

BLUE HORIZONS FELLOWSHIP

AIR UNIVERSITY

BEYOND THE THIRD OFFSET: REDEFINING TOTAL WAR
THE INEVITABLE USE OF NON-LETHAL BIOLOGICAL WEAPONS

by

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...attaining one hundred victories in one hundred battles is not the pinnacle of excellence. Subjugating the enemy's army without fighting is the true pinnacle of excellence.¹

—Sun Tzu
The Art of War

Preface²

A recent crowd-sourced challenge from the Nigerian Bioscience Academy posted by iGenome Geneva switched on the inventive light bulb in two very different men living continents apart. Accessing only online resources and DIY biology, the first man (Ben Freeman of Atlanta, GA) solved the challenge in 18 days and claimed the \$15K award. This was a nice profit considering his largest outlays were under a thousand dollars. Ben outsourced genomic sequencing to biolabproject.org for \$400, paid another \$350 for pharmacological processing services, and finally mailed the winning synthetic biologics to Lagos for \$200.

Although the prize money was real, the contest was actually a phishing scheme funded by Iran. The Quds Force then exploited Ben's breakthrough and conducted three unattributed biological attacks. Two thousand Saudi peacekeepers mysteriously died in Yemen. Another twenty fatalities at Turkey's Konya Airbase—the installation's entire leadership cadre—prompted Istanbul to wage a yearlong military campaign against the scapegoated PKK. The third attack remains unnoticed.

Ben, an HVAC technician, also decided to experiment with a variation of his bio creation, a highly toxic pathogen that infects through inhalation. This synthetic biological was engineered to hide in plain site by mimicking microbes common to the natural environment. This is why Ben evaded detection after killing 5K people traveling through Hartsfield International airport, his employer's largest client. The civilian aviation industry suffered a reported \$200M in losses.

The second man (Liu Zhiang, Beijing University) solved Hezbollah's DNA challenge in just 6 days but passed up the reward. Instead, Liu continued to tinker away until he perfected a new binary toxin. His work was exactly what the People's Liberation Army had been waiting for. One year later, POTUS received a hand-written note from the President of China stating the following:

Imperial aggression will no longer be tolerated. The People's Republic of China hereby demands all U.S. military forces to immediately withdraw from and thereafter remain outside the Chinese Exclusive Economic Zone. As a display of resolve, the Wind of the Dragon will breathe across the region for some time but without enduring effect. Subsequent demonstrations, however, could prove more consequential. Let common sense prevail so our peoples can mutually prosper in peaceful pursuits like education, research and trade.

Two days later, three thousand personnel across in Hawaii and Korea were so sick that they could not work for five days. Nobody died. Civilians were unaffected. U.S. media outlets aired concerns ranging from food contamination to a botched military drug trial.

Although the preceding scenario is fictitious, rapid advances from the ongoing revolution in the biological sciences make such threats inevitable. The cost-effective

¹ Sun Tzu, translated by Ralph D. Sawyer. *The Art of War* (Cambridge, MA: Westview Press, 1994), 177.

² Biosecurity advocates have published many biological warnings, with one even targeting the individual DNA of POTUS. See A. Hessel, M. Goodman & S. Kotler, "Hacking the president's DNA," *The Atlantic*, Nov 2012.

capability explosion in synthetic biology, nano-medicine, bioengineering and big data analytics has been nothing short of remarkable.³ Director Of National Intelligence James Clapper reported to Congress that, “Advances in genome editing in 2015 have compelled groups of high-profile US and European biologists to question unregulated editing of the human germline (cells that are relevant for reproduction), which might create inheritable genetic changes.”⁴ These concerns are warranted because we now stand on the forefront of a new class of biological weapons that are defined by the following 13 key characteristics:⁵

- Relatively cheap
- Easy to make
- Readily available
- Undetectable
- Non-attributable
- Scalable
- Tailorable in potency (minor illness to death)
- Tailorable in duration (programmable latency, effect duration and binary effects)
- Tailorable in target selection (individuals, groups, or indiscriminate)
- Easy to deliver
- Less than zero warning time
- Accessible to individuals, states and other non-state actors
- Underlying science is dual-use

No previous weapon in the history of mankind has shared all these characteristics. The existence of such a class of weapons is changing the character and nature of war and ushering in a new era of warfare. The target is the individual body, the battlefield biological, the consequences affect humanity.

³ Increases in computing power, backed by Moore’s Law, gradually reduced the cost to fully sequence an individual’s DNA from the \$3B Human Genome Project to \$100M by 2001 to just \$1K today. See “DNA Sequencing costs.” (JAN 2016) National Human Genome Research Institute <https://www.genome.gov/sequencingcosts/>; Marc Goodman, “A vision of crimes in the future,” (JUN 2012) TEDGlobal 2012, https://www.ted.com/talks/marc_goodman_a_vision_of_crimes_in_the_future#-788150; Sarah Buhr, “At-Home Full Genome-Sequencing Is Now Just A Spit Tube Away.” (FEB 2016) TechCrunch article <http://techcrunch.com/2016/02/09/at-home-full-genome-sequencing-is-now-just-a-spit-tube-away>.

⁴ James R. Clapper, “Worldwide Threat Assessment of the US Intelligence Community,” 9 FEB 2016, Senate Armed Services Committee, Statement for the Record, p 9, http://www.dni.gov/files/documents/SASC_Unclassified_2016_ATA_SFR_FINAL.pdf

⁵ Amy Maxmen, “The Genesis Engine,” *Wired*, AUG 2015, <http://www.wired.com/2015/07/crispr-dna-editing-2/>.

Introduction

*...in battle one engages with the orthodox and gains victory through the unorthodox. Thus one who excels at sending forth the unorthodox is as inexhaustible as Heaven...*⁶

—Sun Tzu
The Art of War

Deputy Secretary of Defense Bob Work recently explained that the new Defense Innovation Initiative and the third offset strategies, “are much more than just technology. They’re about increasing the competitive advantage of our American forces and our allies over the coming decades.”⁷ Indeed, if realized, the third offset’s human-machine teaming and related capabilities will preserve American military advantage in the face of increasingly contested environments. Nevertheless, the enemy still gets a vote. How will China, Russia and other potential adversaries compete against the third offset? Most likely, America’s transparent, open society will continue to be challenged by a wide variety of political, economic, social and military strategies. But there will also be something new. Adversaries will identify human biology—instead of machines, technology or data—as a preferred domain to fight in. Unless we contest the human domain, adversaries will lay siege to our biology as the weakest link in America’s future fighting force.

In general, this paper argues that hostile nations, organizations and individuals will redefine warfare in order to render America’s third offset strategies impotent. Adversaries will inevitably target anyone, anywhere with biological attacks that are

⁶ Sun Tzu, translated by Ralph D. Sawyer. *The Art of War* (Cambridge, MA: Westview Press, 1994), 148.

⁷ Deputy Secretary of Defense Speech. “The Third U.S. Offset Strategy and its Implications for Partners and Allies” As Delivered by Deputy Secretary of Defense Bob Work, Willard Hotel, Washington, D.C., January 28, 2015. <http://www.defense.gov/News/Speeches/Speech-View/Article/606641/the-third-us-offset-strategy-and-its-implications-for-partners-and-allies>

cloaked in doubt and plausible deniability. In doing so, the enemy will redefine total war and likely initiate a biological arms race. Specifically, this paper argues that if left unchecked, adversaries will hold American Airmen at risk with non-lethal biological weapons of mass *distraction, disruption & destruction* that can be employed virtually anytime, anywhere—even in CONUS—without attribution. Furthermore, many of these bio weapons will be undetectable and therefore pose a sobering force protection dilemma: will we even know when we're under attack?

How will rival nations realize this ominous new era of advanced biological warfare (BW)? Simply put, our adversaries will exploit current, existing and radically new technologies emerging from the bioscience revolution and apply them to the timeless art of war. In the past, advanced technologies were primarily funded by government R&D and later trickled down to the private sector as dual-use applications became appropriate.^{8,9} Since 1988, however, the reverse has been increasingly true.^{10,11} The private sector now drives over 70% of science and technology R&D in the U.S., China and Japan.^{12,13} By remaining tapped into private innovation trends, foreign governments will be able to manufacture cheap, non-attributable bioweapons.^{14,15,16,17} So long as they

⁸ Ronald G. Havelock & David S. Bushnell, "Technology Transfer at DARPA: A Diagnostic Analysis," (Fairfax, VA: Technology Transfer Study Center, George Mason University, 1985) p 48-51. <http://www.dtic.mil/dtic/tr/fulltext/u2/a164457.pdf>

⁹ Committee on Criteria for Federal Support of Research and Development, "Allocating Federal Funds for Science and Technology." National Academy of Sciences, National Academy of Engineering Institute of Medicine National Research Council (Washington, D.C.: National Academy Press, 1995), p 41-46. http://www.ncbi.nlm.nih.gov/books/NBK45555/pdf/Bookshelf_NBK45555.pdf

¹⁰ National Science Board, "Science and Engineering Indicators 2016," <http://www.nsf.gov/statistics/2016/nsb20161/uploads/1/7/chapter-4.pdf>, Chap 4, p 17

¹¹ National Science Board, "Science and Engineering Indicators 2010," <http://www.nsf.gov/statistics/seind10/pdf/seind10.pdf>, Chap 4.

¹² Ibid., Table 4-13

¹³ National Science Board, "Science and Engineering Indicators 2016," <http://www.nsf.gov/statistics/2016/nsb20161/uploads/1/7/chapter-4.pdf>, Chap 4, p 45

¹⁴ "2016 Global life sciences outlook." (Deloitte, 2015), p 3-5. <https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Life-Sciences-Health-Care/gx-lshc-2016-life-sciences-outlook.pdf>. The size and growth of medical-related bioscience industries underscores the magnitude of opportunity. For example, estimated global medical technology revenues will increase from \$369 billion in 2015 to \$454 billion in 2019. Additionally, biotech drug sales were an estimated \$289 billion in 2014 and are projected to grow to \$445 billion by 2019.

have an Internet connection, international terrorists and DIY biohackers will also benefit from these emerging capabilities. As such, BW's evolving nature will enable a new paradigm of armed conflict: non-lethal bio attacks that achieve political-military objectives with neither the negative, attributable fallout typically associated with germ warfare nor the need for conventional armed confrontation. Thus, next generation bioweapons will enable adversaries to wage a war of attrition against America without fear of retaliation. Furthermore, bolder adversaries will demonstrate high-end capabilities in non-lethal forms as a means of credible non-nuclear deterrence or political extortion.

The subject of biodefense remains too broad to fully discuss its entirety in a single paper. As such, this paper examines BW in the year 2040 in line with the future context of the 2016 Blue Horizons Fellowship strategy question as posed by the Chief of Staff.¹⁸ In order to narrow down the topic to a relevant scope, this paper focuses primarily on the following aspects:

- Non-lethal effects
- Undetectable

¹⁵ World Preview 2014, Outlook to 2020," EvaluatePharma, (London, UK: Evaluate Ltd, 2014), Executive Summary. <http://www.evaluategroup.com/PDFs%20for%20Download/EvaluatePharma-World-Preview-2014-Outlook-to-2020-Executive-Summary.pdf>. Within the top 100 prescription products estimated for 2020, biological products (biologicals) are expected to account for over 50% of sales. According to 42 U.S.C. § 262(i), "biological product" refers to a virus, therapeutic serum, toxin, antitoxin, vaccine, blood, blood component or derivative, allergenic product, protein (except any chemically synthesized polypeptide), or analogous product, or arsphenamine or derivative of arsphenamine (or any other trivalent organic arsenic compound), applicable to the prevention, treatment, or cure of a disease or condition of human beings.

¹⁶ "Synthetic Biology Market (Synthetic DNA, Synthetic Genes, Synthetic Cells, XNA, Chassis Organisms, DNA Synthesis, Oligonucleotide Synthesis) - Global Industry Analysis, Size, Share, Growth, Trends and Forecast 2013 – 2019," (Transpaency Market Research, 2014) <http://www.transparencymarketresearch.com/synthetic-biology-market.html>. According to this forecast report, the global synthetic biology market will expand 32.60% CAGR from 2013 to 2019. The synthetic biology market is expected to be worth US\$13.4 billion by 2019.

¹⁷ "Global Synthetic Biology Market Size, Share, Development, Growth and Demand Forecast to 2020" (P&S Market Research, 2015), <https://www.psmarketresearch.com/press-release/global-synthetic-biology-market>. According to this report, the global synthetic biology market was estimated at \$3.934 billion in 2014 and will grow at 35.4% CAGR through 2020.

¹⁸ Academic Year 2016 Blue Horizons Fellowship Question: What competitive strategy and associated capabilities, capacities, technology investments, and integrating concepts should the Air Force pursue to prevail across the five most likely key components of the highly contested environments in 2040: electromagnetic spectrum access (including cyber and EW), counter base and counter tanker operations, counter sensor and counter decision, counterplatform (including space), and counter weapon?

- Non-attributable
- Highly Tailorable
- Deliverable in CONUS
- Airmen as human targets

Appendix 1 further discusses these delineators with reference to BW aspects outside this paper's scope.

With this focus in mind, the paper tackles four key areas of the biological threat, each addressed in a separate chapter. Chapter 1 dispels common myths about BW and in doing so characterizes the real threat at hand. Chapter 2 identifies the vast range of the emerging biological threat. Chapter 3 unveils a BW model of adversary-controlled escalation, ranging from targeted distraction all the way to mass destruction. Escalatory control positions adversaries to bleed America dry through low-intensity, non-attributable use. In addition, owning the initiative allows adversaries to overtly demonstrate non-lethal capabilities in order to deter or extort. Chapter 4 highlights key actions the Air Force must take between now and 2040 to mitigate this game-changing threat. Finally, a concluding discussion addresses how total war has been redefined, the risks inherent to America's third offset strategies, the associated force protection dilemma and why non-lethal BW is inevitable.

Chapter 1

*A scornful attitude toward new ideas, to nonstandard approaches, to other points of view is unacceptable in military science. And it is even more unacceptable for practitioners to have this attitude toward science.*¹⁹

—General Valery Gerasimov
Chief of the General Staff of the Russian Federation Armed Forces

An Ostrich Head in the Sand

Despite growing concern among counterterrorism and intelligence experts, many government officials continue to neglect the BW threat.²⁰ House Representative Martha McSally (R-AZ), Chairman for the Subcommittee on Emergency Preparedness, Response, and Communications, expressed her discontent with the government's failure to take effective action on biodefense:

I am honestly surprised that some of the recommendations made six and eight years ago have not been implemented, and that even after the Ebola response we cannot seem to identify the federal official who has the responsibility and authority to coordinate the dozen or so senior officials with responsibility for biological preparedness and defense. It's just baffling.²¹

Government officials who ignore the BW threat typically believe a false narrative about bioweapons. The following five myths expose the most common misconceptions.

¹⁹ Architect of Russia's new hybrid warfare, Gen Gerasimov recently published articles describing the benefits of waging war with a fusion of economic, political and military weapons that build upon mass societal deception and dominance in information operations. Biological technologies naturally fit into this hybrid paradigm yet the topic has been ignored in public Russian discourse. This omission may likely be more classic deception because Russia's military elite clearly seeks to exploit science in non-standard ways. Thus, it is naïve to think they will shy away from game-changing bioweapons. See Valery Gerasimov, "The Value of Science Is in the Foresight: New Challenges Demand Rethinking the Forms and Methods of Carrying out Combat Operations," trans. Robert Coalson, *Military-Industrial Kurier*, 27 FEB 2013, <http://www.theatlantic.com/education/archive/2015/10/complex-academic-writing/412255/>.

²⁰ Jim Davis argues that senior civilian and military officials often falsely believe myths about biological weapons. Davis' six myths can be summed as follows: One, there has never been a significant biological attack; Two, the US has never been attacked with a bio weapon; Three, developing bio weapons requires significant intelligence, education and funds; Four, bio warfare is too difficult because it was tried but failed; Five, moral restraints preclude bio weapons use; Six, long incubation periods prior to visible symptoms make bio weapons useless. Jim A. Davis, "A Biological Warfare Wake-up Call: Prevalent Myths and Likely Scenarios," in *The Gathering Biological Warfare Storm*, ed. Jim A. Davis & Barry R. Schneider (Maxwell AFB, AL: USAF Counterproliferation Center, 2002), 290-295.

²¹ Martha McSally (R-Ariz.), "Strategic Perspectives on the Bioterrorism Threat," Statement of Subcommittee Chairman, Subcommittee on Emergency Preparedness, Response, and Communications, 22 APR 2015, <https://homeland.house.gov/hearing/subcommittee-hearing-strategic-perspectives-bioterrorism-threat/>

Myth 1: Legal & Moral Constraints Work

The only laws our adversaries cannot escape are the laws of physics. In this light, international agreements that prohibit the use of bioweapons remain highly susceptible to violation. The 1925 Geneva Protocol, for example, was repeatedly ignored despite banning the use of chemical and biological weapons in war.²² The Biological Weapons Convention (BWC), has also been grossly violated despite boasting 165 States Parties and 12 Signatory States.^{23,24,25} Most notably, the BWC failed to prevent the Soviet Union's large-scale offensive biological warfare program. In 1973, less than a year after signing the BWC, the Soviets created *Biopreparat*, a secret but robust entity bioweapons program that hid under the cover of medical work on vaccines.²⁶ The Soviet example highlights the BWC's twofold inability to identify and prevent banned activities. First, the BWC remains woefully vague and lacks implementation and verification regimes.²⁷ Second, and more fundamentally important, the science behind offensive biological programs is inherently dual-use up to the point of weaponization and therefore illicit

²² There are 140 States Parties to the Geneva Protocol, which first took effect in 1928. The U.S. ratified the Geneva Protocol only in 1975 with a declaration that negates the treaty's obligations in the event another state or one of its allies takes actions banned under the protocol. Japan, an original signatory, violated the Protocol numerous times during WWII. Saddam Hussein's Iraq used violated the Protocol repeatedly against Iranian troops and his own Kurdish minority. South Africa accused Cuba of violations during its intervention in Angola, and the U.N. officials later levied accusations to the same. Most recently, Syria's Assad regime violated the protocol. See International Red Cross, <https://www.icrc.org/applic/ihl/ihl.nsf/vwTreaties1949.xsp>; United Nations, <http://disarmament.un.org/treaties/t/1925/text>; Kathleen D. Hawk et al. "Florida and the Mariel Boatlift of 1980: The First Twenty Days," (Tuscaloosa, AL: University of Alabama Press, 2014), p 250.

²³ The BWC took effect in 1975 and was first signed in 1972. The BWC's full title is The Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological and Toxin Weapons and on Their Destruction. With 173 State Parties, only 14 nations have either not ratified the BWC or remain uncommitted to it. The most egregious violations were committed by the Soviet Union. Russia has still not demonstrated the eradication of banned activities. Both Egypt and Syria have yet to ratify their signatures, the latter of which has recently violated bans on chemical weapons use. See: The Biological and Toxin Weapons Convention Website, <http://www.opbw.org>, The U.N. Office Geneva, [http://www.unog.ch/80256EE600585943/\(httpPages\)/04FBBDD6315AC720C1257180004B1B2F?OpenDocument](http://www.unog.ch/80256EE600585943/(httpPages)/04FBBDD6315AC720C1257180004B1B2F?OpenDocument)

²⁴ The United Nations Office for Disarmament Affairs, <http://www.un.org/disarmament/WMD/Bio/>

²⁵ "Biological Weapons Convention Background Information," United Nations Office at Geneva, [http://www.unog.ch/80256EE600585943/\(httpPages\)/87CF9BFD24A8D05FC1257574004B285B?OpenDocument](http://www.unog.ch/80256EE600585943/(httpPages)/87CF9BFD24A8D05FC1257574004B285B?OpenDocument)

²⁶ David E. Hoffman, "The Dead Hand," (New York, NY: Random House, 2009), p 132.

²⁷ Jozef Goldblat, "The Biological Weapons Convention—An Overview," JUN 1997, International Review of the Red Cross, No. 318, <https://www.icrc.org/eng/resources/documents/misc/57jnpa.htm>

activities are easily concealed.²⁸ This dual-use nature will always mask bioweapons activities with some degree of plausible deniability ranging from suspicious to entirely undetectable.

Instead of disarming banned programs, the BWC may actually encourage proliferation in some cases. Clearly, the Soviets never intended to comply with the BWC. The Soviets understood they could either conceal violations entirely or avoid accountability for exposed infractions. Unsurprisingly, there is no evidence that Russia ever liquidated the banned bioweapon stockpiles and programs that it inherited in 1991. It can be argued that Soviet intelligence personnel and the scientists who engaged in illicit activities truly believed the U.S. was cheating and therefore parity was required.²⁹ Such claims, however, ignore the reality that many nations falsely pledge support to uphold international agreements solely to exploit the benefits of cheating.

BWC violators can gain an asymmetric military advantage only when others adhere to their obligations. Director of National Intelligence James Clapper recently reported to Congress that emerging bioweapons pose a real WMD threat because other nations simply choose to play by different rules:

Research in genome editing conducted by countries with different regulatory or ethical standards than those of Western countries probably increases the risk of the creation of potentially harmful biological agents or products.³⁰

Unfortunately, bio violators will always exist. Since the BWC's inception, for example, the number of nations suspected by the U.S. government to possess banned BW programs

²⁸ Joshua Lederberg, ed., "Biological Weapons: Limiting the Threat," (Cambridge, MA: Belfer Center for Science and International Affairs, 1999), p 4.

²⁹ Ken Alibek with Stephen Handelman, "Biohazard," (New York, NY: Random House, 1999), p 183.

³⁰ James R. Clapper, "Worldwide Threat Assessment of the US Intelligence Community," 9 FEB 2016, Senate Armed Services Committee, Statement for the Record, p 9, http://www.dni.gov/files/documents/SASC_Unclassified_2016_ATA_SFR_FINAL.pdf

doubled.³¹ This does not suggest the U.S. should pursue offensive BW capabilities or quit non-proliferation engagement, but rather obliges U.S. officials to acknowledge the threat, recognize why it persists and prepare more comprehensively to defend against it.

Myth 2: Only State Actors Can Afford Bioweapons

Although the Soviet BW program required great quantities of resources and sophistication, biological weapons in general are actually relatively cheap, easy to make and accessible to a broad spectrum of adversaries.³² DIY biology communities across the globe, like *diybio.org*, highlight that anyone with a modest budget, Internet access and a basic understanding of biology can create an effective biological warfare capability.³³ Furthermore, low-tech delivery mechanisms are easy to procure and use. Biological weapons can be effectively dispersed for inhalation or dermal contact by portable means, ranging from small cosmetic aerosol canisters to larger sprayers intended for light industrial or agricultural use. Others can be placed in water supplies or systems, animal feed or other food sources, conceivably in anything that can be ingested including medications or vitamins, candy or breath mints, toothpaste or nasal spray. The aforementioned characteristics—cheap, easy to make, widely accessible, scalable and tailorable in potency, duration, and target selection—make biological weapons a logical

³¹ J.D. Holum, “Remarks for the Fourth Review Conference of the Biological Weapons Convention,” (Geneva, Switzerland: U.S. Arms Control and Disarmament Agency, NOV 1996). According to *Nuclear Threat Initiative* www.nti.org, as 16 nations have been suspected of maintaining an offensive bioweapons program.

³² Richard Danzig and Pamela Berkowsky, “Why should we be concerned about biological warfare?” in “Biological Weapons: Limiting the Threat,” Joshua Lederberg, ed., (Cambridge, MA: Belfer Center for Science and International Affairs, 1999), p 9.

³³ The Internet is flooded with hundreds of published articles and websites that detail techniques for whole genome sequencing as well as DNA databases for many known viruses and bacteria with pathogenic properties. For example, Zika virus genome can be found at <http://www.ncbi.nlm.nih.gov/nuccore/KJ776791>.

choice for many different adversaries ranging from states and terror groups to rogue individuals and DIY biohackers.³⁴

Myth 3: Bioweapons Just Aren't Practical

Bioweapons are often viewed as impractical because they are unpredictable, nearly impossible to train with, and previous attempts to use them are seen to have failed. President Nixon terminated the U.S. offensive program in 1969, labeling bioweapons a liability with consequences that are “massive, unpredictable, and potentially uncontrollable.”³⁵ Bioweapons are also viewed as impractical because they are extremely difficult to train with in order to maintain combat ready personnel charged with their safekeeping and use. If militaries neglect training, either to keep their bioweapons secret or to avoid mishaps, then they are also unlikely to actually use them outside a small set of extreme, existential scenarios. Military leaders also voice concerns about the risk of bioweapons inflicting damage on friendly forces. This viewpoint is particularly salient when other non-biological options are available to achieve the desired military effects.

Harvard's Matthew Meselson asserted the practicality of bioweapons when describing the real intentions behind the termination of America's offensive bio program. He argued, “it took a little thought, but not much, to realize that to pioneer a cheap weapon of mass destruction is exactly what the United States should never do.”³⁶ The

³⁴ Bin Laden asked for and received a May 2003 fatwa, or religious edict, from Shaykh Nasir bin Hamid al-Fahd to sanction the use of WMD against non-Muslim adversaries. The fatwa was entitled “A Treatise on the Legal Status of Using Weapons of Mass Destruction Against Infidels” and condoned the use of WMD. See James Phillips, “The Evolving Al-Qaeda Threat,” 17 March 2006, *The Heritage Foundation*, Lecture #928 on Department of Homeland Security, <http://www.heritage.org/research/lecture/the-evolving-al-qaeda-threat>

³⁵ “Nixon Ends Biological Weapons Program,” Public Broadcasting Station (PBS), general article, <http://www.pbs.org/wgbh/americanexperience/features/general-article/weapon-nixon-ends/>

³⁶ “U.S. Biological Weapons Research,” Public Broadcasting Station (PBS), Then & Now article, <http://www.pbs.org/wgbh/americanexperience/features/then-and-now/weapon-then-now/>

fact of the matter is, despite any negative stigma, bioweapons remain highly practical because they are cheap, easy to make and easy to use.

Myth 4: “We’ll nuke ‘em”

Some opine that the BWC matters little, effective or not, because nobody will attack the U.S. with bioweapons for fear of retaliation. President Nixon made this argument when he boldly asserted, "if somebody uses germs on us, we'll nuke 'em."³⁷ There are five fundamental flaws with this line of thinking.

First, the “we’ll nuke ‘em” strategy remains extremely hard to execute against terror groups or other non-state actors. Unfortunately, biological weapons remain cheap and easy to make. Therefore, DIY biohackers, other terrorists and criminal organizations do not require access to state-run WMD programs to execute bio attacks. These adversaries, however, may actually welcome the chaos and escalation brought on by an American retaliation against a suspected state sponsor.

Second, the U.S. has been attacked with bioweapons before, most notably in 2001 when letters laced with anthrax were mailed to media outlets and the U.S. Congress.³⁸ 22 people were infected with anthrax and five died as a result. The government’s investigation concluded 9 years later without a single conviction, while decontamination efforts lasted several years. The anthrax letters occurred in the wake of Al-Qaeda’s 9/11 attacks, the hallmark example that terrorists harbor zero moral qualms when it comes to

³⁷ William Safire, “On Language: Weapons of Mass Destruction,” *The New York Times Magazine*, 19 APR 1998, p 22.

³⁸ Other notable bio attacks include: Numerous attacks during the Civil War to include the use of smallpox, yellow fever and dead animals to contaminate food and water supplies; 1982 Tylenol murders and follow-on copy cat poisonings (unknown perpetrators, potassium cyanide); 1984 restaurant salad bar attacks (Rajneeshee Cult, salmonella typhimurium); 2003, 2004, 2013 ricin letters to a few members of Congress, the White House & POTUS (2003 & 2004 perpetrators remain unknown); See: au.af.mil, <http://www.au.af.mil/au/awc/awcgate/medaspec/ch-2electrv699.pdf> *Time*, <http://content.time.com/time/nation/article/0,8599,1878063,00.html>; *CNN*, <http://www.cnn.com/2013/05/31/us/ricin-fast-facts/>; CDC.GOV, http://www.cdc.gov/php/docs/forensic_epidemiology/Additional%20Materials/Articles/Torok%20et%20al.pdf

indiscriminately killing large numbers of civilians with non-traditional methods of destruction. As such, we must anticipate all forms of brazen attacks to include BW.

Third, some future biological attacks will be non-lethal and therefore not warrant a conventional or nuclear response. The effects of mass distraction and disruption caused by non-lethal BW attacks are highly advantageous to enemies that desire to damage the U.S. without triggering a retaliatory response traditionally associated with WMD red lines.³⁹ Arguably, the Commander in Chief will view a nuclear retaliation as a highly disproportionate response to an attack that results in very few fatalities if any at all.

Fourth, future biological attacks will be highly deniable or outright non-attributable. POTUS can do little by way of retaliation when the attacker remains unidentified. The risks associated with a mistaken response presumably outweigh the perceived benefits of a blind retaliation calculated on intuition or perceived intent. Therefore, one can reasonably expect some hostile nations to remain undeterred by nukes or even conventional capabilities if they believe a biological attack will remain non-attributable.

Finally, emerging bioweapons will defeat even the most sophisticated biosensors, posing an increased challenge for tactical detection as well as force-wide health awareness. With zero detection time, current bioweapons become detectable only after an attack occurs. Attacks that remain unknown even after use, however, offer no post hoc warning. In such cases, how will a commander even know personnel have been attacked? These attacks, with less than zero warning, can potentially stay unknown indefinitely.

³⁹ However difficult it might be to calculate the exact cost of the 2001 anthrax attacks (FBI investigation dubbed *Amerithrax*), the consequences were enormous in time and expense. In terms of distraction, the FBI calculated that the anthrax investigation—2001 through 2010—incurred several hundred thousand investigator work hours (see <https://www.fbi.gov/about-us/history/famous-cases/anthrax-amerithrax>). In terms of cost, decontamination efforts in the year following the attacks were estimated between \$320 million and \$1 billion (see Schmitt & Zacchia “Total decontamination cost of the anthrax letter attacks” in *Biosecurity and Bioterrorism: Biodefense Strategy, Practice & Science*, 10, 1, 2012, http://spectrum.library.concordia.ca/974056/1/Schmitt_Spectrum.pdf).

The medical community offers some hope in that the CDC and hospitals across the U.S. already catalogue symptoms in order to identify naturally occurring pathogen outbreaks. Nevertheless, this kind of epidemiological detection will become ineffective once attacks target not health but cognition. It is possible that Americans have already been attacked but we simply remain unaware. Although this appears highly unlikely now, it is clear that our current nuclear triad offers little deterrence to undetectable bio threats.

Myth 5: The Interagency Has It Covered!

Despite the federal government spending \$6 billion a year countering biological threats, the Air Force cannot currently rely upon the interagency to provide a coordinated, effective response to either germ warfare or naturally occurring outbreaks.⁴⁰ According to the 2015 Blue Ribbon Study Panel on Biodefense, “There is no centralized leader for biodefense. There is no comprehensive national strategic plan for biodefense. There is no all-inclusive dedicated budget for biodefense.”⁴¹ *Appendix 2* lists over 30 key agencies and programs focused in some way on biodefense, yet not a single one offers Airmen a credible solution to counter the increasingly imminent threat. Simply put, if the Air Force cannot rely upon the interagency during a post-attack response then it certainly cannot expect others to safeguard the health of Airmen in any proactive way. Therefore, the status quo remains as follows: Airmen first get attacked by a bioweapon, then something about it may or may not be done, and it is not yet clear who will lead or execute those efforts.

⁴⁰ Maggie Fox, “The Biothreat is Real—And We’re Not Ready, Report Says,” NBC News, 28 OCT 2015, <http://www.nbcnews.com/health/health-news/biothreat-real-were-not-ready-report-says-n452906>

⁴¹ “A National Blueprint for Biodefense: Leadership and Major Reform Needed to Optimize Efforts,” (Blue Ribbon Study Panel on Biodefense, October 2015), Bipartisan Report, vii. http://www.biodefenselibrary.org/SiteAssets/Pages/default/1425-2139_BRSP_Report_100815b%5b1%5d%5b6%5d.pdf

This Isn't Your Father's Oldsmobile

Debunking the aforementioned myths properly frames the emerging threat as harnessing new, game-changing characteristics. Contrary to outdated misconceptions, bioweapons are practical, inexpensive and relatively easy to use. The undetectable, non-attributable nature of next generation biological attacks greatly enhances opportunities to slowly attrit an adversary without major confrontation. Furthermore, moral and legal agreements that restrict WMD use do not apply universally, yet anyone can access the technology behind bioweapons⁴². Nuclear weapons cannot deter the full spectrum of adversaries likely to use bioweapons. Even more disconcerting, the Air Force cannot currently rely upon a national biodefense enterprise to keep Airmen safe.

⁴² The Biosafety in Microbiological and Biomedical Laboratories (BMBL) code of practice for biosafety provides guidelines for “safe handling and containment of infectious microorganisms and hazardous biological materials.” Although the majority of biopracitioners may adhere to such principles, individuals and groups with nefarious intentions are not deterred by American restrictions or principles of best practice. The Federal Select Agent Program (7 CFR Part 331, 9 CFR Part 121, and 42 CFR Part 73) greatly mitigates threats to public health and safety from within the bioscience community, however, such programs ignore the growing space of synthetic biologicals—unique, new creations never seen before and do not populate watch lists for excluded agents or toxins. See BMBL at <http://www.cdc.gov/biosafety/publications/bmb15/BMBL.pdf>

Chapter 2

...the fact that human thoughts and feelings are so open to biological intervention shows that the problem of controlling human behavior is mainly a technical problem; a problem of neurons, hormones and complex molecules; the kind of problem that is accessible to scientific attack.⁴³

—Theodore Kaczynski
The Unabomber

Art of the Possible

The same global trends shaping America's emerging offset strategies also underpin the inevitable use of bioweapons. This overlap becomes evident when comparing current innovation strategies with previous offsets. For example, the third offset differs from the first two in three fundamental ways: first, the third offset is “never-ending” due to greater knowledge, accelerating technology refresh rates and growing competition with near-peer adversaries; second, the spectrum of adversaries is much broader than during the Cold War; and third, the commercial sector, rather than military research labs, drives the preponderance of new military capabilities.⁴⁴ Most of our foes already embrace conflict as a long-term battle of endurance if not an eternal struggle. Adversaries ranging from individuals to nation-states also benefit from many of the same dual-use technologies available to the U.S., such as targeted genome editing. Given this context of ripe dual-use science, it becomes evident that while America pursues its declared game-changers (hypersonics, direct energy, autonomy, etc.), adversaries will pursue asymmetric opportunities like next generation bioweapons.

⁴³ This is, by the way, the 20th anniversary of his capture. Sentenced to 4 life terms for killing three and injuring 23, he is in Supermax in Colorado at age 78. UNA stood for universities and airlines. In his “Unabomber Manifesto,” Kaczynski asserted that people will undergo biological modifications to adapt to the modernity. Manifesto (22 Sep 1995) <http://www.washingtonpost.com/wp-srv/national/longterm/unabomber/manifesto.text.htm>, quote par 158. Biography at www.biography.com.

⁴⁴ Deputy Secretary of Defense Speech. “The Third U.S. Offset Strategy and its Implications for Partners and Allies” As Delivered by Deputy Secretary of Defense Bob Work, Willard Hotel, Washington, D.C., January 28, 2015. <http://www.defense.gov/News/Speeches/Speech-View/Article/606641/the-third-us-offset-strategy-and-its-implications-for-partners-and-allies>

THE INNOVATION TRIFECTA

In layman's terms, the triad of science underpinning the emergence of game-changing bioweapons is part biology, part computer and part engineering. Leaps in innovation require a unique blend of ingredients mixed in the right way at the right time. The convergence of biology, engineering and computers over the past decade has become the secret sauce for many advances destined to revolutionize medicine, agriculture and industry. Most have dual-use implications. Targeted genome engineering, synthetic biology and nanodelivery technologies are three such breakthroughs that can greatly enrich our quality of life from medicine to manufacturing. The flip side of these innovative technologies, however, is the ability to selectively wipe out individuals, groups or all of humanity with bioweapons that are undetectable, non-attributable, highly tailorable and scalable.

Targeted genome engineering refers to the specific modification of a living organism's internal operating instructions, the genome. In other words, the genome is an organism's complete and unique blueprint for how it's made, and in humans every cell with a nucleus holds a copy. The human genome contains over 3 billion building blocks, called base pairs, which form our DNA. Scientists unlocked the ability to fully sequence a person's genetic code through the Human Genome Project. This project took 13 years, finishing in 2003 with a price tag in the billions. Now, a single benchtop machine can sequence an entire human genome in under 24 hours for around \$1000.⁴⁵ In this way, advances in computer processing power have been nothing short of revolutionary.

⁴⁵ Julia Kollwe, "DNA machine can sequence human genomes in hours," (17 Feb 2012), *The Guardian*, <https://www.theguardian.com/science/2012/feb/17/dna-machine-human-sequencing>

Once the human genome could be sequenced, scientists next set out to tinker with it. Just as binary code uses ones and zeros, DNA uses four inputs: A, T, C & G. Similarly, just as computer programmers manipulate binary to modify a program, so too can scientists manipulate DNA. CRISPR/Cas 9 is the newest method for this kind of DNA programming, or targeted genome engineering.⁴⁶ The backstory to CRISPR is that although mankind now wields it, bacteria created it. CRISPR is actually a bacterial immune response that kills attacking viruses by spoofing their unique DNA. This antiviral defense employs three key processes. First, CRISPR recognizes the viruses that it has been exposed to. Next, it manufactures segments of DNA that conform to the attacker's unique code. CRISPR's final move uses an enzyme to cut out a DNA segment from the virus and replace it with an engineered segment that disables the adversary.

Director of National Intelligence James Clapper recently cautioned that, "Given the broad distribution, low cost, and accelerated pace of development of this dual-use technology, its deliberate or unintentional misuse might lead to far-reaching economic and national security implications."⁴⁷ The Director's concerns are warranted because CRISPR can be used to modify the DNA of not just viruses but all living organisms—from bacteria and fungi to plants, animals and people—using readily accessible equipment at low cost and with great precision. Therefore, CRISPR's final move, called

⁴⁶ Clustered Regularly Interspaced Short Palindromic Repeat (CRISPR), a bacterial immune system function used in targeted genome engineering, uses an RNA-guided DNA endonuclease enzyme termed Cas-9 (CRISPR Associated Enzyme 9), hence the name CRISPR/Cas 9. Zinc-finger nucleases (ZFNs) and transcription activator-like effector nucleases (TALENs) are two additional genome-editing techniques, however, both are viewed as less efficient than CRISPR-Cas 9 because they require the additional use of a modified protein-DNA interface. For detailed discussions, see New England Biolabs at <https://www.neb.com/tools-and-resources/feature-articles/crispr-cas9-and-targeted-genome-editing-a-new-era-in-molecular-biology>, Thomas Gaj, Charles A. Gersbach, Carlos F. Barbas III at [http://www.cell.com/trends/biotechnology/abstract/S0167-7799\(13\)00087-5](http://www.cell.com/trends/biotechnology/abstract/S0167-7799(13)00087-5), and Jim Yeadon <https://www.jax.org/news-and-insights/jax-blog/2014/march/pros-and-cons-of-znfs-talens-and-crispr-cas>

⁴⁷ James R. Clapper, "Worldwide Threat Assessment of the US Intelligence Community," 9 FEB 2016, Senate Armed Services Committee, Statement for the Record, p 9, http://www.dni.gov/files/documents/SASC_Unclassified_2016_ATA_SFR_FINAL.pdf

insertion/deletion, is truly game changing because it can be applied to alter (or sabotage) all living DNA (see Appendix 3 for additional CRISPR details).

Nanodelivery technology refers to the area of medicine that delivers drugs bonded to nanoparticles to specifically targeted cells by virtue of their tiny size and ease of transit through the body.⁴⁸ Practitioners have skillfully employed numerous active and passive delivery methods to ensure desired effects are achieved at the right location and time.⁴⁹ These polymeric techniques are often called smart delivery systems because the polymers that act as bonding agents for the drugs are carefully selected and combined to achieve desired effects. Polymeric techniques have now been combined with other nanoparticles, like liposomes and synthetic particles, to add increased delivery options based on properties like heat, light, magnetism and pH.⁵⁰ These hybrid systems of nanocomposites greatly enhance pharmacology and treatment regimens. Just as doctors now hope to eradicate cancers and other diseases through smart nanodelivery systems, so too can disruptive actors create hyper precise pathogen delivery weapons.

Synthetic biology refers to a distinct discipline that combines the science trifecta discussed above: biology, computers and engineering. The 2012 National Bioeconomy Blueprint defines synthetic biology as, “the design and wholesale construction of new biological parts and systems, and the re-design of existing, natural biological systems for

⁴⁸ Iran’s nanotech activity is on a dramatic rise, buoyed by the Iran Nanotechnology Initiative Council. Iranian researchers developed 9 new nanodrugs in Oct 2015 that all utilized hybrid nanocomposite delivery systems. Iran is now ranked fifth in the world for registration of international nanotechnology standards. 31% of all inventions registered in Iran, as of 2015, are reportedly related to nanotechnology. Iranian Red Crescent Society researchers even claim to have made great breakthroughs in treating HIV as part of their nanodrug program in Mali. See “Iran 7th in world nanotechnology ranking,” 15 Feb 2015, *MEHR News Agency*, <http://en.mehmews.com/news/105969/Iran-7th-in-world-nanotechnology-ranking>. See “Iran producing 9 new nano drugs,” *FARS News Agency*, 17 Oct 2015, <http://en.farsnews.com/newstext.aspx?nn=13940725000293>.

⁴⁹ Yong Liu, T. Niu, L. Zhang, J. Yang, “Nano drug review,” *Natural Science*, 2010, Vol. 2, No. 1, 41-48. <http://dx.doi.org/10.4236/ns.2010.21006>

⁵⁰ Jae-Ho Lee, “Nanoparticle-assisted drug release,” *Nanomedicine & Biotherapeutic Discovery*, 2014, Vol. 4, No. 2.

tailored purposes, [and] integrates engineering and computer-assisted design approaches with biological research.”⁵¹ The operative phrase in synthetic biology is *tailored purpose*. Anything can be tailored: viruses, bacteria, fungi, algae, prions, enzymes, proteins and so on. Indeed, practitioners of synthetic biology can modify existing pathogens and toxins or engineer never-seen-before creations to achieve specific characteristics and effects. Therefore, the possibilities for synthetic bioweapons are truly as scary as they are limitless. If a homegrown terrorist like Ted Kaczynski, the Unabomber, recognized the implications of synthetic biology two decades ago, then arguably every credible adversary has by now concluded the same.⁵²

BIOLOGICAL WEAPON TYPES

Synthetic biology, CRISPR and nanodrugs are not the only advances driving the bioscience revolution, but they best highlight the science behind the game-changing characteristics of emerging bioweapons: highly tailorable, non-attributable and undetectable. These attributes in turn make them easier to use. Just as a cyber attack requires access to the target computer, bioweapons require access to the target organism. When people are the target, access can be gained through anything that enters or comes into contact with the body. Traditional vectors are food, water and air. Tailorable bioweapons, however, can be delivered in any multitude of ways such as annual vaccines or flu shots, cosmetics and hairspray, detergents and soaps, vitamins and medicine,

⁵¹ “National Bioeconomy Blueprint,” *The White House*, Apr 2012, p15, http://www.whitehouse.gov/sites/default/files/microsites/ostp/national_bioeconomy_blueprint_april_2012.pdf

⁵² Ted Kaczynski, in his 1996 *Unabomber Manifesto*, claimed “Genetic engineering of human beings is already beginning to occur in the form of “gene therapy,” and there is no reason to assume that such methods will not eventually be used to modify those aspects of the body that affect mental functioning.” He further states, “the fact that human thoughts and feelings are so open to biological intervention shows that the problem of controlling human behavior is mainly a technical problem; a problem of neurons, hormones and complex molecules; the kind of problem that is accessible to scientific attack.” See: <http://www.washingtonpost.com/wp-srv/national/longterm/unabomber/manifesto.text.htm>, paragraphs 149 & 158.

insects and pollens, toilette paper and Kleenex, and so on.⁵³ Large-scale delivery access and the synergistic effects of biology, computers and engineering underpin the emerging class of biological weapons.⁵⁴

Designer Genes are bioweapons that use targeted genome engineering, or CRISPR's wheelhouse, to enhance existing bioweapons with tailored characteristics. The European Bioinformatics Institute, currently maintains fully sequenced genomes on 4026 viruses, 2010 phage (viruses that replicate inside bacteria), 3316 bacteria, 1067 plasmids, and most can be viewed by any user online.⁵⁵ With access to these and other genomes scientists and DIY biohackers can either modify existing pathogens create entirely new ones. Already in 2010, Craig Venter created a synthetic chromosome that he dubbed as, "the first self-replicating species that we've had on the planet whose parent is a computer."⁵⁶ From designer genes the future bioweaponeer will graduate to manufactured designer diseases.

Host-swapping weapons, a subset of designer genes, are pathogens modified to cause disease in new organisms previously unaffected. For example, researchers in India successfully modified foot-and-mouth disease to infect humans. Unbelievably, they published this research online in the open, which was for some time accessible to anyone.⁵⁷

Binary biological weapons combine two or more components in order to achieve

⁵³ https://www.ted.com/playlists/144/should_we_redesign_humans; NOV 2010; TEDxPeachtree; Paul Root Wolpe, "It's time to question bio-engineering;" TED Talk Video

⁵⁴ Six bioweapon types (Binary Weapons, Designer Genes, Gene Therapy, Stealth Virus, Host-Swapping Diseases, Designer Genes) were developed by the JASON Group in 1997 and later described by Stanford Professor Stephen M. Block in his chapter, "Living Nightmares: Biological Threats Enabled by Molecular Biology," in *The New Terror: Facing the Threat of Biological and Chemical Weapons*, eds. Sidney Drell, Abraham D. Sofaer, and George D. Wilson (Stanford, CA: Hoover Institution Press, 1999), 51-71.

⁵⁵ European Bioinformatics Institute, "Genomes Pages," <http://www.ebi.ac.uk/genomes/index.html>

⁵⁶ Hessel, Goodman & Kotler. Note: Craig Venter has three times featured in *Time* magazines list of 100 most influential people.

⁵⁷ Tablet op discussion on biodefense at AFRL, Wright-Patterson AFB, Mar 2016.

a desired effect, either lethal or non-lethal. Binary weapons can trigger when the required elements come into contact with each other inside an organism. During the last century, this was considered possible by placing toxin-producing plasmids into contact with host bacteria that then become virulent. Soviet scientists allegedly perfected this capability using *Yersinia pestis*, the plague.⁵⁸

Stealth Bioweapons are similar to their binary counterparts because the attacker controls activation. Stealth pathogens are engineered to remain dormant inside the target until tailored detonation criteria are met, such as time delay or specific environmental, chemical or biological conditions. A bacteria engineered to release swine flu, for example, could harmlessly occupy the target's gut until activated by the presence of aspirin. The lying in wait feature makes these weapons good candidates to hold targets at risk at distance. Stealth weapons can also be used strategically as a cheap alternative to nuclear weapons.

Gene Therapy Weapons employ targeted genome engineering to edit a target's genetic code for malicious purposes. Gene therapy can target two kinds of cells, somatic and germline. Changes to the germline code are heritable, whereas modified somatic cells do not affect offspring.⁵⁹ Medical researchers may target germline cells hoping to eradicate disease-causing genes from a species. Bioweaponers can do the same just in reverse, inserting malicious DNA into an otherwise healthy victim. In the future, attackers will selectively target genes known to result in degraded health, emotional imbalance or impaired cognition. Patient adversaries may tailor these effects to be passed

⁵⁸ This assertion was made by a Soviet defector codenamed "Temple Fortune." David Hoffman, "The Dead Hand," (New York, NY: Anchor Books, 2010), 429.

⁵⁹ Edward Lanphier et al., "Don't edit the human germline," *Nature*, 12 Mar 2015, vol. 519, issue 7544, <http://www.nature.com/news/don-t-edit-the-human-germ-line-1.17111>

on from one generation to the next. Furthermore, gene therapy can target code unique to individuals or common to ethnic groups.

NON-LETHAL BIOLOGICAL SCENARIOS

The following scenarios highlight just a few potential ways the aforementioned bioweapons can be used. This list is by no means complete. While impossible to fully detail adversarial creativity, these scenarios help frame the character and nature of the biological threat, which can be used at the tactical, operational and strategic levels of war.

Scenario 1: Binary Poker. This paper's opening vignette emphasized the power of binary weapons for strategic purposes. Stealth pathogens can achieve similar objectives to deter or extort.

Scenario 2: No Way To Know. Non-lethal attacks against human performance can take on many forms, however an attack on cognition could persist unrecognized indefinitely. Last week a fountain drink dispenser at the Robins AFB food court was contaminated with gene therapy weapons designed to reduce cognitive performance by 8% on average with no visible symptoms other than reduced performance. How would the commanders even know? The leadership will certainly recognize the performance drop but how would they know to look away from the usual suspects (morale, training, medical, task saturation, deployments, etc.) and focus on the bioattack? Who will know civilians and dependents were also attacked?

Scenario 3: Air Force Blue Flu. A French company supplied key ingredients for this year's annual flu mist. Last year a Chinese-run pharmaceutical maker in Canada acquired the company. The flu shots contained a stealth virus programed to detonate

when in contact with anthrax vaccines. Consequently, 34% of personnel completing pre-deployment lines fell extremely ill two days later, unable to deploy. The problem compounded until the anthrax vaccines were identified as the problem and discontinued.

Scenario 4: Generation Bomb. A patient adversary sees little room for global domination in the next few decades, so it takes actions designed to dramatically improve the situation for posterity's sake. A germline attack is conducted through a compromised domestic beer brewer with nationwide facilities. 40 years later one fifth of all American males suffer from advanced congenital heart disease before the age of 30.

Scenario 5: Slow genocide. An autocratically ruled adversary with an ethnically homogenous majority decides to pacify a surging rebellion staged predominantly by an ethnic minority. Birth rates in the troubled provinces decline dramatically for an entire decade. The government officially blames unknown environmental stressors, but world press agencies report a suspected ethnic weapon.

Scenario 6: Leadership Decapitation. The catering crew that provides beverages and snacks for the annual Corona Top summit removes trash and cleans up tableware as expected. An unknown third party intercepts some items before they make it to the dumpster or dishwasher. 10 months later, half of the Air Force senior leadership was hospitalized with non-lethal, but debilitating brain tumors. Unbeknownst to the Pentagon, an undetected gene therapy attack had been conducted in Washington. Although thousands were infected, only participants from the Corona Top summit were affected.

Scenario 7: Supply Chain Attack. Air Force electronic medical records are stolen in a massive cyber attack. 37% of the officers and senior enlisted records

correspond to an *express-script.com* master list of deliveries (also stolen by cyber attack). Every year thereafter, no fewer than 200 of these individuals develop clinical depression and in seemingly random fashion. In fact, they were all victims of an undetected pathogen placed into mail-delivered prescriptions. The increasing trend of Airmen undergoing treatment for depression, although expensive, is lauded as a successful culture shift for an Air Force that previously shunned mental health resources. In other news, a Middle Eastern bank now owns several online grocery stores in California that customize in home-delivery service.

Scenario 8: The Bad Gut. A DIY biohacker works as a lab assistant for a microbiota project at a major American university. Human gut samples from the local population make their way to her garage lab. The nearby airbase soon suffers from dysentery-causing stealth bacteria. Air Force biosensors fail to detect the bacteria as all indications suggest the bioweapons are legitimate gut inhabitants. A large state-actor also has graduate students on the university research team. They too delivery similar attacks, however, they feature bacteria highly resistant to all forms of known medications

Scenario 9: Zika Mosquitos. The Zika virus has been around for decades without much attention in virology communities or the mass media.⁶⁰ Why has it ballooned to pandemic proportions so suddenly? A media savvy adversary has the public believing global climate change to be the culprit, however, the virus actually underwent targeted genome engineering with CRISPR for enhanced survivability and transfer by mosquitos. This Zika attack is a test trial in the adversary's program to develop a non-nuclear deterrence capability.

⁶⁰ The first human case of Zika infection in humans was reported in 1957. See CDC at <http://www.cdc.gov/zika/about/index.html>

Table 2-1 The New Nature of Non-lethal Biological Weapons of Mass Distraction, Disruption & Destruction (WMD3)

| Summing Up the Unique Nature of the New Non-Lethal Biological Weapons | |
|---|--|
| Former Perceptions Limited Bioweapons Use | New Realities Now Make Biological Attacks Inevitable |
| <ul style="list-style-type: none"> • Bioweapons Convention in effect • Unpopular/Negative Stigma | <ul style="list-style-type: none"> • Other cultures and governments cheat. Unfortunately, many see U.S. BWC compliance as a raw opportunity to exploit. • Non-attributable due to Bioscience revolution • Many extremists simply do not care about civilian deaths or other collateral damage |
| <ul style="list-style-type: none"> • Desired effects can be achieved by using other conventional weapons | |
| <ul style="list-style-type: none"> • Perception as unpredictable & unreliable (infect unintended people, including own) • Potential for significant collateral damage | <ul style="list-style-type: none"> • Non-lethal, scalable and highly-tailorable in potency, duration and target selection |
| <ul style="list-style-type: none"> • Can linger for decades well beyond intended timeframe for use (e.g. anthrax up to 50 years in soil) | |
| <ul style="list-style-type: none"> • Never 100% effective | <ul style="list-style-type: none"> • Can linger for decades innocuously while waiting to be triggered by an adversary, even in CONUS • New hyperefficiency from advances in genomics/nano-delivery; ensures only negligible levels of collateral damage |
| <ul style="list-style-type: none"> • Despite late/slow attack warning, biological weapons are detected upon use | |
| <ul style="list-style-type: none"> • Unable to test empirically due to ethic/moral reasons | <ul style="list-style-type: none"> • High-end attacks undetectable even after the fact; physical or cognitive symptoms, if noticed, may be the only attack indication • Human-on-a-chip technology and other advances in bioinformatics & modeling |
| <ul style="list-style-type: none"> • Require state-sponsored resources to make and disseminate | |
| <ul style="list-style-type: none"> • BW programs can be monitored by U.S. intelligence and international agencies | <ul style="list-style-type: none"> • Relatively cheap, available and easy to use • Underlying science is highly dual-use and easily concealed |
| <ul style="list-style-type: none"> • America's nuclear deterrence prevents adversaries from using bioweapons for fear of retaliation | |
| <ul style="list-style-type: none"> • Seen as an instrument of war in the past, bioweapons were rarely even considered due to more practical options for strategic deterrence or conventional warfare | <ul style="list-style-type: none"> • Terrorists, religious cults and other individuals view bioweapons as an instrument of terror |

Chapter 3

...the First World War was chemical; the Second World War was nuclear; and... the Third World War—God Forbid—will be biological⁶¹

—Sir William Stewart
Former UK Government Chief Scientific Adviser

Why Not Bio?

Adversaries are attracted to non-lethal bioweapons because modern asymmetric warfare objectives fit well with their disruptive versatility: relatively cheap, easy to use, readily accessible, undetectable, non-attributable, and tailorable in potency, duration and target selection. Traditionally, bioweapons have been categorized as weapons of mass destruction (WMD) because of their potential to kill large amounts of people or wreak large-scale destruction upon the environment. When considering the full range of emerging tailorable effects, particularly the non-lethal effects, it may be more accurate to call them weapons of mass *distraction, disruption* and *destruction*, or WMD3. The distinction between these terms (defined in Table 3-1) as it relates to impact illustrates the escalation rung ladder that an adversary can control depending of the specific bioweapons employed. For the scope of this paper, it is sufficient to characterize *destruction* as relating to the most severe attacks, *distraction* as relating to the least impactful, and *disruption* covering the range in between.⁶²

⁶¹ Sir William Stewart as quoted by Patricia Reaney, “Animal Disease is Reminder of Bioterrorism Danger,” in Reuters news report, 3 September 2001. Sir William Stewart acted as Government Chief Scientific Officer 1990-1995.

⁶² The National Institutes of Health’s (NIH) National Institute of Allergy and Infectious Diseases (NIAID) classifies pathogens into three priority categories (A, B & C) with Category A Priority Pathogens deemed as the most dangerous to national security and public health. All three categories include pathogens of varying degrees of morbidity and mortality. In addition, it is hard to separate the categories in terms of ease of access or dissemination. Therefore, the NIAID Priority Pathogen Categories are not well suited for a discussion focused on non-lethal uses of bioweapons. As such, this paper utilizes the WMD3 approach to categorize non-lethal threats

Table 3-1 Distraction, Disruption & Destruction (D3) Defined

Distraction:

Minor disturbances that draw an adversary's attention away from its planned tasks and objectives in order to initiate a reactive process of dedicating resources to Observe, Orient, Decide and Act (OODA) on the distraction. Distractive actions may divide attention, sow confusion and/or strain unity of effort. A strategy of distraction ultimately seeks to induce an adversary to take actions that little by little dilute readiness or capacity through an accumulation of cost and time imposition. When left unresolved, distractions may fade away, become part of the status quo, or escalate in consequence (see disruption).

Disruption:

Major disturbances aimed to throw normal adversarial processes, activities and capabilities into confusion or disorder, often by forcible separation or division into parts. A disruption strategy seeks to interrupt or impede an adversary's ability to execute key OODA loops. Disruption often occurs by way of radical change involving the introduction of new social, political, economic or military phenomena. The amount of resources and time devoted to combat disruptive effects typically exceed the outlays required to mitigate distractive effects. If left unresolved over time, disruptive effects may lead to the break down of entire capabilities, processes or institutions (see destruction).

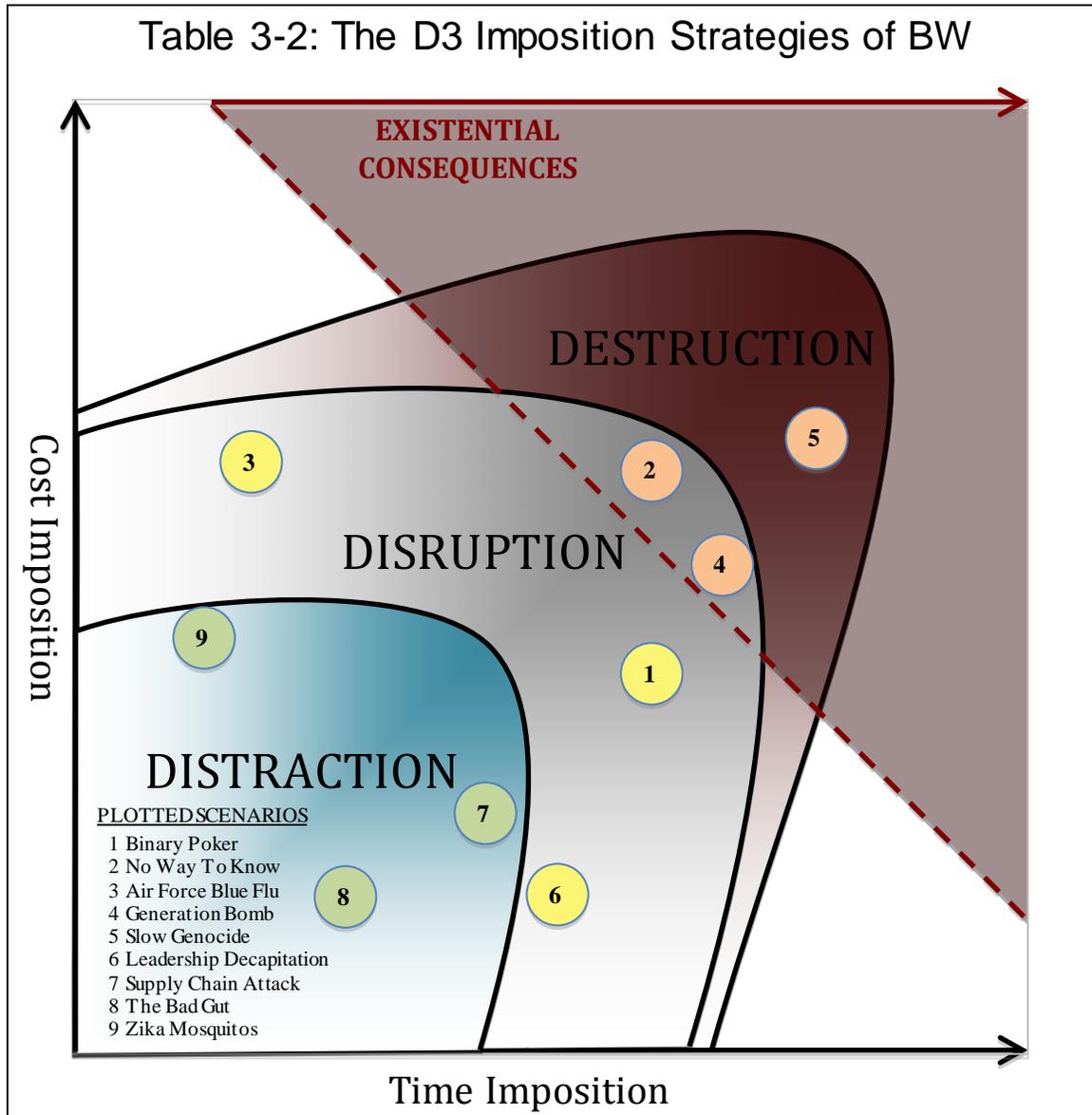
Destruction:

Grave disturbances that inflict so much damage to processes, capabilities and physical things that they must be replaced, not fixed. Increasing amounts of destruction pose an existential threat to the adversary as vital OODA loops become severely degraded or non-functioning. Destructive events are likely to generate great attention and focus within government, society and the mass media. Destruction, when viewed as an existential threat, will likely prompt large-scale retaliatory actions deemed necessary for survival. Thus, non-lethal attack strategies aimed to avoid destructive effects afford an adversary the opportunity to inflict long-term damage through attrition without necessarily triggering a mass retaliation. If left unresolved, destructive forces can lead to adversarial ruin.

Table 3-2 depicts the D3 escalation in terms of cost and time imposition. Cost imposition includes the costs associated with negating the direct effects of an attack as well as other indirect consequences due to economic, political, military and social costs and lost opportunities. The cheap-to-make and easy-to-use nature of bioweapons plays well to cost imposition strategies aimed against America's expensive third offset. Similarly, time imposition refers to the temporal burdens directly associated with a bio attack as well as second and third order effects on society and government. Non-lethal distraction and disruption can lead to lethally destructive results if left undetected or unmitigated. Table 3-2 also delineates where attack consequences begin to threaten the

in terms of perceived cost & time imposition. See the NIAID website, "Emerging Infectious Diseases/Pathogens," <https://www.niaid.nih.gov/topics/biodefenselated/biodefense/pages/cata.aspx>.

target existentially. This line should be considered as flexible and situational dependent. Finally, Table 3-2 plots numerically the approximated effects of the nine BW scenarios from Chapter 2.



The inevitability of biological attacks can be understood within a context of adversarial competition with America. The new class of bioweapons offers an affordable, non-attributable counter against America's third offset for those unable or unwilling to

expend the high competition costs associated with it. Specific to non-lethal applications vis-à-vis the U.S., adversaries will likely pursue bioweapons for three key purposes: (1) to conduct attacks without fear of major retaliation; (2) to extort by way of demonstrating a capability mismatch; or (3) to increase military parity with a strategic, non-nuclear deterrence capability.

The nine plotted scenarios in Table 3-2 are important because they illustrate that an adversary can selectively manage attacks across the spectrum of D3 imposition strategies. With tailorable bioweapons, an adversary can turn the damage dial up or down on an adversary so that consequences stay within a desired D3 zone. As in all forms of warfare, planned effects may differ from actual results.⁶³ With effective application of undetectable and non-attributable forms of non-lethal BW, however, an adversary can keep the consequences below the threshold of triggering a major American response. Modern adversaries undoubtedly understand that new, undetectable bioweapons can slowly erode American power without the need for large-scale military operations. Therefore, disruptive, non-lethal BW will become a key component of global conflict across economic, social, political and military spheres. These can be used with little fear of retaliation as long as the U.S. has not prepared for such.

The D3 construct highlights a rung escalation ladder that the adversary controls. Namely, an adversary can demonstrate the high-end possibility of destruction with low-end employment. In the absence of a credible deterrence, there becomes a capability mismatch. In such cases, the target may likely be extorted in lieu of hostilities. This

⁶³ A targeted nation may view biological events as random or naturally occurring, where as these events may actually be calculated efforts by an adversary trying to evaluate cause and effect relationships within the D3 continuum. With practice and over time an adversary will better understand how to best use and tailor its bioweapons to either trigger or avoid specific particular consequences. It is possible such efforts are already underway in the world.

paper's opening vignette described this strategy as employed by China. In cases where an adversary is unlikely to succumb to blackmail, biological demonstrations can still be used to establish a credible non-nuclear strategic deterrence.

Crucial to their deterrence value, next generation bioweapons can be demonstrated with far greater sophistication than conventional, cyber or nuclear forces. For example, cyber capabilities remain on the shelf for fear of loosing required but highly perishable attack vectors. Nuclear weapons still uphold America's strategic deterrence umbrella, however the consequences of using them are never short of cataclysmic. To the contrary, non-lethal bioweapons can be used effectively across all levels of war with tailorable impact. For strategic deterrence, these weapons can be dialed up so that they too can be cataclysmic, yet with one key difference: nukes offer mutually assured destruction while the new class of bioweapons can be tailored to wipeout specific groups of DNA wholesale or according to prescribed conditions controlled by the user, a literal kill switch. Consequently, many adversaries including nuclear-armed nations are pursuing or will soon embrace this next generation of bioweapons. They will do so in order to attacks without fear of retaliation, to extort, or to command a non-nuclear deterrence capability of greater strategic flexibility than offered by nuclear, conventional and cyber weapons.

Chapter 4

*Thus it is said that one who knows the enemy and knows himself will not be endangered in a hundred engagements. One who does not know the enemy but knows himself will sometimes be victorious, sometimes meet with defeat. One who knows neither the enemy nor himself will invariably be defeated in every engagement.*⁶⁴

—Sun Tzu
The Art of War

Knowledge is Power: Mitigating Actions the Air Force Can Take

The preceding chapters debunked biological myths, identified the science behind emerging capabilities, and explained the rationale behind non-lethal BW scenarios. In effect, these chapters have uncovered a new way to wage total war: defeat the adversary by fighting inside human bodies. Emerging bioweapons can be used practically anywhere due to globalized travel, trade and open access to knowledge. Subsequently, all bodies become targets. In the past contested domains were thought of as limited geographic bubbles outside the U.S. where significant anti-access, area denial (A2/AD) barriers are amassed, some military in nature and others political, social or economic.⁶⁵ A2/AD bubbles are viewed as contested in any of five key domains: air, sea, land, space and cyberspace. Now, there is a sixth key domain: the human body. Consequently, bioweapons now expand contested space from limited A2/AD bubbles to a single competition spanning the globe, including CONUS. Americans are now under threat everywhere—in our workplaces, homes, schools, churches and all public spaces. In fact, Airmen and their families may be easier to target in CONUS than in bases overseas.

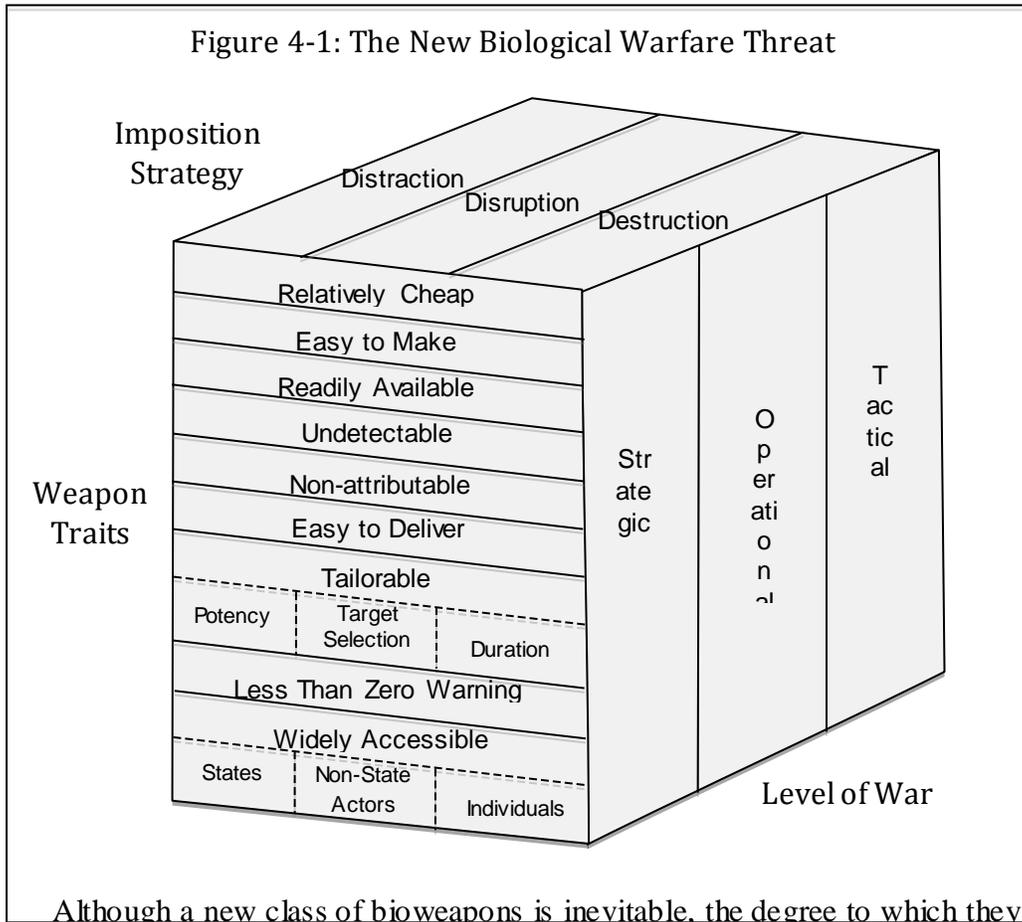
⁶⁴ Sun Tzu, translated by Ralph D. Sawyer. *The Art of War* (Cambridge, MA: Westview Press, 1994), 179.

⁶⁵ Nathan Freier, “The Emerging Anti-Access/Area-Denial Challenge,” 17 May 2012, Center for Strategic and International Studies in Washington, D.C., <https://csis.org/publication/emerging-anti-accessarea-denial-challenge>

As Sun Tzu suggests, America will be in relatively good shape when we understand the enemy and ourselves. If this is true, we must look introspectively and acknowledge that America has no national biodefense.⁶⁶ The Air Force is not yet positioned to deal with this emerging force protection challenge. Although we may understand most adversaries fairly well, we do not yet honor the biological threat in all its forms. Bioweapons are not WMDs, rather WMD3s (discussed in Chapter 3) capable of mass destruction yet equally tailorable to non-lethal imposition strategies at all levels of war. Figure 4-1 illustrates the magnitude of the BW threat.

⁶⁶ The 2015 Blue Ribbon panel on Biodefense, co-chaired by former Sen. Joseph Lieberman, concluded “Simply put, the Nation does not afford the biological threat the same level of attention as it does other threats: There is no centralized leader for biodefense. There is no comprehensive national strategic plan for biodefense. There is no all-inclusive dedicated budget for biodefense.” See Blue Ribbon Study Panel on Biodefense, http://www.biodefensestudy.org/SiteAssets/Pages/default/1425-2139_BRSP_Report_100815b%5b1%5d%5b6%5d.pdf

Figure 4-1: The New Biological Warfare Threat



Although a new class of bioweapons is inevitable, the degree to which they affect

Air Force depends on how we choose to mitigate the threat. There is no silver bullet on offense or defense. Nevertheless, the advantage decidedly favors a first-mover who uses undetectable, non-attributable weapons that detonate with less than zero warning time.⁶⁷

These weapon characteristics do not, however, resign biodefense to a federal public health matter only to be acted upon post hoc. Instead, the Air Force must pursue a proactive biodefense through the accumulation of pertinent knowledge that leads to unrivaled situational awareness. To that end, the Air Force must invest in several key areas: 24/7 total force awareness (TFA), environmental sensing, big data analytics, and

⁶⁷ Since America chooses to remain on moral high ground and shun offensive programs, attention must focus on defense. It would also be worthwhile for the DOD to open up policy discussions on human biological modification of our own personnel to ensure a level playing ground against adversaries likely engaging in these activities already.

smart biological armor. Investing in these areas will lay the groundwork for a new force protection paradigm that acknowledges and plans for combat in the sixth domain: our bodies.

24/7 Total Force Awareness (TFA).

There are two key parts to biological monitoring: health and performance. Privacy, policy and data security issues immediately abound with this kind of monitoring. Yet if American corporations can convince their employees to voluntarily wear fitness monitors as part of a wellness or risk reduction program, then certainly the Air Force can successfully navigate the policy debate.⁶⁸ Industry's carrot for employee cooperation takes form in health insurance deductions. American corporations themselves are also experiencing reduced operating costs as a result of wearable monitoring technology.⁶⁹ Airmen will not require a carrot, as they understand wearables can benefit both job performance and force protection. At the end of the day, the carrot is for Air Force leaders: a smaller health bill.

Human monitoring must go way beyond wellness programs and reduced health costs. In fact, a comprehensive 24/7 human monitoring enterprise is the only way to maintain full situational awareness on force readiness. The Air Force Future Operating Concept describes a multi-domain operations center (MDOC) to exercise dynamic

⁶⁸ Andrew Dart, "The Case for Connected Wearables," 26 Mar 2015, <http://insurancethoughtleadership.com/case-connected-wearables/>; Parmy Olson, "Wearable Tech is Plugging into Health Insurance," 19 Jun 2014, <http://www.forbes.com/sites/parmyolson/2014/06/19/wearable-tech-health-insurance/#766b3d785ba1>; *Travelers* (Insurance co.), "The Wearables Revolution Has Arrived," <https://www.travelers.com/business-insurance/technology-insurance/Wearables-Risk-Trav-BTCWH.0000-D.PDF>

⁶⁹ Julie Bort, "This Company Saved A Lot Of Money By Tracking Their Employees With Fitbits," *Business Insider*, 7 Jul 2014, <http://www.businessinsider.com/company-saved-money-with-fitbits-2014-7>

command and control.⁷⁰ Arguably, the MDOC construct should also include an ability to monitor the real-time health and performance of Airmen in order to dynamically identify and mitigate biological attacks. 24/7 monitoring is the only way to systematically identify BW attacks on cognition.⁷¹ Should an adversary use a stealth virus or bacteria to impair cognition, the symptoms will show only by way of human performance. Although defending against cognitive attack will be challenging in the best of circumstances, our biodefense will be useless without detailed biological baselines for every Airman and then monitored round the clock.

Fortunately, the Air Force already maintains several core competencies in the realm of wearable technology and physiological, cognitive & performance monitoring—they should be expanded. The Air Force Research Lab (AFRL) *24/7 Combat Fitness Program*, for example, is an industry leader in wearable technology and human performance monitoring. Working with special operations units and elite athletic programs, the *24/7 Combat Fitness Program* has made commendable progress with algorithm development and a biological situational awareness tool called the *Dashboard for the Human Weapon System* (see Appendix 4).⁷² They continue to shrink the size of increasingly capable wearables. AFRL has also excelled in physiological monitoring with

⁷⁰ “Air Force Future Operating Concept,” Sep 2015, <http://www.af.mil/Portals/1/images/airpower/AFFOC.pdf>, 14.

⁷¹ Without total force baselines and subsequent 24/7 monitoring, it will be hard to employ epidemiological tools to provide the MDOC with dynamic forecasts of novel disease emergence or the exploitation of biological agents by adversaries, affecting force health or cognition. For a further discussion see: “National Biosurveillance Science and Technology Roadmap,” National Science and Technology Council, JUN 2013, p 11, https://www.whitehouse.gov/sites/default/files/microsites/ostp/biosurveillance_roadmap_2013.pdf

⁷² Joshua Hagen, “Human Performance Monitoring for Special Operators and Elite Athletes,” ppt briefing at STRONGLaboratory, AFRL, Wright-Patterson AFB, OH, 16 Mar 2016, Distribution A: Approved for public release; distribution unlimited, Case Number: 88ABW-2015-5064, 20 Oct 15

the *Aircrew Mounted Physiologic Sensor Suite*, demonstrating a further need to understand how we monitor human-machine teaming.⁷³

While the commercial wearables industry is exploding, topping \$2B in sales in 2015, these products (Apple Watch, Fitbit, etc.) are unlikely to feature the robust monitoring performance that future Airmen will require.⁷⁴ By 2040, 24/7 monitoring will likely include implantables as well as wearables no larger than a small Band-Aid. These devices will go beyond current parameters (heart rate, calorie burn, hydration, sleep etc.) and monitor metrics like cognition, eye movement, and the gut's microbiota as well as search blood, saliva and sweat for biological anomalies. Implantables will likely be powered by the body. In order to get there, the Air Force should greatly expand AFRL's R&D efforts to also include solving the data challenges of transfer, storage, security and analytics that a total force enterprise will require. As appropriate, DARPA should be encouraged to do the same.

Environmental Sensing.

Various federal agencies already work in the area of environmental sensing. For example, the Department of Homeland Security's (DHS) Office of Health Affairs and the DHS Science & Technology Directorate both support *BioWatch*, a nation-wide program charged with environmental biosensing. DOD efforts led by the Defense Threat Reduction Agency (DTRA) are conducted in parallel. Regardless of reported inefficiencies in these efforts, the Air Force does not need to pursue its own

⁷³ David Burch, PhD, "Physiologic Monitoring of Pilot Performance," ppt briefing received at AFRL, Wright-Patterson AFB, OH, 16 Mar 2016, Distribution A: Approved for public release; distribution unlimited, Case Number: 88ABW-2015-5069, 20 Oct 15

⁷⁴ Statista, "Forecast market value wearable devices worldwide 2012-2018," <http://www.statista.com/statistics/302482/wearable-device-market-value/>

environmental R&D.⁷⁵ Air Force scientists must, however, collaborate with DHS and DTRA to ensure that the future Air Force 24/7 TFA enterprise remains compatible with federal sensors and the data they collect. Integration into environmental sensing will increase Air Force human situational awareness with more data to perform epidemiological algorithms when under attack. Ultimately, the Air Force must focus investments into its own TFA enterprise surrounding its most capable sensor: Airmen.

Big Data Analytics.

Other Blue Horizons papers explain the value big data analytics. As such, this paper assumes the Air Force will pursue big data capabilities. As discussed, a successful 24/7 TFA enterprise will require near real-time analysis of biological data monitoring. Additionally, big data analysis of global human pattern of life may be the only way to provide advanced forewarning of bioweapons that themselves provide less than zero warning time. Big data algorithms, however, are only as powerful as the data they are designed to collect. Therefore, the Air Force should support the DOD establish a comprehensive HUMINT-based biosurveillance network. Science Attachés, with access to the Intelligence Community's stove-piped biological intelligence data, should be positioned around the world to keep abreast of social, economic, political and military trends specific to dual-use technologies that underpin modern BW. Without such a network, the Air Force practically concedes all hope for early warning indications of BW.

⁷⁵ The 2015 Blue Ribbon panel on Biodefense concluded that, "The entire BioWatch program is dying for lack of innovation." The Select Agent Program, run jointly by the CDC and USDA also received sharp critique for its biosafety blind spots. See Joseph I. Lieberman and Thomas J. Ridge in "A National Blueprint for Biodefense: Leadership and Major Reform Needed to Optimize Efforts," (Blue Ribbon Study Panel on Biodefense, October 2015), 59-60.

Smart Biological Armor.

The Air Force must pursue the next generation of medical countermeasures (MCM) that can be used in concert with a 24/7 TFA enterprise. Currently, various federal entities (DOD, The U.S. Department of Health & Human Services, CDC, FDA, etc.), universities and medical centers all develop and distribute MCMs. These countermeasures come in three varieties: biologic products (vaccines, blood products, antibodies etc.), drugs (antimicrobial and antiviral drugs), and devices (diagnostic tests, and personal protective equipment PPE), ventilators etc.).⁷⁶ Naturally, the Air Force should support these joint efforts as needed. Nevertheless, Air Force specific investments must focus on the next generation of PPE that will work not only on our bodies but inside. For example, AFRL's *Microbiome* research is crucial to understanding the gut-brain connection. Home to trillions of microorganisms that outnumber human cells 10:1, our bodies are ripe for malicious BW.⁷⁷ Microbes, both naturally occurring and engineered, can negatively impact our health. In addition, they may also harbor the potential to affect our mood, memory and cognition. Microbiota are just one example of the many subdomains in our bodies that require biodefense. Just as virus protection software actively protects a computer, smart biological armor will work alongside a 24/7 TFA enterprise to ensure an active defense with a smart ability to push and receive data.

As Francis Bacon noted, "knowledge is power." A defensive enterprise lacking knowledge may therefore be powerless. The emerging BW threat is especially daunting because it so easily evades detection and therefore minimizes our knowing about it. The

⁷⁶ FDA, "Emergency preparedness and response," Jan 2016

<http://www.fda.gov/EmergencyPreparedness/Counterterrorism/MedicalCountermeasures/AboutMCMi/ucm431268.htm>

⁷⁷ National Institutes of Health, "NIH Human Microbiome Project defines normal bacterial makeup of the body," 13 Jun 2012, <http://www.nih.gov/news-events/news-releases/nih-human-microbiome-project-defines-normal-bacterial-makeup-body>

Air Force can stick its head in the sand like an ostrich or cheerlead while others handle biodefense. Nether will help Airmen when bioweapons begin to distract, disrupt and—God forbid—destruct. In order to amass knowledge and gain situational awareness in the newest contested domain, the Air Force must pursue a 24/7 TFA enterprise augmented by compatible environmental sensing, big data analytics, and smart biological armor. Then we will truly begin to know the threat and ourselves.

Chapter 5

*While biological events may be inevitable, their level of impact on our country is not.*⁷⁸

—Joseph Lieberman
Former Senator (D-CT)
&

—Thomas Ridge
Former Secretary of Homeland Security

Conclusion

If the argument taken in this paper has relevance and represents even a small portion of the threat array as I have described, then the third offset, whatever it may be, is essentially irrelevant because adversaries contend to fight with non-lethal BW—not just first and not just on our military but now and against the civilian population in CONUS. To do so, knowing just how at risk our families, households and communities are, will achieve far greater political, social and economic results than biological affects limited to military objectives. The real target of non-lethal BW is the degradation of the civilian population here and now and for generations to come. If America chooses to accept this reality, however, and takes sufficient mitigating precautions, then perhaps we have a chance to survive the inevitable attacks to come.

⁷⁸ Joseph I. Lieberman and Thomas J. Ridge in “A National Blueprint for Biodefense: Leadership and Major Reform Needed to Optimize Efforts,” (Blue Ribbon Study Panel on Biodefense, October 2015), Preface, Bipartisan Report, p iv.
http://www.biodefensestudy.org/SiteAssets/Pages/default/1425-2139_BRSP_Report_100815b%5b1%5d%5b6%5d.pdf

Appendices

APPENDIX 1: Six Future Characteristics of Biological Attacks

| Narrowing Function | Rationale Behind Narrowing Choices |
|----------------------|--|
| 1. Non-lethal | Non-lethal bio (vs. lethal) better illustrates how adversaries might approach a slow war of attrition while avoiding an American retaliation. Equally important, non-lethal BW allows an adversary to demonstrate capabilities purely for purposes of deterrence or extortion. Lethal BW also remains a doomsday threat, but fails to capture the new, vital characteristics of next generation bioweapons. |
| 2. Non-attributable | Non-attributable BW cuts right to the heart of several common myths about bioweapons. Non-attributable effects can eliminate altogether legal, moral or retribution concerns an adversary may have. As such, their use is inevitable. Lethal bioweapons will also become more likely, especially when DIY biohackers and terrorists become more skilled at tailoring pathogens via targeted genome engineering. |
| 3. Undetectable | Undetectable bioweapons redefine force protection needs. Zero detection time implies that an attack becomes a known event, albeit only once it occurs. Less than zero detection time (undetectable) refers to attacks that remain unknown unknowns without proper epidemiological health and cognition monitoring. For example, how does a commander even know her personnel's cognition was attacked by an undetectable, non-lethal biological without 24/7 monitoring of personalized baselines for both health and performance across the total force population? |
| 4. Highly Tailorable | The highly tailorable nature of new bioweapons is paramount to understanding the BW's versatility to selectively induce mass distraction, disruption or destruction (D3) at all levels of war by targeting across large groups or individuals. Indiscriminate bioweapons and pandemics will still pose a threat for mass destruction. |
| 5. Usable in CONUS | Central to the CSAF's Blue Horizon question is the concept of contested space. Typically, the A2/AD concept comes to mind when contested domains are discussed. Non-lethal BW changes the nature of contested in two key ways. First, the human body is a new contested domain like air or cyber. Second, the relatively small A2/AD bubbles found on a map in somebody else's part of the world does not apply. Non-lethal BW will occur not only abroad, but in CONUS too. |
| 6. AF Human targets | In order to highlight BW as an Air Force problem and emphasize the force protection challenges that commanders will face, this paper focused on Airmen as targets. National biodefense, however, opens up many more targets the government must be mindful to safeguard. BW can wreak havoc if waged against agriculture, livestock, water, fuel and other essential resources for a healthy American economy and society. Naturally occurring pandemics also remain a threat for national concern. |

APPENDIX 2: Interagency Efforts in Biodefense^{79,80,81,82,83,,}

| Agency | Key Organizations & Functions |
|--|--|
| U.S. Department of Health & Human Services (HSS) | Project BioShield, Strategic National Stockpile (prepares for and responds to public health medical emergencies) |
| | Biomedical Advanced Research and Development Authority (BARDA) (prepares for and responds to public health medical emergencies) |
| | National Institutes of Health (NIH) |
| Centers for Disease Control and Prevention (CDC) | Public health emergency preparedness and response; Bioterrorism and natural occurring outbreaks or pandemics |
| Department of Agriculture (USDA) | Office of the Chief Scientist (OCS) |
| | Animal and Plant Health Inspection Service (APHIS) |
| | National Institute of Food and Agriculture (NIFA) |
| Department of Commerce (DOC) | National Institute of Standards and Technology (NIST) |
| Department of Defense (DOD) | Defense Threat Reduction Agency (DTRA) |
| | Defense Advanced Research Project Agency (DARPA) |
| | Air Force Research Lab (AFRL) |
| | Office of Naval Research (ONR) |
| | Army Medical Research Institute of Infectious Diseases (USAMRIID) |
| Department of Energy (DOE) | Office of Energy Efficiency & Renewable Energy (EERE) |
| | Office of Science (SC) |
| National Aeronautics and Space Administration (NASA) | NASA Ames Research |
| National Science Foundation (NSF) | Directorate for Engineering Directorate for Biological Sciences |
| | Foundation (NSF) |

⁷⁹ Strategic National Stockpile (SNS), HHS Radiation Emergency Medical Management, <https://www.remm.nlm.gov/sns.htm>

⁸⁰ Project BioShield Annual Report, 2014. United States Department of Health & Human Services, Office of the Assistant Secretary, <https://www.medicalcountermeasures.gov/media/36816/pbs-report-2014.pdf>

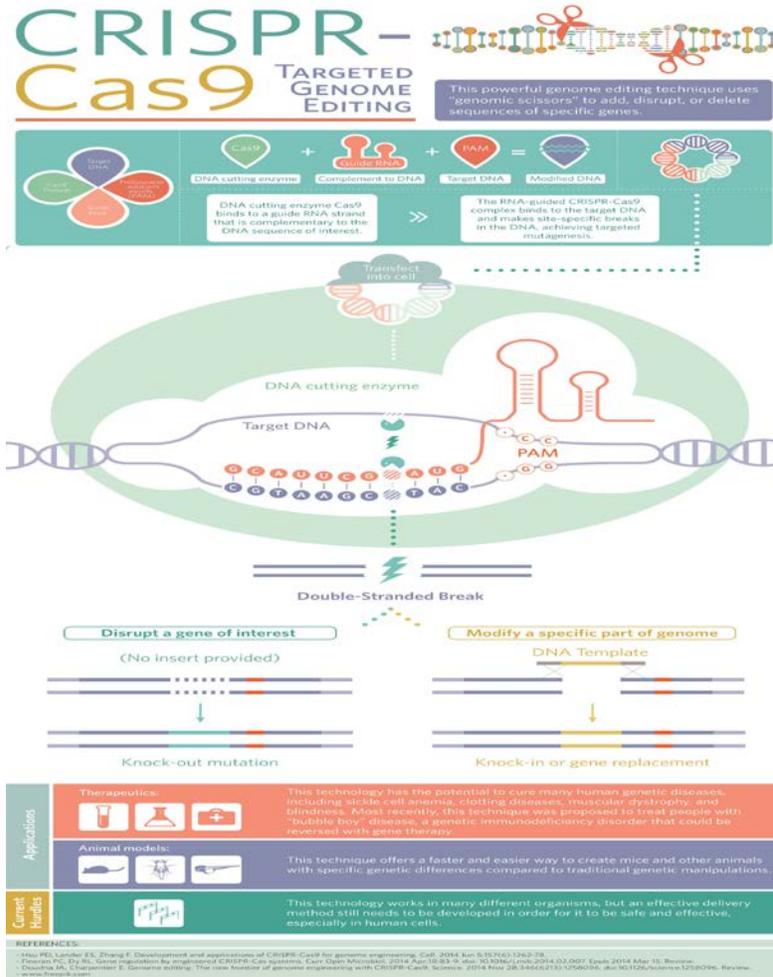
⁸¹ Bioterrorism, CDC, <http://www.cdc.gov/healthcommunication/ToolsTemplates/EntertainmentEd/Tips/Bioterrorism.html>

⁸² "Synthetic Biology," U.S. Department of Energy, Report to Congress, 2013, http://www.synberc.org/sites/default/files/DOE%20Synthetic%20Biology%20Report%20to%20Congress_Fnl.pdf

⁸³ National Incident Management System, <https://www.fema.gov/national-incident-management-system>

| | |
|---|---|
| Synthetic Biology Working Group | Co-chaired by DOD and DOE; includes Office of Management and Budget (OMB), the Office of Science & Technology Policy (OSTP), and the State Department |
| Intragovernmental Select Agents and Toxins Technical Advisory Committee (ISATTAC) | Comprised of Federal employees from the DOD, CDC, NIH, FDA, the USDA/Animal and Plant Health Inspection Service (APHIS), USDA/Agricultural Research Service (ARS), and USDA/Center for Veterinary Biologics (CVB) |
| | |
| U.S. Department of Homeland Security (DHS) | Federal Emergency Management Agency (FEMA) |
| | National Incident Management System (NIMS) |

APPENDIX 3: CRISPR/Cas 9 Explained⁸⁴



⁸⁴ Crispr-Cas9: Targeted Genome Editing, http://i1.wp.com/knowingneurons.files.wordpress.com/2015/03/crispr_updated_final_size.jpg?ssl=1