Maintaining Maritime Safety Through the Use of Navigational Equipment in Accordance with Solas Chapter V

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Abstract:
Maritime navigation safety remains critical amid rising global and Indonesian shipping incidents, particularly collisions in congested routes, where human error and inconsistent GPS performance in tropical waters contribute significantly to risks despite SOLAS Chapter V mandates for standardized equipment. This study aimed to analyze the implementation and effectiveness of Radar and GPS usage in ensuring safe navigation on the LPG/C Gas Arar vessel during busy Teluk Semangka–Panjang voyages. A qualitative descriptive case study was conducted with purposive sampling of four key deck officers, employing structured observations, semi-structured interviews, and document analysis during sea practice from July 2024 to 2025; data were triangulated and thematically coded using NVivo 14 following Miles et al. (2014). Findings revealed operational Radar and GPS equipment with high SOLAS compliance via SOPs, comprehensive passage plans (Appraisal, Planning, Execution, Monitoring), and effective Bridge Team Meetings, although Radar dominance due to GPS waypoint limitations posed technical risks, mitigated by crew experience and cross-verification. In conclusion, integrated navigation enhances safety but requires GPS optimization; implications include training recommendations to reduce errors by 25–40% in Indonesian LPG fleets.
Keywords: *Bridge Team Management, GPS Navigation, Maritime Safety, Radar Usage and SOLAS Chapter V.*

I. INTRODUCTION

The safety of maritime navigation has become a crucial issue in the era of globalized maritime trade, where ship traffic volume has increased significantly. According to data from the International Maritime Organization (IMO), global shipping accidents reached 890 incidents in 2023, with collisions and groundings accounting for 40% of these, causing economic losses of up to billions of US dollars (IMO, 2024, cited in Wang et al., 2024). At the national level, Indonesia, as an archipelagic nation, recorded 156 ship accidents in 2023–2024, mainly in busy waters such as the Strait of Malacca and the Strait of Bali, emphasizing the urgency of implementing advanced navigation technology (Ministry of Transportation, 2024; Santoso & Pratiwi, 2023). The relevance of this topic is not only practical in reducing the risk of life and property, but also scientific in encouraging innovation in safety management based on international regulations.

Furthermore, recent trends indicate a high reliance on navigational tools such as RADAR and GPS for risk mitigation in busy shipping lanes. Empirical studies in Southeast Asia revealed that 65% of navigational incidents were caused by misinterpretation of GPS data in adverse weather conditions (Haryanto & Wijaya, 2022). Field events in Indonesia, including LPG/C vessel accidents in busy waters, exacerbate this situation, with human error contributing to up to 75% of cases (Sea Transportation Accident Investigation and Analysis Agency, 2023). Therefore, compliance with SOLAS Chapter V—which mandates the use of standardized navigational equipment—is a key foundation for improving ship operational efficiency and safety.

Previous research has explored the role of navigational aids in maritime safety. For example, Wang et al. (2024) found that integrating radar with automatic radar plotting aids (ARPA) reduced the risk of collisions on tankers in international waters by up to 30%. Similarly, Santosa (2019) emphasized that a safety management system (SMS) integrated with SOLAS Chapter V ensures the seaworthiness of ships through certification of original equipment. These findings confirm that modern navigational technology supports a proactive safety culture, including crew training and routine maintenance.

However, other studies have shown significant inconsistencies. While Haryanto and Wijaya (2022) reported on the effectiveness of GPS in crowded navigation, Santoso and Pratiwi (2023) identified contradictions in Indonesian LPG gas vessels, where GPS accuracy decreased by 25% due to signal interference in tropical waters. Methodological limitations in these studies include a purely qualitative approach without longitudinal empirical analysis, a lack of focus on the specific context of LPG/C vessels, and the neglect of human error variables such as the competence of the officer on watch. Furthermore, real-life cases such as the KM Sirimau accident in the Boling Strait in 2022—due to inaccurate GPS position plotting by the second officer—highlight this gap (Investigation Agency, 2023).

From there, the explicit research gap lies in the lack of comprehensive studies that integrate the use of RADAR and GPS in accordance with SOLAS Chapter V on LPG/C Gas Arar vessels in busy Indonesian shipping lanes, by considering human factors and safety management simultaneously. This problem statement is formulated as: What is the description and effectiveness of the use of these navigation equipment in maintaining navigation safety, considering the inconsistency of previous findings and the high number of local incidents?

This study aims to analyze the navigation safety picture through the use of RADAR and GPS in accordance with SOLAS Chapter V on the LPG/C Gas Arar vessel, and evaluate its effectiveness in mitigating risks in busy shipping lanes. The urgency of this current study is driven by the increase in gas vessel traffic in Indonesia post-2023, while the novelty lies in the mixed-methods approach that combines field observations and analysis of the specific case of Gas Arar—different from previous studies that are general in nature. The theoretical contribution includes the development of a SOLAS-based safety management model for LPG vessels, while the practical contribution provides training recommendations for crews to reduce human error by up to 40%, thus enriching the global maritime literature.

II. METHODS

This research adopts a descriptive qualitative case study design with an inductive approach, which allows for an in-depth exploration of navigation safety phenomena through the use of RADAR and GPS in accordance with SOLAS Chapter V on the LPG/C Gas Arar vessel. This approach aligns with Sugiyono's (2017) definition, which states that qualitative research emphasizes natural processes and subject perspectives, while Emzir (2018) adds that case studies are effective in uncovering specific contexts such as maritime operations. Recent studies such as Haryanto and Wijaya (2022) and Santoso and Pratiwi (2023) reinforce this choice by demonstrating the success of similar methods in analyzing human error in ship navigation in Indonesian waters, thus ensuring their theoretical basis is relevant to the research objectives.

The study population included all deck officers and navigational crew on the LPG/C Gas Arar vessel owned by PT. Pertamina International Shipping, with a focus on key informants directly involved in RADAR and GPS operations. A purposive sampling technique was used to select four key informants—Chief Officer, Second Officer, Third Officer, and Able Seaman—based on inclusion criteria such as a minimum of two years of experience in busy shipping lanes and regular involvement in navigational equipment operations, while exclusion was applied to non-deck personnel. This small sample size aligns with Sudaryono (2020) and Creswell and Poth (2021), who recommend data saturation in qualitative case studies to ensure depth of analysis without losing contextual generalizability.

The research instruments consisted of a structured observation guide, a semi-structured interview protocol, and a documentation sheet, all developed based on SOLAS Chapter V indicators such as position plotting accuracy, equipment maintenance, and emergency safety procedures. Instrument validity was tested through source triangulation and member checking, while reliability was achieved through field trail audits, as described by Sugiyono (2017) and Yin (2023). Recent research, such as Wang et al. (2024), demonstrated the effectiveness of a similar protocol in maritime studies, with interview questions covering aspects of safety monitoring, equipment functionality, and routine evaluations to comprehensively address the research problem.

The research procedure was carried out chronologically during the sea practice (Prala) from July 16, 2024, to July 25, 2025, on board the LPG/C Gas Arar vessel, starting with the preparation stage in the form of coordinating ethical permits from PT. Pertamina International Shipping and pilot testing of instruments. Subsequently, data collection was carried out through participant observation during the voyage in busy channels, in-depth interviews with informants (45–60 minutes per session, recorded with consent), and collection of documents such as navigation logbooks and SOLAS certificates. This process concluded with transcription and initial verification of data on site, with this chronological justification following Emzir (2018) and Haryanto and Wijaya (2022) to maintain the temporal integrity of the field-based case study.

Data analysis followed the model of Miles, Huberman, and Saldana (2014), which includes data reduction through thematic coding (selecting navigation safety and human error patterns), presenting data in narrative matrices and flowcharts, and drawing conclusions through cross-verification with SOLAS theory. NVivo 14 software was used to manage transcripts and identify recurring themes, ensuring a cohesive inductive analysis aligned with the research objectives. This approach is supported by Sugiyono (2017) and Santoso and Pratiwi (2023), who emphasize triangulation for validity in the Indonesian maritime context.

Strict ethical considerations were applied, including obtaining written informed consent from each informant prior to interviews and observations, maintaining anonymity through pseudonyms, and securely storing data on an encrypted server. Research permission was obtained from ship and company management in June 2024, without formal ethical clearance due to the internal nature of Prala, but in accordance with Creswell and Poth (2021) guidelines and Indonesian research ethics regulations (Kemenristekdikti, 2022). This ensured there were no conflicts of interest and protected participants from potential risks during the voyage.

III. RESULTS AND DISCUSSION

Data Presentation

1. Observation Results

The primary navigation equipment (radar and GPS) on the LPG/C Gas vessel Arar is in good operational condition and is actively used during shipping, particularly on the busy Teluk Semangka–Panjang route. These findings illustrate the level of navigational safety through the use of navigational equipment during ship operations.

a. RADAR Condition

When ships navigate this busy shipping lane, radar is a key tool for monitoring the movements of other vessels, especially at night or when visibility is limited. Officers on watch utilize features such as the Electronic Bearing Line (EBL) and Variable Range Marker (VRM) to help calculate the Closest Point of Approach (CPA) and Time to CPA (TCPA), thus identifying potential collision hazards early.

Fig. 1 X-Band Radar on LPG/C Gas Arar ship

Fig, 2 Radar Button

b. GPS Condition

GPS conditions help maintain accurate navigational routes. The vessel's position displayed by GPS is compared with a previously prepared navigation plan. This demonstrates the critical role GPS plays in maintaining safe navigation, in accordance with the principles stipulated in SOLAS Chapter V.

Fig. 3 GPS on the LPG/C Gas Arar ship

The officer on watch and the captain rely more on radar than on GPS (due to GPS waypoint limitations), so the waypoints for the Teluk Semangka–Panjang route are inputted into the internal radar—risky if there are technical problems. The use of both should be integrated to optimize safety. The implementation of SOLAS Chapter V is quite good, but requires vigilance, maintenance, watchkeeping on the bridge, and intense communication during heavy traffic (in accordance with Regulation 34 on safe navigation).

Table 1 Guide Observation

No	Observed Aspects	Observation Indicators	Compliance (Yes No)	Information
1.	Completeness of navigation equipment	The ship is equipped with Radar and GPS in accordance with SOLAS Chapter V regulation 19.	Yes	LPG/C Gas Arar Ship Equipped with Radar and GPS
2.	Equipment condition	Radar and GPS are in good operational condition before sailing.	Yes	Radar and GPS equipment condition is good
3.	Initial check	The officer on duty checks the RADAR function before entering the busy route.	Yes	It is carried out when the ship will carry out OHN departure and arrival.
4.	Radar Settings	Range, gain, sea clutter, and rain settings are adjusted to suit sailing conditions.	Yes	The duty officer always arranges for such compliance
5.	Target detection	Radar is used to detect other ships and monitor their movements.	Yes	Because many ships enter and exit the Panjang shipping lane, especially barges.
6.	Collision hazard analysis	The duty officer calculates CPA and TCPA using Radar	Yes	Calculations are always carried out to ensure the safety of shipping.
7.	GPS usage	The ship's position is monitored periodically via GPS.	No	GPS usage is only for positioning, not for inputted features or waypoints.
8.	Compliance with passage plan	GPS position compared to passage plan	No	The voyage plan is inputted in Radar and Ecdis only.
9.	Position	The ship's position is	Yes	Recorded

No	Observed Aspects	Observation Indicators	Compliance (Yes No)	Information
	recording	recorded regularly in the logbook.		according to the movement and position of the ship
10.	Decision-making	The officer on watch takes action (changes course/speed) based on navigation data or SPR (Ship Performance Report)	Yes	The communication between the captain and the officer on watch was very good in making navigation decisions.
11.	Coordination at the Platform	There is effective communication between the watch officer and the captain during busy situations.	Yes	Effective communication is well established
12.	Navigational Precautions	Visual observations are still carried out in addition to using navigation tools.	Yes	This was done because there were also many boats or nets that were not caught by radar.
14.	Technical Constraints	There was a technical problem with the Radar or GPS during the voyage.	No	Radar and GPS always synchronize position, clock and course
15.	Operator Competence	The officer on duty understands and is able to operate Radar and GPS well	Yes	Because the duty officer has good training

C. Documentation Results


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f) Posisi gyro repeater di kompartemen *steering gear* harus sedemikian rupa sehingga terlihat jelas dari posisi pengoperasian sistem

9.2 PERALATAN NAVIGASI

9.2.1 Umum

a) Penggunaan penuh semua peralatan navigasi harus dilakukan untuk menentukan posisi kapal dan memastikan keamanannya

b) Semua petugas navigasi harus benar-benar memahami peralatan dan keterbatasannya. Petugas navigasi harus membaca manual dan benar-benar memahami prosedur pengoperasian peralatan.

c) harus ada metode pengecekan silang posisi kapal dengan menggunakan metode alternatif.

d) Semua peralatan navigasi harus diperiksa oleh perwira jaga untuk memastikannya beroperasi penuh. *defects*, jika ada, harus segera ditangani. Perusahaan harus diberitahu tentang bantuan teknisi darat yang diperlukan untuk memperbaiki peralatan navigasi yang rusak.

e) Pemeliharaan Peralatan harus dilakukan sesuai dengan instruksi Pabrik.

f) Perbaikan di luar ruang lingkup staf kapal akan diatur melalui teknisi darat jika diperlukan. Cacat harus dimasukkan ke dalam Formulir 301 - Daftar Perbaikan Cacat / Kerusakan dan tindak lanjut dilakukan sampai diperbaiki.

g) Untuk pemeliharaan, Petugas Elektro-Teknis akan membantu Petugas ke-2 dan Petugas ke-3.

h) Sebuah register akan dipertahankan yang menunjukkan bahwa pemeliharaan telah dilaksanakan atau akan dijadikan bagian dari sistem pemeliharaan yang direncanakan.

i) *Ketika maker* merekomendasikan pemeriksaan tegangan, arus dll, nilai harus dicatat setelah memeriksa hal yang sama

9.2.2 Radar

a) Radar harus digunakan oleh seluruh officer dari:
- matahari terbenam sampai matahari terbit,
- ketika petugas berpikir bahwa dia perlu melakukannya,
- selama visibilitas terbatas,
- saat transit melalui area dengan kepadatan lalu lintas tinggi (termasuk kapal penangkap ikan)

b) Target harus diplot dan semua informasi mengenai Kursus, Kecepatan, CPA, TCPA, harus diperoleh dan dianalisis.

c) *Blind & Shadow sector* harus diidentifikasi, dan diagram harus ditempatkan di dekat radar

Fig. 4 Shipboard Procedure Manual Radar

Pertamina International Shipping's guidance document outlines operational requirements for the use and maintenance of ship navigation equipment. Section 9.2, which addresses navigation equipment, explains that all navigation equipment must be in place to ensure safe navigation.


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d) Kinerja radar harus diperiksa oleh *performance monitor* setiap kali radar digunakan. Akurasi VRM, EBL dan Heading Marker harus diperiksa setiap kali radar dinyalakan dan selama setiap jam jaga.

e) Catatan radar dan catatan pemeliharaan radar harus disimpan, dan Nakhoda harus memeriksa dan memverifikasi catatan radar sekali setiap bulan.

9.2.3 ARPA

a) Panduan Produsen harus dipahami secara menyeluruh untuk memahami sepenuhnya dan menggunakan ARPA untuk mendapatkan keuntungan maksimal.

b) Keakuratan peralatan ARPA dan metode plot lainnya harus diverifikasi dengan pemeriksaan silang, dengan pengamatan visual dan dengan informasi jalur / kecepatan yang diberikan oleh kapal lain. Setiap kali membuat plot dalam situasi multi target, prioritas untuk mendapatkan informasi maksimum harus terlebih dahulu diberikan untuk menutup kontak terdekat, dan kemudian diarahkan ke kontak yang lebih jauh yang tidak menunjukkan perubahan arah kompas yang signifikan.

c) Harus dicatat bahwa CPA yang dihitung oleh ARPA memiliki ketidakakuratan dan CPA yang kurang dari 1 NM harus ditanggapi dengan serius.

d) Untuk penggunaan anti-tabrakan, *ground stabilized mode* harus dihindari.

e) Pemeliharaan radar harus dilakukan sesuai spesifikasi pembuatnya. Sebelum pekerjaan apapun dilakukan pada scanner, semua tindakan pencegahan seperti melepas sekering, memasang tanda yang sangat jelas, dll harus dilakukan dan prosedur penguncian tag-out diterapkan.

f) Jika ruang lingkup perawatan di luar kemampuan staf kapal, maka teknisi darat akan diatur oleh kantor

9.2.4 Gyro Compass

a) Peralatan Gyro harus digunakan dan diservis secara ketat sesuai dengan instruksi pabrik. Perusahaan akan berusaha agar gyro dikerjakan oleh otoritas yang kompeten.

b) Kontrol koreksi garis lintang dan kecepatan untuk gyro harus disesuaikan setiap jam jaga oleh petugas penjaga jam.

c) Perubahan dari kemudi manual ke Pilot Otomatis dan sebaliknya harus ditentukan dengan sangat jelas dan dipasang di dekat kompas gyro.

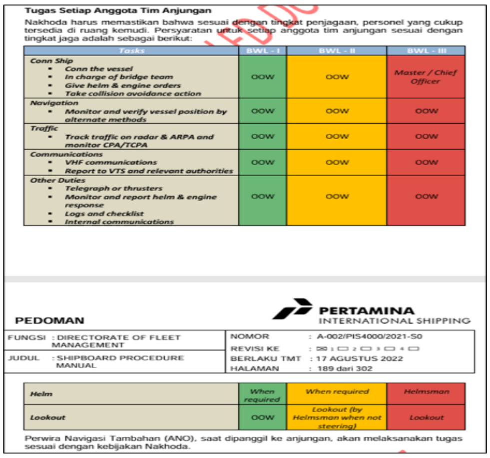
d) Master Gyro compass harus dibiarkan beroperasi kecuali ada alasan untuk mengamankannya. Jika diamankan, itu harus dimulai dalam waktu yang cukup untuk memungkinkan menetap di meridian sebelum dimulai. Master gyro, repeater, dan perekam kursus harus disinkronkan dan diperiksa untuk pengoperasian yang benar sebelum memulai.

e) Pemeliharaan kompas gyro akan menjadi tanggung jawab petugas ke-2 dan Petugas Teknis Elektro.

f) Alarm Gyro tentu saja harus diuji setidaknya sekali sehari oleh Petugas Kedua.

Fig. 5 Shipboard Procedure Manual Arpa

The Radar section explains that radar performance must be monitored using a performance monitor each time it is used. The accuracy of the critical components, VRM, EBL, and heading marker, must be checked when the radar is turned on.



Tugas Setiap Anggota Tim Anjungan

Nakhoda harus memastikan bahwa sesuai dengan tingkat penjagaan, personel yang cukup tersedia di ruang kemudi. Persyaratan untuk setiap anggota tim anjungan sesuai dengan tingkat jaga adalah sebagai berikut:

Tasks	BWL - I	BWL - II	BWL - III
Conn Ship ▪ *Conn the vessel* ▪ *In charge of bridge team* ▪ *Give helm & engine orders* ▪ *Take collision avoidance action*	OOW	OOW	*Master / Chief Officer*
Navigation ▪ *Monitor and verify vessel position by alternate methods*	OOW	OOW	OOW
Traffic ▪ *Track traffic on radar & ARPA and monitor CPA/TCPA*	OOW	OOW	OOW
Communications ▪ *VHF communications* ▪ *Report to VTS and relevant authorities*	OOW	OOW	OOW
Other Duties ▪ *Telegraph or thrusters* ▪ *Monitor and report helm & engine response* ▪ *Logs and checklist* ▪ *Internal communications*	OOW	OOW	OOW

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Helm	*When required*	*When required*	*Helmsman*
Lookout	OOW	*Lookout (by Helmsman when not steering)*	*Lookout*

Perwira Navigasi Tambahan (ANO), saat dipanggil ke anjungan, akan melaksanakan tugas sesuai dengan kebijakan Nakhoda.

Figure 6 Shipboard Procedure Manual Team Member Duties

The duties of each member of the Bridge Team demonstrate that navigational safety management relies heavily on a clear division of tasks, coordination among bridge personnel, and a monitoring system. This division of roles ensures the effectiveness of all navigational functions, minimizing the potential for human error and maintaining navigational safety.

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- Penyediaan personel jaga tambahan dalam situasi luar biasa, misalnya lalu lintas padat, lorong sempit, atau jarak pandang terbatas.
- Jaga radio dan prosedur GMDSS.
- Pengaturan keselamatan ECDIS.
- Petunjuk tentang Keamanan Siber.

Saat mengambil alih komando, Nakhoda akan mengadakan rapat untuk semua perwira dek, penjaga dan pekerja magang dek mengenai peran mereka, tugas navigasi dan membahas tata tertib. Jika perwira navigasi baru bergabung dengan kapal, rapat baru akan diadakan untuk pendatang baru. Catatan rapat ini harus disimpan dalam buku catatan dek.

c) Semua perwira navigasi, peserta pelatihan dan penjaga jaga (AB dan OS) harus menandatangani perintah tetap untuk "Dibaca dan dipahami" dengan tanggal.

8.1.9 Perintah Anjungan Harian Nakhoda (*Master's Daily Bridge Orders*)

Nakhoda harus menuliskan perintah anjungan harian yang sesuai di Buku Perintah Nakhoda. Perintah tersebut harus diparaf oleh setiap OOW. Perintah dapat mencakup:

a) Referensi terhadap penyimpangan dalam rencana lintasan jika ada.
b) Jarak yang harus dijaga dari daratan.
c) CPA/TCPA harus dijaga.
d) BCR harus dijaga.
e) Jarak aman harus dijaga dari bahaya/bantuan navigasi.
f) Instruksi lain, sebagaimana yang dianggap perlu oleh Nakhoda berdasarkan keadaan dan kondisi yang berlaku.

Memanggil Nakhoda

OOW harus segera memberi tahu Nakhoda dalam keadaan berikut:

a) Jika jarak pandang terbatas.
b) Jika kondisi lalu lintas atau pergerakan kapal lain menimbulkan kekhawatiran termasuk ketidakmampuan untuk mempertahankan CPA, TCPA, dan BCR minimum yang diperlukan sesuai perintah nakhoda.
c) Jika mengalami kesulitan dalam mempertahankan haluan dan/atau kecepatan.
d) Jika gagal melihat daratan, tanda navigasi, atau memperoleh pengukuran kedalaman sesuai perkiraan waktu.
e) Jika daratan atau tanda navigasi terlihat atau terjadi perubahan sonar secara tiba-tiba.

UNCONTROLLED DOCUMENT

Fig. 7 Shipboard Procedure Manual Master's Orders

The Master's Daily Bridge Orders (DBD) are written by the Master and initialed by the officer on watch. These orders cover ship track control, safe distances, and monitoring of sailing conditions, which must be reported immediately to the Master. Data also shows that navigational safety depends not only on equipment but also on human resource management, effective communication, and the Master's leadership in controlling navigational operations.

c. Interview Results

Table 2 Summary of Interview Results

No	Theme Focus	*Chief Officer*	*Second Officer*	*Third Officer*	*Able Seaman*	Conclusion
1.	Safety of navigation & implementation of procedures	Supervision and briefing	*Passage plan*approved by the Captain	Radar and GPS Monitoring	*Lookout*	Have a clear role during the voyage
2.	Compliance with SOLAS Chapter V regulations	Navigation SOP	Procedures for using navigation tools	Reporting of situations and conditions	Following the directions of the duty	The entire crew has carried out the SOP.

No	Theme Focus	*Chief Officer*	*Second Officer*	*Third Officer*	*Able Seaman* officer	Conclusion
3.	Monitoring and function of navigation equipment	*Maintenance*routine	Regular monitoring and running hours	Equipment readiness	Physical care	Done regularly and navigation tools function well
4.	Navigation planning and safety control	*Checklist*daily and Bridge Resource Management	Detailed plans and provide warning records in specific shipping areas	Implementation of the route planning that has been approved by the Captain	Hazard monitoring and reporting support	It has been approved and well coordinated
5.	Evaluation of navigation equipment	Recording in logbook and daily	Every change of guard duty	Every guard duty	During guard duty	Reporting and changing of guard duty is very good

The crew adheres to navigation SOPs in accordance with SOLAS; the officer's role is clear. The second officer had difficulty with GPS waypoints (only on the internal radar), but the captain agreed to save the old waypoints (the route often changes) and apply them to the ECDIS. There have been no collisions/departures due to the good experience of the officers/crew. The captain regularly briefs on instructions for entering/exiting the channel (visual alert + radar/GPS), which are recorded in the logbook.

Data analysis

Table 3 Data Triangulation

Focus/Theme	Interview Findings	Observation Findings	Documentation Findings	Interpretation of Triangulation Results
Maintain shipping safety in accordance with SOLAS Chapter V	The officer on duty stated that shipping safety is implemented through clear guard duty, implementation of lookouts, use of navigation equipment according to procedures, regular monitoring of Radar and GPS.	There is visible active surveillance on the bridge when entering busy shipping.	There is a passage plan approved by the Master and an approved checklist of navigation safety procedures.	The data shows consistency that the implementation of maritime safety has been carried out in accordance with the provisions of SOLAS Chapter V through the implementation of watchkeeping procedures and the continuous use of navigational equipment.
Use of navigation equipment and navigation	The officer on duty stated that the navigation equipment was used according	Active use of Radar and GPS during cruise	An up-to-date passage plan document that helps in monitoring	The use and planning of navigation is carried out systematically

Focus/Theme	Interview Findings	Observation Findings	Documentation Findings	Interpretation of Triangulation Results
planning	to procedures, periodic monitoring and visual checks were carried out, and the passage plan had been planned according to the approved procedures.		when entering and exiting the shipping lane.	and in a planned manner according to ship navigation operational procedures.
Navigational surveillance and control in busy shipping lanes	The captain and the officer on watch communicated clearly and intelligibly, and coordinated well during the voyage.	Active communication on the Bridge, and monitoring of the situation around the ship and implementation of Bridge Resource Management	There are watch report notes and a shipping supervision checklist	Demonstrates that navigation supervision and control has been carried out in a coordinated manner through communication, recording and clear work procedures.

The triangulation data explains that Radar Parallel Indexing, Cross-Track Monitoring with GPS, and other techniques will be used to monitor ship trajectories. The targets used must be safe and easily identifiable, conspicuous, located outside of clutter, and limited to a sufficient number for navigation.

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IV. Discussion

1. Radar and GPS are navigation tools used on ships as safety tools during shipping. The LPG/C Gas Arar ship, when crossing a busy shipping lane from Teluk Semangka to Panjang, found that the supervision of the use of Radar and GPS navigation equipment was carried out more intensively and optimally. Shipping safety in the use of Radar Range settings is reduced and states that the Closest Point of Approach (CPA) and Time to CPA (TCPA) are the main references in assessing the potential for collision hazards. The use of GPS provides an accurate and real-time picture of the ship's position. Based on the results of observations, the ship's position is periodically compared with the voyage plan that has been made before departure.

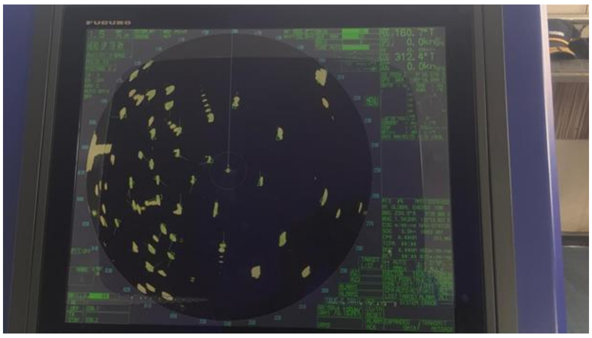
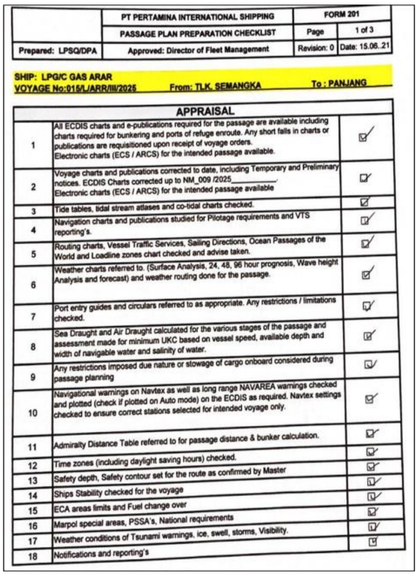


Fig. 8 Position of the ship entering the shipping lane

OnFigure 8 is a Radar image showing the position of the ship when entering the Long Channel area with a position of Latitude 5°30.279'S Longitude 105°18.049'E. Based on Figure 4.11, navigation safety is monitored safely because the officer on duty conducts regular surveillance with CPA and TCPA Radar, and position data from GPS is also continuously verified with traffic conditions monitored on the Radar screen. The captain emphasized the importance of cross-checking between equipment to avoid misinterpretation of navigation data and the passage plan that has been made.

Fig. 9 Author and Second Officer input waypoint

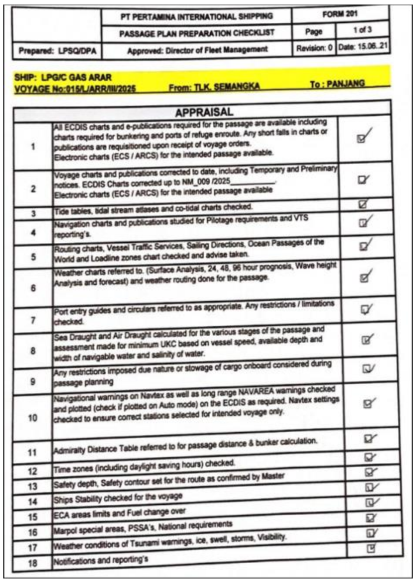
Figure 9: The author and second officer prepare the Teluk Semangka–Panjang route. In accordance with SOLAS Ch. V Reg. 34, the captain approves a comprehensive passage plan (Appraisal, Planning, Execution, Monitoring) for safe navigation. PT. Pertamina Int. Shipping has a standard operating procedure (SOP) checklist that assists officers in preparing the voyage plan.



	PT PERTAMINA INTERNATIONAL SHIPPING	FORM 201	
	PASSAGE PLAN PREPARATION CHECKLIST	Page	1 of 3
Prepared: LPSQ/DPA	Approved: Director of Fleet Management	Revision: 0	Date: 15.06..21

SHIP: LPG/C GAS ARAR
VOYAGE No:015/L/ARR/III/2025 From: TLK. SEMANGKA To : PANJANG

APPRAISAL		
1	All ECDIS charts and e-publications required for the passage are available including charts required for bunkering and ports of refuge enroute. Any short falls in charts or publications are requisitioned upon receipt of voyage orders. Electronic charts (ECS / ARCS) for the intended passage available.	☑
2	Voyage charts and publications corrected to date, including Temporary and Preliminary notices. ECDIS Charts corrected up to NM_009 /2025__________. Electronic charts (ECS / ARCS) for the intended passage available	☑
3	Tide tables, tidal stream atlases and co-tidal charts checked.	☑
4	Navigation charts and publications studied for Pilotage requirements and VTS reporting's.	☑
5	Routing charts, Vessel Traffic Services, Sailing Directions, Ocean Passages of the World and Loadline zones chart checked and advise taken.	☑
6	Weather charts referred to. (Surface Analysis, 24, 48, 96 hour prognosis, Wave height Analysis and forecast) and weather routing done for the passage.	☑
7	Port entry guides and circulars referred to as appropriate. Any restrictions / limitations checked.	☑
8	Sea Draught and Air Draught calculated for the various stages of the passage and assessment made for minimum UKC based on vessel speed, available depth and width of navigable water and salinity of water.	☑
9	Any restrictions imposed due nature or stowage of cargo onboard considered during passage planning	☑
10	Navigational warnings on Navtex as well as long range NAVAREA warnings checked and plotted (check if plotted on Auto mode) on the ECDIS as required. Navtex settings checked to ensure correct stations selected for intended voyage only.	☑
11	Admiralty Distance Table referred to for passage distance & bunker calculation.	☑
12	Time zones (including daylight saving hours) checked.	☑
13	Safety depth, Safety contour set for the route as confirmed by Master	☑
14	Ships Stability checked for the voyage	☑
15	ECA areas limits and Fuel change over	☑
16	Marpol special areas, PSSA's, National requirements	☑
17	Weather conditions of Tsunami warnings, ice, swell, storms, Visibility.	☑
18	Notifications and reporting's	



	PT PERTAMINA INTERNATIONAL SHIPPING	FORM 201	
	PASSAGE PLAN PREPARATION CHECKLIST	Page	1 of 3
Prepared: LPSQ/DPA	Approved: Director of Fleet Management	Revision: 0	Date: 15.06..21

SHIP: LPG/C GAS ARAR
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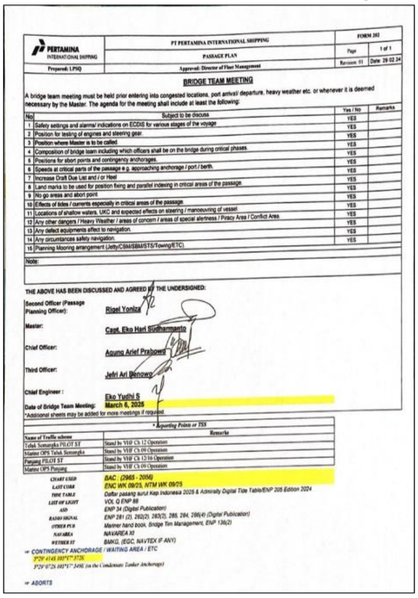
11	Admiralty Distance Table referred to for passage distance & bunker calculation.	☑
12	Time zones (including daylight saving hours) checked.	☑
13	Safety depth, Safety contour set for the route as confirmed by Master	☑
14	Ships Stability checked for the voyage	☑
15	ECA areas limits and Fuel change over	☑
16	Marpol special areas, PSSA's, National requirements	☑
17	Weather conditions of Tsunami warnings, ice, swell, storms, Visibility.	☑
18	Notifications and reporting's	

Fig. 10 Appraisal Checklist form 201 and Planning Checklist form 201



PERTAMINA INTERNATIONAL SHIPPING	PT PERTAMINA INTERNATIONAL SHIPPING	FORM 202	
	PASSAGE PLAN	Page	1 of 1
Prepared: LPSQ	Approved: Director of Fleet Management	Revision: 01	Date: 29 02 24

BRIDGE TEAM MEETING

A bridge team meeting must be held prior entering into congested locations, port arrival/ departure, heavy weather etc. or whenever it is deemed necessary by the Master. The agenda for the meeting shall include at least the following:

No	Subject to be discuss	Yes / No	Remarks
1	Safety settings and alarms/ indications on ECDIS for various stages of the voyage	YES	
2	Position for testing of engines and steering gear	YES	
3	Position where Master is to be called	YES	
4	Composition of bridge team including which officers shall be on the bridge during critical phases	YES	
5	Positions for abort points and contingency anchorages	YES	
6	Speeds at critical parts of the passage e.g. approaching anchorage / port / berth	YES	
7	Increase Draft Due List and / or Heel	YES	
8	Land marks to be used for position fixing and parallel indexing in critical areas of the passage	YES	
9	No go areas and abort point	YES	
10	Effects of tides / currents especially in critical areas of the passage	YES	
11	Locations of shallow waters, UKC and expected effects on steering / manoeuvring of vessel	YES	
12	Any other dangers / Heavy Weather / areas of concern / areas of special alertness / Piracy Area / Conflict Area	YES	
13	Any defect equipments affect to navigation	YES	
14	Any circumtances safety navigation	YES	
15	Planning Mooring arrangement (Jetty/CBM/SBM/STS/Towing/ETC)		

Note:

THE ABOVE HAS BEEN DISCUSSED AND AGREED BY THE UNDERSIGNED:

Second Officer (Passage Planning Officer): Rigel Yoniza
Master: Capt. Eko Hari Sudharmanto
Chief Officer: Agung Arief Prabowo
Third Officer: Jefri Ari Benowo
Chief Engineer : Eko Yudhi S
Date of Bridge Team Meeting: March 6, 2025
*Additional sheets may be added for more meetings if required

* Reporting Points or TSS	
Name of Traffic scheme	Remarks
Teluk Semangka PILOT ST	Stand by VHF Ch 12 Operation
Marine OPS Teluk Semangka	Stand by VHF Ch 09 Operation
Panjang PILOT ST	Stand by VHF Ch 12/16 Operation
Marine OPS Panjang	Stand by VHF Ch 09 Operation

CHART USED: BAC : (2965 - 2056)
LAST CORR: ENC WK 09/25, NTM WK 09/25
TIDE TABLE: Daftar pasang surut Kep Indonesia 2025 & Admiralty Digital Tide Table/ENP 205 Edition 2024
LIST OF LIGHT: VOL Q ENP 88
ASD: ENP 34 (Digital Publication)
RADIO SIGNAL: ENP 281 (2), 282(2), 283(2), 285, 284, 286(4) (Digital Publication)
OTHER PUB: Mariner hand book, Bridge Tim Management, ENP 136(2)
NAVAREA: NAVAREA XI
WETHER ST: BMKG, (EGC, NAVTEX IF ANY)

CONTINGENCY ANCHORAGE / WAITING AREA / ETC

ABORTS

Fig. 11 Approval of passage plan by Master form 202

Figure 11 Form 202 Bridge Team Meeting (BTM) for bridge team coordination before sailing (congested areas, bad weather, etc.), approved by the Second Officer (passage planner), Master, Chief Officer, Third Officer, Chief Engineer—preventive to minimize human risk. Figure 12 Detailed Pertamina Int. Shipping passage plan for the STS Teluk Semangka–Panjang route, with waypoints (coordinates, distance, course, ETT) by the Second Officer.

PERTAMINA INTERNATIONAL SHIPPING | PT PERTAMINA INTERNATIONAL SHIPPING | FORM 202
PASSAGE PLAN | Page: 1 of 1
Prepared: LPSQ | Approved: Director of Fleet Management | Revision: 01 | Date: 29.02.24

SHIP: LPG/C ARAR | CALL SIGN: JZFE
Voyage : 015/L/ARR/III/2025 | Dep Draft F: 4.50 | * Company UKC Policy refer to Shipboard Procedure Manual 8.2.4 Under Keel Clearance
From Port: : STS TLK. SEMANGKA | To Port : : PANJANG | Draft A: 4.90 | * Bridge & Engine Room Manning Level refer to Shipboard Procedure Manual 8.3.3 Watch Arrangements – Manning in Bridge and Engine Room

No	BA Chart	WPT LAT	WPT LONG	COURSE	DIST	DTG	Paralel Index	Catzoc	Minimum UKC	Deep Countour	Safety Countour Safety Depth	Shallow Countour	Speed & Current Direction (Knot)	Plotting Interval	Posn fixing method (Visual, RADAR, GPS)	Guard Ring	Bridge Manning Level	Engine Room Manning Level	Tidal Stream (+/-)	SECURITY	VHF	* Master's Remarks/ Additional Instructions or Deviation from Plan
BERTH TO PILOT STATION																						
1		05° 32' 700" S	104° 34' 200" E			84.10		A2	0.49	15	8	6	3	5'	V, R, G	0.3	C	C	0.8	1	16/09/12	STS AREA
2		05° 34' 000" S	104° 38' 000" E	109.0	4.00	80.10		A2	0.49	15	8	6	8	15'/30'	V, R, G	0.3	C	C	1	1	16/09/12	SEMANGKA REPORT VHF CH.09/CH.012
TOTAL DISTANCE					4.00																	
2																						
3		05° 57' 000" S	105° 10' 000" E	126.0	39.30	40.80		B	2.45	15	8	6	10.5	60'	V, R, G	0.5	A	A	1	1	16	LEGUNDI
4		05° 51' 000" S	105° 26' 000" E	69.0	17.00	23.80		B	2.45	15	8	6	10.5	60'	V, R, G	0.5	A	A	1	1	16	SERDANG
5		05° 43' 000" S	105° 25' 000" E	353	8.00	15.80		B	2.45	15	8	6	10.5	60'	V, R, G	0.5	A	A	1	1	16	CUKUCIMA
30.4					64.30																	
\																						
6		05° 34' 000" S	105° 19' 000" E	326.0	10.8	13.00		A2	0.00	15	8	6	5	5'	V, R, G	0.3	C	C	0.5	1	16/09/12	P TEGAL
7		05° 29' 000" S	105° 18' 900" E	359.0	5	8.00		A2	0.00	15	8	6	3	5'	V, R, G	0.3	C	C	0.5	1	16/09/12	PANJANG REPORT VHF CH.16/CH.12/CH.09
TOTAL DISTANCE					15.80																	

* Column remarks can input additional information (Channel VHF or VHF VTIS or Pilot channel, Call Master Point, Specific order or experience previous last voyage)
* Passage Plan must be cover Berth to Berth. If any contingency plan or anchor, Passage Plan must be update!

Fig.12 Passage Plan from Teluk Semangka to Panjang

In addition, each route segment is equipped with safety parameters such as minimum safe depth, shallow water contours, safe distance from navigational hazards, and the characteristics of the waters traversed.

Operational navigation arrangements, such as the vessel's position plotting interval and positioning methods (visual, radar, and GPS), emphasize that human resources and the vessel's technical readiness are integral to navigation planning.

Data on navigational safety communications is available, including Very High Frequency (VHF) channels used for reporting to port authorities and ship traffic systems via Channel 12 for scouting and Channel 09 for Pertamina Operations. This information indicates that navigation planning encompasses not only physical trajectories but also communication procedures as part of navigational safety.

Fig.13 VHF Channel 12

2. Regarding the use of navigation equipment to maintain safety, research results show that Radar and GPS are used in a complementary manner. Target data from Radar is not directly used as the basis for decisions without confirming the ship's position via GPS. Instead, position data from GPS is also verified with traffic conditions monitored on the Radar screen. In some situations, officers on watch tend to focus more on the Radar display to maintain the shipping lane rather than conducting in-depth analysis of GPS usage. This condition has the potential to pose a risk if there is a sudden change in other vessels in the vicinity. Therefore, although the use of navigation equipment is generally in accordance with the provisions of SOLAS Chapter V, optimization of the use of all GPS features still needs to be improved, especially the input of waypoints.

V. CONCLUSION

This study found that the main navigation equipment such as Radar and GPS on the LPG/C Gas Arar vessel operated well and were actively used on the busy Teluk Semangka–Panjang route, with high compliance with SOLAS Chapter V through SOPs, comprehensive passage plans (Appraisal, Planning, Execution, Monitoring), Bridge Team Meetings, and effective bridge team coordination. The use of Radar dominated for CPA/TCPA detection and traffic monitoring, while GPS was limited to waypoints so it was inputted into Radar/ECDIS, ensuring no collision incidents thanks to crew experience and the Master's briefing. Triangulation of interview data, observations, and documents confirmed that the integration of navigation tools complemented each other to increase safety.

However, limitations include the single-case study focus (Gas Arar) that lacks broad generalizability, the reliance on participant observation during a short period (July 2024–2025), and the lack of quantitative data, such as GPS error rates, in tropical conditions. Suggestions for further research include a longitudinal, mixed-methods, multi-vessel comparative analysis of LPG/C vessels, including technical disruption simulations and human error metrics. Practical implications include recommendations for GPS waypoint optimization, integrated Radar-GPS training, and routine audits of Pertamina's SMS to reduce risk by 25–40% in Indonesia's busy waterways.

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