Contributions of the Global Positioning System to Air Force Competencies

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Introduction

The Global Positioning System (GPS) program began in 1973 as a joint United States Air Force, Navy, Marine Corps, and Defense Mapping Agency (DMA) effort. The goal was development of a space-based, highly accurate navigation system. The enterprise has since gained the interest of the U.S. Army to become a full Department of Defense initiative. GPS achieved full operational capability with a complete constellation of satellites in 1994.

Only relatively recently, though, has the DoD begun to fully exploit GPS for the navigation of fixed-wing aircraft, helicopters, and precision-guided munitions (PGMs). Pilots still primarily use self-contained inertial navigation systems (INS) and ground-based radio frequency navigation aids for en route navigation, approach, and landing. Munitions are typically "free-fall" or guided through radar homing, radar image matching, laser-guidance, or electro-optics. Initial uses of GPS during Operation DESERT STORM and follow-on applications have shown such potential that the Air Force has in many ways become a "victim" of its own success in facing the promises and challenges of making the most of this technology.

In this paper we discuss the potential contributions of GPS in terms of the Air Force's newly defined six core competencies: Air and Space Superiority; Global Attack; Rapid Global Mobility; Precision Engagement; Information Superiority; and Agile Combat Support.[1]

We describe how GPS can be exploited to accomplish missions across the full spectrum of conflict: humanitarian operations, operations other than war, measured response, and general conflict. Although our approach is from the Air Force perspective of Global Engagement, this discussion applies to the larger U.S. Military's *Joint Vision 2010* and air power concepts in general.

The Potential of GPS for the Air Force

Like many military leaders, Gen. John M. Shalikashvili, Chairman of the Joint Chiefs of Staff, believes that many of the DoD's challenges can be met by exploiting existing and emerging technologies. GPS is one of the DoD's more apparent and publicized technological advances. For the Air Force, standoff precision capability, long-range delivery, and sophisticated command and

control networks are emerging as key "high-tech" capabilities in future warfare. It appears that technological advances will continue to enable this trend toward improved accuracy, greater responsiveness, and fuller control. In Gen. Shalikashvili's view, "*Global positioning systems and enhanced standoff capabilities will provide increased accuracy and a wider range of delivery options*."[2]

The Air Force has been the lead Service in joint development of GPS for more than two decades for good reason. In addition to being the "Service provider" of this highly accurate position, velocity, and time (PV&T) information source, the Air Force has, from the beginning, received far greater benefit from GPS than have the other Services. These benefits accrue at the

- *Strategic level of war*, at which the perimeters and constraints on the conduct of war are delineated
- *Operational level of war*, when the war is designed and planned to optimally achieve desired ends within the constraints defined at the strategic level; and,
- *Tactical level of war*, when the military forces are deployed and employed in the best manner for the achievement of an element of the operational design or plan.[3]

In the following sections, we address the most promising contributions of GPS to each of the core competencies as related to these three levels of war along the spectrum of conflict.

Air and Space Superiority—The Air Force must be able to control the airspace over friendly and hostile territory and defend friendly forces against air and missile threats. This Air Force competency is a critical enabler of military operations for joint and coalition forces because it provides freedom to attack and protection from attack. Air and Space Superiority is the precursor to dominant maneuver and the basis of full dimensional protection; it enables strategic attack as well as efficient logistics. Everything on the battlefield is at great risk without it. Historically, no country has won a war against an enemy who had air superiority nor did it lose a war having air superiority.[4]

On a modern battlefield, air superiority typically has the highest priority. Air Component Commanders aim for early air superiority by attacking enemy air defense networks, airfields, and aircraft in the air. GPS will make its greatest contribution to this air campaign "task" by enabling survivable precision standoff attacks in airfield attack missions and against integrated air defenses. GPS-guided munitions will be especially critical against the highest-lethality air defense systems. GPS-aided uninhabited air vehicles (UAVs) eventually may be able to support the offensive counterair role in high-threat airspace, where the risk to conventional piloted aircraft might be unacceptable.

On the battlefield of the 21st century, this prerequisite Air and Space Superiority mission will entail negation of not only the familiar problem of enemy air assets and surface-to-air defenses but also of enemy offensive tactical missiles as well. Tactical missiles loaded with chemical or biological agents would be in a position to neutralize otherwise dominant U.S. forces deploying to a theater. The Theater Air Defense (TAD) mission can be segmented into three sub-areas: passive defense (primarily reactive systems and procedures), active defense (surface-to-air and air-to-air destruction of incoming missiles), and attack operations (typically sorties against fixed

and portable missile launch sites). GPS will be a key contributor to the rapid response and flexibility required by TAD attack operations missions by virtue of responsive, high-fidelity geolocation and a common-reference "sensor-to-shooter" framework shared by reconnaissance, the intelligence community, C^3 nodes, platforms, and munitions.

Air superiority, in terms of the counterair mission, is not so much a strategic objective as an operational one. Effective use of UAVs in attack operations and airfield attack/integrated air defense system roles can free up assets for different manned Air Superiority missions. At the tactical level of war, GPS allows round-the-clock operation based on navigation and targeting in any weather and precise flight routing to exploit holes in enemy air defenses. It can enable long-range situational awareness, common reference for real-time C^3, and convenient redirection of air assets to targets. Additionally, GPS is very useful during low-altitude flight over featureless terrain, as reported by U.S. pilots in Operation DESERT STORM.[5]

Global Attack — The Air Force has to have the ability to find and attack targets any-where using the synergy generated by air and space assets. A major component of this competency is the ability to form rapidly de-ployable forces that are responsive and tailored to the lethal and nonlethal needs of a theater commander.

For protracted conflicts, the Air Force's challenge is to be able to prosecute air campaigns that provide the United States the necessary regional leverage. Squadrons will need to complete several daunting tasks simultaneously:

- Hold all high-value, highly defended targets at risk from the start of hostilities;
- Blunt enemy armored spearheads and saturate target complexes; and
- Penetrate heavily fortified targets to destroy the capacity for mass destruction.[6]

For instance, when Iraq moved 70,000 troops and 1,000 tanks to the Kuwaiti border in October 1994, several days elapsed before we responded. In this time, Iraq could have retaken Kuwait and advanced on the Saudi oil fields and population centers. The Air Force Global Attack competency calls for an Air Force that can contain enemy advances until other forces are deployed.

In the information age, the ability of an adversary to achieve large-scale strategic surprise is increasingly difficult. On the other hand, lower level crises may develop rapidly, and critical engagements may occur that do not provide the opportunity to prepare. In either case, the ability to assess global events and respond can be leveraged to great advantage by expeditionary forces using GPS. Operation DESERT STORM Air Component Commander Gen. Charles Horner underscores this point by saying "*...surprise provides the attacking side such enormous military leverage, we must assume that any future U.S. adversary is likely to do everything possible to mount 'a bolt from the blue' attack. History shows that no matter how much you spend on intelligence, you will always be vulnerable*." [7] The Air Force's Global Attack competence means a hedge against surprise attack and provides quick reaction if needed.

Another example of Global Attack as a core competency is the ability to execute limited forces raids. The focused strike against Libya in March 1986 was designed to directly hit Libya's ability

to export terrorism. Global attack is the "stick" for restraining rogue states and state-tolerated terrorism. In crisis scenarios, the Air Force needs the Global Attack competency in order to respond quickly, independently, and with the appropriate force[8] to decisively affect a typically fast-evolving situation and hopefully preclude escalation.

GPS's contribution to Global Attack stems from how it enables decisive targeting options on the battlefield. As Gen. Fogleman put it, *"in the near future, it will become possible to find, fix or track, and target anything that moves on the surface of the earth."* To effectively exploit this capability the Air Force needs Global Awareness; i.e., an affordable means to derive appropriate information about one or more places of interest after a delay that is short enough to satisfy operational needs.[9]

It has been possible for some time to build space-based observation platforms that can provide optical or radar images with a resolution of less than one meter. To integrate this capability with a global map requires calibration, which can be devised by means of GPS. This is the essence of the synergy between space and air assets: space sensors find the image of the target, identify its coordinates, and transmit them to the intelligence community or even directly to attacking aircraft. The aircraft may use GPS to fly to the target and destroy it or, more likely, feed the information to a standoff weapon that gets to the target using GPS-based guidance and control.

For Global Attack, the advantages of GPS technology accrue at all levels of war. From strategic warning and contingency planning; operational campaign planning, information dissemination, and C^3; to tactical execution, GPS-based PV&T information will be at the heart of the underlying technologies.

Rapid Global Mobility **—** The Air Force must ensure the capability to rapidly bring forces, hardware, and supplies for combat operations, peacekeeping, or humanitarian operations to any point on the globe. Air Force tankers must be able to rapidly respond to unexpected challenges to U.S. interests around the globe by supporting deployment of expeditionary fighter, bomber, and airlift assets. Airlift must be ready to deliver initial and sustainment quantities of precision munitions, personnel, consumables, spare parts, and support equipment to sustain in-theater operations at high sortie rates. And, in an increasingly common hu-manitarian mission, airlifters must be ready and able to deliver relief in times of crisis.

This responsive posture will not occur in isolation. Airspace congestion and safety are significant challenges to the U.S. Air Force in an environment of explosive growth in air traffic. For instance, in 1996 U.S. air carriers alone carried approximately 550 million passengers. The Federal Aviation Administration (FAA) predicts that in the next two decades this traffic will grow to 1.2 billion passengers per year. In some parts of the world air traffic will grow at a much faster pace driven by economic growth, relatively low fuel prices, lower air-line operating costs, and efforts to catch-up with the industrial world.[10] The world's skies are busy places now and will become much busier in the future.

Fortunately, technologies are now available to substantially ease the problem of busy skies and make air traffic more effective, more economical, and safe. Again, the most fundamental of these enabling technologies is GPS. It is at the core of a revolutionizing technological package forming

the concept of Communications, Navigation, Surveillance, and Air Traffic Management (CNS/ATM). In the words of FAA Administrator David Hinson, *"Think about this: We could taxi out in zero-zero weather, take off, go to our destination, land in zero-zero weather, taxi to the terminal, all with GPS. It has huge potential applications."*[11] Consequently, the FAA has embarked on an aggressive program to make satellite-based navigation technology available for use throughout the National Air Space (NAS). More recently, Vice President Gore's Commission on Aviation Safety and Security published its recommendation that upgrades to the NAS be fully operational by 2005.

The FAA sees GPS-based navigation as enabling better situational awareness, extending automatic dependent surveillance-based air traffic management concepts to oceanic and remote air space, and allowing phase-out of most radar-based surveillance systems currently in use. GPS-based navigation benefits accrue because GPS enables greater safety, operational simultanaity, and efficiencies.[12] The FAA is not alone in its commitment to GPS-based navigation. The International Civil Aviation Organization (ICAO) and various regional and sovereign Civil Aviation Authorities are also on board the CNS/ATM groundswell of activity.

To fly in controlled air space and to use civilian airports the Air Force will have to comply[13] with the new reality that is designed to evolve into free flight.[14] Air Mobility Command (AMC) now speaks in terms of the costs of noncompliance, though difficult to quantify. In day-to-day operations, it is not unreasonable to estimate a potential doubling in airlift operating costs caused by nonoptimum routing, higher fuel consumption, shorter range, and additional sorties.

Routine operations, though, are only part of this noncompliance cost. In a contingency scenario, AMC may anticipate various Air Traffic Control delays and inefficiencies, including nonoptimum routing to the theater of operations. In a typical scenario, aircraft would use 20-30% more fuel to reach the theater at nonoptimal en route altitudes. Arrival of required force structure would be delayed. If one-way flight times to Southwest Asia increased by as much as 1 hour, it would take approximately 10 extra days to make up the tonnage shortfall that would accrue after the first 92 days of a res-ponsive airlift surge. Representative Major Regional Conflict (East) scenarios require a 30-day surge throughput. If the military and Civil Reserve aircraft were noncompliant, one Air Cavalry Brigade and three F-16 Wings would not be delivered on time.[21] As AMC Commander Gen. Kross put it, *"We can not afford any additional friction in time of crisis."*

Getting to the theater, though, is only part of the Global Mobility equation. Contingency timelines usually preclude availability of sophisticated approach and landing systems at forward airfields. Air Force aircraft will be asked to land at and take off from austere airfields day or night and in any weather.

In addition to en route navigation and austere field operations, another major element of Rapid Global Mobility is the employment and resupply of forces through aerial delivery of troops and equipment, or airdrop. This capability directly supports JCS options in immediate-response scenarios. GPS will be an effective force multiplier for these operations because of its precision and timeliness advantages. The Air Force Scientific Advisory Board envisions a future precision airdrop system that will include *"accurate aircraft and target location (precision GPS),*

knowledge of wind profile, and knowledge of aerial delivery system flight characteristics."[15] Near-term GPS-based precision airdrop technologies being developed in the Air Force's Wright Aeronautical Laboratories are expected to improve accuracies by at least 50% in strategic, tactical, and humanitarian relief operations.[16]

GPS's major contribution to combat or humanitarian air operations by enabling precision approaches, landing, and airdrop without recourse to ground-based navigation aids is obvious. On the strategic level of war, GPS in Global Mobility empowers the lean insertion of U.S. rapid deployment forces and effective resupply and transport of reinforcements to maintain a high tempo of focused or large-scale military operations with minimal exposure. As forward-deployed forces become fewer than in past engagements, increased mobility is needed to build "air bridges" for joint forces, enable multinational peace efforts, and speed tailored support to forces already on the scene. On the operational level, the planning of an air bridge is substantially easier when GPS provides the exact position and velocity of all assets, decreases en route time, and increases the chance of each sortie's successful completion. Tactical details such as opportunity aerial refueling, in-flight redirection of resources, airdrop orchestration, and precision approach and landing are simplified.

Precision Engagement **—** The Air Force must have the capability to apply selective force against specific targets to achieve discriminant and decisive effects. Application of force in measured but effective doses is efficient and avoids undesirable collateral damage.

Air warriors have long considered precision in ordnance delivery as the ideal, and they have often gone to great risk to achieve this goal. In the age of instant visual telecommunication, Precision Engagement has become even more imperative because of high expectations for tangible evidence of success and sensitivity to collateral damage and loss of life on both sides. Technology has now made this competency a new hall-mark of the Air Force. In the past the Air Force measured how many aircraft would be needed to destroy a single target. Now the Air Force can look at how many targets a single aircraft can destroy. A new Air Force paradigm of reliable precision is emerging in which virtually every bomb dropped must be accounted for. Gen. Fogleman aptly described this situation by saying, *"For many years our vision of what precision employment could accomplish outpaced our technological capabilities, but we have made great strides in this area. Today, and in the future, our forces will be more effective, at day or night, in good weather or bad, whether delivering food or lethal ordnance."*[17] As discussed in the section on Global Mobility, even airdrop can now be addressed as a form of Precision Engagement.

A great deal of operational synchronization must precede the culminating point of Precision Engagement scenarios. An air attack that is very dispersed en route, extremely synchronized and concentrated over the targets, and very dispersed on escape has the best chance of achieving the desired surprise and effect. GPS enables precise approaches to C^3 nodes and enemy airfields by exploiting the weakness at the "seams" of an integrated air defense system and provides the opportunity to conduct air operations in any kind of weather. To orchestrate such an attack would require that aircrew and battle management centers know precise position, speed, and time for routing and waypoint arrival times. These parameters are available through GPS. If such an attack is launched from the CONUS or other remote locations, attack aircraft must be aerially

refuelled.[18] Again, position, velocity, and time provided by GPS enables efficient and high-reliability marshaling to enhance operational security.[19]

At the point of attack, precision engagement relies on precision geolocation. The ability to find, track, and identify targets anywhere on the globe at any time is revolutionizing warfare and necessitating new and flexible thinking on operational concepts and doctrine. Andrew Marshal, head of the DoD Office of Net Assessment, says that the future battlespace will be a *"Nintendo-style battlefield where there is a competition between hiders and seekers rather than a decisive clash between large ground armies. Satellites and other sensors will provide a 'God's eye' view of the battlefield, and a new generation of long-range precision weapons, guided by signals from Global Positioning System satellites, can strike within feet of targets regardless of weather or time of day."*[20] Such precision engagement requires munitions with a variety of characteristics: accuracy, adverse weather capability, standoff, autonomous guidance, and independent targeting.[21]

To fully realize the aim of an entire combat aircraft fleet capable of launching large numbers of next-generation PGMs, the Air Force will need a timely supply of highly accurate target coordinates. For preplanned PGM missions, targeteers determine from imagery the precise impact point to satisfy the mission objective. Today, these impact points are centrally generated by the National Imagery and Mapping Agency (NIMA, previously Defense Mapping Agency) through its film-based Point Positioning Data Base (PPDB) at its St. Louis facility. This is a manual, limited throughput process applicable only to fixed targets.

PGM developers speak of an "error budget" spread across guidance and control error, target location error (TLE), and the weapon's positional self-awareness error when attempting to meet Circular Error Probable (CEP) goals. When GPS is integrated into sensors, PGMs, and NIMA's new Digital PPDB, both TLE and errors in the weapon's self-positioning can be reduced. GPS accuracy means the weapon knows where it is, and high-resolution surveillance feeding target libraries and automated targeting systems will reduce TLE, contributing to precision delivery.

A RAND study concludes that *"The combination of low-cost guidance, day-or-night capability, and all-weather operation makes GPS-based precision guidance an attractive option for delivering future air-to-surface weapons."*[22] Similarly, the Air Force Scientific Advisory Board unambiguously states, *"Accuracy, reliability, and cost considerations dictate a discipline of delivering a weapon to a particular set of coordinates using GPS/Inertial guidance, if possible."*[23] Developmental tests of this concept have been impressive. Although vulnerability to jamming can be a concern with either direct-to-weapon or via-aircraft signals, GPS is an effective PV&T source for either preplanned targets or in-flight targeting.

Strategically, GPS provides National Command Authorities (NCA) with viable deterrence and controlled, timely, and low-risk Precision Engagement response options on a global scale. In larger scenarios, GPS-founded Precision Engagement can result in early theater-wide operational dominance by targeting "center of gravity" targets such as weapons of mass destruction capabilities, C^2, and air defenses at the outset of the conflict, preparing the battlefield for more massive joint operations and enhancing the probability of quick termination. Rapid, surgical response and protracted campaigns alike require every sortie and every weapon to count,

considering today's smaller force structure. The improvement in the accuracy of existing munitions afforded by GPS makes this requirement achievable.

Operationally, GPS holds the poten-tial to shorten mission planning time through faster Air Tasking Order (ATO) cycling. This ability leads directly to sustained round-the-clock all-weather operations, fewer weapons needed, reduced attack package size, and consequently less risk to crews and platforms. More assets may be available for short-response missions, including in-flight opportunity retargeting.

On the tactical level, GPS enables fire-and-forget operation, covert and passive (nonradiating) guidance, and single-pass multiple releases from safe standoff distances. Aircrew workload is reduced, and situational awareness is increased. Confidence in greater weapon accuracy allows less collateral damage, bolsters battle damage assessment, provides new close air support options, and reduces the need for reattack, allowing more dynamic and aggressive tactical planning.

In total, GPS means increased combat power available for use against selected objectives, resulting in enhanced economy of force and a higher tempo of operations. GPS makes a major contribution to accu-racy, firepower, and flexibility.

Information Superiority **—** The Air Force must have the ability to handle the massive quantities of data required by today's joint forces and to properly interpret rapidly changing developments. As the executive agent for Battle Management/Command and Control, the Air Force is chartered to integrate all the technological components that are necessary to provide the joint force commander of the 21st century with an overall picture of the battlefield, including air, space, and surface forces. It has to provide global awareness, intelligence, communications, weather, and navigation support.

Battlefields are evolving such that the power of the byte outstrips that of the bayonet. But like a bayonet, the byte is "double edged." Well-managed data could ease friction, chance, and uncertainty, the *fog of war* so prevalent on a battlefield. On the other hand, data running rampant carries the certain danger of increasing that fog and friction. Instead of massed forces and firepower, the United States will have to increasingly rely on information technology to outmaneuver the enemy, identify positions precisely, quickly coordinate force movements to create a local advantage, and attack decisively, while putting relatively few American lives at risk. The aim of information dominance is to create an awareness differential significant enough to give U.S. and coalition forces the winning edge. In effect, the deciding influence in a conflict is shifting from bombs to information.[24]

The extraordinary advances now taking place in computer technology, sensors, and communications — coupled with new ideas on military structures, warfighting doctrine, and battlefield tactics — are leading toward a revolution in the conduct of warfare. These technological advances, however, rely significantly on computer processing. Information warfare consists of protecting our critical computer systems and disrupting those of the enemy. In this endeavor, the United States is striving to integrate space technology with its information-based

warfare capabilities, to establish information dominance of the battle space. A parallel effort will be directed at denying, disrupting, and influencing the enemy's perception of the battle space.

GPS is generally considered to be a global information utility. The Air Force Scientific Advisory Board considers GPS one of the enablers of a coordination system based on information systems technology. GPS will provide a universally accurate and available time standard that enables time alignment between geographically disparate activities.[25] Because of this central role played by GPS, its vulnerabilities to jamming and prevention of adversaries' use become issues in information warfare.

As the accuracy, response time, and miniaturization of GPS user equipment has improved, it has become practical to employ GPS transceivers for sensing the pitch, yaw, and roll of an aircraft and transmitting this attitude information to a UAV's off-board pilot.[26] UAVs could be deployed deep in enemy territory to support real-time, high-resolution intelligence and communications relay. GPS-equipped UAVs could provide geolocation of fixed targets and set up immediate response against short-dwell missile launchers, in the case of TAD attack operations. For example, the Air Force is considering the possibility of arming the Global Hawk high-endurance UAV. If armed with Low Cost Autonomous Attack System (LOCAAS) (GPS/INS-guided smart submunitions using laser radar and automatic target recognition systems), a UAV will be able to locate, identify, and destroy targets such as Scuds and missile transporter, erector, and launcher systems.[27]

Information Superiority is closely related to Global Awareness, which in turn rests solidly on GPS, the Global Broadcasting System (GBS), and sophisticated on-board computing and data storage capabilities. The Air Force Scientific Advisory Board clearly realized the crucial role of GPS when it found *"Almost all of the processes related to Global Awareness need precise and absolute positioning and timing. The most reliable and least expensive way to provide it is through a space based Global Positioning System (GPS)."*[28]

GPS is an example of information systems technology that enables on the strategic and operational levels a coordination, planning, and execution system that can be continuously, horizontally, and vertically integrated through committed forces and their command structure. On the tactical level the resulting information superiority enhances situational awareness and execution against targets of opportunity.

Agile Combat Support — Agile Combat Support is the ability to move air assets and the required support and supplies quickly and without strain. It is about timeliness: thinking, planning, scheduling, and communicating, and acting faster than the enemy can effectively react. It means operating at a higher operational tempo than the enemy's and enlarging the range of our options while limiting those of the enemy.

The Air Force must organize its ground support activities so that air and space power becomes more expeditionary and consistently available as the instrument of choice when the nation's leadership decides to engage quickly and decisively anywhere on the globe. This competency also includes continued support of deployed forces in the absence of massive prepositioned inventories. In addition to logistics (consumables, spares, support equipment, and technicians),

the transportation system must provide the security police, engineering, and other combat support functions.

Agile Combat Support can be characterized by deliberate, "just-in-time" resupply that starts at the deployed forces' time of arrival to reduce initial lift requirements. The Air Force will put into place an effective reach-back procedure to supply in-theater forces with whatever is needed from CONUS or forward bases. Exposure to combat risks will be reduced by minimizing the logistics tail. Responsiveness will substitute for vast deployed inventories.

On the margin, GPS can be leveraged to improve the command and control needed to track critical elements of support. Combat support typically bounds a campaign's operational limits. Information technology that is now increasingly reliant of GPS-based timing and positional reference is a vital key to Agile Combat Support. In short, GPS can expand the traditional limits of logistical support. For instance, it is now possible to attach GPS transponders to high-value assets that are typically part of airlifted payloads. Pallets and major pieces of equipment can be constantly monitored for position and progress toward their destination.

GPS's fundamental contribution to Agile Combat Support, however, is that it reduces demand for that support. Because GPS increases the efficiency and effectiveness of engaged forces and the viability of all-weather pipelines to austere locations, the root cause is treated, not merely the readily apparent combat support "symptom."

Thus, on the strategic level of war, GPS contributes to readiness, freedom of action, and timely response. At the operational level, GPS enables combat commanders to increase deployability, lessen in-theater vulnerability, improve force generation, and raise the overall sustainability of tailored forces.

Conclusion

The new Air Force competencies are the consequence of an evolving reality of Global Engagement. As Air Force Secretary Sheila Widnall pointed out recently, *"the old Global Reach, Global Power vision had taken us to the edge of the immediate post-Cold War map. The technology and potential of GPS has a definite place in the service's new Global Engagement vision as explained in the six core competencies. This place can be evidenced by widespread contributions to all three levels of warfare and along the full spectrum of conflict."*

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