An Analytical Assessment of the Situational Awareness of Seafarers & Their Trust in Automated Systems

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Synopsis

As technology improves, transport industries will want to implement these developments accordingly. The maritime industry is now on the cusp of one of the largest advancements to the industry in recent history, with the introduction of autonomous operating systems. The International Maritime Organisation (IMO) has revealed that the maritime industry is ready to allow onboard automated systems a larger amount of control, thus elevating the system status to a more autonomous control level. With the level of autonomy increasing from current systems; to full automation and finally to fully autonomous shipping, the maritime industry will experience a complete overhaul of all onboard systems, conditions and operational parameters, all of which seagoing vessels utilise daily. This as a result, will introduce a new age of operational systems which seafarers will have to adapt, train, and become accustomed to. However as new levels of technology are introduced to the maritime industry, younger seafarers will be trained sufficiently on such machines. The current aging demographic shows that within the next 10-15 years there will be a large amount of retirements from current navigational officers and master mariners. As a result, the seafarers currently undergoing training at this point will become the future senior navigational officers of tomorrow resulting in a group of seafarers who will be trained in both manual and potentially autonomous navigation. This introduction of autonomy can benefit ship owners and shipping companies worldwide however, without training in critical situations the resultant fallout could be cataclysmic. This paper analyses 50 individuals, varying in experience as part of the navigational crew onboard vessels, and their conduct in performing a bridge watch whilst carrying out a variety of tasks within a simulation suite. It was found that age, rank, and education level of the individuals proved to be key factors in the assessment, regarding situational awareness and reliance on automated bridge systems.

Keywords: Autonomy; Situational Awareness; Automation; Human Factors; Automation Bias; Maritime Operations

1. Introduction

As the maritime industry develops alongside current technological advancements, autonomous transportation is a step towards the future for the industry. The maritime industry's direction of travel toward autonomy has been made apparent through various projects being undertaken to standardise implementing such systems onboard vessels. The Maritime Unmanned Navigation through Intelligence in Network (MUNIN) project assessed potential systems to be fitted to vessels for autonomous operation, development of the concept for unmanned autonomous ships and implementing the initial programmes (MUNIN, 2017). Meanwhile, the Advanced Autonomous Waterborne Applications (AAWA) initiative provided an analysis of the legalities behind autonomous operations (Jokioinen, 2016). The maritime industry is now at the forefront of a fundamental transformation which could potentially be as historically impactful as changing from sails to engines.

Thus, the following study has been conducted, which analyses a group of 50 individuals all studying to advance their careers in the navigational officer sector of the maritime industry and their reliance on current onboard automation systems and potential changes in situational awareness.

1.1. The increasing of use of autonomy

In recent years, levels of automation have seen a global growth within the transportation industry. The benefits of moving towards full automation and then remote autonomous operation are vast as they provide a level of safety and cost benefits that outweighs the use of humans, but only if the system is operated correctly (Staruch, 2017). Nevertheless, automation like everything can experience malfunctions or if operated erroneously then automated systems can produce a level of danger to the operator, vessel, and environment. Research undertaken, has shown that implementing automated systems on a basic level can ultimately result in; a degradation in situational awareness; an increase in automation bias and automation complacency (Pazouki, et al., 2018). This reliance on the system can further be magnified to qualified officers, as accidents such as the grounding of the *Priscilla* can be attributed to automation complacency, among other key factors such as fatigue, boredom and not following or

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utilising any aids or systems provided to support navigational officers during their bridge watch (Marine Accident Investigation Branch - MAIB, 2019).

Present maritime operations are primarily conducted under the control and influence of a human operator, this includes expectations of operators being able to make critical decisions and conduct bridge watchkeeping alarm management, whilst maintaining control of the vessel in its daily passage. However, with studies showing that 85% of seagoing accidents may be attributed to human factors (Cordon, et al., 2015), this poses the question “Does the maritime industry and shipping companies, rely too heavily on navigational officers?” As a result, by increasing the control of autonomous systems, this could impact the safety and performance of the vessel by alleviating the workload for seafarers by the system completing monotonous tasks.

Despite the benefits of introducing autonomous systems onboard vessels, the systems will only function to a level, limited by the ability of the operator. Therefore, should the operator fail to identify an error or input data incorrectly, a fault will occur. There is potential to allow systems more control and overrule orders given by the operator, however at this point they would become self-sufficient machines, which in turn could present a potentially significant ethical issue. In 2017 a report was published by the Danish Maritime Authority, which found that there needs to be a prioritisation of protective navigational decisions when programming autonomous ships. Additionally, the report outlined what decisions should be left to the human operator, as the system cannot make morally correct decisions, when the vessel is underway (Danish Maritime Authority, 2017).

1.2. Preparation for the next stage of autonomy

Establishing the varying stages of autonomy has been paramount for the maritime industry, as it can show the degrees of control given to the onboard systems. During the IMO’s 100th session, the Maritime Safety Committee (MSC) approved a framework, for a regulatory scoping exercise on maritime autonomous surface ships (MASS) to provide a hierarchy for levels of autonomous control for vessels. This was approved to meet the overall time constraints applied to the industry, by current ongoing projects to bring the smart ship concept into fruition (Maritime Safety Committee - IMO, 2018). Table 1 shows the outcome of the framework of the MSC’s regulatory scoping exercise and the resultant degrees of autonomy and operational control.

Table 1: Levels of Autonomy and Control Matrix (Maritime Safety Committee - IMO, 2018)

Autonomy and Control Matrix				
Levels of autonomy and control Combining levels of autonomy and control that relate to the way that a ship is configured and operated, enables unambiguous classification for the purposes of safe and efficient operation and regulation.			*Operational control (Qualified deck and/or engine personnel)* B0 No Qualified operators on board but qualified operators available at a remote location	B1 Qualified operators on board
Level of autonomy (Technical)	A0	Manual The function and systems of the vessel are under manual control and operation, this includes using basic automated systems for simple tasks	–	A0 – B1
	A1	Delegated The operator still has control over the vessel; however, the system can implement decisions and actions with permission.	A1 – B0	A1 – B1
	A2	Supervised The operator is informed by the system regarding any actions taken, however the system does not require permission to implement decisions and actions. Yet, the operator can override the system.	A2 – B0	A2 – B1
	A3	Autonomous The system informs the operator in event of emergency or when normal operation parameters are breached. Ship can implement decisions and actions without permission, yet operator can override the system.	A3 – B0	A3 – B1

With IMO preparing to advance the level of autonomy onboard vessels, research is being conducted to analyse and assess how the maritime industry prepares for the transition. Studies conducted by Mitsui & Co in 2019, as seen in Table 2, show that the industry is currently preparing to introduce autonomy onboard vessels, and initially autonomous shipping will be in local and coastal waters to start this paradigm shift (Wariishi, 2019). This transition can be confirmed by the production of the container feeder vessel, *Yara Birkeland* (Kongsberg, 2017). With the maritime industry moving closer towards the 2nd stage of autonomy, by 2030, it is imperative that over the coming years navigational officer are competent and proficient using current onboard automation systems.

Table 2: Overview of Autonomous Ship Introduction & Major Technological Challenges (Wariishi, 2019)

	[Stage 1] Proof of Concept Phase ~2025	**[Stage 2] Ships using IoT (Autonomy Levels 1~2) 2025 ~2030**	**[Stage 3] Ships with Automated Operating Functions (Autonomy Levels 2~4) 2030~2040**	**[Stage 4] Ships with Highly Automated Operations (Autonomy Levels 4~) 2040~2050**
Expected Effects	Toward practical use for coastal ships and in limited sea areas	• Achieve efficient navigation through stronger coordination between land and sea. • Improve maintenance efficiency by strengthening preventive maintenance. • Enhance safety and reduce workload for crews through partial automation.	• Promote optimisation of operations, including. increasing fuel efficiency and degree of punctuality. • Stabilise operations with advanced traceability. • Achieve both labour-saving and safe operations with ship-to-shore coordination. • Improve work conditions for seafarers through a reduction in labour force.	• Realise continuous optimisation of marine transportation. • Strengthen cooperation between marine transportation and ports/warehouses/land transportation • Possible development of new marine transportation infrastructure, such as individualised transportation and marine mobile warehousing.
Challenges	Calculate introduction effects, identify issues, develop new technologies	• Obstacle detection/collision avoidance technologies. • Development of AI for autonomous ships. • Increase speed and reduce costs of offshore communications.	• Development of advanced AI for autonomous ships. • Low-latency offshore communications. • Precise and advanced manoeuvring technologies.	• Maintenance-free power • Automation of onboard ship operations and tasks

2. Materials and methods

As the maritime industry moves towards the introduction of autonomous systems, despite increasing the level of operational safety of the system, human factors will always have an impact on how the system operates. From case studies researched from the Marine Accident Incident Branch (MAIB) such as *Priscilla* (Marine Accident Investigation Branch - MAIB, 2019) and *Ruyter* (Marine Accident Investigation Branch - MAIB, 2018), it can be seen that each incident developed due to a sequence of failures which ultimately led to the accident.

In this paper, the results of a study, using a group of 50 individuals, varying in rank, age, and education level, from the navigational section of shipping crews, operating a simulated vessel within the wheelhouse, is reported. The study monitored each candidate and their own experience within the bridge. Each scenario was carried out using Kongsberg secondary bridge suites, all implementing Kongsberg Polaris simulator software and Seaview R5 visual software.

2.1. Experimental framework

The framework of the experiment was to assess whether automated systems onboard ships, which are viewed as reliable by seafarers, would impact their judgement to carry out a safe watch as per the requirements of MGN 315: Keeping a safe navigational watch on merchant vessels (Maritime and Coastguard Agency , 2006). Different accidents were researched within the maritime industry, which aided in creating the subsequent experiments. In preparation for each experiment, a different scenario was created, using the simulator suite. Additionally, subjects were issued work packs for each test station to imitate basic paperwork that is expected to be completed on the

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bridge during the navigational officers' watch time. Once each scenario had been created, a study was conducted and results for the experiment were collated to be analysed.

To maintain continuity throughout each test station, the same vessel, and operational parameters, which were pre-programmed into the simulation software, were used. For the experiment, the ship chosen was a bulk carrier travelling at 14 knots following a course heading of 000. The vessel's autopilot had been configured to sound an off-course limit alarm once the vessel had exceeded a course of 20 degrees. The vessel's particulars can be found in Table 3.

Table 3: Test Ship Particulars

L.O.A [m]	Beam [m]	Draught Aft [m]	Draught Fwd [m]	Deadweight [Tonnes]	L.P.P [m]	Max Power [kw]	Full Speed [knots]
215	31.8	11.5	11.5	22691	162.9	9,180	14.4

It was key for the experiment to be as authentic and immersive as possible. Hence three 20-minute exercises were designed with unique faults that would occur within each scenario. Candidates would have to undertake all scenarios to ensure that they could be assessed on each testing station. However, the order in which the candidate completed the tests was arbitrary and based on the candidate's choice. Before the start of the first exercise, all candidates were given a familiarisation briefing, where candidates were informed how to operate the system, in terms of controlling the simulated vessel and communications with the instructor. Following the briefing, each candidate then completed each exercise. The scenarios were created to ensure that all candidates experienced: a mechanical fault, a rudder offset; a series of alarms, routine fire alarm testing; and an automation fault, autopilot gyro drift.

Each scenario was given a different fault, traffic condition and time stamp within the corresponding test station. The data displayed in Table 4 indicates the arrangement of each scenario.

Table 4: Outline of Testing Stations

Scenario	Time Stamp	Fault	Number of ships in Traffic
1	0000	Rudder Offset	1
2	0800	Gyro Drift	3
3	1600	Fire Alarm Testing	2

Beyond the variables, all scenarios were configured in a manner to provoke the candidate to respond to errors and faults which occurred in the simulation. Visual cues in the form of cloud patterns, star positions and the wake were in view for each candidate. Resultant alarms activated to allow the candidate to inspect the fault further at their own discretion and communications were set up between each test station and the monitoring station to create a feeling of supervision for the candidate, allowing them to call the captain or anyone else they deemed relevant for the exercise. Candidates were analysed using CCTV and microphones located in each testing station thus allowing the instructor to record and monitor the candidate throughout each exercise.

Candidates were issued with a work pack upon entry to the experiment. In each work pack candidates received the following items; three quiz answer sheets to complete in their corresponding workstations, a ship particulars work sheet, which they could attempt to complete over the course of their time in the simulator suites and a log book with three scenario pages for them to highlight any abnormalities in the exercises.

By monitoring, analysing their work packs and debriefing them, every candidate was able to convey acknowledgment of any abnormalities, if detected, within each scenario. Table 5 shows the traffic vessels parameters required, for each scenario.

Table 5: Parameters of Traffic Vessels Within Simulations

Exercise	Vessel	Distance [Nm]	Bearing	Speed [knots]	Heading
0000	001	10.1	050	12	135
	001	3	245	18	330
0800	002	4	015	12	180
	003	12	345	24	090
1600	001	5	180	13	350

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	002	10	215	18	080

2.2. Scenario 1 – 0000 Hours Rudder Offset (RO)

Candidates will enter a darkened wheelhouse, due to the timestamp being 0000 hours. The plot shown in Figure 1(a), is a display of the radar within the simulator.

At 11 minutes into the exercise the rudder of the vessel will begin to offset to an angle of 7.5 degrees to starboard. Additionally, the turning indicator will begin to freeze simultaneously, as this will also hamper any manual operations and encourage the candidate to believe that the vessel may not be turning as the indicator is not moving. The frozen turning indicator will self-correct at 18 minutes into the exercise. From the start of the RO the magnetic compass will begin to make a clicking sound indicating that the vessel is turning, furthermore the radars of the vessel will begin to indicate that the vessel is turning as the fault is purely mechanical and not systemic. Should the candidate look out of the windows, onto the simulated sky, they will begin to see that the stars are moving. Thus, indicating that the vessel is no longer keeping a 000 heading.

if the vessels course is left unaltered, the auto pilot alarm will begin to sound at 14 minutes and 56 seconds into the exercise. This will be the final prompt for the candidate to alter the course and acknowledge the alteration of heading for the vessel. Should the candidate proceed to not alter the course or take control of the vessel by the 20 minute time limit, the candidate will be given a time score of 540 seconds thus indicating that the candidate failed to recognise the fault. The radar plot in Figure 1(b) shows the direction of the vessel, should the control remain untouched throughout the exercise.

Radar Display Plots 0000

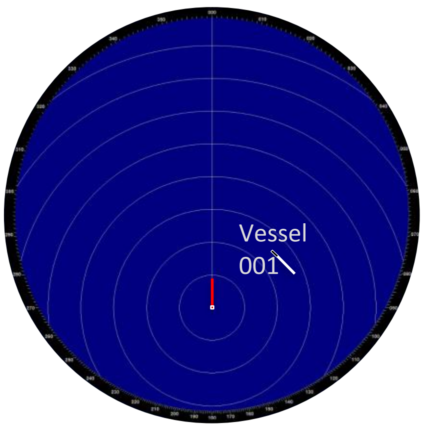

Figure 1(a): Radar Display Start of Exercise

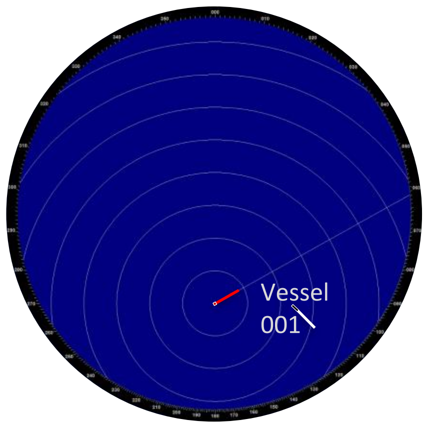

Figure 1(b): Radar Display End of Exercise

2.3. Scenario 2 – 0800 Gyro Drift (GD)

When entering the simulator suite, the candidate will be presented with the radar display shown in Figure 2(a). At 9 minutes into the exercise the vessel will begin to experience a GD. The vessel will begin to deviate from its course at a drift rate of 3 degrees per minute until the vessel reaches an off-course limit of 20 degrees.

As the vessel begins to experience the GD the vessel's magnetic compass will begin to start clicking thus indicating to the candidate that the vessel is deviating from its original course. However, as this error has affected the vessel's gyros, the heading display and radar readings will deliver an output that the vessel is on a course heading of 000. During this exercise, the candidate will have to look closely at the positions of the surrounding vessels and use the tracking function on the radar, to help them assess the situation. As the bridge is fitted with a backup gyro, for redundancy, the candidate may changeover to the vessel's second gyro and from there they can clearly see that there has been a course deviation.

If the vessels course is left unaltered, the auto pilot off track alarm will begin to sound 15 minutes and 54 seconds into the exercise. The sounding of the off-course alarm will act as the final prompt for the candidate to assess and attempt to correct the error. Should the candidate proceed to not alter the course or take control of the vessel by the 20 minute time limit, the candidate will be given a time score of 660 seconds thus indicating that the

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candidate failed to recognise the fault. Figure 2(b) and (c) shows the radar plots of gyros 1 and 2 where gyro 1 shows the error display whereas gyro 2 shows the true course of the vessel.

Radar Display Plots 0800

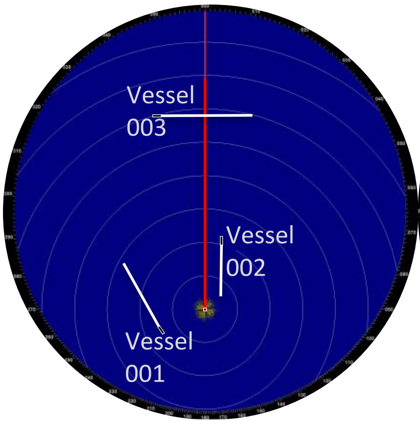

Figure 2(a): Radar Display at Start of Exercise

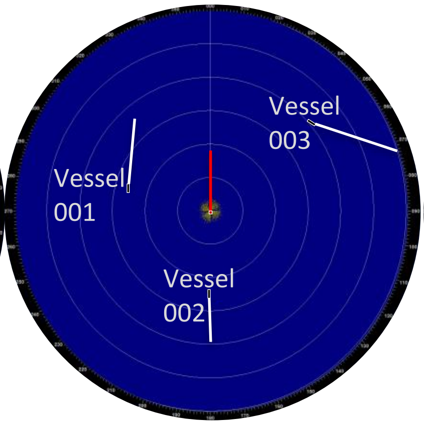

Figure 2(b): Radar Display at End of Exercise (Gyro 1)

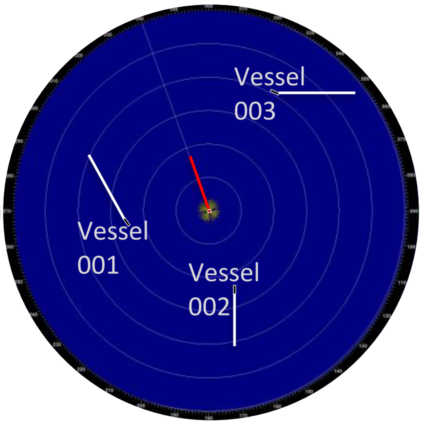

Figure 2(c): Radar Display at End of Exercise (Gyro 2)

2.4. Scenario 3 – 1600 Fire Alarm

When entering the simulator suite, the candidate will be presented with the radar display as shown in Figure 3(a). During this scenario, the candidate will not experience any faults which will put the vessel at risk of harm. At 1 minute and 30 seconds the fire alarm panel will sound a fire alarm in zone 1 of the vessel, however upon calling the captain and engine room the candidate will be told that there is routine fire alarm testing taking place, which will be carried out during the course of this simulation. The candidate will then experience alarms sounding every 90 seconds in the exercise, thus enhancing the sense of alertness.

Due to there being no deviation from the course, the vessel moves as expected. This can be seen from Figure 3(b) which displays the final radar plot at the end of the exercise.

Radar Display Plots 1600

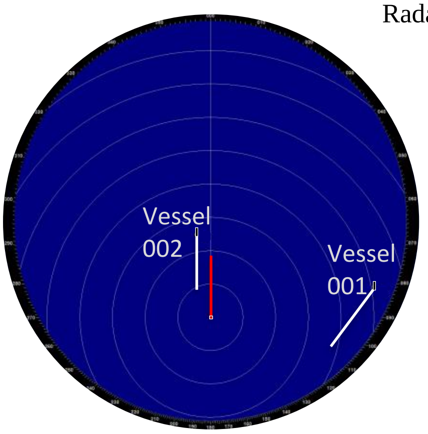

Figure 3(a): Radar Display Start of Exercise

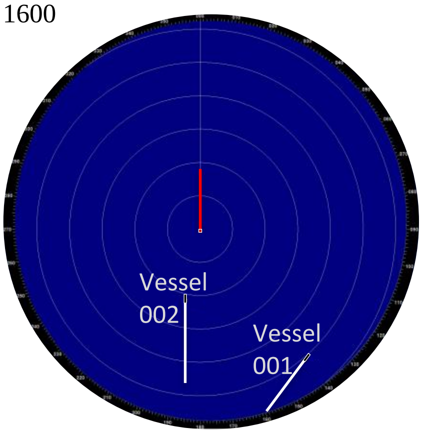

Figure 3(b): Radar Display End of Exercise

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3. Analysis and Results

Once every candidate had been tested, results were gathered and processed for statistical analysis. The data analysed was the time it took for the candidates to react to the fault for the RO and the GD exercises. Statistical analysis was conducted for the following demographics of candidates: Age, Rank and Education level. By collating the data into these demographics, it was then possible to analyse the results further. Table 6 shows the variety of candidates in terms of the demographics.

To measure the reaction times for each individual candidate, the candidate was monitored using visual and audio CCTV, which allowed the instructor to record when the candidate reacted to the fault of the test station. Each candidate was given a reaction time ranging from the start of the fault, 0 seconds, to the end of the exercise, 540 seconds and 660 seconds for the RO and GD exercises, respectively.

Table 6: Candidate Demographics

Age

Category	Candidates	DNR [%]	
		RO	GD
21 & under	16	25	93.75
22-25	12	8.3	58.4
26-29	14	0	57.14
30 & over	8	0	62.5

DNR – Did Not React
RO – Rudder Offset
GD – Gyro Drift
CP 1 – Cadet Phase 1
CP 3 – Cadet Phase 3
CP 5 – Cadet Phase 5
AC – Academic Cadet
3/O – 3rd Officer
2/0 – 2nd Officer

Rank

Category	Candidates	DNR [%]	
		RO	GD
CP 1	11	36	72
CP3	3	0	100
CP 5	14	0	64.3
AC	8	12.5	100
3/O	6	0	50
2/O	8	0	50

Education Level

Category	Candidates	DNR [%]	
		RO	GD
High School	19	21	84.2
Diploma	20	0	75
Degree	11	9	36

3.1. Raw Data

The graph displayed in Figure 4 shows every candidate's individual response time to both the GD and the RO exercises. In the graph, the times at which both exercises finish are highlighted along with the times at which the autopilot off-track alarm begins to sound, 236 seconds after the introduction of the RO fault and 414 seconds after the introduction of the GD fault.

As shown in Figure 4, 52% of the total number of candidates were successful in reacting to the RO fault, before the signalling of the alarm. The overall percentage of successful candidates was anticipated to exceed this value as the candidates should have a heightened sense of alertness due to the exercise being conducted in darkness. However, with correct prompting i.e. autopilot off-track alarm, 90% of the candidates reacted accordingly and were alert to the fault at hand.

As shown in Figure 4 16% of the total number of test candidates responded to the fault prior to the sounding of the alarm. This low value is of concern. A further 14% of the candidates required the alarm to sound before they reacted to the course deviation. Bridge watch navigational alarm systems such as this can be deactivated. The deactivation of such systems can result in hazardous consequences and accidents such as the grounding of the *Ruyter* have been attributed to this (Marine Accident Investigation Branch - MAIB, 2019).

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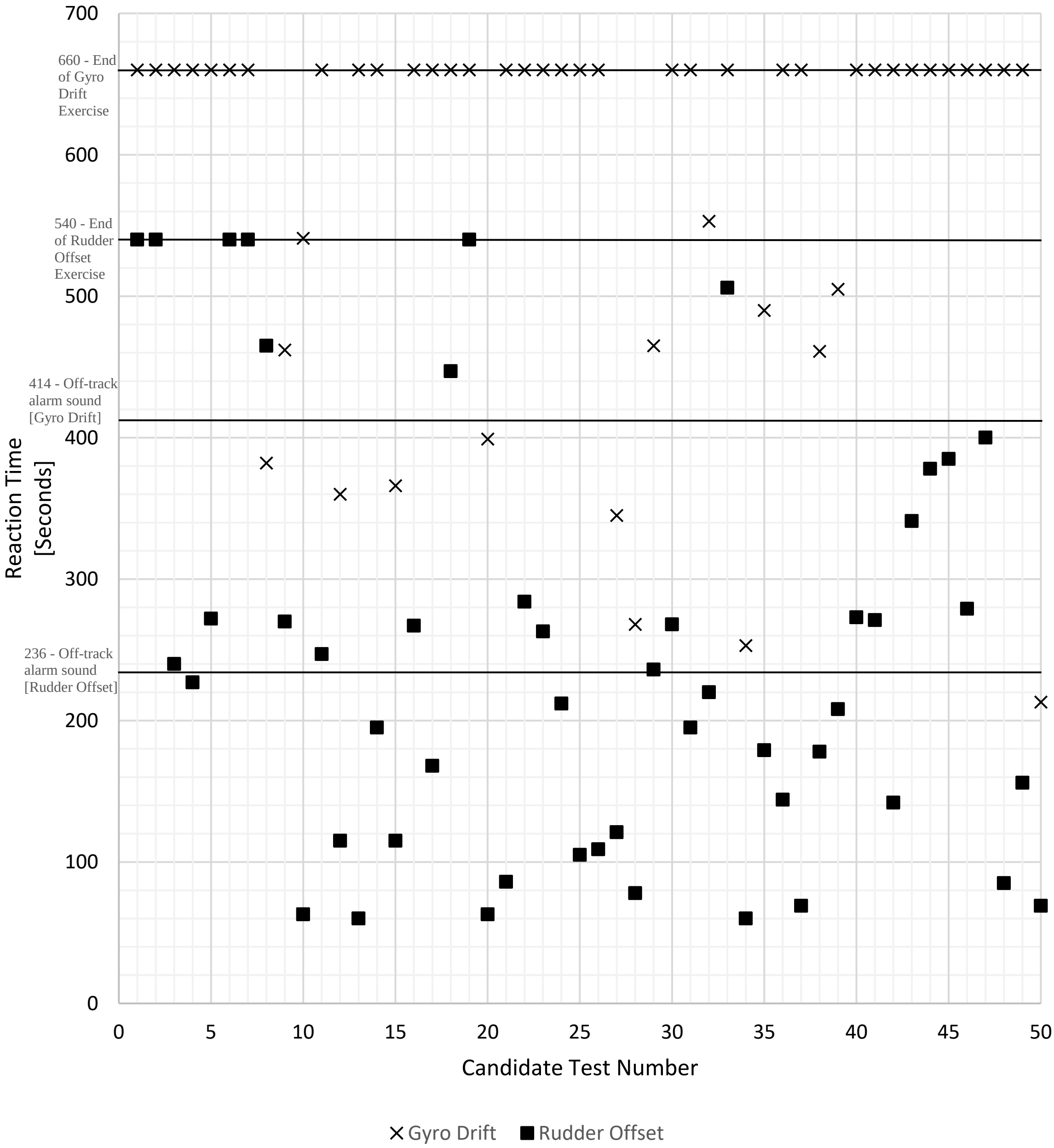

Figure 4: Individual Reaction Times for GD and RO Exercises

3.2. Age of candidate

As shown in Figure 5, 90% of the candidates successfully responded to the RO fault, whereas only 30% of candidates successfully reacted to the GD failure.

Figure 5 illustrates fastest, slowest, and average reaction times for each candidate age pool. For the RO exercise, fastest and slowest reaction times came from the 21 & Under group, with times of 60 seconds and 506 seconds, respectively. Regarding the RO fault only 5 candidates failed to react to the fault, with four of those candidates belonging to the “21 & Under” group and one candidate belonging to the “22-25” group.

In comparison the fastest reaction time for the GD exercise can be attributed to the “22-25” group with a reaction time of 213 seconds and the slowest can be attributed to the “26-29” group, with a reaction time of 553 seconds. Both the RO and GD exercises the largest collective of unsuccessful attempts belongs to the “21 & Under” group. Age of the candidates should correlate to the overall experience each candidate has onboard vessels i.e. it is assumed that the younger the candidate is, the less navigational officer experience they have. This assumption may also be strengthend as the slowest reaction times of the “30 & Over” group are quicker than all other groups for the RO and are quicker than both the “22-25” and “26-29” groups for the GD. This suggests that, for candidates

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who successfully reacted to the fault, as the age of the candidate increases so does their level of situational awareness.

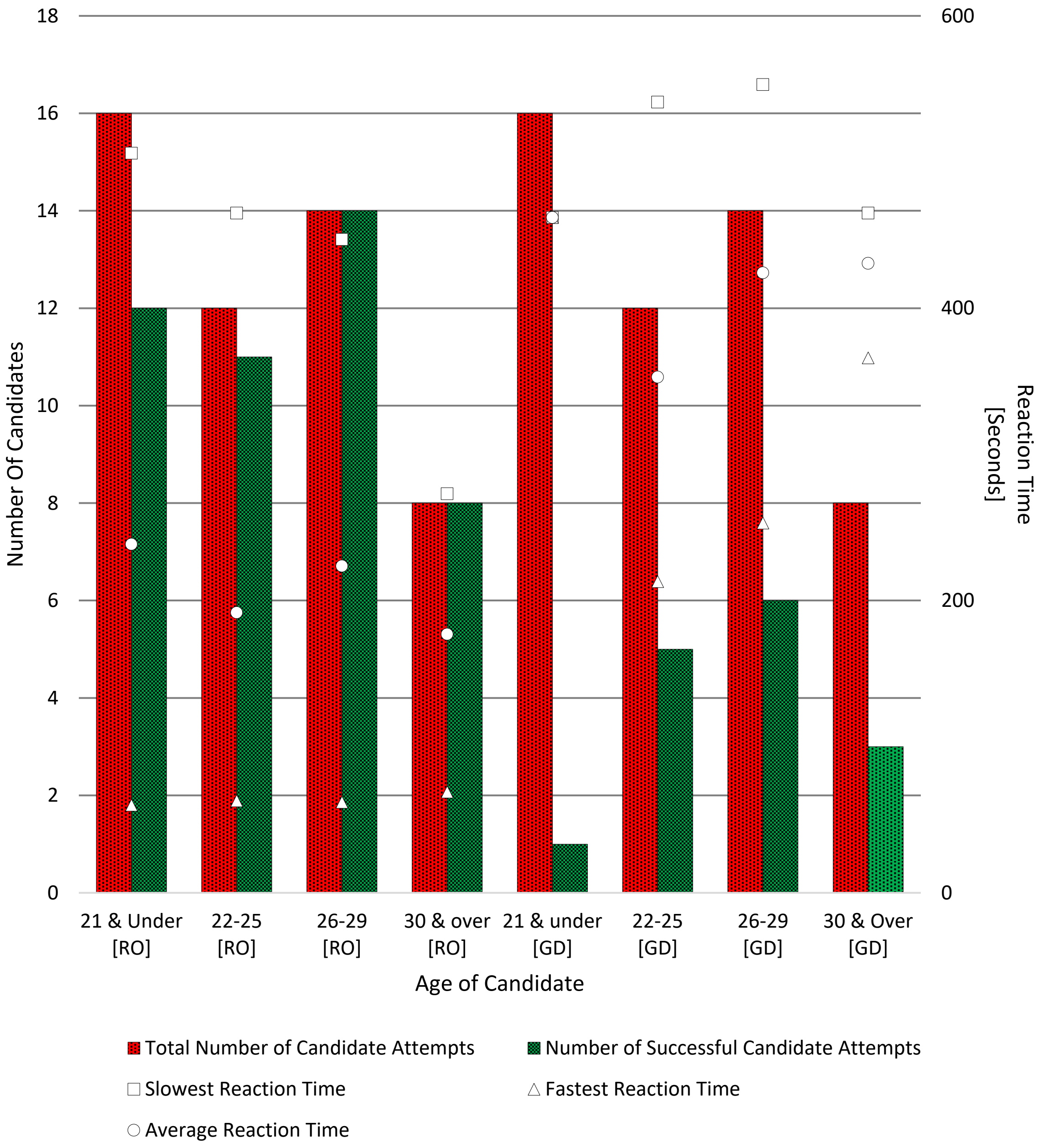

Figure 5: Average, Maximum & Minimum Age of Candidate vs Reaction Time

3.3. Rank of candidate

As shown in Figure 6 the largest number of unsuccessful candidates for the RO exercise came from the phase 1 cadet group, with 4 candidates failing to react to the fault, and the second largest can be attributed to the academic cadet group, with one candidate failing to react to the fault. This was as expected, due to the unfamiliarity of the non-seagoing cadets with the wheelhouse. Moreover, it should also be noted that the fastest reaction times came from the phase 5 cadet group, at 60 seconds. However, the slowest successful reaction time also came from the phase 5 cadet group, with 506 seconds. Additionally, it should be noted that all qualified officers performed as expected with most officers reacting to the RO within 200 seconds of the fault occurring.

As shown in Figure 6 many unsuccessful attempts came from the cadet groups, moreover 50% of both 2nd and 3rd officers failed to react to the fault within the allotted timeframe. It should also be noted the fastest reaction time overall came from a 2nd officer who had completed the Navigation, Aids, Equipment and Simulation Training

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(NAEST) management course, prior to attempting the exercise. Therefore, it was expected that this candidate performed to a higher standard than other candidates at the same rank.

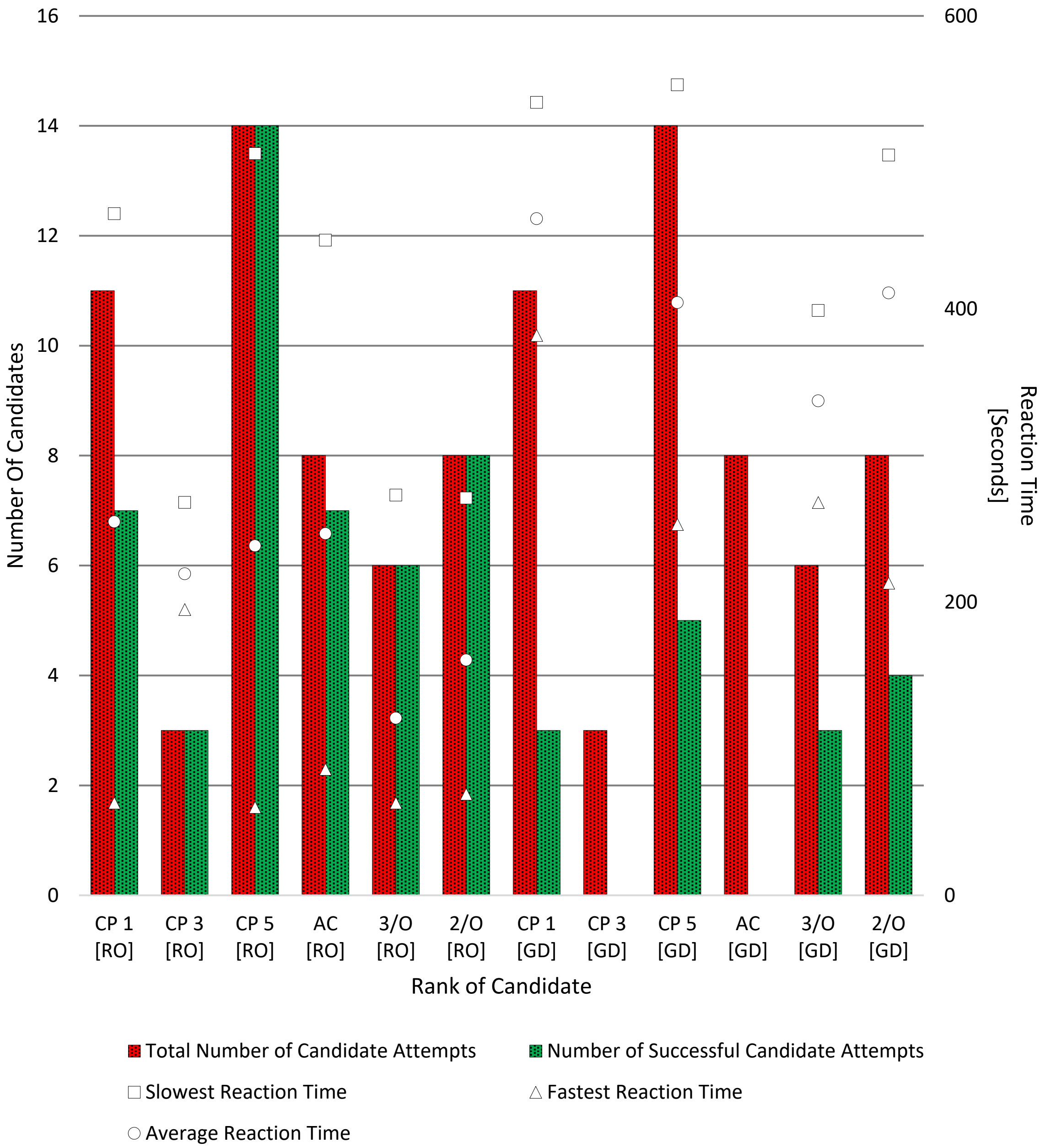

Figure 6: Average, Maximum & Minimum Reaction Time vs Rank of Candidate

3.4. Candidate Education Level

Due to the wide variation in the candidates' levels of education, the data was confined to the following demographic pools: High School, Diploma and Degree. As shown in Figure 7 the groups which had unsuccessful attempts were High School and Degree levels, with 3 and 1, respectively. As a larger percentage of candidates with Diploma and Degree level of education reacted to the faults, it was assumed that the candidates with a higher level of education had greater bridge watchkeeping experience and therefore were more observant and reactive when presented with a fault as seen in the RO exercise.

For the GD exercise, the largest pool of successful candidates was from the Degree level, with seven individuals, additionally it should be noted that this group also contained the slowest reaction time, 553 seconds. However, the fastest reaction time belonged to the Diploma group, 213 seconds.

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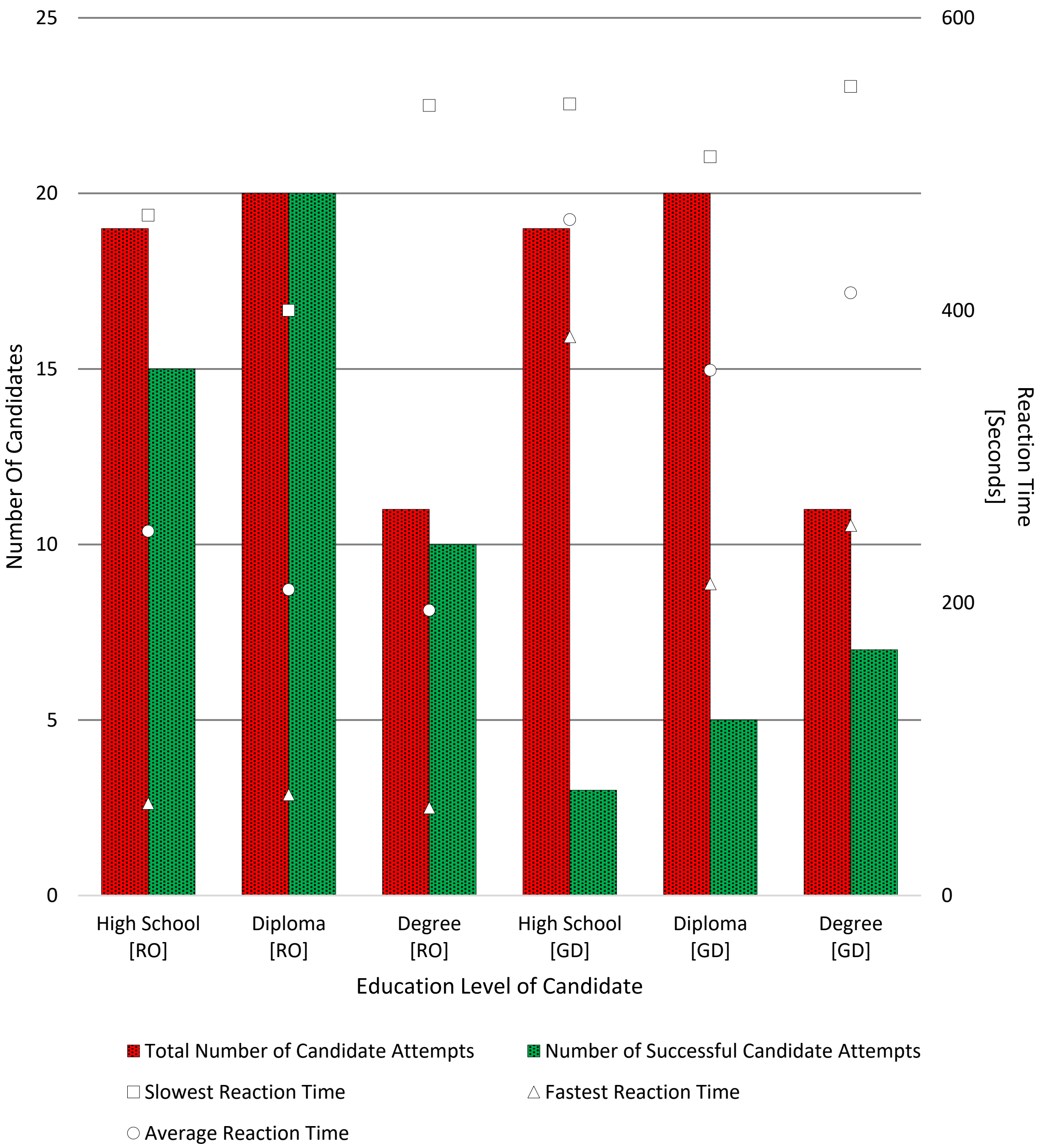

Figure 7: Average, Maximum & Minimum Reaction Time vs Candidate Education Level

4. Conclusion

The exercises were chosen for this study, as they covered a broad outline of various incidents and probable difficulties faced among navigational officers (Grech, et al., 2008). With 70% of all test candidates failing to identify any fault within the GD exercise, it is possible that candidates have experienced automation complacency or automation bias, thus resulting in candidates showing more trust in the system over their own abilities. This complacency or bias could have affected candidates watchkeeping routing i.e. assessing the magnetic compass.

With the maritime industry heading towards implementing autonomous systems onboard vessels, further training for navigational officers is required, to develop and train the situational awareness of seafaring officers. The learning curve for navigational officers will be steep, however using current onboard navigational aids and equipment the curve may not be as steep as anticipated. As mentioned, the fastest performing individual on the exercises had previously attended a NAEST management course, which enhances an officer's ability with onboard bridge systems. Should this course be accessible and mandatory for all navigational officers during their cadetship then there is the potential for a higher quality of navigational officer entering into shipping companies globally.

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For navigational officers to become more adept with future systems it is crucial that they should be experts with the current onboard automated systems such as the autopilot. From the study conducted, only 50% of qualified officers reacted to the automated system failures within the allotted time frame. Therefore, the outcome of this paper has identified a large variance in skill between officers who are of the same rank.

With the maritime industry heading towards implementing autonomous systems it is imperative that the skill level of navigational officers, both present and future, needs to be of a high standard. Hence, by increasing the quantity and standard of practical training, for both cadets and navigational officers, the maritime industry will be able to ensure that the future masters and mates of the industry will be capable of adapting to the eventual learning curve, which autonomous systems will bring.

As the maritime industry progresses to the later stages of autonomy, seafarers will see the benefit as it will allow human performance to improve as the systems will undertake monotonal tasks. However, human operators will still be required to oversee and correct potentially unethical decisions systems may make.

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