SECTION THREE

CALIBRATING THE THREAT FROM CHEMICAL, BIOLOGICAL AND RADIOLOGICAL CAPABILITIES

Characterising the Regulatory Environment

> In recent years, a new proliferation dynamic has developed, with greater availability of components, technologies, expertise, and information. This availability stems from the willingness of various state suppliers, or companies within those states, to sell materials, and a veritable information explosion from academic and commercial sources, or the Internet. It also may be fueled by weakened security at some key NBC related facilities in the former Soviet Union, the search for employment by unemployed scientists and technicians associated with active or formerly active Soviet programs, and the transfer or sharing of technology among states trying to develop programs.[1]

The development of more effective controls against non-state micro-proliferation and the use of WMD capabilities depends on an understanding of what characterises and defines the CBR materials as much as it does in providing for efficient regulatory structures. Understanding the critical paths and development sequences involved in the attainment of a capability is the only way vulnerabilities, and indeed risk, can be calibrated. Recognising those unique and dual-use characteristics that distinguish the regulation of CBR risk materials from existing regulatory structures, which in the main are focused at occupational

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[1] Office of the Secretary of Defence, *Proliferation: Threat and Response*, p 4.

health and safety requirements, is a critical first step towards more effective control and an increased preemptive capacity throughout any regulatory structure.

Capability development processes are difficult to define for WMD state programs with the range of permutations and combinations of agents, development routes, uses and weaponisation characteristics providing for an infinite range of options.[2] Attempting to apply the processes associated with a state program to a non-state development process that is determined as much by the 'state of mind' of the belligerents involved, individually and collectively, stretches any existing analytical paradigms beyond capacity. The issue is then further exacerbated as there is little anecdotal evidence and non-state actors would not be expected to be constrained by the same efficiencies and outcomes that would be required of a state WMD program.[3] Yet the utility in examining state WMD programs is not necessarily found in the processes for research, production, testing and weaponisation, but rather in the analysis of the limitations and vulnerabilities.[4]

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[2] For example, nine production process have been identified in open literature for sulfur mustard. For further information see S. M. Samani, *Chemical Warfare Agents: Toxicokinetics and Toxidynamics of Mustard*, Academic Press, New York, 1992, pp 13-43. For more general information on mustard and other agents see H.D.Crone, op. cit., For information on technologies related to production and sulfur mustard see Office of Technology Assessment. *Background Paper: Technologies Underlying Weapons of Mass Destruction*. Washington DC, 1993, Chapter Two, and Department of Defence, Military Critical Technologies, op. cit., Section III.

[3] One of the most interesting examples of a past state WMD program and one which affirms the potential of CB agents for discriminate and non-state use was to be found in the now defunct covert South African CB program. The program only came to public attention relatively recently, mainly as a result of the information and testimony presented at the South African Truth and Reconciliation Commission. The program, referred to as 'Project Coast', included a bizarre range of biological agents and delivery systems, most being used by the state against individuals or groups of people deemed to be security risks or enemies of the state. Agents researched and employed included cholera and anthrax which were at times incorporated within the gum of envelopes, filters of cigarettes and inside chocolates. Other agents included thallium, ricin, nerve agents, snake venom, paratyphoid, plague, hepatitis A and HIV. A lot of information on the scope of the program and numbers of victims over the years is still unknown, and will probably remain so. If nothing else, the program demonstrated wide innovation and technical capacity both in the nature of the agents developed and in the delivery systems utilised. For further information see T. Mangold and J. Goldberg, *Plague Wars: A True Story of Biological Warfare*, United Kingdom, MacMillan Press, 1999, pp 255-265.

[4] Most expertise in NBC research and development has historically and functionally been held within classified defence programs. As a consequence, despite the increasing diffusion of technical information related to the subject, the relevancy of forensic science, microbiology and chemistry specialists is limited, particularly on aspects specific to warfare agents and their weaponisation, production, protection etc. Office of Technology Assessment, *Proliferation of Weapons of Mass Destruction: Assessing the Risks*, Technology Assessment Board of 103rd Congress OTA-ISC-559, Congress Publication, Washington DC, 1993, pp 2-31.

There is a wide array of misinformation on the capabilities of dual-use CBR materials, equipment, services and more so on the capacity of non-state organisations to utilise and employ them. Assertions tend towards overstatements in lethality, ease of production, capability and the relevancy in many of the controls that are applied in the regulation of CBR risk materials. The complexity of the issue is mired within the categorisation and classification of the materials as much as it is in simply attempting to define what are the risk CBR capabilities. While this thesis focuses on attempting to develop a greater level of preemption through the management of risk, this can only be achieved if the regulatory controls actually reflect an effective capacity to reduce, detect, enforce and respond to non-state threats. In essence, this means that regulatory controls must maintain a relevancy, specificity and application across the entire spectrum of CBR activities if measures are to have any real and preemptive influence.[5]

In essence, it is the issue of ensuring that regulatory controls are relevant and that risk is effectively defined within a non-state context that will determine the efficacy of deterrence measures. Hence, this section of the thesis seeks to examine the concept of risk in terms of more efficiently defining and categorising CBR agents, micro-organisms, toxins and radioisotopes. The section then examines in detail each of the CBR capabilities separately, analysing regulatory issues specific to the characteristics of both the materials and their potential for non-state use. The methodology used to assess this involves looking at the components in the capability process in aggregate and as discriminate sections, where key vulnerabilities and elements of risk can then more clearly be identified.

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[5] In *Toxic Terror*, Tucker profiles twelve of the more widely known historical CBR incidents. His assertion, which is consistent with wider reporting (or misreporting) of CBR cases, is that there has been so much misinformation that it has become self perpetuating with many analysts now continuing to contribute to the cycle of this misinformation through largely uninformed reporting. He highlights three cases that have some elements of accurate reporting within the activities of the different groups but, the overall nature and validity of the cases suggests that they may not have occurred as reported or interpreted (or may not even have occurred at all). These incidents refer to putative reporting of chemical or biological agent use by the Baader-Meinhof Gang, Red Army Faction and a radical United States group – The Weather Underground. A similar theme is highlighted in reporting on the Japanese Cult – Aum Shinrikyo, in particular their purported biological agent development program, major components of which now appear to have been products of misinformation. Tucker, op. cit., pp 249-269. For further information see Leitenberg, 'The Experience of the Japanese Aum Shinrikyo Group and Biological Agents', pp 159-172.

Rather than attempting to provide detailed scientific, technical or engineering profiles on the characterisation of all CBR materials, only those limitations and vulnerabilities that may be relevant to non-state use, or that may influence the exercise of any counter-measures, are examined. Ultimately, the purpose of the section is then to examine the range of capabilities against which regulatory controls are currently exercised and on this basis how identified vulnerabilities within the CBR capability development process can be used to increase the control of these risk capabilities.

Defining the Regulation of CBR Materials.

The prescriptive and didactic analysis of agents and applications throughout most academic and military NBC texts often fails to adequately represent the variation and potential range of capabilities, particularly in the analysis of those that may be of potential utility within a non-state WMD context.[6] The decision to adopt, develop or acquire a capability is determined by many influences. There can be little doubt the influence that wider public awareness, the media and current activity trends has had in creating an environment more susceptible and vulnerable to CBR type activities – a fact not lost on potential belligerents. An example of this is best highlighted in the environment that followed the deaths of four people from inhalational anthrax in the United States in the two months following 11 September 2001. The threat environment following the anthrax attacks in the United States not only served to increase government and public awareness of any vulnerabilities, but advertised the lack of capacity in responding to such threats. Indeed, the actions of the government and the media has also served to identify the range of specific agents against which society is most vulnerable – in this case *Bacillus anthracis*. The difficulty will also always be that the capability to deliver an effective hoax requires no commensurate real capacity. This issue has not been lost on the thousands of disaffected people and anarchists that have saturated governments throughout the world with hoaxes. The proliferation of hoax activity, in particular, appears to have been perpetuated

[6] For further information on the use of chemicals within society and issues relating to the utility of the Chemical Weapons Convention scheduled chemicals within industry, see H. Crone, *Banning Chemical Weapons – The Scientific Background*, Cambridge University Press, Melbourne, 1992.

by protagonists mainly on the basis of lessons learned rather than by a rational and deductive analysis of the most effective agent.

The identification of capabilities derived from sampling, equipment used or services employed, involves a more quantitative analysis process when compared to attempts to recognise behavioural and activity patterns. And so it is in the selection of a CBR agent for development and use, whether for state or non-state employment. State sponsored WMD programs more often selected volatile liquids or those that were stable under certain environmental conditions when identifying agents of potential utility. These more often provided for an acute inhalation hazard and percutaneous threat which was the most effective and of the widest utility for any offensive use.[7] There are of course numerous other factors that impact on defining the effectiveness and utility of CBR capabilities. These may include volatility, toxicity, lethality, viscosity and temperature parameters (surface, air, gradient, wet bulb or dry bulb). Unlike state WMD programs, however, which may focus on aspects of increased production or stockpiling, the uniqueness of non-state development means that there may be significant changes from the standardised processes and routes applied to WMD state program development. The consequences of this are that signatures and the recognition of activities may be fundamentally different to those involved in non-state development. Just as critical are those processes in non-state development that may be circumvented or circumscribed altogether given the different requirements. The augmentation and stabilisation of materials through the use of additives or specialised processing to increase storage, purity and any utility for weaponisation, such as the use of binary agents, need not be as significant an issue within non-state development.

Considerations of efficiency and cost are not necessarily complementary to effectiveness when applied to non-state concepts of development. Most modern safety and efficiency considerations were dismissed by Iraq in the development

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[7] ibid., p 3. This is in fact a simplification of the selection criteria as agents are identified and developed for specific environmental conditions (for example exposure, temperature, stability, degradation, etc.), or for factors such as their capacity to break through protective systems, such as individual protection equipment. For example, mask penetrants such as some of the blood agents.

of its own WMD capabilities. Similarly, it would be expected that the same considerations would then apply, and indeed even more so, in non-state development.[8] Considerations of safety, handling and efficiency would more probably be offset against those of expediency, covertness and utility. The use of biosafety handling facilities, high production costs through the degradation of materials and the need for anti-corrosion resistant containment systems to increase safety, effectiveness and efficiency, could be easily circumscribed or considered as acceptable costs. For example, in the production of chemical agents, specific processes in the production run require corrosion resistant equipment. A non-state organisation, particularly in producing only reduced quantities of agent when compared to a state program or a commercial processing plant, may accept the corrosion or choose to replace the damaged equipment more frequently. While this degradation may ultimately impact on the efficiency of the process, it may still produce the desired outcome. While in commercial terms this would be considered as inefficient, to a highly motivated and well resourced non-state organisation, it is not insurmountable and may not necessarily matter.

Attempting to correlate developmental activity to an increased potential for interdiction, particularly given the range of variables, does not have a simple template against which the likelihood or effectiveness can be calibrated.[9] While identifying the processes involved assists in understanding the outcomes, it does not define how a program might evolve. It is, however, those core vulnerabilities and risks within the development process that provide the best opportunity for

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[8] Iraq's willingness to tolerate a high incidence of injuries and deaths among the staff involved in research, production and weaponisation has been well established. Iraqi officials admitted to United Nations inspectors that there were about 100 accidents per year involving chemical agents – 10 of them major. 'News Chronology: August through November 1991', *Chemical Weapons Convention Bulletin Number 14*, Harvard Sussex Program on Chemical and Biological Weapons Armament and Arms Limitations, United States, December 1991, p 16, footnote 50, as cited in Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 47.

[9] The risk for analysts in evaluating processes is in applying cultural and ethnocentric biases, most particularly western safety standards or their own typologies applied to containment, handling and processing systems, against those of the belligerents. It is unlikely that a non-state organisation would establish many of the western safety standards and in many cases, it appears more probable they would accept the risk to their own people as well as the degradation in the process efficiency. For example, the Aum's Satian sarin production facility contained major safety breaches where personnel were not properly protected; eating and sleeping occurred in close vicinity to the production processes; and there were no scrubber and air evacuation systems. Ishikura, op. cit., pp 45-62.

any regulatory controls to influence. Hence, analysis of capabilities is possibly best identified by stages of greatest risk within the process, such as research and development, production, testing, weaponisation and actual employment. For example, rather than attempting to define the various processes associated with the range of combinations in the alkylation reactions for the production of nerve agents, there is greater value in identifying the vulnerabilities. In the case of alkylation reactions, the risks are in the processes and equipment for the handling of high temperatures and corrosive reagents.

While there has always been the potential to use CBR agents as weapons of terror and mass destruction, the prospect has generally been dismissed on the basis of visceral reasons or as a theoretical improbability. It was either considered as not commensurate with known non-state motivations and capabilities or the access and availability of the technologies and materials was believed to be too restrictive. Embedded within these widely held misperceptions were unrealistic expectations in the capability of many of the materials. While there is no contention over the extreme lethality and toxicity associated with many of these materials, it would only be under optimal conditions that their actual potential would more likely be realised. This would be dependent on the confluence of a wide range of environmental, meteorological and situational conditions such as to suggest an extremely improbable set of conditions. Yet establishing the actual improbability and outcomes for any type of use is critical in calibrating risk, and hence, a significant component of this section within the thesis is focussed on the processes and vulnerabilities that are identified in the assessment of potential.

The failure to provide for balance and rigor in the assessment and calibration of threat leads to a perpetuation in risk itself. The common misperception is to compare CBR capabilities to a poor man's atomic bomb. There is no shortage of these widely held perceptions. Whilst not only misleading, they are in many cases, counter productive and highlight the radical disjuncture between reality and perception.[10]

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[10] J. D. Douglass and N. C Livingstone, *America the Vulnerable: The Threat of Chemical and Biological Warfare*. Lexington Books, United States, 1987, pp 16-18. To make a comparative analysis of nuclear and CBR capabilities is to equate essentially two unrelated issues. The immediate outcomes in terms of

> [chemical and biological weapons] can be produced without much difficulty and in relatively short time. Such weapons could be built clandestinely by individuals of moderate educational attainment with only a minimum of tools and space. Nearly all of the equipment needed could be improvised or purchased without arousing suspicion...
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> They pose far less hazard than attempting to build a nuclear weapon and can be applied covertly, allowing the terrorists ample opportunity to get away before the attack is discovered. Dissemination of the agent can be easily disguised...
>
> Chemical and biological warfare agents, by comparison to fissionable devices, are characterised by a high degree of reliability. Because of the inability to test it, any terrorist built nuclear bomb would stand a high probability of being a dud. A chemical, biological and radiological device, on the other hand, could be field tested with only moderate risk to the security of the project.[11]

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physiological effects are quite different. For example, the blast, shock and heat effects from a nuclear blast compared to respiratory, blast (different effects), ocular and contact hazards from many CBR materials is quite wide ranging and varied. While there is a similarity in the physiological impact in terms of the visceral fear both categories of weapons evoke, the technical competencies involved in the development of a nuclear capability are quite separate from those in CBR capability development and use.

[11] ibid. p 16. The confusion and misrepresentation in the comparison between nuclear and CBR capabilities is often compounded by the assumption in the ease of development of CBR capabilities, particularly when contrasted with the difficulties in acquisition alone of enriched uranium or plutonium, each a key component (dependent on the route of development) for a fissile nuclear weapon. The comparison is emotive and unfounded. While the technical requirements for development of a WMD CBR capability are analysed in later sections of the thesis, needless to say the claims regarding the ease in access and production of an effective capability, particularly those asserted in Douglass and Livinstone's quote, are significantly overstated. For a detailed overview of the technologies and proficiencies required for the production of CB weapons, see Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, Chapters Two and Three, and Department of Defence, *Military Critical Technologies*, Sections III and IV.

Analysis of previous non-state activities suggests that most development will be facilitated as a result of fraudulent or illegal procurement of precursors, seed stock, cultures, etc. Even in the case of the Japanese Cult Aum Shinrikyo, which reportedly produced a relatively wide range of sophisticated chemical and biological agents, the precursor materials used were obtained through legitimate networks and front companies. This was mainly executed through the falsification of documentation, misrepresentation of intent and the provision of false information, with most dual-use materials being acquired domestically.[12]

The work carried out to support WMD activities has generally always been contained within military state sponsored programs which have been either covert or classified. The programs, whether offensive or defensive, have broadly consisted of activities directed towards protection enhancement, equipment development, biomedical analysis, detection, prophylaxis or the characterisation of agents. The growing concern is that many of these programs, even those within the west, which are all now defensive in scope, are becoming increasingly porous. Wider entitlements within the freedom of information processes, along with secrecy periods on previously classified research now lapsing, often twenty, thirty or fifty years from when these agents were first developed, indicates that the availability of critical components on CBR production and weaponisation research is more openly available than ever before. This is particularly the case through institutions such as universities and national reference libraries. For example, production techniques for most of the major chemical agents have been published 'in the open patent or chemical literature including data on reaction kinetics, catalysts and operating parameters'.[13] As a consequence, the availability of research material on CBR agents appears to have increased considerably, yet establishing how significant this risk is will remain indeterminate simply due to the volume of information available. This reaffirms the earlier point that the increasing availability in sensitive information can be

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[12] In addition to companies established by the Cult, such as Hasegawa Chemical and Shimomura Chemicals, they also operated through a range of other legitimate firms that were owned by Cult members, yet also aided in the acquisition of precursor materials and equipment. G. Cameron, 'Multi-track Micro-proliferation: Lessons from Aum Shinrikyo and Al Qaida', p 93.

[13] Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 18.

closely correlated to the growing number of hoaxes and incidents of possession, particularly in areas with a high incidence of existing activities, such as in the United States.[14]

The utility of many chemical and biological warfare agents is well established. While many of the same warfare agents were first used over eighty years ago, their capacity to cause major physiological and psychological damage, despite developments in protection and detection, is as real now as it has ever been. 'Few military technologies have evolved as little as chemical weapons over the past fifty years, and indeed the current generation of vesicants and nerve agents are based on scientific discoveries made during the two World Wars'.[15] The issue of the enduring utility of these capabilities is highlighted in the relative success of Iraq's covert WMD program. The program actually utilised processes for the production of thiodiglycol which primarily involved the production of vesicants developed by Germany during World War I. 'It does not require a particularly sophisticated chemical industry and could be performed in a basement laboratory'.[16]

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[14] Data from the FBI estimate between 400-500 anthrax hoaxes per year. M. Nemeth, 'Anthrax Hoax Becomes a Copycat Trend', *Associated Press*, (accessed 21 March 2001), http://www.news-press.com/news/today/010301anthrax.html. While there are a range of reasons for the increasing frequency of hoax activity, from 'copy cat syndrome' to genuine anti-government sentiment, the increasing trends are partially attributable to the wider availability of previously sensitive or classified materials related to development, production etc. Access to this type of literature is often facilitated through Internet sites and literature released by disaffected individuals or groups. For example, available through the Internet are the Uncle Fester manuals and Poor Mans James Bond books which outline a range of process for development of explosive materials through to the selection of materials for the construction of 'mantraps'. While much of this material is of questionable value and of limited scientific veracity, there are some manuals that provide sensitive and explicit details of CB agent production and the wide availability of this information makes the orchestration of an elaborate hoax or development of a rudimentary capability, a prescriptive and mechanical process.

[15] For further information see Office of Technological Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, pp 15-118.

[16] Thiodiglycol is basically one step away from production of sulfur mustard and only requires a reaction with hydrochloric acid which is widely available within industries throughout most industrial nations. The comment on the ease of production refers to mustard production. The production of more lethal nerve agents is a significantly more technical and dangerous processes, commonly involving four and five step reaction processes. These involve complex heating and cooling reaction vessels for unstable intermediataries that react explosively with water, steam-heating and water-cooling (which must be replaced with special heat-exchange fluids and heating oils that require the use of cooling towers rather than steam vents). Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, pp 22, 45.

The physical state of these agents varies from liquids, vapours, gases or an aersolised suspension. The physical state is dependent on many factors, ranging from the type of agent, its means of release, to ultimately its efficacy. Yet the actual route of entry in the body, in the end, is the major determinant of the efficacy in any outcome. Hence, an effective attack using CB agents would be determined, *inter alia*, by such factors as the particulate size, virulence and volatility, which are all key factors that influence the route of entry and the dose received.[17] In essence, the specific CBR agent, micro-organism, toxin or radioisotope that would be the most effective is dependent on an extremely complex array of technical and environmental factors, yet the strongest determinant of success is in the selection of those CBR materials that are most complementary to the tactical or strategic outcomes sought.

Regulatory Definitional Criteria

Defining the nature of CBR threats and risk is as complex as defining the term terrorism. Defining the issue is exacerbated by consumption, processing, volumes and ratio problems. Yet the critical issue is in defining what dual-use capabilities are of utility to the non-state actor and in establishing the criteria of the materials, equipment or services that are to be controlled. For example, toxins are defined as chemical agents in the Chemical Weapons Convention (CWC), yet it only includes the regulation of saxitoxin and ricin.[18]

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[17] See World Health Organisation, *Health Aspects of Chemical and Biological Weapons*, 1969. Despite the date of release, this publication remains one of the most comprehensive and detailed sources of information on CB agents and their physiological effects. It is also one of the few publications that provides analysis on casualty estimates based on the technical parameters and characterisation of the agents and their method of release. While most of the data is focused on state programs, data on delivery and the effectiveness of agents in various physical states is relevant to many aspects of non-state use of CBR agents. The World Health Organisation released a draft second edition titled '*Health Aspects of Chemical and Biological Weapons*' in August 2001, yet this publication lacks the earlier detailed data derived from modeling and live agent testing (drawn from the United States former offensive research and development program).

[18] Ricin is the only toxin to exist naturally in large quantities, is a by product of castor oil production and is achieved through a process involving physical separation. This is a relatively cheap process, with few major equipment requirements – a point not lost on many United States based criminal groups. The use of ricin has received wide publicity as a result of the assassination, facilitated by the Russian KGB, of a Bulgarian émigré, Georgi Markov, in the United Kingdom in 1978. The weapon utilised incorporated a ricin pellet which was inserted on the head of an umbrella and then injected percutaneously. Right wing groups in the United States in particular appear to have been attracted to the KGB's use of ricin and a number of these groups have been involved in several incidents involving possession of ricin. More recently four men from a group known as the Patriot's Council, manufactured ricin with the intent of using it for assassination purposes. The men were convicted in Minnesota in 1995 for violating the

Paradoxically, all other toxins, including ricin and saxitoxin, are then also covered in the definitions of biological agents within the Biological Weapons Convention (BWC).[19] The important point is that the efficacy of these international controls and the effective application of domestic legislation is critically dependent on an understanding of what constitutes a chemical agent, isotope, micro-organism or a toxin if the controls are to be applied effectively throughout the spectrum of CBR activities.

The difficulty within most of the definitions is in reflecting considerations of intent or potential. Yet these considerations must also be traded off against inadvertently or unnecessarily imposing restrictions, or at least minimising, the impact on legitimate activity involving research and trade. The problem with the use of 'intent' within any definition is in the extremes in which it may be interpreted or applied. For example, the Australian Customs Service qualifies the definition of CB capabilities as those materials that are to be utilised for 'offensive use' as a 'warfare agent' or for 'warlike purposes'. The distinction between warlike and offensive purposes and simply establishing hostile intent is significant in that the warlike actions are premised on specific conditions and a function of a state's actions rather than those of the individual. This renders any efforts to control CB materials relatively ineffective as they are then further predicated on use by armed military forces – an extremely difficult context in which to prove an application for non-state use within the current Australian environment.[20]

While the definition of CBR agents should include aspects of intent, how it is currently applied nationally renders it an incomplete and ambiguous concept. Whatever the definition applied, it must be functional and have the capacity to be

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Biological Weapons Anti-Terrorism Act of 1989. Saxitoxin is a paralytic shell fish toxin harvested from puffer fish, yet due to production and acquisition problems, is less likely to have the utility of ricin, particularly when considered for its utility in non-state use. Department of Defence, *Military Critical Technologies – Weapons of Mass Destruction*, pp 90-91, and Office of Technological Assessment. *Background Paper: Technologies Underlying Weapons of Mass Destruction*, pp 90-94.

[19] While having some of the same characteristics of as chemical and biological agents, toxins are non-living poisons which have been made by living organisms (unlike chemicals which are manufactured).

[20] See Australian Customs Act for more defined specific criteria for the export (Regulation 13E – Customs Act 1901) and import (Section 233 – Customs Act) of controlled goods. The relevancy and development of these controls is addressed in Appendix Two to Section Four of the thesis.

widely applied throughout legislation and regulatory controls and yet also incorporate aspects of technological change and context. Additionally, as is currently the case, materials may be controlled for use in state programs, yet the same materials are then not regulated on a national basis or in discrete quantities. Hence, while the definitional criteria should seek to incorporate the characterisation of CBR materials, it must also reflect performance based criteria. As an example, the World Health Organisation limits the definition of CBR materials as follows:

> Warfare agents which include all substances employed for their toxic effects on man, animals or plants. This definition is intended to exclude chemicals employed for specific tasks or within certain conditions such as high explosives, smoke and incendiary substances (eg napalm, magnesium, and white phosphorus) that exert their primary effects through physical force, fire, air-deprivation or reduced visibility.[21]

Despite the appearance of a wide ranging application, this definition highlights the difficulty in articulating functions of technical criteria against those that are outcome based. The World Health Organisation definition excludes most non-state activities, particularly those involving improvised use and the release of CB materials via unconventional methods. Additionally, any application of the definition is confined to use in armed conflict or during a state of war, thereby more likely limiting the release of materials to conventional weaponised delivery.

It is the utility of the agent, micro-organism, toxin and radioisotope which is ultimately the key determinant of how CBR materials should be defined, yet nearly any material can be toxic or lethal in quantity or application. Many materials, however, through either only being produced on a relatively small industrial scale, a low mammalian toxicity or simply a lack of availability, impact

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[21] World Health Organisation, op. cit., p 12.

on considerations outside those just concerned with utility. Controls covering those less regulated agents such as chlorine, ammonia and phosgene, should not be predicated on simply defining their use on the basis of utility. Rather, they must include wider considerations of risk, particularly when contrasted against the historical record in the use of these same materials. The previous examples of the Australian Customs and the World Health Organisation's attempts to define outcome and technical criteria are not only confusing, but more importantly, are unlikely to apply to most situations involving non-state development. As critically, they are unlikely to have any real application as a statutory definition within any nationally mandated legislative structure. Hence, the establishment of regulatory and definitional criteria on the basis of risk provides for not just a wider scope in any application, but also includes those important considerations of capability, threat and consequence.

CHEMICAL AGENTS AS WEAPONS OF MASS DESTRUCTION

The generic term 'chemical agents' covers a wide range of commercial and military agents, however, the use of the term 'chemical warfare agents', also in itself denotes specific considerations of utility, toxicity, lethality or incapacitating result. There is no clear, single or unambiguous definition which covers the continuum of chemical agents. Any use of the term should seek to retain as wide a functionality as practicable within its scope. For example, a chemical lachrymatory agent such as tear gas when employed in an offensive manner by military forces, regardless of its limited incapacitating ability, would be classified as a warfare agent.[22] More so than with biological agents or within the nuclear industry, the development of a chemical capability is fundamentally more than the acquisition or development of a toxic or lethal compound.

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[22] The use of lachrymatory agents is similar to herbicides, however, the Chemical Weapons Convention is specific in excluding its classification as a warfare agent when it is used as part of a police action during a period of civil disobedience or unrest. Its use, however, by military forces in a theatre of war then categorises it as a warfare agent, thus placing the country which employed the agent in breach of the Convention. Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction 1994, (accessed 1 February 2001), http://www.opcw.nl/.

The spectrum of chemical agents is itself diverse and ill-defined, with an estimate of upwards of 750,000 new chemicals introduced each year.[23] While toxicity and lethality remain fundamental considerations in the development of any agent for military purposes. In terms of the utility for non-state development, access and acquisition are as significant, suggesting that the most lethal may not necessarily reflect the most effective agent.[24] The historical record suggests selection of an agent by a non-state organisation is also largely based on opportunity. That is, it is a compromise between such factors as intent, access, outcome and the regulatory controls that control use.[25] Trends in current reporting of incidents worldwide highlight the predominance of chemical threats, hoaxes, interest and attempts at acquisition, as opposed to any significant trends in actual development. Most chemical incidents have been directed at possession and the use of lachrymatory agents – specifically tearing agents, however, there is also a high incidence in the reporting of cyanide and chlorine, reaffirming the limited nature of non-state chemical agent development and use.[26]

In terms of the actual chemical spectrum of agents, at one extreme are the toxic industrial chemicals, which includes poisons and contaminants that are typically used for agricultural, industrial or research purposes (which incident reporting has noted predominantly involves poisoning, assassination and hoax type

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[23] For further information on the application of chemical warfare agents and the range of organophosphates, see Ishikura, op. cit., pp 76-79. Ishikura's use and the origin of the figure of 750,000 new chemicals annually is unclear (see section three, footnote number 24). It is more likely Ishikura's estimate is based on combinations of agents, admixtures, new synthesis routes etc. The critical aspect of the estimate is not in the total but in the potential. Even if the actual figure is one tenth of the estimate made by Ishikura, its significance is in highlighting the porosity of the chemical industry and the pervasiveness of chemicals in use.

[24] As at 1 March 2001, the Chemical Abstracts Service (CAS) Registry contains 17,688,891 organic and inorganic substances and 12,072,228 biosequences. The Organisation of Economic Co-operation and Development list of high production volume chemicals contains 5,234 chemicals which are produced at levels of greater than 1000 tons per year. In terms of those chemicals for instance in the Chemical Weapons Convention lists, compared to all others, the difference is minuscule. Chemical Abstracts Service Registry, (accessed 24 April 2001), www://cas.org/cgi-bin/regreport.pl, Chemical Abstracts Service Online Chemicals Catalogs File, (accessed 24 April 2001), www.cas.org/CASFILES/chemical.html, Chemical Abstracts Service Regulated Chemicals Listing Database, (accessed 24 April 2001), www.cas.org/CASFILES/chemlist.html. Organisation for Economic Co-operation and Development, *List of High Production Volume Chemicals*, Environmental Directorate, Paris, 2000.

[25] *2000 Monterey WMD Terrorism Chronology.*

[26] ibid.

activities).[27] Increasing in potential, yet still within the toxic industrial spectrum, are those agents with an increased volatility, lethality and risk which are more likely to be effective as acute inhalation hazards, that is, they could be disseminated as a gas or an aerosolised suspension. This includes some of the agents previously utilised as warfare agents such as phosgene, chlorine, ammonia and cyanide, with most having the greatest utility within an area that is restricted in airflow or within a confined space.[28] At the extreme end of the spectrum, particularly in terms of lethality and toxicity, are the chemical warfare agents, which includes organophosphorus compounds, vesicants and arsenicals.

There are approximately sixty warfare agents of any real utility (not including many of the homologues), that have been stockpiled or previously utilized within state WMD chemical offensive programs.[29] While it may be the expectation that many of these warfare agents and their precursors would have only a limited availability throughout industry, in fact it is quite the opposite. Table 2 provides an overview based on producability and the range of civil applications, in which

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[27] The use of the term 'toxic industrial chemicals' is as wide ranging as the term 'chemicals' is. The United Kingdom, Canada and the United States (Australia has not attempted to define the term) define an industrial chemical as any agent which has a LCt_{50} value of less than 100,000mg.min/m^3 on any mammalian species and is produced in quantities exceeding 30 tonnes per year at one production facility. That is, it includes those chemicals that would normally be gases, liquids or solids and with high vapour pressures at 20 degrees Celsius. Given the lower volumes and scales of production within Australia, qualifying criteria would apply on similar criteria, however, it should be based on national aggregates and apply to one ton production quantities. S.V. Armour, R. Shayer, J. Rista, J. Hughart, *Toxic Industrial Chemicals In Military Operations*, Symposium on Operational Medical Issues in Chemical and Biological Defence, Washington DC. 2000, pp 4-5.

[28] The determination of what then constitutes a toxic industrial chemical (within Australia this refers to those classes of chemicals which are listed as 'Industrial Chemicals' and 'Agricultural and Veterinary Chemicals'), means further identifying criteria other than on toxicity and production. The Registry of Toxic Effects of Chemical Substances has 1164 chemicals which meet this criteria (based on toxicity). Further defining those that have an appreciable vapour pressure at 20 degrees Celsius (in solids, liquids or gases) or that are considered as 'hazardous' in the United States Department of Transportation Emergency Response Guide (which is what Australian hazardous materials response and regulatory requirements are based on) or by the United Kingdom Health and Safety Executive, the list can be further defined to 156 chemicals. This criteria, however, does not consider combustion products, carriers, chronic exposures, percutaneous exposures or solids. ibid., pp 4-6 and Registry of Toxic Effects of Chemical Substances, United States Department of Health and Human Services, National Institute for Occupational health and Safety, Registry of Toxic Effects of Chemical Substances, Division of Standards Development and Technology Transfer, Cincinnati Ohio, 2000.

[29] Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 18.

many of these agents during commercial or industrial processes are consumed or produced.[30]

Table 2 – Civil Application of Chemical Warfare Agents and Precursors

Chemical Warfare Agent	Category	Specific Agent or Derivative	Civil Applications
Blister	Vesicants Urticant Arsenicals	HN – Nitrogen Mustard HN-1, HN-2, HN-3 HD – Distilled Mustard HS – Sulfur Mustard CX - Phosgene Oxime L – Lewisite	-Organic synthesis -Carriers for dyes textiles -Lubricant additives -Manufacturing plastics -Chlorinating agents -Catalysts -Pesticides -Engineering plastics -Solvents -Manufacturing ethylene-oxide and ethylene -glycol -Paper manufacturing
Nerve	G-Series	GB GD GA GB/GF	-Organic synthesis -Paint solvent -Lubricant additives -Plasticisers -Flame retardants -Surfactants -Dyestuffs -Hydraulic fluids -Pharmaceuticals -Textile softeners
	V-Series	VX	
Blood		AC CK	Extraction of gold and silver Fumigant Manufacturing dyes Hardening of metals Nylon production
Choking		CG – Phosgene	-Basic component for synthetic chemistry used in a wide range of industries

Similarly, as a guide to identifying the range and number of facilities that may handle these agents or conduct research on chemical warfare agents in Australia, Table 3 reflects national production, research and consumption facilities for Chemical Weapons Convention chemicals as at late 2000. The table highlights both the diffusion of the chemicals and their relatively wide access and availability throughout the research, government and commercial sectors nationally.[31]

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[30] For further information on chemical agents, prophylaxis and protection see United States Department of Defence, Office of Surgeon General, *Textbook of Military Medicine, Warfare, Weaponry and the Casualty Part 1 - Medical Aspects of Chemical and Biological Warfare*, United States, 1997, pp 15-70.

[31] The expectation that as Australia only maintains a relatively modest effect directed towards defensive chemical and biological research and as a state party to regimes such as the Chemical Weapons Convention and Biological Weapons Conventions, that it would not hold any of these more lethal classes

Table 3 – Chemical Weapons Convention Scheduled Facilities in Australia as at June 1999

Number	Type	Facility
1	Protective Facility	Schedule 1
7	Research Facility	Schedule 1
2	Consumption Facility	Schedule 1
11	Processing Facility	Schedule 2
4	Production Facility	Schedule 3

Note: Trade data is based on permit applications and there remains the potential for companies involved with Schedule Chemicals to be unaware of their obligations within the national legislation - Chemical Weapons Convention Act 1994. Source: Australian Safeguards and Non-proliferation Office Annual Report 1998/1999, p 42.

WMD capable countries such as Iran, Syria and Iraq highlight the hypocrisy and relative ease with which these capabilities can be maintained within covert programs through deception and denial measures.[32] WMD programs are often integrated into existing civil or government research and production programs whereby capabilities can be maintained, often on an enormous military scale, with few signatures of activity.[33] Interestingly all WMD offensive programs, including the previous program in the United States, encountered difficulties throughout the development stages, most particularly in weaponisation, agent development and employment of delivery platforms.[34] Yet in attempting to minimise many of these activities there are a range of concealment measures, particularly for a state

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of materials, or the industrial or military required for their use. Surprisingly, however, the availability of many of the extremely toxic and specialised chemicals and pathogens are available throughout a range of academic, research and commercial facilities, albeit in only minor quantities. For example, agents such as saxitoxin are used for cancer and cardiac research and nitrogen mustard for work on cancer. There is no contention over the use or value of these materials within Australia and there has never been a major security incident (at least reported) involving the release, loss or theft of scheduled chemicals. Nevertheless, they pose a potential security risk if stored, secured, handled, transported or accounted for ineffectively. Commonwealth of Australia, *The Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and On Their Destruction – Initial Declaration*, 22 May 1997.

[32] Tanter, op. cit., 83-128, 177-204, and Office of Secretary of Defence, *Proliferation: Threat and Response*, pp 33-52.

[33] The final determination in the status of the Iraq WMD program by the United Nations Special Commission (UNSCOM), now the United Nations Monitoring and Verification Inspection Controls (UNMOVIC), remains outstanding. Finalisation of precursors, production, quantities and locations, specifically for mustard and VX production and weaponisation, are unlikely to ever be resolved completely, despite United Nations inspections in Iraq over a period of nearly ten years. For further information on outstanding and declared issues related to Iraq's last declaration to the United Nations Security Council see T. Findlay and S. van Moyland, *Verification Watch Online Publications*, United Kingdom, May 1998, (Accessed 12 January 2001), www.vertic.org/tnv/may1998/watch.htmlUnited.

[34] Office of Technology Assessment, *Proliferation of Weapons of Mass Destruction: Assessing the Risks, Technology Assessment Board of the 103rd Congress*, United States, 1993, pp 10-11 (table 1-1).

program, that can be adopted to reduce wider visibility of any illegal activities. In order to facilitate this, some countries may seek self sufficiency in precursor production or may manufacture controlled equipment themselves, thereby reducing the requirement to import key materials and equipment.[35] This can be juxtaposed to non-state development where the greater the self-sufficiency and the more established the proliferation networks, the wider the potential for covert activity, hence, the greater difficulty in the detection of any capabilities. While indigenous production is most unlikely given the limited scale of non-state requirements, similar measures aimed at reducing acquisition, effluent, production and testing signatures may just as easily disguise other proliferation or development activities.

The limited expertise and finite nature of resources available to a covert state WMD program are magnified when compared to a non-state organisation. The requirement to produce extremely toxic chemicals requires specific handling processes, acquisition of specialised equipment, appropriate facilities and importantly, a range of disparate and highly specialised services and knowledge. These are not easily recruited, acquired, hired or employed in a small and covert operation that would be envisaged for non-state chemical development. An example of the frustrations and limitations in non-state development is to be found in the problems experienced by the Aum Shinrikyo Cult in the production of sarin. The Aum had sought to manufacture up to 70 tonnes of sarin in their Satian facility by September 1994, however, due to technical and equipment difficulties, by March 1994 they had only produced 53 kg as a limited pilot run. Additionally, there had been a significant number of trade offs in reducing other often unrelated activities and capabilities, such as in the reduced capacity to produce small arms, in achieving just this limited quantity of sarin.[36]

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[35] Office of the Secretary of Defence, *Proliferation: Threat and Response*, pp 34, 38 and 45. Also see Office of Technology Assessment, *Proliferation of Weapons of Mass Destruction: Assessing the Risks*, pp 2-32, 37-41,

[36] Cameron, 'Multi-track Micro-proliferation: Lessons from Aum Shinrikyo and Al Qaida', pp 277-310. Estimates vary based on the modeling of agents, dissemination systems and environmental conditions. A United States Department of Defence model, known as VLSTRACK 3.0, estimates that releasing ten kilograms of sarin into the open air in favourable weather conditions will have a lethal effect over approximately one-hundredth of a square kilometre. Since population densities in urban areas are typically around 5000 people per square kilometre, such an attack would kill about 50 people. Releasing 100 kilograms of sarin into the open air then affects about ten times the area and would therefore kill

Chemical Capability Development – Considerations and Vulnerabilities.

The key to effecting wide ranging, relevant and applicable control of chemicals is in critically identifying those activities that influence vulnerability and risk – both of the belligerents and of the state. Implicit within this process is the need to understand and identify core activities in the critical path development of any chemical capability. The ability then to shift targeting and interdiction capabilities to more specifically focussed activities throughout the development spectrum not only increases the potential for interdiction and preemption, but greatly enhances the applicability and effectiveness of any regulatory and legislative controls.

While it also applies across the spectrum of CBR capabilities, the most misunderstood and underestimated phase in chemical capability development is in the weaponisation of an agent. In the development of a chemical agent capability there is a need to consider the use of additives to further augment or assist in the release of the agent. This may include additives such as stabilisers, which are used to prevent degradation of agent exposed to hot temperatures and to allow the agent to be stored for long periods.[37] While not always critical, these measures can be if prolonged storage is required or the agent is to undergo a process of combustion or detonation that might normally accompany any explosive release.[38] Other weaponisation technologies may include the use of

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approximately 500 people. Estimates in the release of 1000 kilograms would then indicate that there would be in the vicinity of 10,000 people killed. Therefore only an open-air attack using excessive quantities of agent delivered within a short period of time in order to achieve the correct dosage, would result in an effect greater than those attainable through the use of conventional explosives. The logical conclusion is then that if non-state actors were to seek to overcome these limitations, the use of more effective targeting would potentially enhance the outcome of the attack, that is, if the targeting was directed at an enclosed space. United States Congress, op. cit., pp 42-61 and footnote 92.

[37] There is an infinite range of chemicals, yet surprisingly there are very few that provide for wide ranging utility when employed as non-state weapons. It is for this reason, along with the ability to sweep up all the other lesser agents and their precursors, that the analysis will be directed towards the high end spectrum agents which includes many of the warfare agents and some toxic industrial chemicals such as cyanide, chlorine and phosgene. It is the warfare agents that not only provide for the greatest potential and utility, but that are also outside of some national regulatory criteria due to their uniqueness or simply lack of availability. An example is the toxic industrial chemical amiton.

[38] Stabilisers are designed to absorb acids released by chemical decomposition and therefore maintain the effectiveness of the agent. The types and processing used would be dependent on the agent, period and type of storage.

freezing point depressants to permit use under certain environmental conditions or thickeners to increase viscosity and persistency of an agent. While there may be all, none, or only a few of these technologies incorporated within an agent to improve its utility, the enhancement of the agent may provide for a significantly increased potential. Where speed and secrecy of production is more critical, it is more probable that these additional processes and materials may be excluded, but there are clear trade offs. For example, a lack of critical additives and stabilisers, along with low agent purity, may reduce the time available between the production or acquisition of chemical agent and consequently, the time period until any actual use (due to degradation or chemical agent decomposition).[39] Therefore, tactical considerations in the planning and execution phases of an attack begin to take on a new complexity. Placement and positioning of the weapon, unlike the use of conventional explosives, are then more constrained by technical and environmental factors. The further imposition of time critical factors and their relative impact on the agent, may seriously influence any desired outcomes.

The production of chemical warfare agents within a non-state organisation presents a significant liability in terms of the inherent technical hurdles. This is particularly so in aspects of handling and safety which must be overcome to achieve even small scale production. In production of nerve agents (organophosphorus production), tabun (GA) is one of the simplest and its development is generally based on a production process utilised by the Germans in World War I, which was in fact employed by Iraq. As the production of tabun does not include the more difficult alkylation reaction that is needed in other production processes for G and V series nerve agents, it is often more easily achievable. The major hurdle in the production of tabun is in the cyanation reaction which involves the containment of highly toxic gases. While the simplest of the nerve agents, it still took the Germans nearly two years to perfect the process. Iraq, which used the same process, experienced similar difficulties,

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[39] Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, pp 21-40, and Department of Defence, *Military Critical Technologies*, pp 1-37.

only ever producing an agent of approximately 40 percent purity during the Iran-Iraq War.[40]

The other G series nerve agents such as sarin (GB) and soman (GD), have similar processes, however, they contain different alcohols: isopropyl alcohol for sarin and pinacolyl alcohol for soman. There are between two to five steps in a process of development for most G series agents depending on the synthetic pathway selected. There are two major difficulties within the production process for these higher end spectrum agents. The first is due to the corrosive nature of the process and the need for anti-corrosion equipment, and the second is in the alkylation reaction.[41] There is sometimes a third obstacle applying to the development of a high purity agent, where the highly toxic final product must be distilled.[42] This final distillation process is unlikely to be applied in a non-state program (as it increases storage life and reduces degradation of agent) as the time from production to actual use would most probably be within a shorter timeframe than for an agent produced within a state WMD program (which the state would normally offset through the stockpiling of agent). Despite media oversimplification of the ease of production of these agents, it remains a relative concept and whilst not insurmountable, the technical demands required for production alone would likely negate much of the expected utility.

Finally, in the extreme range of the chemical warfare agents are the V series nerve agents. These agents do not present as significant an inhalation hazard due to their relatively low volatility, yet are extremely lethal as a percutaneous hazard.[43] The production of VX and soman remain the most complex and

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[40] Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 25.

[41] ibid. p 24. The alkylation reaction is rarely used in the production of commercial pesticides and is technically demanding. Also see United States Department of Defence, *Military Critical Technologies*, pp 1-37.

[42] Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 26.

[43] The lethal dose of VX on bare skin is approximately 10 mgm for a 70 kg person. VX is probably one of the better known nerve agents due the wide publicity of its lethality and the association with the United States bombing of Al Shifa pharmaceutical plant in Sudan in 1998. The United States asserted that on the basis of sampling of a precursor chemical indicating the presence of VX (the precursor was EMPTA) at a pharmaceutical plant in Sudan, that the facility was associated with Usama Bin Laden's chemical development efforts. The evidence which was used by the United States to justify this attack has

similarly to other G series agents, there is difficulty in the various reactions along with severe restrictions (more through a function of availability and volume) on access to any precursors.

The easiest to produce of the chemical 'warfare' agents but which are still at the higher end of the chemical production spectrum, are blister agents. One of the easier ones to produce is sulfur mustard, where there are approximately nine well established production processes already openly documented.[44] During World War I blister agents (categorised as vesicants, arsenicals or oximes), were generally produced as by-products from manufacturing industries which utilised alcohol, bleaching powder and sodium sulfite. The two common chemicals which are generally used for the production of mustard and are manufactured on a major scale globally, are the starter materials sulfur monochloride and ethylene.[45] The difference, however, with the range of blister and incapacitant agents, is that while the opportunities for development appear more easily achieved, use in a non-state context runs entirely counter to established precepts in the use of CB capabilities – particularly if the desired outcome is for mass casualties. Incapacitants or non-lethal agents would have only a limited to negligible utility for non-state activities, other than through the psychological benefit of use derived predominantly from the visceral fear with which the use of chemical agents are regarded. When this is placed in a context of an organisation's cost-benefit analysis process, a scenario for use would seem improbable given the disproportionate response likely and the potential for only a limited casualty outcome.

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subsequently been questioned and is widely considered to have been selective and of questionable veracity, most notably the assertion that the facility targeted was being used for the production of VX in support of activities by Usama Bin Laden. For further information on VX and its effects see Satu, op. cit., pp 68-109. For further information on the background to the attack against Sudan see Hoffman, *Inside Terrorism*, pp 210-211 and M. P. Scharf, 'Enforcement Through Sanctions, Force and Criminalisation', in *The New Terror: Facing the Threat of Biological and Chemical Weapons*, eds , S. D. Drell, A. D Sofaer, G. D. Wilson, Hoover Institution Press, United States, 1999, pp 439-479.

[44] Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 25.

[45] B. Gordon, *Chemical Weapons Process Parameters. Volume I: Main Report*, United States, November 1992, as cited in Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 21.

At the lower end of the chemical agent spectrum are the organophosphorus pesticides. These chemicals appear to be of greater utility given their wide commercial availability, however, their lack of lethality and low volatility often renders them ineffective.[46] That is, these chemicals more often cannot achieve the required lethal dose when released as an aerosol or in suspension as an acute inhalation hazard.[47] The release of these pesticides in quantity, such as through a major industrial accident, may provide the dose required. Yet this would be a highly uncertain process, particularly against a static facility, being difficult to deliver to target and employ effectively, at least in the quantities that would be required to achieve a LD_{50} dose.[48] Table 4 provides a relative profile of the various toxicity estimates for industrial and agricultural chemicals. Yet as the table reflects,

Table 4 - Acute Toxicity Estimates for a Variety of Chemicals

Chemical	Dose	Factor
Nerve Agent Puffer Fish	10 ug/kg	1
Nicotine Hydrogen Cyanide	1 mg/kg	100
2,4-D herbicide	100 mg/kg	10,000
DDT insecticide	300 mg/kg	30,000
Malathion insecticide Aspirin	500 mg/kg	50,000
Alcohol	4 g/kg	400,000
Water	10 g/kg	100,000

Note: The dose cited is that causing death in a short time to adult persons. The route of administration is by mouth, except for nerve agents, puffer fish toxin and water, in which the route is by injection into a vein. The dose is the originator's estimate and all figures are approximate and derived from accidents in which the exact dose was not known. Crone, op.cit., p 4.

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[46] As a comparison, nerve agents are approximately 100 to 1000 times more toxic than most organophosphorus pesticides.

[47] The difficulty in establishing risk for many chemicals is in defining their efficacy as acute hazards. That is, most inhalation data is for rodents and for exposure times in excess of one hour (an unlikely outcome from contamination in a non-state incident). Toxicity parameters are based on human estimates, hence challenge levels for protective and detection equipment is derived from this very limited data. What this potentially means is that the capacity to accurately estimate the LDt_{50} and LCt_{50} and to establish precedence, priority and risk, is limited. The term LCt_{50} is used to denote the vapour or aerosol exposure (Ct) necessary to cause death in 50% of the population exposed (L denotes lethal and 50 denotes 50% of the population). In the same manner, the terms LD_{50} is used to denote the dose that is lethal for 50% of the population exposed by other routes of administration. Office of Surgeon General, op. cit., p 142.

[48] One of the biggest ever industrial accidents involved the release of approximately 30-40 tons of methylisocynate in Bhopal, Madya Pradesh, India in 1984. The release involved the industrial chemical used for the production of the insecticide carbaryl. It was released from a storage tank into which it was reported water had leaked. Estimates are that over 2500 people were killed and up to 100,000 were injured (with approximately 50,000 of these requiring hospitalisation). There are of course increasing concerns regarding the potential vulnerability of these types of industrial targets, particularly in relation to non-state attack. Compared with high end spectrum capabilities, they negate the requirement for specialised proficiencies in the development, weaponisation and production WMD capabilities. Office for the Prohibition of Chemical Weapons Report, Chemical Accidents: Causes, Effects and Important Influencing Factors, Hague, 3 December 1997. Accessed on 12 January 2000 at http://www.opcw.nl/chemhaz/chemacci.htm. Also see J. Stern, 'Apocalypse Never, but the Threat is Real WMD Terrorism: An Exchange', *Survival*, Volume 40, Number 4 (Winter 1998-1999), United States, p 177.

toxicity alone is not a determinant of utility. Additionally, while there may be some utility (as a function of dose) when chemicals are released within a confined area, the concentrations required would still be dependent on sustainability (or dose rate), at least if the intent is to achieve mass casualties. The ease of achieving production of the materials industrially is often overstated with the conversion of commercial plants to produce chemical warfare agents, such as fertiliser facilities, being a complex and time consuming process. Indeed, the utility of jury rigging many industrial facilities, particularly pesticide industries, is more often impractical or unrealistic. For example, pesticide plants do not normally contain equipment for performing the cyanation reaction needed for tabun, the alkylation reaction needed for sarin, soman and VX, or the fluorination reaction needed for sarin.[49] Conversion of single or multi-purpose chemical facilities is not as straightforward as is often hypothesised, particularly in the case of non-state belligerents who would have to carry out all work covertly.

As a consequence of many of these imposed technical constraints, it could be concluded that based on current technologies, the achievement of mass casualties from a chemical agent, at least via the respiratory route, would probably only be effectively achieved through the release of a chemical warfare agent (as opposed to the use of less toxic industrial chemicals), or through the release of a bulk industrial quantity of agent. In terms of articulating these vulnerabilities and technical impediments into a greater risk for the belligerents and increased opportunities for the state, this is best implemented through ubiquitous and effective national regulatory and legislative structures. This in essence involves the increased regulation of capabilities on the basis of the risk, specifically for those precursors, services and equipment that might offer the greatest dual-use potential for weaponisation.[50]

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[49] Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 55.

[50] For further information on dissemination systems and characteristics of agent requirements for effective use see United States Congress, op. cit., Also see United States Department of Defence, *Military Critical Technologies*, pp 1-37, and D. A. Wilening, 'BCW Attack Scenarios', in *The New Terror: Facing the Threat of Biological and Chemical Weapons*, eds Drell, S.D., Sofaer, A.D., and Wilson, G.D., Hoover Institution Press, United States, 1999, pp 86-89.

The difficulty, however, is in how to calibrate risk, particularly against those chemical agents at the low end of the spectrum. The release of a chemical agent within a confined environment where a significantly greater dose may be achieved, increases the options for the use of lower volatility agents. This scenario is similar to the one where the Japanese Cult Aum Shinrikyo sought to optimise the characteristics of sarin through the release of the agent within an enclosed subway system. This method, while plausible, still had major problems caused by diffusion and the inability of the agent to be effectively targeted.[51] In the case of water source contamination and poisonings, the use of chemical agents through this delivery method relies on mass ingestion, but this appears more as a unique and possibly implausible situation. That is, one where people would continue to consume the agent even after noting the development of symptoms, water discoloration or a pungent taste and/or odour – all of which would appear improbable, at least for delivery in a covert mass casualty attack.[52]

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[51] The issue of water source contamination is easily associated with acts of terrorist terrorism yet reporting reflects a predominance in the use by single issue groups and criminal elements, normally for the purposes of extortion or as a threat. Considering that most water provided through a mains reticulation system is flushed, used for washing, discharged or wasted, very little is actually consumed, despite its potability. This means that to effect an outcome involving the correct dose, the chances of delivery to the intended target and with the potential for diffusion of the source, the prospect of any significant outcome, other than psychological, it extremely difficult. This is not to exclude the use of contaminants being directly inserted into a controlled water source, such as a drinking fountain, but similar considerations of the right target and the achievement of mass casualties would suggest any major outcome would appear unlikely. Purver, op. cit., p 106. Also see Burrows, D. and Renner, S. E, 'Biological Warfare Agents as Threats to Potable Wate'r, *Environmental Health Perspectives*, Volume 107 Number 12, United States Army Centre for Health Promotion and Preventative Medicine, Aberdeen Proving Ground, 12 December 1999, pp 975-984.

[52] The use of agents against multiple targets may overcome these impediments, however, it would require detailed and well coordinated action prior to wider public notification through the press or electronic media. One case in particular, while not involving a chemical agent but a toxin, involved widespread contamination of foodstuffs as an act of terror. The incident involved the Rajneeshees Cult which utilised *Salmonella enterica* serotype Typhimurium to target restaurant salad bars in the area of Dallas around the period September 1984. This incident is the only one listed by the FBI as a successful incident of bioterrorism, which in the end resulted in the poisoning of 751 people yet there were no reported fatalities. Interestingly the charges brought against members of the Cult were not based on the use of WMD terrorist materials but assault, harassment and conspiracy charges. Police believe that the incident was a test run for a later attack involving the area water supplies, however, these attacks were never executed. The motivation for the Cult's use of the biological agent appears to have been to influence and/or take over the control of the Wasco County Court through poisoning voters and thereby influencing the outcome of the scheduled November 1984 county elections. Despite analysts reporting this incident as an act of bioterrorism (see Purver, op. cit., p39), the prescribed aims, use of agent and desire *not* to kill mass casualties, suggests that the incident was more criminal in scope as it primarily involved acts of conspiracy and extortion. The information available on the subsequent attempts by the Cult to poison the water supplies, however, does appear to better fit the profile of a terrorist group (albeit the act of political violence associated with the poisoning attempt does in a sense still categorise their initial actions as terrorist in scope). In terms of indicators of activity, the group had previously demonstrated no propensity towards violent action and while this first incident may have been an initial indicator, the likelihood of interdiction, other than through a process of probability, makes the targeting of these less obtrusive and parochial organisations extremely difficult. S. Carus, 'The Rajneeshees', in *Toxic Terror: Assessing*

Additionally, the delivery of an effective dose through a water source, particularly given the difficulties in the volume of agent required, would more probably only result in nothing more than a public health incident. This does not appear to be commensurate with most non-state activities, other than through the negative psychological influences such actions might evoke, which would more likely be perpetrated as a criminal act involving threats or extortion, than as an act of terrorism.[53]

Development Phases: Signatures and Interdiction of Non-State Chemical Development

Prior to attempting to determine specific signatures within the non-state capability development of chemical agents, equipment or services, it is necessary to provide a context to non-state development. The accuracy of any process model is limited due mainly to there being no clearly determined critical path for development and the difficulty in determining those areas of possible redundancy which can then be relatively easily circumscribed or circumvented. Diagram 3 provides a developmental model which seeks to outline specific phases in the capability process. Yet the incorporation of specific processes within each of the phases is not possible simply due to the wide range of permutations and combinations in the different development routes, available precursors and equipment processes utilised. The Diagram does, however, reflect the complexity of the development process involved, yet despite all of these process models, chemicals can still be utilised as neat agent, albeit not that effectively.

Terrorist Use of Chemical and Biological Weapons, ed J. B. Tucker, MIT Press, United States, 2000, pp 115-138.

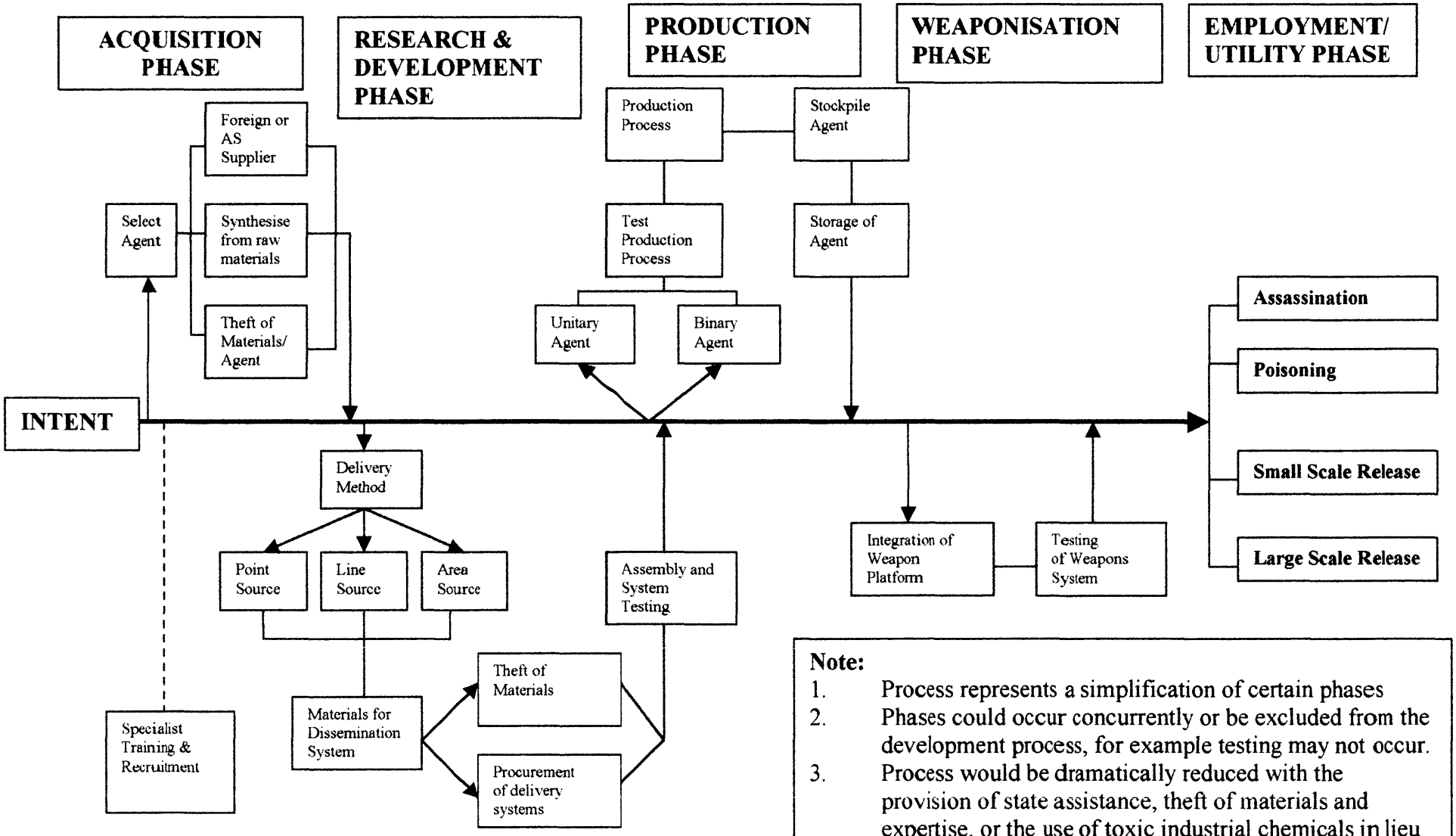
[53] W. D. Burrows, S. E. Renner, *Biological Warfare Agents as Threats to Potable Water – Environmental Health Perspectives*. Volume 107 Number 12, United States Army Centre for Health Promotion and Preventative Medicine, Aberdeen Proving Ground, 12 December 1999, pp 975-984.

Table 5 – Activity, Concealment and Detection Signatures for Non-State Chemical Capability Development[54]

Development Stage	Signature	Detection Methods	Concealment Method Comments
Acquisition Phase	-Patterns of feed material or precursor acquisition -Inconsistencies on end certification of controlled Schedules 1,2 and 3 Chemical Weapons Convention chemicals -Strange or unusual vials and containment systems being detected via airport X-ray or monitoring systems -Reporting of interest in range of sensitive and legal chemicals	-Monitoring of open source and/or trade data -Tagging of suspect shipments by customs -Immigration and customs alerts and equipment watch lists distributed -Stockpiling and caching of specialised equipment -Imagery of drums and other unusual activity	-Transshipment -Divert acquisition -Mix with legitimate use materials -Develop clandestine networks -Synthesise chemical precursors -Fraudulent paperwork -Deception activities -Multiple acquisition outside of threshold or volume controlled quantities
Research and Development Phase	-Scientific and technical publications (presence or absence) -Accessing university and academic literature from open source material -Recruitment of scientifically/chemically trained personnel (this may also included mechanical, chemical and/or electrical engineers)	-Sampling of residues -Visual observation of activity -Infrastructure analysis -Monitoring of open source trade data -Overhead imaging or human intelligence -Information alerts through industry and academia	-Sacrifice worker safety -Manage publication activities and use widely available technical information rather than new techniques or new agents -No pilot scale test of agent -Separate precursors for storage and transport
Production Phase	-Security measures -Effluent -Corrosion resistant reactor systems and other fittings -Rare chemical processes eg alkylation or cyanation -Special safety and containment measures -Sampling residues within the facility -Biomarkers in plant workers -Strange smells, odours and activity -Observation of well protected personnel (respirators and protective suits)	-Overhead imaging or -Human Intelligence -Sampling of air, water or soil near suspect production facility or area utilising various forms of chemical analysis; laser remote sensing of emission plumes -On-site inspection of suspect facilities or production area to include analysis of absorbent parts -Analysis of urine and blood samples of suspect personnel	-Chemical alteration or masking of effluent -Removal of waste offsite for disposal or treatment -Use decontaminating solvents -Practice quick replacement of parts such as rubber flanges and seals that might absorb residues -Prevent collection of samples and evidence by practising contamination control procedures
Weaponisation Testing Phase	-Inquiries, accessing and acquisition of engineering equipment and services on farming, pesticides, aerosolisation, explosives -Testing in remote localities indicated by dead animals or strange ground patterns -Acquisition of specialised containment systems	-Monitoring of open source trade data -Overhead imaging or human intelligence -Presence of dead animals and other related activity -Caches of unrelated chemical and engineering equipment -Improvised explosive device activity	-Limit testing -Utilise standard commercial equipment -Conduct assembly and testing in clandestine and/or remote area -Do not conduct testing

[54] Adapted from a matrix on signature, detection and concealment measures for state WMD programs in the Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 53. Changes have been made to phases, signatures, detection and concealment functions to closer align these to monitoring and interdiction of non-state organisations seeking to develop a chemical agent capability.

DIAGRAM 3 – POSSIBLE DEVELOPMENTAL PROGRAM FOR A NON-STATE CHEMICAL CAPABILITY



Note:

1. Process represents a simplification of certain phases
2. Phases could occur concurrently or be excluded from the development process, for example testing may not occur.
3. Process would be dramatically reduced with the provision of state assistance, theft of materials and expertise. or the use of toxic industrial chemicals in lieu

Complementing Diagram 3, Table 5 identifies the signatures of activity, concealment mechanisms and possible interdiction opportunities throughout the various phases in non-state chemical capability development. Yet despite the appearance of numerous targeting and collection opportunities, even in covert state WMD programs such as Iraq's (which the United Nations has been inspecting for over ten years), there still remained wide ambiguity and uncertainty in the assessment of Iraq's WMD agents, precursors and routes of production.[55] Despite the appearance of interdiction opportunities throughout the spectrum of development, the acquisition of specific equipment, materials and services provides one of the best, and often the only, indicators of potential capability development activity.

The demands imposed on the non-state organisation in the development process may often force it to operate outside of established and secure proliferation and business networks – potentially providing key indicators and signatures of micro-proliferation activity. As with all information processes, the vulnerability is in recognising and discriminating these indicators from the background clutter associated with volumes of normal (or abnormal) research and commercial activity. Additionally, the need to extend reporting and regulatory structures beyond those directly applicable to the immediate area, in this case the chemical sector, is critical in defining the actual scope of any possible development activity, particularly as it is likely to involve a range of asynchronous activities. It is this imposed dependence by the non-state organisation on extrinsic factors and influences, along with a requirement for discriminatory triggers throughout all regulatory structures, that will ultimately provide the widest potential for state parties to interdict any developmental capabilities.

There are a wide range of potential indicators to be derived from activity patterns associated with people actually working with these agents or indeed from the people themselves, particularly when it may have involved them handling or producing toxic chemicals. For example, decontamination systems and effluent from production processes may offer key signatures of intent based on sampling

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[55] United States Office of the Secretary of Defence, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, pp 15-70.

for example. It may also provide critical information on production processes, the layout of a facility or the association of water catchment and reticulation systems with agent production and development processes. Chemical signatures could also be derived from personnel operating within, or near, any facility, or indeed throughout wildlife in the surrounding area. Even minor exposure may result in distinctive physiological indicators or biomarkers, which themselves may be indicative of a specific process or agent.[56] Similarly, other physical indicators may be derived from the containment or barrier systems employed which may involve recognition of ventilation, filtration, scrubbers, alarms, protective equipment (for example respirators and protective suits) and possible waste processing systems, all of which may provide visual indicators or trace agent samples.[57]

It is not the intent, nor is there the capacity within this thesis, to provide an exhaustive listing of material and activity signatures associated with each agent or development process. Rather, it is to highlight that from an understanding of the key processes, the vulnerabilities and identifying signatures, controls can be more effectively established to influence behaviour and decision making processes – imposing an increased element of risk to the belligerents who may seek to obtain these capabilities. The need to ensure there are the discriminatory and reporting processes, along with the capacity to understand proliferant and developmental activities, is as important as any capability used in actually responding to the use of these threats.

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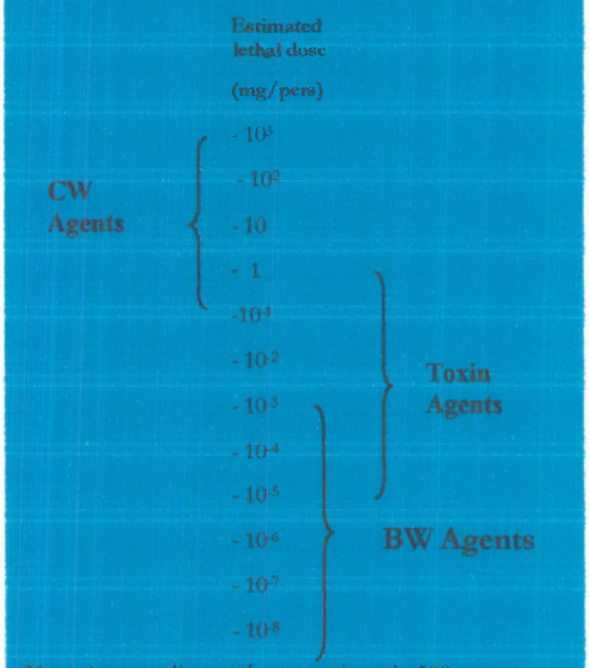
[56] For example, sulfur mustard breaks down in the environment into thiodiglycol and two impurities, thioxane and dithiane, which can be identified as signatures of mustard production. Most nerve agents (such as sarin, soman and VX – but not tabun) contain a phosphorus-methyl bond that is difficult to break and it remains intact after chemical treatment and can only be destroyed by aggressive treatments such as high-temperature incineration. L. Ember, 'Chemical Weapons residues Verify Iraqi Use on Kurds', *Chemical and Engineering News*, Volume 71, Number 18, 3 May 1993, pp 8-9, as cited in Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 62.

[57] There are a range of by products generated as waste, which dependent on the agent, would normally contain hot acids contaminated with lethal agent and a large quantity of phosphates. Wastes would also be generated by the need to flush systems with decontaminate. There would be approximately one half to one ton of waste generated for every ton of agent. This, however, is predicated on some recycling of waste occurring with the reuse/recycling of chemicals such as thionyl chloride back into the production process. While this is unlikely to occur in the terrorist development program, regardless of the program undertaken, a large quantity of waste will be the result, whatever the process. This alone may have the potential to provide a wide range of signatures from aerosol and ground sampling to biomarkers within individuals exposed to the process or contaminants involved. Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, pp 31-32.

BIOLOGICAL MICRO-ORGANISMS AND TOXINS AS A WEAPON OF MASS DESTRUCTION

Similar to the processes for defining which chemical warfare agents are of utility, considerations of pathogenicity, toxicity and infectiousness in biological micro-organisms and toxins are not necessarily reflective of a utility for non-state use. While there are hundreds of pathogenic microbes, there are only about thirty that would be considered to have utility for use as biological weapons.[58] Most particularly in the case of biological micro-organisms, it is the physical characteristics that may exclude or reduce their utility, specifically those aspects that influence handling, storage, decay, efficacy and dose/dose rate.[59] Table 6 provides an interesting comparison of chemical and biological agents and while it notes a markedly higher toxicity for most biological micro-organisms and toxins, it fails to adequately reflect aspects of utility (particularly dissemination). Alibek, a former scientist in the Russian biological warfare program, notes the following:

Table 6 – Toxicity of CB Agents



Note: 1 paper clip weighs approximately 500 mg

Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 77.

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[58] Department of the Army, United States Army Medical Research and Development Command. *Final Programmatic Environmental Impact Statement: Biological Defence Research Program*, Fort Detrick, United States, 1989, p A7-2, as cited in Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 76.

[59] For an interesting and detailed analysis of the former United States offensive biological warfare program, specifically the problems inherent in the selection of biological agents, see, E. Regis, *The History of America's Secret Germ Warfare Project: The Biology of Doom*, Henry Holt and Company Publishing, United States, 1999. The publication examines the research work and selection by the United States of three lethal biological agents and toxins and four incapacitating agents. These were claimed to have been tested and sprayed on 2000 live human volunteers, along with research programs which included the covert aerosol release in cities and over testing grounds of biological materials.

> Acquiring a biological agent of sufficient virulence is only one of the prerequisites for conducting biological terrorism on a mass scale. The most virulent culture in a test tube is useless as an offensive weapon until it has been put through a process that gives it stability and predictability. The manufacturing technique is, in a sense, the real weapon, and it is harder to develop than individual agents.[60]

Unlike chemicals, it is difficult to differentiate between high and low end spectrum biological agents. Those that might be utilised for poisonings and assassination are often the same as those that might be selected for their utility as WMD agents. The only difference is the quantity of agent, intent and the dissemination system utilised. Most media reporting and analysis tends to focus on anthrax and ricin, however, this more often simply reflects frequency of occurrence rather than the potential utility of the micro-organism and toxin.[61] Most pathogenic agents would in some form be considered as biological warfare agents, however, their potential is dependent on considerations of access, acquisition, contiguousness, lethality, route of entry and the production and processing required to 'develop' the agent for use in, or as, a weapon.

Trends of increased reports of bioterrorism (mainly due to the growing incidence of hoaxes) has increased the visibility and profile of the spectre of this as a perceived threat.[62] Australia has been largely quarantined from global trends in bioterrorism. Yet not surprisingly, most of this type of activity has been limited to criminal use and has mainly been confined to food contamination and poisonings (which in most cases would not warrant it being reported as a CBR

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[60] K.Alibek, *Biohazard*, Random House, United States, 1998, p 97.

[61] B. Tucker, 'Historical Trends Related to Bioterrorism: An Empirical Analysis', *Journal of Emerging Infectious Diseases – Tracking trends and analysing new and re-emerging infectious disease issues around the world*, Volume 5, Number 4, July – Aug, 1999, pp 498-504.

[62] D.R. Franz, and R. Zajtchuk, 'Biological Terrorism: Understanding the Threat, Preparation and Medical Response', *Disease-a-Month*, Volume 46 Number 2, February 2000, pp 140-142.

related incident).[63] Coincidentally, the frequency of national bioterrorism reporting, which has subsequently found to be limited to hoax activity, soared following the 11 September 2001 terrorist attacks and the anthrax contamination of mail in the United States following the attacks. While the level of activity and security threats is hard to quantify in terms of any supporting empirical data, trends are also partially reflected in the heightened incidence of reporting by the public of suspicious mail and parcels. [64] It is estimated there were over 1000 separate incidents reported to the Australian police and emergency services in the weeks that followed the United States anthrax mail alert.[65] While Australia's strict quarantine regulations are theoretically designed to stop, or at least inhibit the spread of natural outbreaks and criminal acts, such as smuggling, they would not act as an impediment to an organised and resourced non-state organisation which may choose to perpetrate an act of bioterrorism.[66]

The wide diffusion of dual-use chemical agents, equipment and services that may potentially be misused is even more marked in the case of biological agents.

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[63] Australian Federal Police, *Australian Bomb Data Centre Annual Report 2000*, April 2001.

[64] This figure does not account for the flood of anthrax related hoaxes following the anthrax contamination scare in the United States which began with the death of a Florida man on 4 October 2001, from inhalational anthrax delivered via the post. The Australian Liberal – Coalition Government has indicated that the Commonwealth will introduce tougher new hoax legislation, however, the details and scope of any new legislation is unclear. The paradox is that while the Commonwealth may seek to introduce new legislation, the application of law and order is the responsibility of the eight jurisdictions, hence, the limited potential for the law appears at odds with effecting change outside of the States and Territories. That is, Commonwealth jurisdiction extends to areas such as defence property and installations, yet outside of these it is the responsibility of the States and Territories (see Section Five).

[65] The capture of hoax (and indeed all CBR reporting) activity by Commonwealth, States and Territories is an inefficient and incomplete process. Hoaxes are too often recorded as 'miscellaneous' or as 'criminal damage', as these categorisations do not obligate the recipient of the hoax message, call or information, to initiate further actions. When a call is received or reported to police, these categorisations do not oblige the recipient to report the incident beyond the point of receipt or to the Australian Bomb Data Centre (who have the responsibility for the capture all bomb related activity reporting). There is no empirical data available that reflects prosecutions per number of hoaxes initiated in Australia. There have been 248 hoaxes recorded in Australian since 1991, however, there is no data available to indicate closure, prosecution or conviction rates (does not reflect trends in data post 11 September 2001). Estimates by the Federal Police for hoax activity within the ACT suggests that a figure of 0.05 percent of reports of hoax activity would have been prosecuted. Hoaxes would normally be prosecuted under charges related to conspiracy or public nuisance activities as all the jurisdictions, with the exception of Victoria, lack the legislation relevant to this area. Personal communication with Defence Liaison, Australian Bomb Data Centre, 1998-2001. Data on hoax activity in Australia over the last 10 years was drawn from the *Australian Federal Police Bomb Data Centre 2000 Annual Report*, Canberra, 30 March 2001

[66] A. Gibbs and R. Meischke, *Pests and Parasites as Migrants: An Australian Perspective*, Cambridge University Press, Australia, 1985, p 26. For a broad overview of the risk to Australia from bioterrorism see A. Robertson, 'Bioterrorism – An Australian Perspective', *Australian Defence Force Health Publication*, Volume 1, Canberra, 1 September 2000, pp 99-106.

Table 7 – Current Biological Warfare Agent Threats

Biological Agent	Symptoms	Mortality
Marburg virus	9-11 days	>25 percent lethal
Ebola virus	3-8 days	50-80 percent lethal
Variola (Smallpox)	10-14 days	>30 percent lethal
Venezuelan Equine Encephalitis Virus (VEE)	2-5 days	Incapacitate
Bacillus Anthracis (anthrax)	2-4 days	Lethal
Vibrio Cholerae (Cholera)	2-3 days	Lethal
Fracisella Tularensis (Tularemia)	1-5 days	Incapacitant
Yersinia Pestis (Plague)	2-4 days	Lethal
Coxiella Burnetti (Q fever)	12-21 days	Incapacitant
Ebola Virus (Ebola fever)	3-8 days	Lethal

United States Department of Defence, Office of Surgeon General, op.cit., 1997. and United States Medical Research Institute of Infectious Diseases, *Medical Management of Biological Casualties – Handbook*, Third Edition, Fort Detrick Maryland, United States, July 1998.

Biological materials are in essence all dual-use. The pervasive and dual-use nature to biological materials and services means that the majority of activities carried out in the area of research, academia or through the provision of medical services, is nearly impossible to distinguish from defensive or offensive development. The World Health Organisation defines biological agents as those that depend for their effects on multiplication within the target organism and are intended for use in war to cause disease or death in man, animals or plants.[67] The definition, however, excludes toxins elaborated by some microbes (eg. Botulinal toxin and staphylococcal enterotoxin), when they are performed outside the target organism. The difficulty, unlike chemical warfare agents and toxic industrial chemicals, is in what defines a biological warfare agent. This is not clearly defined (and neither can it be) and is entirely a function of intent as opposed to purely the consideration of factors such as toxicity or lethality. Table 7 provides an overview of those biological agents more commonly referred to as warfare agents, yet all are naturally occurring and would also be included in public health reporting. The United States' definition is just as limited and restricts the criteria to 'the use, for military or terrorist purposes, of a living organism or material derived from them, which is intended to cause death or incapacitation in man, animals or plants.[68] The difficulty in articulating a suitable criteria is in the inclusion of provisions which allow for the widest possible use, yet that does not constrain any application to only a specific environment, such as for military or warlike purposes. For greatest effectiveness, any definition applicable to the use

[67] World Health Organisation, op. cit., p12.

[68] United States Defence Threat Reduction Agency, *Weapons of Mass Destruction Terms Handbook*, DTRA-AR-40H, United States, 1 July 2000, p 4.

of biological materials offensively, must include a characterisation of the agent involved and aspects of intent as a performance based outcome – without which there is little prospect of ever establishing anything more than a simple case of possession.

The development of a biological capability tends to be information-intensive as opposed to chemical production, which is capital-intensive, as most of the relevant data on biological production and development is available through published scientific literature.[69] When compared to chemical and radiological isotopes, biological agents are the least capable of being used *effectively* by non-state actors because of the numerous technical hurdles in their production, weaponisation and dissemination. This is, however, diametrically opposed to what is reflected within reporting trends – particularly for ricin and anthrax.[70] The difference is best illustrated by the fact that despite between 600 – 700 anthrax hoaxes annually in the United States (prior to the anthrax incidents in late 2001), a total of only 18 people had died over the last century from inhalational anthrax, all of which were through separate incidents and none attributable to an act of bioterrorism.[71]

While biological agents appear to offer the greatest potential in terms of effecting a mass casualty outcome, mainly because of their extreme toxicity, pathogenicity and in some cases infectiousness, the realisation of these factors into an effective weapons system remains beyond the capacity of even most state sponsored biological programs. The putative reputation of biological capabilities has no

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[69] Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 85.

[70] Swedish National Defence Research Institute, Biological Warfare Agents, National Defence Publications, Stockholm, 1986, pp 28-34.

[71] M. Nemeth, 'Anthrax hoax becomes copycat trend', *Associated Press*, 21 March 2001 The exact number of anthrax hoaxes in the United States, as is the case in Australia, is difficult to determine. This is due mainly to the different domestic reporting structures and while the FBI reflects cases opened in their database of statistical profiles of activity, this does not reflect the full scope of the actual activity. In terms of any substantial outcomes from anthrax itself, eighteen deaths have been attributed to inhalational anthrax in the United States over the last one hundred years, albeit none of these were attributable to an act of bioterrorism. The figure is illustrative, however, of the vulnerability and endemic nature of inhalational anthrax within the continental United States. As at December 2001, a further six people in the United States had died from inhalational anthrax, yet all of these were individual attacks/cases result from the distribution of anthrax via the mail service (possibly perpetrated by the same non-state actor). There has never been a recorded case of a death in Australia from inhalational anthrax.

doubt been influenced by the media, particularly in the promotion of best sellers such as *'The Eleventh Plague'*, *'Cobra Event'* and *'Plague Wars'*.[72] The Monterey 2000 WMD Terrorism Chronology, however, reflects a predominance of activity restricted to simple culturing processes or acquisition via theft. These have been limited to the threatened use and/or possession of anthrax and ricin, a stark contrast to any perceptions in the capabilities of these agents.[73] The analogy commonly used is that if you have the capacity to brew beer through a simple fermentation process, then there is the potential to develop a basic but effective biological warfare agent. The reality, however, is quite different.[74]

Unlike the development of a chemical capability, a biological capability focuses on actual production of agents as opposed to synthesis or acquisition processes. Production varies dependent on the type of agent, that is, viral, bacterial or toxin, the type of containment and the processing utilised to produce the micro-organism or toxin. While theft of a biological agents may appear to be the most likely acquisition route, unlike chemical agents, this would more likely result in only the availability of an initial seed stock and would then still require further effort to culture, propagate or harvest usable quantities. Like chemical agents, defining specific processes in the development of biological capabilities is not possible given the permutations in the process and different routes available. However, there are also certain critical processes and stages in biological

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[72] T. Mangold, and J. Goldberg, *Plague Wars: A True Story of Biological Warfare*, MacMillan, United States, 1999, R. Preston's, *Cobra Event*, Random House, New York, 2000, and L. A. Cole, *The Eleventh Plague: The Politcs of Biological and Chemical Warfare*, W. H. Freeman and Company, United States, 1996.

[73] *'Interview with Larry Wayne Harris'*, 60 Minutes on Channel 9, 16 July 1998. The interview with Mr Harris, who had been charged in the United States with possession and intent to acquire anthrax and ricin, was aimed at highlighting the ease of production of many biological agents, in this case ricin. Mr Harris has previously published a wide range of material on agents, use and production and has previously been arrested for possession of ricin. What the interview with Mr Harris failed to demonstrate was the actual difficulties in dissemination of agent, particularly of the agent he was demonstrating which was ricin. While Mr Harris demonstrated for viewers the relative ease in producing ricin in his own kitchen with a basic home-made centrifuge, the physical state of the agent and its purity meant that it could have only been used effectively if ingested (and even then the purity and toxicity of the agent could not be determined). The physical state and particulate size of the agent (ricin) produced would have limited dissemination where the achievement of the materials as an acute inhalation hazard would have been technical and scientifically, beyond the capacity of Mr Harris. This is not to dismiss the agents' potential for use as a discriminate poison, however, its wider applications as claimed by Mr Harris was not based on any evidence presented or demonstrated.

[74] R. Harris and J. Paxman, 1982, *Higher Form of Killing – The Secret Story of Chemical and Biological Warfare*, Hill and Wang, New York, pp 68-106.

development which may stop, inhibit or further compromise production. For example, difficulties in production are exacerbated through problems from mutations (leading to a loss of potency) and the contamination of cultures (resulting from a lack of sterilisation) – confirming that development is by no means a simple process.

Table 8 - Method of Storing Biological Micro-organisms

1. Drying in sterile soil mainly for bacteria which produce spores.
2. Storage at low temperatures
   a. +4 °C for short periods, 1-2 weeks
   b. –20 °C sensitive method requiring caution
   c. –70 °C preferable to the higher temperatures but involves the death of some bacteria
   d. –170 °C satisfactory method, complicated and costly
   e. Combination of cooling and drying, a method offering great advantages. Some loss of virulence and viability can take place after some time.

Source: Swedish National Defence Research Institute, op.cit., p 28.

Many biological agents reproduce and only small amounts of a starter organism are required so the use of appropriate growth media or nutrients in a cell culture system can generate, at least theoretically, enought agent to infect numerous targets.[75] Pathogens can be cultivated in living animals such as eggs and horses, dependent on the agent being produced and whether it is viral or bacterial. Additionally, production of biological agents would normally be expected to utilise polished stainless steel surfaces, self-containment, and if well established – negative pressure systems to reduce agent contamination.[76] Efficiency of the production processes, whether batch or continuous culturing, is

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[75] In his analysis of biological incidents reported in the Monterey WMD Terrorism Chronology 1998 of biological agents and weapons, Carus noted that in one-third of the cases involving actual acquisition, the perpetrators obtained biological agents or toxins from legitimate suppliers (The American Type Culture Collection was the source of the agent in at least two cases). In nearly 17 percent of the cases the perpetrators acquired their biological agents by stealing them from research or medical laboratories and almost all of the thefts involved people who had legitimate access to the facilities where the biological agents were kept. In only one of the reported incidents was an effort allegedly made to infiltrate a laboratory to steal a biological agent. Interestingly, only 17 percent of the cases involved manufacture of the agent and this was in relation to the production of ricin (there were several cases of people trying to culture *C.botulinum* to produce botulinum toxin). Most significantly, there is no case in which a toxin was successfully produced. Finally, only in two cases did the perpetrators obtain the biological agent from a natural reservoir and attempt to transmit it without any processing. S. Carus, 'Unlawful Acquisition and Use of Biological Agents', in *Biological Weapons: Limiting the Threat*, ed J. Lederberg, MIT Press, Massachusetts, 1999, pp 223-224.

[76] While it is critical that the biological production processes are sterile and efficient, the reporting of the biological production processes utilised by the infamous Japanese biological warfare unit – 731, demonstrated that even under the most basic of conditions, particularly if there is an acceptance of extreme risk to workers, the production of large quantities of agent, is still achievable. For further information on Unit 731 and the research and development work that accompanied their illegal use of

directly related to the agent purity. Agent purity is reflected in such factors as the nature of the sealing joints, condition of the pressure chambers, containment of the venting systems, etc. For example, critical in the production process is the removal of collapsed steam or condensation formed on the equipment as this creates pockets of standing water which are prone to bacterial growth and the contamination of the production process.[77] Estimates of production processes in state sponsored biological programs suggests that approximately 60 – 70 percent agent purity is acceptable. Whether this could be achieved by a non-state organisation is questionable and certainly the existing evidence of the Aum's biological activities, indicates difficulty throughout a range of biological agent production processes.[78] Table 8 provides an overview of some of the storage and handling specifications which highlights the technical difficulties associated with development, particularly for handling and storage, of live organisms.

One of the core difficulties in the development of biological agents is in the potential exposure hazards and the requirement for the containment of highly pathogenic or infectious agents. Most of the agents that are of potential utility to non-state actors are those that would normally be contained within a biosafety level three or four facility.[79] These normally consist of stringent control measures involving umbilical air regulation systems, negative pressure containment facilities and filtered air and scrubber processes.[80] While

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agents for human testing, particularly within Manchuria, see P. Williams and C. Wallace, *Unit 731. Japan's Secret biological Warfare in World War II*, New York, 1989.

[77] Department of Defence, *Military Critical Technologies*, p II-3-9.

[78] Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 88.

[79] A biosafety level four facility is the highest level of protection. In the production of anthrax, botulin toxin and afflatoxins, Iraq provided very little in the way or protection for workers involved in production of pathogenic materials. Despite the immunisation of some workers, the standards for safety and containment within many of the Iraqi biological facilities was well below western standards. It is more likely they were comparable to standards established for biosafety level two facilities, despite research on agents requiring significantly higher standards of handling and containment. R.A. Zilinskas, 'Iraq's biological Warfare Program: The Past as Future?', in *Biological Weapons: Limiting the Threat*, ed J. Lederberg, MIT Press, United States, 1999, pp 137-158. The United States Centre for Disease Control Website provides a summary of the specific requirements for biosafety levels one, two, three and four. Additionally, the site outlines the specific equipment, barrier and containment processes required. (accessed 1 February 2001), http://www.cdc.gov/od/ohs/biosfty/bmbl4/bmbl4s3t.htm.

[80] For further information on the handling of pathogenic materials and problems encountered in the management of these systems, particularly in the research and development of the United States offensive biological warfare program, see Regis, op. cit., pp 47-61.

containment would be important in non-state biological development processes, it is neither an indicator, nor critical, other than for safety from exposure during development. For example, United Nations Inspection teams in Iraq noted the poor state of handling and biological production equipment where workers were exposed to a wide range of infectious and pathogenic hazards.[81] There are commercial containment systems available that could also overcome some of these difficulties, however, even with increased contamination controls, decontamination protocols and immunisation and vaccination regimes, the risk would still be significant and most likely unacceptable compared to most western occupational health and safety standards.

As with chemical agents, the most complex and technically demanding phase in the development process is the weaponisation of agent. One of the more significant hurdles within this phase is the processing of the biological materials for weaponisation in order to more effectively enhance their stability and viability. Agents such as *Bacillus anthracis*, *Francisella tularensis* and *Clostridium botulinum* have previously been weaponised within state sponsored biological programs, however, all the programs experienced difficulties due to the loss of toxicity, efficacy and in the stability of agent. As living organisms, biological agents will eventually deteriorate and when this is considered against other handling and storage constraints, it imposes significant operational constraints, particularly time critical considerations, on the effective use of biological agents.

There are a range of measures of varying complexity available to enhance viability, however, these are often complex processes and require sophisticated stabilisation and handling procedures. Measures may include freeze drying or lyophilisation processes where the agent solution is reduced to a dried material which is then milled into a fine particle. While this increases the potency of an agent, this process in particular is extremely hazardous and potentially exposes the people involved to life threatening respiratory hazards. Other considerations

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[81] Author's comments and observations from personal participation in United Nations Weapons Inspections (United Nations Special Commission for Iraq - UNSCOM) of WMD facilities throughout Iraq during the period 1996-1998.

may include a loss of potency through storage and handling where estimates indicate a reduction by as much as a factor of 10 to 100 over a period of one to five years. The consequence of this is that if a non-state actor sought to stockpile biological pathogenic agent(s), degradation and decay may dramatically impact on the agent's viability if it was not properly prepared.[82]

Similarly to the use of additives as stabilisers in chemical warfare agents, the stability of a microbial aerosol may be increased by the use of antiagglomerants such as silicas, which aid in reducing clumping.[83] More advanced stabilisation technologies may also include microencapsulation which is a polymer coating process that protects the micro-organism and further enhances the stabilisation of the agent.[84] Importantly, micro-encapsulation also protects the agent from desiccation and the mechanical and shock stresses imposed through explosive dissemination.[85] The enduring theme, however, throughout all these additional measures, is that the technical demands to produce a stable and virulent agent, of effective and viable purity, is scientifically demanding and difficult even for the most advanced state sponsored biological program.

Interestingly, while the routes of entry into the body for biological agents are the same as those for chemical agents, the efficacy can be dramatically increased comparatively if the agent is efficiently delivered internally, particularly through ingestion or as an inhalational hazard. As with chemical and radiological agents, the most effective delivery method is best exercised through the respiratory

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[82] Stockholm International Peace Research Institute (SIPRI), 'The Problem of Chemical and Biological Warfare', *Technical Aspects of Early Warning and Verification*, Volume VI, Almquvist and Wiksell, Stockholm, 1975, p 24, as cited in Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 93.

[83] Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, pp 91-93.

[84] Microencapsulation is similar to naturally forming spores. As an example, *Bacillus anthracis* (anthrax) is best utilised in sporal form where it is in a state of dormancy, but it still retains its virulence. The United Kingdom conducted extensive live agent tests utilising anthrax on a small island called Gruinard, off the Scottish coast during WWII. The island still remains contaminated with anthrax some fifty years after the event and compensation to the original owners was only settled in 1993. It is, however, indicative of both the virulence of sporal anthrax and the potential persistency of the agent.

[85] Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 94.

system as an acute inhalation dose.[86] The efficacy of an attack is dependent on the concentration of organisms able to be delivered, or more precisely, the dose. Table 9 provides a comparative analysis of the rate of fall of aerosol particles highlighting the criticality in the balance between size and the potential hazard area. Estimates suggest that a release of biological agent as an aerosol only converts about 85 percent of the starting material into droplets of the desired range. The result is then potentially further degraded through alkalinity, acidity, humidity, temperature and ultra violet exposure, which then serves to destroy, or significantly reduce, the effect of any remaining agent.[87]

Table 9 - Rate of Fall of Aerosol Particles

Particle Size Micron	Sedimentation Time in Hours	Drift Range in Kilometres
1	926	16,667
2	231	4,167
5	37	658
10	9	164

Note: The sedimentation times and drift range of spherical aerosol particles in the case of drops from an altitude of 100 m and a vertical wind of 5 m per second without turbulence. Provided by Swedish National Defence Research Institute, op.cit., p 29.

Other critical factors in the release of biological pathogenic materials include the particulate size that can be produced. This is a significant factor, particularly in determining the efficacy of any micro-organism, which in the end impacts on duration, dispersion and dose. Scientific literature suggests an ideal range of one to five micrometres diameter which reduces the settling velocity and allows the dose to enter directly into the pulmonary alveoli.[88] An additional benefit of agents within this size range is the hazard from secondary aerosols. That is, once an agent has settled, subsequent movement disturbs the microbes and due to the slow settling velocity, a secondary respiratory hazard maybe generated, thus creating a more persistent and potentially lethal outcome.

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[86] The effect of even lower toxicity agents can be enhanced if delivered through the respiratory system. When agents enter via this route they bypass the normal protective mechanisms such as local inflammatory processes. For further information on weaponisation and delivery processes see Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, op. cit., pp 92-108. For further information on symptoms from delivery via the respiratory route, see United States Office of Surgeon General, op. cit., pp 247-271.

[87] Swedish National Defence Research Institute, op. cit., pp 28-34.

[88] In experiments on the effect of particle size on respiratory infection, tularemia bacteria was administered to guinea pigs as an aerosol. At 1 micron only 3 bacterial cells per animal were needed to kill 50 percent of the guinea pigs but when the particle size was increased to 7 microns, the number of bacteria per animal required to kill half of the guinea pigs rose to 6,500. W.D. Sawyer, (Major). Airborne Infection, *Military Medicine*, February 1963, pp 90-92 as cited in Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 96.

Despite the capacity of biological agents, they remain more difficult to effectively disperse as an acute inhalation hazard. Estimates suggest that between two to five percent of agent will remain viable following detonation during explosive dissemination. Additionally, the particle size when released, particularly if released explosively, is generally not homogenous, thereby degrading the efficiency of entry into the body for the agent.[89] One other key factor in the use of biological micro-organisms is that due to the indiscriminant nature of the biological agent and the need to achieve an effective dose, it is necessary to ensure greater redundancy in the actual quantity of agent produced for release.[90] While there is no empirical data available on modeling redundancies for biological agent release, the figure would more probably be at least greater by a factor of two to five given the degradation rate imposed through the influences of detonation and attempts to achieve greater agent viability and purity.[91] These limitations, particularly when contrasted with the technical difficulties in development, further qualifies earlier assessments on the problems in developing and effectively disseminating biological micro-organisms and toxins. The consequence being that a non-state capability would have to have an increased technical dependency on specialist resources, modeling data on aerosolisation techniques and on the physiology and characterisation of biological materials if it was to be effectively used in a non-state context.

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[89] Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 96. Also Swedish National Defence Research Institute, op. cit., pp 28-34.

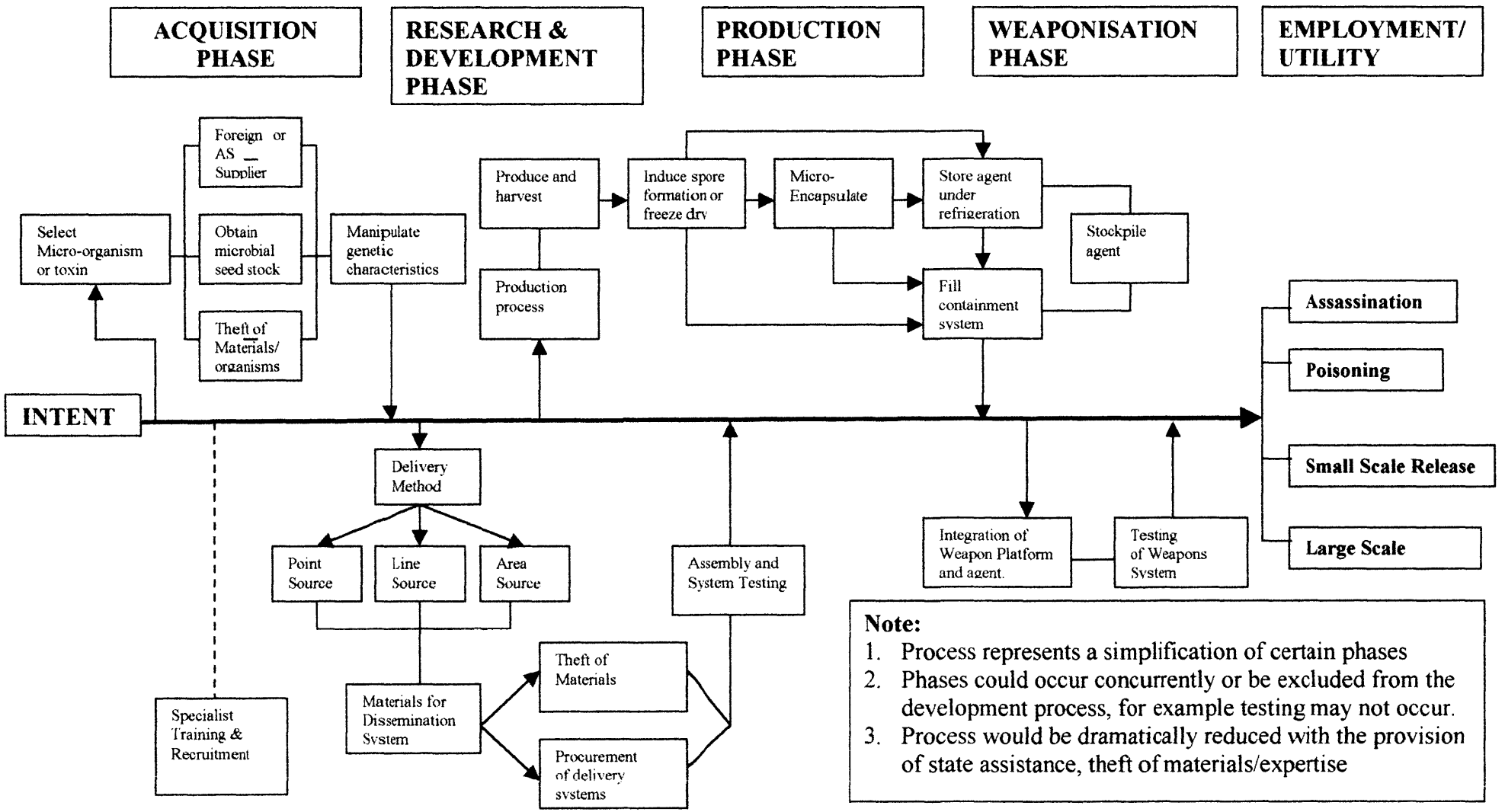
[90] Paradoxically, analysis of bioterrorism reporting up to and including 1998 notes that of more than one hundred cases examined, in not one case were explosives utilised in the dissemination of biological agent. Most involved the contamination of foodstuffs, water, the use of vectors, direct injection or aerosol dissemination. The caution in the outcomes of the analysis, however, is that there has yet to be an incident of effective non-state use of a biological agent, explosively or otherwise, delivered and an acute inhalation hazard. Noting trends in transnational terrorist organisations, for example HAMAS, it appears more likely dissemination attempts will be via explosive release due mainly to the familiarity and relative simplicity of the process than when compared to the technical requirement for aerosolisation. W. S. Carus, 'Unlawful Acquisition and Use of Biological Agents', in *Biological Weapons – Limiting the Threat*, ed J. Lederberg, MIT Press, Massachusetts, 1999, pp 211-232.

[91] For further reading on the difficulties in both development of biological materials and its dissemination see Leitenberg's account or the purported activities of the Aum Shinrikyo's attempt to release aerosolised anthrax on 28 June 1993. Apart from questions over the actual agent used, the outcome was completely ineffectual, despite extensive preparations, research and testing. M. Leitenberg, 'The Experience of the Japanese Aum Shinrikyo Group and Biological Agents', in *Hype or Reality: The New Terrorism and Mass Casualty Attacks*, ed B. Roberts, Chemical and Biological Arms Control Institute, Washington DC., 2000, p 168.

Development Phases: Signatures and Interdiction of Non-State Biological Development

Like non-state chemical agent development, Diagram 4 provides an overview of the processes that might be associated with the critical path development of a biological capability within a non-state context. Earlier sections throughout the thesis reaffirmed the dynamic nature of these processes which can be circumvented, circumscribed, removed or simply overcome, given the different requirements to those within a state biological program. As for chemical development, the phases also provide identified areas of vulnerability in the capability cycle. Similarly, articulating these into risk mitigation strategies would in the main be exercised through the imposition of enhanced regulatory controls to target and reduce acquisition and production activity. The diffuse nature of biological capability development processes, more so than for chemicals or radioisotopes, highlights the potential vulnerability and challenges involved.

DIAGRAM 4 – POSSIBLE DEVELOPMENTAL PROGRAM FOR A NON-STATE BIOLOGICAL CAPABILITY



Note:

1. Process represents a simplification of certain phases
2. Phases could occur concurrently or be excluded from the development process, for example testing may not occur.
3. Process would be dramatically reduced with the provision of state assistance, theft of materials/expertise

Table 10 – Activity, Concealment and Detection Signatures for Non-State Biological Capability Development[92]

Development Stage	Signature	Detection Methods	Concealment Method
Acquisition Phase	-Presence or availability of explosives and or generative systems -Equipment suitable for containing caustic materials -Engineering tools for release of agents in an aerosolised form (range of 1-25 um) -Acquisition of specialised equipment eg seed stocks, cell lines etc	-Monitoring trade data -Checks for purchases of finely machined materials and tools with specific tolerances -Checks of purchase and procurement of agricultural agent dissemination systems -Checks of missing explosives and detonation or booster systems -Monitoring Australia Group denials	-Operate through a front company or intermediatories -Purchase farming and agricultural equipment from auctions or rural distributors targeting commercial goods not controlled as export lists -Purchase goods from Non-aligned Australia Group countries -Procure from multiple sources -Acquire via transhipment or on falsified end-user certification
Research and Development Phase	-Scientific and technical publications (presence or absence) -Activity in specific Internet sites and chatrooms -Laboratory animals -Facilities and/or equipment such as scrubbers, ventulation -Odours and waste generated -Security systems located around improvised laboratory facilities	-Literature survey and activity analysis -Human intelligence -On site surveillance and/or inspections -Tracking of exports to suspect groups or destinations -Monatoring of domestic industry activity -Reporting of theft or requests for information or biological materials	-Manage publication activities -Use widely available technical publications rather than design new techniques or agents -Conduct activities through the Internet -Remote location with discrete security measures -Compartmentalise phase and restrict access of personnel
Production Phase	-Large numbers of eggs or laboratory animals for virus production -Storage facilities -Acquisition of specialised equipment eg. fermenters, lyophilizers, -Security measures -Basic sterilisation and/or -Decon facilities -Evidence of immunisation or infection in people or animals nearby -Key technical pers observed at probable facility	-Overhead imaging or human intelligence -Thermal and IR monitoring -Sampling of air, water or soil near the suspect facility (together with various forms of biochemistry analysis) -Bio-markers -Reports of odours or unusual activity	-Conceal measures, or place production facility within other secure or isolated facilities -Use tissue culture rather than animals for production of viruses -Obtains equipment from multiple suppliers or intermediatories -Divert equipment from legitimate civil industry or activities -Jury rig equipment -Decontaminate production facility -Sacrifice worker safety -Material and equipment claimed for use for medical applications -Minimise personnel involved
Weaponisation Testing Phase	-Unusual activity related to outdoor testing or modelling of dispersion patterns -Specialist safety and respiratory equipment -Containment systems -Anomalous characteristics of disease outbreak -Test facilities and Cold Storage -Blast and fragmentation evidence -Unrelated or obscure activity suggesting a dry run at other venue or location	-Procurement of specific modelling or hazard software -Acquisition of specialised biological handling and production equipment eg centrifuges and separators -Field epidemiology and genetic finger printing of disease agent -Sampling of soil, vegetation and personnel -Post blast and modelling analysis -Imagery, monitoring and surveillance	-Produce agent shortly before use to minimise the signature and the requirement for long duration storage -Mask thermal infra-red emissions from refrigerators -Remote location -No or partial testing -Reduce view from imaging, surveillance and monitoring by conducting testing indoors. -Conduct dry runs -Reduce waste and impose rigid contamination control processes

[92] Derived from an activities matrix developed from Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 112. Also draws on concealment and production activities from Swedish National Defence Research Institute, op. cit., Changes have been made to phases, signatures, detection and concealment functions to closer align these to monitoring and interdiction against non-state organisations seeking to develop a biological agent capability.

The identification of signatures and indicators associated with the development of a biological capability is further complicated through the wide availability of biological materials, equipment and services, *all* of which are dual-use, as opposed to specific to task. Table 10 provides an overview of the possible signatures, indicators, concealment mechanisms and counter-measures that might be associated with the misuse of capabilities involving non-state development. Despite the difficulty in the detection of covert or illegal biological development, many of the concealment, procurement and proliferation mechanisms employed can be countered and indeed overcome, with strengthened and targeted regulatory structures.[93] For example, despite the failure of the Aum's covert biological program and the escalatory signatures of activity as early as the 1990s, there remained no reporting of any biological capability, capacity or intent (most reporting was derived from Aum members' testimony during court testimony and evidence presented following the 1995 sarin Tokyo subway attack). The failure of the Japanese security and intelligence agencies in detecting any of the Aum's CB capability development is now well established, yet it is potentially no different from many similar environments that currently exist today throughout most western democracies.

Advances in biotechnology, especially for production processes, makes detection of covert biological capabilities more difficult than ever before. Increases in the efficiencies of equipment and production of biological capabilities have significantly reduced the size, volume and processing requirements, and also many of the more well established signatures and indicators normally associated with considerations of development. This is particularly so when the quantities potentially required for non-state use are greatly reduced when compared with those for state WMD programs. That is, they are more likely to be in the vicinity of grams and kilograms rather than tons. Even though a facility's infrastructure may include fermentation systems, cell culturing, egg incubation, harvesting, purification and/or lyophilisation processes and equipment, these signatures will

[93] Office of the Secretary of Defence, *Proliferation: Threat and Response*, op. cit., Sections III and IV, and United States Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, pp 36-42, 99-114.

nearly always remain ambiguous and dual-use in scope.[94] In the testing and production phases of biological agent development activities may include stockpiling and the use of decontaminants, such as hyperchlorites and bleaches or the use of specialised equipment, such as spray systems or agricultural machinery. One of the more distinctive signatures, particularly in less controlled processes involving covert biological agent production, is the inadvertent release of unusual odours.[95] Interestingly, it was this particular indicator in the case of the Japanese Aum Shinrikyo Cult's biological production at the Satian facility that initially resulted in strong interest by surrounding residents and the authorities.[96] Why the authorities did not act further, particularly when considered in the context of the other suspicious activity associated with the Cult and the facility, is still unclear.

As with all indicators, they must be assessed in aggregate and against the context in which they were collected. Biological activity indicators are notoriously inconclusive, relying often on what can be widely ambiguous signatures, such as the procurement or availability of cold storage and specific testing equipment (particularly if it has been modified). One of the more conclusive indicators, however, is the use of animals. For example, pathogenic free rodents or the appearance of dead animals at possible production or testing areas, along with

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[94] Some of the non-protein toxin work is of such a unique nature that the technical demands for production of the agent would almost preclude it from terrorist development (but possibly not from acquisition). Office of Technical Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, p 90.

[95] However, associating an odour with a *particular* activity or process is a very unreliable indicator. For example, numerous large industrial processes often release a range of gases which are associated with strong odours. This is particularly the case if they utilise a water filtration, effluent discharge or evaporative systems. Interestingly, the historical reporting of the activities of the WWII Japanese biological offensive research and production units, Unit 731 and Unit 100, which had been involved in biological research on pathogenic and infectious materials (including on human subjects), had been widely reported as having discharged strong and pungent odours from many of its batching and culturing production facilities. Commonly reported by residents located near these biological facilities (who were themselves often used as forced labour in the research work) was a continuous discharge of foul odours and oppressive gases. The foul smells were most probably attributable to the different culture mediums used and the lack of filtration and extraction systems within the production processes. Paradoxically, it is possible that many of these same basic processes, for which extensive research information is now widely and publicly available, would most likely still be utilised by a non-state actor in biological capability development For information on Unit 731 and Unit 100, see P. Williams and C. Wallace, *Unit 731: Japan's Secret biological Warfare in World War II*, New York, United States, 1989, pp 91-112. For a outline of various process, industrial and those on a small scale, see Office of Technology, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, op. cit., pp 71-118

[96] Ishikura, op. cit., pp 35-70 (Section – 'Horrifying Biological Weapons: Experimental Stage').

analysis of carcasses, might provide the strongest signatures of covert CBR activity. For example, while the exact nature of the Japanese Cult's activities at Banjawarn station in Western Australia remains inconclusive, the appearance of dead sheep throughout the immediate area was a key indicator of suspicious activity, yet it was not recognised until the investigative follow up from the 1995 Tokyo subway attack, nearly two years afterwards.[97] Finally, the accidental release of an agent, particularly one not endemic to the area, may be the strongest indicator of testing or use.[98] Unfortunately, recognising it outside of normal environmental sampling, public health reporting or background analysis can be difficult, particularly as the majority of Australia's national sampling and reporting regimes are passive.[99]

As in the analysis of chemical development activity signatures, it is not the intent and nor is there the capacity within this thesis to provide an exhaustive listing of material and activity signatures associated with each biological agent development process. It is the understanding of the key processes and the relative difficulty in their development which subsequently allows for the recognition of core vulnerabilities and inherent risks, particularly if these are to be exploited in applying counter-measures against them. Yet while the exercise of regulatory requirements is one of the more established vehicles to deter these threats, it can only be effected through specificity in the definitional and legislative structure and a commitment to apply and enforce any regulatory controls.

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[97] Australian Institute of Criminology, op. cit., pp 2-7.

[98] While not of terrorist origin, a study of the unusual anthrax epidemic in April 1979 in Sverdlovsk, Union of Soviet Socialist Republics, is an interesting analysis of potential indicators of covert and/or illegal biological research and development activity. The West's attention was first drawn to the area by the high fatality rate from an outbreak of inhalational anthrax and suspicion of a Soviet Research Facility coincidentally being co-located. There were claims the dissemination was food-borne, however, subsequent analysis and reporting asserts it was the result of an accidental release of aerosolised anthrax. For a full account of the interviews and research surrounding the incident see M. Meselson, J. Guillemin., M. Hugh-Jones, A. Langmuir, I. Popova, A. Shelokov, O. Yampolskaya, 'The Sverdlovsk Anthrax Outbreak of 1979', in *Biological Weapons: Limiting the Threat*, ed J. Lederberg, in *Biological Weapons – Limiting the Threat*, ed J. Lederberg, MIT Press, United States, 1999, pp 193-211

[99] The term 'passive' refers to sentinel and non-invasive surveillance systems as opposed to those processes and actions that actively monitor, detect and engage emergency and medical services in the collection of information.

RADIOISOTOPES AS WEAPONS OF MASS DESTRUCTION

Radiological agents, whilst appearing to be a relatively new concept or weapon, are not. There have been previous state sponsored WMD programs which have investigated the military utility of radioisotopes as weapons, however, their utility was consistently found to be limited.[100] For example, Iraq attempted to use zirconium-95 but ceased further development in late 1987 purportedly due to frustrations in the weaponisation and effective dissemination of agent. Even the United States and United Kingdom had previously attempted to use a range of radiological isotopes, both as fills in conventional weapons and as specifically designed systems, yet similarly, without a great deal of success.[101] Unlike a nuclear weapon based on a fission or fusion reaction, radiological agents (more often colloquially referred to as 'dirty weapons'), refers to the deliberate release of a radioisotope as an inhalation, ingestion or percutaneous hazard.

In establishing what is included within the use of the term radiological, it is just as critical to understand what is not. Weapons that may entail the use of a blanket that becomes radioactive by the neutrons produced as the weapons detonate, and/or any fissile or fusion material are also excluded (as these would normally be expected to involve a fission or fusion reaction). Nuclear technologies, as noted earlier, will not be included within the scope of this thesis as they are covered under a range of other national and international regulatory

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[100] For an analysis of the process (and subsequent frustrations) within the Iraq WMD program involving the research and weaponisation of radioisotopes see United Nations, *Tenth Report of the Executive Chairman of the Special Commission established by the Secretary-General*, New York, 17 December 1995, S/1995/1038.

[101] Iraq declared testing of radiological isotopes, which they claimed commenced in 1987, at the Muthanna State Establishment. The Iraqis claimed the experimentation was to study the military effectiveness and utility of employing irradiated materials within weapon systems. A number of lead-shielded metal containers with irradiated zirconium oxide were exploded at a chemical weapons test site. Each container, which weighed about one ton (because of the extensive shielding), had from 0.5 to 1 kilogram of irradiated zirconium oxide contained within. Iraq claims that because of the lack of success with the testing and safety problems in handling and transport of irradiated materials they shelved the program at the end of 1987. In total, only a few kilograms of zirconium oxide was irradiated in the research reactor in Tuwaitha for the purposes of this project. There remains inconsistencies within the declarations by Iraq, specifically a contradiction in a later declaration over the location and quantity produced of specialist casings (from Muthanna-4 systems which were aerial bombs modified for chemical delivery but established as prototypes for the dispersion of zirconium oxide). United Nations, S/1995/1038, 1995, op. cit., pp 13-14. Also see the Federation of American Scientists on their *Nuclear Forces Guide - Radiological Weapons*, (accessed 21 March 2001), http://www.fax.org/nuke/guide/Iraq/other/radiological.htm

regimes and arms control norms. As a consequence, the thesis will refer to radiological capabilities as including those weapons that are designed to utilise a radioactive material to cause destruction, damage or injury through the deliberate release of radiation produced by the decay of radioactive material. This differs from the United States' definition, which is limited to the 'dispersion of radioactive material from a conventional explosive'. This definition limits the method of release by which radioisotopes may be disseminated, of which explosives is only one method.[102]

The utility of using radiological isotopes as a weapon for non-state use was popularised by an incident involving Chechen militants. The incident involved the Chechen leader, Shamil Basayev, who had threatened the use of a device packed with Caesium-137 and conventional explosives against the Russian Government, placing a source in Ismailovo Park in Moscow in November 1995.[103] There have been other radiological incidents reported, yet more often these have only involved threats and the theft of radiological materials. Despite the accounts of the increasing availability and proliferation of fissile materials from the Soviet Union, as yet there has not been an incident involving any actual casualties (other than through the effects of blast and fragmentation).[104] While most non-state reporting of interest appears to have been directed at enriched Uranium and Plutonium (to be utilised for nuclear weapons development), there has been a growing incidence of radioisotopes being employed to lend greater credibility to hoaxes or threats of release.[105]

The distinction in the capabilities between nuclear and radioisotopes is not just distinguishable on the basis of military and commercial applications, but clearly

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[102] United States Defence Threat Reduction Agency, *Weapons of Mass Destruction Terms Handbook*, DTRA-AR-40H, 1 July 2000, p 107.

[103] United Kingdom, Commons Hansard for Monday 13 December 1999, Column 100 – Speaker Mr Jonathan Sayeed.

[104] Hoffman, *Inside Terrorism*, p 204. For further information on theft, proliferation and acquisition of nuclear related materials see Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, pp 129-144.

[105] It was reported that Ramzi Yousef had attempted to acquire via the black market, Strontium-90 and Cesium-137, for use in the 1993 World Trade Centre bombing. His efforts, however, were unsuccessful as he reportedly was unable to acquire material (which Reeve claims was to be facilitated by his contacts with Bin Laden's terrorist network) to include in the bomb. Reeve, op. cit., p 147.

in the disparity between the different outcomes. Controls and the regulatory measures that account for radiological materials throughout the Former Soviet Union particularly, have become more porous, with black market micro-proliferation of materials widely reported. For example, at the Radon factory and nuclear waste disposal site near the village of Tolstoy-yurt, north of the Chechen capital Grozny, quantities of Caesium-137 and Strontium-90 have been frequently reported as missing. As at the start of the war in 1994 in Chechnya, the Radon facility contained some 900 cubic metres of nuclear material with radioactivity levels of 1,500 curies. At least half of the material is now reportedly missing.[106] Unlike biological and chemical agents, the availability and lack of controls over isotopes indicates that if a determined non-state actor sought to acquire these materials, they could relatively easily be obtained from a variety of accessible and low visibility procurement networks.

Various non-state attack scenarios which attempt to employ radiological agents are generally based on the axiom that they are lethal and capable of a mass casualty outcome – they are not, at least in terms of being delivered as an acute hazard. Albeit some radioisotopes are lethal if ingested or inhaled in high doses which, as for many toxic chemicals, cannot be achieved unless voluntarily or forcefully administered on a mass scale. Even then, dependent on the dose and isotope, the delay in the onset of symptoms may extend from weeks to years. This delay does not fit with the patterns identified in the analysis of non-state motivating rationales. Theoretically, the accumulative, chronic and acute physiological results of this type, similar to many of the carcinogenic and mutagenic effects of toxic industrial chemicals, creates a situation that may potentially result in masses of people with lingering health problems for years afterwards. This type of outcome, along with a lack of knowledge an isotope may even have been released, would not appear commensurate with an organisation fighting to legitimise, or positively influence, public opinion, particularly for separatist and ethno-nationalist groups.

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[106] *The Sunday Times*. 'Russian Nuclear Material Stolen during War in Chechnya – High Radiation Levels in Grozny', 10 November 1996.

The physical state of most radiological agents, without specialist processing, is as a liquid, solid (as a particulate) or as a gas. It is, however, the routes of entry into the body that are of the greatest concern, most particularly those via the respiratory system as the other routes can be relatively easily protected against. Hazards from radiation are caused through either contact (penetration of gamma into the body), orally and/or through ingestion.[107] The latter two routes concern alpha and beta emitting isotopes as these, particularly alpha emitters, are the most significant health threat, at least within a non-state mass casualty context. This is due mainly to the potential biological effects from ingestion and/or inhalation. The somatic effects from low level radiation exposure are generally confined to cataracts, changes in growth and development, nonspecific life shortening, and cancers, rather than the more dramatic and immediate results derived from chemicals or the use of conventional weapons.[108] The routes of entry and the physical state of the isotopes play a potentially major part in the ease of proliferation of these agents, particularly when the quantities are small and the isotopes can be moved covertly. Any real utility derived from use can be relatively easily countered through the delayed effects of radioisotopes, the difficulty in achieving a LD_{50} and the relative ease in protecting against these types of hazards.

Unlike some chemical and biological agents, nearly all radiological agents have utility within industry or in the commercial sector. Radioisotopes such as Curium-244 and Cobalt-60 are relatively widely used and generally available – at least under legitimate licensing and accreditation criteria and standards.[109] Two of the most prolific isotopes within industry are Phosphorus-32 and Strontium-90, however, typically quantities available would be in the vicinity of millicuries, which is relatively insignificant in terms of its utility for any non-state weapons application. Regulatory controls for radioisotopes (as opposed to nuclear

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[107] For an analysis of ionising radiation and its biological effects see *Ionising Radiation and its Biological Effects*, United Kingdom Institute of Naval Medicine – Training Division, Publication BR 3030(1), Rolls-Royce and Associates Limited, London, 1991.

[108] D.T. Devine and R.L. Chaput, 'Low Level Effects', *Military Radiobiology*, eds , J.J. Conkin and R.I. Walker, Armed Forces Radiobiology Research Institute, New York, 1987, p 379.

[109] The standards of use, carriage, storage and accreditation are set out in Standards Association of Australia, *Australian Standard 2243.4- Ionising Radiations*, Sydney, 1986.

materials) are normally embedded within domestic legislation. For example, in the United States there are nearly 50,000 licenses issued for the handling and storage of high activity isotopes, such as Strontium-90, with locations publicly available from the United States Nuclear Regulatory Commission over the Internet.[110]

Table 11 - Probable Effects of Acute Whole-Body Radiation Dose

Acute Dose (rem)	Probable clinical effect
0-75	No effects apparent. Chromosome aberrations and temporary depression in white blood cell levels found in some individuals
75-200	Vomiting in 5-50 percent of exposed individuals within a few hours, with fatigue and loss of appetite. Moderate blood changes. Recovery within a few weeks for most symptoms
200-600 (LD50 is at approximately 400 rem)	For dose of 300 rem or more, all exposed individuals will exhibit vomiting within two hours or less. Severe blood changes, with haemorrhage and increased susceptibility to infection, particularly at higher doses. Loss of hair after two weeks for doses over 300 rem. Recovery within one month to a year for most individuals exposed at lower end of range; only 20 percent survive upper end of range
600-1000 (LD90 is at approximately 600 rem)	Vomiting within one hour, severe blood changes, haemorrhage, infection, and loss of hair. Some 80-100 percent of exposed individuals will succumb within two months; those who survive will be convalescent over a long period

Source: Adapted from Australian Radiation Protection and Nuclear Safety Agency, *Guidance Manual – Medical Management of Individuals Involved in Radiation Accidents*, Technical Report Series Number 131, Australian Government Publishers, Melbourne, 2000, pp 24-59.

While one advantage of radionuclides is that no processing is necessary for use, the disadvantage is that the effect is primarily psychological (at least when employed in a non-state weapon), other than the broader less catastrophic occupational health and safety implications. Unlike many chemical and biological agents, field detection and identification of specific isotopes is not always immediately obvious, even to trained personnel utilising specialist detection equipment.[111] Recognition based on sight may also be difficult as contrary to

[110] Following the terrorist attacks against the United States on 11 September 2001 and the increasing need for security of sensitive and vulnerable public facilities and sites, the United States Nuclear Regulatory Commission website was closed and no longer provides details of facilities, storage capacity or hazardous materials handling criteria (based on licensing). While Australia does not have a website established that provides a similar service, information listing similar details (mainly derived from facility declarations) can be obtained through Freedom of Information entitlements from the Australian Safeguards and Non-Proliferation Office in the Department of Foreign Affairs and Trade. Personal communication Dr J. Kelly, Analyst, Australian Nuclear, Scientific and Technology Organisation, 6 November 2001, and United States Nuclear Regulatory Commission Website, (accessed 14 March 2001), http://www.nrc.gov/NMSS/IMNS/materials.html.

[111] Refers specifically to detection at the field or initial response level using standard Australian Defence Force detection equipment for alpha, beta, gamma and low energy x-ray by systems such as the AN PDR-77 and FAG-40 sets which are the standard in-service equipment in the Australian Defence Force. There are a wide range of detectors available that will monitor extremely low levels of radiation, however, more often portability and practicality prohibit their wider use with response forces.

popular myth, radiological sources often only consist of metal objects, such as bolts or nuts, which have been irradiated.[112] Even the symptoms are often difficult to identify. These factors, and the delays in the onset of symptoms, would be the strongest limitation in the lack of utility of radioisotopes. Table 11 outlines the effects and exposure levels referred to as the Whole Body Radiation Dose (note the acute and latent effects represented in the delay and onset of symptoms). These provide thresholds for exposure and along with activity levels, the basis for the current regulation of the more hazardous or high activity level isotopes.[113] The achievement of levels higher than even the secondary REM category (75 – 200 REM), would require either chronic exposure or a unique set of circumstances involving acute exposure to high doses over short periods – a situation unlikely in most non-state use scenarios.

While the routes of acquisition are similar to those for chemical agents, the robustness of radioisotopes means there is no degradation of agent and therefore none of the limitations and decomposition of agent found in chemical and biological production, storage and dissemination. The major difference is that isotopes would be acquired, rather than manufactured.[114] While radiological sources have half-lives, they cannot be destroyed, therefore any putative hazard will generally be persistent (but this is dependent on the isotope's half-life). The key factors in analysing the effect of radiological agents are time (as a function of decay), distance (as a function of reduced penetration) and shielding (as a function of the type of radiation and its penetration hazard).[115]

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[112] While this often applies to isotopes used for training and calibration, many also come in liquid form, particularly medical isotopes.

[113] Australia maintains approximately 200-250 high activity isotopes throughout a range of facilities. High activity sources are utilised in teletherapy, whole blood irradiation, industrial radiography and sterilisation and food preservation. High activity sources are those defined (although it depends on the actual application) within the approximate limits of 1-1000 TBq. The two main sources classed as high activity sources in Australia were Cobalt-60 and Caesium-137. J. Loy, 'Contributed Report by Australia', International Conference of National Regulatory Authorities With Competence in the Safety of Radiation Sources and the Security of Radioactive Materials, Australia, December 2001.

[114] Acquisition of isotopes is considered the only viable means of acquiring a capability in the context of non-state use. The potential for non-state actors irradiating their own sources is considered technically, scientifically and practically limited and unlikely. As a consequence, considerations of production as detailed in chemical and biological development processes, do not apply where possession would be facilitated through acquisition.

[115] Presentation to the Emergency Preparedness Canada Consequence Management Workshop, Canadian Preparedness College, Arnprior, Ontario, 26 May 1998, by Major C. Carbert, Commandant Canadian Forces Nuclear, Biological and Chemical School - *Presentation on Nuclear, Biological and Radiological*

Unlike the difficulties and wide range of permutations in chemical and biological development (represented in Diagrams 3 and 4), establishing a critical path for the capability development of a radioisotope is a simpler process. Other than the various routes for acquisition, the only variables, with no processing or production required, are in the method for release and the employment of the device. Indeed the use of most isotopes has so far been limited to the simple threats of use, with only two reported instances involving dissemination via explosives.[116]

The most significant advantage in using radiological isotopes is that they cannot be destroyed through the influences of heat, shock or friction that may result from a process of combustion or detonation. Despite the lack of utility in terms of the delays in the onset of symptoms (if they appear at all), radiological agents are not vulnerable to poor handling, transport or storage difficulties, a significant benefit when compared to biological micro-organisms and some chemical agents. As a consequence, there is an increased range of dissemination options. The optimal delivery form for an isotope is more probably via ingestion due to the efficacy of most isotopes and the difficulties in delivery as an acute inhalation hazard. If the source were solid or liquid, dissemination would most likely be directly as a contact contaminant or by explosive, where it would more likely be dispersed based on the net explosive weight of the device and isotope containment (if utilised). The result, other than psychological, would be to create a contact hazard with a moderate to low initial inhalation risk followed by a possibly increasing risk from secondary aerosols/particulates (however, this would diminish over time as a function of quantity, physical state, environmental conditions and type of source).

The possible use by non-state belligerents of radioisotopes is therefore somewhat problematic. While reporting still notes threats and possession of radioisotopes,

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Weapons and Agents. For further information on protection from ionising radiation see United Kingdom Institute of Naval Medicine, op. cit., For further information on chronic exposure to low level radiation as a consequence of non-state action see Devine, op. cit., pp 379-392.

[116] *2000 Monterey WMD Terrorism Chronology*.

it suggests that there is either an incomplete or inadequate understanding by belligerents of these materials. More probably, however, it indicates imitative or learned behaviour derived from other known activities, or simply misperceptions in the utility of these materials. Indeed, while the Chechens have been reported as having threatened and attempted to disseminate radioactive materials explosively, the desired outcome, other than psychological, was not reflected in the materials used or method of dissemination employed. Regardless of the intent, the collateral damage and immediate outcomes from any release of most isotopes will always remain relatively limited, particularly when contrasted against the use and potential of conventional weapons and even the ineffective use of CB capabilities, such as the Aum Shinrikyo subway incident.

TARGETING AND DISSEMINATION CONSIDERATIONS

> It is important to discriminate between discrete and indiscriminate attacks. Just because chemical and biological agents are often described as 'weapons of mass destruction' does not mean that the ability to inflict mass casualties is an inherent property. The use of VX nerve agent or the biological toxin ricin for assassination purposes is fundamentally different from releasing an aerosol of anthrax over a city.[117]

The challenges in aerosolising a CBR agent, micro-organism, toxin or radioisotope, whether explosively, mechanically or through pneumatic or pressure release systems, remains a major technical impediment. The key in effecting a suitable CBR dissemination system is in the integration of the physical characteristics of the materials with their release as a vapour or aerosol, not gravity, to move the materials. That is, movement and the rate of travel through the atmosphere is dependent on those physical and chemical forces that might bind the molecules or particles to specific surfaces in which they come

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[117] Tucker. op. cit., p 254.

into contact.[118] It is possibly dissemination, along with aspects of production, that most defines the capacity of state and non-state organisations to effectively employ CBR capabilities.[119] Yet current activities still only indicate the likely use of explosive dissemination, relying more on the benefits of primary and secondary fragmentation and the agent's effect through the cutaneous route, rather than through the actual aerosolisation and subsequent inhalation of agent.[120]

Just as with biological agent dissemination, the effective release of chemicals requires agent that it is thermally and mechanically stable enough to sustain the explosive detonation, combustion or mechanical release. State programs moved to overcome limitations in weaponisation, handling and storage hazards through the development of unitary and binary chemical agents, which sought to increase storage life and reduce the hazards in handling.[121] The development of this technology, however, is likely to be well beyond the capability of a non-state organisation given limitations in the development of specialised carrier systems and the technical requirements and knowledge for the production of a stable and high purity binary agent.

The method of dissemination is a strong determinant of the outcome, possibly more so than development and production, yet it is also critically dependent on the environment in and around the target area. One of the better examples to illustrate this is in the Aum's release of sarin nerve agent during the Tokyo

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[118] World Health Organisation (2001 draft), op. cit., pp 31-32.

[119] Iraq provides an interesting example of the frustrations inherent in the process of effective dissemination. Iraq sponsored a range of WMD programs, yet despite their efforts as a program they were unable to overcome a range of technical problems in the design of artillery shells, aerial bombs, missile warheads and spray devices (from helicopter and fixed wing along with drop tanks for jet fighters). Testing (declared by Iraq in its 3rd FFCD) noted attempts with poor results at weaponisation using Mirage F1 (2,200 litre tanks) and MIG 21 as an unmanned aerial vehicle (UAV). The dissemination systems were generally reliant on jury rigged, modified and/or conventional systems which often also incorporated explosive dissemination. Dr Kraatz-Wadsack, United Nations Monitoring and Verification Commission, *Briefing – Iraq's Biological Weapons Program*, Washington D.C., 17 July 2000, (note this was the successor to the United Nations Special Commission for Iraq).

[120] Y. Limor, 'The Snakes Head is Smashed – For Now', *Middle East Intelligence Bulletin*. Israeli Government Press Office, Ma'ariv, 27 November 1998, p 14, (accessed 19 March 2001), http://www.meib.org/articles/0003_meb.htm.

[121] Office of Technology Assessment, *Background Paper: Technologies Underlying Weapons of Mass Destruction*, pp 33-34.

subway attack in 1995. While the Cult selected an area where large numbers of people would be concentrated and the airflow was restricted, the sarin was essentially released as neat agent – a relatively inefficient method. Similarly, an incident which followed the Cult's 20 March 1995 subway attack occurred on the 5 May 1995 and reaffirmed the Cult's limited knowledge of dissemination. A burning vinyl bag of sodium cyanide, which was subsequently doused with water by a Japanese first response agency, was found in the male toilets at Shinjuuku Station. Adjacent to it was another similar vinyl bag which contained diluted sulfuric acid.[122] While in theory if both materials had mixed, hydrogen cyanide gas would have resulted, the mixing process, however, was extremely rudimentary and relatively ineffective.[123]

The challenge in the dissemination of materials is more complex than simply the attempt to mix two chemicals or trying to achieve an aerial suspension. It is as critically dependent on the characterisation of the materials as it is in the actual manner of release. An example which highlights this and assists in further developing the strategy of harm management and the concept of controls being exercised on the basis of risk (rather than toxicity, lethality, etc.), involves the use of the micro-organisms tularemia and anthrax. Tularemia (*francisella tularensis)*, with a thirty percent mortality rate, is considered less 'harmful' when compared to anthrax (*Bacillus anthracis*).[124] When delivered through the inhalation route, anthrax has a mortality rate estimated at one hundred percent.[125] However, the greater effectiveness of tularemia, only requiring one organism for an infective dose compared to up to 10,000 for anthrax, means that the area of

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[122] *2000 Monterey Aum Chronology*, pp 2-7. Also see Y. Shimbun, 'Aum Reportedly Planted Cyandide Gas Device at Shinjuku Station', *The Daily Yomiuri*, 14 June 1995, p 1. and Shimbun, 'Double-Bag Ignition Device Used in Gas Attack Attempt', *The Daily Yomiuri*, 11 May 1995, p 2.

[123] J. K. Campbell, Research Study - Weapons of Mass Destruction and Terrorism: Proliferation by Non-State Actors, United States Department of Defence, United States, 1997, p 23. and *2000 Monterey Aum Chronology*, pp 3-5.

[124] Journals of American Medical Association, *Tularemia as a Biological Weapon – Medical and Public Health Management*, Working Group on Civil Defence, Volume 285 Number 21, United States, 6 June 2001, (accessed 12 November 2001), http://jama.ama-assn.org/issues/v285n21/ffull/jst10001.html.

[125] M.N. Swartz, 'Current Concepts: Recognition and Management of Anthrax -- An Update', *New England Journal of Medicine*, Massachusetts Medical Society, United States, 30 November 2001, and K.J. Roche, M.W. Chang and H. Lazarus, 'Images in Clinical Medicine Cutaneous Anthrax Infection', *New England Journal of Medicine*, Massachusetts Medical Society, United States, 30 November 2001, pp 1-6.

contamination may potentially be greater than for anthrax.[126] The result may then be a wider lethal dose throughout a larger number of people, suggesting that the risk is as great, or greater. The deduction is then that the regulatory measures should be similar, or at least tighter, for *francisella tularensis*, than for *Bacillus anthracis* – they are not.[127] The example uses two more well known biological agents that may be of potential utility to the non-state actor, yet the fundamental precept is that both organisms should be subject to more pervasive controls.[128] The example also highlights the irregularity throughout the spectrum, particularly between those agents of relatively lesser hazard which when used in certain circumstances may have the necessary utility to be considered a high risk.

Use by non-state actors of CBR capabilities has to date been limited to a localised area, at specific facilities or only involved limited and discriminate use in targeting. This more often utilised agents not commensurate with any capacity to actually cause mass casualties. For example, the use of anthrax delivered via mail throughout the United States in the period following September 2001. Despite the psychological impact, the attacks only resulted in a small number of fatalities (all through separate incidents).[129] While there was uncorroborated reporting as early as April 1992 of the Aum attempting to utilise a line source method in the release of a biological agent, albeit unsuccessfully, this remains one of the few attempts to target facilities in this manner.[130] Most

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[126] Journals of American Medical Association, *Anthrax as a Biological Weapon – Medical and Public Health Management*, Working Group on Civil Defence, Volume 281 Number 18, United States, 12 May 1999, (accessed 6 December 2000), http://jama.ama-assn.org/issues/v281n18/ffull/jst80027.html.

[127] United States Department of Defence, Office of Surgeon General. *Textbook of Military Medicine. Warfare. Weaponry and the Casualty Part 1 - Medical Aspects of Chemical and Biological Warfare.* Washington DC, 1997, pp 469-474. Risk incorporates a wide range of issues and particularly within the case of anthrax, it is relatively easy to propagate and has been popularised by the activities of extremists like Larry Wayne Harris, who has publicly spoken of its use and utility in covert action. For a more detailed analysis of Larry Wayne Harris's activities and those associated with similar types of development (along with an analysis of his potential) see, J. E. Stern, 'Larry Wayne Harris (1998)', in *Toxic Terror: Assessing Terrorist Use of Chemical and Biological Weapons*, ed J. B. Tucker, MIT Press, Washington DC, 2000, pp 227-246.

[128] T. J. Cieslak, and E. M. Eitzen, *Bioterrorism: Agents of Concern*, Public Health Management Practice, Washington DC, 2000, pp 19-29.

[129] *2000 Monterey WMD Terrorism Chronology*, pp 2-11.

[130] The uncorroborated reporting of the attacks involved the spraying of botulinum toxin from three trucks against a range of targets which included two United States naval facilities, Narita airport, the Diet, the Imperial Palace and the headquarters of a rival religious group. The attempts to disperse agent failed, however, it is unclear whether this is attributable to (as Leitenberg suggests in 'The Experience of the Japanese Aum Shinrikyo Group and Biological Agents', pp 161-162), failing to isolate cultures of

targeting has been from a point source release, yet actual delivery systems have failed to further develop or incorporate area and line source dissemination, most particularly those involving the integration of fluid and aerosolisation engineering technologies.[131]

The operational impediments imposed through technical constraints in CBR acquisition, production, employment and effective dissemination, cannot be underestimated. This is not to assess that they cannot be overcome, yet employment of a CBR WMD capability and the capacity to then project and direct its application, particularly strategically, may potentially impose significant organisational opportunity costs to any group. Even in the strategic projection and use by transnational terrorists of conventional explosive capabilities, major personnel, resource, financial and operational risks are imposed on the organisation, greatly increasing the potential for interdiction or compromise. Even non-CBR WMD incidents such as the Oklahoma, World Trade Centre and East Africa bombings, imposed significant recruitment, logistical and personnel costs, along with a high dependence on indigenous resources and local infrastructure – and it was these specific aspects that ultimately compromised the operations and resulted in interdiction, albeit in all of the cases after the event.[132] The geographical isolation, extended lines of communication and logistical demands of transnational operations, particularly within an Australian environment, would no doubt be a significant and inhibiting

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botulinum toxin from earlier samples collected from the facilities and personnel, or simply because they were not ready or proficient in the development and release of the toxin. The issue remains that the aerosolisation and delivery of an effective dose as an acute inhalation hazard even today still remains a significant hurdle in the delivery of biological agent. Kaplan, op. cit., pp 51-57. Also see W. J. Broad, 'Sowing Death: How Japanese Germ Terror Alerted the World', *The New York Times*, United States, 26 May 1998.

[131] Dissemination of CBR materials can be effected via three methods of release. The first is a point release, where agent is released from a single static source. The second method is an area release which involves the dissemination of agent from multiple sources, normally static, across a wide area. This method is normally the result of an aerial attack using bomblets or munitions. The third method is a line source release which involves the dissemination of agent, normally from a single source, but in a continuous line, from one point to another. This method is normally the result of aerial or ground spraying.

[132] In regards to the East Africa bombings, while there has been an indictment for Usama Bin Laden since November 1998 by the United States, a trial and the presentation of evidence, however, is still pending. Although there have been arrests made in relation to the attacks, which reportedly links Al Qaida and Usama Bin Laden to the attacks, his association and involvement is still unclear. Office of Secretary of State, *Patterns of Global Terrorism*, pp 17-18, 51-53. Also see Alexander, op. cit., pp 33-50.

factor in the cost-benefit and consideration-action cycle in a non-state organisation. The impediments, however, are not impossible to overcome.

The difficulty is then in articulating these limitations into preemptive controls, or more critically, exploiting the acquisition, production, testing and weaponisation vulnerabilities that impose risks to the organisation in the capability development process. The consequence of these technical obstacles should be the increased control of specific risk items of materials and equipment that are involved in these processes. This may include equipment such as agricultural and engineering aerosolisation systems that operate below or within defined 'risk' parameters (more than likely based on limitations in particulate sizing, discharge holding volumes and overall utility). In conjunction with equipment controls, there is the need for more pervasive regulation and management of the risks within the provision and availability of dual-use services and sensitive technologies, particularly those with direct or dual-use utility in areas such as the agricultural sciences and fluid mechanics.

The diffusion of engineering and technical capabilities, or indeed any of the capabilities that relate to the provision of specialist skills and knowledge, makes the imposition of effective controls to limit proliferation extremely difficult to monitor and enforce. Surprisingly, there are currently no controls or compliance requirements for the provision of any of these services nationally. While the controls on materials, services and equipment will never overcome a determined non-state actor seeking to acquire and develop these capabilities, what cannot be understated is the psychological deterrence value derived from regulatory controls, even if they fall short of a complete and comprehensive control of all materials, equipment and services. The paradox, however, as in all these counter-measures, is that an effective deterrent through its visibility or actual result, can also make a superb target.[133]

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[133] Wohlstetter, op. cit., p viii.

CONCLUSION

The efficacy of deterrence structures is premised on a thorough understanding in the application of risk management processes throughout the regulatory continuum. The dichotomy between perceptions of capability and the actual capacity of many CBR capabilities is often exacerbated in the lack of any definitional framework that might underlie regulatory controls. Without the necessary specificity and capacity to be effectively applied to regulate CBR capabilities, which can only be established through an understanding of the unique characterisation of the materials, equipment and services involved, any supporting legislation or regulatory structures that are built around mitigating the risk of misuse become ineffective. Controlling the use of CBR capabilities then becomes more than simply the determination of what agents have the highest mammalian toxicity or lethality. It is about understanding their wider utility as well as the context in how a non-state organisation might undertake the development of a capability and where opportunities by the state exist for the exploitation of vulnerabilities throughout the CBR spectrum.

Focussing efforts at the CBR WMD high end of the spectrum of activities not only provides for counter-measures to be directed at those materials of greatest potential, but it inevitably sweeps up a greater proportion of the regulating effort throughout the lower end of the activity spectrum. While any primacy in the development of more efficient controls must be directed towards the high risk capabilities, particularly those with the potential for a catastrophic outcome, reporting consistently highlights the generally criminal nature of most CBR activities with a predominance of incidents only involving possession and threats of low end spectrum CBR capabilities.[134] The capacity to provide a regulatory capability across the CBR activity spectrum is not only a deterrent to all non-state belligerents, but is a large component in the reduction and management of risk. Importantly, in identifying the micro and macro scope of activities involved in capability development, along with the escalatory activities

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[134] *2000 Monterey WMD Terrorism Chronology*, pp 2-11.

necessary to produce an effective outcome, preemption can more effectively be applied through reduction, detection, enforcement and response measures.

Yet how much can be established from the historical and existing activities of non-state belligerents? If current trends in reporting are to be used as a litmus test of wider and potential activity, then there would only be a limited justification for current efforts and expenditure directed at countering WMD activity. Current efforts would more aptly be described as 'mass disruption' as opposed to 'mass destruction'. Analysis indicates the following:

- Limited use and employment of toxic industrial chemicals for poisoning, assassination and disruption activities, thereby constraining dissemination to a confined area, as a chronic inhalational hazard or as a direct contact and ingestion hazard.

- Significant developmental constraints on producing and delivering biological materials restricting delivery of agent to a wet slurry (as opposed to a desiccated powder), thereby constraining dissemination to ingestion and percutaneous applications.[135]

- Use of commercial radiological isotopes limited to threats of use and intimidation in the main facilitated by the psychological and visceral fears imposed through the action of the threat rather as a consequence of the possible (limited) physiological outcomes.

The technical, scientific and engineering obstacles towards non-state capability development can neither be over or underestimated. Current trends reflect widespread inefficiencies, a lack of scientific proficiency, constrained and limited use of existing capabilities, poor equipment and materials and inadequate acquisition networks. When combined with the appearance of a limited understanding by non-state belligerents of the characterisation of CBR materials and what they can achieve, the potential of these capabilities would appear

[135] World Health Organisation (Draft), op. cit., pp 32-38.

unrealised. Yet extrapolating these existing limitations to trends which may constrain future non-state activities more often tends towards miscalculation and exacerbating aspects of the risk given the potential consequences for errors in judgement.

Limitations and constraints in capability development will, however, not continue indefinitely or unrealised. The erosion in constraints, whether through the greater availability of sensitive information, wider access to dual-use equipment and materials or in the increased availability of more technically and scientifically proficient non-state belligerents, will of course greatly contribute towards accelerating change in the capacity of non-state belligerents to overcome any hurdles. The key is in ensuring there already exists the preemptive capacity within the deterrence structures that can change behavioural patterns and influence non-state decision-action processes, well out from any outcome. That is, it is the capacity to focus on the development and application of norms on restraint, rather than simply those efforts at deterring the effect itself, that will realise the widest benefits.

While this section has sought to explore the developmental processes and phases associated with CBR capability development, there remains no clear roadmap in establishing a trend or propensity towards the development of a specific technology. Analysis depends on applying first principles to establish the potential of the capabilities rather than what has already been demonstrated. What can be determined, however, is that there is no inevitability or predestination in the development of higher end spectrum capabilities from what is being observed throughout the currently low levels of CBR activity reporting. The realisation of this, that there may be no linear development, is crucial in the adoption of more effective and targeted counter-measures.

To use a simple representation, a comparison can be made with a large sector of the bomb-related activity currently occurring within Australia. A range of activities are reported annually, from experimentation with pipe bombs and low explosives to the wide use of a range of chemical incendiaries. Yet these activities are unlikely to reflect an inevitability in the development of high

explosive mass casualty capabilities. Applying the analogy to non-state organisations, interest, possession and possible use of low end spectrum agents does not similarly reflect a propensity towards high end spectrum agents. The Aum Shinrikyo Cult, however, provides an interesting example to the contrary. They actively utilised low level agents as poisons and drugs for approximately five years prior to the events which culminated in the attack using sarin nerve agent on the Tokyo subway. This involved a clear pattern of escalations in violence, risk taking and of changes in the technical proficiency of the Cult.

Many other terrorist organisations have been associated on a recurring basis with the use of low end spectrum agents, such as cyanide. They have actively employed these types of agents to poison water sources, yet have always been discriminate in the nature of any attack. Yet these earlier lower level activities in themselves have not necessarily provided the impetus or developmental first steps in the adoption of more lethal and capable technologies, CBR or otherwise. While a crucial aspect within a non-state organisation is undoubtedly the technical proficiency of the group, as has been established, the value system and belief structure it adheres to are also just as critical. That is, it is the group's preparedness to adopt different forms of violence and the organisational disengagement mechanisms it applies which are the most likely factors that might compel a group to adopt a mass casualty capability. It is the conflation of these two seemingly separate issues, the technical capacities and organisational dynamic within and outside of the non-state organisation that the forthcoming sections of the thesis will address with the intent of more effectively identifying signatures and counter-measures. That is, those aspects within the regulatory structures that better allow for preemption and the more effective management of risk as these will ultimately determine the effectiveness of any national deterrence strategy.

Leitenberg, a senior fellow at the Centre for International Security Affairs in the United States, sums up the potential threat from CBR capabilities by arguing governments should firstly reassess the plausibility of CBR terrorism. He seeks to have government apprehensions become more consonant with historical experience and an understanding of the technical problems that must be

overcome by non-state organisations in attempting to prepare and use these capabilities.[136] This identifies the critical need for an accurate understanding of the agents, their mechanisms of action and indicators of development. It is only through an understanding of these support and proliferation mechanisms, and the CBR non-state capability development process, that a balanced and unbiased analysis of the actual risk can be progressed – as opposed to simply perpetuating the current misperceptions of vulnerability.

An example extracted from the Australian Safeguards and Non-proliferation Office 1999 Annual Report, sums up a portion of the previous discussion on defining the risk and in developing an understanding of the nature of what it is that is to be regulated. While the example demonstrates the porosity and lack of regulatory controls, it highlights the potential throughout the regulatory system for it to be circumscribed and the difference between perceptions and expectations. The Non-Proliferation and Safeguards Office in an attempt to more accurately estimate industry activity in scheduled chemicals, sought to capture importation data on the movement into Australia of Chemical Weapons Convention schedule two and three chemicals. The findings indicated that there existed no licensing requirement outside of specified thresholds for importation along with no capacity within the Customs processes to capture the associated trade activity or reporting. The current limited range of data available was established as unreliable and it was assumed (accurately as it turned out), that it was not reflective of commercial trends (which was necessary for the assessment of risk).

To better facilitate the capture of information on imports of high risk chemicals, the Office initiated a limited industry survey. There were twenty five companies that responded positively that they had imported (legitimately) Chemical Weapons Convention schedule two and three chemicals (these categories refer to the particularly hazardous chemical warfare agents and their precursors – albeit with a range of dual-use applications).[137] Of particular interest was the fact that

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[136] Leitenberg, 'The Experience of the Japanese Aum Shinrikyo Group and Biological Agents', p168.

[137] For further information on controls relating to scheduled chemicals, import and export regulatory measures see the Australian Safeguards and Non-proliferation Office homepage http://www.dfat.gov.au/

the data only reflected a limited sample of importers and there was no mechanism to assess or calibrate activity in this, and in many other areas, the national regulatory reporting and monitoring structure. The more crucial point, however, is one of the wide misperception and lack of information on critical vulnerabilities and activities, that in the end, are the key determinants of risk – which until that point was completely indeterminate. Critically, prior to the survey there had been no idea, as an estimate or otherwise, of the level or scope of the national activity involving potentially 'high risk' agents. This same situation is replicated throughout all CBR sectors across the Australian regulatory landscape.

While potential is a key factor in the calculation of risk, the fundamental issue is that there must still be a capacity to understand and respond to threat indicators. The key precept examined throughout this section is that the nature of these changing unconventional threats may not present signatures that are readily understood, or indeed collection assets may not even be collecting against these areas or are in fact targeting the wrong areas. The difficulty is that it is more likely that critical information may not be captured, or is not recognised for what it is. Expectations of long timeframes for development, covering months or years, as was the case with the Aum Shinrikyo Cult, become somewhat moot if escalatory indicators are not understood or responded to. Recognising this as a limitation identifies a clear and critical need to ensure there is the capacity, whether through existing or new regulatory controls and structures, that indicators can be collected, processed and understood for what they may potentially be – a developing non-state unconventional threat.

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cwco/pages/impexp.html#tariff. For summaries of activities see the Australian Department of Foreign Affairs and Trade, Australian Safeguards and Non-Proliferation Office, *Australian Safeguards and Non-proliferation Annual Report 1998-1999*, Australian Government Publishers, Canberra, 2000, pp 42-43.