Engagement of Time Sensitive Targets with Guided Ballistic Shells

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Abstract: This paper aims to give a general overview of the advancement in artillery technology that allows shells to correct their trajectory whilst in-flight. This paper also investigates the feasibility of using communications technologies to allow re-targeting of such shells to new co-ordinates to offer a more accurate targeting of time sensitive targets, the use of such technologies to alter lethal effects is also briefly discussed.

1. Introduction

Network Enabled Capability (NEC) offers a highly adaptive approach to defence in a world where conflict can involve fighting against technically advanced enemies through to insurgents. To enable decisions to be made quickly in a challenging environment the command structure needs to be equipped with relevant and up to date information, and have a shared situational awareness; NEC offers this. Following the delivery of a white paper entitled 'Delivering Security in a Changing World' [1] the UK MoD is actively adopting the new approach to management of information, people and assets, posed by NEC, in its procurement of equipment and the altering of battlefield doctrine .

Information flow in battlefield scenarios is highly important, any delay or latency leads to inaccuracy. The speed in information flow between Command Control Communications Computers Information Surveillance Targeting and Reconnaissance (C^4ISTAR) assets, Permanent Joint Head Quarters (PJHQ) and effect platforms is directly related to the precision of response to threats in theatre; Figure 1 illustrates this complex flow of information.

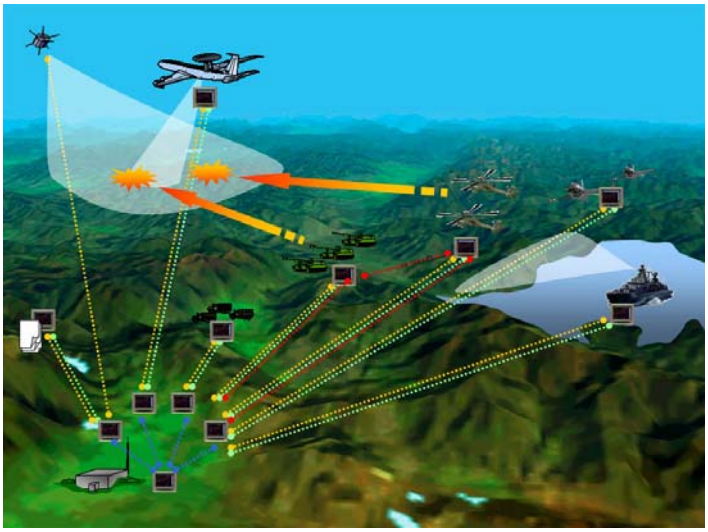

Figure 1; Complex information flow on the battlefield

Time Sensitive Targets (TST) pose the greatest threat in the battlefield in terms of unanswered assaults. The enemy or 'red force' may be a technically advanced force, equipped with Surface to Surface Missile (SSM) launchers (Figure 2) or operate in an asymmetric manner, e.g. the Taleban operates in this manner, and may only be equipped with towed artillery or Light Armoured Vehicles (LAV). TSTs are defined by their ability to advance rapidly, strike and retreat rapidly, offering a highly effective platform to deliver lethal effects, but which are infrequently engaged because of their covert nature.

(Images courtesy of Janes information group 2006)

Figure 2; SSM launcher (left) and towed artillery (right)

2. Engaging TSTs with Guided Ballistic Shells

In an example scenario a TST is engaged with artillery fire using a carrier shell equipped with a Global Positioning System (GPS) receiver, technology currently in development. The shell dispenses it's cargo of Sensor Fuzed Munitions (SFM) into the target area of the fleeting TST. SFMs general use Explosively Formed Projectiles (EFP) to defeat their targets. An EFP is a short rod which is formed by explosively deforming a metallic dish shaped liner. The EFP is projected downwards on to the roof of it's target with a typical impact velocity of ~1800 m/s, penetrating and destroying it. In the case of artillery shells there is a requirement to engage targets at a long stand-off in the 25km regime (a future requirement of 100Km has been discussed within MoD), It is therefore possible that the TST may have moved out of the preset target area during the flight of the shell. To ensure that the SFMs are properly deployed in the target area some retargeting technology is clearly required.

The carrier shell ejects the SFM's over the target area which then find their targets using their built in sensors. Currently this ejection mechanism works on a timed fuze, constraining the SFMs to a target area that is designated at launch, however it is possible for ISTAR assets to alter this by correcting the trajectory of the munition whilst in flight, and augmenting the release pattern of the SFMs.

Figure 3 Ballistic SFM dispensed over a target area

Guided Ballistic Shell (GBS) designs such as Excalibur, as described at Global Security.org [2], shown in Figure 4, are currently in development. Such weapons are guided to a target co-ordinate given a GPS input, Inertial Measurement Unit (IMU) measurements and response from fins or canards mounted externally to the shell body.

Figure 4 Sectioned view of Excalibur GBS

GBS such as Excalibur are a fire and forget solution in that they do not require intervention or a Man In The Loop (MITL) system such as a laser designator. However when engaging TSTs updating of target co-ordinates is a requirement. Re-targeting can be achieved in flight using current communications technologies such as Link 16 receivers used by NATO forces, and further discussed in Janes Avionics [3]. Current networks, however, may not be able to achieve the low latency requirement.

DARPA (Defence Advanced Research Projects Agency) are currently engaged in a development programme for the Tactical Targeting Network Technology (TTNT). TTNT is a high throughput, low-latency solution for addressing the sensor to shooter link, and is an Internet Protocol (IP) based, high-speed, dynamic ad-hoc network designed to enable the defeat of TSTs. TTNT provides a network capable of transmitting 2Mbps of data over 100 nautical miles in 2ms. TTNT was demonstrated at the Joint Expeditionary Force Experiment (JEFX) in 2006 [4], and is designed to be a low-cost, digital hardware module that is inserted into an existing Link 16 data-distribution radio. With a UHF digital data receiver built into a GBS, TTNT can be used to retarget the GBS or alter the ejection pattern of the SFMs in the carrier shell. The receiver would be a simple unit capable of handling co-ordinate data using an IP form that would replace the pre launch target data. These new co-ordinates would then be compared to GPS and IMU data and the appropriate changes to the trajectory would be made through angular changes in canard orientation. A simple block diagram of the components is shown in Figure 5. Instructions regarding ejection of the SFMs can also be sent to the GBS, enabling the SFMs to be ejected in different patterns depending upon the orientation and altitude of the GBS. With a unit cost of $70,000 for a GBS, the implementation of a miniaturised UHF receiver would have a minimal impact on cost and improve the effectiveness to dispensed round ratio.

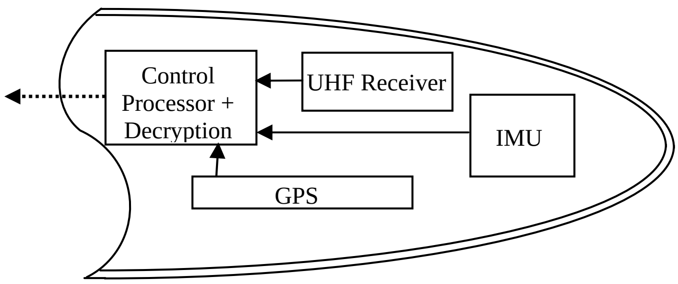

Figure 5 Block diagram of guidance control system in GBS nose

ISTAR assets such as the Airborne Warning and Control System (AWACS) will be able to track TSTs from a long stand-off, as their trajectory is known. The course and speed of the TST will be plotted and target co-ordinates can be produced and passed on to the GBS following launch. In the 25km range the updating process would not be carried out a significant number of times, however with a future requirement of 100km range course updates could be carried out over a period of 2-3 minutes depending upon wind speed/direction and atmospheric conditions. As the TST can change course and speed without notice it is important that a low latency communication network such as TTNT is used to transmit the required information to ensure course changes can be implemented within a few seconds allowing several corrections to be made in the terminal phases of the GBS flight.

3. Discussion

This application of post launch re-targeting technology is extreme; it relies on high G launch hardened communication equipment, which could however be introduced with technology that has either been developed or is currently being developed. Further complexities such as the ability to transmit it's co-ordinates in space could be introduced into a GBS, although this may not practical due to the power requirements for the transmitter to send digital signals over a 10km range. UHF digital receivers that are currently available and working in the 450-850MHz range occupy a volume of <25cm^3, have a mass of ~0.1kgs, with an operating range of up to 20kms. With an output of 500mW and a power requirement of <15v, these receivers are constructed to withstand high g launch.

The ability to communicate with shells in flight will require the discreet identification of each munition, through a programmed decryption key, to enable decryption of data sent using the Link 16 format. The information could be passed on whilst the shell is in the breech of the gun, through use of inductive fuze setting technology that is currently in-service throughout NATO

Further to the ability to re-target a munition, the ability to transmit digital signals to the shell could lead to the ability to alter the lethal mechanism delivered by the SFM from EFP to fragmentation. A simple digital signal is required to alter the initiation signal from the Electronic Safety and Arming Unit (ESAU) to initiate the explosive charge in a manner to produce large fragments from the metallic liner in the SFM rather than an EFP. Such a lethal mechanism would be used to more effectively engage soft skinned, or area targets, but would require significant re-engineering of the shell body and the SFMs.

4. Conclusions

The implementation of communication technology within a ballistic shell is possible, with the cost of insertion having an insignificant impact on overall system cost. The implementation of relatively cheap UHF receiver technology combined with in-service secure communications enables C^4ISTAR assets to ‘reach’ into the battlefield and control the course of the battle whilst offering a shared situational awareness with the PJHQ and coalition ‘blue’ forces.

The cost of engagements would also be reduced through the reduction in number of munitions that need to be fired through the improvement in kill probability per munition.

References

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