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MASTER OF MILITARY STUDIES

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**TITLE:** Conventional Prompt Global Strike: Capabilities Today While Planning for Tomorrow

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## *Preface*

I wrote this paper about Conventional Prompt Global Strike (CPGS) because the U.S. military does not currently possess the capability to conventionally strike a target anywhere in the world in less than 1, 4, 12 or in some cases 24 hours. With the diversity of threats to America increasing, and the reality of the 2012 budget constraints, I sought to create options for providing a CPGS capability in the near and mid-term.

Classification limited the depth of discussion in parts of this paper, but it has become apparent to me that the U.S. needs to pursue CPGS through kinetic and non-kinetic means. Defeating hardened, or deeply buried targets, will become an even bigger problem as America's adversaries go to greater depths to protect their valuable personnel and equipment. Ideally, these targets could be neutralized with cyber weapons, but in cases where they cannot, the U.S. military needs to develop a weapon that can defeat them on short notice. CPGS weapons can meet this need, and provide the National Command Authority additional options to defend America.

## Executive Summary

**Title:** Conventional Prompt Global Strike: Capabilities Today While Planning for Tomorrow

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**Thesis:** The only U.S. weapons that can destroy a target anywhere in the world in less than an hour are Nuclear armed Intercontinental Ballistic Missiles (N-ICBMs). These weapons provide significant deterrence, but have little use outside of large scale nuclear war. As America downsizes its military, and reduces Overseas Contingency Operations (OCO), the ability to quickly strike a time sensitive target (TST) will decrease. In order to provide America with a conventional targeting capability for TSTs this paper makes the following recommendations:

### Near Term Recommendations (1-5 years)

1. Provide the CCDRs of U.S. Africa, Central, and Pacific Commands with adequate forces and weapons to destroy a target within any portion of their area of responsibility (AOR) within 12 hours.

2. Provide CCDRs rapid offensive cyber capability, with execution authority and supporting command and control (C2), to neutralize targets operating within their AOR.

### Mid Term Recommendations (5-10 years)

1. Fund the Air Force to develop and acquire long range hypersonic weapons that can penetrate any Anti-Access/Area Denial (A2AD) environment. These weapons should be launched from Vandenberg AFB in California and Patrick AFB in Florida, and be able to destroy a static target anywhere in the world in less than 60 minutes from launch.

2. Fund the Navy to develop a super-sonic weapon able to penetrate any A2AD environment; and strike a target with a 500 pound payload, at a range of over 2,500 nautical miles.

**Discussion:** Conventional Prompt Global Strike (CPGS)<sup>1</sup> is the proposed capability to strike a TST anywhere in the world within one hour. This capability would give the U.S. military the ability to quickly destroy threats ranging from terrorist leadership safe houses to near-peer adversary's high value targets. In areas where America is conducting Overseas Contingency Operations (OCO) this type of capability already exists through TST cells, but it is unlikely that every CCDR has the ability to neutralize a target anywhere within their operational environment within one hour. In reality, it would likely take over 24 hours for the military to destroy a target in an area where America is not conducting an OCO. The military does currently possess weapons and delivery systems that could fulfill the CPGS mission, but these weapons are not available in sufficient numbers to hold every potential target at risk.

**Conclusion:** America needs to develop a family of CPGS weapons, for the Air Force and Navy, to provide the National Command Authority with CPGS targeting options.

## **Introduction**

Conventional Prompt Global Strike (CPGS)<sup>2</sup> is the proposed capability to strike a time-sensitive target (TST) anywhere in the world within one hour. This capability would give the National Command Authority and Combatant Commanders (CCDR) the ability to destroy threats to America ranging from terrorist leadership safe houses to near-peer adversary's high value targets. In areas where America is conducting Overseas Contingency Operations (OCO) this type of capability already exists through TST cells, but it is unlikely that every CCDR has the ability to neutralize a target anywhere within their operational environment within one hour. In reality, it would likely take over 24 hours for the military to destroy a target in an area where America is not conducting an OCO. The military does currently possess weapons and delivery systems that could fulfill the CPGS mission, but these weapons are not available in sufficient numbers to hold the majority of global TSTs at risk.

The commonly proposed option for a CPGS capability is to develop a conventional warhead for an Intercontinental Ballistic Missile (C-ICBM). Additionally, ICBM command and control coordination measures could be used to quickly launch a C-ICBM against nearly any target in the world.<sup>3</sup> This paper disagrees with developing a conventional warhead for ICBM missiles for multiple reasons.

1. If the U.S. launches a C-ICBM, without prior coordination with Russia and China, America risks nuclear retaliation. This problem would be intensified if the launch came from a U.S. submarine submerged in an unknown location. The risk of nuclear response from Russia and China could be reduced by using a coordination hot line and by deploying the C-ICBMs to Vandenburg and Patrick Air Force Bases. The U.S. doesn't have N-ICBMs stationed at these

two bases, and a launch from these locations would have a significantly different trajectory than missiles launched from the missile fields around Montana and the Dakotas. But, even with risk reduction measures an ICBM's 30 minute time of flight provides very little time for coordination.<sup>4</sup> The risk of nuclear exchange is not worth re-using ICBMs for CPGS.

**2.** ICBM warheads can, or soon will be able to be shot down by anti-ballistic missile systems (ABMS), due their predictable trajectory, lack of end game maneuvering, and relatively large radar signature. A modern example of an ABMS in development is the Russian S-500, Triumfator Missile Defense System. This system has missiles designed to destroy ballistic missiles and warheads both endo-atmospheric and exo-atmospheric.<sup>5</sup>

**3.** ICBM warheads are not guided by the Global Positioning System (GPS) constellation of satellites and not accurate enough to reliably destroy a target with a relatively small conventional warhead.<sup>6</sup>

**4.** ICBMs are not re-targetable in flight. This poses a significant problem if an adversary moves a target every 1-3 hours, and operates inside of the TST cycle.

**5.** ICBMs cannot destroy a moving target. It is likely that an enemy would use vehicles or ships to store, move, or employ systems that threaten America.

**6.** ICBM warheads cannot hit a target anywhere in the world from any approach azimuth. Many deeply buried targets, and targets inside of mountains, require specific warhead approach angles for optimal destruction.

**7.** The same money could be used to develop a more accurate, survivable, and capable weapon for conventional response.

## **Why the United States Needs Conventional Prompt Global Strike Weapons**

The size and budget of the U.S. military is shrinking, but the global security environment remains dangerous and unpredictable. Rogue nations, global terrorist organizations, narco-terrorists, pirates, and near-peer adversaries continue to challenge America and its allies. The mission of the military is to protect America from foreign threats, but the American public and politicians have no tolerance for U.S. casualties, and little patience for OCOs. But, Americans still expect pre-emptive action from the military, and elimination or neutralization of every threat. CPGS weapons are needed because they will provide the military with a rapid preemptive, or reactionary targeting option that is both politically acceptable and tactically sound. CPGS weapons can be launched from within the United States, or out at sea, leaving military members safe at home or aboard their ships and submarines.

In addition to being politically acceptable, launching several CPGS weapons will likely cost less than sending an airborne strike package to destroy a target. America's air power can operate with impunity over countries with limited air defenses, but defending against an IADS exponentially increases the cost and risk of a strike mission. Sending one bomber across a target will require inflight refueling for all aircraft involved, airborne C2, electronic warfare aircraft, fighter escort, and combat search and rescue aircraft to be put on alert. Additionally, most of these aircraft will need to be forward deployed; further increasing the total cost and political sensitivity of the mission. The cost, time, and risk of conducting an airborne strike could quickly become more expensive than launching several CPGS weapons.

Another advantage of developing CPGS weapons is their deterrence effect. These weapons will force America's adversaries to either develop costly systems to defeat CPGS

weapons, or create intricate deception techniques to confuse the American intelligence community.

America needs a CPGS capability, but developing new weapons systems takes time and money. As a result, this paper makes the following recommendations to develop a CPGS capability:

#### **Near Term Recommendations (1-5 years)**

1. Provide the CCDRs of U.S. Africa, Central, and Pacific Commands with adequate forces and weapons to destroy a target within any portion of their area of responsibility (AOR) within 12 hours.

2. Provide CCDRs rapid offensive cyber capability, with execution authority and supporting command and control (C2), to neutralize targets operating within their AOR.

#### **Mid Term Recommendations (5-10 years)**

1. Fund the Air Force to develop and acquire long range hypersonic weapons that can penetrate any Anti-Access/Area Denial (A2AD) environment. These weapons should be launched from Vandenberg AFB in California and Patrick AFB in Florida, and be able to destroy a static target anywhere in the world in less than 60 minutes from launch.

2. Fund the Navy to develop a super-sonic weapon able to penetrate any A2AD environment; and strike a target with a 500 pound payload, at a range of over 2,500 nautical miles.

#### **Background**

As early as 2001, the Bush Administration called for the U.S. military to consider conventionally arming long-range ballistic missiles for offensive strike. In FY2007 and FY2008, the Defense Budgets requested funding “to pursue the deployment of conventional warheads on Trident missiles,”<sup>7</sup> but congress rejected the request and instead transferred \$100 million into a fund for broad research of prompt global strike technologies.<sup>8</sup> It is difficult to estimate the amount of money the Department of Defense (DOD) is currently spending to develop CPGS, but it is clear that the DOD is pursuing hypersonic weapons. In 2011, the DOD launched two hypersonic vehicles; the failed Defense Advanced Research Projects Agency’s (DARPA) Hypersonic Technology Vehicle Two (HTV-2),<sup>9</sup> and the successful launch of the Army’s

Advanced Hypersonic Weapon (AHW).<sup>10</sup> Hypersonic weapons are still in the developmental stage, but the technology is promising for CPGS due to its speed, survivability against defensive systems, and incredible energy at impact.

### **CPGS Timeline and Target Set**

The U.S. military can currently defeat any target in the world through a combination of kinetic and non-kinetic attack, but in areas where the military is not actively engaged in OCO it will take much longer than one hour to neutralize a threat. This creates a dilemma for the U.S. and intelligence communities. They can identify a significant threat to America, but might not have the ability to quickly destroy it without using an N-ICBM.

It is an unfortunate reality that America has a gap in its global targeting capability. The conventional strike force, made up of aircraft, conventional ballistic missiles, ships, submarines, and special operations forces (SOF), cannot destroy any target in Asia, Africa, or South America within an hour. The “one hour strike requirement” for CPGS might seem artificially short, considering the significant intelligence, surveillance, and reconnaissance (ISR) assets required to commit to engaging a target, but one hour or less from request to impact is required for many of the targets mentioned below.

- 1.** Ballistic missiles, armed with nuclear, biological, or chemical (NBC) warheads, being prepared to launch.
- 2.** Key terrorist leadership meeting in an area with no other kinetic kill option.
- 3.** Deeply buried underground bunker that is being used to manufacture or store NBC weapons.
- 4.** Anti-satellite missile being prepared to launch.
- 5.** A2AD targets during wartime. These could include command and control facilities, essential infrastructure, aircraft carriers or warships, surfaced submarines, or key integrated air defense system nodes (IADS).

## **Near Term Recommendation: Cyber, SOF, and Kinetic CPGS With Today's Force**

This paper assumes that America will continue building security cooperation agreements, and conduct military training missions (MTM), to build and sustain relationships with foreign countries to counter terrorism and disruptive rogue elements. MTMs, coalition exercises, and foreign basing projects America's mid-weight power; while deterring aggression, and providing a multitude of response options to counter future threats.

The U.S. military currently has the capability to provide the U.S. Africa, Central, and Pacific COCOMs with adequate forces to hold nearly any target in their AO at risk through the strategic positioning of military forces. The following recommendations are not a long term fix for a CPGS capability, but will provide a stop gap for target destruction inside of 12 hours. This paper assumes that SOF forces will be used whenever available and appropriate for kinetic targeting. It also assumes that America will continue to form coalitions with friendly governments to improve multi-lateral security.

### **Cyber Weapons for CPGS**

Many CPGS targets must be hit by a physical weapon to ensure destruction, but some targets can, or must, be neutralized by cyber weapons. If the 10 largest banks in America all receive a distributed denial of service attack,<sup>11</sup> from servers located outside of America, the military must be able to neutralize the threat without kinetic weapons. This type of attack would require prompt action, and countering it is the responsibility of the United States Cyber Command (USCYBERCOM) and our coalition partners. These organizations have access to a variety of tools that can disable, manipulate, influence, and in some cases physically destroy electronic or mechanical systems. Cyber weapons can be used to defend America against cyber attack, and can also be used to neutralize traditional threats.

The advantage of using a cyber weapon to defeat a conventional threat is that the affect can be immediate, American troops are not put in harms way, the attack could be non-attributable, and the cost is likely much less than launching a kinetic strike. But, the major disadvantage of using cyber weapons for CPGS targets is that they require electronic access and a significant amount of time and resources to develop a targeting solution. As a result, the majority of cyber targets have to be pre-planned, providing few reactionary options. As technology improves, and America's cyber weapons advance, CPGS with cyber will be much more realistic. Virtually all NBC production facilities, and conventional delivery methods, require electronic control systems. Current technology limits America's ability to access these systems, but in the future America will be able to target these systems through their hardware, or by gaining entry into the systems through insiders, wireless means, power distribution networks, or physical communication lines. Once access is gained to these networks malware can be implanted to exploit, and if needed attack the system.<sup>12</sup>

Cyber weapons aren't the only answer to the CPGS targeting problem, but do offer options in areas of the world where there is limited or no military presence. If a cyber weapon is not the kill mechanism for a target, these weapons could still be used to increase the likelihood of conventional weapon success. An example is to use a cyber weapon to disrupt the Supervisory Control and Data Acquisition System (SCADA) controlling the power supply to an air defense sector right before a Tomahawk Land Attack Missiles (TLAM) enters the engagement zone of a SAM system.

### **SOF for CPGS**

Covert and overt SOF, with their indigenous support and infrastructure, provide a unique opportunity to provide a kinetic option for CPGS targets. These forces have become a main

effort in OCO, and will need to increase their area of influence as conventional forces withdraw from the Middle East and Europe. SOF are the ideal weapon to destroy CPGS targets; they can destroy static or moving targets, can make immediate battle damage assessment, and can confirm the intelligence situation before taking kinetic action. The disadvantage of using SOF for a CPGS target is the exposure of U.S. forces. SOF teams can operate with a small independent footprint, but most direct action missions that make headlines have large support packages that rival an airborne strike package.

For the reasons stated above, SOF should be used whenever practical to destroy CPGS targets. In the mid term, CPGS weapons should be developed that provide SOF and combatant commanders additional kinetic options.

#### **United States Africa Command (USAFRICOM)**

The USAFRICOM AOR will require a significant number of air and naval forces to hold any target within the African continent at risk. Fortunately, most of the potential targets in Africa are terrorist organizations, or rogue actors, that have weak air defenses to counter U.S. aircraft or missile attacks. Targets in north and eastern Africa could be held at risk by putting Air Force fighters or bombers, and supporting tankers, on alert at Aviano air Base in Italy and at an airfield in Djibouti. ISR and attack drones could also be flown in areas where America has been granted over flight by the host nation. These strike forces could be complimented by Navy guided-missile destroyers and submarines that can launch TLAMs against static targets. The options for providing a CPGS targeting capability in central and southern Africa are much more limited, and the capability would have to be provided by Navy destroyers, submarines, carrier strike groups, and Marine Expeditionary Units (MEU).

MEUs provide a very unique option for CPGS. They provide a CCDR with a pre-positioned Marine Air-Ground Task Force (MAGTF) capable of using its infantry battalion, fixed and rotary wing attack aircraft, and artillery to destroy CPGS targets. For anti-access targets, the MEU could infiltrate low altitude with AH-1Ws and AV-8Bs, or launch MGM-140 surface to surface missiles off of the deck of their amphibious ships.

### **United States Central Command (USCENTCOM)**

U.S. air, naval, land, and SOF forces are already positioned to provide response options for the entire USCENTCOM AOR, except in countries that use to be members of the Former Soviet Union (FSU). America is fortunate that countries from the FSU are not controlled by radical regimes, and that Russia still maintains a stabilizing influence in the area; though this influence can be counter-democratic if the party to be elected doesn't favor a strong relationship with Russia. America should continue to build relationships with Russia and FSU countries to counter-terrorism and weapon of mass destruction (WMD) proliferation. These relationships will strengthen Russian and FSU internal security while protecting America's interests.

### **United States Pacific Command (USPACOM)**

The entire USPACOM AOR, outside of the Chinese A2AD area, can be held at risk by B-2s stationed on alert in Guam; complimented by strategic positioning of Navy guided missile destroyers and submarines. These forces can be reinforced in high threat regions by deploying carrier strike groups, putting strike fighters on alert in Japan and Korea, and by increasing the U.S. presence in the Philippines.

In the near term, it is extremely unlikely that America will need to employ a kinetic CPGS weapon inside of the Chinese A2AD zone. But, defending from a Chinese sponsored

cyber attack is a possibility. In the near term, CPGS cyber tools should be developed to protect U.S. interests from this type of attack.

### **Mid Term Recommendations: Air Force Hypersonic and Advanced Naval Weapons**

The near-term option for CPGS will provide CCDRs increased targeting options, but the cost of deploying and prepositioning the required forces will likely prevent its adoption. For this reason, the military must develop CPGS weapons that can hold any target in the world at risk, while simultaneously providing additional attack options during wartime. This paper recommends developing two separate weapons for CPGS; a long range hypersonic weapon for the Air Force, and a 2,500 plus nautical mile supersonic cruise missile for the Navy. Two weapons are needed for targeting flexibility; and because the cost and complexity of developing a single weapon, for a diverse target set, would result in extreme complexity and cost. The following paragraphs list recommended requirements for a comprehensive CPGS targeting capability.

#### **Recommended CPGS Requirements**

A CPGS weapon should be **highly survivable in an A2AD environment through a combination of speed, maneuverability, low observable (LO) attributes, and an internal navigation system able to operate without a global positioning system (GPS) signal.**

America's military rivals continue to improve their IADS, SAM systems, and counter communication and positioning systems in an attempt to neutralize the U.S. military's technological advantage across the operational environment. As soon as America develops an advanced LO aircraft or weapon, its rivals make a better IADS, SAM system, or jammer to counter it. Instead of continually one-upping the competition with a more LO aircraft, or jam resistant GPS antenna, CPGS weapons must make a significant leap in maneuverability, speed,

LO design, and precision navigation independent of GPS in order to be able to destroy a target in any environment. By combining high speed and maneuverability, with sophisticated LO design and materials, CPGS weapons should provide America with a highly reliable weapon regardless of the A2AD environment.

A CPGS missile should be able to use GPS signals reliably for navigation during the majority of the weapon's time of flight, but the weapon should also be able to independently update its navigation system; through an image sensor or air-to-ground radar that scene matches known points on the ground to determine its relative position. A CPGS weapon must be able to navigate to its target without GPS, and hit its desired point of impact with extreme accuracy. This paper defines extreme accuracy as the ability to deliver a warhead within three meters of its desired impact point; 90 percent of the time, with or without GPS.

CPGS weapons should also have the **ability to hit static targets, deeply buried or hardened targets, and moving targets.** The range of potential targets for CPGS varies from a high level terrorist meeting to an underground NBC facility. This diverse target set requires developing at least two different warheads; a warhead designed to destroy personnel, vehicles, and non-hardened buildings, and a warhead designed for penetration and bunker/tunnel defeat.

### **Air Force Long Range Hypersonic Weapon**

The mission for the Air Force Hypersonic weapon is primarily hard target defeat (tunnels, bunkers, deeply buried targets), defeating targets defended by extremely sophisticated IADS, and destroying targets that are not within the range, capability, or time required from launch to impact for the Naval CPGS weapon.

The naval CPGS weapon will be limited in range to 2,500 nautical miles in order to reduce its cost, size, and radar signature. This leaves a gap in the ability to hit targets inside of

large continents, or in locations where the Navy doesn't have a CPGS capable ship or submarine deployed. The naval version of the CPGS weapon will also be limited in its ability to defeat hardened targets. It should be able to penetrate a typical bunker, but will not be able to defeat tunnels or deeply buried underground facilities. The naval CPGS weapon will also have a longer time of flight than the Air Force Hypersonic weapon. The Air Force weapon will impact a target across the globe in approximately 30 minutes. The Navy's weapon should be super-sonic, but will still take over two hours, at mach 2, to reach a maximum range target. Technology might allow the Navy's missile to fly at speeds over mach 2, but this will likely reduce its range.

Developing a hypersonic CPGS weapon will require new technologies to be refined and matured to develop a reliable delivery vehicle and warhead that can survive a rocket boost and hypersonic glide above Mach 5.<sup>13</sup> America has launched ICBMs, satellites, and shuttles for decades, but these systems didn't have to glide in the atmosphere for 30 minutes at hypersonic speeds; sustaining extreme levels of intense heat, and stress on the delivery vehicle, during hypersonic cross-range maneuvering. The best unclassified description of a hypersonic glide weapon comes from the roadmap for the Hypersonics Programs of the Department of Defense.

“Prompt Global Strike Missile: The maneuverable hypersonic boost-glide weapon system capability is to deliver precision conventional effects with global reach (approximately 9000 nautical miles) within one hour. The weapon system could be boosted by excel and/or commercial motors, or perhaps via future responsive space lift platforms. In either case, the majority of the flight trajectory would be endoatmospheric and have sufficient maneuverability to avoid overflight of restricted airspace (600-3000 nautical mile cross-range capability). Delivered payload is on the order of 1000-2000lbs, with flexible kinetic and non-kinetic configurations including multiple precision guided sub-munitions, unitary penetrating munitions, and/or sensor packages. Physical characteristics of the hypersonic vehicle are 12 feet length, 4 feet width, and up to 3500lb weight. The vehicle speeds are nominally Mach 24 reentry, a Mach 10-15 glide, and Mach 4 terminal impact.”<sup>14</sup>

This paper recommends that the Air Force develop and operate long range hypersonic weapons from Vandenberg AFB in California and Patrick AFB in Florida. Both of these bases

currently conduct ICBM testing and have operation test ranges. Additionally, the Air Force doesn't have N-ICBMs at these bases; significantly reducing the risk that an adversary will misinterpret a CPGS missile launching from Vandenberg or Patrick as being a nuclear armed ICBM. To further reduce the risk of nuclear retaliation, the U.S. could allow arms inspectors access to the CPGS alert facilities; to confirm that CPGS missiles are not armed with nuclear warheads. An additional advantage of using these bases, is that booster sections from the CPGS missiles will fall into the ocean instead of over the Continental U.S. or Canada. Targets to the north or west of the Continental U.S. would be targeted by missiles from Vandenberg, and targets to the south or east would be targeted with missiles from Patrick.

The Air Force is the ideal service to develop, procure, and operate a CPGS hypersonic missile for the joint force; the Air Force already has an operational command and control system in place that is prepared for N-ICBM launches, the Air Force owns and operates ICBM and space launch facilities at Vandenberg and Patrick Air Force Bases, and the Air Force has the corporate knowledge and experience with ICBM and space launches, within Air Force Global Strike Command and Air Force Space Command, to effectively execute the CPGS mission.

**The CPGS hypersonic weapon should be designed for high value and highly defended static targets and at a minimum should have the following capabilities:**

- 1. Speed to destroy a target anywhere in the world in less than 60 minutes after launch.**
- 2. Maneuverability and LO attributes** that will avoid or defeat any A2AD environment for the foreseeable future. The speed of a hypersonic system alone will defeat most modern SAM systems, but adding LO attributes and maneuvers will exponentially increase its survival. Maneuverability will also allow the delivery vehicle to avoid overflying areas that are politically sensitive.
- 3. The ability to destroy both a traditionally constructed brick and mortar building, and a deeply buried underground facility.** This will likely require two separate warheads. The sub-munition warhead, mentioned in the Roadmap for Hypersonics Programs of the DOD, would be ideal for destroying non-hardened and/or area targets. A

height of function fuse would direct when the sub-munitions are dispersed; dictating the size of the area hit by the sub-munitions and their impact density. But, with a Mach four impact velocity it might not be necessary to have explosive sub-munitions. A combination of rods and cylinders, made up of a metal that would ignite due to friction once it leaves the delivery vehicle, could cause significant damage to buildings, vehicles, and personnel without being explosive. Destroying a deeply buried underground facility may not be achievable via target penetration; it could require creating massive vibrations, through cross harmonics, which would violently shake a target. Cross harmonics would require multiple weapons, impacting near simultaneously, to create a shock wave that would collapse an underground structure and/or destroy its equipment. Another warhead option is to use beryllium or tungsten rods, sometimes referred to as “Rods of God,”<sup>15</sup> to penetrate a deeply buried target. Multiple rods penetrating a deeply buried target would cause significant damage, but America’s adversaries are starting to burry facilities extremely deep, and build them into mountains, where it is unlikely a rod could penetrate.

**4. Self destruct capability in flight.** If the target moves, or collateral damage becomes an issue, the weapon must be able to self-destruct during its 60 minute time of flight.

## **Hypersonic Testing**

The capabilities mentioned above will be expensive and "wickedly" complex, but the U.S. has recently conducted three tests of hypersonic systems that show promise; the X-51, DARPA Falcon Hypersonic Test Vehicle (HTV), and the Army’s Advanced Hypersonic Weapon (AHW).

Boeing Phantom Works designed, built, and on May 26, 2010 launched the X-51A WaveRider flight test demonstrator from a B-52H bomber.<sup>16</sup> During this launch, the WaveRider “completed the longest supersonic combustion scramjet-powered flight in history, flying at approximately Mach 5 for 143 seconds. This technology is setting the foundation for hypersonic application”<sup>17</sup> and could power a hypersonic CPGS delivery vehicle. NASA describes a scramjet (supersonic-combustion ramjet) as a “ramjet engine in which the airflow through the engine remains supersonic, or greater than the speed of sound. Scramjet powered vehicles are envisioned to operate at speeds up to at least Mach 15.”<sup>18</sup> It is beyond the scope of this paper to recommend that a CPGS hypersonic delivery vehicle needs a scramjet engine, or if it should

simply glide at hypersonic speeds to its target; but regardless, scramjet technology is improving and could power prolonged hypersonic flight.

The second recent hypersonic test was the August 11, 2011 launch of the DARPA's HTV-2 (see Figure 1 for flight profile diagram). During this test a Minotaur IV rocket boosted the HTV-2 to over Mach 20 inside of the atmosphere. After separation from the rocket, the HTV-2 "demonstrated stable aerodynamically controlled Mach 20 flight for nearly three minutes."<sup>19</sup> Unfortunately, due to an in flight anomaly, the HTV-2 couldn't complete its entire flight and was purposely destroyed in flight. The HTV-2 failed to fly its entire profile, but provided useful data for future hypersonic vehicle development.

On November 17, 2011 "the U.S. Army Space and Missile Defense Command/Army Forces Strategic Command conducted the first test flight of the AHW concept. A three-stage booster system launched the AHW glide vehicle and successfully deployed it on the desired flight trajectory. The vehicle flew a non-ballistic glide trajectory at hypersonic speed to the planned impact location at the Reagan Test Site"<sup>20</sup> in the Pacific Ocean. This test proved that a delivery vehicle could glide at hypersonic speeds, for an extended period of time, while successfully navigating to a target. The next step in hypersonic glide testing will be demonstrating aggressive lateral maneuvers to prove the ability to use cross-range.

Hypersonic controlled flight inside of the atmosphere will require technology that is still being developed and tested. This paper recommends using a hypersonic weapon for CPGS in the 5-10 year time period. It is unlikely that a hypersonic weapon could become operational in five years, but realistic weapon testing should occur. But, a hypersonic weapon will be expensive, and it is unlikely that more than a 20-50 of these weapons will be initially produced. Therefore,

it is imperative that the U.S. develops a lower cost, higher volume, CPGS weapon that can be launched by the Navy from its ships and submarines.

### **Navy Long Range CPGS Weapon**

The Navy needs to develop a long range CPGS weapon; for employment from its submarines and ships, and to compliment the Air Force Hypersonic CPGS weapon. This will provide the National Command Authority with additional CPGS options, and add a needed compliment to America's naval power. The U.S. Navy has persistent global presence and deterrence, because their ships and submarines are constantly sailing to different locations. Once the Navy is equipped with a long range CPGS weapon, they will be able to hold a large portion of CPGS targets at risk. This paper envisions the Navy's CPGS missile as being the weapon of choice, over the Air Force weapon, due to its lower cost, greater number of weapons in the inventory, lower collateral damage, and ability to hit a moving target. But, the Navy's CPGS weapon will not be a good match for every target; and will carry a much smaller warhead, be less survivable in a high threat environment, and have a limited hard target defeat capability.

**The Navy Long Range CPGS Weapon should be designed for static or moving targets and have the following capabilities:**

**1. 2,500 nautical mile minimum range at super-sonic speeds.** This will allow a Navy ship or submarine to launch a weapon, from 100 miles off of the coast of any continent, and hit a target anywhere in the world except in the innermost reaches of Asia (see map 1). The supersonic speed requirement is recommended for decreased flight time and increased survivability in a high threat environment.

**2. Ability to be re-targeted in flight and destroy a moving target.** The potential exists that a CPGS target will move during the time of flight of the weapon. U.S. surveillance assets can detect target movement, and the weapon's operators should be able to re-target it in flight. If the target remains moving, the weapon should have the ability to guide to the target as long as it is being illuminated by a designator. The most common type of target illuminator is a laser, and is recommended due to its simplicity, low cost, and the diversity of lasing devices.

**3. 500 pound class warhead** able to kill personnel in the open, a traditionally constructed brick and mortar building, or a hardened bunker. This paper anticipates the Navy CPGS weapon being used relatively frequently to target high value terrorist meetings, and training camps, in areas where U.S. military personnel do not have safe access. The weapon also needs to be able to destroy traditionally built buildings and hardened bunkers. America's near-peer adversaries have learned that they can significantly increase the chance of surviving a U.S. attack by reinforcing structures, or by burying them underground. It won't be long until terrorist organizations come to the same realization. Additionally, the Navy CPGS weapon is likely to be used extensively in wartime, and needs to be able to destroy typical bunkers and hardened targets.

**4. Low Observable attributes in front, side, and rear aspects.** The design, materials, and flight profile of the Navy CPGS weapon must ensure it will survive to its target in an A2AD environment. This weapon will not be hypersonic, and cannot use speed and maneuverability alone to survive. Instead, this weapon must use an advanced LO design and materials to defeat advanced IADS.

Many of the attributes of the naval variant of the CPGS weapon are already met by the BGM-109 Tomahawk Land Attack Missile (TLAM).<sup>21</sup> The TLAM is a proven subsonic weapon with multiple warhead options, a re-targeting capability, and a 1,350 nautical mile maximum range. It is an ideal weapon for CPGS, except it needs a longer range, low observable attributes, and the ability to penetrate hardened targets.

The Navy identified these shortfalls, and on May 11, 2010 announced an Industry Day with DARPA to disseminate information about the ArcLight Program.

“The goal of the ArcLight program is to demonstrate a tactical, long range, time critical, boost/glide vehicle capable of carrying a payload of 100 lbs over 2,000 nm in less than 25 minutes. The boost/glide vehicle will be launched from a Mark 41 Vertical Launch System (VLS) capable booster stack. Development of the ArcLight vehicle will enable tactical, long range strike weapons capable of engaging time critical targets. There are currently 8,500 VLS tubes in the US Navy including Cruisers (CG-47), Destroyers (DDG-51) and submarines (SSN, SSGN).”<sup>22</sup>

The ArcLight program is promising for CPGS, but this paper recommends adding low observable attributes to the weapon, increasing its range, and increasing the size of the weapon's warhead. A CPGS weapon must be low observable and able to destroy a target in an A2AD environment. Additionally, a 2,000 nautical mile range would enable the ArcLight missile to

reach most global targets, but defeating advanced IADS will likely require maneuvering and varying flight profiles, which will decrease the weapons maximum range. Finally, a 100 pound warhead is too small to confidently destroy a target much larger than a pick-up truck or single room building. Modern explosives and warhead design will greatly enhance weapons effects, compared to older 500 and 1,000 pound weapons, but it is difficult to replace warhead mass with technology alone. Instead of using two or more ArcLight weapons to ensure target destruction, make the warhead larger.

The ArcLight program shows promise, but may not be the Navy's answer for CPGS. But, it is certain that there is a need for a Navy CPGS option, particularly with America's renewed interest in security in the Pacific. The need for this capability is reinforced by Defense Secretary Leon Panetta stating in January of 2012, that "the Navy will invest in a design that will allow new Virginia class submarines to be modified to carry more cruise missiles and develop an undersea conventional prompt strike option."<sup>23</sup> This does not guarantee that the CPGS weapon Secretary Panetta is referring to will be carried on other submarines and ships, but it is a good assumption.

## **Conclusion**

America needs the capability to destroy a target anywhere in the world within an hour. Threats to America are becoming more sophisticated, elusive, and deadly as rogue nations and terrorist organization make America their common enemy. Budget constraints, and the will of the American populous, will decrease the size of the U.S. military and reduce OCOs. But, this doesn't reduce the requirement of the military to defend America from foreign threats. Due to a shrinking military, reduced OCOs, and increasingly violent nature of international relations the U.S. needs a CPGS capability.

This paper describes a near and mid term option for obtaining a CPGS capability. In the near term, forward deploy and posture current forces in high-risk areas to provide an increased TST capability. The DOD also needs to focus significant effort on developing cyber tools for CPGS. The cost of developing, saving, and employing a cyber tool is significantly less than for a kinetic weapon. Substantial investment needs to be made into offensive cyber tools to compliment, and in some cases replace, CPGS weapons.

In the midterm, develop two CPGS weapons for the DOD; a hypersonic weapon for the Air Force, and a supersonic missile for the Navy. These weapons will increase America's global targeting capability, while providing a substantial deterrent to our enemies.

America is fortunate to not have a peer adversary in 2012, but changes in the global security environment are certain. Adding CPGS weapons to the inventory will provide additional response options for the National Command Authority, increase the security of the nation, and put fewer Americans at risk.

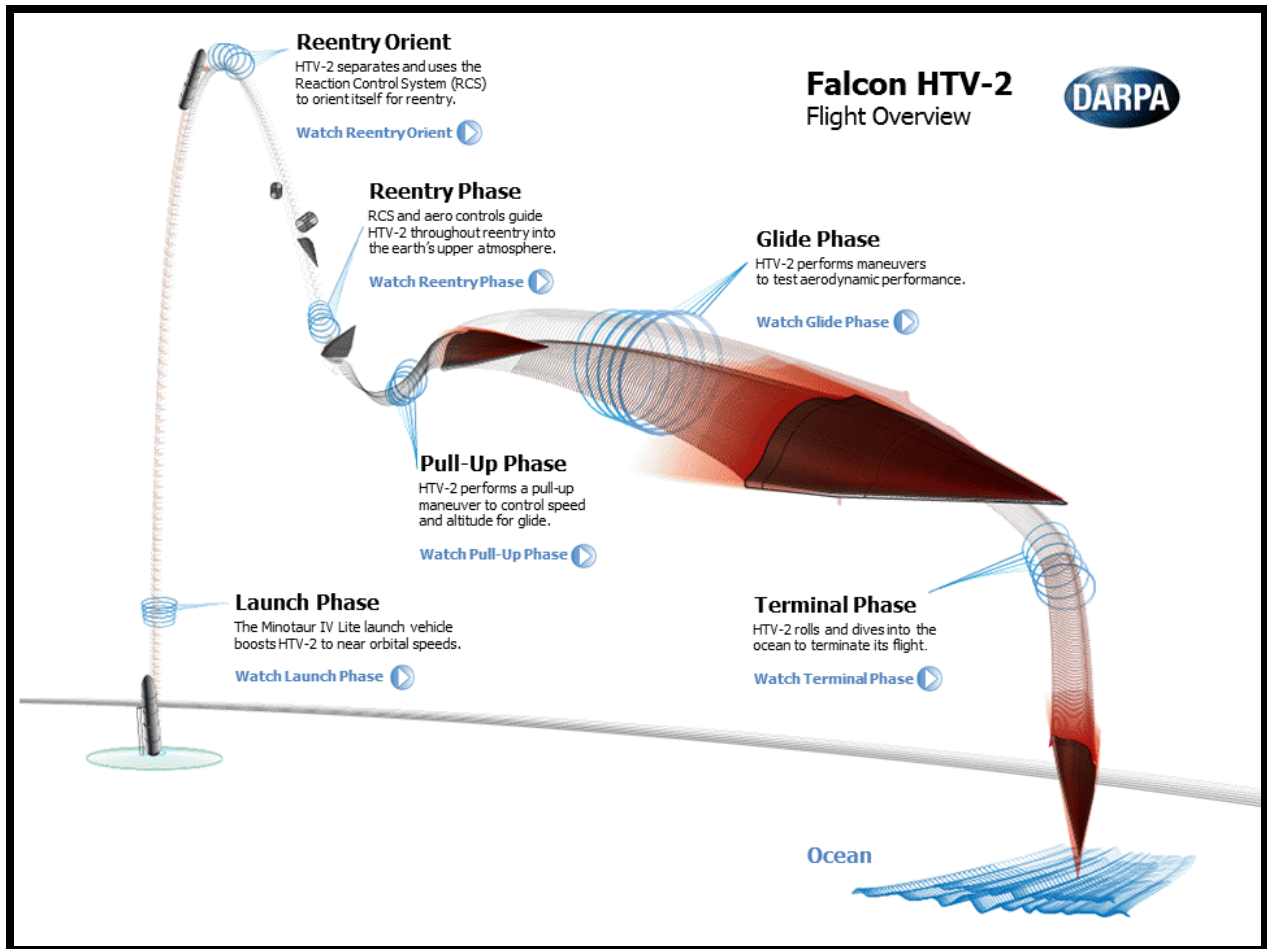


Figure (1) Falcon HTV-2 Flight Profile<sup>24</sup>



Map (1) World map with 2,500 nautical mile range rings<sup>25</sup>

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