GPS AND WEAPON TECHNOLOGY METHODS FOR MISSILES: AN OVERVIEW

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Abstract-*This paper focused on use of GPS technology and Relative GPS/ATACMS Scenario. We have also looked at Relative Techniques Employing Ground-Based Receivers. The missile can be guided by a number of ways for example by using radio waves, infrared, laser and by using GPS and INS. Radio waves are used when missile is guided by a human operator or by using radar system. Infrared is used to guide the missile when target emits thermal energy. With the help of infrared thermal energy emit by the target which is detected, then missile is guided by following heat produce by the target. Laser guidance works by pointing laser on the target, then missile is guided by following laser beam. Finally we have also discussed the advantages and difficulties in GPS based weapons.*

Key Words*: *Global Positioning System (GPS), Inertial Navigation System (INS), Precision-Guided Munitions, Army's Tactical Missile System (ATACMS), Missile control.

1.INTRODUCTION

The Global Positioning System (GPS) is a satellite based navigation system offering precision navigation capability. Originally designed for military use, civilian access has been permitted to specific parts of the GPS. The GPS signal is available 24 hours per day throughout the world and in all weather, conditions.

A precision-guided munition (PGM, smart weapon, smart munition, smart bomb) is a guided munition intended to precisely hit a specific target, and to minimize collateral damage.

Because the damage effects of explosive weapons decrease with distance due to an inverse cube law, even modest improvements in accuracy (hence reduction in miss distance) enable a target to be attacked with fewer or smaller bombs. Thus, even if some guided bombs miss, fewer air crews are put at risk and the harm to civilians and the amount of collateral damage may be reduced.

Looking back into the history of rockets and guided missiles, we find that rockets were used in China and India around 1000 AD for fireworks as well as for war purposes. During the 18th century, unguided rocket propelled missiles were used by Hyder Ali and his son Tipu Sultan against the British.

The Soviet Union launched the first man-made satellite, Sputnik 1, in 1957. Two American physicists, William Guier and George Weiffenbach, at Johns Hopkins's Applied Physics Laboratory (APL), decided to monitor Sputnik's radio transmissions.

2. GPS

GPS determines the position of the user by triangulation/ trilateration. Knowing the position of the satellite and the distance from the other satellite; combinations of satellites can be used to determine the exact position of the receiver. A GPS receiver uses trilateration (a more complex version of triangulation) to determine its position on the surface of the earth by timing signals from three satellites in the Global Positioning System.

The GPS is a network of satellites that orbit the earth and send a signal to GPS receivers providing precise details of the receiver's location, the time of day, and the speed the device is moving in relation to the three satellites. Each satellite in the GPS constellation sends out periodic signals along with a time signal. These are received by GPS devices, which then calculate the distance between the device and each satellite based on the delay between the time the signal was sent and the time when it was received. The signals travel at the speed of light, but there is a delay because the satellites are at an altitude of tens of thousands of kilometers above the earth.

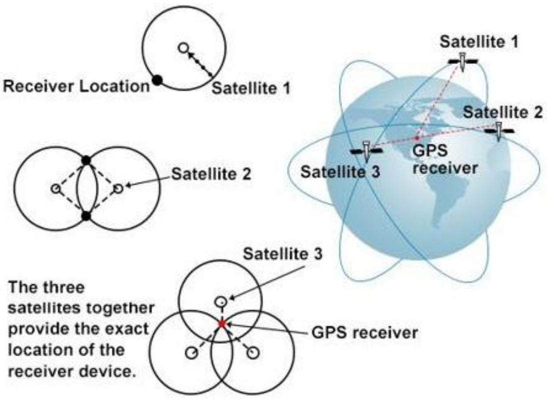

Fig-1: Trilateration Method

2.1 Real Time Relative Target Location Techniques

GPS/INS guided weapon, using the same set of satellites as reference receiver, will be able to maintain precision strike accuracies over long flight distances and flight times. The next part of the problem is to determine the target location relative to the reference receiver. This target location, when used by the weapons GPS/INS navigation system, will result in precision strike accuracy even though it can be substantially in error in an "absolute" sense. The target is then determined by adding this relative location to the reference GPS receiver location is shown in Figure 2.

One concept in which the relative targeting is done by a foot soldier with a reference GPS receiver and a target location device. The target location device might consist of a laser range finder combined with an attitude determination device. The target location (relative to the soldier) would be added to the GPS location to determine the target location in GPS coordinates. The target location and the satellite set used by the reference receiver would be transmitted to the weapon. The receiver on the weapon would use this set of satellites and the guidance would use the computed target location to achieve precision accuracy.

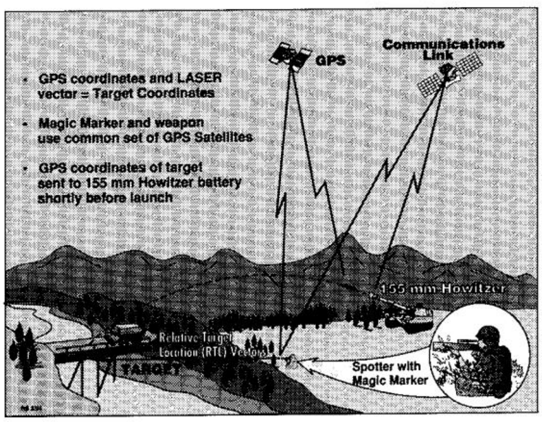

Fig-2: Determining Relative Location

2.2 Relative Techniques Employing Ground-Based Receivers

In this section, we shall consider how various existing or planned GPS-guided weapons could exploit a hypothetical capability to accurately determine 3-D relative target location vectors that are determined prior to the mission. We shall make the explicit assumption that someday we may have the capability to accurately determine these vectors to an accuracy of less than 10 ft. (1 a per axis) over distances up to, say, 540 nmi (1000 km).

First, consider the cruise missile scenario shown in Figure 3. Here, a ground-based receiver has been located with respect to a target. It will be necessary for the ground-based receiver to update the cruise missile shortly before its arrival at the target. It is not certain how "short" this time must be to be consistent with our accuracy goals. However, the results of Section 2 indicate that several minutes are permissible. So, a few minutes before impact, we transmit from the cooperative receiver to the weapon the receiver's indicated position and the set of satellites it is using to form its navigation solution. A communications relay (satellite or aircraft) might be used if there were line-of-sight constraints. It is also assumed that prior to launch we store the relative vector from the cooperative receiver to the target in the cruise missile's flight computer. Then, on receipt of the short data message from the cooperative receiver, the cruise missile ensures it is tracking the correct set of satellites and then adds the indicated GPS position of the target and steers itself to that location.

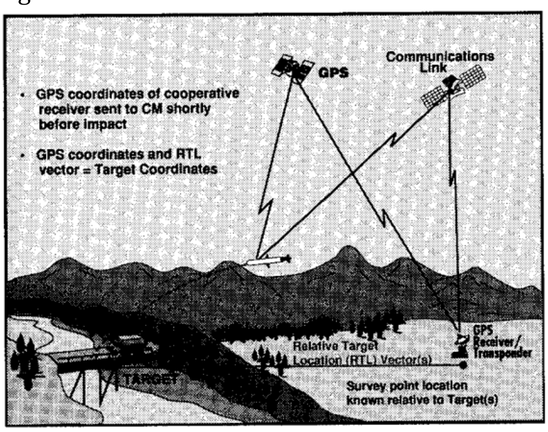

Fig-3: Cruise Missile Precision Strike Concept Employing Relative GPS

2.3 Relative GPS/ATACMS Scenario

Possibly the simplest scenario might involve the Army's extended range (ER) version of the Army's Tactical Missile System (ATACMS)]. An ER-ATACMS battery could set up on one of these cooperative sites. Then the GPS receiver in the weapon itself could act as the "cooperative "receiver thus, not requiring even communications link, since cooperative receiver and weapon receiver are one in the same and dote targeting by adding on to its own indicated position the relative target location vector just before launch and then using the same GPS satellites to navigate from there to the target.

This scenario is shown in Figure 4. Of course, a separate cooperative receiver can also be used as in the other scenarios, thereby allowing the ATACMS battery to set up where ever it pleases (now, however, a communications link is required between the cooperative receiver and the ATACMS battery). Variations on these scenarios can be applied to many other existing or contemplated GPS-guided weapon systems. The points could be in friendly territory and have been mapped relative to the target prior to the mission. In some tactical situations, it might even be conceivable to include the reference station and the target in the same SAR image.

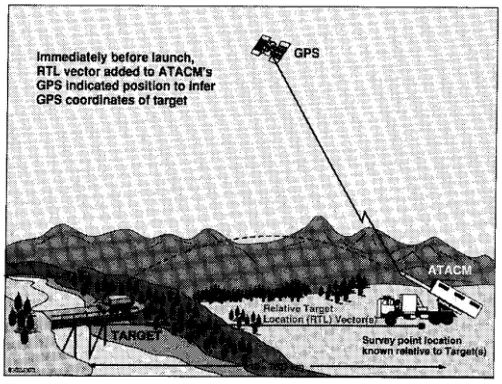

Fig-4: Relative GPS/ATACMS Scenario

3. Missile Control

The reader would have by now seen that a missile gets propelled and guided towards its target destination by the systems explained earlier. In missiles, the control function is to ensure stability of the missile and implement the guidance signals received from external sources or generated on board. The control, after processing the guidance signals, actuates the aerodynamic surfaces on thrust vector to generate turn of the missile speed and direction as required.

The guidance system is to detect whether the missile is flying above or below, to the left or right, of the required path. It obtains these deviations or errors and sends signals to the control system to reduce these errors to zero. The task of the control system therefore is to maneuver the missile quickly and efficiently making use of these signals.

In order to appreciate controls, we shall briefly describe the motion of the missile as a free body. The missile has a total of six degrees of freedom of movement. Out of this, three degrees are translational or linear about the three axes viz., x, y and z; while the other degrees are rotational movement about three axes termed as pitch, yaw and roll.

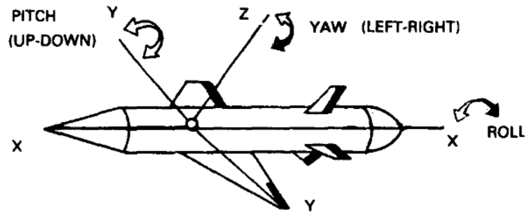

Fig-5: The Six Degrees of Freedom of Movement of a Missile-Three Translational and Three Rotational

There are missiles in which roll is controlled. Roll can be sensed on board using a free gyro sensor and nominated through actuation of controls. Some missiles have roll induced by design to use it for stability. The other axes which are controlled for motion are pitch and yaw axes.

BENEFITS

1. GPS weapon system is reliable in all weather conditions

2. Extremely accurate, three-dimensional location information (providing latitude, longitude, and altitude)

3. No manual errors occur while aiming

4. Extremely accurate velocity information

5. Precise timing services

6. More accuracy than conventional war weapons

7. Weapons can be launched from distant location

DIFFICULTIES

1. The GPS signal is unable to pass through solid structures

2. Potential terrorist capabilities (delivering biological weapons, hitting high-value targets, etc.)

3. GPS signals relatively weak (actually buried in background noise)

4. Signals can be blocked by buildings and other structures

5. Susceptible to interference or jamming

6. Reflected signals (multipath) because position error

4. CONCLUSIONS

In this way we studied Precision-guided weapons, especially those equipped with GPS technology, have greatly improved the military's strike capabilities and reduced many of the difficulties of war. However, there are still significant changes to be made to improve the efficiency of modern weapons technologies that can be made to maximize the efficiency of modern weapons technology.

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