

GPS: A military perspective

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Abstract

Accurate and to date information on the location of enemy and own forces is one of the most critical information a military commander seeks. In today's fast paced electronic battlefield such information if disseminated timely can act as a major force multiplier. As the realms of technology have extended right into space, its use has become a powerful tool for the world for both civilian and military purposes. Global Positioning System (GPS) is one such technology. Military forces the world over are using GPS for diverse applications both during wartime and peacetime. These include navigation, targeting, rescue, guidance and facility management. One such arm of the military is the artillery. Today the artillery has not only emerged with longer range but also with precision shelling. This paper is an attempt to look into the application of GPS in artillery

Introduction:

Origin of GPS

The **Navigation Satellite Timing And Ranging (NAVSTAR)** GPS was developed by the US Department of Defense (DoD) as a worldwide navigational and positioning resource both for military and civilian uses. The system is based on a constellation of twenty-four satellites in six orbits (Fig 1) acting as reference points for receivers on ground (Hurn, 1993).



Fig.1: Image showing orbits of various GPS satellites.

For the Military use any system to be used must possess certain basic criteria's, these are Accurate, All Weather, Easy to use and have to be Portable.

Accuracy of GPS may vary from few meters to few tens of meters, which meets the military needs for navigational purposes. However, for precise location of targets for aerial bombings, missile strike etc accuracy to a level of mm is required. This can be achieved through Differential GPS (DGPS). Nevertheless to achieve this level of

accuracy, proper error modeling is necessary. The GPS satellite signals are also not affected to that extent due to bad weather as conventional terrestrial radio signals. This is an important requirement, as military forces need all weather navigation systems. Most of today's GPS receivers are quite easy to use and give the position in both the geographical latitude and longitude and the local map projection system coordinates besides providing data in WGS-84 coordinate system. Moreover over the years, the GPS receivers have also drastically reduced in size and weight, and thus become more portable. For example, today wristwatches commercially available off the shelf have GPS receivers built in them.

Use of GPS in Artillery:

Artillery is King of the Battlefield. Today the artillery needs to have longer range, should fire with precision, using minimal ammunition to cause maximum destruction.

Artillery has remained and will probably continue to remain the backbone of the infantry. Artillery guns vary in size and range. They have a basic function to create damage to an extent that either destroys the enemy target or creates a fear to destroy the enemy moral.

The basic functions of artillery are as follows;

1. Target Damage Criteria

Target damage is the effect of fires on a given military target. It results in total, partial, or temporary loss of the target's combat effectiveness. The categories of target damage are annihilation, demolition, neutralization, and harassment.

2. Annihilation: fires make unobserved targets combat-ineffective, needing major construction to be usable. For annihilation or neutralization missions against fires as many (or as few) rounds as necessary for the observer to indicate that the target has sustained the required amount of damage. For unobserved fire, a general table of ammunition expenditure norms is used as the basis for artillery fire planning. For area targets such as platoon strong points or nuclear artillery assets, they must fire enough rounds to destroy from 50 to 60 percent of the targets within the group. These fires result in the group ceasing to exist as a fighting force.

Demolition refers to the destruction of buildings and engineer works (bridges, fortifications, roads). Demolition requires enough rounds to make such material objects unfit for further use. It is a subset of annihilation.

3. Neutralization fire inflicts enough losses on a target to-- Cause it to temporarily lose its combat effectiveness; Restrict or prohibit its manoeuvre; Disrupt its C2 capability. To achieve neutralization, artillery must deliver enough rounds to destroy 30 percent of a group of unobserved targets.

4. Harassment uses a limited number of artillery pieces and ammunition within a prescribed time to deliver harassment fires. The goal of these fires is to put psychological pressure on enemy personnel in concentrated defensive areas, command posts, and rear installations. Successful harassment fire inhibits manoeuvre, lowers morale, interrupts rest, and weakens enemy combat readiness.

5. Counter-battery Fire accomplishes the neutralization or annihilation of enemy artillery batteries. Combat with enemy artillery is one of the artillery's most important missions. It enables ground forces to achieve fire superiority on the battlefield. Combat with enemy artillery requires more than counter-battery fire. It requires the destruction of

C2 centers as well as artillery. It also requires the cooperation of other ground combat arms and aviation.

6. Manoeuvre by Fire occurs when a unit shifts fire from one target, or group of targets, to another without changing firing positions. This is a combined arms concept in which the artillery plays a critical role. Manoeuvre by fire masses fires on the most important enemy installations or force groupings. Its intention is to destroy them in a short period of time or to redistribute fires to destroy several targets simultaneously.

With time conventional artillery has changed. It is no longer a single shot of various calibres fired just to support the infantry. Today the Artillery works on the principle of “**AC4IS - ARTILLERY CORPS COMMAND, COMMUNICATION, CONTROL AND INTELLIGENCE SYSTEM**”. To acquire this it involves use of integrated system like the artillery fire control system **ART SYS 2000**, which is designed for field artillery fire control in accordance with the tasks of modern war management. The system is interoperable with the **Command Information Systems (CIS)** of joint forces. ART SYS 2000 is a complete system, battle proven. It comprises all equipment needed for accomplishment of artillery tasks, ranging from observer's instruments and Fire Direction Center (FDC) to fire positions.

ART SYS 2000 includes digital communications and differential GPS (D-GPS) technology. ART SYS 2000 enables the fast reaction time of artillery units, with firing accuracy, optimal efficiency, and minimal use of ammunition and ease of operation. This is achieved by using the most recent technologies and their integration into the system. The GPS equipment that works in real time differential mode (D-GPS) is integrated into the system. This means that the GPS base station (B-GPS) is also an element of ART SYS 2000. B-GPS broadcasts differential correction messages to the GPS receivers of observers and fire positions.

The typical accuracy of coordinate measurement using D-GPS in ART SYS 2000 is 2m to 5m within the time interval of one to three minutes. The coordinate measurement is soldier friendly and in the case of self-propelled artillery is fully automated. The new D-GPS generation has even better accuracy: less than one-meter in less than one minute of measuring interval.

AC4IS supports entire artillery corps with the information and communication infrastructure, thus improving its efficiency through all levels of command in combat tasks. This support includes:

- Decision making
- Command issuing
- Communication
- Artillery fire control

We are proud that our army possesses one of the Gun. It is the “**Archer FH77 BW L52 Self-Propelled Howitzer**” made in Sweden. The gun is a 155mm 52-calibre gun. The weapon is equipped with a fire control system, laying system and inertial navigation and a muzzle velocity radar. Data from the radar is downloaded to the onboard computerised fire control system. The howitzer has a continuous fire rate of 75 rounds an hour, an intensive fire rate of 20 rounds (i.e. a full magazine) in 2.5 minutes, and a salvo fire rate of three rounds in 15 seconds. The **MRSI capability, multiple round simultaneous impacts**, is up to six rounds. Direct-sighting can be used for target ranges up to 2,000m.



Bofors in Action During Kargil War. (<http://vayu-sena.tripod.com/>)



The FH77B Bofors (<http://www.rediff.com/>)

Munitions: As with the guns, which were become more versatile and powerful, there was also a need to develop munitions that were accurate and precise. Such munitions in form of artillery shells ought to have internal guidance systems to make artillery barrage using least number of shells with precision, thus causing maximum damage. These were the smart shells of new generation. Field artillery is used nowadays for indirect fire. Indirect fire can be subdivided into observed and predicted fire. In the case of predicted fire, the fire is delivered without adjustment so that all known corrections are applied beforehand; since there is no requirement of target visibility, it is an effective means of engagement but the prediction accuracy is critical to achieve maximum surprise. Today most field artillery pieces have a barrel size between four and six inches (100 to 155mm). With increasing size of the guns with large calibres the problem was of hitting the target. Artillery shells are affected by altitude, humidity, wind, temperature, state of bore wear, the angle of the ground the gun is sitting on, and the gun's relative elevation

relative to the target. Barrel wear changes muzzle velocity which affects range enough that during World War II British gunners sought to calibrate their guns every third day. Hitting anything requires many computations and precise work. These shells often have internal and inertial guidance systems making them more accurate. An artillery shell comprises of a payload, a guidance system including a radio receiver and an antenna array coupled to the radio receiver.

The first generation of such smart shells was developed back in the 1980s, the 155mm Copperhead round was developed, at great expense, to take out tanks with one shell. The Copperhead was laser guided. That is, it homed in on laser light that a forward observer, with a laser “gun”, was creating by pointing the laser at the target.

The new generation shells are that of “The Excalibur shell”, which are in use by the US army and was tested widely during the Iraq war. This shell uses GPS guidance. and lands a shell within 30 feet of the target. Actual tests have shown the shells will land within half that distance. The army wants this kind of accuracy for fighting in urban areas, and to reduce the number of shells needed to destroy a target.

The third generation smart shell is also in development. This is the Projectile Guidance Kit (PGK), which is actually a large fuze that screws into the front of a 155mm or 105mm shell. This longer “fuze” contains a GPS and small fins to guide the shell to a precision hit equal to an Excalibur shell. These shells weigh between 15 and 45kg, and can accurately strike targets up to 50km away.

SMARt 155 is an intelligent, effective and robust fire-and-forget artillery shell. It consists of a thin-walled carrier shell with an expulsion unit and two sub-munitions. Each sub-munition contains an orientation and stabilisation unit with, despin flaps and auto-rotating parachute; multi-mode sensor-fuze system with MMW radar, MMW radiometer, IR sensor, signal-processing unit and power supply; and an explosively formed penetrator (EFP) warhead with heavy-metal liner.



XM982 Excalibur 155mm Precision Guided Munitions (www.shipbucket.com)

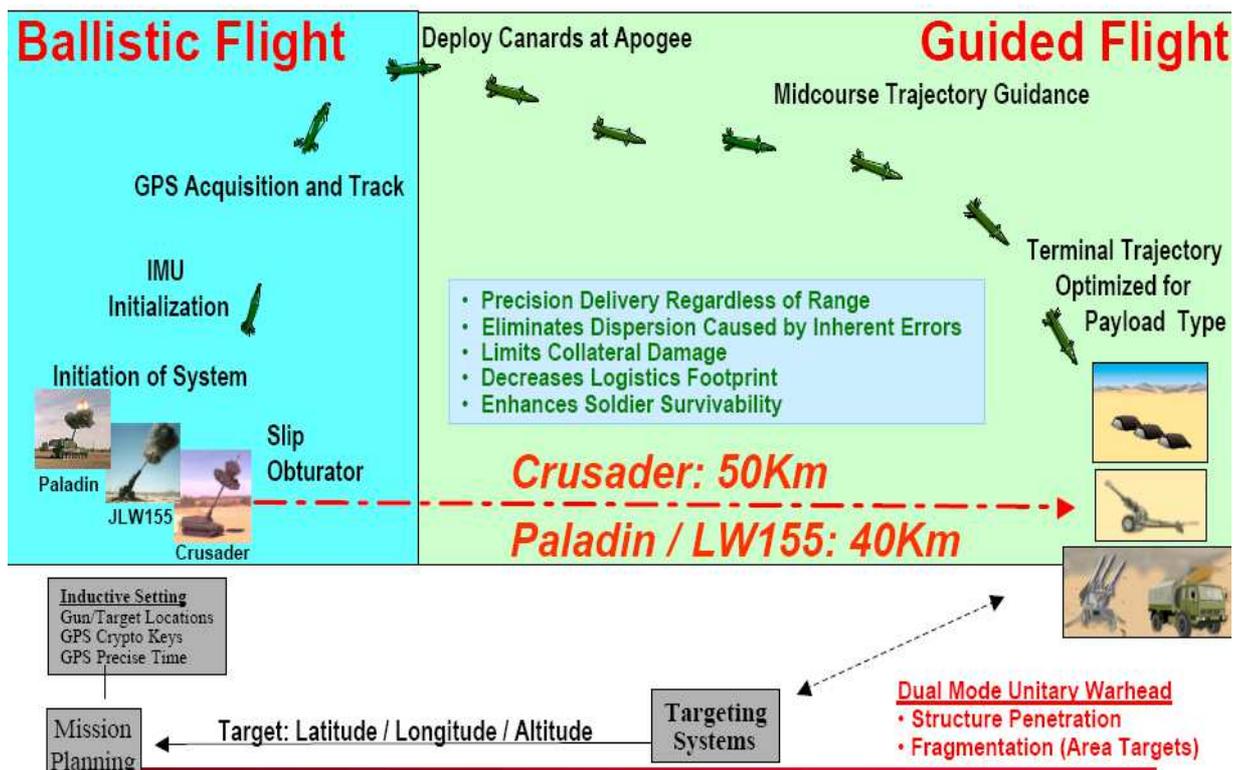
SMARt is fired using the same guns, firing-tables and procedures as in-service improved conventional munition (ICM). After ejection from the shell, the multi-mode sensor system scans the target area in a spiral pattern. The sensor system is designed to cope with outer-measures and camouflage of targets, ensuring unabated detection performance against combat vehicles.

Immediately after target detection the EFP warhead is fired, forming a fin-stabilised kinetic energy penetrator that travels to the target at multi-sonic speed and penetrates the

target from the top. Because of its superior penetration performance, SMARt 155's primary targets are main battle tanks but armoured fighting vehicles such as self-propelled howitzers, rocket launchers, armoured personnel carriers and air-defence units also are detected and defeated. The SMARt 155 EFP warhead uses a single-fragment, heavy-metal penetrator with unmatched penetration performance and behind-armour effectiveness. For special requirements a multi-fragment war-head is available.

A battery of M109 Howitzers firing SMARt 155 will defeat a reinforced tank company of heavily armoured main battle tanks in less than 15 seconds with only one volley from each gun. A battery of PzH 2000 will do the same in less than 10 seconds at extended ranges with little more than one minute operating in the firing position.

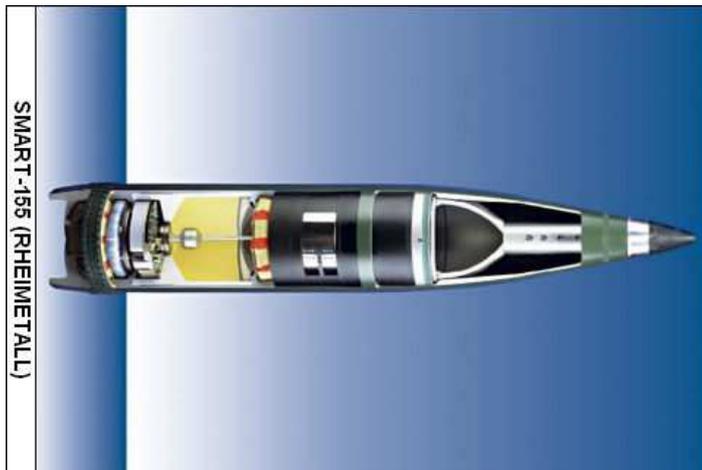
Cargo shells with smart submunitions. The US Army worked with Aerojet to develop such an munition with the designation of "M898 Sense And Destroy Armor (SADARM)". SADARM consists of two submunitions in a 155-millimeter shell. As the shell descends into the target area after launch, it ejects the two submunitions, which then release a ballute to stabilize themselves, and finally release parachutes to slow their descent. Each submunition carries an infrared and a millimeter-wave sensor, and as the submunition descends it scans the area below it for the signature of an armored vehicle. On targeting an armored vehicle, the submunition fires an explosively-formed projectile into the thin-skinned top of the vehicle.



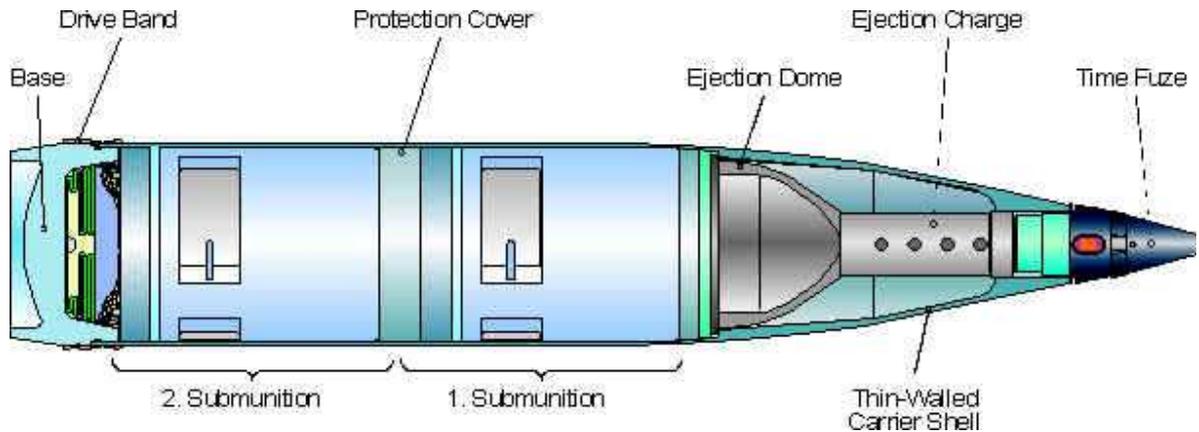
XM92 Excalibur Operational Sequence.



Raytheon Guided Projectiles (<http://www.dtic.mil/ndia/2002gun/hartline.pdf>)



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