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Improved Command and Control (C2) capabilities in urban and challenging terrains.

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Abstract: Army's Network Centric Warfare strategy aims to bolster Information Dominance capabilities, utilizing Command and Control (C2) systems like the Army Battle Command Systems (ABCS), stayed on advancing knowledges for example networking, communications, and positioning. Maintaining current Situation Awareness (SA) information is vital for successful C2 systems, requiring incessant and opportune location data from pertinent stages in the battlefield. The accuracy and obtainability of this location evidence straight impact active efficiency. Traditionally, positioning served the purpose of "own ship" pilotage, answering the question of navigating from Point A to Point B. However, the part of placement as a communal reserve is evolving, increasing the status of location evidence quality and availability. The primary source of this position data is the NAVSTAR Global Positioning System (GPS), offering a consistent coordinate reference with accuracy unaffected by time or distance traveled, and with lower integration costs compared to alternatives like Inertial Navigation Units (INU) or Doppler Radar Navigation Sets. It's crucial to note that GPS is susceptible to Electro-Magnetic Interference (EMI) and signal blockage in Urban and Compound Terrain. Technological initiatives are focused on exploring advanced integration techniques that combine externally aided and self-contained navigation systems.

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1. Introduction

A fundamental principle of the "Digitized Army" is "Information Dominance," where the precision and accessibility of individual power location data straight impact the active efficiency of the future Army. Traditionally, location evidence served the purpose of guiding one's own ship from Point A to Point B. However, the evolving role of location evidence is now viewed as a common reserve, contributing to nearly flawless State Awareness (SA) for the purpose of enhancing Command and Control (C2) efficiency and achieving power increase [1].

The Army Battle Command Systems (ABCS) and other C2 systems rely significantly on precise digital position reports from all battlefield platforms. Since it provides a uniform and global coordinate reference, the NAVSTAR Global Positioning System (GPS) is the main source of this location data. GPS accuracy is independent of journey time and distance, in contrast to self-contained navigation devices like Doppler Radar Navigation Sets and Inertial Navigation Units (INU). Moreover, compared to INUs or Doppler systems, GPS receivers are noticeably less expensive to integrate, run, and maintain.

2. ALIGNING, NAVIGATION AND TIMING: IN THE SETTING OF ACTIVE KNOWLEDGE AND REGULATOR

It is impossible to overestimate the importance of precise and often updated digital position updates in the context of operational Command and Control (C2). The incident during Operation Enduring Freedom where a forward air controller mistakenly called for a Joint Direct Attack Munition (JDAM) on what they believed to be a target but was actually their own location serves as an example of how reports based on incomplete or inaccurate information can have serious repercussions. A dead battery and inadequate training were mentioned as the causes of this unfortunate incident.

The US Army Training and Doctrine Command (TRADOC) emphasizes the need of having high-quality positioning and navigation data, as shown in TRADOC Pamphlet 525-66 on Force Operating Capabilities and operational requirement documents (ORD) for the Future Combat System and the Land Warrior (FOC). These specifications spell out the necessity for a very accurate positioning system that can function in a variety of settings and weather circumstances. They also stress the significance of complete compatibility with all Army Battle Command Systems (ABCS), which include Maneuver, Air Defense, Combat Service Support, Fire Support, and Intelligence and Electronic Warfare. These agreements acknowledge that electronic threats to positioning systems exist, and they also stress the need to create defenses against those threats.[2].

New information from operations Enduring Freedom (OEF) and Iraqi Freedom (OIF) emphasizes the need for affordable positioning devices, even advocating for supplying them to all soldiers. According to an Inside the Army article, many soldiers carried their own commercial GPS receivers, which raised questions within the Department of Defense (DOD) regarding the devices' vulnerability.

Though they aren't made explicit in requirements documents, the availability and precision of synchronized time on the battlefield are much more important. Time is a critical component of intelligence, communications, and sensor operations; nearly every combat unit employs it for cryptology and frequency hopping.

"The ability to have accurate and real-time information about friendly, hostile, neutral, and noncombatant places; a common, relevant image of the battlefield scaled to a specific level of interest and unique necessity" is the definition of situational awareness given by FM 100-14.[3]."

The Common Operational Picture (COP), which is a collective depiction, is produced when individuals report their situations. Additional intelligence is provided by friendly troops and sensors, which report hostile, neutral, and noncombatant locations. These locations are either estimated using known friendly positions or are "lasered" using laser-ranging technology. After that, this data is transformed into digital coordinates and added to the COP. The provision of precise and timely position information for these units is the critical component that makes these capabilities possible.[4].

As per the definition provided by Joint Pub 1-02, command and control is "the use of power and direction over assigned and attached forces by a duly appointed commander in order to complete the mission. A commander plans, directs, coordinates, and controls forces and operations in order to complete a task. These functions are carried out through the organization of people, equipment, communications, facilities, and procedures. Likewise known as C2." Superior situational awareness increases the likelihood that commanders will make wise choices. A large portion of the "fog of war" is removed by accurate position information on friendly forces, which is acquired through frequently updated reports. This makes it possible for commanders to give their men more precise orders.[5].

In summary, Positioning, Navigation, and Timing (PNT) data unquestionably serve as a force multiplier and constitute the cornerstone of Command and Control (C2). The crucial role that GPS plays in the country's transportation network is acknowledged by the US. Similarly, for dismounted soldiers who need a high degree of protection, GPS and

other locating devices described in this study should be considered an essential part of the battlefield infrastructure.[6].

2.1 BATTLESPACE TACTICAL NAVIGATION

The goal of the Battlespace Tactical Navigation (BTN) Science and Technology Objective (STO) program is to solve a number of technical issues pertaining to GPS and navigation. The Army is particularly concerned about GPS's susceptibility to jamming and electro-magnetic interference (EMI).

Unlike other services, the Army possesses a greater number and variety of platforms equipped with GPS receivers, accounting for 86% of the Department of Defense's (DoD) GPS receivers. Upgrading individual user equipment suites for these platforms entails a substantial expense. Furthermore, the Army engages in diverse missions that may require different interference mitigation approaches. Additionally, it operates in a higher EMI environment, particularly during signal acquisition, due to its proximity to jammers and longer mission durations.

BTN has developed technologies aimed at enhancing the robustness of GPS reception in challenging electronic countermeasure (ECM) environments. One category of these technologies includes anti-jam (A/J) antennas, which will be further detailed below [7].

2.2 ANTI-JAM FEELER RETROFIT FOR THE AN/PSN-11 EXACT FRIVOLOUS GPS HEADSET

BTN has effectively created a number of innovations, such as many iterations of an anti-jam (A/J) antenna made to work with the portable Precise Lightweight GPS receiver (PLGR). Toyon Research, Inc. and Electro-Radiation, Inc. (ERI) collaborated on the creation of retrofit null forming antennas made especially for the PLGR.

Electro-Radiation Inc. (ERI) played a role in the development of the A/J antenna. The ERI antenna was created as part of an ACT II project carried out by CECOM and sponsored by the Space and Missile Defense Battlelab. This initiative utilized a topic authored by CECOM.

Network Assisted Navigation builds upon initiatives started in the commercial sector, particularly in the context of E-911 service for cell phones. This technology leverages information accessible through radio/network links to support GPS or other navigation sensors in low or degraded signal environments where obtaining a navigation solution would be challenging.

RF ranging employs time of flight information, similar to GPS ranging, with the user ensemble forming the "constellation." Advanced algorithms can determine the relative location of a group, such as a squad of soldiers within a building. When some group members have absolute positions, like accurate GPS data, absolute position solutions can be derived. Overcoming issues like wall penetration attenuation and mitigating multipath and reflections presents technical challenges.

Advanced Pedometric improves the Point Research, Inc. Dead Reckoning module by incorporating enhanced motion classification algorithms to detect backward or sideways walking and running [8].

The goal of the integration effort for Micro-Machined Electromechanical Systems (MEMS) Inertial Measurement Units (IMU) is to build compact, reliable, and accurate accelerometers and gyroscopes by leveraging military and commercial breakthroughs in MEMS. These sensors work in concert with other ATO-developed technology to improve overall navigation performance.

We are in the third year of a four-year program that is the APNTFF ATO. At first, it concentrated on investigating potential solutions to enhance GPS-only position location capabilities in difficult GPS settings. Right now, the main goals are to improve, integrate, and show off an integrated breadboard navigation system's capabilities in a meaningful setting.

Network Assisted GPS, RF Ranging, and Enhanced Pedometry were the three main technologies that the APNTFF program investigated while supporting the creation of "wearable" breadboard or prototype experimental dismounted positioning systems

during the first two years of the program. NAVSYS received special funding to create and supply six breadboards that utilize network-assisted GPS technology.[9].

3. Results

Spot Exploration Business and Vectronix gotten supporting to creäte and supply Better Pedometry approaches. These improvements trained dual essential sections that permitted restricted the functionality of this equipment for descended warriors through the Ground Soldier steering subsystem advance. The first improvement was to allow step characterizations other than the forward walking step characterization that was previously in place. The second improvement addressed the mitigation of magnetic anomaly conditions that are frequently encountered in building and urban operations.

Point Research and Vectronix have both effectively produced devices that improve GPS performance by using MEMS inertial sensors and human motion modeling or measurement. These systems were designed to provide a self-contained indoor positioning capability that took into account realistic soldier maneuvers like crouching, crawling, running, jumping, crab walking, backward walking, and side-to-side walking, with a target accuracy of 2 to 3 percent of the distance traveled. Since the demonstration systems were intended to be self-sufficient, no auxiliary infrastructure was needed.

These devices were designed to investigate technologies that showed promise for enhancing dismounted soldiers' tactical operations and situational awareness. All of the systems could function both indoors and in difficult urban positioning situations. The October/November 2004 experiments comprised both Outside Scenarios (with surveyed waypoints) and Mixed Environment Scenarios (with both indoor and outdoor segments combined). These scenarios made it possible to test the relevant systems in one or more modes of operation, which made it easier to compare the performance of different systems and modes.

While specifics are still unavailable, the analysis of the technology demonstration systems' trials is underway. In general, all of the technology breadboard systems showed varied degrees of success in achieving their design goals. The three main technologies under investigation—Enhanced Pedometry, RF Ranging, and Networked Assisted GPS—showed varying degrees of position performance. When taken into consideration separately, none of the technologies examined demonstrated any promise in achieving the positional objectives for dismounted infantry.

Working together with Northrop Grumman, the APNTFF program is continuously evolving. According to Northrop Grumman's concept, a prototype dismounted soldier "wearable" navigation system would incorporate technologies such as RF Ranging, MEMS IMU, Network Assisted GPS, and Enhanced Pedometry. The goal of this integration is to make it easier to do additional research on integrated positioning performance. This effort's main goal is to solve the locating issues dismounted soldiers have in areas with poor GPS reception.

Characterizing system faults and creating integration methods to combine data from the selected technologies will be the main focus of the work. It is anticipated that the integrated breadboard system under development will surpass the ideal bounds in terms of dimensions, mass, energy output, and expense for the dismounted soldier. Consequently, significant system development would be needed to create fieldable prototypes or implement them operationally when the integrated development and demonstration phase of the APNTFF program is over.

Future development requirements can take into account integration with other systems or equipment, repackaging, shrinking, or improved capabilities.

4. Conclusions

This paper has explored the transformation of systems providing position and time information, moving beyond their traditional role as navigation aids for individual users.

These systems now play a more significant role in enhancing Situation Awareness for larger units by reporting the positions of individual platforms. The demonstrated improvement in Situational Awareness has directly elevated Command and Control capabilities, establishing it as a force multiplier. The success of this evolution has given rise to numerous new concepts for the utilization of position and time information. These emerging concepts generally impose greater demands on the reliability, accuracy, and timeliness of the position location and time information than current systems can practically and cost-effectively deliver.

Currently, there isn't unique steering group of coordination that maybe regarded the best suited for numerous army purposes. The skills picked for probe were deeply chose to improve the army's steering expertise in complicated armed environments, while also addressing considerations of Size, Weight, Power, and cost (SWAP) associated with the technology. Solutions designed for these challenging military environments also have the potential to enhance overall navigation systems when deployed in less demanding environments. It is caustic that the earlier our group originate to meeting the current army supplies for location and judgement, the incessant development of novel ideas for upcoming working abilities reliably drives the essential for improved abilities from the army's steering schemes, thereby cumulative SWAP and charge restraints.

Conflicts of Interest: Declare conflicts of interest or state "The authors declare no conflict of interest."

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