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Analyzing the Modern Warfare and Weapon Systems Supported by Improved GPS Informations

Kwang-Soob Ko*†

* Division of Maritime Transportation System, Mokpo National Maritime University, Mokpo 530-729, Korea

Abstract : *This paper focuses on analyzing the modern warfare and weapon systems supported by improved GPS informations. The GPS capability was investigated through the real experimental test for verifying the most recent GPS features under its modernization processing. And then it was verified that such capabilities, accuracy and availability, of a typical L1, C/A code GPS receiver are equivalent to the military receiver's ones. It was also sure that the influence of GPS improved informations on NCW(Network-Centric Warfare), PGM(Precision Guided Munition) and C4SIR(Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) should be increased and the modern warfare may be strongly dependent on GNSS informations.*

Key Words : *Modern & future warfare, NCW, C4SIR, GPS, PGM*

1. Introduction

The PGM(Precision Guided Munition) was actually used in the Gulf war and the modern weapon systems like PGMs have been evidently increased in the wars in Kosovo, Afghanistan and Iraq. The use of UAV(Unmanned Aerial Vehicle) has also dramatically increased in these wars for signals intelligence, surveillance reconnaissance, deception, land and air offensive, precision strike, communications relay, electronic warfare and target detection. Most recently, the fact that the commercial drone equipped with a satellite navigation receiver has been used to transport products. It has also verified that GNSS(Global Navigation Satellite System) providing real time 3-D coordinates, velocity and timing can play a key role in such modern weapon systems. According to the statistics, there have been the dramatic use of those weapon systems in modern wars(KNWC, 2003).

Futhermore, the development of policy and implementation of services on GNSS have actively been improved by USA, Russia, EU and China. As a result, it seems that the functional parameters of GNSS such as coverage, availability, reliability must be improved and then the benefits of GNSS will be more useful for the military and civilian usages compared to the previous decade. On the other hand, there will be also increasing the malicious usage of satellite navigation signals conducted by particular counties or groups which would significantly threaten the national security or the public safety(GPS World, 2012). This research mainly focuses on the future and modern warfare supported by weapon systems based on benefits of improved recent GPS receiving informations, which have a decisive effect on the modern and future warfare. To do this, the study is performed as follows; Step 1: Analysis on revolutionary advanced modern warfare based on NCW(Network-Centric Warfare), PGM and C4SIR (Command, Control, Communication, and Computer & Intelligence, Surveillance and Reconnaissance). Step 2: Verifying improved GPS receiving informations through outdoor experimental test in order to realize the positive and negative issues of improved L1,C/A receiver. Step 3: Investigation regarding features of benefits and restrictions of the GPS use. Step 4: Discussion and conclusion.

2. Analysis on Revolutionary Advanced Modern Warfare and Weapon Systems

2.1 The Military Technologies for Developing Modern Weapon Systems

Changes of war-fighting concepts based on science and technology have brought a revolutionary change in the real battlefield. State-of-the-art information and communication technology and computer technology effectively get to know battlefield situations in different locations. Moreover, the real-time

† kwangsoob@hanmail.net, 061-240-7154

command and the control environment enable network-centric operations to become available. In addition, the development of precision-guided and attack technique also enable the long-range precision strike warfare by various attacking means. The integrated warfare, so-called NCW + C4ISR + PGM, has improved the efficiency multiplier effect, Synergy of attack power and unmanned systems are being developed, which made it possible to implement the concept of unmanned battlefields. The normal three-dimensional battlefield has been expanded to 5-dimensional battlefield involved the space and cyber domain with those military technologies(ROK Navy, 2011). As an example, a battle ship can obtain informations in real time from land-based stations, aircraft, unmanned aerial vehicles, satellites and other ships through the integration of various sensors and communication systems. It means that the war pattern has been affected by information and communication technology, sensor technology, guidance & navigation technology. The modern innovative weapons systems have been also produced with the mutual integration of such various technologies. The key techniques, which enable to develop modern weapon systems, are summarized through materials investigation(DATQ Part III, 2007; KNA, 2011).

The improvement of high-speed communications technology and extension of communication range enable to network remote units with real-time command and control. The mutual understanding and sharing on the real-time battlefield situation also have been advanced with improving the processing technology of the large volume of information, information propagation speed. Finally, due to the development of these technologies, decision time was shortened.

Despite the nighttime and bad weather, reconnaissance and early warning monitoring were possible due to the operating various satellites and unmanned systems, advanced sensors and detection technology. More importantly, the battle field of multi-dimensional wide area can be monitored using sensors and sensing devices such as submarines, EO/IR, a phased array radar and SAR.

Precision strikes on distant targets have been possible due to the development of precision targeting and guidance techniques based on GPS INS(Inertial Navigation Systems), infrared aiming devices, lasers, etc. Moreover, the attack has been possible with against various targets far away with the use of one of GNSS like GPS. It should be a dramatic motivated transition on the war based on NCW.

2.2 Analyzing the Modern Warfare Characteristics based on NCW, PGM and C4ISR

NCW has become the hottest issue on the modern or future warfare during the previous decade. The aspect of the modern/future warfare is to perform a long-range precision engagement and effective operations based on information superiority in order to win in a short period of time by destroying the enemy's command and control capabilities and major strategic objectives(DoD, 1997; KIDA, 2003; ROK Navy, 2011).

The Network-centric warfare, called network-centric operations, introduced in a 1998 US Naval Institute Proceedings article written by US Vice Admiral Arthur K. Cebrowski and John Garstka. The modern or future warfare should be organically linked with all the power and activity on the time and space to create a synergistic effect of the power management. To do this, the integrated warfare simultaneously should be taken under networked environment. The main concept of NCW is to connect all the troops and weapons to the network not only for ensuring fast and accurate flow of information and situational awareness but also for maximizing the effectiveness of military force. The network-centric operations are based on precision-guided weapons and sensors, information technology(Kim, 2006; DATQ Part II, 2007). The technologies connecting all the units in the network may also be vulnerable by the enemy interference. Therefore, the security and interoperability should be guaranteed. It may be also necessary to understand NCW in three perspectives such as strategic and philosophical dimension, operational dimension, and technical dimension(US JCS, 2010; KNA, 2011)

C4SIR and PGMs are key contents producing the powerful synergy in conducting such a warfare under the NCW circumstance. As advanced the integrated technologies collecting battlefield informations through various sensors as well as conducting satellite command and control of battlefields in past decade, the accurate and rapid engagement using long-range precision-guided precision strike weapons also have been possible against distant targets. These state-of-the-art command and control schemes and information collection means, and long-range precision-guided weapons as a combined result have been a breakthrough in the modern warfare or currently in Afganistan war. The importance of precision-guided weapons in the contemporary and future battlefield has been constantly increasing. The figures 1 and 2 are the philosophy and operation in future and modern warfare, respectively.

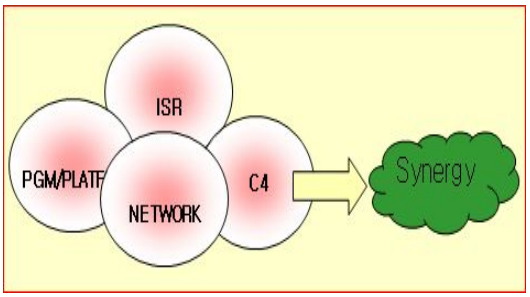

Fig. 1. The Modern Warfare based on NCW.

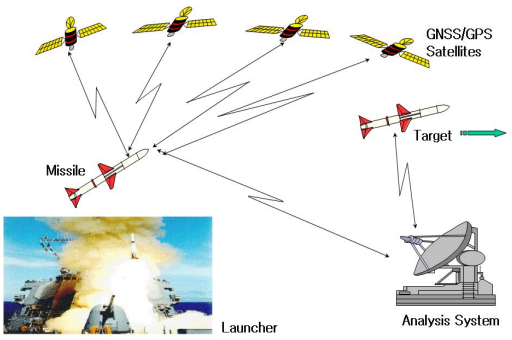

Fig. 2. The Concept of PGM Attack Supported GPS Informations in a battlefield.

The precision-guided weapons, which used in the Gulf war, have been distinctly increased the ratio of usage, around 30 % in Kosovo, 60 % in Afghanistan, 80 % - 90 % in Iraq(KNWC, 2003). The naval battle field has been also significantly expanded geographically. Currently, the range of ships to ships missiles and land cruise missile horizontally expanded to thousand miles. The ship to air missile and the maritime missile defense system have been expanded to vertically hundreds of miles.

3. The Analysis on the Positive and Negative Issues of Improved GPS Signals to Modern Weapon Systems

3.1 Verifying the Recent GPS Features with Real Experimental Test

Today, there are several GNSSs such as the globally operational GPS, GLONASS, Compass transmitting satellite navigation signals and Galileo under developing. In addition, France, Japan and India are also developing their regional satellite navigation systems. The latest issues on major GNSS, GPS, are briefly investigated and then the real experimental test on recent GPS is performed to verify how L1, C/A GPS receiver capabilities have been improved since GPS modernization processing. There are currently 31 healthy satellites in constellation, which are 10 Block IIA satellites, 12 Block IIR satellites, 7 Block IIR-M satellites and 2 Block IIF satellites. GPS is broadcasting a civil signal at L1, second civil signal L2C designed to meet commercials needs from 7 Block IIR-M satellites and third civil signal L5 designed to meet demanding requirements for transportation safety by 2 Block IIF satellites(Ko and Choi, 2012; Ko, 2012).

The experimental procedures and test are follows:

Step 1: Installing Experimental Equipment at outdoor field

Step 2: Real test and statics processing

Step 3: Analyzing parameters and discussion on their potential impact to positive and negative issue

This experiment does not focus on the detail analyzing but focuses on the only verification of the recent L1, C/A receiver's accuracy and satellite visibility. GNSS receiver evaluation kit(L1, C/A)(U-BLOX, 2014) was used for collecting outdoor data in order to obtain main features of recent GPS capabilities such as visibility and accuracy. The outdoor test was performed at the blocked area, specially inside apartment complex to consider a bad combat fields. The results of the experimental test are shown in figure 3 and 4. The figure 3 represents the positioning plotting with accuracy deviation circle at a static position $(N34.8197^\circ, E126.3925^\circ)$. The figure 4 depicts the sky view of GPS satellites in elevation and azimuth chart during the experimental test. The GDOP derived from such satellites combinations affects the position accuracy shown in figure 3. As a result, it was realized that the accuracy obtained by an civilian L1, C/A code receiver has been improved as precise as the military receivers. The additional verification is that 7-8 GPS satellites were viewed in any time during experimental test.

It will cause concerning about the malice use of accurate signal. The above description on the experimental test may be slightly changed under different conditions, however it make sense that the result is meaningful and important because this test is targeting on the getting informations on the most recent GPS capabilities.

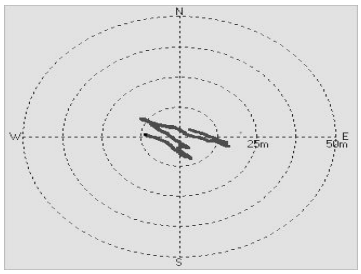

Fig. 3. The Experimental Accuracy of L1, C/A GPS throughout Outdoor Test.

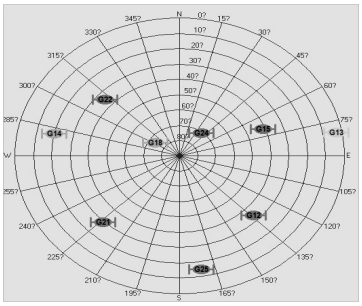

Fig. 4. The GPS Satellites Sky View during Experimental Test.

3.2 Features of Benefits and Restrictions on GPS Signal

According to Joint Vision 2010 by US Joint Chiefs of Staff, the long-range precision capability, combined with a wide range of delivery systems is emerging as a key factor in future warfare. Technological advances will continue the trend toward improved precision. It also says that GPS capabilities provides an accuracy of the long range weapon systems and a wider range of delivery systems. The capability will increase the combat power available. There are various advantages of GPS informations for military applications and NCW as follows(Cosser, 2011);

- a completely unified coordinate system for all units and military personal in battlefields
- positional frame of reference for all units and military personal in battlefields
- accurate shared timebase across all military units
- the relative location to enemy from friendly units
- time synchronization of multiple weapon and multiple military communication networks
- UAV navigational guidance
- target tracking for using various weapon systems against air target, land target and naval target
- allowing accurate targeting of various weapons such as missile and projectile guidance
- allowing precise reconnaissance, search and rescue

As mentioned early, it has been stressed that the modern warfighting and operations are conducted under NCW, which is fully networked with various units, platforms, forces. It should be here noted that GPS provides a number of valuable capabilities to be exploited in NCW.

The powerful nations have been developing their own competitive global navigation satellite systems, which have contributed to improve the warfare capability with NCW, PGMs and C4SIR. Protecting military signal and the technical and political efforts have been continuously carried out during the development of their global satellite navigation system. The key features are investigated and described.

3.2.1 Restriction Policies on L1,C/A Code Receiver

There has been the important US policy on the civilian C/A receivers with the L1 frequency. These receivers working above 11 miles altitude, 1,001Knot and ones designed/modified for use with UAV, cruise missile systems are classified as weapons by US government. All of them should be controlled and required for State Department export licenses(Arms Control Association, 2006). According to 2012 FRP, the DoD does not have an operational requirement to use the GPS civil signals designated L1C, L2C, and L5. DoD policy prohibits the use of civil signals or augmentation systems in wartime environments(DOT, DoD & DHS, 2012). The purpose of the restriction is to prevent foreign governments or terrorist groups from using GPS civilian signals for their own missile technology.

3.2.2 Stopping Selective Availability and Degrading Technology

SA(Selective Availability), managed by US DoD, refers to a method for generating the intentional errors in order to limit the use of the civilian sector. If the SA is applied to the GPS signal transmitted from GPS satellites, the position accuracy is approximately degraded to 100m in surface and 30m in vertical direction. The US Federal Aviation Administration (FAA, Federal Aviation Administration) was constantly required to remove the SA because they can reduce their own finances needed to maintain radio navigation system. SA, which was conducted to limit the use of a civilian GPS, was temporarily removed at the time of the Gulf War for U.S military operations.

As following the statement of US President Bill Clinton, May 1, 2000, SA function virtually was eliminated(White house, 2000).
Since May 1, 2000, one has obtained an accurate positioning information by any commercial receiver.

Because SA feature is not yet completely removed, it can be reintroduced at any time by adjusting the error, but it seems that there may be no plans to perform the SA by the United States. At this moment, however, one should consider on the newly announcement by US government, for capability which can degrade the civilian signal to a different degree. The U.S. announced that it can now degrade the GPS signal in a small area(Strategy World, 2007).

3.2.3 Jamming Issues and Modernization Impacts

GPS signal powers have been known so weak around as low as -160 dbW in the surface receivers. The GNSS's signal strength can not be dramatically increased because of the long distance between navigation satellites and receivers on the earth surface. Therefore, the users receivers are easily vulnerable by unintentional or intentional interference, and resulting in loss of the navigation informations such as positioning, velocity and timing can lead users to dangerous situations(Kopp, 2008; US DOT, 2001).

GPS modernization project would be greatly summarized into three categories(DOT, DoD & DHS, 2012). First, insert a new M functions for military purposes to L1, L2 frequency, and the second is to use the L5 carrier signal frequency to a new and aviation field, and the third function is to add the code to civil frequency L2. The GPS Modernization effort focuses on improving positioning and timing accuracy, availability, integrity monitoring support capability, and enhancement to the operational control segment. Specially, GPS III satellites will improve accuracy, availability, and integrity and provide increased anti-jam performance to meet for the future civil and military users.

4. Discussion and Conclusion

This paper focuses on the future and modern warfare supported by the weapon systems based on the improved GPS informations. Firstly, the several military technologies to develop the future and modern warfare has been investigated and discussed with sensor technology, guidance navigation technology and information/communication technology. Secondly, NCW, the key future/modern warfare, was analyzed with PGM and C4SIR improved by modern military technologies. Thirdly, the GPS capability was investigated through the real experimental test in order to recognize capabilities involving accuracy and availability on the most recent GPS features which might have been improved by GPS modernization in past decade. And then it was verified that such capabilities, accuracy and availability, of a typical L1, C/A code GPS receiver are equivalent to the military receiver's ones. Finally, the GPS policies such as restrictions, SA and modernization, which seriously affect civilian receivers capabilities, are investigated. Additionally, the GPS benefits for positive military applications and the negative issues for the malice purpose, were discussed. According to this study and discussion, it is sure that the influence of GPS improved informations on NCW, PGM and C4SIR should be increased and the modern warfare may be strongly dependent on GNSS informations. Specially, one should realize that the improved civilian GPS receiver's capabilities can be used for peaceful purposes as well as for malicious uses. As the satellite navigation systems by great powers are being developed, it is also expected that several distinct issues on policies and technologies of GNSS regarding asymmetric warfares, legitimate military purpose permits, satellite signal protection measures, illegal use prevention measures will be continuously emerged.

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