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Traditional Methods to Determine the Ships' Position and Navigation Safety

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Abstract

The Russian-Ukrainian military conflict has shown the vulnerability of ship electronic navigation systems used in navigation. The Global Positioning System(GPS) may incorrectly display the vessel's coordinates both due to blocking of satellite signals by means of electronic warfare and due to cyber-attack, spoofing attack on the satellites themselves. The Electronic Cart Display Information System(ECDIS) coupled with the GPS will also incorrectly display the vessel's position and area around. The same problems we can occur with Automation Information System (AIS) data. Therefore, proper training of future navigation officers in traditional methods of determining the ship's position is gaining new momentum. The STCW Code includes celestial navigation, visual methods of determining the vessel's position and dead reckoning among the mandatory competencies for officer in charge of a navigational watch:

- *Celestial navigation – Ability to use bodies to determine the ship's position*
- *Terrestrial and coastal navigation – Ability to determine the ship position by use of: landmarks, aids to navigation, including lighthouses, beacons and buoys, dead reckoning, taking into account winds, tides, currents and estimated speed.*
- *Thorough knowledge of and ability to uses nautical charts, and publications, such as sailing directions, tide tables, notices to mariners, radio navigational warnings and ship's routing information.*

However, the sextant, as the main instrument of celestial navigation, is not a mandatory navigational instrument according to the SOLAS Convention. The widespread use of ECDIS has led to the fact that junior deck officer cannot determine the ship's position using traditional navigation methods. This paper highlights the relevance of traditional navigation methods, such as celestial navigation and visual orientation using coastal landmarks, as essential backup tools for maintaining the safety of maritime operations. The necessity of preserving and developing these skills among navigators and cadets in maritime educational institutions is emphasized.

Keywords: Traditional Navigation, Celestial Navigation, Coastal Landmarks, Backup Systems, Navigation Safety, STCW Convention.

Introduction

The global maritime industry relies heavily on satellite-based systems such as GPS, GLONASS, Galileo, and BeiDou. This dependency introduces new risks ranging from signal jamming to cyberattacks. GNSS failure may lead to severe consequences for the vessel's positional accuracy and navigational safety. In this regard, the revival of traditional navigation skills becomes strategically important. Celestial navigation and visual techniques have a proven historical track record and can serve as crucial fallback methods in the absence of satellite data. However, their effective use requires a fundamental rethinking of maritime education and the adaptation of traditional skills to modern navigation practice [1].

Threats to Satellite Navigation

From 2016 to 2024, incidents of GNSS interference in maritime transport increased dramatically, posing serious threats to navigation safety. These disruptions have been caused both by intentional actions (jamming and spoofing) and technical failures. For example, in 2019, the Center for Advanced Defense Studies documented about 10,000 cases of GPS spoofing in the Black Sea, Crimea, and Syria. Other affected regions include the Baltic Sea, the Mediterranean, the Persian Gulf, and major Chinese ports [2-5].

Example Incidents

- Black Sea (2017): Over 20 vessels simultaneously reported false GPS coordinates, locating them at Gelendzhik Airport, 25–30 nautical miles off their actual positions.
- Shanghai Port, China (2019): Spoofing incidents caused ships to transmit incorrect coordinates, placing them onshore [5, 6].
- Baltic Sea (2024): 84 hours of GNSS interference were recorded, including six major jamming events totaling 29 hours in October [7-10].
- Gulf of Finland (2024): 145 cases of GNSS interference were registered, mainly affecting coastal navigation [11].

Consequences for Vessels

- Loss of positional accuracy
- Malfunction of AIS systems
- Increased risk of collisions and grounding

Current Status of Traditional Navigation Skills

Modern generations of navigators are gradually losing both practical and theoretical skills in traditional navigation. Studies show modern officers face significant challenges operating without GPS:

- Deterioration of sextant and celestial calculation skills
- Inability to perform dead reckoning without electronics
- Poor understanding of coastal navigation by bearings
- Limited knowledge of radionavigation systems

Advantages of Traditional Methods

Traditional navigation provides:

- Full autonomy (no external signals required)
- Proven reliability over centuries
- Immunity to electronic warfare
- Cost-effectiveness of equipment

Adapting Traditional Methods to Modern Needs

With modern computational tools, hybrid backup navigation systems combining inertial, radio, and celestial components can be developed.

- Automated sextants and computer-assisted celestial systems allow fast, accurate fixes
- Optical systems and machine vision algorithms enable navigation by coastal features
- Integration enhances system redundancy during GNSS outages [12-15].

Cost Justification

Implementing such systems should be weighed against the cost of potential:

- Accidents
- Environmental damage
- Search and rescue operations

Global Practices and Training Standards

Leading institutions like the US Merchant Marine Academy, Tokyo University of Marine Science, Hamburg Maritime Academy, and National University "Odessa Maritime Academy" incorporate practical celestial and visual navigation training using both real instruments and simulators.

International standards, particularly the STCW Convention, mandate competencies in traditional navigation methods. IMO resolutions support their retention and the implementation of backup navigation systems. IAMU promotes global harmonization of training via exchanges and research initiatives [16].

Conclusion

The study shows that adapting traditional methods to modern maritime practice is not only possible but critically necessary to ensure safe navigation. Integrating classical techniques with digital systems provides robust fallback options in GNSS-denied scenarios [17-19].

A comprehensive approach to integration should include:

- Redesign of Training Standards to ensure that celestial and coastal navigation techniques are practiced regularly alongside electronic navigation.
- Development of Modern Hybrid Systems that allow for seamless transition between GNSS and traditional methods in emergency scenarios.
- Investment in Simulation-Based Training to improve familiarity with traditional methods in GNSS-denied environments.
- Continued Research and Innovation in automating aspects of traditional navigation (e.g., automated celestial calculations, digital sextants, image-recognition of coastal features).
- International Collaboration and Harmonization to ensure that all seafarers, regardless of country of origin, receive standardized competency in fallback navigation.

Success Depends on

- Technical modernization with retention of classical principles
- Overhauled curricula emphasizing hands-on practice
- Investment in training infrastructure and faculty development

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