons of Russia and the US would plunge the world into an extreme nuclear winter, very severe weather disruption and mass starvation across the entire northern hemisphere. Once you combine these stark impacts with the deliberate targeting of cities, devastation of all public services (e.g. power, water, and health), severe radiation,[20] the complete collapse of global trade and any semblance of an economy, the survival of human civilisation itself would be in doubt as we would be thrown back into a pre-industrial age in a poisoned and hostile environment.

This information has now been discussed at the highest level at the UN General Assembly and Nuclear non-proliferation treaty (NPT) review conferences. The information now needs to be disseminated to politicians at all levels particularly in the nuclear weapons states, so that key decisions about these weapons can take account of this information. Unfortunately, presumably because the evidence would undermine the policies of the two main political parties, the UK Ministry of Defence (MoD) has refused to acknowledge any research in this area and confirmed this approach in Parliament as recently as January 2015.[21]

3. Accidental nuclear war and other risks

The threat from nuclear weapons does not just arise from their intentional use – but also from numerous potential accident scenarios. Considering the UK Trident system, the worst case scenario is the risk of accidental missile launch at sea arising, for example, from the possibility of a mistaken or hacked communication with a submarine, miscalculation by military command in a time of tension or a severe system failure during a readiness to fire exercise. There are also other risks at a smaller scale – and we give a summary of the full range of risks in this section.

Highly radioactive warhead material and explosives (part of the warhead mechanism surrounding the radioactive core) have to be regularly moved across the UK by road between the Atomic Weapons Establishment (AWE) in Berkshire and the Faslane submarine base and nearby warhead bunkers not far from Glasgow. This carries a risk of explosion, fire or release of radioactive materials in urban areas. Other movements of nuclear materials are required to refuel the submarines' nuclear reactors. Retired submarines and their highly radioactive reactor cores currently have no safe permanent storage and lie docked at Devonport base in Plymouth posing a hazard. The AWE and the Sellafield nuclear reprocessing plants have been subject to numerous radioactive releases, fires, floods and other safety breaches.[22]

Several serious incidents have occurred relating to the UK Trident missile system and submarines. Recent disclosures by a seaman who served on a Trident submarine has again brought issues into the public domain.[23] According to the MoD's own nuclear regulator, submarine nuclear reactors are inherently less safe than their land based counterparts. The US made Trident missiles are also regularly moved across the Atlantic to the US for maintenance and replacement. A Trident submarine has been involved in at least one underwater collision with another nuclear armed submarine.

However, the UK's Trident submarine and missile system does not exist in isolation. The UK is one of only four nuclear powers – the others being the USA, Russia, and France – that deploy nuclear weapons in a 'ready-to-fire' state (see Table 3). These nuclear deployments hark back to and continue the nuclear confrontation of the Cold War. With the evidence that only a small fraction of these weapons could wipe out humanity, it is now clear that such huge weapons deployments pose an enormous risk to all life on the planet.

This is not a theoretical risk. Historical evidence, including that recently revealed in previously classified files, shows that the world has come very close to nuclear destruction on many occasions.[24] Nuclear disaster was in some cases only averted by brave individuals who did not follow set procedures. For example, one recent report documented an average of about one 'near miss' every three years during the 40 years up to 2002.[25] Serious incidents have arisen due to faulty computer chips, mistaken satellite data, confusion over civilian rockets launches and misinterpretation of military exercises. And these are only the incidents that we know about. There will doubtless be others still shrouded in secrecy.

Warheads kept on a 'launch ready' basis create the most significant risks.[26] These weapons are kept ready to launch so that they could be fired before a nuclear first strike hit them. Most of these – 1,800 – are US and Russian land-based warheads on 800 missiles. But UK Trident and French nuclear weapons are also ready to fire at quite short notice. Because of the speed of ballistic missiles – many times the speed of sound – any warning time is measured in tens of minutes, leaving very little time to make a considered decision and to avoid a mistake. Even worse, recently the last working Russian early warning satellite failed, leaving Russia with sharply reduced early warning times down to 10 minutes or less.[27]

Several former commanders of US nuclear forces have argued that weapons should be taken off ready-to-fire status to remove the possibility of catastrophic accidental nuclear war[28] - this is a particular risk during times of heightened international tensions, such as that seen recently over war in the Ukraine.

But any submarine-based missile system with a high targeting accuracy, such as Trident, has the ability to be used in a surprise nuclear attack close to the shore of an 'enemy' creating a very short warning period. This is itself destabilising. Notably, partly because of the risks involved in deploying nuclear weapons, none of the other five nuclear states, including China, keep nuclear weapons in a ready-to-fire state.

4. A new international momentum to ban nuclear weapons

The issues of nuclear risk and unacceptable humanitarian impacts were discussed at a series of non-nuclear-weapons state sponsored conferences in Oslo, Norway in 2013 and Nayarit, Mexico and Vienna, Austria in 2014 - with expert input from scientific organisations including SGR. These discussions led to a newly reawakened realisation of the extremely destructive nature of nuclear weapons culminating in a Humanitarian Pledge signed by over 100 nations and heated discussions at the NPT review conference in New York in May 2015. The Pledge calls on "all states parties to the NPT to renew their commitment to Article VI [of the 1968 Treaty on the Non-Proliferation of Nuclear Weapons (NPT)], and to identify and pursue effective measures to fill a legal gap for the prohibition and elimination of nuclear weapons." [29]

The primary legal gap is that all other weapons of mass destruction - biological and chemical - are prohibited, while nuclear weapons are not.[30]

The nuclear weapons states take a deeply hypocritical position. They argue that they need nuclear weapons to address vaguely stated 'security concerns' but they are unable to say how these weapons will realistically keep even themselves 'safe' and deter each other, while they undeniably pose a world-wide risk of nuclear annihilation. They are also spending large budgets on new nuclear weapons.[31] For example the US budget is $1,000 billion over the next 30 years.[32] The one sided nature of this is highlighted by the fact that some 35-40 countries have the ability to construct nuclear weapons but have chosen either to dismantle their nuclear programmes or not commence them.[33] The UN recognises nine nuclear-weapons-free zones – as shown in Figure 1 below - covering more than half the countries in the world. Some zones include entire continents, e.g. all of Africa, all of South America, Central Asia, Australasia, and Antarctica.[34] Clearly most countries do not believe that nuclear weapons are vital for their defence and have taken constructive steps to eliminate them.

It is to be hoped that the Humanitarian Pledge will be taken forward urgently in a similar process to that which banned anti-personnel mines and cluster munitions.[35]

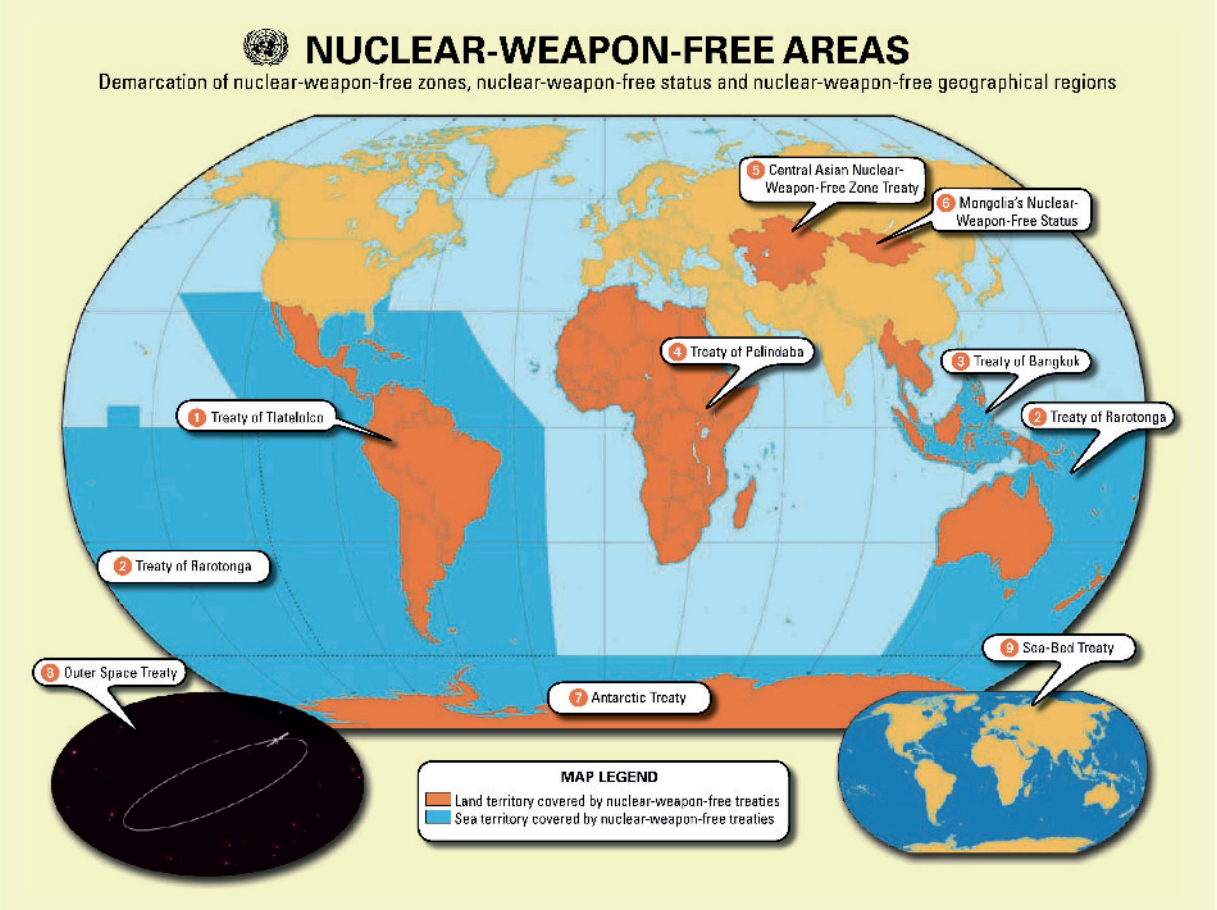


Figure 1. Nuclear Weapons-Free Zones

TREATIES ESTABLISHING NUCLEAR-WEAPON-FREE AREAS

Nuclear-weapon-free zones

1. The 1967 Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean
2. The 1985 South Pacific Nuclear Free ZoneTreaty
3. The 1995 Southeast Asia Nuclear-Weapon-Free Zone Treaty
4. The 1996 African Nuclear Weapon-Free ZoneTreaty
5. The 2006 Treaty: Nuclear-Weapon-Free Zone in Central Asia

The treaties establishing the nuclear-weapon-free zones, inter alia, ban nuclear weapons within the respective territories of the zones, including the acquisition, possession, placement, testing and use of such weapons.

Nuclear-weapon-free status

6. In 1992, Mongolia declared its nuclear-weapon-free status, which is internationally recognized and prohibits, *inter alia*, the acquisition, possession, placement, testing and use of nuclear weapons on its territory.

Nuclear-weapon-free geographical regions

7. The 1959 AntarcticTreaty, inter alia, prohibits any measures of military nature on the continent of Antarctica, including any testing of nuclear weapons.
8. The 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space including the Moon and Other Celestial Bodies, *inter alia*, prohibits placing nuclear weapons in orbit around Earth, installing or testing these weapons on the Moon and other celestial bodies as well as stationing these weapons in outer space in any other manner.
9. The 1971 Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Sea-Bed and the Ocean Floor and in the Subsoil Thereof, *inter alia*, prohibits the emplacement of nuclear weapons on the bottom of the ocean and in the subsoil thereof.

As of 2010, the above nine nuclear-weapon-free zones are in effect. Some of the treaties related to these zones are at different stages with regard to the signature, ratification and entry into force, as well as with regard to the signature and ratification of their associated protocols containing security assurances from the nuclear-weapon States.

The delineation of the nuclear-weapon-free areas presented on this map is indicative only.

United Nationa Office for Disarmament Affairs On the web - www.un.org/disarmament/WMD/Nuclear/NWFZ

5. Final words and conclusions

SGR's view is that the evidence is compelling that continued deployment of nuclear weapons by nuclear armed states, including the UK, creates a significant risk of a nuclear weapons accident or unintentional nuclear war, and therefore risks the future of human civilisation.

The arsenals of the UK and almost all other nuclear powers exceed civilisation-threatening threshold levels above which a devastating nuclear winter is a serious risk. This means that any perceived advantage of either their use or the threat of their use is strongly outweighed by the risks. It is rather like people soaked in petrol in a tinder dry forest threatening each other with blow-torches whilst ignoring pleas to extinguish their flames from others who live in the forest.

This knowledge should act as an imperative for nuclear armed states to immediately remove any nuclear weapons from launch-on-warning status, rapidly end deployment of all nuclear weapons, and quickly reduce the current stockpiles of nuclear weapons to zero through dismantlement of the warheads. There is ample evidence that threats of the use of the grossly inflated destructive power of current arsenals can now only be seen to be empty and suicidal and conferring no credible military or political advantage. A nuclear ban treaty – as proposed in the Humanitarian Pledge – seems the most promising route to achieve these aims.

Turning to the particular case against the UK replacing Trident, the preceding analysis has highlighted the suicidal and genocidal nature of the Trident system. The first steps in the disarmament process are to remove Trident from continuous patrol at sea, place the nuclear warheads in storage, cancel Trident replacement, and actively support negotiations on a nuclear ban treaty. Neither Trident, nor its possible successor, can deter terrorist groups or cyber attacks which are identified as primary threats in the current UK defence and security policies. And clearly neither US nor UK nor French nuclear weapons deterred Russian intervention in Ukraine any more than UK nuclear weapons deterred the Argentinean invasion of the Falklands/ Malvinas in the early 1980s.

SGR studies have already suggested that the UK could radically improve its overall security by properly considering a full range of threats to security, for example, climate change and resource shortages, and by adopting a more defensively oriented force posture, including a greater focus on diplomacy and work to tackle the roots of conflict, rather than the current focus upon military force projection[36] and costly, counterproductive or illegal (e.g. Iraq and Afghanistan) military interventions in foreign countries. This analysis has been backed up by recent research by the Oxford Research Group.[37] SGR has estimated that such changes could save the UK around £1bn a year in R&D costs alone, let alone many times larger savings that could be made in actual weapons systems procurement.[38]

Turning to replacing Trident, £4bn[39] has already been spent on development work for four new nuclear submarines since an initial go-ahead in 2007. Trident Mk-II would add yet another huge £19-25bn[40] bill to the UK's already over-sized military budget amounting to 35% of the military equipment budget over a ten year period. On top of this there would be annual running costs of around £2-2.5bn.[41] Over its complete lifetime the total cost is likely to be near £100bn.

The UK faces very severe budgetary constraints and major budgetary pressures to help fund its welfare and health budgets and the pressing need to tackle climate change via a transition to a low carbon economy. In the face of a complete lack of any rational justification for retaining Trident, the UK should seize this opportunity to make significant savings to its military budgets. These savings combined with a more defensive military stance would go a long way to solving the budget pressures the UK currently faces.

On top of these issues, there is a strong moral and self-interest argument against replacing Trident in order to support a growing international call to recognise that nuclear weapons should be banned in international law along with other weapons of mass destruction such as chemical weapons that are regarded as completely unacceptable.

There is an opportunity for the UK to regain influence in the world through constructive actions, by not replacing Trident.

With the lack of any credible defence or military utility, to retain UK weapons of mass destruction would represent a huge act of folly - no more than a grandiose gesture in order to try to retain some fading vestige of international influence in the face of any moral justification. Such a policy would be deeply misguided.



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About this report

This report updates and summarises the latest scientific and technical information about the risks posed by the continued deployment of the UK's nuclear weapons. It highlights the following.

- The explosive power of the nuclear weapons carried on just one Trident submarine is equivalent to about 320 Hiroshima bombs and is capable of inflicting more than 10 million civilian casualties.
- The most up-to-date scientific models predict that this firepower would cause devastating climatic disruption threatening global food supplies and leading to mass starvation.
- UK nuclear weapons are on patrol around the clock, and the possibility of unintended use poses an unacceptable risk. Whilst the chances may be low, the consequences would be catastrophic.

About Scientists for Global Responsibility (SGR)

SGR is an independent UK-based membership organisation of hundreds of natural and social scientists, engineers, IT professionals and architects. We promote science, design and technology that contribute to peace, social justice, and environmental sustainability. Founded in 1992, our work involves research, education, advocacy and providing a support network for ethically concerned science, design and technology professionals. SGR is affiliated to the International Network of Engineers and Scientists for Global Responsibility (INES).

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