Journal of Information Systems Engineering and Management
2025, 10(38s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Stress Analysis of Master while Sailing Entering Makassar Port Using Heart Rate Variability (HRV) Data and Simulator

Rina Haryani, Sidrotul Muntaha, Gassing, Joe Ronald.K.Bokau
Politeknik Pelayaran Barombong, Indonesia
Email: rinahryni18@gmail.com, massidro67@gmail.com , rifqiygassing@gmail.com, joeronald.kb@gmail.com

ARTICLE INFO

Received: 18 Dec 2024

Revised: 20 Feb 2025

Accepted: 27 Feb 2025

ABSTRACT

Maritime is one unity of a system consisting of transportation in waters, ports, safety and security, and protection of the maritime environment up to the present moment. This transport system plays a crucial role in driving the economy and fostering national unity. This research attempts to reveal levels of stress experienced by the Master (Captain) through simulation using the Heart Rate Variability (HRV) data measurement instrument. This research is conducted using both qualitative and quantitative methods. Data collection techniques were carried out through a questionnaire (survey) to gauge perceptions of experiences during the simulator, documentation, and measurements using the HRV monitor tool. Data analysis techniques involved processing data that is in non-numerical form and focusing on its quality. This study shows that although the Regulation for the Prevention of Collisions at Sea (COLREG) has been taught in shipping schools in Indonesia, human factors remain the primary reason for accidents at sea, contributing to 46.7%, which is influenced by a lack of understanding of the aforementioned regulations. The research experiment during a voyage on entering the Makassar port reveals that encountering other vessels during navigation significantly increases the stress levels of the Captain. The highest stress levels are experienced when other vessels approach from certain angles, especially in head-on, crossing at 90 degrees from the left, and at a 135-degree angle from either the left or right. In addition, age and the captain's experience have no significant relationship with stress levels in this situation.

Keywords: Captain Stress, Makassar Port, Heart Rate Variability (HRV), Simulator

INTRODUCTION

In an island country like Indonesia, maritime plays an important role in every aspect of national development. Ports serve as a crucial network for transporting goods from inland areas to coastal regions, effectively bridging the interface between ships and land. Makassar Port is an important harbour in the middle part of Indonesia aimed at advancing one objective of the Indonesian government, namely reducing the economic gap between the western and eastern parts of Indonesia. Realising this potential, the Indonesian government has developed the harbour and targets completion in 2025. The container terminal capacity will increase from 1.3 million TEUs to 3 million TEUs. The development of the Port of Makassar, especially Makassar New Port (MNP), has become the subject of extensive studies and strategic planning. Some studies have focused on various aspects of port development, including ecoport management, capacity utilisation, and integration with transportation modes (Haryani et al., 2023; Ricardianto et al., 2022). The strategic importance of the New Makassar Port in supporting trading connectivity and international transportation has been highlighted (Lestari, 2021; Syamsiah et al., 2021). In addition, the role of feeder harbours, such as Cape Ringgit Harbour, in supporting the main harbour and sea toll programs has been emphasised (Humang et al., 2021).

Furthermore, the development of the harbour has been associated with the acceleration of development in the Eastern Indonesia Region (Syamsiah et al., 2021). Additionally, potential cargo demand and the role of the harbour as an international hub have become subjects of analysis and strategic planning (Sinaga et al., 2018). The significance of Makassar's history as a strategic port city with an established trading network has been acknowledged, emphasising its role in regional and international trade. The impact of economic development and transportation infrastructure in the context of regional trade gateways has been studied, highlighting the importance of port infrastructure development (Ishikura, 2020).

In conclusion, the development of Makassar Port, particularly the New Makassar Harbour, is a multifaceted and strategic effort that includes various aspects, such as ecoport management, sustainability, regional economic effects, and historical significance. Research and strategic planning conducted in these areas provide valuable insights for the sustainable and strategic development of the port in harmony with the broader goals of regional economic development and international trading connectivity. However, there is something missing. We have not found any publications on boat safety at the Makassar Port interface. Research regarding human factors, which according to the KNKT are one major reason for accidents, is lacking. The human factor often becomes a mere talking point in discussions about shipping accidents. This begins with the aspect of education and a lack of training (competence issues) or due to conflicts that cause decision-making during critical times to be constrained, delayed, or avoided entirely, or even due to negligence. However, it can also be due to internal pressure factors within the human being, such as stress, frustration, or other psychological aspects. Therefore, this research will focus solely on the navigational related to safety in situation on entering Makassar Port.

RESEARCH METHODS

We conducted this research using both qualitative and quantitative methods. The qualitative method aimed to understand the experiences of the research subjects, like their behaviour, thoughts, motivations, and actions, by using detailed descriptions in words and language within their natural environment through different natural approaches. We conducted this research on the campus of Barombong Maritime Polytechnic, Makassar. The type of data used in this research consists of primary and secondary data. This type of data serves as a source for the study, gathering information from various research sources and consisting of both primary and secondary data. The primary data in this research is HRV data, processed through the Cubism application after measurements were taken using a chest strap with the Polar H10 chest strap and the Polar Vantage V smartwatch. Both tools are connected to a mobile phone via Bluetooth, and HRV data is accessed through the Elite HRV application.

The rationale for selecting HRV as a psychological stress indicator, emphasizing its relevance in understanding stress-related physiological responses. HRV is highest during rest and decreases during stress or physical activity. It varies between individuals and is generally higher in younger, physically fit, and healthy individuals (Koskinen et al., 2009; Nunan et al., 2010). The autonomic nervous system (ANS) regulates heart rate (HR), with sympathetic (SNS) activation increasing HR and decreasing HRV, while parasympathetic (PNS) activity lowers HR and increases HRV (Berntson et al., 1997).

The secondary data in this research is demographic data from the study subjects, which is limited to age and work experience, as these factors are considered potential contributors to stress. Data collection

Journal of Information Systems Engineering and Management
2025, 10(38s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

techniques were carried out using a questionnaire (survey) to gauge perceptions of experiences during the simulator, as well as documentation and measurements with the HRV monitoring tool. According to Sugiyono (2019), data collection techniques are the most important step in research, as the primary objective of research is to obtain data. In this research, the tools used include the Polar H10 chest strap heart rate monitor, which is installed on the chest of the object being studied, namely the captain of the ship during simulations in the simulator.

Data analysis techniques involve processing data that is in non-numerical form and focusing on its quality. Sugiyono (2019) asserts that qualitative research conducts data analysis both during and after the data collection period. Activities involved in data analysis include data reduction, data presentation, and the drawing of conclusions and verification, which is referred to as the model of data analysis by Miles and Huberman (as cited in Sugiyono, 2019).

DISCUSSION

Simulators and Scenarios Used

This research uses *the Full Mission Ship-Handling* simulator with 360 ° view owned by Barombong Maritime Polytechnic with specification as following :

Table 1. Simulator details

No	Description	Details
1	*Function Area*	*Bridge Operation Simulator*
2	*Class Notation*	*Integrated Simulator System, NAUT (AW, NAVY, HSC, OC, OSV) Dyn Pos, Ice, Tug, In*
3	*Name and Type of Designation*	*K-Sim ® Navigation – Ships Bridge Simulator*
4	*Manufacturer*	*Kongsberg Digital AS – Maritime Solution – Horten, Norway*
5	*Compliance*	*Class A – Standard for Certification of Maritime Simulators*

Figure 1. *Full Mission Ship Handling* Simulator – from the helmsman side

Journal of Information Systems Engineering and Management
2025, 10(38s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/ **Research Article**

Figure 2. *Full Mission Ship Handling* Simulator – from above

Scenario design

The scenario taken is a result of mapping risks in the water areas around Makassar Port, specifically the fairway entering Makassar Port, with an emphasis on the following situations.:

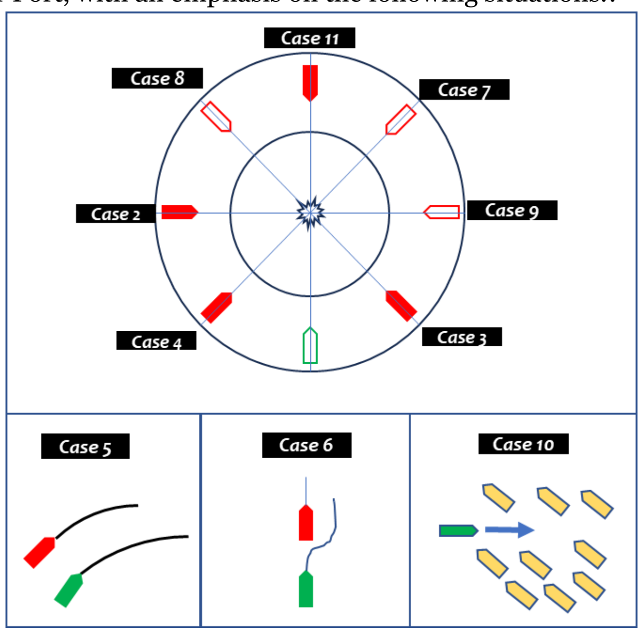

Figure 3. Embedded situation into the scenario

For case 1-2, these become segment 1; cases 3-4 become segment 2; cases 5-6 become segment 3; cases 7-8 become segment 4; case 10 becomes segment 5; and for segment 6, the effect of stress on participants will be examined in the condition where the boat enters the port.

Implementation of the simulation

Before starting the simulation, especially a short briefing was conducted one day prior, where the participants were advised to maximize their rest time (a minimum of 8 hours), avoid consuming alcohol and substances that may trigger fluctuations in heart rate, and refrain from drinking coffee in the morning along with smoking. Before entering the simulation room, the participants chose one helmsman and one navigation officer to assist with their roles in the research. Thereafter, they entered the simulator together and were given a brief overview of the situations and conditions they would face, in accordance with Figure

Journal of Information Systems Engineering and Management
2025, 10(38s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/ **Research Article**

4.6. At the same time, participants filled out a related questionnaire that included their demographics and then attached a chest strap to their chests and synchronized it with the researcher's mobile phone.

Figure 4. Participants use *chest strap*

In the application, Elite HRV can see the condition of HRV data in general directly (real-time) with an appearance as follows:

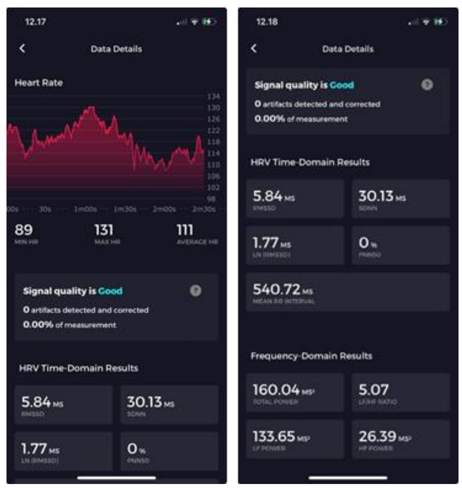

Figure 5. Example results *real-time* data observation in the *Elite HRV software*

Research result

a) Demographics

The participant in the simulation acted as Captain, consisting of 24 selected individuals from diverse backgrounds, including students who are in the midst of competency tests for nautical skills. This ensures that the urgency of implementing the simulator test aligns with the pressures to obtain a good result in the competency test. Consequently, every participant can engage in the simulation with seriousness and under pressure. The demographics of the participants include, among others:

Table 2. Demographics Respondent

No.	Group	Description	Frequency	%
1	Sex	Male	24	100
		Female	0	0
2	Age	24-34	5	20.8
		35-44	14	58.4

Journal of Information Systems Engineering and Management
2025, 10(38s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

		45-62	5	20.8
3	Certificates	Master	2	8.3
		Chief Mate	22	91.7
4	Experience	< 5 years	3	12.5
		6-20 years	17	70.8
		> 20 years	4	16.7
3	Position on Ship	Master	17	70.8
		Chief Mate	7	29.2

Based on the table above, demographic data show that all participants are male (100%), with no women present. The majority of participants are aged between 35 and 44 years (58.4%), while those aged 24-34 and 45-62 years each comprise 20.8%. A significant number of respondents (91.7%) hold certificates of competence as Chief Mate, while only 8.3% possess certification as Master. In terms of experience, 70.8% have 6–20 years of experience; 16.7% have more than 20 years of experience; and 12.5% have less than 5 years of experience. Regarding their ranking, currently, 70.8% are Master, while 29.2% are Chief Mates with Master experience.

b) HRV Data - PNS

Below is the example on the HRV data obtained through data processing in Kubios software:

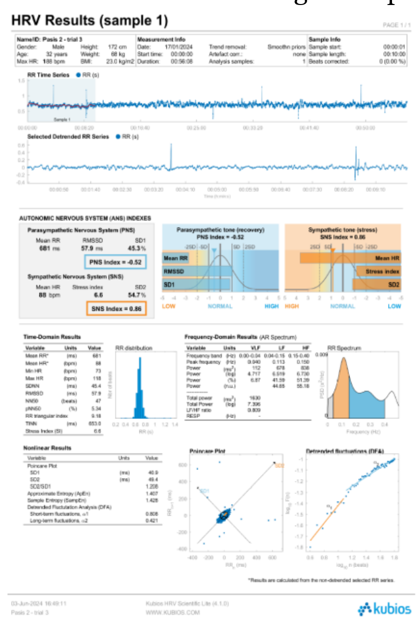

Figure 6. Example results HRV data extraction in Kubios software

From this data, it is then sorted. into every 10 minutes in accordance with each given segments, presented in this following table 3 of the PNS (Parasympathetic Nervous System) data as follow:

Table 3. Parasympathetic Nervous System Data

	PNS Index

Journal of Information Systems Engineering and Management
2025, 10(38s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

Participant No	1st Segment	2nd Segment	3rd Segment	4th Segment	5th Segment	6th Segment
1	1.47	-0.77	-0.99	-1.09	-1.07	-1.05
2	-2.35	-2.32	-2.13	-2.2	-2.28	-2.1
3	-0.52	-1.39	-1.4	-1.12	-0.98	-0.83
4	-2.29	-2.09	-2.07	-1.92	-1.92	-2.11
5	-2.62	-2.41	-2.63	-2.35	-2.28	-2.37
6	-3.5	-3.12	-3.23	-3.23	-3.07	-3.09
7	-2.88	-2.87	-2.89	-2.79	-2.87	-2.85
8	-3.06	-2.97	-3.03	-2.93	-2.91	-2.9
9	0.01	-0.07	-0.39	-0.48	-0.24	-0.2
10	-1.34	-1.26	-1.22	-1.35	-1.33	-1.24
11	-2.04	-2.14	-2.16	-1.9	-1.97	-1.86
12	1.61	0.55	0.7	1.54	1.94	1.74
13	-2.91	-3.89	-3.95	-3.44	-3.32	-3.18
14	-2.03	-1.92	-1.96	-1.66	-1.73	-1.87
15	-1.69	-1.64	-1.59	-1.66	-1.63	-1.51
16	-1.36	-1.12	-0.93	-1.06	-1.07	-0.99
17	-2.62	-2.7	-2.57	-2.65	-2.54	-2.51
18	-2.2	-2.27	-2.18	-2.26	-2.3	-2.22
19	-2.28	-2.3	-2.19	-2.34	-2.33	-2.3
20	-2.26	-2.19	-2.38	-2.32	-2.33	-2.31
21	-0.83	-0.85	-0.82	-0.67	-1.13	-1.15
22	-2.22	-2.48	-2.46	-2.42	-2.62	-2.49
23	-2.66	-2.79	-2.75	-2.74	-2.81	-2.62
24	-1.44	-1.38	-1.38	-1.23	-1.34	-1.23

In accordance with table 3, then it can be seen the fluctuating PNS index data. Table the serve mark PNS index (Parasympathetic Nervous System) in six segment different for 24 participants.

The PNS index on Participants no. 5, 6, 7, 8, 17, 18, 19 and 20 showed low PNS scores in all segment, with scores consistently below -2, reflects decrease function parasympathetic, which has the potential due to by stress or other influencing factors regulation in their autonomous nervous system (ANS).

On the contrary, only 12 participants who showed PNS values are positive in most segments, especially in the later segments (4 to 6), show above normal parasympathetic activity or recovery response and effective relaxation.

In short, most of the participant show PNS index below normal (< -2), which indicates decrease activity parasympathetic throughout the simulation, while a number of show value inside or above normal range, indicating varying autonomic responses among participants.

c) HRV Data - SNS

Below is the SNS data obtained from data processing through Kubios software:

Table 4. SNS Data

	SNS Index

Journal of Information Systems Engineering and Management
2025, 10(38s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

Participant No	1st Segment	2nd Segment	3rd Segment	4th Segment	5th Segment	6th Segment
1	-0.07	0.62	0.87	1	0.88	0.77
2	3.39	3.37	3.32	3.39	2.99	3.05
3	0.82	1.64	1.74	0.92	0.81	0.59
4	3.22	2.67	2.59	2.39	2.8	3.01
5	3.99	3.32	3.54	3.18	3.22	3.45
6	6.73	4.92	5.23	5.54	4.48	5.47
7	5.36	4.96	5.13	4.68	4.79	4.63
8	5.4	4.98	5.2	4.74	4.65	4.53
9	0.13	0.08	0.18	0.27	0.14	0.03
10	1.65	1.25	1.13	1.27	1.49	1.33
11	3.04	3.34	3.74	3.12	3.29	2.12
12	1.33	3.12	3.25	2.77	1.29	1.41
13	5.95	12.43	12.47	8	6.74	5.76
14	2.94	2.62	2.86	2.09	2.25	2.39
15	2.22	2.38	2.55	2.4	2.18	1.7
16	1.47	1.13	0.73	1	1.1	0.96
17	4.17	4.35	3.72	4.27	3.75	4.17
18	3.81	3.59	3.03	3.15	4.35	2.72
19	4.16	4.18	3.37	4.02	4.68	4.42
20	3.58	3.21	4.02	3.67	3.73	3.58
21	0.62	0.88	0.75	0.58	1.14	0.92
22	2.96	5.3	4.79	4.85	4.88	6.42
23	3.68	4.2	3.19	3.84	3.82	3.61
24	2.26	1.85	1.97	1.79	1.72	1.81

In SNS index = 0 (zero) indicates average sympathetic activity compared with normal. Value positive reflect sympathetic activity level above normal, while negative show sympathetic activity lower than average. During stress or intense exercise, the SNS index can range Far more high, potential reach mark between 5 and 35.

The SNS table displays value at six segment for each 24 participants, where the value zero show average sympathetic activity, value positive reflect above normal sympathetic activity, and values above 5 indicate stress or high SNS activity. Several participants show SNS value in range 0.1 to 5, indicating above normal sympathetic activity.

Participants no. 6, 7, 8, 13, and 22 showed SNS value in general consistently above 5 in several segment, which shows level high stress or improvement sympathetic activity. Data show varying sympathetic responses among participants, with some experience improvement stress or sympathetic activity intense during certain segment.

d) Stress levels result according the encounter situation

The most segment with high stress levels can observed on Figure 7 where segments 1 and 2 with cases 1, 2, 3 and 4 are scenario on ship encounter. The decline in PNS and improvement SNS index frequently happened, showed existence of significant autonomic shift going to SNS dominance (stress level). In conclusion, the autonomous data from the PNS and SNS indices

Journal of Information Systems Engineering and Management
2025, 10(38s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

show that Master stress level are highest on segment 2 (cases 3 and 4), marked with low PNS activation and its height SNS index.

This shows that these given scenario cause the biggest pressure on physiological stress on participants. These findings also underscore the importance on specific evaluation segment in understanding the dynamic balance between parasympathetic and sympathetic responses in various conditions, which may impact on intervention management stress on similar situation.

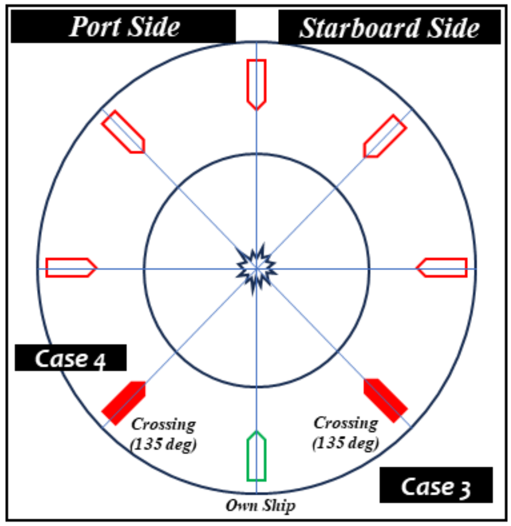

Figure 7. Encounter case that have an impact on stress levels

e) Statistical Test Results

Homogeneity test was performed on PNS and SNS index with the results as follow:

Table 5. Homogeneity Test of Variance

Segment	Sum of Squares	df	Mean Square	F	p-value (Sig.)
PNS Segment 1	1,076 (Between Groups)	2	0.538	0.298	0.746
	37,980 (Within Groups)	21	1,809		
PNS Segment 2	0.956 (Between Groups)	2	0.478	0.445	0.647
	22,579 (Within Groups)	21	1,075		
PNS Segment 3	0.884 (Between Groups)	2	0.442	0.405	0.672
	22,921 (Within Groups)	21	1,091		
PNS Segment 4	0.555 (Between Groups)	2	0.277	0.225	0.8
	25,895 (Within Groups)	21	1.233		
PNS Segment 5	0.433 (Between Groups)	2	0.216	0.16	0.853
	28,462 (Within Groups)	21	1.355		
PNS Segment 6	0.484 (Between Groups)	2	0.242	0.191	0.828
	26,652 (Within Groups)	21	1,269		
SNS Segment 1	1,740 (Between Groups)	2	0.87	0.248	0.783
	73,721 (Within Groups)	21	3,511		

Journal of Information Systems Engineering and Management
2025, 10(38s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

SNS Segment 2	17,241 (Between Groups)	2	8.62	1,509	0.244
	119,960 (Within Groups)	21	5,712		
SNS Segment 3	17,235 (Between Groups)	2	8,617	1,512	0.244
	119,714 (Within Groups)	21	5,701		
SNS Segment 4	3.356 (Between Groups)	2	1,678	0.482	0.624
	73,067 (Within Groups)	21			
SNS Segment 5	1,765 (Between Groups)	2	0.883	0.294	0.748
	63,048 (Within Groups)	21	3.002		
SNS Segment 6	1.938 (Between Groups)	2	0.969	0.29	0.751
	70,098 (Within Groups)	21	3.338		

From the results on the table 5, the homogeneity assumptions variants fulfilled for ANOVA, comparing PNS index in various segments (1 to 6) based on experience level of the participants. We only conducted an ANOVA test on PNS vs Experience and SNS vs Experience because age did not fulfil the normality or homogeneity variance (we will conduct the Kruskal-Wallis test for PSS vs Age and SNS vs Age). We inspect the assumption before continue to ANOVA and the result as follow:

Table 6. ANOVA Results of PNS and SNS vs Experience

Experience	
Variables	p-value
PNS Segment 1	0.575
PNS Segment 2	0.830
PNS Segment 3	0.783
PNS Segment 4	0.859
PNS Segment 5	0.924
PNS Segment 6	0.866
SNS Segment 1	0.726
SNS Segment 2	0.100
SNS Segment 3	0.100
SNS Segment 4	0.134
SNS Segment 5	0.197
SNS Segment 6	0.960

The result show that there is no significant difference statistically on PNS & SNS index based on participants experience in one of the segments ($p > 0.05$ for all segment).

Especially for PNS, segment 1, $F(2, 21) = 0.298$, $p = 0.746$; Segment 2, $F(2, 21) = 0.445$, $p = 0.647$; Segment 3, $F(2, 21) = 0.405$, $p = 0.672$; Segment 4, $F(2, 21) = 0.225$, $p = 0.800$; Segment 5, $F(2, 21) = 0.160$, $p = 0.853$; and Segment 6, $F(2, 21) = 0.191$, $p = 0.828$. These findings indicate that experience is not significantly influence PNS activities of the participant during measured segment.

Journal of Information Systems Engineering and Management
2025, 10(38s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

In SNS index, for Segment 1, $F(2, 21) = 0.248$, $p = 0.783$; Segment 2, $F(2, 21) = 1.509$, $p = 0.244$; Segment 3, $F(2, 21) = 1.512$, $p = 0.244$; Segment 4, $F(2, 21) = 0.482$, $p = 0.624$; Segment 5, $F(2, 21) = 0.294$, $p = 0.748$; and Segment 6, $F(2, 21) = 0.290$, $p = 0.751$. These results indicate that experience is also not significantly influence SNS activity in any of the given segment.

f) Correlation Test Results

Because No There is findings significant in ANOVA regarding PNS & SNS Index vs Experience. We try test Kruskal Wallis on age and experience for test influence age and experience of index system nerve parasympathetic (PNS) and sympathetic (SNS) in six segment.

Table 7. ANOVA Results

Category - PNS	Chi-Square	df	Asymp. Sig.
PNS Seg 1 vs Age	0.188	2	0.91
PNS Seg 2 vs Age	0.598	2	0.742
PNS Seg 3 vs Age	0.592	2	0.744
PNS Seg 4 vs Age	0.407	2	0.816
PNS Seg 5 vs Age	0.146	2	0.93
PNS Seg 6 vs Age	0.203	2	0.903
PNS Seg 1 vs Experience	0.405	2	0.817
PNS Seg 2 vs Experience	0.397	2	0.82
PNS Seg 3 vs Experience	0.397	2	0.82
PNS Seg 4 vs Experience	0.494	2	0.781
PNS Seg 5 vs Experience	0.212	2	0.899
PNS Seg 6 vs Experience	0.635	2	0.728
SNS Seg 1 vs Age	0.679	2	0.712
SNS Seg 2 vs Age	1.791	2	0.408
SNS Seg 3 vs Age	2.045	2	0.36
SNS Seg 4 vs Age	1.063	2	0.588
SNS Seg 5 vs Age	0.393	2	0.822
SNS Seg 6 vs Age	0.381	2	0.826
SNS Seg 1 vs Experience	0.245	2	0.885
SNS Seg 2 vs Experience	0.456	2	0.796
SNS Seg 3 vs Experience	0.565	2	0.754
SNS Seg 4 vs Experience	0.184	2	0.912
SNS Seg 5 vs Experience	0.228	2	0.892
SNS Seg 6 vs Experience	0.432	2	0.806

The results show no statistically significant differences in the PNS and SNS indices across different age and experience groups in any segment ($p > 0.05$ for all tests). Specifically, for the PNS index, age did not have a significant impact on any segment (e.g., Segment 1: $\chi^2(2) = 0.188$,

Journal of Information Systems Engineering and Management
2025, 10(38s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

p = 0.910; Segment 2: $\chi^2(2) = 0.598$, p = 0.742), nor did experience (e.g., Segment 1: $\chi^2(2)$ = 0.405, p = 0.817).

Similarly, for the SNS index, no significant differences were observed based on age (e.g., Segment 1: $\chi^2(2) = 0.679$, p = 0.712) or experience (e.g., Segment 1: $\chi^2(2) = 0.245$, p = 0.885), indicating that age and experience do not significantly affect autonomic nervous system responses in various scenarios.

After that, we perform spearman correlation analysis with the result as follow:

Table 8. Correlation Results

Spearman's rho	sns1	sns2	sns3	sns4	sns5	sns6	pns1	pns2	pns3	pns4	pns5	pns6
sns1	1											
sns2	.881**	1										
sns3	.855**	.923**	1									
sns4	.894**	.971**	.945**	1								
sns5	.890**	.953**	.883**	.944**	1							
sns6	.897**	.947**	.903**	.968**	.960**	1						
pns1	-.952**	-.846**	-.805**	-.860**	-.843**	-.892**	1					
pns2	-.935**	-.922**	-.859**	-.914**	-.903**	-.923**	.961**	1				
pns3	-.934**	-.897**	-.874**	-.905**	-.899**	-.912**	.946**	.983**	1			
pns4	-.940**	-.910**	-.861**	-.924**	-.920**	-.937**	.955**	.987**	.990**	1		
pns5	-.928**	-.917**	-.864**	-.931**	-.948**	-.950**	.939**	.970**	.966**	.982**	1	
pns6	-.932**	-.890**	-.846**	-.910**	-.918**	-.941**	.955**	.969**	.975**	.989**	.986**	1

Spearman correlation analysis was conducted to evaluate the relationship between the PNS and SNS indices in six segments, as well as the relationship between these indices and the age and experience of the participants.

The results show a strong positive correlation between the SNS index in all segments (ρ = 0.855 to 0.971, p <0.01) and an equally strong positive correlation between the PNS index (ρ = 0.910 to 0.990, p <0.01).

As expected, the SNS and PNS indices were strongly and negatively correlated in all segments (ρ = -0.846 to -0.952, p <0.01), highlighting the inverse relationship between sympathetic and parasympathetic activity.

CONCLUSION

Collision prevention regulations at sea (COLREG) have been taught in every maritime school in Indonesia, especially for every sailor with a Nautical background. However, data from the National Transportation Safety Committee (KNKT) from 2017 to 2023 concluded that one of the main factors causing maritime accidents in Indonesia is the human factor, with a percentage of 46.7%. One of the reasons why human error is a determining factor in maritime accidents is due to the lack of understanding of regulations related to collision prevention and safety. This study attempts to reveal the results of the captain's experiment when entering the port of Makassar and encountering other ships during the voyage, which is concluded as follows:

1. In a process of facing the risk of danger when encountering another ship while entering the Makassar shipping lane, it was found that Captain no. 6, 7, 8, 13, and 22 (5 out of 24) consistently showed SNS values above 5 in several segments, indicating a high level of stress or increased SNS activation. It was also found that the stress levels of all participants in each segment were above the normal threshold. This indicates that the scenario created causes a uniform stress condition and it is also concluded that every ship meeting another ship causes stress to the captain or navigation officer during real sailing conditions.

2. In the condition of the angle of approach of another ship when entering the Makassar shipping lane, the highest stress for the captain occurs when encountering another ship directly in front of the vessel, crossing at a 90-degree angle from the left and crossing at a 135-degree angle from both the left and right.

3. The relationship between the age and experience of the captain and the level of stress when facing danger risks while encountering another ship in the Makassar shipping lane is considered not to have a statistically significant relationship.

The recommendations from the results of this study include:

1. The scenario design derived from direct research data using AIS data can be very beneficial for reconstructing events and measuring the stress levels of Captains or Navigation Officers. With a simulator approach, in the future, scenarios that can represent real-world conditions can be recreated and the stress levels experienced can be determined.

2. This research is the beginning of a method with a simulator approach that can later be connected with applications/surveys/data collection methods as parameters in terms of perceived stress and mental workload, which can later be correlated and reveal other factors in the aspect of human error such as fatigue and others.

3. The angle of approach of another ship, which is assessed to cause varying levels of stress, can serve as a basis for coding or hyperparameters in research in the field of artificial intelligence for decision-making modeling to avoid collisions between ships in unmanned vessels.

BIBLIOGRAPHY

[1] Haryani, E. B. S., Alamsyah, A. R., & Suhalis, A. (2023). Integration between ecoport management and capacity utilization of container terminals as a sustainable seaports development strategy. IOP Conference Series Earth and Environmental Science, 1221(1), 012058. https://doi.org/10.1088/1755-1315/1221/1/012058

[2] Ricardianto, P., Thamrin, M., & Pahala, Y. (2022). Determination of Port Facilities and Container Flow Growth Toward the Development of Makassar Port, Indonesia. Journal of Economics Management Entrepreneurship and Business (JEMEB), 2(2), 103–113. https://doi.org/10.52909/jemeb.v2i2.95

[3] Lestari, E. (2021). Impact of the development of Makassar new port (MNP) in supporting sea tolls. Linguistics and Culture Review, 5(S1), 1265–1275. https://doi.org/10.21744/lingcure.v5ns1.1603

[4] Syamsiah, S., Fauzi, A., Djabier, A., & Nurwahidah, N. (2021). The Compatibility Analysis of Human Resources Competencies of Makassar New Port (MNP) and its Curriculum. Jurnal Pendidikan Dan Pengajaran, 54(2), 255. https://doi.org/10.23887/jpp.v54i2.33108

[5] Sinaga, R., Humang, W. P., & Kurniawan, A. (2018). Potential cargo demand of Kuala Tanjung Port as international hub port in Western Indonesia. MATEC Web of Conferences, 181, 09001. https://doi.org/10.1051/matecconf/201818109001

[6] Ishikura, T. (2020). Regional economic effects of transport infrastructure development featuring trade gateway region-asymmetric spatial CGE model approach. Transportation Research Procedia, 48, 1750–1765. https://doi.org/10.1016/j.trpro.2020.08.211

[7] Sugiyono. (2019). Metode penelitian kuantitatif, kualitatif dan R&D. Alfabeta.

[8] Koskinen, T.; Kähönen, M.; Jula, A.; Laitinen, T.; Keltikangas-Järvinen, L.; Viikari, J.; Välimäki, I.; Raitakari, O.T. Short-term heart rate variability in healthy young adults: The Cardiovascular Risk in Young Finns Study. Auton. Neurosci. 2009, 145, 81–88.

[9] Nunan, D.; Sandercock, G.R.; Brodie, D.A. A quantitative systematic review of normal values for short-term heart rate variability in healthy adults. Pacing Clin. Electrophysiol. 2010, 33, 1407–1417

[10]Berntson, G.G.; Bigger, J.T.; Eckberg, D.L.; Grossman, P.; Kaufmann, P.G.; Malik, M.; Nagaraja, H.N.; Porges, S.W.; Saul, J.P.; Stone, P.H.; et al. Heart rate variability: Origins, methods, and interpretive caveats. Psychophysiology 1997, 34, 623–648