Part I

Governance for Nuclear, Biological and Chemical Weapons of Mass Destruction

1 Nuclear One-Worldisms, Planetary Vulnerability and Whole Earth Security

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Creating the Armageddon Gadget

Since arriving on the world scene in the waning days of the greatest global war in history, nuclear weapons have occupied a central role in both world political affairs and thinking about the overall human prospect. Because of the immense destructive potential of nuclear weapons, the consequences of a nuclear war would be a civilisational catastrophe. Even more alarmingly, a large nuclear war might render humanity extinct, a consequence of human activity without any historical precedent. With nuclear weapons, humanity has created the means of committing species suicide, of potentially consigning itself to the ultimate ash heap of history (Calder 1979; Office of Technology Assessment 1979; Schell 1982).

Despite these facts, the international system of sovereign states, or more precisely a handful of the 'great powers', in a giant spurt of rapid mobilisation, reacted to this perilous possibility by quickly bringing into existence a planet-spanning megamachine of violence, prepared for immediate use (Cirincione 2007; Rhodes, 2007). Over the course of their global Cold War struggle, the United States and the Soviet Union, known as 'the superpowers', amassed staggeringly immense arsenals of ever more powerful and versatile nuclear weapons. Tens of thousands of nuclear weapons were fabricated and deployed, with several tonnes of TNT equivalent for every person on the planet. By coupling these weapons with delivery vehicles of progressively greater range, speed, and accuracy, and deploying them on a planet-spanning network of bases and mobile delivery platforms, the United States and the Soviet Union set in place the capacity to wreck historically unimaginable levels of destruction nearly instantaneously (Arkin and Fieldhouse 1985).

In a very basic way, the construction and persistence of this staggeringly hypertrophic violence supply system call into question the entirety of modern civilisational progress and the scientific/technological world view animating it. The last several centuries, particularly the 20th, have produced enormous improvements in the human estate. The combination of rapidly growing knowledge about nature and new engineering techniques has empowered humanity to build vast, planet-spanning complexes of machines and infrastructures, an *anthroplex*, a fabricated 'second nature'. The vast bulk of the anthroplex is configured to better serve human needs, wants and desires. But since the beginning of the nuclear era, another machine-infrastructure complex, a nuclear violence supply machine, has also been built by a subset of humanity. While gargantuan in

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absolute size, it is much smaller than the civil-servicing anthroplex and much less visible. It also spans the planet and helped create and exploit a cascade of extraordinarily powerful new technologies. In basic practical material terms, this nuclear violence complex of things amounts to a giant self-demolition device, an Armageddon gadget, a planetary suicide vest, enabling the practical negation of modernity's progress and perhaps humanity (Anders 1962; Lifton and Falk 1982; Mian and Pelopidas 2023; Thompson 1980).

As this giant destruction apparatus was being constructed, a great debate raged over the choices posed by the new technology and the features of a world order needed for security in the nuclear age. While this debate remains unresolved, civilisational and human survival hinge upon getting, and implementing, the right answers to these questions. In this debate, views on the implications of nuclear weapons for security and world order have varied widely, and prospects for fully resolving the debate are dim (Connelly *et al.* 2012). One cluster of views, 'nuclear one-worldism' (NOW), is the focus of this chapter.

NOW holds that the development of nuclear weapons, and ancillary technologies, is nothing short of a revolutionary transformation in the human relationship with nature. Achieving security requires significant, and cumulatively revolutionary, changes in security politics and world political order. In the revolutionary school understanding of nuclear weapons, the vast deployments of instantly useable megaviolence is essentially a giant and insane mistake, a vast folly, an avoidable danger that humanity has created needlessly for itself. This view has been widely voiced by many, from the leaders of the nuclear states themselves to many leading scientists, political thinkers, commentators and religious leaders, as well as the leaders, organic intellectuals and members of mass public movements (van Munster and Casper Sylvest 2015). NOW thinking has been part of the Great Debate from its inception, has evolved and developed in important ways and has had some real and significant influence on politics and policy. But NOW is not the dominant view among nuclear thinkers, especially those most closely affiliated with militaries and states.

Nuclear revolutionary thinking is exceedingly immodest, addressing nothing short of the fate of civilisation and humanity. But the aims of this chapter are modest: to simply and fully summarise the main ideas of the revolutionary school and NOW, to convey 'what nuclear one-worlders think'. As such, the objective here is not to extend NOW thinking or demonstrate its superiority to other answers offered by other schools of nuclear theory and practice. This modest step is valuable because such ideas, while abundant, often quite sophisticated, widely held and sometimes influential, are almost invisible in many accounts of the nuclear question and are also quite fragmented. It also points towards a larger effort, beyond the scope of this short chapter, to demonstrate the superiority of these ideas and their underlying assumptions about material change and world political and security orders.

Progress, Reversal and Ominous Global Trends

NOW and related ideas provide the theories justifying and guiding a second great experiment in denuclearisation order building, unfolding across the nuclear era. Alongside and against the great and fateful experiment in nuclear weaponisation and in building the nuclear anthroplex, there has been an alternative nuclear experiment in new political world order building. A large menu of arms control and disarmament measures have been developed by nuclear thinkers and sometimes vigorously promoted by popular movements. International negotiations on arms became a standard, often central, part of

interstate diplomacy and politics. And, slowly but surely, partial denuclearisation and control measures have been negotiated and implemented. Nuclear weapons test bans, prohibitions on nuclear weapons based in orbital space, Antarctica and the seabed were established. Then came bilateral U.S.-Soviet arms control regime-building (SALT I & II, START I & II, INF, New START), climaxing in the unexpected and peaceful end of the Cold War and its great nuclear settlement, which produced substantial reductions in nuclear forces (George, Farley and Dallin 1988). Former rivals became partial nuclear security allies, taking a myriad of steps towards political reconciliation, conflict avoidance and peacemaking, as well as democratisation. As a result, reciprocal international arms control and disarmament, previously rare in world history, became a significant feature of the interstate system. With these hopeful developments, the nuclear peril, and hence concern over the nuclear question, seemed to recede in importance.

Unfortunately, since roughly the turn of the 21st century, these important successes in new world order building have started to unravel, and a range of new nuclear dangers have emerged. The 9/11 terrorist attacks, followed by the anthrax letter attacks, highlighted the potential for a variety or revisionist and radical non-state actors, potentially the size of gangs or cults, to acquire and use nuclear or other weapons of mass destruction (Cronin 2020; Cronin and Ludes 2004; Smith, 2006; Witte and Blum 2015). The collapse of the Soviet Union also raised the spectre of its vast trove of nuclear weapons and fissile material 'leaking' into the hands of other actors. The diffusion of nuclear capability, dubbed 'proliferation', a secondary concern during the Cold War, seemed to take on new urgency, especially for the United States, as several small and relatively weak states acquired, or took steps to acquire, nuclear arsenals.

More disastrously, the great power accommodation between Russia and the United States marking the end of the Cold War has slowly soured, and its arms control accomplishments have steadily unravelled (Deudney and Ikenberry 2010). The United States, a leader through much of the Cold War in supporting strategic arms control, withdrew from several landmark treaties at the same time as its offensive nuclear forces—under the rubric of various 'modernisations'—became increasingly capable. With the recent outbreak of the Russia-Ukraine war, Russia and the members of NATO, led by the United States, are engaged in an extremely violent proxy war in Ukraine, which some observers liken to the Cuban Missile Crisis of 1962. Overall relations between the two nuclear superpower states are at a low not seen since the worst days of the Cold War. Critics of the arms control project view this unravelling as the failure of arms control, but it is more accurately viewed as a failure by states to persist in maintaining and extending the measures which had appreciably reduced the nuclear peril (Krepon 2021).

Further dangers and uncertainties are growing. Rapid weaponisation of new technological capabilities is occurring in orbital space and the oceans, as well as in cyberspace, which increasingly envelops everything. China's growing economic and military power, its regional hegemonic aspirations, and its hardening autocratic regime have converted its late Cold War and post-war quasi-alliance with America into a growing, global, great power rivalry. China and India are making their nuclear forces larger and more capable. A handful of smaller states with deeply troubled relations with their neighbours, most notably North Korea, Iran, Israel, and Pakistan are pushing ahead with nuclear programmes.

These nuclear trends are occurring alongside multiple other major emerging problems with ominous implications for the human prospect and world order. Most notably, climate change is underway, and efforts to moderate it are falling short of what is needed, and so the world is increasingly locked into a world of increasing droughts, floods, severe

storms, mass extinction, rising sea levels, and mass migrations. Also, the world capitalist system, which has spread powerfully everywhere, appears to have fundamental internal instabilities which portend further crises, inflations, recessions, and even collapses. And the COVID-19 pandemic, killing millions and costing trillions, reminds us of the high probability of even greater pandemics to come.

Given these developments, the current prospects for the revival and extension of significant nuclear arms control and disarmament appear dim. While the need for such measures is arguably greater than ever, the prospects for more progress seem to be steadily dimming.

The Nuclear-Political Question

A first step in understanding the views of the revolution school is to return to the matrix of arguments in the Great Debate. The possibility of nuclear destruction has triggered a practical, high-stakes, widespread, and extended debate, at the core of which is a very simple question, the *nuclear-political question* (NPQ): what political arrangements are needed to preserve security (and liberty) in the nuclear era (Aron 1965; Baylis and O'Neill 2000; Boyer 1985; Deudney 2018; Nye, Allison and Albert 1988; Walker 2012)? This question poses the dark puzzles upon whose successful resolution the fate of states and civilisation, and perhaps humanity, now depend. This seemingly simple question unfolds into a series of questions about actual and possible alternative political arrangements. Unfortunately, beyond the recognition that nuclear explosive technology affords quantities of destructive energy so prodigious as to dwarf all previous instrumentalities of warfare, virtually nothing is agreed upon.

Because the state and state-system have been so predominant in security politics, both before and during the nuclear age, and because states and their rivalries have played such an outsized role in calling nuclear weapons into existence and widely deploying them, much of the debate over the NPQ has focused on the adequacies and limitations of state policies, and more general questions about the adequacy of the state-centric world order, thus marginalising non-state actors and non-state alternatives.

Repair, Reform or Revolution?

Across the Great Debate, answers to the NPQ have tended to largely fall into three rough clusters along a simple spectrum: repair, reform and revolution. All these ways of answering the NPQ have evolved across the nuclear era, and there are many, often visible and heated, debates within each of the schools.

The repair school offers the simplest answer to the NPQ: nuclear weapons, while novel in important ways, do not require major changes in the role of the state and war or world order. The nuclear problem can be adequately dealt with by repairs at the intrastate level of strategy, force structure and policy. The repair school expects the nuclear age to be more or less like the pre-nuclear age in most important respects. They expect, and recommend, that states pursue a time-hallowed approach of deploying and potentially using any available weapon to pursue national security through military strength, threat and coercion. In this way of thinking, nuclear weapons are just another new weapon, one in the long sequence of military innovations. And like their many predecessors, nuclear weapons will be, and should be, countered, or surpassed, by further innovations in weaponry. Nuclear weapons exist and persist because they seem to solve problems which

many states face. Many states see nuclear weapons as a source of security, and many claim that the very enormity of the destructiveness of nuclear weapons will guarantee that they are extremely unlikely to ever be used, thus providing a sturdy and valued basis for great power peace.

While many versions of nuclear repairism proclaim their allegiance to the aim of avoiding nuclear war through deterrence, they recommend deployment of nuclear weapons in large numbers for a wide range of military options (Kahn 1961; Kroenig 2012). Given the nature of international politics, or even of humanity, this path is largely natural and inevitable. Not surprisingly, repairers see most arms control, and especially deep disarmament and nuclear zero, as some combination of failed, unworkable and undesirable. Arms control is difficult to achieve and maintain, and is 'impossible when necessary, and unnecessary when possible' (Gray 1992). Arms control is a distraction from the grim but necessary work of prudently deploying nuclear weapons, as well as a perilous step towards oppressive world government. In many ways, the repair-through-strategy approach has been dominant, as measured by influence on nuclear state policy.

The central idea of the reform school is deterrence, augmented with diplomacy and arms control to stabilise deterrence (Allison, Carnesale and Nye 1985; Brodie 1946; Gallois 1961; Goldstein 2000; Jervis 1984; Morgan 2003; Tucker 1985; Waltz 1990). The basic idea of nuclear deterrence is that nuclear forces, if properly configured, would render the initiation of a nuclear war suicidal and thus very unlikely. Arms control thinkers in the reform school emphasise that simple deterrence is unacceptably dangerous because of accidents, complexity and failures of rationality and speed (Blair 1993; Feiveson 1999). Crises may spiral out of control (Acton 2018; Ball 1982; Lebow 1987; Posen 1991). Nuclear security requires changes in state policy and military force structure, combined with the expansion of mutual agreements among states to resolve conflicts and configure weapons in less threatening ways (Bull 1961; Russell 2003; Sauer 2015; Schelling and Halperin 1961; Tannenwald 2007). The reform programme entails no alteration in the dominant role of states, the character of states or the main features of interstate anarchy. The aim is to moderate and preserve, not eliminate, interstate anarchy and state primacy. During the Cold War, reformist approaches were in continuous clash with the views and programmes of the repair school.

Revolution and NOW

Third is the revolution school and NOW, and its claims that nuclear weapons constitute a material revolution of unprecedented magnitude and that the survival of civilisation (and perhaps the species) depends on achieving major changes in world political order. In this view, nuclear weapons mark a fundamental change in the human relationship with nature. NOW advances a double and coupled revolution argument: there has been a revolutionary change in the nature of things of such magnitude as to require (for survival) a revolutionary change in world political order, and especially the role of the state in it.

In this way of thinking, nuclear weapons are revolutionary in their implications for basic features of world political order, posing a fundamental challenge to the viability of the state as provider of security. The near anarchic state-system must be altered in fundamental ways, and nuclear weapons must be as completely eliminated as possible. Some revolutionists hold that some form of a world government or world state is now needed for achieving security, but others reject world institutions configured as states, fearing a difficult-to-check devolution into an oppressive world totalitarian despotism.

The ideas of the revolution school flourished in the early nuclear era but were largely a marginalised outlier during most of the Cold War. Revolutionary views are less widely reflected in state policy, and less widely held by statist nuclear thinkers. Since the middle 1980s, a new and stronger version of the revolutionary position has emerged. New knowledge of the potentially disastrous impacts of nuclear war on the planet's biosphere, combined with growing awareness of the prospects for the 'leakage' of nuclear capability into the hands of potentially radical non-state actors, became important parts of the case for comprehensive denuclearisation. These developments have been inadequately recognised in many accounts of the nuclear question, are ignored or mischaracterised by reformers and repairers and are in many ways unintelligible to most forms of realism.

One difficulty in thinking clearly about nuclear revolution arguments is that the term 'revolution' has been employed to refer to changes and measures which are better recognised as reforms. In the large, sophisticated and prominent body of argument and debate about the role of deterrence, the adoption by states of deterrence as their core nuclear policy is cast as 'the nuclear revolution' (Green 2020; Jervis 1989). But within any realistic reading of the scope of nuclear argument, this claim is really a moderate reform.

While NOW perspectives are marginal in the thinking of nuclear states, strong anti-nuclearism has been politically influential, remains a strong presence politically and is in some ways growing (Cortright 2008; Knopf 1998; Wittner 2009). There is a large (and always growing) number of non-nuclear states that could acquire nuclear weapons with reasonable effort (the 'nuclear overhang') but that have renounced nuclear acquisition (Kassenova 2022; Levite 2003; Pelopidas 2015). And several states with nuclear programmes and weapons have completely relinquished them ('reverse nuclearisation'). There has also been a growth in the number and spatial reach of nuclear-weapons-free-zones (NWFZ) (Mpofu-Walsh 2020). The 'Ban Treaty' in which contracting states completely renounce nuclear possession was rapidly negotiated, passed by the United Nations General Assembly, ratified widely, and has gone into force (Daalder and Lodal 2008; Fihn 2017; Meyer and Sauer 2018).

Three Phases of the Great Debate

The debate between NOW and other answers to the NPQ has passed through three fairly distinct phases. This evolution has been propelled by developments in both technology and politics, as well as by conceptual impasses and innovations.

The first phase of the Great Debate, the *Big Bang* phase, stretching from roughly 1945 to 1960, was dominated by revolutionary nuclear one-worldist thinking. In part, this early interest in NOW arguments derived from the widespread expectation that nuclear war would occur in the absence of such a reconfigured world political order and that the time for averting such a disastrous war was very short. It is notable that such thinking flourished and predominated in the years before large numbers of nuclear weapons were built and deployed, before thermonuclear weapons were invented and before the full planetary ecological consequences of a general nuclear war were understood.

The second phase of the Great Debate, the *Cold War Trinity* phase, occurred during the middle and late Cold War and centred on deterrence. Within this framework for thinking about nuclear security, there was a set of basic disagreements that centred around the question of how many nuclear weapons, prepared to do what, were needed to achieve deterrence. On this question, there were fairly sharp divides that coalesced into three fairly distinct schools of theory and practice: *war strategism*, *simple deterrence* and

arms control. The simple deterrence school viewed nuclear deterrence as extremely robust, almost an automatic consequence of the presence of a minimum number of nuclear weapons. But the war strategists and arms controllers saw it as potentially fragile and in need of augmentation, but in diametrically opposed ways.

The project of arms control, as it was understood and partially carried out during the Cold War, has had, at times, a confused and vexed relationship with the revolutionary NOW school of thinking and agenda (Lebovic 2013; Sims 1990). Some, such as Jonathan Schell, viewed arms control as a flawed alternative to deep denuclearisation, but these bodies of thinking and their agendas are better thought of a parts of a continuum, stretching from 'shallow arms control' to 'deep arms control' (Schell 2000). Both aim to restructure and to reduce use, and the project of 'lengthening the fuse' animates both. Some see the nuclear arms control project as inherently limited, because it does not seek to eliminate nuclear deterrence. But, as Jonathan Schell, building on the core notion of Robert Oppenheimer's early control proposal, clearly articulated, nuclear use is *always* inherently only a few steps away. And the paralysing power of deterrence will persist, in a 'recessed' or 'virtual' form, in a world without actual nuclear weapons.

The third round in the great nuclear debate, the *Bombs Away* phase, began in the later years of the Cold War and is ongoing (Bracken 2012; Payne 2001; Yoshihara and Holmes 2012). It encompasses arguments that move considerably beyond the state-centric assumptions of the previous two phases and advances proposals that are in many ways quite radical. It assigns great importance to a menagerie of actors beyond states, who were traditionally subordinated to the prerogatives and imperatives of states. This phase is also marked by sharper differences in both understandings of the problem and remedies. Despite this diversity, there is one common feature of the current phase: weakened confidence in the stabilising role of deterrence (Krepinevich, Jr. 2019). Without the deterrence anchor, both war strategism and arms control have become increasingly radicalised, but in diametrically opposed directions: on the one hand towards 'pre-emptive counterforce' and 'limited nuclear war' scenarios (Acton 2013; Lieber and Press 2006, 2017; Roberts 2016) and on the other towards deep disarmament and nuclear zero.

NOW 2.0

Over the course of the nuclear era, there have been notable changes in both the diagnostic and remedy arguments of the revolutionary NOW school, which cumulatively and in combination make another version of NOW. In subsequent sections of this chapter, I explore several of these arguments, but before doing so, it is useful to briefly note six important ways in which the denuclearisation case and NOW have strengthened.

First, the harm of nuclear war is greater than previously thought because new knowledge from Earth System science shows the likely damaging impacts of a large nuclear war on the planetary biosphere and geophysical system would range from the severely catastrophic (many billions killed) to the existential (human species terminated—along with numerous other species).

Second, the Cold War historical record shows the probability of a major nuclear war was significantly higher than previously thought. New information made available over the last several decades indicates that the Cuban Missile Crisis of 1962 (previously widely recognised as 'the most dangerous moment in world history') came much closer to the use of nuclear weapons than previously thought (Blight 1992; Plokhy 2021; Sherwin

2020; Stern 2003). This record points to the centrality of 'dumb luck' in averting what Kennedy called 'the ultimate failure' (Lebow and Pelopidas 2023).

Third, the historical record also suggests the probability of nuclear detonations is higher than previously thought because of the occurrence of accidents involving nuclear weapons ('broken arrows') and their delivery and control systems (Perrow 1984; Sagan 1993; Schlosser 2013; Sokolski 2014).

Fourth, the historical record, combined with extensive thinking about the frailties of human beings and their limited capacities for reason (cognitive, emotional, social), suggests that nuclear war is more likely and that nuclear war is more likely to be uncontrollable (Erickson *et al.* 2013; Kull 1988; Lebow and Stein 1986; McDermott 2017).

Fifth, the probability of nuclear weapons use is higher than previously thought because of the potential for nuclear capabilities to leak from states into the hands of a potentially large number of non-state actors with plausible motives to employ them (cults, national and international revolutionary movements, coupists, criminal gangs, accelerationists, and anarchists) (Ferguson and Potter 2006; Ikle 2006; Willrich and Taylor 1974). The response requires international 'counter-terrorism', policing and intelligence cooperation. State anti-terrorism has significant 'liberty fallout' erosive of many individual rights (Ayres 1975; Scheppele 2006).

Sixth, building and maintaining the nuclear annihilation apparatus has had significant institutional costs by making states monarchic and despotic, more secretive and less subject to democratic accountability (Dahl 1985; Deudney 2010; Scarry 2013).

One-Worldism, Globalism and Planetary Earth

To see the core logics and unity of NOW as an answer to the nuclear question, it is essential to see NOW as embodying a far broader civilisational 'one world' or 'globalist' and 'planetary' world view which has, over several centuries, emerged, and become a powerful presence virtually everywhere. Its basic insight is that a cascade of technological super-empowerments, occurring in the finite and fixed space of planet Earth, have produced a massive 'collapse of distance', and thus an overall human situation marked by high levels of interaction, interdependence and mutual vulnerability. Along with NOW, multiple other 'one-worldisms' have emerged, most notably biospheric ('catastrophic environmentalism)' and informational ('noosphere', 'world brain' and 'global electronic village'), as well as a 'space one-worldism'. Each is elaborately developed, rapidly evolving and organic to ongoing world order-building projects for these objects and domains.

The human world has been becoming global and planetary for a long time, and in many ways. A universalist 'one world' insight had existed aspirationally, in ethical cosmopolitanisms and in some religions, which were present, but never dominant, in pre-modern societies. Notions that the Earth as a whole had been created by supernatural divine actions suggested the presence of basic unity. And the slow spread of humans across the terrestrial Earth was the first and longest practical globalisation.

The early modern Copernican revolution produced a global conceptual revolution by establishing that humanity's many and far-flung abodes were all parts of one object, globular in shape, which was also a planet, a wonderer, racing through a staggeringly vast void and isolated from other global worlds by vast distances. This shift in practical material world view also helped trigger another rapid conceptual and practical globalisation in a multi-century burst of further geographical exploration on and off the planet, providing detailed maps of the fuller Earth within which humans and their activities were situated.

Early modern Europe also gave birth to modern experimental science and the systematic application of this knowledge to invent new technologies and build new machines to serve human ends. The early applications of this new way of proceeding greatly augmented the power of one group in Europe, triggering a wave of global-scope imperialism, colonialism and exploitation (Abernathy 2000; Headrick 2010). Then, in the long 19th century, the Industrial Revolution, with the Europeans and their settler colonies again leading, triggered both another wave of imperial expansion, as well as the vast increase in the destructiveness of the chronic intra-European wars, culminating in the 'total war' destructions of World War I and II. Then, in the middle years of the 20th century, there was another burst of revolutionary technological advance, with nuclear weapons, powerful rockets and satellites, digital computers, and the beginnings of genetic engineering, a burst roughly coincident with a 'great acceleration' in economic activity, energy use and population growth, and their resulting biospheric devastations. Because of the magnitude of these empowerments and accompanying enlargements in the spatial range of human activities, it is appropriate to refer to the resulting overall situation as planetary rather than global.

It is notable that in attempting to make simple characterisations of the new situation in ways relevant to appropriate new world order building, many analogise the new bigger world with the familiar small spaces, places and objects, most notably the 'global village' and 'spaceship Earth' (Pemberton 1991; Rosenboim 2017). The unmistakable message is that we humans are all now 'in the same boat' in which we will sink or swim largely together. And these images of the human situation as small, crowded and dependent on complicated machinery and good navigation point to the imperative to 'act globally as we had previously acted locally' and to build new architectures of political restraints matched to the new technological super-empowerments. In sharp contrast, anarchy in homes, villages, neighbourhoods, and ships, especially when combined with super-empowered weaponry, emerges as catastrophically dangerous. Just as no one would bring assault weapons to a business meeting, fill once's home with crates of dynamite or place powerful howitzers in their back yard to blast neighbours, so too nuclear weapons have no place on planet Earth.

In this situation, previously domestic and municipal-scale forms of government are appropriate. In reconfiguring the planetary megaviolence part of the anthroplex for nuclear security, familiar measures such as zoning ordinances, building codes, appliance safety standards, pollution control regulations, and eminent domain are useful models. The Armageddon gadget, a material artefact with planetary scope, is a 'public works' infrastructure, but one irrationally built for quick civilisational self-demolition. Comprehensive nuclear deweaponisation requires this odd and insane thing, this infrastructure-for-suicide, be dismantled and its parts and places re-assembled very differently.

Multiple Superpower Technological Revolutions

The story of very recent revolutionary scientific and technological advances related to actual nuclear developments only begins with nuclear weapons and extends to several other recent bursts of change—in scientific understandings of the natural and material world, in the institutionalisation of discovery and invention and in transport and communication technological capabilities and spatial expansions—that are large enough to be appropriately recognised as revolutionary. The arguments of NOW in the Great Debate, the course of actual nuclear material and political history and the case for (and contours of) deep arms control are unintelligible without taking into consideration this broader horizon of material transformation.

In addition to the nuclear revolution in the volume destructiveness, there have been revolutions in transportation (long-range aircraft and ballistic missiles) and information (computers, satellite observations and 'accuracy revolutions'). The actual Armageddon gadget, what is commonly called nuclear 'force structures' and their ancillary supports, is an amalgam of information, transportation and nuclear artefacts and infrastructures.

Rapid developments in aeronautics and astronautics have altered the *velocity* of violence in revolutionary ways. Across the first half of the 20th century, the speeds of human transportation machines leapt—railroads to ballistic missiles—some four orders of magnitude. With ballistic missiles, everywhere was potentially and rapidly accessed from anywhere within less than an hour. When the superpower states coupled the immense destruction of nuclear weapons with extremely rapid planet-scope transportation capabilities, they dramatically altered their time horizon for mobilisation and response, a situation in which 'there will be no time' (Borden 1946). And revolutionary advances in technological abilities to gather, transmit, process, and employ information have produced enormous expansions in volume, velocity and spatial reach. With the militarisation of the electromagnetic spectrum, particularly radio waves, the tendrils of the war machine have become completely all-enveloping.

Taken together, these new capabilities have produced a major expansion in the spatial extent of the violence megamachine, what amounts to a geographic revolution, another shift from global to planetary scope. As battlespace for great power war became planetary, the security of territorial state came to hinge almost entirely on violence machines deployed in the vast fluids, airs and voids of the planet. States were haunted— and attracted—by the possibility that one state might militarily dominate these spaces and establish an imperial hierarchical abolition of interstate anarchy.

What are the implications for arms control order building of the fact that actual nuclear force structures are a complex artefactual system incorporating the products of adjacent empowerment revolutions in destruction, transportation, information and invention, and employing the planetary spatial enlargement of battlespace? To start, what is commonly referred to as 'nuclear arms control' has never been about the direct control of nuclear weapons but rather mainly about their transportation systems and their spatial deployments (nuclear-free zones, domain bans for Antarctica, orbital space, and celestial bodies). The main U.S.-Soviet nuclear arms control measures were mainly about the control of 'nuclear delivery systems'. And among delivery vehicles, ballistic missiles have been of first importance, followed by long-range aircraft (Deudney 2020). As such, arms control has been attempting to control, or at least circumscribe, the revolutionary leap in the velocity and spatial reach of violence. These facts suggest that the neglected agenda of zero ballistic missiles (ZBM) deserves more analysis and prioritisation (Frye 1992).

The Earth System Science Revolution and Biospheric Nuclear Vulnerability

Perhaps the single most important new feature of recent NOW thinking has been its incorporation of a new understanding of nuclear war as a biospheric phenomenon. Over the course of the last two centuries, understanding of the natural systems of the planet has greatly improved. These new discoveries about the Earth, and about the growing human effects on the Earth, have catalysed a fundamental revolution in Earth science and amount to a re-discovery of the Earth. This advance in geographical knowledge about the contours of nature is comparable in its magnitude to the early modern Copernican revolution, which firmly established the globality of the Earth and its identity as a planet.

This scientific revolution in knowledge about the Earth System led to discoveries of new ways in which a nuclear war would be far more harmful than previously understood. In effect, an immense new vector of global/planetary vulnerability was discovered. The new Earth System knowledge revealed that a major nuclear war would be an act of assured suicide via biospheric assault and murder. The features of this scientific revolution and its nuclear-relevant implications can be briefly summarised.

First, it is interesting to note that investigations of the geographies of the newly opened planetary battlespaces (enabled by rocket transportation, satellite information gathering and computer modelling), producing the discovery of major secondary effects of nuclear weapons and the discovery of the features of the climate system, have been entangled in fundamental ways from the beginning. Knowledges of the secondary effects of nuclear weapons—fallout, electromagnetic pulse, biospheric collapse and nuclear winter—all were based on new understandings of the biosphere and climate (and orbital space). The U.S. military during the Cold War funded a great expansion in the Earth sciences in order to track radionuclides produced by nuclear detonations and to gain a better understanding of how to operate on the expanded planetary terrains—and potential battlespaces—opened by the rocket transportation revolution.

From the beginning of the nuclear age, the notion that nuclear war would potentially eliminate humanity had been widely voiced. In the early Cold War, it was the externalities from the nuclear weapons testing, most notably 'fallout', the dispersal of carcinogenic radionuclides into all parts of the biosphere, that caused widespread concern. These discoveries and public knowledge about them have been widely recognised as catalysts for the negotiation of the Limited Test Ban Treaty of 1963 (Higuchi 2020; Jacobs 2022). But aside from the immediate blast effects and the lingering radiation, it was unclear how a nuclear exchange might actually produce human extinction. In the 1970s and 1980s, scientific understandings of the likely effects of nuclear war took major steps forward. Researchers began to realise that nuclear war would produce major effects on the biosphere, leading to the collapse of the habitability parameters that humanity had both taken for granted and been ignorant of.

Even before they were invented, the ability of nuclear explosions to produce enormous quantities of heat, blast effects and fires had been well understood, and indeed was the reason they were invented, at such great cost, in the first place. Trinity, Hiroshima and Nagasaki abundantly confirmed the anticipations of their creators. But then scientists discovered two other unanticipated and secondary side effects of nuclear explosions stemming from the fires they ignite (Eden 2004).

In the 1970s, scientists discovered the possibility of civilisational collapse through the combustion by-products (especially nitrogen oxides and particulate matter, soot) of numerous nuclear detonations and their resulting fires. The injection of these substances into upper layers of the atmosphere would probably dramatically reduce the protective film of ozone in the stratosphere that naturally blocks out harmful forms of ultraviolent radiation. Unshielded, the sun's radiation would cause blindness throughout the animal kingdom, the destruction of microorganisms at the base of the oceanic food chain, and massive increases in human cancer rates. These discoveries, synthesised in reports by the U.S. National Academy of Sciences, received wide attention, notably in the work of the *New Yorker* writer Jonathan Schell in *Fate of the Earth* (National Academy of Sciences 1975).

In the 1980s, another related grave biospheric vulnerability to nuclear war was discovered. In part by studying other planets and in part by studying the global climate effects

of several major volcanic eruptions, atmospheric scientists came to understand the immense influences of sun-blocking atmospheric dust on global temperatures. Calculations (often made on powerful computers built for modelling nuclear explosions) indicated that soot produced by the fires of numerous burning cities would create a 'nuclear winter', in which the surface temperature in the interiors of the continents would fall significantly for at least several years, devastating plant and animal life and food production (Badash 2009; Ehrlich *et al.* 1984; Grinspoon 1986).

The revolution in Earth science, significantly spawned by the military questions and resources, has produced knowledge which subverted the appeal of nuclear weapons, a quite unwelcome finding to the nuclear military and state (Furchette and Roberts 2014; Hamblin 2013). Military funding did not corrupt science; rather, new scientific knowledge severely undermined the appeal of the military's 'absolute weapon' and the vast organisational and material deployments ready to employ it. In the simplest terms, the military sent scientists to find new information to assist in the conduct of warfare in new environments. The scientists came back with the finding that a general war would be significantly suicidal in character, not from some assured retaliation of a well-armed nuclear adversary, but from the inescapable 'retaliation' produced by the natural systems of the planet. Aiming to better expand the spatial scope of battlespace to the vast fluid commons of the planet, the military-sponsored research which discovered that human survival required severely circumscribing the instrumentalities for conducting general war. Even though the military innovation project could not effectively weaponise the larger geophysical and biophysical features of the planet—despite serious efforts to explore such possibilities—these parts of the planet were already parts of the 'kill chain' of large-scale nuclear destruction. SAD (Self Assured Destruction), in addition to MAD (Mutually Assured Destruction), were realities of the nuclear Earth. Overall, the implications of new Earth knowledge for the practice of war and for viability of long-established state approaches to providing security have greatly strengthened the revolutionary answer to the NPQ. With the coming of industrial violence, 'war is too important to be left to the generals', as Clemenceau famously proclaimed. With the coming of planetary habitat vulnerability, nuclear war is too important to be left to states.

Scientific-Technological Modernity, the 'Invention of Invention' and Weaponisation Races

It is not accidental that so many revolutions in understanding nature and in building powerful technologies have emerged so quickly. These advances have resulted from a more general change in the relation between science and technology and human society, often expressed as the 'invention of invention'. Of course, the entire record of human history, and especially military history, has been marked by technological discoveries and inventions, sometimes with major consequences. But until the Enlightenment and its spread and deepening, scientific research and technological innovation were very slow, minimally resourced, poorly institutionalised, and largely accidental. A signal institutional feature of modernity, accelerating and broadening with the Industrial Revolution and then exploding in the 20th century, has been the development of large, well-funded and staffed organisations devoted to making technological advances. This trend has been particularly pronounced for military purposes. During the Cold War, both the United States and the Soviet Union embraced technological advances as essential to achieving security (as well as material progress generally), and their rivalry produced a succession

of major military technological advances (Evangelista 1989; Kaldor 1981; Oreskes and Krige 2014; Rubinson 2016; Weinberger 2018).

Rapidly advancing technology creates a future horizon of fear, a steady succession of new dilemmas, uncertainties and choices, and the general sense that both sides are trapped on an escalator of violent empowerment that they can neither abandon nor effectively control. Despite extensive and increasingly sophisticated efforts of 'technological forecasting' (which technologies will become possible?) and 'technology assessment' (what are the second-order, indirect consequences of deployments?), the future remains significantly and recalcitrantly opaque, condemning arms-racing states to paths with difficult-to-foresee consequences. And every arms control accomplishment, no matter how politically strenuous to achieve, is confronted with chronic, almost planned, obsolescence.

NOW and the End of the Cold War

Another part of the historical story of NOW is the influence of these ideas on the end of the great Soviet-American Cold War (Deudney and Ikenberry 2011). The reasons this conflict ended when and how it did are many and remain subject to vigorous debate among historians and political scientists. But several key facts about this great historical juncture are widely accepted. It ended very quickly and unexpectedly peacefully. Its settlement was centred on a set of far-reaching arms control and disarmament treaties. Also largely beyond debate are the central roles played by the Soviet leader, Mikhail Gorbachev, and the American president, Ronald Reagan. There is strong evidence that NOW ideas catalysed and guided the extraordinary Gorbachev-Reagan diplomacy and shaped the settlement.

A focal point for all accounts of the end of the Cold War, and the influence of one-worldist ideas, is Gorbachev and his like-minded colleagues and advisers. The Gorbachev group believed that the Soviet Union was a woefully inadequate realisation of the promises of Soviet-Marxist political thought. To bring reality closer to the ideal, they embarked upon major reforms, domestically and in international affairs. Gorbachev's new foreign and security policy, known as 'New Thinking', articulated a straightforwardly one-worldist understanding of nuclear (and environmental) perils and the need for major changes in world political order. This new agenda for world order verged on the revolutionary: nuclear arms control and disarmament should be rapidly pursued to complete elimination. The United Nations's capacity to resolve conflict, keep the peace and solve problems of interdependence should be dramatically expanded. For the first time, the leader of the most heavily armed nuclear state articulated, and acted upon, a strong version of the one-worldist thinking and programme for political change. This was a radical shift for the Lenin-Stalin regime, built through mass repression and war (Zubok 2007).

One foundation for Gorbachev's 'New Thinking' were innovations in Soviet-Marxist theories of historical and dialectical materialism (Shenfield 1987). The leaders who built and ruled the Soviet state placed great importance on getting ideology right and acting vigorously to implement its dictates. During the Gorbachev era, the official version of Marxism in the Soviet Union shifted significantly because of new, scientifically established facts about nuclear weapons. Where Marx and his many followers had emphasised the centrality of class and class conflict, the new version posited the human species as the universal class whose interests were to be protected and advanced. In simplest terms, the 'material forces' had been revolutionised by technological advances in weaponry and

required a significant reorganisation of the 'superstructure' of political relations, institutions, and ideologies. With this updated, globalist historical materialism, the Communist Party and its leaders would continue to play their role as the vanguard of human progress and modernity on the largest scale.

Soviet NOW was also advanced by leading Soviet scientists who were globalists. Extremely secretive, the Soviet state closely regulated information flows and travel opportunities. But because of the strong Soviet commitment to scientific and technological progress, scientists and engineers were esteemed, privileged and often influential. Many leading Soviet scientists, including physicists prominent in nuclear development, most notably Evgeny Velikhov, head of the Soviet Academy of Sciences and Gorbachev's science adviser, participated in international scientific conferences and exchanges. At Pugwash events, they exchanged arms control ideas with leading Western physicists, many also prominent in weaponeering (Pugwash's influence was acknowledged internationally with the Nobel Peace Prize in 1995 [Evangelista 1999]).

It takes two to tango, and almost miraculously, Reagan was ready to dance, to the dismay and disbelief of many. Reagan's strong anti-nuclearism, not prominent in his long career as a hard-line anti-communist, first appeared in his activist leadership in the Los Angeles peace movement of the late 1940s and was re-ignited in the 1980s by dangerous nuclear developments and the mass anxieties and movements they triggered, making him the 'Manchurian candidate' of the global anti-nuclear movement (Lettow 2005; Mann 2009; Taubman 2012).

From Classical NOW and World Statism to Republican-Federal NOW and Whole Earth Security

Turning from the diagnostic side of NOW to its visions of world order remedies, there has been a significant evolution from NOW 1.0 to NOW 2.0.

NOW thinkers in the first phase of the Great Debate almost all thought nuclear security required a world state (Craig 2004; Deudney 2007; Herz 1959). The American analyst and chronic intellectual extremist James Burnham provides an 'imperial NOW' with his proposal for the United States to employ its early monopoly of nuclear weapons to quickly destroy the Soviet Union and then form a world government. The members of the Chicago Committee to Draft a World Constitution came up with 'maximal world federal NOW, urging the creation of a full-blown, liberal democratic, federal constitutional state'. Others, 'minimal world federalists', urged the creation of a state possessing nothing but a monopoly of nuclear weapons to keep the peace among states. The eminent realist thinker Hans Morgenthau argued that a world state was necessary but not possible until a world identity analogous to nationalism in states emerged, making for 'tragic NOW'. All NOW world state thinkers were acutely aware of the danger of a world government becoming a dark-end-of-history despotism. They proposed a large number of institutional 'checks and balances', but none seemed strong enough to rely on, and thus they reached something of a conceptual impasse (Deudney 2019).

The general tendency of subsequent NOW thinking has been away from world-state solutions and towards much more decentralised and horizontal architectures of restraints. In one version of such recent thinking, I have elsewhere proposed what I refer to as a modified, or 'Republican-Federal NOW', in which architectures and theories of institutional restraint drawn from republican theory and practice are employed to conceptualise and design authoritative but non-state, world security orders (Deudney 1995a, 2000).

Instead of building a world state and then figuring out how to control it, the path would be successively deeper steps of arms control and disarmament. Institutionally, this would take the form of a *planetary nuclear republican constitutional union* designed to be explicitly as much an avoidance of hierarchy as of anarchy. Such a nuclear union would not institutionalise anything resembling a world statist government. Instead of aggregating nuclear capacity in the hands of one actor, a world nuclear constitutional union would specifically proscribe any actor from possessing deployed nuclear weapons. Ideally, this union would prohibit any international and intergovernmental organ from possessing more than the most residual capacities for violence. The union codified in such a nuclear constitution should be confederal, not federal, meaning that explicit options for withdrawal would be included.

In thinking about the possible key features of such a world security order, the concept of 'whole earth security' (WES) is also useful (Deudney 1983). By this I mean a political order focused solely on the regulation of superpower capabilities, to be achieved by the strategic neutralisation of the extraterritorial realms of the planet, and the joint regulation of the full chain of steps in superpower weaponisation, coupled with the political arrangements to operate and sustain such a set of material re-configurations.

Realist thinkers have often analogised states as billiard balls of varying sizes, which bang against one another in the permissive environment of international anarchy. Advocates of moderating international anarchy with measures such as public international law, international organisations and regimes often analogise their enterprise as one of slowly immobilising state violence by weaving nets of restraint, progressing through cobwebs, strings, ropes and metal cords. The main diagnostic claim of NOW is that the nuclear and related revolutions have, in an instant, transformed the 'hard shell' billiard ball state into eggs, fragile and subject to catastrophe from collisions. The WES insight is that this process should seek not a bigger billiard ball but rather an egg carton-like structure of superpower and extraterritorial deweaponisation.

Elements of a WES System

Four clusters of nuclear security measures are key parts of a WES system. First, at the centre of a WES regime is a new order for nuclear fissionable material. Without this material, nuclear weapons are impossible. And there is a surprisingly small total amount of fissile uranium and plutonium, roughly enough to fill to the rafters of a high school basketball gymnasium. And this material has very distinctive physical properties, most notably its routine and detectable radiological emissions. The various proposals for a Fissile Material Cut-Off Treaty (FMCT) provide the essential starting package: a full global inventory, then cession of further plutonium production (and reductions in uranium enrichment) (Feiveson *et al*. 2014). The implementation of such measures would be a step to 'nuclear zero', but there are several quite different visions of a 'zero nuclear world' (Paul 2012; Perkovitch and Acton 2008; Schultz *et al*. 2008; Steinberger, Udgaonkar and Rotblat 1993).

One path, always available in principle, would be to create a guardianship military apparatus with global scope, and with a complete monopoly of the residual nuclear capability. Another direction would burn (in reactors) or bury deeply the residual. Both these paths would probably be strenuously resisted by nuclear states. A more appealing alternative would be to establish a nuclear 'recessed deterrent' or 'virtual arsenal' force structure. After all deployed nuclear weapons were dismantled and the total quantity of fissile material significantly shrunk, residual capacities to reconstitute nuclear weapons would

be elaborately preserved in isolated and massively hardened sites with robust anti-aircraft and missile defences. These facilities would be alike across all the member states and would be subject to extensive mutual monitoring. The 'around zero' force structure would be essentially designed to 'lengthen the fuse' to increase the amount of time separating the decision to *use* nuclear weapons from the ability to *have* nuclear weapons (Mazarr 1995; Schell 1984, 1998). This reconfigured nuclear force structure also would be configured for what engineers and designers refer to as 'graceful degradation'.

Second is a cluster of test bans and 'open labs' measures to deal with the problems posed by the relentless rapidity of technological innovation arms racing and its project of finding and making ever better ways to destroy and kill. Some of the most effective arms control measures have been test bans, which hobble both development and deployment of new weapons. But to really cork the kill-tech genie bottle, restraints should be placed earlier in the sequence of steps stretching from basic scientific discovery, through technological innovation, to deployment. One simple measure would be to build a global regime in which all states publicise the results of their tests or, even better, only conduct tests on a fully cooperative basis with all other states.

Making such restrictions effective would require versions of the 'open labs' proposal, advanced by Niels Bohr in the early nuclear era (Bohr 1950; Rabinowitch 1959). Remarkably, despite the tremendous potential military applications of basic scientific research, the conduct of scientific research across the international system is still significantly 'open'. Preserving and extending this open information system should remain a high priority. As throughout the Cold War (e.g., the IGY and the ISS), cooperative large-scale scientific projects are an effective way to bolster open science. The Antarctic Treaty regime of disarmament combined with open science, with short-notice visits for verification, is a model that should be expanded and employed in Lunar and Martian exploration. Pushing the openness regime a further step back in the 'kill supply chain' into the weapons design and testing steps is obviously radical from the standpoint of current practice and thinking, but, once implemented, could become regularised and institutionalised as just another part of 'how things are done'.

A third set of nuclear-secure world order measures are institutional. Once the bomb is shrunk and decoupled from rapid delivery systems, the time made available by the reconfigured material infrastructure should be exploited by establishing more institutional checks and balances on the nuclear-use decisions, replacing the current despotic nuclear command arrangements. The decision would be in the hands of 'concurrent authorities' (meaning that more than one actor would be in the decision loop [Raven-Hansen 1987]). And through a process of *correlative constitutionalism*, states would make parallel alterations to their domestic constitutions, producing a mutual restraint arrangement without building and empowering a general enforcer of restraint. To further inhibit violations of the nuclear constitutional order, criminal law would be made universally applicable to all individuals, meaning that 'sovereign immunity' would be partially peeled back, exposing all state leaders and operatives to personal criminal liability. To enforce, uniform standards of policing would be established, and universally accessible courts, with universal jurisdiction on regime-related matters, would also be constructed (Waskow 1963).

Fourth, a nuclear-secure world order should include specifically configured educational systems, as well as ceremonial and ritual activities. These measures would combat nuclear forgetting and compensate for the 'out-of-sight-out-of-mind' character of nuclear weapons and destruction (Deudney 1995b; Mitchell 2021; Weart 1988). The members of the constitutional union of nuclear power restraint should agree to institutionalise in

their educational systems parallel bodies of instruction about the realities of nuclear weapons and the consequences of their use. Leaders of the members of the union would take oaths and periodically gather and ritually and ceremonially pledge their allegiance to the provisions of the union's constitution. It might even be valuable to periodically cooperatively and ritually detonate a nuclear weapon in some remote place, configured for those with nuclear authorities and responsibilities to sit as close as minimally safe.

Another feature of this vision of a world nuclear security order is that parts of it can be built directly by the states that are currently nuclear-weapons-free and supporting the nuclear ban treaty. These states could start implementing anti-nuclear educational, ceremonial and ritual measures among themselves and then invite and pressure the nuclear states to join them.

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