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Unmanned Aerial Vehicles and Weapons of Mass Destruction

A Lethal Combination?

JEFFREY N. RENEHAN, MAJOR, USAF

School of Advanced Airpower Studies

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JEFFREY N. RENEHAN, Major, USAF
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Abstract

This study analyzes the characteristics and capabilities of unmanned aerial vehicles (UAV) to determine their capability to carry weapons of mass destruction (WMD). The author presents an overview of the various forms of WMD—chemical, biological, and nuclear weapons. The objective is to review the characteristics of both UAVs and WMD to determine if they are capable of being used together as an effective weapon. The result indicates that there is great potential for the use of UAVs as delivery systems for WMD, particularly by developing nations and nonstate actors such as terrorist groups who may not have the technical capability to employ other means. The potential exists for the proliferation of both UAVs and WMD to become widespread and thus a major security concern. There is no clear solution to this problem; however, actions including bringing the issue to the forefront, strengthening export and arms controls, deterrence, and defense will have a synergistic effect that will help mitigate this threat.

About the Author

Lt Col (Col-select) Jeffrey N. Renehan is a master missileer who received his commission in 1981 through the Reserve Officer Training Corps and in 1982 received his Minuteman intercontinental ballistic missile (ICBM) initial combat crew qualification training. He has a bachelor's degree in business from the University of Colorado and a master of business administration from the University of South Dakota. During his initial tour, he served as an ICBM operations combat crew deputy, flight commander deputy, instructor deputy, and commander. He also served as an emergency war order instructor and as the 44th Strategic Missile Wing executive officer. Next, he was selected for the Strategic Air Command's ICBM operational test launch program, known as Top Hand. Two years later, he was assigned to the secretary of the Air Force's ICBM modernization acquisition office in the Pentagon where he served as a program element monitor and congressional liaison officer. In 1992 he was selected for a joint duty assignment at the Department of State as the space and missile policy advisor to the assistant secretary of state for political military affairs. In June 1996 he graduated from the School of Advanced Airpower Studies and was assigned to the 576th Test Squadron as the squadron commander designee.

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Chapter 1

Introduction

Weapons of mass destruction—nuclear, biological, and chemical—along with the systems that deliver them, pose a major threat to our security and that of our allies and other friendly nations. Thus, a key part of our strategy is to seek to stem the proliferation of such weapons and to develop an effective capability to deal with these threats.

—President William J. Clinton
A National Security Strategy of Engagement and Enlargement

The cold war may be over, but the effects caused by the change from a bipolar global geopolitical situation to a multipolar (or unipolar) situation may be more ominous than once imagined. Regional stability, long a concern of the United States (US), has now become an increasingly prevalent problem. The break up of the former Soviet Union has spurred the creation of many new nations and has reduced the degree of superpower control over other third world states paving the way for increased political, social, and economic strife. One of the biggest concerns of the current US administration is the proliferation of weapons of mass destruction (WMD) and the systems that deliver them.

WMD delivery systems often receive less attention than do the weapons themselves. Technology in this area has evolved to the point that effective WMD delivery systems are not limited to just ballistic missiles and aircraft. Much smaller, more accurate, and less expensive unmanned systems are being developed everyday. One of the most potentially important new categories of delivery systems is unmanned air vehicles (UAV). The question specifically is, Are UAVs adaptable as WMD delivery vehicles? If so, what are the implications for international stability and defense? What options are available for combating their proliferation to countries of concern? If they do not present a threat in this capacity, is there a danger of overreacting to a misperceived threat and thus expending needless time, resources, and money?

WMD and their associated delivery systems have been a global concern for many years. Many believe that this concern began with the development of the first nuclear weapon by the United States in the Manhattan project. It really starts much earlier. The conventional definition of WMD includes chemical and biological weapons in addition to nuclear ones. Some of the earliest recorded uses of biological warfare occurred in the fourteenth century, when the Mongols placed plague-infected cadavers on their catapults and flung them into the walled city of Caffa. Mustard gas and other chemical agents were used in the trenches of World War I and were delivered by a number of means, including artillery and airplanes. Additionally, Iran and Iraq used chemical weapons during their conflict in the 1980s.[1] During the 1991 Gulf War, there was great concern that Iraq might have the capability to deliver chemical, biological, and even nuclear weapons with Scud missiles. WMD have been available for many years, their deployment just limited by the delivery systems available at the time. Consequently, the combination of more efficient WMD and more effective delivery systems have become an area of great concern.

The principal Western response to this problem was the formation of the missile technology control regime (MTCR) in 1987. At that time, seven industrialized nations (the United States, Germany, France, Italy, Japan, the U.K., and Canada) identified a need to prevent the spread of delivery systems for WMD. The MTCR Guidelines state that "the purpose of these guidelines is to limit the risks of proliferation of weapons of mass destruction (i.e., nuclear, chemical, and biological weapons), by controlling transfers that could make a contribution to delivery systems (other than manned aircraft) for such weapons."[2] Because the MTCR focuses on the delivery systems for WMD, not the weapons themselves, it differs from other regimes and treaties which deal with the weapons themselves, such as, the Nuclear Nonproliferation Treaty (NPT) and the Chemical Weapons Convention (CWC). "Delivery systems" in the case of the MTCR, refers to all unmanned systems, including ballistic missiles, cruise missiles, and, less prominently, UAVs and drones.

UAVs are defined as powered aerial vehicles sustained in flight by aerodynamic lift over most of their flight path and guided without an onboard crew. They may be expendable or recoverable and can fly autonomously (via an inertial navigation system) or be piloted remotely.[3] Remotely piloted vehicles (RPV) are usually considered a subset of UAVs. They are unmanned aircraft capable of being controlled from a distant location through a communications link.[4] While both are normally designed to be recoverable and nonautonomous, they can be adapted for expendable and autonomous use. This is done by modifying the software and guidance equipment to fly a one-way mission with autonomous guidance to the terminal area.

Historically, the greatest use of UAVs has been made in the areas of intelligence gathering, surveillance, and battle damage assessment (BDA), where they allow armed forces to avoid placing pilots at risk. They have also been used to gather nonmilitary information in environments that are hazardous to human beings. For example, B-17 bombers were adapted to fly by remote control during the Bikini Atoll nuclear bomb tests.[5] The Israelis have also used UAVs extensively for reconnaissance purposes. During the Gulf War, the coalition allies used them for intelligence and BDA purposes. In fact, the Pioneer UAV was praised as "the single most valuable intelligence collector" in the war against Iraq.[6] They have proved to be extremely reliable and have had high mission completion rates. During the Gulf War, only one UAV was lost in more than 300 missions.[7] Finally, they have been successfully used in Bosnia as airborne surveillance platforms. Their small size and low altitude capability make them extremely hard to locate and destroy. To date, after hundreds of missions into hostile territory, only two Predator UAVs have been lost.[8]

This study examines the potential of UAVs to be WMD delivery vehicles and their inherent advantages that may make them attractive to developing nations as they build their arsenals. Due to the broad nature of this topic, this study focuses on the subject of the potential delivery of WMD with UAVs by underdeveloped and third world nations. However, the findings are equally applicable to nonstate actors (such as terrorist groups) and more advanced countries.

Chapter 2 provides basic, unclassified information about the characteristics and capabilities of some of the UAVs that are currently in development and production. It also discusses the capabilities which make them particularly suitable as WMD carriers. Chapter 3 presents a basic overview of chemical, biological, and nuclear weapons. It demonstrates that the size, weight, and other characteristics of these weapons make them potentially suitable for use with UAVs. For some WMD, UAVs may even be the ideal delivery system.

Chapter 4 presents a scenario that illustrates how UAVs and WMD could be married into a complete delivery system by a developing nation. Chapter 5 examines the nature and extent of the strategic threat posed by UAV-delivered WMD. The evidence presented in chapters 2 and 3 shows that these systems are capable of being married together to form effective WMD delivery systems. This raises some interesting problems for the international nonproliferation community. In light of this, the final chapter looks at the policy alternatives available to the United States to prevent widespread dissemination of these systems.

Notes

1. Randall J. Larsen and Robert P. Kadlec, *Bio War: A Threat to America's Current Deployable Forces* (Arlington, Va.: Aerospace Education Foundation and the Air Force National Defense Fellows, April 1995), 4–5.

2. *Missile Technology Control Regime Guidelines* (Washington, D.C.: Department of State, PM/CBM, 1995), 1.

3. Air Chief Marshal Sir Michael Armitage, *Unmanned Aircraft* (London: Brassey's Defence Publishers, 1988), xi.

4. Ibid., xi–xii.

5. David R. Mets, "Eglin and the Dawn of the Nuclear Age," *Eglin Eagle*, 26 April 1985, 8.

6. Lt Gen Walter Boomer, USMC, Marine Corps Central Command Element Headquarters (MARCENT) papers.

7. *Unmanned Aerial Vehicles 1994 Master Plan* (Washington, D.C.: Government Printing Office, 31 May 1994), 3–9.

8. John G. Roos, "That F-Word," *Armed Forces Journal International*, September 1995, 19.

Chapter 2

Unmanned Aerial Vehicle and Remotely Piloted Vehicle Technologies

Small, survivable, "damned elusive" and increasingly smart, the unmanned aircraft is enjoying a resurgence of interest in its varied capabilities on the modern battlefield.

—Kenneth Munson
Air International

Unmanned aerial vehicles are not new. The technology to develop and employ them has been available for many years. However, recent technological developments have combined to make UAVs smaller, faster, more accurate, more reliable, and generally more capable than they have been in the past. In order to begin answering the question of whether UAVs could effectively deliver WMD, this chapter presents an overview of the capabilities of some typical UAVs. It begins by providing some definitions as a common starting point for discussion and then presents examples of some current and projected aircraft.

Definitions

Different types of UAVs are known by many names, often leading to unnecessary confusion. The following definitions will be used in the current study.[1]

> Unmanned aerial vehicle (UAV): An aerial vehicle that has no onboard pilot and is capable of preprogrammed autonomous operation or operations received from a human operator located some distance (either on the ground or on a seaborne or airborne platform) from the vehicle.
>
> Remotely piloted vehicle (RPV): Usually considered a subset of UAVs, RPVs are aerial vehicles that do not have an onboard pilot and are capable of receiving continuous or intermittent commands from a human operator located at a ground, seaborne, or airborne station some distance from the vehicle.
>
> Drone: An aerial vehicle that has no onboard pilot and is preprogrammed prior to launch to accomplish a set of functions with no further human intervention or command. The drone may use onboard sensors to autonomously make mission adjustments. Drones are usually designed for such uses as expendable targets with relatively short operating distances and loiter times.
>
> Guided missile: An unmanned aerial vehicle whose trajectory can be altered by external or internal mechanisms (i.e., seeker heads, laser designators, or fly-by-wire systems).
>
> Cruise missile: A guided unmanned aerial vehicle whose flight path is executed at approximately constant velocity. The cruise missile seeks to complete its preprogrammed mission, but may alter its course based upon onboard sensor information.

There are similarities among all of these definitions. Historically, UAVs have been developed for use as intelligence gathering and battlefield surveillance devices. Their designs have emphasized the needs to be affordable, portable, easily launched, easily maintained, reliable, and recoverable. The last characteristic, recoverability, further sets them apart from other unmanned vehicles. The key issue for their use as WMD delivery vehicles is that the same capabilities that make them good surveillance tools also makes them very well suited to a strike role.

Unmanned Aerial Vehicle Examples

The key point to keep in mind during this review of UAV technology is not the details of the particular systems per se, but the unique characteristics they display and their potential to carry WMD. Chapter 3 provides a review of salient WMD characteristics and by combining the information provided in both chapters, the reader will gain some appreciation of the possibility of marrying the two for WMD delivery purposes.

Space does not allow for a review of every UAV on the market today. However, the following examples will provide an overview of the basic characteristics of a range of models from small ones with low payload capabilities through the higher end types which approach cruise missile characteristics.

For a synopsis of the capabilities of the UAVs highlighted in this chapter, see table 1.[2]

Table 1

Unmanned Aerial Vehicles

UAV	*Launch Weight*	*Payload*	*Range*	*Loiter Time*	*Guidance*	*Dimensions**	*Cost Per Vehicle*
Exdrone	40.5 kg	11 kg	120 km	2.5 hrs	Manual/Auto	1.6 m x 2.5 m	$20 k
Pioneer	200 kg	50 kg	185 km	6–9 hrs	Manual/Auto	4.3 m x 5.1 m	$660 k
Hunter	667 kg	143 kg	150 km	14 hrs	Manual/Auto	7 m x 9 m	$1.2 M
Delilah	180 kg	55 kg	400 km	5 hrs	Manual/Auto	2.7 m x 1.5 m	about $200 k
Scarab	1,077 kg	132 kg	3,150 km	N/A	Manual/Auto	6.2 m x 3.4 m	N/A
Model 410	817 kg	227 kg	2,000 km	10 hrs	Manual/Auto	6.6 m x 9.6 m	N/A
Tier II Plus	10,394 kg	907 kg	5,000 km	42 hrs	Manual/Auto	N/A	$10 M
Tier III Minus	N/A	230 kg	800 km	N/A	Manual/Auto	N/A	$10 M

Source: Information in this table was derived from a combination of "All the Worlds' Unmanned Air Vehicles," *Interavia Aerospace Review*, December 1991, 47; "Dossier," *International Defense Review*, May 1995, 84; and Kenneth Munson, "Pilotless Pimpernels," *Air International*, February 1992, 88.

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*The dimensions given are length x wingspan. Cost data are approximate estimates.

The Exdrone UAV is a small, delta-wing vehicle designed by Battlefield Air Interdiction (BAI) Aerosystems for the US Marine Corps and is used for reconnaissance on the battlefield. It is powered by a one-cylinder, two-cycle internal combustion engine which produces about 5.2 horsepower, giving it a top speed of about 185 kilometers (km) per hour. The Exdrone's ceiling is about 10,000 feet.[3]

The Pioneer UAV is also a small vehicle designed for surveillance and reconnaissance. It is of typical tailed aircraft design, manufactured by Israeli Aircraft Industries and is currently in service with the US Navy. It is powered by a two-cylinder, two-stroke, engine that produces about 28 horsepower which allows a top speed of about 170 km per hour. The Pioneer's ceiling is about 15,000 feet.[4]

The Pioneer demonstrated its unique capabilities during the Gulf War. US forces flew it on more than 300 combat missions over hostile territory. Only one vehicle was shot down, and three others were hit by ground fire but were recovered.[5] This was a graphic demonstration of UAV penetration and survivability characteristics.

The intended follow-on to the Pioneer UAV was the Hunter, designed and produced by Israeli Aircraft Industries and TRW for surveillance and target acquisition missions. It is powered by two Teledyne Continental GR-18 rotary piston engines that produce a total of about 45 horsepower which allows a top speed of about 225 km per hour and a ceiling of about 19,000 feet. The Hunter program has been canceled due to logistic supportability and propulsion problems. However, it still is an excellent example of the capabilities of UAVs and how technology is evolving to increase their capabilities.[6]

The Delilah UAV is also produced by Israeli Aircraft Industries. It is an outgrowth of earlier Israeli adaptations of the Northrop Chukar, which was used as an aerial target drone. It is a more advanced design than the UAVs discussed above and is powered by one Noel Penny NPT 151-4 turbojet engine rated at 165 pounds of thrust, which allows speeds of up to 900 km per hour. The Delilah's ceiling is approximately 32,000 feet.[7] A unique characteristic of the Delilah is that it is designed to be nonrecoverable. The flight control system is a preprogrammed inertial navigation system with a global positioning system (GPS) update that is purely autonomous, in fact, it is described as a "fire and forget" system.

The next two UAV systems are both produced by the Teledyne Ryan Corporation. The first is the BQM-145A, the Scarab. It was developed in the 1980s and was sold to Egypt as a ground-launched tactical reconnaissance vehicle. It is powered by one Teledyne CAE 373-8C turbojet engine rated at 970 pounds of thrust which gives it a maximum speed of over 845 kilometers per hour. The Scarab's ceiling is approximately 43,000 feet.[8]

The second Teledyne Ryan UAV is the Model 410. Large enough to carry full-size, up to 227 kilograms (kg), instead of miniaturized payloads. It was designed for long-range or long-endurance missions, and it was first flown on 27 May 1988 with a man on board. Its first unmanned flight was in 1992. It is powered by one Textron Lycoming TIO-320-C1B flat-four piston engine rated at 160 horsepower which allows a maximum speed of over 322 km per hour. The Model 410's ceiling is approximately 30,000 feet.[9]

UAV technology, like most technology, is not stagnant but is continuing to evolve. One segment of the next generation of UAVs that US manufacturers are developing for the US Air Force is the Tier II/III family of endurance model UAVs which will provide significant new reconnaissance capability for the US military.[10]

The Tier II Plus program, the high altitude endurance UAV, is currently being developed to provide a high endurance vehicle capable of continuous, all weather surveillance. This vehicle is capable of operating to ranges in excess of 4,500 km. It has a ceiling of 65,000 feet, a top speed of over 500 km per hour, and a payload of over 600 kg. It, too, is capable of fully autonomous flight and is planned to cost less than $10 million per aircraft.[11]

Finally, the Tier III Minus program, the low observable high altitude endurance UAV, further demonstrates how evolving technology is being incorporated into making them more survivable and capable. This vehicle, nicknamed Dark Star, is projected to have a range of approximately 800 km, a ceiling of more than 40,000 feet, a top speed of about 400 kilometers per hour, and a payload of approximately 230 kg. The key feature of the Tier III Minus program is its use of low observable or stealth technology. This gives it much greater penetration and survivability characteristics than equivalent nonstealthy systems. Finally, as with its sister Tier II programs, it will be capable of fully autonomous flight. The program is currently in source selection so cost data is not available at this time.[12]

In addition to complete systems available for sale, another way to obtain a UAV system is to build it by obtaining the major subsystems and then assembling them. The nominal cost of materials for a small UAV capable of autonomous flight and equipped with a commercially available agricultural spraying device is less than $90,000.[13] Although much less sophisticated, a vehicle of this type would have roughly the same size and range/payload characteristics as the Pioneer system. Home-built aircraft companies provide access to advanced materials, equipment, and guidance technology. For instance, a basic, accurate, autonomous navigation and control system with a GPS update can be assembled for less than $25,000.[14] The other subsystems, such as the airframe and the engine, make up the remainder of the cost. There are currently more than 20 countries and five international consortia that produce UAVs and their components.[15] The MTCR controls the export of these parts, if they are destined to be used in a system that will carry WMD. However, discovering this intent is very difficult. Once a state or other actor obtains these parts, constructing a UAV is about as complicated as making a home-built airplane.[16]

The purpose of this study was not to present an all-encompassing encyclopedia of available UAV technology, but rather to show the range of UAVs that are being produced around the world today. Technology is evolving in such a way that these vehicles are steadily becoming more capable and much less expensive.

This also makes them increasingly adaptable to missions other than the current applications of surveillance and reconnaissance.

Global Positioning System

GPS has been mentioned throughout this chapter in discussing accurate guidance systems for UAVs. Unclassified sources show that GPS has the capability to provide remarkable accuracy. There are two types of signals provided by the GPS satellites. Authorized users with cryptographic equipment, keys, and specially equipped receivers use the precise positioning system (PPS). The United States and allied military, certain US government agencies, and selected civil users specifically approved by the US government can use the PPS which provides accuracy of less than 10 meters. Civil users worldwide use the standard positioning system (SPS). This system is intentionally degraded by the Department of Defense by the use of a code called Selective Availability. However, accuracy in this mode is still less than 100 meters.

There is a technique to increase the accuracy of systems using either GPS system called Differential GPS. This technique corrects bias errors at the mobile receiver with measured bias errors at a known position. A reference receiver, or base station, computes corrections for each satellite signal. This is a complicated procedure and requires a mobile GPS receiver that can receive the bias changes via radio link and process in-flight computations and course corrections.

Costs vary depending on capabilities. Small civil SPS receivers can be purchased for less than $500. Receivers capable of using differential corrections cost between $1,000 and $5,000. Receivers that can act as Differential GPS reference receivers (computing and providing correction data) cost between $5,000 and $40,000, depending on their capabilities.[17]

Conclusion

UAVs are suitable for a variety of roles, including strike missions, and are capable of carrying a wide range of payloads. Again, the models presented are only a representative sample and many others, produced all over the world, are available for general purchase.

However, the basic technology and concept of UAVs are not new or unique ideas. The question arises of why UAVs haven't yet been employed more widely in roles such as strike missions. The answer is twofold. First, technology, especially navigation technology, has evolved, and continues to evolve, to such an extent that UAVs are now far more capable than ever before. The models presented are good examples of this. A second reason is that technically advanced countries have the means and the technology to choose advanced systems like ballistic missiles or cruise missiles instead of UAVs.[18]

However, with UAV capabilities improving and costs decreasing, UAVs could be coming into their own as an alternative to more advanced systems. A few years ago only a few companies such as Teledyne Ryan Corporation and Israeli Aircraft Industries showed interest in UAVs, but now companies are so certain of the future of UAVs that many are entering the market.[19] Capabilities such as increased range and payload, autonomous air vehicle avionics, precision navigation systems, long loiter times, hypervelocity, portability, and transportability are making UAVs and RPVs particularly attractive.[20] In fact, low altitude, unmanned vehicles have particular significance as force multipliers for ground attack, in addition to traditional roles of battlefield reconnaissance. Finally, as US experiences hunting Scuds in the Gulf War showed, it is almost impossible to locate and destroy a small mobile system that is covertly deployed. In fact, the Gulf War intelligence community never could furnish reliable information on the number and location of Iraq's Scud launchers. This forced an intensive anti-Scud campaign that seriously reduced the number of Scud firings, but never totally ended them.[21] UAVs should be even harder to find than mobile Scuds were, given their smaller size and reduced maintenance and support requirements.

This chapter shows that UAVs are very diverse platforms, capable of a myriad of missions. By taking advantage of evolving technology, manufacturers have turned simple target drones into remotely piloted and/or autonomous aerial vehicles with exceptional capabilities. To use UAVs for strike missions, the next question is what types of weapons could be effectively married to UAVs in order to provide an effective weapon. The next chapter presents a review of the unique characteristics of one possible answer: weapons of mass destruction—chemical, biological, and nuclear weapons.

Notes

1. Will Davis, *The Human Role in Future Unmanned Vehicle Systems* (Air Force Systems Command, Office of the Deputy for Development Planning, December 1988), 3.

2. Approximate costs—in table 1 and on all UAVs presented in this chapter—are unclassified estimates and were obtained from telephone interviews with the Department of Defense, Program Executive Office, Cruise Missile Project, and Unmanned Aerial Vehicle Joint Project. Conclusions drawn from this information are my own and do not reflect the opinions or policy of this office.

3. "All the Worlds' Unmanned Air Vehicles," *Interavia Aerospace Review*, December 1991, 47.

4. Specifics on the Pioneer system come from a combination of "All the Worlds' Unmanned Air Vehicles," 47; "Dossier," *International Defense Review*, May 1995, 84; and Kenneth Munson, "Pilotless Pimpernels," *Air International*, February 1992, 88.

5. *Unmanned Aerial Vehicles 1994 Master Plan* (Washington, D.C.: Government Printing Office, 31 May 1994), 3–5.

6. Specifics on the Hunter system come from a combination of "All the Worlds' Unmanned Air Vehicles," 46; "Dossier," *International Defense Review*, May 1995, 88; and Munson, 88.

7. Munson, 88.

8. Specifics on the Scarab system come from a combination of "All the Worlds' Unmanned Air Vehicles," 47; "Dossier," 94; and Munson, 89.

9. Specifics on the Teledyne Model 410 system come from a combination of "All the Worlds' Unmanned Air Vehicles," 47; "Dossier," 93; and Munson, 89.

10. John Entzminger, "Acquiring Affordable UAVs," *Journal of Electronic Defense*, January 1995, 35.

11. Ibid., 35–39.

12. Data on the Tier III Minus program was obtained from telephone interviews with the Department of Defense, Program Executive Office, Cruise Missile Project, and Unmanned Aerial Vehicle Joint Project. Conclusions drawn from this information are my own and do not reflect the opinions or policy of this office.

13. The author conducted an informal industry survey of a number of UAV kit manufacturers, agricultural supply companies, and GPS producers. The costs presented here are a result of this survey and are very rough estimates. Costs could vary considerably, depending on the characteristics and capabilities that are sought.

14. Ibid.

15. J. R. Wilson, "Suddenly Everyone Wants a UAV," *Interavia Aerospace Review*, December 1991, 46–47.

16. Construction techniques and ease of assembly were obtained from the informal survey.

17. All GPS information was obtained from the University of Texas, Department of Engineering, on the World Wide Web at site http://www.utexas.edu/depts/grg/gcraft/notes/gps/gps.html.

18. Col Harald G. Hermes, USAF, *The Nonnuclear Cruise Missile—Low Cost Force Augmentor* (Maxwell AFB, Ala.: Air War College, 1980), 214–16. For example, the US Tomahawk missile (TLAM) is 18 feet long and 20 inches in diameter. It is powered by a small turbofan engine which produces ranges in excess of 1,500 miles and speeds of 550 miles per hour. Navigation is performed with an inertial navigation system updated periodically with the Terrain Contour Matching (TERCOM) system. This system compares terrain gradients observed by the TLAM's radar altimeter to those stored in its computer. In the terminal phase, accuracy at the target is further improved using Scene Matching Area Correlator (SMAC). SMAC compares a stored photo of the target with one obtained in flight. Finally, the TLAM's payload capability allows it to carry a variety of loads and makes it a very flexible weapons delivery platform.

19. Wilson, 43.

20. Davis, 63–64.

21. Richard P. Hallion, *Storm over Iraq, Air Power in the Gulf War* (Washington and London: Smithsonian Institution Press, 1992), 245.

Chapter 3

Weapons of Mass Destruction

I, William J. Clinton, President of the United States of America, find that the proliferation of nuclear, biological, and chemical weapons ("weapons of mass destruction") and the means of delivering such weapons, constitutes an unusual and extraordinary threat to the national security, foreign policy, and economy of the United States, and hereby declare a national emergency to deal with that threat.

—*Presidential Executive Order*
14 November 1994

Few international dangers confronting the United States have more serious and far-reaching implications for national security and worldwide stability than the proliferation of weapons of mass destruction.[1] WMD include nuclear, chemical, and biological weapons. The proliferation of WMD is a global problem that reaches across national, geographic, political, cultural, and social boundaries. It also involves all types of countries, including those led by reactionary and unstable regimes. For example, North Korea, Libya, Syria, Iran, and Iraq are all identified as actively pursuing WMD programs.[2]

While the proliferation of these types of weapons is clearly a problem, an even greater concern is if and when someone will decide to use them. For example, the episode in Japan in which a terrorist group released the nerve agent Sarin into a crowded subway elicited worldwide shock and concern.[3]

Controlling the spread of WMD is no simple matter. Many of the technologies associated with WMD programs (especially the nonnuclear ones) have legitimate civilian or military applications unrelated to WMD. This makes it difficult to restrict trade in those technologies because developing nations have legitimate needs for them. For example, chemicals used to make nerve agents are also used to make plastics and to process foodstuffs. A modern pharmaceutical industry can produce biological warfare (BW) agents as easily as vaccines and antibiotics, using the same equipment and raw materials. Additionally, as potential proliferation countries' economies improve and their industrial bases mature, their dependence on foreign countries to provide the technologies necessary for WMD development and production decline, making early detection and interdiction of new programs increasingly difficult.[4]

This chapter presents an unclassified overview of chemical, biological, and nuclear weapons focusing especially on their potential deliverability by UAVs. It is not meant to be all inclusive, but simply to give the reader an appreciation of the scope, characteristics, and destructive capabilities of these weapons.

Chemical Weapons

Chemical warfare (CW) is the military use of toxic substances whose effects on exposed personnel result in incapacitation or death. The impact of chemical effects as opposed to physical effects (such as blast and heat) distinguishes chemical weapons from conventional weapons. Optimally, the chosen delivery system disseminates the chemical agent as a cloud of fine droplets, known as an aerosol. This permits the highly toxic agent to cover a relatively large amount of territory evenly and efficiently.[5]

History

Modern chemical warfare began in 1915, when the Germans used chlorine gas, a choking agent, on French troops. Allied forces soon responded in kind, which resulted in an escalation of chemical warfare by both sides that lasted until the end of the war. By the time of the signing of the armistice in November 1918, more than one million people had been injured by chemical weapons and nearly 100,000 had been killed. Chemical weapons were also used sporadically after World War I (by Italy in Ethiopia in 1937 and the Egyptians in Yemen during the mid-1960s), however, large scale use of chemical weapons did not resume until Iraq used them against Iran in 1983.[6] Even though a precedent of sorts had been set in World War I, chemical weapons were not used in World War II.

Chemical Warfare Agents

Chemical agents are classified in a number of ways. They can be either lethal or nonlethal, and there is not always a clear distinction between the two. Lethal agents, like Sarin, are primarily designed to cause death on the battlefield, although sublethal doses can incapacitate. Nonlethal agents, like tear gas, are primarily designed to incapacitate or injure (although large doses can kill) and are used for purposes such as crowd control.[7] Both kinds are categorized by chemical weapons experts according to the following characteristics.

Mode of action indicates how the agent affects living things. When used as a chemical weapon, the most useful routes of exposure are passive ones, such as inhalation and percutaneous means. Chemicals using the latter damage or enter the body through the skin, eyes, or mucous membranes. Percutaneous poisons are classified according to whether they act orally (by damaging the digestive system or passing into the bloodstream when swallowed) or intravenously (by passing directly into the bloodstream).[8]

Speed of action refers to the delay between exposure and effect. Rapid-acting agents can cause symptoms to appear almost instantaneously and may cause fatalities in as little as a few minutes. With slow-acting agents, symptoms can take anywhere from hours to days to appear, and it may take weeks or months for fatalities to occur. As a general rule, higher doses increase the speed of action.[9]

Toxicity measures the quantity of a substance required to achieve a desired effect. For instance, 70 milligrams (mg) of the nerve agent Sarin per cubic meter of air will kill 50 percent of a human population breathing this mixture. Just 10 mg of the nerve agent VX on the skin will kill the average adult male. One gallon of VX contains 382,000 such doses. By definition, if the VX is applied evenly at this dosage, 50 percent or 191,000 people will die, and the other 191,000 will become seriously ill. Exposure rates of this kind are impractical on the battlefield, but this does give a good example of how highly toxic some agents can be.[10]

Persistency measures the time an agent remains a hazard in the target area. Nonpersistent agents are relatively volatile and evaporate quickly, usually within a few minutes to an hour. Semipersistent agents usually linger for several hours to a day. Persistent agents, which are usually rather thick and oily, can last for several days to a few weeks. In general, the length of time an agent remains a hazard varies widely according to the environment and meteorological conditions. For instance, chemical agents will dissipate more quickly when exposed to high temperatures, wind, rain, and unstable atmospheric conditions.[11]

State refers to the physical form of an agent. Agents can be solid, liquid, or gas—however, most are liquids. The term *gas* is actually something of a misnomer, stemming from the fact that most chemical agents are disseminated as aerosol or vapor clouds which resemble gas clouds.[12]

Classes of Agents

Chemical agents are commonly classified by the type of effect they have on the human body. The most common classes are choking agents, blood agents, blister agents, G- and V-series nerve agents, nonlethal agents, vomiting agents, and psychochemicals. Table 2 provides an overview of these agents, their persistency, and rate of action.

In general, choking agents, due to their corrosive effect on the respiratory system, result in pulmonary edema, filling the lungs with fluid, and choking the victim. Blood agents are absorbed into the body primarily by breathing and prevent the normal utilization of oxygen by the cells and cause rapid damage to body tissues. Blister agents are primarily used to cause medical casualties. They blister the skin and damage the eyes and lungs. G-series nerve agents act rapidly and, in sufficient doses, cause paralysis of the respiratory musculature and subsequent death. V-series nerve agents are similar to, but more advanced than, G-series agents, and tend to be more toxic and persistent. Nonlethal agents include tear gasses (which are highly irritating, particularly to the eyes and respiratory tract, and cause extreme discomfort), vomiting agents (which in addition to causing vomiting may also

Table 2

Chemical Warfare Agents

Agent Class	*Agent Name*	*Symbol*	*Persistency*	*Rate of Action*	*Toxicity*
Nerve	Tabun	GA	Low	Very Rapid	Lethal
	Sarin	GB	Low	Very Rapid	Lethal
	Soman	GD	Moderate	Very Rapid	Lethal
	GF	GF	Moderate	Very Rapid	Lethal
	VX	VX	Very High	Rapid	Lethal
Blister	Sulfur Mustard	H, HD	Very High	Delayed	Nonlethal
	Nitrogen Mustard	HN-1	High	Delayed	Nonlethal
		HN-2	Moderate	Delayed	Nonlethal
		HN-3	Very High	Delayed	Nonlethal
	Phosgene Oxime	CX	Low	Immediate	Nonlethal
	Lewisite	L	High	Rapid	Nonlethal
	Phenyldichloroarsine	PD	Low-Moderate	Rapid	Nonlethal
	Ethyldichloroarsine	ED	Moderate	Delayed	Nonlethal
	Methyldichloroarsine	MD	Low	Rapid	Nonlethal
Choking	Phosgene	CG	Low	Delayed	Lethal
	Diphosgene	DP	Low	Variable	Lethal
Blood	Hydrogen Cyanide	AC	Low	Rapid	Lethal
	Cyanogen Chloride	CK	Low	Rapid	Lethal
	Arsine	SA	Low	Delayed	Lethal
Riot Control (vomiting)	Diphenylchloroarsine	DA	Low	Rapid	Nonlethal
	Diphenylcyanoarsine	DC	Low	Rapid	Nonlethal
	Adamsite	DM	Low	Rapid	Nonlethal
Riot Control (Tear Gas)	Chloroacetophenone	CN	Low	Immediate	Nonlethal
	Chloropicrin	PS	Low–High	Immediate	Nonlethal
	Bromobenzylidene	CA	Moderate–Very High	Immediate	Nonlethal
	O-Chlorobenzylidene Malononitrile	CS	Low–High	Immediate	Nonlethal
Psycho-chemical	3-Quinuclidinyl Benzilate	BZ	High	Delayed	Nonlethal

Source: *The Chemical and Biological Warfare Threat* (Washington, D.C.: Government Printing Office, April 1995), 8.

irritate the eyes and respiratory system), and psychochemicals (which alter the nervous system, thereby causing visual and aural hallucinations, a sense of unreality, and changes in thought processes and behavior).[13]

There are many ways to disseminate chemical agents. The most common are munitions that are fired or dropped on a target by artillery or aircraft. These munitions normally contain burster charges surrounded by the chemical agent. The burster ruptures the munition and causes the chemical agent to spread as a stream or cloud of small droplets.[14] This system is limited by the size of the munition and the carrying capability of the systems used to deliver it.

However, a more effective way to disseminate these agents is through the use of aerosol generators which allow for a more controlled release. A spray tank can be used to disseminate agents from aircraft, just as crop dusters are used to spread insecticides. Such a system provides the capability to spread the agent in a fine aerosol form over a large, relatively controlled target area. Further, it lends itself to the use of UAVs or manned aircraft as the delivery system because of their capability to loiter over a target and accurately place the agent.[15]

Production

An inherent advantage of chemical weapons is that they are relatively simple to produce. Many are based on technology that is 80 years old or older, putting them well within the reach of virtually any developing nation that wants them. Additionally, the production of chemical agents is much like that of chemicals used for legitimate industrial and agricultural purposes. Both chemical agents and commercial chemicals involve the use of standard chemical processing equipment, including reactor vessels, in which production actually occurs; distillation columns and filters, where compounds are separated or purified; heat exchangers, to control temperature; and various pumps, pipes, valves, and other items that control the movement of chemicals throughout the plant.[16]

Actions are being taken to control export of this equipment when intelligence sources show that it is destined for use in chemical weapons programs by existing export control regimes such as the Australia Group (AG).[17] The synergistic efforts of these regimes with the Chemical Weapons Convention (CWC) and the Biological Weapons Convention (BWC) have combined to make it very difficult (but not impossible) for countries of concern to obtain the necessary items to develop active chemical weapons programs.

Biological Weapons

While chemical weapons programs can be developed with relatively low capital investment and with dual use technology, chemical weapons are difficult to stockpile and large amounts are required to pose a serious threat to well-trained and well-equipped troops.[18] According to Gen Colin L. Powell, "It is for these reasons, among others, that many people believe a more significant threat is that of biological weapons. The one that scares me to death, perhaps even more so than tactical nuclear weapons, and the one we have the least capability against is biological weapons."[19]

BW agents are inherently more toxic than CW nerve agents of comparable weight. Additionally, they are potentially more effective because most of them are naturally occurring pathogens (like bacteria and viruses) which are self-replicating and have specific physiologically targeted effects. This is in contrast to chemical agents, which tend to disrupt physiological pathways in a more general way.[20]

In 1995 as many as 100 nations were estimated to have the technological capability to develop biological weapons programs.[21] This, combined with the fact that biological weapons are attractive for terrorist use, make them a major security concern today.

History

Some of the earliest recorded uses of biological warfare occurred in the fourteenth century. During the siege of the Crimean seaport of Caffa, the Mongols placed plague-infected cadavers on catapults and flung them into the walled city. The cadavers proved more effective than any other projectiles. The plague spread throughout the city and the Genoese inhabitants fled. Several medical historians even believe that the "Black Death" that subsequently spread across Europe, killing nearly one-third of the European population, actually began on the catapults at the siege of Caffa.[22]

The first modern use of biological agents probably occurred in World War I. The Germans were accused of using cholera in Italy and the plague in Saint Petersburg in 1915. While there was no widespread use of these agents in World War II, every major combatant had a BW program. In fact, by the end of the war, the United States had developed large scale research, development, production, and weaponization facilities. These weapons included both antipersonnel and anticrop diseases.[23]

The United States continued BW research and development efforts until 1969, when President Richard M. Nixon announced a unilateral ban on the use of lethal biological agents and weapons. All further biological research was limited to defensive measures such as immunization, detection, and safety. In 1975 President Gerald R. Ford signed the Biological Weapons Convention prohibiting the development, production, and stockpiling of bacteriological and toxin weapons. However, BW programs continued or were subsequently developed by countries such as North Korea, Libya, Syria, Iran, and Iraq.[24]

Agents

There are approximately 160 known disease-causing species that affect human beings. Of these, more than 60 are discussed in unclassified literature as potential BW agents.[25] Agents that have been widely recognized as having military utility are determined to be suitable based on four characteristics. First is *infectivity or virulence*—a small dose should produce a predictable response such as death or incapacitation. Second is *producibility*—how easily they can be produced and stored. Third is *stability*—the resistance an agent has to the effects of ultraviolet light, heat, cold, and other environmental factors. Fourth is *ability to disseminate*—how easy an agent is to package in a form that can be used effectively in a weapon.[26]

Agents can be divided into two main categories: pathogens and toxins. Pathogens are defined as organisms that cause disease in man and may be grown and exploited for military purposes. They include bacteria, viruses, and rickettsia. They may enter the body in a number of ways, including through the skin, ingestion, inhalation, or intravenous, or intramuscular injection. Toxins are poisonous compounds produced by living organisms. They are usually proteins that act upon specific receptors in the body and can either be lethal or highly incapacitating. Toxins are produced by a variety of organisms, including microbes, snakes, insects, spiders, sea creatures, and plants.[27]

The lethality of many of these agents is extraordinary, even when compared to chemical agents. For instance, 10 grams of anthrax spores could kill as many people as a ton of the nerve agent Sarin. With ideal conditions (a clear, calm night) a single aircraft (or UAV) using an aerosol generator to dispense a 100 kg anthrax payload (99 percent of this weight being the suspension material that allows the anthrax to be dispensed in this manner) could adequately cover a 300 km^2 area (about the size of Washington, D.C.) and inflict between 1,000,000 and 3,000,000 deaths (assuming a population of 3,000 to 10,000 people per km^2).[28] According to a 1970 report by the World Health Organization, "Inhalation of one microscopic (anthrax) spore will result in death within 48 hours. Distributed appropriately, one gram would be enough to kill more than one-third of the population of the United States."[29]

Aerosol delivery is the most effective method of disseminating biological agents. To achieve the greatest effectiveness, agents must be delivered in small aerosol particles to ensure the particles will reach the lungs. As with chemicals, aerosol devices like commercial crop sprayers are an exceptionally effective means of delivery. BW can also be delivered using conventional munitions, similar to those used for chemical weapons as discussed above.[30]

Production

Obtaining small quantities of biological agents is relatively easy. Anthrax spores exist wherever there are large numbers of sheep. Ricin can be extracted from castor beans, and Botulinum Type A, the most lethal toxin known, can be produced from bacterial strains that are readily isolated in nature.[31] Additionally, other agents, particularly some toxins, are widely used in medical research on neuromuscular diseases. Almost any agent can be legally acquired from organizations such as the American Type Culture Collection (ATCC) of Rockville, Maryland. This is an example of a legitimate business that routinely sells agents to the worldwide medical community.[32]

BW agents can be produced in either liquid or dry powdered form. Liquid agents are the cheapest and safest to produce but require special handling during transport and storage to minimize biological decay (however, this does not apply to toxins). Dried powder agents offer increased stability and improved dissemination efficiency but create greater safety hazards during production.[33]

No special facilities are required for the production of BW agents, since their production involves dual-use equipment and technologies such as those associated with legitimate endeavors. For instance, pharmaceutical plants and "baby milk" factories have some of the same equipment. From afar, these plants are indistinguishable from BW production plants. This makes them very difficult to locate and take effective interdiction efforts against.

Furthermore, developing defenses against BW requires agents upon which to experiment, so even if a country maintains a purely defensive BW program, it will, by definition, have the tools to create an offensive BW program. Also, there is no equipment unique to BW agent production, although the Australia Group has defined parameters of equipment that would be of particular utility for BW production purposes.[34]

Finally, advances in biotechnology have eliminated the need for a stockpile of BW agents. Proliferating nations need only a starter culture of agent, they can then wait until they need to use a biological weapon to produce the quantities required. This is in contrast to chemical weapons programs that require a continuing supply of sizable quantities of precursor chemicals and raw materials. Table 3 gives examples of some common BW agents and their associated lethality.

Table 3

Examples of Biological Warfare Agents

Disease	*Causative Agent*	*Incubation*	*Fatalities (%)*
Anthrax	Bacillus Anthracis	1–5 days	80
Plague	Yersinia Pestis	1–3 days	90
Tularemia	Francisella Tularensis	1–10 days	5–20
Cholera	Vibrio Cholerae	2–5 days	25–50
Venezuelan Equine Encephalitis	VEE Virus	2–5 days	<1
Q Fever	Coxiella Burnetti	12–21 days	<1
Botulism	Clostridium Botulinum Toxin	3 days	30
Staphylococcal Enterotoxemia (food poisoning)	Staphylococcus Enterotoxin Type B	1–6 days	<1
Multiple Organ Toxicity	Trichothecene Mycotoxin	Dose Dependent	

Source: *The Chemical and Biological Warfare Threat* (Washington, D.C.: Government Printing Office, April 1995), 28.

Nuclear Weapons

The weapon that most commonly comes to mind when weapons of mass destruction are mentioned is nuclear weapons. The specter of their use (or nonuse) arguably contained the world's superpowers from engaging in direct conflicts during the cold war. To many people this means that the possession of nuclear weapons brings security for their owners and their allies. It can also be argued that they provide a means for a country to establish itself on the world geopolitical scene as a major player.

History

The first nuclear weapon used in war, code-named "Little Boy," was dropped on the Japanese city of Hiroshima on 6 August 1945. This weapon contained uranium 235 and was detonated using the gun-assembly technique. The bomb was 10 feet long, weighed 8,900 pounds, and created a blast of about 10 to 15 kilotons. Detonating at an altitude of 1,900 feet, it caused a firestorm in the center of the city that burned for days and killed approximately 69,000 of Hiroshima's 350,000 inhabitants. Twenty-two thousand more died soon after from the effects of the blast and another 30,000 died in the weeks and months that followed due to the effects of radiation.[35]

Three days later, the city of Nagasaki was the target for "Fat Man." This weapon used plutonium and the implosion technique to cause its devastating effects. Both it and Little Boy were fission weapons, producing energy by splitting the nuclei of unstable heavy atoms, such as uranium or plutonium. Part of the reaction is converted into energy, and if this happens quickly enough, a nuclear explosion is the result. Fat Man was detonated at 1,650 feet and had a yield of approximately 22 kilotons; some 70,000 people died from its effects.[36]

Research and development continued and physicists began experimenting with the concept of fusion, the combination of light atoms such as radioactive hydrogen isotopes. The results of these experiments was the hydrogen bomb, using a fission device as the trigger, with power hundreds of times greater than the fission type dropped on Hiroshima.[37]

Nuclear Weapons

The nuclear weapons constructed so far have used the isotopes uranium 235 or plutonium 239 as the fissile material. To trigger a fission reaction, it is necessary to put together a mass of these materials large enough to ensure that the high-energy neutron particles inside do not escape from the surface of the mass, but strike other heavy atoms within the material, causing them to release more neutrons and setting up a chain reaction. The smallest amount of material which will do this is called the critical mass. This amount depends on the purity and density of the material used and the physical characteristics of the bomb. Additionally, if it is surrounded by a reflective metal, like natural uranium, more neutrons are bounced back into the material, reducing the critical mass and thus the amount of material required to obtain the same explosive yield.[38]

The immediate effects of a nuclear explosion are blast, heat, and radiation. The extent to which each one comes into play depends on the size and type of weapon and the way it is employed (ground burst, air burst, water burst, etc.). In a standard case, roughly half the energy would be released as blast, a third as heat, and the remainder as radiation, both immediately at the initial detonation and over the long term in the form of fallout.[39]

For example, a 100 kiloton weapon detonated in the air (at an altitude of less than 5,000 feet) would produce the following effects: at one to eight seconds after detonation, a fireball will appear with a temperature of about 1,000 degrees Celsius. This will sear the flesh of people in the open and dry roast or asphyxiate those in deep shelters within the blast area. Additionally, it is estimated that it will cause retinal burns to those who glance at the flash within a distance of about 10 miles from ground zero. This will be followed by the blast which, by 37 seconds after detonation, carries half the weapon's total energy. Finally, as the explosion takes on the familiar "mushroom" shape, winds suck back into the cloud, adding to the destructive effects.[40]

The last effects come in the form of radiation. Various weapons and conditions produce different combinations of radiation (neutrons, x rays, gamma rays, alpha and beta particles). The amount of absorbed radiation is measured in rads. While there is some controversy as to the "safe" amount of radiation a human body can be exposed to (and we are routinely exposed to very small amounts through natural exposure and for medical reasons), there really is no safe level of radiation exposure, and no threshold dose is so low that the risk of illness is zero.[41] In the above example, the explosion would produce the highest doses of radiation (thousands of rads) within one kilometer of ground zero. At two kilometers, the amount decreases significantly (hundreds of rads) and will continue to decrease with the distance from ground zero. However, lethal levels will extend well out from ground zero based on the prevailing winds and atmospheric conditions. The long-term effects will be felt for quite some time. Breathing even minute radioactive fallout will cause additional adverse physical effects. For instance, for cancer alone, the International Commission for Radiological Protection gives the following figures—leukemia, 20; lung, 20; bone, 5; thyroid, 5; breast, 25; and others, 50—for fatal cancers per 10,000 people induced by a dose of 100 rads.[42]

Production

The process of making nuclear weapons is highly complex and difficult. Despite the assertion that the information required to build a device is available in the public domain, considerable physics, engineering, and explosives expertise is required actually to produce a nuclear weapon. Additionally, proper high technology facilities and instrumentation must be used to achieve the required precision that such an effort demands.[43]

The fabrication of nuclear devices is made difficult by a number of other factors as well. For example, obtaining the necessary radiological material to produce a device capable of producing a nuclear explosion is a vital and relatively difficult task. This material is commonly referred to as weapon grade special nuclear material, and although weapons can be produced with lower grade material, it usually means uranium enriched to over 90 percent of the isotope uranium 235 or plutonium with greater than 90 percent plutonium 239.[44]

Great amounts of technical skill and specialized equipment must be used in order to construct an efficient weapon. However, if maximum yield is not a key factor (as it may not be for a first time nuclear nation), lower yield, dirty weapons (weapons that are not as efficient and spread more fissionable material rather than use it optimally in the nuclear explosion) are a possible option and require less technical expertise. The gun barrel design is one such approach.

One final option for someone aspiring to obtain nuclear weapons capability would be to purchase or steal the whole weapon. This, obviously, is the most expedient way to obtain them. However, even with the increased risk that they may be available from the former Soviet Union, the worldwide proliferation community works exceptionally hard to ensure that this type of action does not occur.

Given these facts, what would be the size of a basic weapon? Unclassified sources show that simple gun barrel designs are effective for low yield weapons. This design entails one piece of uranium shaped into a cylinder to fit into a short cannon and fired through rings surrounded by tungsten and steel. On firing at extremely high muzzle velocity, the uranium passes through the rings making the mass instantaneously greater than the critical mass and setting off a chain reaction. This system is similar to ones used in tactical nuclear artillery warheads, and while it produces a low yield (unclassified yield is between 10 and 15 kilotons), it is fairly small (roughly two feet long) and weighs less than 250 kilograms.[45]

As suggested above, reports that any graduate student in physics could construct a bomb are simply not true. However, any nation with the scientific knowledge to run a nuclear reactor for electrical power generation could be expected to have the necessary skills to build a bomb. Furthermore, enriched uranium and reprocessed plutonium are both by-products of normal civilian nuclear programs. This means that countries without the necessary technical expertise, but with the money and the will, could possibly obtain the necessary materials surreptitiously.[46] Additionally, reported leakage of significant amounts of weapon-grade material from the former Soviet Union could provide a great advantage to potential nuclear "wanna-bes."[47] Sandra Meadows in a study by the Office of Technology Assessment (OTA) states that "the possibility of black-market sales of weapon-usable material may represent one of the greatest proliferation dangers now being faced."[48] Combine this with the "brain drain" (the selling of nuclear knowledge by skilled physicists from around the world), this creates a situation in which a country without the indigenous capability to build nuclear weapons might be able to obtain the necessary materials and expertise to construct them.

Conclusion

Weapons of mass destruction present a unique problem for worldwide security. Regardless of the form they take, chemical, biological, or nuclear, they have the capability to wreak havoc when employed by those who have the will to use them. As the preceding information shows, relatively small amounts of any of them can be extremely destructive. Even one or two kilograms of biological agents can be highly lethal. Chemical agents, even though they require a greater amount, are also extremely lethal. Nuclear weapons technology development has made very small warheads possible. Even though they are difficult to manufacture or obtain, they still present a significant proliferation threat. Given this fact, and the capabilities of UAVs presented in chapter 2, it appears that the two could be married to form a complete weapon. The next chapter examines this possibility.

Notes

1. *The Weapons Proliferation Threat* (Washington, D.C.: Nonproliferation Center, March 1995), 1.
2. Ibid., 1.
3. Randall J. Larsen and Robert P. Kadlec, *Bio War: A Threat to America's Current Deployable Forces* (Arlington, Va.: Aerospace Education Foundation and the Air Force National Defense Fellows, April 1995), 3.
4. *The Weapons Proliferation Threat*, 2.
5. *The Chemical and Biological Warfare Threat* (Washington, D.C.: Government Printing Office, April 1995), 1.
6. Ibid.
7. Ibid.
8. Ibid.
9. Ibid.
10. Ibid., 2.
11. Ibid.
12. Ibid.
13. Steve Fetter, "Ballistic Missiles and Weapons of Mass Destruction. What Is the Threat? What Should Be Done?" *International Security*, Summer 1991, 16.
14. Ibid., 17–18.
15. Ibid., 19.
16. *The Chemical and Biological Warfare Threat*, 5.
17. Ibid., 6–7. "The Australia Group is an informal organization of participating nations who are committed to ensuring that exports of materials and equipment do not contribute to the spread of chemical or biological weapons. The group meets biannually to discuss export controls, share chemical and biological weapons (CBW) proliferation information and to expand membership by encouraging all countries to adopt CBW proliferation controls. As with any nonproliferation regime, the Australia Group have impeded, but completely stopped CBW proliferation. However, through continuing the efforts listed above, it will remain a force in stopping the illegal transfer of CBW related material and equipment."
18. Larsen and Kadlec, 2.
19. *Biological Weapons Proliferation* (Washington, D.C.: Defense Nuclear Agency and the US Army Medical Research Institute of Infectious Diseases, April 1994), 1.
20. *The Chemical and Biological Warfare Threat,* 25.

21. Ibid., vi.
22. Larsen and Kadlec, 4.
23. Ibid., 5–8.
24. *The Weapons Proliferation Threat,* 8–14.
25. *Biological Weapons Proliferation*, 11.
26. Larsen and Kadlec, 11–12.
27. *The Chemical and Biological Warfare Threat*, 26.
28. Larsen and Kadlec, 12.
29. *Health Aspects of Chemical and Biological Weapons* (Washington, D.C.: World Health Organization, 1970), 1.
30. Larsen and Kadlec, 12.
31. *Biological Weapons Proliferation,* 15.
32. Larsen and Kadlec, 14.
33. Ibid.
34. *The Chemical and Biological Warfare Threat*, 26–30.
35. James C. Warf, *All Things Nuclear* (Los Angeles: Southern California Association of Scientists, 1989), 19–20.
36. Ibid., 20.
37. Christopher Campbell, *Nuclear Weapons Fact Book* (Novato, Calif.: Presidio Press, 1984), 10.
38. Ibid.
39. Ibid.
40. Ibid., 12–18.
41. Warf, 54.
42. Campbell, 15.
43. Albert E. Snell and Edward J. Keusenkothen, "Mass Destruction Weapons Enter Arsenal of Terrorists," *National Defense*, January 1995, 21.
44. Ibid.
45. Warf, 109.
46. Steve Weissman and Herbert Krosney, *The Islamic Bomb* (New York: Time Books, 1981), 24–25.
47. Sandra I. Meadows, "Religious, Ethnic, Nationalistic Revelries Force Redefinition of US Defense Policy," *National Defense*, January 1995, 19.
48. Ibid.

Chapter 4

A Proliferation Scenario

Chapters 2 and 3 outline various characteristics and capabilities of UAVs and WMD. From this information, one can readily draw the conclusion that UAVs are capable of providing a very good platform with which to deliver WMD. The following scenario provides an illustration of how this could occur.

Assume a nation (or terrorist group) decides, for whatever reason, that it needs a system to deliver some type of WMD. It is not particularly wealthy, nor does it possess a high degree of technical expertise. It also does not have established international partners from which it can reliably obtain financial or technical expertise.

The leaders of this nation or group believe that to be successful in this endeavor, they need to obtain a complete delivery system surreptitiously before announcing to the world their intentions. Consequently, they want to obtain the necessary equipment under the guise of peaceful applications. They see a convenient way to accomplish this goal by using UAVs to deliver WMD. However, they must make some preliminary decisions before they can proceed with acquiring the equipment and technology. First, they must decide what type of WMD they are interested in delivering. This will determine the type of UAV that will be required to deliver it.

As described in chapter 3, nuclear weapons would be the hardest to obtain and would require the greatest capability in a UAV delivery platform. For instance, the range and payload capability required to deliver a very low yield device would exceed the capabilities of all but the most expensive and technically advanced UAVs. Trying to obtain either one of these systems or the nuclear weapon would certainly cause protests from the international nonproliferation community. While it might be possible to obtain all the required equipment and materials clandestinely, doing so would be extremely difficult and expensive. Consequently, for the purposes of this example, nuclear weapons would probably not be a viable alternative.

Chemical and biological weapons, on the other hand, would be much easier and cheaper to obtain and could be indigenously produced under the guise of peaceful research. They also require a far less capable UAV delivery system. Chapter 3 outlines the characteristics of these weapons and demonstrates that small quantities, delivered by aerosol generation equipment, would be extremely effective. For this scenario, assume that chemical and/or biological weapons are the WMD of choice.

Once the weapon has been selected, the nation or group can determine and acquire the proper type of UAV to employ as a delivery system. It could accomplish this in two ways. First it could approach legitimate UAV manufacturers using the rationale that it needs a UAV for a peaceful purpose, for example, as an efficient method of crop dusting to increase agricultural production. Second, it could approach UAV and aircraft home building manufacturers to obtain the parts to build its own UAV. Either way, it could tailor the system to fit its needs and resources.

In this hypothetical example, assume that the nation or group has access to anthrax spores and also has the capability to produce the chemical agent Sarin. It determines that in order to achieve its objectives, it needs to deliver at least a 50 kg payload (including liquefied biological or chemical agent and the spray equipment) sprayed on a target at least 150 km away. This system would be adequate to disseminate the agent over a battlefield, a water supply, or a small city.

An example of a complete UAV system that meets these requirements would be the Pioneer UAV. This system has a payload of 50 kg and a nominal range of 185 km, with a loiter time of nine hours. It has the necessary payload capability to carry the agent and the spraying system. It has the basic range (which could be more than doubled on a one-way mission because the return trip and extended loiter time over the target would not be required), and costs about $500,000 per vehicle (not including the payload). The other option, as outlined in chapter 2, is a home-built UAV, possessing roughly the same characteristics, which could be assembled from parts purchased from various UAV and aircraft kit manufacturers. This UAV would include a basic autonomous navigation and control system consisting of an autopilot and GPS receiver. This type of navigation system would make the UAV very accurate (less than 100 meters). Both of these options would provide a UAV with the necessary capability and require relatively little technical support and skill. Additionally, the vehicle is portable and does not require a sophisticated launch platform. The other required equipment is the sprayer. However, this is probably the easiest part to obtain because it is the same type of equipment used in commercial crop dusting and is widely available from sources around the world.

Naturally, the more money and technical expertise a nation or group possesses, the more capable the delivery system it could obtain and thus, the greater its WMD options. The example above is at the lowest end of the technical/monetary scale. This makes its capabilities more limited, but it is probably the easiest type of program to develop and conceal.

A very important note here is that all this must be done secretly. As chapter 5 will show, international arms and export control regimes are constantly on the lookout for those wishing to develop these types of systems. Once a determination is made that UAVs were destined for a WMD delivery role, the international nonproliferation community would make every effort to stop the program.

However, it would be fairly easy to conceal such a program because both UAVs and WMD (excluding nuclear weapons) have many dual (civil and military) uses.

Chapter 5

Analysis

Curbing the proliferation of Weapons of mass destruction and their delivery vehicles is a challenging task. Many potential proliferators are convinced they need to develop WMD and their associated delivery systems to protect their national security. It is estimated that some nations will begin exploiting the full range of UAVs, including delivering WMD in the next decade.

—*Report to Congress on the Proliferation of Missiles and WMD*
March 1995

Chapters 2 and 3 outline the characteristics and capabilities of UAVs and WMD and chapter 4 presents a scenario that demonstrated how UAVs and WMD could be combined into an effective weapon system. Weapons of mass destruction have the capability to provide an enormous lethal punch in small quantities. While most industrialized nations with the technological and economic means to do so would probably choose more advanced delivery systems, some third world, developing nations and nonstate actors (like terrorist groups) may find this combination highly appealing.

This chapter examines what is and what could be done to stop the spread of WMD and UAV technology and the nonproliferation regimes and treaties that are currently in force and concludes with the author's assessment of the situation and some recommendations.

The Nuclear Nonproliferation Treaty

Increasingly, nuclear proliferation is acknowledged to be one of the greatest threats to global and regional peace and security. The full scope safeguards of the NPT and the International Atomic Energy Agency (IAEA) provide a first line of defense against this threat.[1]

The goals of the NPT are to prevent the further spread of nuclear weapons, to foster peaceful nuclear cooperation under safeguards, and to encourage negotiations to end the nuclear arms race with a view to general and complete disarmament. The NPT claims success in these goals. NPT adherence can eliminate the potential for a dangerous and costly nuclear arms race among nonnuclear weapon states while ensuring that the benefits of the peaceful applications of nuclear technology are made available to all members. The

NPT stipulates that nuclear weapon states agree not to transfer nuclear weapons to or assist nonnuclear states in acquiring nuclear weapons. Further, nonnuclear states undertake not to receive, manufacture, or otherwise acquire nuclear weapons.[2]

The NPT is not without its shortcomings and limitations. It has been criticized for highlighting the differences between the nuclear "haves" and the "have nots," which critics claim undermines adherence to the treaty. Further, as with any multilateral arms control agreement, it has problems dealing with those states that will not participate.[3] Finally, the IAEA's inspection and enforcement powers under the treaty are limited. A recent example of this was North Korea's refusal to allow IAEA inspection of its nuclear facilities. This resulted in a major diplomatic effort by the United States to convince the North Koreans to comply with IAEA inspectors. It remains to be seen how effective these efforts will be.[4]

The Chemical Weapons Convention

The CWC prohibits all development, production, acquisition, stockpiling, transfer, and use of chemical weapons. It requires destruction of all existing chemical weapons within 10 years after the treaty enters into force. The treaty will enter into force 180 days after 65 signatories deposit their instruments of ratification. As of 1995, 159 countries had signed the CWC and 19 countries had ratified it.[5] Three-quarters of the countries of chemical weapons concern have signed the convention; however, significant nonsignatories include Egypt, Iraq, Jordan, Libya, North Korea, and Syria.[6]

The CWC is a disarmament treaty, but because CW facilities are similar to many commercial chemical plants, and because many member-nations have developed commercial chemical industries, CWC implementation will be a massive and ambitious undertaking. Verification and other aspects of implementation of the CWC will be overseen by a new international agency, the Organization for the Prohibition of Chemical Weapons (OPCW). It will have a staff trained and equipped to inspect military and industrial facilities throughout the world, much like the IAEA does under the auspices of the NPT. Additionally, in order to begin verification as soon as the treaty comes into force, signatories have established a Preparatory Commission (PrepCom) to develop detailed implementing procedures, procure inspection equipment, hire and train inspectors, and lay administrative groundwork for the OPCW.[7]

Biological Weapons Convention

"The 135 parties to the Biological Weapons Convention of 1972 undertake not to develop, produce, stockpile, or acquire microbial or other biological agents or toxins, whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective, or other peaceful purposes."[8]

As with the CWC, this is also an ambitious undertaking. Over the two decades since entry into force of the BWC, confidence in the effectiveness of the convention has been undermined by instances of noncompliance. Developed countries are using the most advanced biotechnology for industrial civilian applications, and a number of developing nations also have extensive programs and expertise in this field. As explained in chapter 3, much of the same biotechnology equipment employed by pharmaceutical programs or hospital laboratories can be used to support a biological warfare program.[9] Another important point to remember is that even countries that are pursuing purely defensive BW programs have all the basic ingredients for an offensive program as well.

In order to help deter violation of, and enhance compliance with the BWC, while protecting legitimate biotechnology research interests, the United States and other signatories are developing a legally binding instrument to provide increased transparency of activities and facilities that could have biological weapons applications. A review of this instrument was conducted at the BWC Review Conference in late 1996.[10]

Australia Group

A complement to both the CWC and the BWC is the Australia Group. This is an informal organization of 28 participating nations,[11] chaired by Australia, which are committed to ensuring that exports of materials and equipment from their countries do not contribute to the spread of chemical or biological weapons (CBW). The group meets biannually to discuss export controls, to share chemical and biological weapons proliferation information, and to expand membership by encouraging all countries to adopt CBW proliferation controls. In 1994 the Australia Group took steps to strengthen existing harmonized controls on chemical weapon precursor chemicals by adopting a common approach for exports of mixtures that contain controlled precursors as normal ingredients in their formulas.[12]

As with any nonproliferation regime, the Australia Group has impeded but not completely stopped CBW proliferation. However, in combination with the CWC and BWC, it will remain a force in stopping the illegal transfer of CBW related material and equipment.

Missile Technology Control Regime

The principal multilateral instrument to combat missile proliferation is the MTCR. The MTCR is an agreement among partner nations[13] to control a common list of items (called the MTCR Annex) according to a set of common export guidelines (the MTCR Guidelines), which each partner implements in accordance with its national legislation. Unlike the other nonproliferation regimes, the MTCR focuses on delivery vehicles, not WMD themselves. These include unmanned ballistic missiles, cruise missiles, and far less visibly, UAVs/RPVs and drones. The guidelines state that MTCR countries will restrict transfers of delivery systems (other than manned aircraft) capable of delivering a payload of 500 kg or more to a distance of at least 300 km, as well as their components and related technology, along with all missiles intended for delivering WMD, regardless of their capabilities.[14]

Complete systems, their subsystems, and specially designed production equipment and technology that meet the "300/500" criteria are considered Category I systems, and in determining their exportability, they are treated with a "strong presumption of denial." In this case, a strong presumption of denial means that a partner must, in its review of an export request, will presume to deny it. To overcome this presumption and ultimately grant the export license, the partner must evaluate the consequences of its actions in terms of the system being exported, to whom it is exported, and how it will be used. For example, the United States sold Trident missiles to the United Kingdom under the foreign military sales program. The strong presumption was overcome in this case due, in part, to the fact that the United Kingdom is an MTCR partner that agreed not to retransfer or sell the missiles and was using them for national defense. Additionally, the guidelines state that there is a strong presumption of denial to deny an export if an MTCR member judges that a missile, whether or not listed in the annex, is intended to deliver WMD.[15] Finally, they state that "until further notice, the transfer of Category I production facilities will not be authorized."[16]

As technology has evolved and the performance of unmanned delivery systems has increased, MTCR controls have also been strengthened. A good example of this is the addition of Item 19 under Category II of the annex. This item captures systems that have a range of 300 kilometers, regardless of their payload. While Category II items are not reviewed with a strong presumption of denial, they are reviewed carefully to determine if they should be exported in accordance with the guidelines.[17]

One final aspect that bears mention is the fact that the MTCR considers range and payload trade-off in determining the status of a particular export. For instance, a particular vehicle may have a range of 1,000 kilometers and a payload of 400 kilograms. If, aerodynamically, it is possible to increase its range by decreasing its payload or increase its payload and decrease its range, this vehicle would then fit into Category I and would be subject to a strong presumption of denial. This type of consideration also applies to UAVs used in a strike role. The range could be extended by using the loiter time and return trip for the one-way mission. This is a very important point when it comes to evaluating the exportability of UAVs because of their inherent range/payload capabilities.

The MTCR has grown to 28 member countries and has amassed a number of successes. For example, the MTCR was instrumental in convincing the

Argentinean government to stop the development and production of its Category I Condor missile program. Additionally, it was a major force in negotiations with the South African government that convinced them to stop the development of their long-range ballistic missile system.

The MTCR's power to enforce the tenets of the agreement is limited (they're even more limited than, say, the NPT). There are no inspection procedures or punitive mechanisms to punish violators. The strength of the regime comes from its ability to foster common export controls among the partners and also to bring severe international pressure on a country violating the rules set forth in the guidelines. A good example of this was a recent case in which intelligence sources showed that China had transferred some M-11 missile parts and equipment to Pakistan. Immediately, the MTCR partners demarched the Chinese government and requested that they cease these activities. Additionally, the United States placed export sanctions on the Chinese. The combination of these efforts proved successful and the transfers stopped.[18]

The key factor in the discussion thus far is that the world community is concerned with the proliferation of WMD and the systems that deliver them. This concern is exemplified by the formation of the various regimes and treaties developed to curb their proliferation. Where they are not completely successful on their own, the synergistic effects of all of them contribute significantly to stemming the flow of these dangerous items. However, export and arms control organizations (along with their enforcement mechanisms and the political pressure they can apply) can only do so much.

Steve Fetter outlines two other policy categories that can help. These categories are carrots and defense.[19] Carrots can come in a number of forms. For instance, security guarantees could be offered to a country that feels threatened. Promising to defend a country if it is attacked may alleviate its desire for WMD. The best option for offering security guarantees appears to lie in collective security agreements. However, this approach does have its limitations, and many nations may feel external guarantees are not sufficiently reliable to forestall the need to acquire WMD and their delivery systems.

Carrots can also come in the form of economic incentives and foreign aid. A good example of this is the agreement made with North Korea in 1995. This agreement included economic incentives to persuade North Korea to allow the IAEA to inspect its nuclear facilities.

Fetter's second category is defense. Even if the controls and carrots listed previously were completely effective, it would still be prudent to invest in some level of defense against WMD and its delivery systems. Identifying specific air defense systems that could protect the United States and its allies from attack by a UAV/WMD weapon system is beyond the scope of this study. However, what is important is that the threat that they pose is real and the value of developing systems to defend against them should not be overlooked.

One final aspect of this question that needs to be addressed is the threat of nonstate actors obtaining UAVs and using them for WMD delivery. Because

UAVs are relatively inexpensive, they are available to international and domestic terrorist groups and other nonstate actors to use in this manner. Events such as the 1995 Sarin attack in the Tokyo subway system indicate that such groups are capable of developing and using WMD. Furthermore, events like Mathias Rust's Cessna flight into Moscow's Red Square show that complete control of airspace, even by a superpower, is virtually impossible.

MTCR controls of unmanned aerial vehicles with short ranges and light payloads are limited to those systems that are known to be destined for use as WMD delivery vehicles. There are no controls on the export of other short-range UAVs. This is especially relevant to terrorist groups who may launch an attack from within a target country. It is also a concern for countries that have cities or other potential targets close to their borders as most countries do.

Export control organizations like the MTCR are concerned only with exports of controlled equipment and technology. They rely on assurances from the buyer and the buyer's country to protect this equipment and technology and use it for its stated end use. To address the potential threats posed by domestic terrorists, individual countries may need to consider internal controls (similar to domestic gun control laws) to prevent such groups from obtaining and using UAVs for terrorist purposes.

Assessment

Given the global concern about WMD proliferation, it is worth returning to the initial question proposed at the beginning of this study, Are UAVs capable of carrying WMD and if so, should this be a concern to nations concerned with nonproliferation? The research presented thus far indicates the answer is yes.

Chapter 2 demonstrates that UAVs are quite capable of carrying WMD. They have sufficient range/payload capability and are relatively inexpensive. Because they are designed to penetrate and loiter over a target and are more accurate than ever before, they are uniquely adaptable to delivering chemical and biological weapons. Additionally, because they are normally designed to be recoverable, they carry enough fuel for the penetration, loiter, and return phases of a mission. On a one-way strike mission, their published ranges could be dramatically extended because they do not need to make the return flight. This could also allow an increase in payload, though probably not a large one. Adding extra payload to a UAV would affect such flight dynamics as the center of gravity of the aircraft, thus preventing an easy range/payload trade-off calculation.

As outlined earlier, chemical and biological weapons are particularly well suited to delivery by UAVs. As little as one or two kilograms of biological agent dispensed with a commercial crop sprayer can cause devastating results. It would take substantially more chemical agents to have the same effects. However, in quantities of 50 to 150 kilograms (well within the carrying capability of many low cost UAVs), chemical agents can be very deadly. The research also shows that both chemical and biological weapons are relatively easy to obtain and do not require great technical knowledge to produce, store, or use.

Nuclear weapons, on the other hand, present greater challenges for employment on UAVs. Acquiring a complete nuclear weapon or the material and technology to fabricate one is extremely difficult and expensive. Additionally, the size and weight requirements for even a small weapon (about 200 kilograms) is right on the edge of the payload capability of all but the most capable and expensive UAVs. While delivering nuclear payloads is a possibility, it is reasonable to conclude that UAVs are much more likely to be used to deliver CW or BW.

Recommendations

The evidence indicates that a marriage of WMD and UAVs is a possibility, that this would provide a low cost alternative to more sophisticated WMD delivery systems. It also appears that this would be an attractive option for an actor who wanted to employ WMD in its arsenal, but might lack the technological capability to do it in another way. If this is a concern, as it appears to be, what can be done about it?

The answer lies partly in an increase in the awareness of the facts that have been outlined earlier; emerging technology is making such systems more capable, more easily obtainable, and less expensive. The place to start is with the nonproliferation regimes. From a WMD standpoint, the CWC, BWC, NPT and so forth, are working to stem the availability, production, and use of these weapons. World sentiment generally appears to abhor the use of WMD, and considerable effort, money, and time have been invested in stopping their use. The key point here is that none of the WMD organizations listed earlier acting alone is nearly as successful as the synergistic effect they have acting together.

With respect to UAVs, the MTCR is the organization that is already in place and functioning with a mandate to attack the problem. The evolution of the MTCR's Guidelines and Annex have taken into account the technological advances of unmanned systems and, through the use of export controls, the regime has had some success in combating the spread of UAVs and their associated technology. However, the MTCR does not represent a complete solution to the problem of UAV proliferation.

Now is the time to "raise the red flag" of the potential of UAV and WMD use. The United States carries considerable weight and acts as a leader in all of the regimes. Additionally, there are new organizations on the horizon that could be used effectively to fight this potential threat. For instance, the successor to the Coordinating Committee on Export Controls which was an arrangement among Western nations and was designed to deny military technology to Communist nations) is the Wassenaar Arrangement.[20]

In December 1995, 28 nations agreed to establish a new international regime to increase transparency and responsibility for the global market in conventional arms and dual-use goods and technology. This new regime is called the Wassenaar Arrangement (after the town outside The Hague where the first rounds of discussions took place). It is now just an international framework that still needs elaboration and refinement, but it would be the perfect forum for discussion of the UAV/WMD question. Additionally, its goals are tailored to respond to the new security threats of the post-cold-war world and will close a critical gap in the international control mechanisms, which have concentrated on preventing the proliferation of weapons of mass destruction and their delivery systems. While the Wassenaar Arrangement will not duplicate the other nonproliferation mechanisms, it will through a variety of means complement and, where necessary reinforce them. It is envisioned as the first global mechanism for controlling transfers of conventional armaments and a venue in which governments can consider collectively the implications of arms transfers on their international and regional security interests. In view of the close association between advanced technologies, including production technologies and modern battlefield weapons, sensitive dual-use commodities will receive the same measure of scrutiny as do arms themselves.

In a nutshell, it is envisioned that the Wassenaar Arrangement will provide an initial international framework to respond to the critical security threats of the post-cold-war world and to promote the overall nonproliferation and conventional arms transfer policies of the international nonproliferation community.[21] Given that it is in its formative months, it could provide the place to seal the leaks associated with the existing regimes and treaties associated with UAVs and WMD.

A key aspect of this (or any other nonproliferation) strategy is to increase the amount of intelligence that is available to tell if a potential buyer plans to use UAVs for WMD delivery. This is easier said than done. As technology has increased rapidly in the areas of UAVs and WMD, it has also made it harder to detect their application as complete weapon systems. Because UAVs are adaptable, moreover, the intent to use them for WMD delivery may not even exist when the export takes place. The need for reliable intelligence has proved to be the linchpin in nonproliferation and military operations alike. As recently as the Gulf War, where the best and most advanced intelligence gathering technology available was used, there were still considerable problems. Intelligence information, interpretation, timeliness, and distribution, despite the availability of imaging system and technology, was at the top of list of disappointments of the war. Gen H. Norman Schwarzkopf was very blunt in his assessment of the intelligence side of the war to the Senate Armed Services Committee when he said "there were so many disagreements within the intelligence community that by the time you got done reading many of the intelligence estimates you received, no matter what happened, they would have been right. And that's not helpful to the guy in the fight."[22] It is particularly noteworthy that the vast extent of Iraq's WMD programs became known only through firsthand inspection after the war ended.

Both UAV and WMD technology have been available for some time. The marriage of the two into a weapon system is obviously not an original idea. Why then has it not been pursued more fully? It is difficult to provide a definite answer, but a number of possibilities exist. First, it may be because the technology is still evolving and therefore the capabilities provided by a marriage of UAVs and WMD is still developing. Advances in such areas as miniaturization of equipment, propulsion systems, accuracy of guidance systems, and advanced materials are all now available for UAV manufacturers. These developments will allow manufacturers to make yet more capable, lower cost systems in the future. If existing UAVs are already very capable of carrying WMD, logic would suggest that many new systems will be even better suited for delivering them.

Further, just because the use of WMD has been limited to this point, it does not mean that they will not be used more widely in the future. As the opening quote of this chapter indicates, the potential for its use clearly exists. The 1995 Tokyo subway nerve gas attack is a recent example. According to one writer, "Although this nongovernmental use of a weapon of mass destruction has shocked the world, those who make it their business to track the proliferation of WMD are surprised that it has taken so long."[23]

Additionally, as third world and developing nations become more economically secure, and their industrial bases mature, they may develop indigenous technologies applicable to WMD and their delivery systems.[24] This means that the number of actors (both state and nonstate) that have the capability to develop these weapons will increase. Whether these actors have the will and inclination to develop and use them remains to be seen.

Even if nonproliferation regimes and export controls are effective, proliferation can still occur. There are other options available that must be considered. Fetter argues that factors such as deterrence, sanctions, preventive war, and active defense are also important means of addressing this type of threat. The first three are punitive in nature and require a willingness on the part of the United States and its allies aggressively to confront state or nonstate actors which pursue UAV/WMD systems. Deterrence through threat of retaliation is often credited with preventing the use of chemical weapons in World War II and nuclear weapons since World War II. Economic sanctions and embargoes have also proved effective in changing an adversaries' actions. Finally, the Gulf War, although not intended as a preventive war, was very effective in destroying Iraq's nascent WMD capability.[25]

An active defense against known threats is vital. The key here is whether the UAV/WMD combination is a serious enough threat to require massive diversion of assets to develop an effective air defense system and doctrine. The answer to this question at this point is not clear. However, the prudent course at this time would be to study the issue seriously and then decide if further action is justified.

In conclusion, the first step to combating the threat of the proliferation of UAV and WMD technology is to ensure that all the member-nations of current nonproliferation regimes and treaties are aware of the fact that these could be combined to form an effective WMD system. Second is to ensure that these regimes and treaties act in a synergistic way in order to increase their effectiveness. Third is to increase the intelligence gathering capability of systems that will be most effective in identifying potential weapons use of UAVs and the proliferation of WMD. Fourth, efforts should be taken to energize new nonproliferation organizations, such as the Wassenaar Arrangement, to incorporate mechanisms that will prevent the spread of UAVs and WMD for weapons purposes. Fifth, countries concerned about the proliferation of these systems should explore the carrots they could offer to actors that may be inclined to acquire them, in order to persuade them to do otherwise. Sixth, the United States and its allies must be prepared to address the possibility of engaging in deterrence through threat of retaliation, sanctions, and preventive war if required. Finally, given that there may still be a threat that these systems could be acquired and used against the United States and its allies, prudence would dictate that some level of effort be devoted to developing systems and procedures to defend against them. A synergistic approach such as this will provide the best means of addressing this problem.

Notes

1. *The Nuclear Non-Proliferation Treaty* (Washington, D.C.: Arms Control and Disarmament Agency, 1995), 1.

2. *Report to Congress, The Proliferation of Missiles and Essential Components of Nuclear, Biological, and Chemical Weapons* (Washington, D.C.: Department of State, March 1995), 17. With the accession of China and France in 1992, all the declared nuclear weapons states are now NPT parties. Additionally, as of the end of 1995, there were 162 total participants to the NPT. Those countries not participating include Algeria, Angola, Brazil, Chile, Cuba, India, Israel, Oman, Pakistan, Slovakia, and Tajikistan.

3. Steve Fetter, "Ballistic Missiles and Weapons of Mass Destruction. What Is the Threat? What Should Be Done?" *International Security*, Summer 1991, 33.

4. *Report to Congress, Threat Control Through Arms Control* (Washington, D.C.: Arms Control and Disarmament Agency, 1995), 73.

5. *Report to Congress, The Proliferation of Missiles and Essential Components of Nuclear, Biological, and Chemical Weapons*, March 1995, 11–12.

6. *Report to Congress, Threat Control Through Arms Control*, 22–23.

7. Ibid.

8. Ibid., 26.

9. *Report to Congress, The Proliferation of Missiles and Essential Components of Nuclear, Biological, and Chemical Weapons*, 13.

10. Ibid.

11. The 28 members of the AG are Argentina, Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Poland, Slovakia,

Spain, Sweden, Switzerland, the United Kingdom, and the United States. Requests to join the group are considered on a case-by-case basis.

12. According to officials of the Office of Chemical and Biological Weapons and Missile Nonproliferation, US Department of State, in an interview with the author.

13. As of the beginning of 1996, the MTCR Partners are Argentina, Australia, Austria, Belgium, Brazil, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Russia, South Africa, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

14. *Report to Congress, The Proliferation of Missiles and Essential Components of Nuclear, Biological, and Chemical Weapons*, 29.

15. *Missile Technology Control Regime Guidelines* (Washington, D.C.: Department of State, PM/CBM, 1995), 1.

16. Ibid.

17. *Missile Technology Control Regime Annex* (Washington, D.C.: Department of State, PM/CBM, 1995), 1–4.

18. Information on this incident was obtained from the author's firsthand account as an action officer in the Department of State, Office of Chemical, Biological and Missile Proliferation (PM/CBM) and was confirmed in an interview with the office director in February 1996.

19. Fetter, 31.

20. *Export Controls and Nonproliferation Policy* (Washington, D.C.: United States Congress, Office of Science and Technology Assessment, May 1995), 4.

21. Dr. Lynn E. Davis, under secretary of state for arms control and international security affairs, "Transcript of a Speech to the Carnegie Endowment for International Peace" (Washington, D.C.: Department of State, 23 January 1996), 1–4.

22. Richard P. Hallion, *Storm over Iraq: Air Power and the Gulf War* (Washington and London: Smithsonian Institution Press, 1992), 204 and 245.

23. "Sarin Savagery," *The Economist*, 25 March 1995, v334, number 7907, 88.

24. *Report to Congress, The Proliferation of Missiles and Essential Components of Nuclear, Biological, and Chemical Weapons*, 4.

25. Fetter, 36–38.

Chapter 6

Conclusion

Americans hold as a fundamental principle the importance of promoting international responsibility in arms transfers and in public accountability for these transfers. Preventing the spread of WMD and their associated delivery systems is essential.

—Dr. Lynn E. Davis

Curbing the proliferation of weapons of mass destruction and their delivery systems is a challenging task. Some potential proliferators seem to be convinced they need to develop WMD and/or associated delivery systems to protect or enhance their national security. Additionally, many nonstate actors (like terrorists groups) also see them as appealing weapons. At the same time, many of the technologies associated with WMD and their delivery systems have legitimate civilian and/or military applications unrelated to WMD. As developing nations increase their economic capabilities, and their industrial bases mature, they may develop indigenous technologies applicable to WMD and their delivery systems, thereby multiplying the number of countries that are potential WMD producers and suppliers.[1]

This study presents an overview of the capabilities of various unmanned aerial vehicles that established that they are capable of carrying WMD. In fact, for some weapons, such as biological and chemical agents, UAVs may well be the optimal system of delivery. It also examines the characteristics, production requirements, and availability of the various forms of WMD—chemical, biological, and nuclear weapons. It concludes that a marriage of WMD and UAVs is a definite possibility, especially for developing nations that may not have the economic or technical means to acquire or employ more advanced delivery systems. This conclusion is based, in part, on the fact that technology has progressed to the point that UAVs are now much more capable in terms of survivability, penetration capability, accuracy, reliability, and range/payload capability than they were a few years ago. Additionally, WMD have also matured and are now less expensive, more easily available, and smaller, which makes their match with UAVs a very real possibility. Finally, the dual-use nature of UAVs (intended to be reconnaissance/surveillance vehicles but possessing the capability for strike missions) and chemical and biological production facilities (which are used for medical purposes as well as weapons) makes detecting their development as weapons extremely difficult.

One possible answer to this problem is a multipurpose, synergistic approach. The basic priority is to bring this issue to the forefront and make all parties aware that the potential exists for the combined use of UAVs and WMD. The United States has the ability to exercise a significant leadership role in the international nonproliferation community. Consequently, its efforts should focus on reducing the incentives for states to develop such systems unilaterally, possibly using offers of security agreements, economic incentives, and/or foreign aid and assistance in order to persuade countries not to obtain these systems.

The United States should also prevent developing nations from acquiring WMD and UAVs intended for their delivery through existing multilateral arms control regimes. It should establish binding treaty commitments to strengthen international nonproliferation norms and seek to increase international enforcement mechanisms that punish violators. It should also encourage countries to control UAV and WMD materials and equipment in accordance with existing treaties and regimes and promote inclusion of controls for them into newly forming organizations, like the Wassenaar Arrangement. The United States and its allies must be prepared to address the possibility of engaging in deterrence through threat of retaliation, sanctions, and preventive war if required. Also, given that there still may be a threat that these systems could be acquired and used against the United States and its allies, prudence would dictate that some level of effort be devoted to developing systems and procedures to defend against them. Finally, the United States should continue its intelligence gathering efforts to detect unauthorized uses of UAV and WMD equipment and technology and share this information with other concerned nations.

The answer to this problem is not simple. In fact, there may not be a completely effective answer at all. However, a combination of solutions, as mentioned above, would have a synergistic effect that could be very successful in preventing the proliferation and use of UAVs as WMD delivery vehicles. In addition to promoting regional and international security, these measures would also aid in the protection of US citizens and interests around the world. The bottom line is that the United States may one day face an enemy that has obtained the capability to employ WMD on UAVs in battle. It is prudent to do everything in our power to prevent this from happening.

Notes

1. *Report to Congress, The Proliferation of Missiles and Essential Components of Nuclear, Biological, and Chemical Weapons* (Washington, D.C.: Department of State, March 1995), 4.

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