

# A Strategic Framework For Strengthening Anti Submarine Warfare (Asw) Capabilities In The Indonesian Archipelagic Sea Lane-2 (ASL-2) To Mitigate Underwater Threats And Protect Indonesia's Maritime Sovereignty

Rian Risky Putrantio<sup>1</sup>, Ferry Supriady<sup>2</sup>, Lucky Wuwung<sup>3</sup>

<sup>1,2,3</sup> Sekolah Staf dan Komando (SESKOAL)

Cipulir, Kebayoran Lama, Kota Jakarta Selatan, DKI Jakarta 12230, Indonesia

[rianriskyputrantio@tnial.mil.id](mailto:rianriskyputrantio@tnial.mil.id)

**Abstract** — The Indonesian Archipelagic Sea Lane II (ASL-2) is a strategic shipping route connecting the northern region of Indonesia with the Indian Ocean through the Makassar Strait, Flores Sea, and Lombok Strait. This position gives ASL-2 significant importance for national defence, navigational security, and the protection of Indonesia's maritime sovereignty. The development of submarines and underwater technologies operated by state actors may pose potential threats to national interests. Current conditions indicate that the Indonesian Navy's Anti-Submarine Warfare (ASW) capability still predominantly relies on Hull Mounted Sonar (HMS), while the use of Towed Array Sonar (TAS) remains limited, an Integrated Underwater Surveillance System (IUSS) has not yet been established, and bathythermograph and hydro-oceanographic data have not been centrally managed. This study aims to analyse the current condition and capability gaps in ASW, identify the internal and external factors affecting its development, and formulate strategies to enhance the Indonesian Navy's ASW capability in ASL-2. This study applies a descriptive qualitative method with a case study approach. Data are collected through interviews, limited observation, documentation, and literature review involving informants selected purposively based on their positions and competencies. The data are analysed using Reflexive Thematic Analysis assisted by NVivo to develop themes and identify strategic factors. The identified internal and external factors are subsequently analysed using IFAS, EFAS, and SWOT to formulate SO, WO, ST, and WT strategic alternatives. This study is expected to produce Policies, Strategies, and Efforts to enhance the Indonesian Navy's ASW capability in ASL-2 based on the research findings. The proposed policies, strategies, and efforts are formulated through thematic analysis assisted by NVivo, identification of internal and external factors, preparation of IFAS and EFAS, and SWOT analysis. This analytical process ensures that the resulting strategy is academically accountable and relevant to the operational requirements of the Indonesian Navy.

**Keywords** — Anti-Submarine Warfare (ASW), ASL-2, underwater threats, SWOT.

## I. INTRODUCTION

Indonesia is an archipelagic country with a strategically important geographical position between two continents and two oceans. This position makes Indonesian waters an important space for international shipping, global trade, national connectivity, and national defense and security. The existence of nine strategic choke points provides significant strategic advantages while simultaneously creating vulnerabilities that require continuous maritime surveillance and security. These vulnerabilities are not limited to the surface domain but also extend to the underwater domain, particularly with the development of submarines, unmanned underwater vehicles (UUVs), underwater sensors, and underwater surveillance systems. Consequently, the underwater domain has become an increasingly important dimension of maritime defense that requires appropriate operational capabilities and strategic planning.

The Alur Laut Kepulauan Indonesia II (ASL-2) is particularly relevant to this issue because it connects the Sulawesi Sea and the Indian Ocean through the Makassar Strait, Flores Sea, and Lombok Strait. Its strategic importance is reinforced by the high intensity of international maritime traffic and the hydro-oceanographic characteristics of its waters. Hadi and Yola reported that approximately 12,189 vessels from various countries passed through ASL-2 in 2023, while their monitoring of the Lombok Strait on 31 December 2023 recorded 35 international vessels. The Lombok Strait is also characterized by relatively deep waters and is part of ASL-2, while oceanographic phenomena in the area can affect underwater navigation and sonar-related activities.

Furthermore, the strategic significance of ASL-2 has increased with the development of the Nusantara Capital City (IKN), which directly faces the Makassar Strait and therefore requires consideration of maritime defense and security. These characteristics make the southern sector of ASL-2, particularly Choke Point 8/Lombok Strait, highly relevant to the development of Anti-Submarine Warfare (ASW) capability.

The Indonesian Navy's ASW capability requires the integration of sensors, platforms, weapons, command and control, personnel, and underwater environmental information to detect, localize, identify, classify, track, and respond to potential submarine threats posed by state actors. The effectiveness of sonar detection is influenced not only by the technical condition and operator capability but also by underwater environmental conditions. Negative sound-speed gradients, for example, can create shadow zones in which submarines may be difficult to detect using conventional sonar. The current condition therefore indicates several capability gaps. Surface combatants still rely predominantly on organic Hull Mounted Sonar (HMS), while the complex acoustic characteristics of tropical waters can limit detection effectiveness. In addition, underwater surveillance in ASL-2 has not yet been supported by a dedicated and continuously operating Integrated Underwater Surveillance System (IUSS). The utilization of Expendable Bathythermograph (XBT) data also remains an important issue because underwater propagation information is required to support sonar operators in assessing the underwater acoustic environment. Consequently, the existing capability has not fully achieved the desired condition of layered, continuous, and integrated underwater surveillance.

The strategic importance of ASL-2 must also be considered within the applicable international maritime legal framework. Under Article 53 of the United Nations Convention on the Law of the Sea (UNCLOS) 1982, ships and aircraft enjoy the right of archipelagic sea lanes passage through designated sea lanes, with passage conducted continuously and expeditiously in the normal mode. Judhariksawan, Daud, and Tandungan further explain that the Makassar Strait, as part of an archipelagic sea lane, is subject to the international law of the sea and that foreign ships, including military vessels and submarines, have rights of passage under the applicable legal regime. Previous studies have also addressed several aspects relevant to the present problem. Defrianto, Pratama, and Malik examined underwater acoustic propagation and shadow zone formation, while Pranaditya Mirza S., Hermawan, and Mostein Adi P. examined the selection of an Underwater Surveillance System to improve early submarine detection capability in ASL-2. At the regional level, Erästö, Su, and Wan examined submarine and ASW capability development in the Indo-Pacific.

Although these studies provide important contributions, they predominantly examine strategic and legal aspects of ASL-2, acoustic propagation, underwater surveillance systems, or regional undersea capability development separately. The study by Pranaditya Mirza S., Hermawan, and Mostein Adi P., for example, focuses specifically on the selection of an underwater monitoring system based on technical, operational, and economic considerations. Similarly, research on acoustic propagation focuses on the formation of shadow zones, while regional studies examine broader submarine and ASW developments in the Indo-Pacific. Thus, a research gap remains in developing an integrated strategy that connects sensor capability, continuous underwater surveillance, hydro-oceanographic and bathythermograph information, platform readiness, human resources, and operational command and control within the specific context of ASL-2. This study therefore aims to analyze the current condition and capability gaps of the Indonesian Navy's ASW capability in ASL-2, identify the internal and external factors influencing capability development, and formulate a strategy for improving ASW capability against potential submarine threats from state actors.

The originality of this study lies in its integrated strategic approach to improving Indonesian Navy ASW capability in ASL-2, particularly in the southern sector around Choke Point 8/Lombok Strait. The study integrates five dimensions: sensor enhancement, continuous underwater surveillance, utilization of underwater environmental and bathythermograph data, readiness of personnel and operational platforms, and command-and-control integration. Unlike previous studies that primarily examine these dimensions separately, this study seeks to connect them within a single strategic framework adapted to the operational and hydro-oceanographic characteristics of ASL-2. The study uses a qualitative descriptive approach with a case study method and is supported by interviews, limited observations, documentation, literature studies, thematic analysis using NVivo, and IFAS, EFAS, and SWOT analysis. The expected contribution is a strategic formulation that can serve as an academic and practical input for the Indonesian Navy in strengthening ASW capability, particularly in addressing underwater threats within a strategically important Indonesian archipelagic sea lane.

## **II. METHOD**

### **Research Methods**

This study employs a descriptive qualitative method with a case study approach to examine the capabilities of the Indonesian Navy (TNI AL) in Anti-Submarine Warfare (ASW) within Indonesian

Archipelagic Sea Lane II (ASL-2), particularly in the southern sector around the Lombok Strait. Primary data are obtained through semi-structured interviews with purposively selected informants possessing relevant expertise and institutional responsibilities in naval operations, ASW, sonar systems, hydro-oceanographic support, maritime security, and defense planning. Secondary data are collected through document analysis and literature reviews of relevant regulations, official documents, naval doctrines, academic books, scientific journals, research reports, and institutional publications. Limited observations are conducted where feasible and permitted by defense information security requirements. Data collection focuses on current operational conditions, emerging underwater threats, supporting and constraining factors, capability gaps, and strategic requirements for ASW development.

Data are analyzed using Reflexive Thematic Analysis (RTA), supported by NVivo for data organization, coding, and analytical memo management. The analysis involves data familiarization, initial coding, theme development and review, theme definition, and interpretation. Identified internal and external strategic factors are subsequently assessed using the Internal Factor Analysis Summary (IFAS) and External Factor Analysis Summary (EFAS), which provide the basis for SWOT analysis and the formulation of strategic recommendations. Data credibility is strengthened through source and methodological triangulation by comparing information across informants, documents, observations, and relevant literature, with selected findings reconfirmed with key informants where necessary. The study adheres to research ethics and defense information security principles by using lawfully accessible data, non-classified documents, and interview information obtained with informed consent. Sensitive tactical details, force dispositions, classified technical capabilities, and restricted operational information are excluded from the research.

### III. RESULTS AND DISCUSSION

#### Strategic Importance of ASL-2 and the Underwater Security Environment.

The strategic assessment of the Indonesian Archipelagic Sea Lane II (ASL-2) highlights the importance of integrating hydro-oceanographic conditions, technological capability, and organizational readiness in developing Anti-Submarine Warfare (ASW) capability. The Lombok Strait constitutes a strategically important component of ASL-2 because of its geographical position and its function as a connection between the Pacific and Indian Oceans. Its underwater environmental characteristics have direct implications for acoustic propagation and the planning of underwater surveillance operations.

The hydrographic evidence from previous research demonstrates substantial spatial variation in the thermocline characteristics of the Lombok Strait. Based on Conductivity, Temperature, and Depth (CTD) observations and subsequent data processing, Iskandar et al. reported thermocline thicknesses of 146.094 m in the northern sector and 87.694 m in the southern sector. The difference between the two values is 58.400 m, representing approximately 39.97% of the northern-sector value. The study also identified differences in sound-speed characteristics between the northern and southern sectors. These findings indicate that the underwater acoustic environment of ASL-2 cannot be treated as spatially homogeneous.

The relevance of environmental conditions to underwater surveillance is further demonstrated by acoustic-propagation modeling. Defrianto, Pratama, and Malik reported a simulated shadow-zone region extending from 0 to 800 m in depth at a source distance of 5,000 m under specified acoustic-model conditions. The difference between the analytical and computational results was 0.0817%. This finding illustrates how acoustic propagation conditions may influence underwater detection and the effectiveness of surveillance systems.

In addition to the hydro-oceanographic evidence, the interview data provide an empirical basis for examining the strategic and organizational requirements of ASW capability development in ASL-2. The analysis considers the availability and suitability of surveillance technology, the integration of environmental information, personnel readiness, information management, and command-and-control arrangements. These aspects are examined in relation to the internal strengths and weaknesses, as well as the external opportunities and threats, identified through the interviews.

**Table 1.** Empirical and Scientific Evidence Relevant to Underwater Security Assessment

| Indicator                |                       | Finding     | Significance                                                            |
|--------------------------|-----------------------|-------------|-------------------------------------------------------------------------|
| CTD observation stations |                       | 13 stations | Provides the spatial sampling basis of the hydrographic study           |
| Northern-sector          | thermocline thickness | 146.094 m   | Demonstrates the observed hydrographic condition in the northern sector |

| Indicator                             | Finding  | Significance                                                                   |
|---------------------------------------|----------|--------------------------------------------------------------------------------|
| Southern-sector thermocline thickness | 87.694 m | Demonstrates the observed hydrographic condition in the southern sector        |
| Difference in thermocline thickness   | 58.400 m | Indicates spatial variation between sectors                                    |
| Relative difference                   | 39.97%   | Expresses the difference relative to the northern-sector value                 |
| Simulated shadow-zone depth           | 0–800 m  | Demonstrates the modeled acoustic-propagation limitation                       |
| Simulated source distance             | 5,000 m  | Defines the source-distance condition used in the acoustic simulation          |
| Analytical-computational difference   | 0.0817%  | Indicates the reported difference between analytical and computational results |

The evidence establishes that hydro-oceanographic information is operationally relevant to underwater surveillance planning. Such information should therefore be incorporated into the assessment of surveillance requirements rather than treated solely as supporting oceanographic data. The interview-based strategic assessment complements this scientific evidence by identifying organizational and technological factors that influence the development and employment of underwater surveillance capabilities. The analysis also indicates that sensor availability alone is insufficient to represent overall underwater surveillance capability. Operational effectiveness depends on the interaction between environmental conditions, system characteristics, operator competence, data processing, information integration, and command-and-control arrangements. Accordingly, ASW capability development in ASL-2 requires an integrated approach that connects environmental knowledge with technological and organizational preparedness.

### Assessment of ASW Capability Requirements.

The interview findings, considered alongside the relevant hydrographic and acoustic-propagation studies, provide the basis for identifying five principal dimensions for assessing ASW capability in ASL-2: (1) sensors and platforms, (2) underwater surveillance, (3) hydro-oceanographic information, (4) human resources and operational readiness, and (5) command and control. These dimensions are consistent with the research by Pranaditya Mirza S., Hermawan, and Adi, which examined the selection of underwater surveillance systems for early submarine detection in ASL-2 by considering technical, operational, and economic factors, including detection capability, resolution, and adaptability to the marine environment.<sup>1</sup>

**Table 2.** Principal Dimensions of ASW Capability Development

| Capability dimension                      | Analytical finding                                                                                  | Operational implication                                                                     |
|-------------------------------------------|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| Sensors and platforms                     | Surveillance capability depends on the availability and suitability of underwater sensing platforms | Sensor selection should correspond to operational requirements and environmental conditions |
| Underwater surveillance                   | Effective detection requires continuous and appropriately organized surveillance                    | Surveillance arrangements should address the characteristics of ASL-2                       |
| Hydro-oceanographic information           | Water-column characteristics influence acoustic propagation                                         | Environmental data should be integrated into surveillance planning                          |
| Human resources and operational readiness | Surveillance technology requires competent operators and maintainers                                | Training and readiness development should accompany technological development               |
| Command and control                       | Surveillance information must support timely operational decisions                                  | Information integration and decision-making mechanisms require systematic development       |

The five dimensions are interdependent. Sensors and platforms provide the technical means for surveillance, while hydro-oceanographic information establishes the environmental context in which those

<sup>1</sup> Pranaditya Mirza S., Benie Hermawan, and Mostein Adi P., “Analisis Pemilihan Underwater Surveillance System Guna Peningkatan Deteksi Dini Kapal Selam di Alur Laut Kepulauan Indonesia (ALKI) II,” *Betelgeuse Journal* 1, no. 2 (2024): 54–66, <https://doi.org/10.59447/betelgeuse.v1i2.33>.

systems operate. Trained personnel are required to operate equipment, interpret information, and maintain system readiness. Meanwhile, information integration and command-and-control arrangements enable surveillance outputs to support operational decision-making. The principal finding is that ASW capability should not be evaluated solely through the number or technical specifications of available sensors. Instead, capability should be assessed as an integrated system encompassing technology, environmental information, personnel, information management, and command and control.

This distinction is important because equipment availability does not automatically translate into operational effectiveness. A technically capable system may not deliver its intended contribution if environmental information is insufficiently integrated, personnel are inadequately prepared, interoperability is limited, or surveillance information cannot be translated into timely decisions. Consequently, ASW development in ASL-2 requires a coordinated capability-development framework rather than an approach focused exclusively on equipment procurement.

### Interview Findings and Comparison with Previous Research

The interview-based analysis provides the empirical foundation for identifying strategic factors affecting ASW capability development in ASL-2. The findings are organized into internal factors, comprising strengths and weaknesses, and external factors, comprising opportunities and threats. The classification is used to connect the conditions identified through the interviews with the scientific and technological context established by previous research. Previous studies have examined several components relevant to underwater security. Iskandar et al. investigated hydrographic characteristics in the Lombok Strait, while Defrianto, Pratama, and Malik examined acoustic propagation through simulation. Pranaditya Mirza S., Hermawan, and Adi addressed the selection of underwater surveillance systems for early submarine detection in ASL-2. These studies provide complementary scientific and technical perspectives for interpreting the strategic requirements examined in the present research.

**Table 3.** Comparison of Previous Research and the Present Study

| Study                                         | Principal finding or analytical focus                                                                                                              | Contribution to the present study                                                       |
|-----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| <b>Iskandar et al.</b>                        | CTD observations identified thermocline thicknesses of 146.094 m in the northern sector and 87.694 m in the southern sector                        | Provides evidence of spatial hydrographic variation in the Lombok Strait                |
| <b>Defrianto, Pratama, and Malik</b>          | Acoustic simulation identified a shadow zone at 0–800 m depth and a source distance of 5,000 m, with a 0.0817% analytical-computational difference | Establishes the relevance of acoustic-propagation conditions to underwater surveillance |
| <b>Pranaditya Mirza S., Hermawan, and Adi</b> | Examined technical, operational, and economic considerations in underwater surveillance-system selection in ASL-2                                  | Provides a reference for assessing surveillance-system requirements                     |
| <b>Present study</b>                          | Integrates interview findings with environmental, technological, organizational, and strategic considerations                                      | Develops an integrated strategic framework for ASW capability development in ASL-2      |

The contribution of the present study lies in connecting the scientific evidence on the underwater environment with interview-based assessments of capability requirements and strategic priorities. Whereas previous studies have focused on particular environmental, acoustic, or technological aspects, this study brings these dimensions together within a strategic assessment framework. The central issue is therefore not merely whether underwater surveillance technology is available, but whether the technology is appropriate for the environmental characteristics of ASL-2, supported by competent personnel, integrated with relevant information, and connected to effective command-and-control processes. This integrated perspective provides a basis for formulating capability-development priorities that consider both operational requirements and organizational conditions. The interview findings are particularly relevant to the identification and assessment of strategic factors subsequently used in the IFAS, EFAS, and SWOT analyses.

### Identification of Strategic Factors from the Interviews

The internal and external strategic factors were identified and assessed through interviews with relevant informants. The resulting factors were organized according to their implications for ASW capability development in ASL-2. Internal factors describe the strengths and weaknesses associated with existing

institutional and technical conditions, while external factors represent opportunities and threats arising from the broader technological, environmental, and operational context.

### Internal Factors

The internal assessment identifies institutional maritime-defense capability, relevant technical expertise, and existing information resources as strengths that can support ASW capability development. These factors provide an organizational and technical foundation for strengthening underwater surveillance. At the same time, the assessment identifies environmental-data integration, interoperability, training and sustainment, and coordinated surveillance as areas requiring further development. These weaknesses indicate that the development of ASW capability involves more than acquiring additional equipment. It also requires improvements in information management, system compatibility, personnel development, maintenance arrangements, and operational coordination.

**Table 4.** Internal Factors Identified through the Research

| Category        | Factor                                             | Strategic significance                                                                             |
|-----------------|----------------------------------------------------|----------------------------------------------------------------------------------------------------|
| <b>Strength</b> | Existing institutional maritime-defense capability | Provides an organizational foundation for ASW capability development                               |
| <b>Strength</b> | Availability of relevant technical expertise       | Provides an organizational foundation for ASW capability development                               |
| <b>Strength</b> | Existing information resources                     | Provides a basis for improved information integration                                              |
| <b>Weakness</b> | Environmental-data integration                     | Requires stronger integration between hydro-oceanographic information and operational surveillance |
| <b>Weakness</b> | Interoperability constraints                       | Require compatibility among sensors, information systems, and command-and-control elements         |
| <b>Weakness</b> | Training and sustainment requirements              | Require continuous personnel development and system sustainment                                    |
| <b>Weakness</b> | Coordinated surveillance limitations               | Require stronger integration of surveillance activities and operational decision-making            |

The internal assessment suggests that institutional capability and technical expertise constitute important foundations for ASW development. Nevertheless, the operational contribution of these strengths depends on the ability to address the identified weaknesses. Environmental-data integration is particularly relevant because acoustic propagation varies with underwater conditions. Interoperability is also important because surveillance effectiveness depends on the ability of sensors, information systems, and command-and-control elements to exchange and use relevant information. In addition, personnel training and system sustainment are necessary to maintain operational readiness over time. The findings therefore support an integrated approach to capability development in which organizational arrangements, technical systems, human resources, and information management are developed together.

### External Factors

The external assessment identifies technological developments in hydrography and acoustics, institutional and technical collaboration, and the availability of hydro-oceanographic research as opportunities for strengthening underwater security capability. However, these opportunities coexist with threats and constraints, including variability in underwater acoustic conditions, increasing complexity of the regional undersea environment, technical and lifecycle-cost constraints, and legal and information-security requirements.

**Table 5.** External Factors Identified through the Research

| Category           | Factor                                                     | Strategic significance                                                                    |
|--------------------|------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| <b>Opportunity</b> | Development of hydrographic and acoustic-data technologies | Creates opportunities to improve environmental characterization and acoustic surveillance |
| <b>Opportunity</b> | Institutional and technical collaboration                  | Provides opportunities for knowledge exchange and capability development                  |

| Category           | Factor                                                     | Strategic significance                                          |
|--------------------|------------------------------------------------------------|-----------------------------------------------------------------|
| <b>Opportunity</b> | Availability of hydro-oceanographic research               | Provides scientific inputs for operational planning             |
| <b>Threat</b>      | Variability in underwater acoustic conditions              | May influence acoustic propagation and surveillance performance |
| <b>Threat</b>      | Increasing complexity of the regional undersea environment | Requires continuous adaptation of surveillance capability       |
| <b>Threat</b>      | Technical and lifecycle-cost constraints                   | May affect the long-term sustainability of surveillance systems |
| <b>Threat</b>      | Legal and information-security requirements                | Require controlled management of surveillance information       |

The external assessment indicates that technological development and scientific research create opportunities for improving underwater security. Nevertheless, these opportunities need to be managed in conjunction with environmental variability, technological limitations, lifecycle requirements, and information-security considerations. The availability of scientific research, for example, provides an opportunity to improve the environmental basis of surveillance planning. Its operational value, however, depends on the ability to integrate the resulting information into surveillance systems and decision-making processes. Similarly, institutional collaboration can support knowledge and capability development, provided that cooperation is aligned with operational requirements and applicable information-security arrangements. The implications of the internal and external assessments are subsequently examined through the IFAS and EFAS matrices to establish a structured basis for strategic formulation.

### IFAS and EFAS Analysis

The Internal Factor Analysis Summary (IFAS) and External Factor Analysis Summary (EFAS) were developed using the strategic factors identified and assessed through the interviews. The matrices organize the identified factors according to their relative strategic importance and the ratings assigned during the research assessment.

The weighted score for each factor is calculated by multiplying its weight by its rating:

$$\text{Weighted Score} = \text{Weight} \times \text{Rating}$$

The total weight in each matrix is 1.00. The resulting weighted scores provide a structured summary of the internal and external strategic assessments.

#### Internal Factor Analysis Summary (IFAS)

The IFAS matrix evaluates the strengths and weaknesses associated with ASW capability development in ASL-2.

**Table 6.** Internal Factor Analysis Summary (IFAS)

| Internal factor                                        | Weight      | Rating   | Weighted score |
|--------------------------------------------------------|-------------|----------|----------------|
| <b>Strengths</b>                                       |             |          |                |
| S1. Existing institutional maritime-defense capability | 0.15        | 4        | 0.60           |
| S2. Availability of relevant technical expertise       | 0.12        | 3        | 0.36           |
| S3. Existing information resources                     | 0.13        | 3        | 0.39           |
| <b>Weaknesses</b>                                      |             |          |                |
| W1. Environmental-data integration                     | 0.18        | 2        | 0.36           |
| W2. Interoperability constraints                       | 0.16        | 2        | 0.32           |
| W3. Training and sustainment requirements              | 0.14        | 2        | 0.28           |
| W4. Coordinated surveillance limitations               | 0.12        | 2        | 0.24           |
| <b>Total</b>                                           | <b>1.00</b> | <b>—</b> | <b>2.55</b>    |

The IFAS analysis produces a total weighted score of **2.55**. Using 2.50 as the conventional midpoint for interpretation, the result indicates that the assessed internal position is slightly above the midpoint. The result suggests that the identified institutional and technical strengths provide a foundation for ASW capability development. The availability of institutional maritime-defense capability, relevant technical expertise, and existing information resources represents a basis for further improvement. Nevertheless, the result should not be interpreted as evidence that existing ASW capability is already operationally sufficient. The weaknesses

identified in the matrix remain relevant to the development of effective underwater surveillance, particularly with regard to environmental-data integration, interoperability, training, sustainment, and surveillance coordination.

The relative importance assigned to environmental-data integration and interoperability highlights the need to ensure that technological systems operate within an integrated information architecture. Meanwhile, training and sustainment requirements indicate that the operational value of surveillance technology depends on personnel competence and the continued availability of functioning systems. The IFAS result therefore presents an internal capability position characterized by an existing institutional foundation alongside identifiable areas for improvement. The strategic implication is that the development of ASW capability should build on existing strengths while systematically addressing the weaknesses identified in the interview-based assessment.

### External Factor Analysis Summary (EFAS)

The EFAS matrix evaluates external opportunities and threats affecting ASW capability development in ASL-2.

**Table 7.** External Factor Analysis Summary (EFAS)

| External factor                                                | Weight      | Rating   | Weighted score |
|----------------------------------------------------------------|-------------|----------|----------------|
| <b>Opportunities</b>                                           |             |          |                |
| O1. Development of hydrographic and acoustic-data technologies | 0.16        | 4        | 0.64           |
| O2. Institutional and technical collaboration                  | 0.14        | 3        | 0.42           |
| O3. Availability of hydro-oceanographic research               | 0.13        | 4        | 0.52           |
| <b>Threats</b>                                                 |             |          |                |
| T1. Variability in underwater acoustic conditions              | 0.18        | 2        | 0.36           |
| T2. Increasing complexity of the regional undersea environment | 0.15        | 2        | 0.30           |
| T3. Technical and lifecycle-cost constraints                   | 0.13        | 2        | 0.26           |
| T4. Legal and information-security requirements                | 0.11        | 3        | 0.33           |
| <b>Total</b>                                                   | <b>1.00</b> | <b>—</b> | <b>2.83</b>    |

The EFAS analysis produces a total weighted score of **2.83**, which is above the conventional midpoint of 2.50. This result indicates that the external environment offers meaningful opportunities for ASW capability development, particularly through advances in hydrographic and acoustic technologies, institutional collaboration, and the availability of scientific information.

The opportunities identified in the matrix provide a basis for improving environmental characterization, strengthening technical knowledge, and supporting the development of surveillance systems. The availability of hydro-oceanographic research is especially relevant because underwater environmental conditions influence acoustic propagation and may affect surveillance performance. However, the opportunities must be considered alongside the identified threats. Variability in underwater acoustic conditions requires surveillance planning to account for environmental characteristics. The complexity of the regional undersea environment also requires continuing adaptation of surveillance arrangements. In addition, technical constraints, lifecycle costs, and information-security requirements need to be considered when planning and sustaining capability development.

The EFAS result consequently indicates that the external environment provides opportunities that can be utilized to support ASW development, provided that the associated threats and constraints are incorporated into planning and implementation. Taken together, the IFAS score of 2.55 and EFAS score of 2.83 provide the analytical basis for formulating strategic alternatives. The scores summarize the assessments documented in the interview-based research and should be interpreted in conjunction with the individual factors rather than as standalone measures of operational performance.

### SWOT Strategic Formulation

The SWOT analysis combines the internal strengths and weaknesses identified through the research with the external opportunities and threats assessed in the EFAS matrix. The purpose is to translate the interview-based assessment into strategic alternatives for developing ASW capability in ASL-2. Four categories of strategies are considered: Strengths–Opportunities (SO), Weaknesses–Opportunities (WO), Strengths–Threats (ST), and Weaknesses–Threats (WT).

**Table 8.** SWOT-Based Strategic Alternatives for ASW Capability Development

| Strategy  | Strategic formulation                                                                                                       | Development direction                                                                  |
|-----------|-----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| <b>SO</b> | Utilize institutional capability, technical expertise, and scientific research to strengthen environmental-data utilization | Integrate scientific information into operational surveillance                         |
| <b>WO</b> | Use technological and institutional opportunities to address weaknesses in data integration, interoperability, and training | Develop integrated information, interoperability, and training programs                |
| <b>ST</b> | Use existing institutional arrangements and technical expertise to respond to environmental and regional uncertainty        | Strengthen adaptive surveillance and operational planning                              |
| <b>WT</b> | Reduce vulnerabilities associated with coordination, sustainment, interoperability, and information governance              | Establish sustainable coordination, maintenance, and information-governance mechanisms |

The SO strategy emphasizes the use of existing institutional capability and technical expertise to take advantage of technological developments and scientific research. This strategy seeks to strengthen the connection between available institutional resources and the opportunities provided by developments in hydrography, acoustics, and underwater surveillance. The WO strategy focuses on addressing internal weaknesses through available external opportunities. The principal areas of attention are environmental-data integration, interoperability, and personnel development. Technological advancement and institutional collaboration can provide opportunities to improve information integration, enhance system compatibility, and strengthen the competence required to operate and maintain surveillance systems. The ST strategy emphasizes the use of existing institutional capability and technical expertise to respond to environmental variability and increasing regional complexity. Its primary direction is to strengthen adaptive surveillance planning and ensure that operational arrangements account for the characteristics of the underwater environment. The WT strategy seeks to reduce vulnerabilities associated with coordination, system sustainment, interoperability, and information governance. This approach emphasizes the need for sustainable organizational arrangements and the continued management of technical and operational risks.

The combined SWOT analysis indicates that ASW capability development should be pursued through an integrated strategic approach. The results do not support a procurement-only orientation because operational effectiveness depends on the relationship between technology, environmental information, personnel readiness, information management, and command and control. The strategic alternatives should therefore be implemented as mutually supporting components of capability development. Technological improvements need to be accompanied by the development of human resources, information integration, interoperability, sustainment, and organizational coordination. This integrated approach provides a stronger basis for improving underwater surveillance capability than treating each component as an independent development activity.

### Integrated ASW Capability Development Framework for ASL-2

The findings from the interviews, hydro-oceanographic and acoustic studies, IFAS, EFAS, and SWOT analysis are integrated into a five-stage capability-development framework. The framework connects operational requirements with environmental assessment, capability assessment, strategic analysis, and the prioritization of development initiatives.

**Table 9.** Integrated ASW Capability Development Framework

| Stage                                 | Principal activity                                                                                                             | Main output                                     |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|
| Operational requirement assessment    | Identify underwater-security and ASW requirements in ASL-2                                                                     | Defined operational requirements                |
| Environmental assessment              | Analyze hydro-oceanographic and acoustic characteristics                                                                       | Environmental-operational database              |
| Capability assessment                 | Assess sensors, surveillance, personnel, readiness, and command and control                                                    | Integrated capability assessment                |
| Strategic analysis                    | Conduct IFAS, EFAS, and SWOT analysis based on the identified research factors                                                 | Structured strategic factors and alternatives   |
| Capability-development prioritization | Select development priorities based on operational relevance, technical feasibility, sustainability, and resource requirements | Prioritized ASW capability-development strategy |

The first stage establishes the operational requirements that guide capability development. These requirements provide the basis for determining the surveillance functions and organizational arrangements necessary to address underwater-security challenges in ASL-2. The second stage assesses the hydro-oceanographic and acoustic environment. The findings reported by Iskandar et al. [1] and Defrianto, Pratama, and Malik [2] demonstrate the relevance of environmental characteristics to underwater surveillance planning. Accordingly, environmental assessment should provide information that supports the interpretation of acoustic conditions and the formulation of surveillance requirements. The third stage assesses the availability and suitability of sensors and platforms, surveillance arrangements, personnel readiness, and command-and-control mechanisms. The objective is to examine capability as an integrated system rather than as a collection of individual equipment items.

The fourth stage translates the research findings into a structured strategic assessment through IFAS, EFAS, and SWOT. The interview-based factors provide the empirical basis for assessing internal strengths and weaknesses and external opportunities and threats. The resulting strategic alternatives establish directions for addressing capability gaps and utilizing available opportunities. The fifth stage prioritizes development initiatives according to operational relevance, technical feasibility, sustainability, and resource requirements. This stage connects strategic analysis with practical capability-development planning.

The framework establishes five mutually supporting capability requirements: appropriate sensors and platforms; continuous and organized underwater surveillance; integrated hydro-oceanographic information; competent and operationally ready personnel; and effective command and control. These requirements are interdependent. Environmental information supports surveillance planning, while sensors and platforms provide the technical means for detection. Personnel readiness enables the effective operation and maintenance of systems, and information integration allows surveillance outputs to support decision-making. Command-and-control arrangements connect these elements within an operational framework.

The strategic priority is therefore not simply the acquisition of additional surveillance equipment, but the development of an integrated ASW capability architecture in which technology, environmental information, personnel, data processing, interoperability, sustainment, and command and control function as mutually supporting components.

### Principal Research Findings and Discussion

The integrated analysis establishes five principal findings concerning ASW capability development in ASL-2. First, the underwater environment of ASL-2 requires location-specific consideration in surveillance planning. The hydrographic evidence from the Lombok Strait demonstrates spatial variation in thermocline thickness, with reported values of 146.094 m in the northern sector and 87.694 m in the southern sector. These findings establish the relevance of hydro-oceanographic information to the assessment of underwater acoustic conditions.

Second, acoustic propagation is an important consideration in underwater surveillance. The simulation reported by Defrianto, Pratama, and Malik identified a shadow-zone region extending from 0 to 800 m in depth at a source distance of 5,000 m under the specified model conditions. This finding demonstrates that environmental and acoustic conditions need to be considered when assessing surveillance requirements. Third, ASW capability is multidimensional. The analysis identifies sensors and platforms, underwater surveillance, hydro-oceanographic information, human resources and readiness, and command and control as interconnected dimensions. The operational contribution of surveillance technology depends on how these elements function together.

Fourth, the interview-based IFAS assessment produces a total weighted score of 2.55. Relative to the conventional midpoint of 2.50, this result indicates that the assessed internal position is slightly above the midpoint. Existing institutional maritime-defense capability, technical expertise, and information resources provide a foundation for development, while environmental-data integration, interoperability, training, sustainment, and surveillance coordination remain important areas for improvement. Fifth, the interview-based EFAS assessment produces a total weighted score of 2.83, indicating that the assessed external environment offers meaningful opportunities for capability development. Advances in hydrographic and acoustic technologies, institutional collaboration, and the availability of hydro-oceanographic research create opportunities for strengthening underwater surveillance. These opportunities must nevertheless be managed alongside environmental variability, regional complexity, lifecycle costs, technical constraints, and information-security requirements.

The combined IFAS, EFAS, and SWOT analyses support an integrated strategic direction for ASW capability development in ASL-2. The direction emphasizes the use of existing institutional strengths, the utilization of technological and scientific opportunities, and the systematic improvement of identified weaknesses. The strategic alternatives also recognize the need to manage environmental and operational threats as part of long-term capability development. The contribution of this study is the integration of interview-based strategic assessment with scientific evidence on hydro-oceanographic characteristics and acoustic propagation. This integration connects environmental conditions with organizational and technological requirements, providing a structured basis for formulating ASW capability-development priorities.

The findings suggest that the effectiveness of underwater surveillance depends not only on the availability of technology but also on its suitability for the operating environment, the competence and readiness of personnel, the integration of relevant information, and the effectiveness of command-and-control arrangements. Therefore, capability development should be planned and implemented as an integrated process that links operational requirements, environmental assessment, technological development, human-resource readiness, and organizational coordination. Overall, the research establishes an evidence-informed strategic framework for developing ASW capability in ASL-2. The framework provides a basis for identifying priorities and structuring development initiatives while recognizing that the realization of operational capability requires the coordinated development of technological, environmental, human, informational, and organizational components.

#### IV. CONCLUSION

Based on the results of the research and discussion presented above, the following conclusions can be drawn:

- a. ASW capability in ASL-2 (Lombok Strait) needs an integrated approach combining technology, ocean data, trained personnel, operational readiness, and command and control.
- b. Current capability has a foundation but needs improvement existing institutional and technical resources score moderately (IFAS 2.55), with gaps in environmental-data integration, interoperability, training, and surveillance coordination.
- c. The study proposes a five-stage strategic framework not just buying more equipment, but building an integrated ASW architecture that connects environmental, technological, human, informational, and organizational dimensions to protect Indonesia's maritime sovereignty.

#### REFERENCES

- Braun, V., & Clarke, V. (2021). Can I use TA? Should I use TA? Should I not use TA? Comparing reflexive thematic analysis and other pattern-based qualitative analytic approaches. *Counselling and Psychotherapy Research*, 21(1), 37–47. <https://doi.org/10.1002/capr.12360>. Wiley Online Library
- Braun, V., & Clarke, V. (2021). One size fits all? What counts as quality practice in (reflexive) thematic analysis? *Qualitative Research in Psychology*, 18(3), 328–352. <https://doi.org/10.1080/14780887.2020.1769238>. DOI
- Byrne, D. (2022). A worked example of Braun and Clarke's approach to reflexive thematic analysis. *Quality & Quantity*, 56, 1391–1412. <https://doi.org/10.1007/s11135-021-01182-y>. Springer
- Defrianto, D., Pratama, N., & Malik, U. (2023). Determination of the shadow zone area in the ocean computationally by simulating the propagation of acoustic rays. *Science, Technology and Communication Journal*, 3(2), 59–64. <https://doi.org/10.59190/stc.v3i2.228>. Sintech Com Journal
- Erästö, T., Su, F., & Wan, W. (2024). Navigating security dilemmas in Indo-Pacific waters: Undersea capabilities and armament dynamics. Stockholm International Peace Research Institute (SIPRI). <https://doi.org/10.55163/DKWB3559>. SIPRI
- Iskandar, I., Sukoco, N. B., Kamija, K., & Pranowo, W. S. (2022). Karakteristik termoklin dan kecepatan suara di Selat Lombok berdasarkan filtering data CTD menggunakan Analysis Toolpak. *Jurnal Chart Datum*, 4(1), 43–50. <https://doi.org/10.37875/chartdatum.v4i1.3>. Paperity

- Jackson, K., & Bazeley, P. (2019). *Qualitative data analysis with NVivo* (3rd ed.). SAGE Publications. Western Sydney University
- Judhariksawan, J., Daud, A. A., & Tandungan, E. S. (2022). Nusantara in front of Makassar Strait: A review of international law of the sea. *Jurnal Pertahanan: Media Informasi tentang Kajian dan Strategi Pertahanan yang Mengedepankan Identity, Nationalism dan Integrity*, 8(3), 426–435. <https://doi.org/10.33172/jp.v8i3.1847>. Jurnal IDU
- International Maritime Organization. (1998). Resolution MSC.72(69): Adoption, designation and substitution of archipelagic sea lanes. Maritime Safety Committee, 19 May 1998. International Maritime Organization
- International Maritime Organization. (1998). Partial system of archipelagic sea lanes in Indonesian archipelagic waters: Sea Lane II—Celebes (Sulawesi) Sea—Makassar Strait—Lombok Strait—Indian Ocean. Annex to Resolution MSC.72(69). International Maritime Organization
- Republic of Indonesia. (1985). Law No. 17 of 1985 concerning ratification of the United Nations Convention on the Law of the Sea. Jakarta: Government of the Republic of Indonesia.
- Republic of Indonesia. (2002). Government Regulation No. 37 of 2002 concerning the rights and obligations of foreign ships and aircraft exercising the right of archipelagic sea lanes passage through designated archipelagic sea lanes. Jakarta: Government of the Republic of Indonesia. United Nations
- United Nations. (1982). United Nations Convention on the Law of the Sea, Montego Bay, 10 December 1982. United Nations Treaty Series, Vol. 1833, p. 3. United Nations Treaty Collection
- Pranaditya Mirza, S., Hermawan, B., & Adi, M. P. (2024). Analisis pemilihan underwater surveillance system guna peningkatan deteksi dini kapal selam di Alur Laut Kepulauan Indonesia (ALKI) II. *Betelgeuse Journal*, 1(2), 54–66. <https://doi.org/10.59447/betelgeuse.v1i2.33>. Journal Akademi TNI AL
- Supriyanto, T., Agustinus, A., Rahmatullah, A., Pranowo, W. S., & Triono, Y. (2025). Karakteristik kolom air di titik penyempitan (choke point) Selat Makasar. *Jurnal Chart Datum*, 10(1). <https://doi.org/10.37875/chartdatum.v10i1.328>.