Chapter 6

Weapons and Warhead Technologies

6.1 Missions and Weapons

Of the nine mission areas identified in Chapter 3 as important baseline missions/tasks for technology analyses, six are weapon-carrying. The ideal weapons and warheads for launch from combat UAVs are delineated for each mission in Table 6-1. Some are existing missiles. In addition, three new missiles with modular warheads are envisioned for phased developments to fulfill a spectrum of combat UAV and manned aircraft missions: a small, planar strike weapon in the 100 lb class, a small kinetic energy penetrator, and a hypervelocity air intercept missile—all with modular warheads. A number of innovative, modular warhead technologies are the keys to achieving high capabilities in small UAV-compatible weapons.

Table 6-1. *Missions and Weapons*

	CWMD	***T/CMD***	***Fixed Target***	***Moving Target***	***SEAD***	***Air to Air***
Weapon	Kinetic Energy Penetrator	Hyper-velocity Missile w/IR Seeker	Dispenser, LOCAAS 3.5 in. Small, Modular Missile	Dispenser, Homing Missile (TOW, Hellfire, Maverick) 3.5 in. Small, Modular Missile	Dispenser, LOCAAS 3.5 in. Small, Modular Missile	AIM-120 AMRAAM AIM-9 Sidewinder Hypervelocity Missile
Warhead	Thermitic Sealant Foam	Kinetic Kill Vehicle w/ Divert Thrusters	Flying Plate Incendiary High Power Microwave	Wide Area Submunitions (CEB)	Flechette Incendiary High Power Microwave	Unitary/Self-Forging Fragments High Power Microwave

6.2 UAV Family of Weapons

The family of weapons proposed for UAVs use near-term technologies that have been demonstrated and are ready for implementation. The weapon required for boost phase intercept (BPI) of TBMs is unique in that it is a hypervelocity, hit-to-kill missile. The missiles required to perform SEAD, interdiction, hardened target destruction, as well as chemical warfare/biological warfare (CW/BW) neutralization may be of a common architecture with different warhead mechanisms. Alternative warheads such as the high-power microwave (HPM) or other mechanisms can be delivered by many existing platforms, depending on the threat requirement.

The resultant missiles required to undertake the six attack mission/tasks identified in Chapter 3 would fall into four basic classes:

- Hypervelocity missile with kinetic kill vehicle (KKV) payload for the BPI threat.
  Nominal Size: 500 lb, 8.5 in. diameter, 84 in. length, 2.5 km/s, 120 km standoff range.

- Kinetic energy penetrating missile for hardened target destruction and SEAD.
  Nominal Size: 75-100 lb, 3.5 in. diameter, 56 in. length.

- Low cost, low velocity cruising kill vehicle (LOCAAS-like) for a variety of interdiction missions.
  Nominal Size: 75-100 lb, 9.5 in. width, 30 in. length, 7.1 in. height.

- Air-to-air missions may not require a unique new missile. Current and upgraded versions of the Sidewinder (AIM-9) and AMRAAM (AIM-120) will meet envisioned near-term needs. If a kinematically superior airframe is required for the future, a derivative of the hypervelocity KKV should meet that need, provided a compromise in weight can be reached.

The following sections describe each of the three weapons that comprise the family of UAV weapons capable of the full spectrum of mission capabilities. The last section describes the recent innovations in the key warhead technologies that enable high lethality to be achieved with small, low-cost weapons.

Hypervelocity Missile. A new missile is required to attack TBMs when conventional missile technology is employed. The basic missile must have the performance capabilities described in Table 6-2. The study group proposes a near-term solution that combines existing non-developmental item (NDI) technologies and components (with a respectable 2.5 km/s [8,000 ft/s] velocity). In the early phase of flight, command-inertial guidance is employed. The KKV is deployed when the interceptor approaches the target intercept zone. The KKV employs an infrared seeker and divert thrusters to achieve a direct hit on the target.

Table 6-2. *Hypervelocity Missile Parametric Design*

Parameter	***Value***
Velocity (at intercept)	2.5 km/s (8 kft/s) minimum
Launch Altitude	>20 km (65,000 ft)
Time of Flight	20-60 sec
Intercept Altitude	20-80 km (65,000 ft - 260,000 ft)
Intercept Range	25-150 km (80,000 ft - 500,000 ft)
Total Missile Weight	225 kg (500 lb)
KKV Mass	25 kg (55 lb)
MWIR Sensor	3-5 microns

UAVs with payloads of 1,000 lb to 2,000 lb at altitudes over 60,000 ft could be excellent platforms to host a new hypervelocity missile for boost phase intercept. The high altitude provides a synergistic capability for the UAV's self-protection and sensor detection of missiles in the boost phase, as well as a relaxation of missile parameters such as intercept velocity, dome heating, and missile weight. In a complementary deployment, this system can obtain target acquisition and cueing information from the airborne laser (ABL) platform, which would be netted to the theater Mission Control Element (MCE).

Due to its high-velocity and high-altitude performance, the KKV missile will have significant alternative applications on conventional aircraft for attacking TBMs, air-to-air missiles, other aircraft, and high-altitude UAVs.

Kinetic Energy Penetrator. A kinetic energy penetrator, with a family of warheads as shown in Figure 6-1, offers a UAV the ability to accomplish a large number of combat tasks. A 3.5 in. diameter, 56 in. long, 75-100 lb, GPS or GPS-updated, inertially guided penetrator provides the ability to functionally kill CW/BW targets; potentially neutralize CW/BW agents; crater runways and destroy aircraft shelters; "sure kill" surface-to-air missile systems; destroy ballistic missile transporter-erector launchers; kill elements of the armored task force including medium tanks, armored personnel carriers, and self propelled artillery; as well as accomplish other combat tasks.

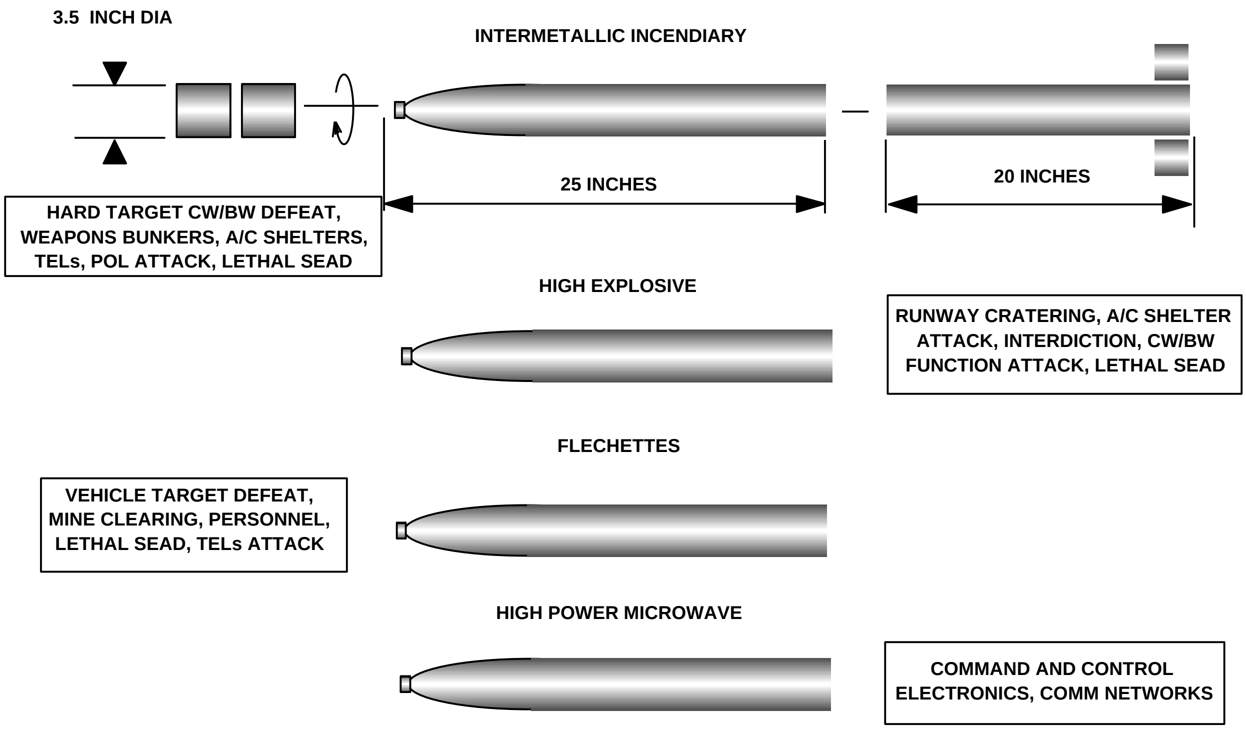

Figure 6-1. *Kinetic Energy Penetrator*

The kinetic energy penetrator is designed to deliver a CL-20[8] high explosive warhead with the ability to generate up to 450 kbars of detonation pressure, an intermetallic incendiary warhead capable of generating 3700°C firestorms, flechette warheads capable of penetrating many targets, or HPM warheads capable of upsetting, disrupting, and destroying electronics and

[8] CL denotes a China Lake-developed warhead.

communication equipment. These warheads would be modular and provide the kinetic energy penetrator with a family of lethal mechanisms that would enable it to accomplish a large number of combat tasks.

The utility of the kinetic energy penetrator is enhanced by its ability to penetrate into and destroy buried and hardened targets such as aircraft shelters and hardened CW/BW facilities. A UAV attack on a hardened CW/BW facility would involve the delivery of a large number of penetrators against the target. The GPS receivers in the penetrators would be activated and the preselected GPS satellite information would be transferred to each penetrator. The penetrators would be dropped from medium altitude—typically 15,000 ft to 25,000 ft—and would guide to individual and separate points 2,500 ft over the target. Their terminal velocity of 1,200 fps to 1,300 fps would be increased to 3,000 fps by a rocket motor ignited at that point. At that velocity, the weapon could penetrate the equivalent of 20 ft of reinforced, 5,000 psi concrete or 250 ft of compacted soil. Upon penetration into the target, a deceleration-sensing fuse would sense the entry of the penetrator into a room, and the warhead would be detonated.

A titanium-boron intermetallic incendiary warhead would be used to incinerate agents within the room. In the case of hard target facility destruction, the deceleration-sensing "smart" fuse would sense the penetration into the structure, where a CL-20 high explosive warhead would be detonated. Several hundred penetrators would be delivered against an underground facility. Other targets could be engaged and destroyed by the kinetic energy penetrator delivering warheads tailored to the targets being engaged.

<u>Low Cost Autonomous Attack System (LOCAAS)</u>. LOCAAS, at this point a technology program with an uncertain future, is a small (<100 lb), highly lethal (P_{ssk}=0.8) munition capable of autonomous target acquisition and classification. It integrates "adaptable warheads," which give it a capability against a wide range of target types. In addition, LOCAAS could deliver a small flying plate warhead. Currently, a single-warhead package can be effectively employed against the full range of material targets from light trucks, relocatable targets, and surface-to-air missile installations to heavy armor. LOCAAS will reduce the payload weight carried on aircraft and UAVs for classical air power missions, such as interdiction, close air support, and SEAD. The long-term impact will be to allow future UAVs to be smaller, lighter, and less expensive. The small size of the individual munitions is consistent with internal carriage and dispensing associated with low-observable UAVs.

LOCAAS munitions utilize a unique seeker technology based on the development of a low-cost, solid-state diode pumped laser seeker. Captive and free-flight testing of the LADAR seeker has demonstrated a 99% probability of acquiring mobile or relocatable targets with a 95% probability of classifying the targets in real time. Currently, the algorithms utilize the range and angle-angle data for target acquisition and classification.

Future improvements are required to increase the range of the seeker by increasing the laser power output and the pulse repetition rate. At a nominal velocity of 330 km/hr and a 9:1 glide ratio, this equates to a search area of 1 km x 3.3 km. Ranges in excess of 5 km have been demonstrated to date. Similarly, the wavelength of the laser must be increased from the nominal

0.87 microns to something beyond 1.6 microns for eye safety and better all-weather performance.

The ability of the LADAR seeker to classify targets reliably has prompted the development of adaptable warheads to better couple the warhead energy to the target in order to maximize the probability of kill (P_k). A powered version to provide standoff and survivability for the launching platform is being considered. Further warhead improvement will ensue as precision warhead initiation systems and higher energy density materials become available.

Air-to-Air Missile. Currently envisioned UAVs will have a useful air-to-air capability that is limited by the size and weight of the missile load and the acquisition range of the UAV sensors. Consequently, the Sidewinder and AMRAAM families of missiles are projected to be appropriate weapons for the near- and mid-term applications. At such time in the future that growth of the UAV vehicle and sensor avionics (on and offboard) justify it, the superior kinematics of the hypervelocity missile could be employed.

The Sidewinder (AIM-9) is a family of IR dog-fight missiles weighing approximately 190 lb to 205 lb. The UAV must provide target bearing for seeker lock-on and fire control inputs such as in-range and identification friend or foe (IFF) indications. Some versions require a gas bottle for detector cooldown. The AMRAAM (AIM-120) is a family of radar guided medium-range missiles weighing approximately 340 lb. Sensors and avionics on the UAV must provide target vectors, IFF, and post-launch updates for command-inertial midcourse guidance.

6.3 Warhead Technology

Ideal weapons for delivery by UAVs are dependent on precision guidance and control and new warhead technology. Recent advances in novel warhead technologies enable small weapons to neutralize a wide range of hard targets effectively.

Flying Plate Warhead. The Naval Surface Weapons Center (NSWC) Indianhead Arsenal, MD, has defined and demonstrated a flying plate warhead that drives a copper disk toward the target with its flat face perpendicular to the direction of flight. The design, using a rubber buffer layer on the back of the disk, couples 40% of the explosive energy into the plate. The flying plate, upon impact with reinforced concrete, can be designed to "core" a hole completely through the target several times the diameter of the disk or to transfer its impact energy to reduce the concrete target to rubble. It also can be employed to perforate steel targets up to a few disk diameters in thickness. The warhead provides the ability to destroy bridge piers, drop structural elements, penetrate bunkers and accomplish other combat tasks.

High-Explosive Warhead. The new energetic, high-explosive warhead delivering a CL-20 explosive provides the ability to generate pressures up to 450 kbar. CL-20 can incorporate the explosive power of much larger warheads into very small warhead configurations. The warhead can be used for function kill in CW/BW facilities and to crater runways, destroy aircraft shelters, and damage other targets.

Intermetallic Incendiary Warhead. NSWC defined and demonstrated a titanium-boron intermetallic, self-propagating, high-temperature, synthesis reaction warhead capable of generating a reactant cloud at 3700°C. The warhead releases extremely large amounts of energy, providing the means to incinerate a variety of targets. Its fire-start capability is such that, once initiated, the fire cannot be quenched. When water is employed to quench the fire, the reaction disassociates the water into hydrogen and oxygen, and a secondary reaction forming oxides of titanium and boron releases additional energy to enhance the firestorm capability of the warhead. The warhead has the ability to destroy aircraft shelters and conventional buildings and damage other targets and offers significant promise of neutralizing biological and chemical agents.

Flechette Warhead. The terminal velocity associated with many of the weapons that can be delivered by UAVs is high enough to allow effective use of 500-600 grain flechettes that are capable of inflicting multiple penetrations of the target. The warhead can be used to disable combat vehicles and "sure kill" enemy air defense sites, transporter erector launchers, and other targets.

High Power Microwave. HPM technology uses repetitive pulses or single-pulse concepts. The warhead, for example, can use an explosively driven flux compression generator to power a single "shot" HPM warhead capable of upsetting, disrupting, and destroying electronics. Concepts exist, employing new microwave circuits, solid state switching arrays, and impulse radiating antennas to generate both narrowband and ultrawideband pulses on a repetitive basis. The warhead can be used to destroy command, control, and communication centers and electronics facilities.

6.4 Weapons Summary

Achieving lethality with small weapons capable of being carried on small combat UAVs requires precision guidance (in most cases) and lethal small warheads. Ongoing technology programs appear to be providing a variety of precision guidance options. Some are in the inventory now. With the advent of some innovative wide kill-area warheads, hardening Air Force guidance systems appears to be the greatest technology requirement. For example, many missile guidance needs can be fulfilled with a reliable (jam-resistant) 30 ft circular error probable (CEP) GPS guidance system.

A number of innovative warheads have demonstrated capabilities that suggest UAV size-compatible weapons could achieve high lethality against difficult targets:

- Thermite warheads that achieve 3,700°C firestorm temperatures. These titanium-boron intermetallic warheads provide high destructive power and may approach the temperatures needed to neutralize CW/BW agents,

- Small flying plate warheads that destroy large, reinforced concrete structures,

- HPM warheads capable of neutralizing electronics at great distances.

These warheads have been demonstrated on "shoestring" budgets. As the key enabler for next-generation UAV (as well as aircraft) weapons, they should be supported with adequate funding to refine the understanding of the phenomenology, quantify their effects, and develop fieldable weapons.

Ongoing technology in combination with technologies identified in this report could enable relatively low-risk development of the family of weapons to meet the needs of the six weapon-carrying combat UAV missions.