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THE ROLE OF GEODESY IN MILITARY OPERATIONS: HISTORICAL DEVELOPMENT AND MODERN USE

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Summary: *Geodesy plays a key role in military strategy, evolving from early cartographic techniques to modern digital technologies. Historically, it was an integral part of the military campaigns from Roman road networks to Napoleonic Wars and modern conflicts. Today, military geodesy integrates GPS, satellite surveillance, drones, and GIS for precise mapping, navigation and infrastructure planning. Technological advances, including artificial intelligence and cyber-resilient systems continue to optimize military intelligence and strategic planning.*

Keywords: *geodesy, military sector, GIS, GPS, drones*

INTRODUCTION

Geodesy is a fundamental discipline in many fields including the military sector, where the accuracy and efficacy of mapping and navigation play a crucial role in the success of military operations. From antiquity to the modern era, geodesy has undergone significant progress, evolving from the basic methods of measurement and mapping to the use of modern satellite and remote technologies. This article examines how geodesy has accompanied military strategies throughout the centuries thus providing essential data for planning, executing, and monitoring military operations. It also discusses the historical significance of geodesy and how modern innovations, such as GPS, drones, and geographic information systems, are transforming military operations today.

The aim of this article is to examine the evolving role of geodesy in military operations, both from a historical and modern perspective. This study focuses on the application of geodesy in the military field, while the subject focuses on the impact of geodetic tools and technologies on the effectiveness of military operations. The research is based on a qualitative approach, primarily using historical and technological analysis of literature sources, case studies, and recent examples. The author's thesis is that the integration of geodetic technologies significantly enhances strategic military planning, operational efficiency, and response in both traditional warfare and contemporary crisis scenarios.

1. HISTORICAL OVERVIEW OF THE ROLE OF GEODESY IN THE MILITARY SECTOR

This historical overview shows how geodesy has played and continues to play a crucial role in the military sector thus providing the necessary tools and data for the successful planning and execution of military operations.

1.1. Antiquity and Middle Ages

The first use of geodesy in the military sector dates back to the time of the ancient Greeks and Romans.

According to historical sources, the ancient Greek philosopher, mathematician, and astronomer Thales of Miletus (Karayaneva, 2021-2025) used the shadow of a wooden pole (gnomon) and the concept of similar triangles to determine the height of the pyramids in Egypt.

The Romans also used geodetic principles (Fig. 1) to build their roads, fortresses and aqueducts. The military engineers of the Roman Empire applied their knowledge of geodesy to plan and build fortifications to defend their territories.

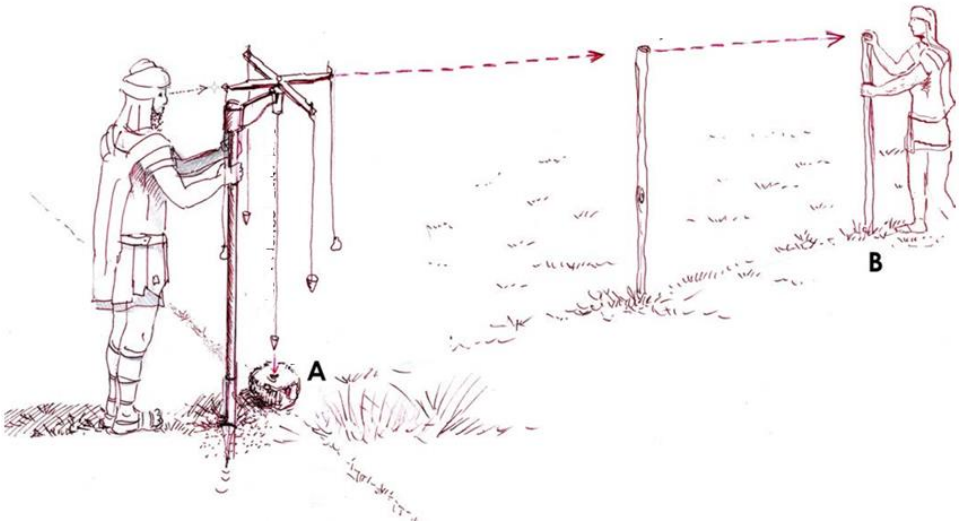

Figure 1. Using the Roman tool Groma (Lewis, 2009; Fava, 2015) to construct straight lines and angles

During the Middle Ages, cartography and topography became increasingly important for planning military operations. European kingdoms invested in producing detailed maps to support their armies (Harvey, 1987).

1.2. Renaissance and Modern Times

During the Renaissance, advancements in mathematics and astronomy also led to significant progress in geodesy. Scientists such as Copernicus and Galileo Galilei (Exertier, 2004) made revolutionary discoveries that changed our understanding of the universe and Earth. These discoveries were also

used in the military sector where accurate measurements and maps became increasingly crucial to the success of military campaigns.

In the 17th and 18th centuries, geodesy developed significantly due to the work of scientists such as Isaac Newton and Jean Picard. The development of more accurate instruments and methods of measurement allowed for the creation of more detailed maps and plans. The military began to use these innovations to plan strategic operations and fortifications.

1.3. XIX century and the Industrial Revolution

During Napoleonic Wars (Dean, 2000), the French army actively used geodesy to plan and execute its campaigns (Fig. 2). French engineers developed new methods of mapping and topographic surveying that allowed them to control large areas and plan complex military maneuvers. These methods included the use of triangulation and other geodetic techniques to create accurate maps.

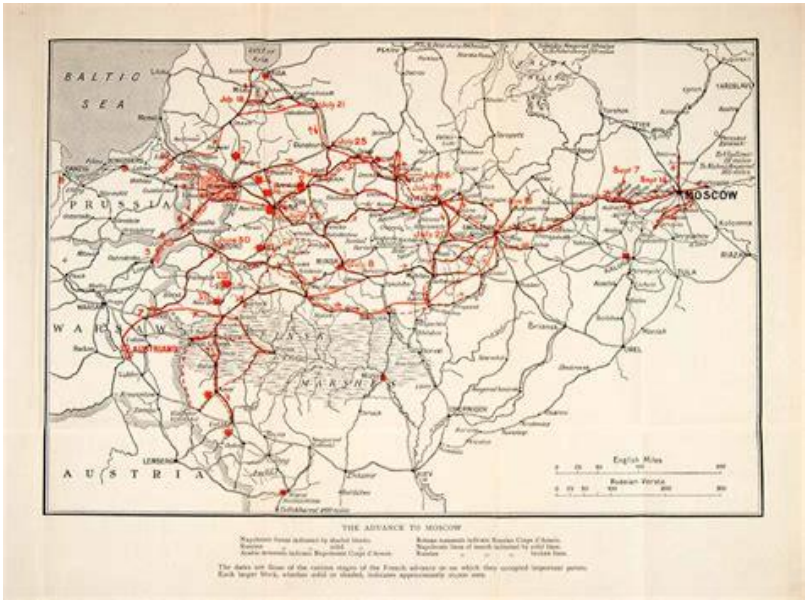

Figure 2. Map showing the advance of the French army (Foord, 1914) on its way to Moscow

The Industrial Revolution of the 19th century led to significant technological innovations that were also used in geodesy. The development of more precise measuring tools and methods such as theodolites and tachymeters allowed for the creation of more detailed and accurate maps. The military began to use these innovations to plan strategic operations and fortifications.

1.4. XX century and modern times

During World War I (Lilley, 2015) and World War II (United States Department of Commerce, 1951), geodesy played a key role in the planning and execution of military operations. Aerial photogrammetry and the use of

aerial imagery for mapping became widespread. Military engineers used geodetic data to plan attacks, defensive lines, and logistical routes.

The Cold War marked a new era in geodesy with the development of satellite technology and global navigation systems such as GPS. These innovations provided the military with unparalleled capabilities for navigation, mapping and terrain monitoring. Geodesy became an integral part of military strategy and tactics.

1.5. XXI century and future perspectives

Today, military geodesy is closely linked to the most contemporary technologies. Unmanned aircrafts (drones), laser scanning and remote monitoring provide the military with unprecedented capabilities for data collection and operational planning. Geospatial analysis and Geographic Information Systems (GIS) play a fundamental role in the analysis and visualization of geodetic data.

The future of military geodesy is likely to be marked by even greater integration of new technologies. Artificial intelligence, machine learning and quantum computers promise to revolutionize the way the military uses geodetic data. These innovations will provide even greater accuracy and efficacy in the planning and execution of military operations.

2. MAIN USES OF GEODESY IN THE MILITARY SECTOR

2.1. Creating topographic maps

One of the main functions of geodesy in the context of security and defense is the creation of accurate maps and topographic data, which are essential for military strategies and operations. By using modern technologies such as GPS, drones (Fig. 3) and satellites, the military can obtain detailed images and information about the terrain allowing them to plan and execute missions more effectively.

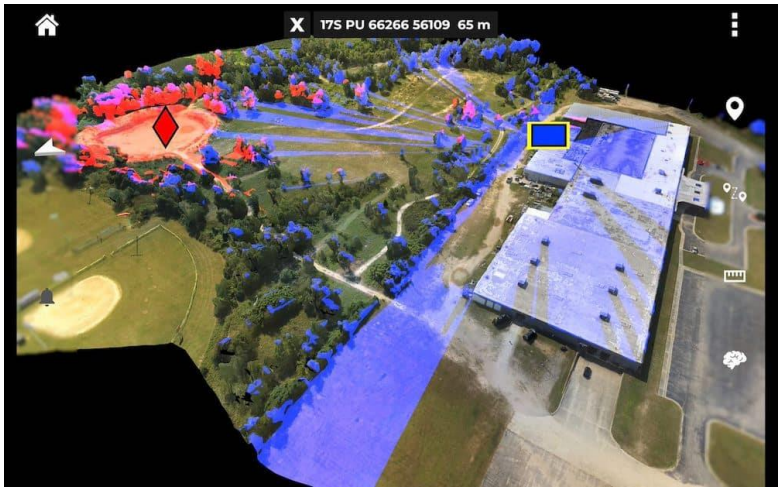

Figure 3. Multi-drone mapping demonstrated to the US army (Staff, 2022)

Topographic maps (Fig. 4) provide detailed information about the terrain including elevations, water sites, vegetation and infrastructure and are fundamental to any military operation. Modern geodetic technologies such as laser scanning and photogrammetry allow the creation of highly accurate and up-to-date maps which are essential for mission planning and execution.

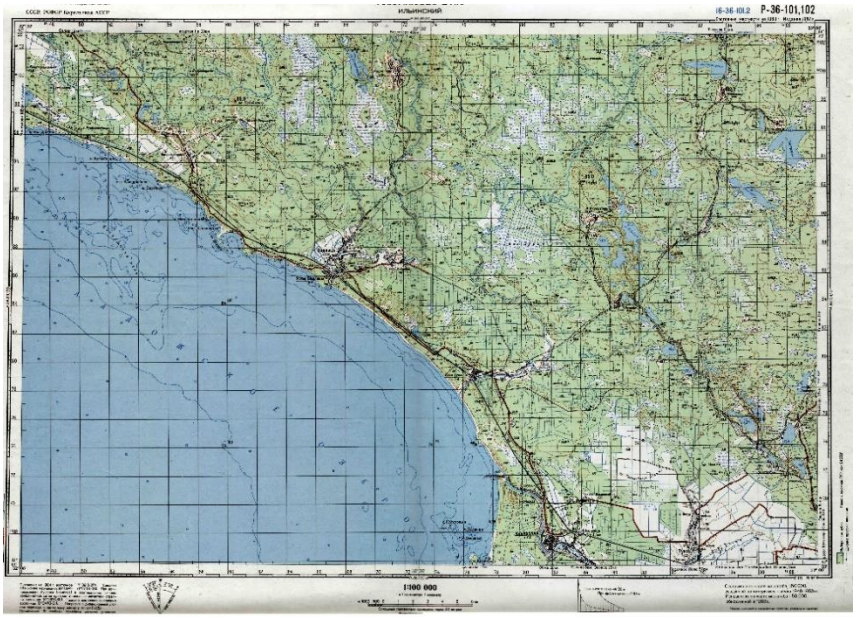

Figure 4. Soviet military topographic maps, 2008

2.2. Navigation and orientation

Accurate geodetic data is crucial for the navigation and orientation of military forces as without reliable maps, soldiers and vehicles could easily get lost or end up in dangerous areas. Geodesy provides the necessary tools for an accurate location and movement of troops where via GPS (Fig. 5) and other navigation systems, military operations can be conducted safely and effectively even in unfamiliar and hostile territories.

Figure 5. Military GPS

As cyberwar develops, geodetic data become increasingly valuable to the military. Cyberattacks can disrupt GPS signals and other navigation systems, highlighting the importance of backup methods for navigation and orientation.

2.3. Infrastructure and logistics

Each military operation requires well-organized logistical support which depends on the accurate geodetic data. Geodesy plays an important role in the planning and construction of military bases, roads, bridges and other infrastructure facilities ensuring these facilities are correctly located and function effectively. The accurate measurements (Fig. 6) and analyses provided by geodesy are essential for the successful implementation of these projects and for providing the necessary logistical support for military operations.

Figure 6. Army Reserve Surveyors set their sights at the National Training Center (Hale, 2010)

2.4. Monitoring and analysis of the terrain and environment

Geodetic methods and technologies allow for continuous monitoring of the terrain and the environment including monitoring of earth movements, erosion, floods and other natural phenomena that can affect military operations. By using sensors and remote monitoring, the military can receive timely information and take the necessary measures to protect their positions and resources. This information is essential for making informed decisions and preventing potential threats.

Here are some examples:

- **Battlefield monitoring**: The military uses geodetic techniques such as GPS and satellite surveillance to create accurate maps of battlefields. This includes measuring terrain, identifying obstacles and assessing troop maneuvering capabilities.
- **Artillery Position Analysis**: Geodetic data is used to determine the best positions for artillery. By using total stations and GPS, the military can calculate missile trajectories and optimize targeting.
- **Monitoring Engineering Facilities**: During the construction of temporary military bases bridges and fortifications, geodesists use lasers and GPS to constantly measure deformations and movements. This ensures that the facilities remain stable and safe for military operations.
- **Monitoring enemy positions**: High-resolution satellite imagery and drones are used to monitor enemy positions and movements. They provide information on the location of enemy forces, their fortifications and possible attack routes.
- **Minefield Analysis**: Geodetic techniques such as magnetometers and ground radars are used to detect and mark minefields. This helps the military avoid dangerous areas and plan safe routes for their operations.
- **Monitoring transportation corridors**: To ensure safe and efficient supply lines, the military uses GPS and satellite surveillance to monitor transportation corridors. This includes checking for obstacles, mines and other threats.
- **Damage assessment**: After military operations, geodetic techniques are used to assess any damages to the infrastructure and the terrain. This includes measuring craters, collapsed buildings, etc. which aids in planning recovery operations.

These examples highlight the key importance of geodetic methods for the success of military operations providing accurate data for decision-making and ensuring operational safety.

In the context of various crises – whether military conflicts, natural disasters, or hybrid threats – modern geodetic technologies provide critical advantages. Their real-time data collection, high precision, and integration with other systems such as AI and GIS significantly increase situational awareness, support rapid decision-making and reduce operational risks. The author believes that in an era marked by unpredictability and asymmetrical threats, the strategic use of geodesy is not merely supportive but essential for successful crisis response and resilience.

2.5. Border Security

Geodesy plays a crucial role in protecting and controlling state borders. By using geodetic techniques and technologies, border services can monitor for illegal crossings and respond quickly to potential threats. The accurate

maps and data provided by geodesy help identify vulnerable points and improve border security.

Monitoring illegal border crossings using geodetic techniques usually involves several methods and technologies:

- **Global Positioning System (GPS)**: Using GPS devices allows border patrols to determine the exact location of violators and to track them in real time.
- **Satellite surveillance**: Satellites can provide high-resolution images of border areas which allows detection of unusual activities or movements.
- **Drones**: Drones equipped with cameras and sensors can patrol hard-to-access or remote areas, transmitting real-time video and data to the command center.
- **Laser scanning and Light Detection and Ranging (LiDAR)**: These technologies can create three-dimensional models of the terrain which helps detect changes or violations in border structures.
- **Sensors and detectors**: Placed along the border, these devices can detect movement, heat or vibrations signaling potential illegal crossing.
- **Geographic Information Systems (GIS)**: GIS systems (Fig. 7) integrate different types of spatial data such as maps, satellite images and sensor data to provide a comprehensive picture of the situation at the border.

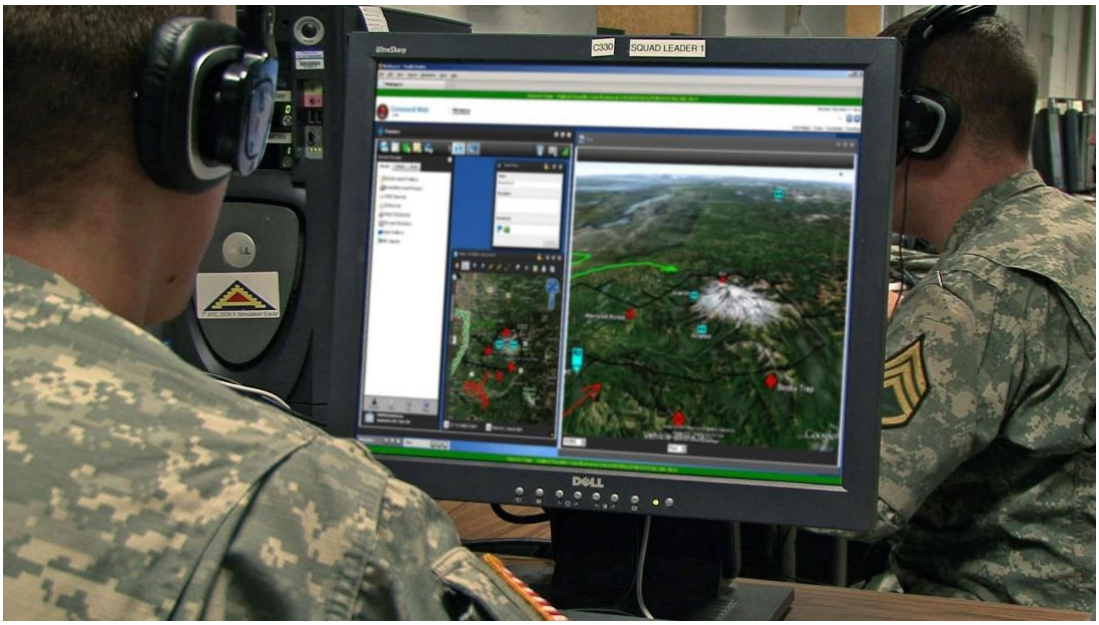

Figure 7. Geospatial map data (Jones, 2013)

These technologies and methods work together to provide a comprehensive approach to border security thus providing border services with the necessary tools to respond quickly and effectively to threats.

CONCLUSION

Geodesy plays an extremely important role in the field of security and defense, providing crucial data and tools for planning, executing and monitoring military operations. From creating accurate maps and navigation systems to securing borders and monitoring terrain, geodetic methods and technologies are an integral part of military strategy and tactics. As new technologies develop, the role of geodesy in the military sector will continue to grow providing even greater accuracy and efficacy in protecting national interests. This article highlights the importance of geodesy in the military context and presents how it contributes to enhanced security and efficiency of military operations.

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