Team Resilience in Maritime Emergency Response: Analytical Framework and Implications from Accident Report Analysis

Hong-Oanh Nguyen[a], Siriwardhana H. Gamage[a], Anthony Beckett[a], Paul Turner[b], Mohammad Sadegh Taskhiri[b], Natalia Nikolova[a,c*]

[a] Australian Maritime College, University of Tasmania, Launceston, 7250 TAS, Australia

[b] School of Technology, Environment & Design, University of Tasmania, Hobart 7005 TAS, Australia

[c] Nikola Vaptsarov Naval Academy, Varna, 9027, Bulgaria

[*]Corresponding author. E-mail: Natalia.Nikolova@utas.edu.au

Keywords: shipping, resilience, analytical framework, crew team communication

ABSTRACT

Maritime accidents keep a rate of 3,200 p.a. with some two-thirds involving damage/loss to ships and/or crew, according to EMSA (2018). This study develops an analytical framework to identify the factors influential to team resilience in maritime accidents. The framework is then applied to evaluate team resilience and performance in two ship accidents. The analysis found communication and coordination are some of the critical factors in onboard teams' emergency response. This is traced back to bridge resources management (BRM) training and its effectiveness in improving onboard team performance and leadership. The effect of team-related factors such as unity and culture, on team resilience is also highlighted.

1. INTRODUCTION

The maritime sector is subject to high risks because of the nature, sea perils, human errors, unexpected events and operational complexity. Despite technological developments in shipbuilding and navigation, as well as improvements in maritime education and training (MET), maritime accidents remain a huge challenge for the maritime industry, causing loss of life and property, and damage to the environment.

The ability of the onboard crew to survive accidents is critical especially when the challenge and the adverse impact are high, difficult to control, and require immediate action with no time to plan adequate response. Teamwork is necessary for the onboard crew because not only teams bring synergy, but ship operations require coordination and communication between crew members to achieve common goals. The International Convention on Standards of Training, Certification and Watchkeeping (STCW) requires that all seafarers must have training, and demonstrate competence in BRM that covers: shared mental model, situational awareness,

error management, contingency planning, challenge and response, and distractions and interruptions (ATSB 2015).

Little attention is given to improve the resilience of the onboard team. To date, only limited research has been conducted on team resilience and emergency response (Morgan et al. 2017; Linthicum 2012). Existing studies tends to overlook factors, such as leadership, coordination, communication, and organisational culture that are critical to the performance of a team. For example, team performance and resilience depend on leadership, which depends on other factors such as influence, inspirational motivation, intellectual stimulation, individualised consideration. Intellectual stimulation promotes intelligence, problem-solving ability, while individualised consideration allows each member to contribute his/her best to the team or weakness to be considered and supported by other members (Bass and Avolio, 1994).

The last four decades have seen extensive research on resilience of employees in workplace. Focus has been given on resilience of teams, organisations and even broader communities in challenging and emergency situations, such as natural disasters, epidemics, crises and accidents. Research was carried out mainly in non-maritime sectors, such as defence, health, social care and sport (Chapman et al, 2018). This opens potential benefits as well as necessity to study the Resilience of Teams in Maritime Emergency Response (ROTIMER).

This paper reviews the role of team performance and resilience in emergency response in the maritime domain. We aim to test what the influential factors in team resilience are and how team performance is being considered in maritime accident investigation. We conduct a literature review and also analyze several maritime accident reports. We check the latter against the team resilience factors to reveal the gaps in accident investigation and improve MET, especially BRM training.

2. REVIEW OF THE LITERATURE ON TEAM RESILIENCE

Teams are also social entities composed of members with high task interdependency and shared and valued common goals (Dyer, 1984). A common theme running throughout research on teamwork is that team members do not exist in isolation. They are usually organised hierarchically and sometimes dispersed geographically. They must integrate, synthesise, and share information to coordinate and cooperate as task demands shift throughout a performance episode to accomplish their mission.

Unlike individual work that concerns the work carried out by person, teamwork requires interactions and interdependence between team members. More importantly, teamwork is not a static process and rather it is a dynamic process (Stachowski et al., 2009). As such, team resilience is also a dynamic, temporal process (Morgan et al., 2017). Teamwork typically involves interaction with varying patterns. The level of interaction is important for team performance (Stachowski et al., 2009).

Another important factor in teamwork is communication or information exchange. Several studies suggest effective communication in emergencies not necessarily greater in quantity Stout et al. (1999). Through effective communication, shared mental allows team members to anticipate needs and provide information needed for the given situation. Existing studies have

also shown that newly composed teams tend to exhibit more flexible interaction patterns and respond more effectively than teams that had been together longer (Dionne et al., 2004).

Information sharing shows how teams adapt their performance processes under varying task conditions (Entin and Serfaty, 1999). It helps improve team cognition and collective orientation as an important attribute of teamwork. Team members who are high in collective orientation are more likely to gain collective intelligence and will predict team performance. They will listen to team members and built a strong association between collective intelligence and team performance in League and Legends (Kim et al., 2017).

Leadership as another factor influential to team performance pertains to many aspects of team work, including decision making, inspirational motivation, intellectual stimulation and influence. Inspirational motivation means a leader's ability to empower team members and promotion of confidence in achievement and execution of goals and tasks (Bass and Avolio, 1994). Intellectual stimulation promotes intelligence, problem-solving ability and or seeking a different perspective when solving problems etc. (Bass and Avolio, 1994). Good leadership positively impacts team cohesion and enhance the team's resilience to withstand stressors (Dionne et al., 2004, Rodríguez-Sánchez and Vera Perea, 2015, van der Beek and Schraagen, 2015).

According to Morgan et al. (2017), team resilience refers to the capacity of a team to overcome crises and difficulties. It is the ability to "either thrive under high liability situations, improvise, and adapt to significant change or stress, or simply recover from the negative experience".

Based on their literature review Alliger et al. (2015) found a consensus about team resilience as a team's ability to "withstand", "resist" and "overcome" stressors. Moreover, team resilience is 'not synonymous' with individual resilience. Team work's focus is on collectivism, not individualism. It is based on the concept that the whole is greater than the sum. Disciplined groups tend to make better decisions than individuals (Page, 2008). Existing studies have different views and approaches to the constructs of team resilience, especially in emergency response. No research has been found on team resilience in maritime emergency response, where onboard teamwork is critical when the ship is exposed to high operational risks and sea perils and it is difficult to get immediate support.

3. ANALYTICAL FRAMEWORK

This section proposes a framework to present the key factors or attributes of team resilience in emergency response. The four factors identified for the literature are: *Leadership* (Morgan et al., 2015, Dimas et al., 2018, Sommer et al., 2016); *Communication/interaction* (Gomes et al., 2014, Gucciardi et al., 2018, Lionel, 2015); *Coordination* (Gomes et al., 2014, Amaral et al., 2015); and *Sharing/cohesion/trust,* (Amaral et al., 2015, Stephens et al., 2013, Lionel, 2015, Kennedy et al., 2016)

Due to the dynamic nature of resilience especially in emergency response (Gucciardi et al., 2018), it is essential to consider the emergency response process, where team resilience takes place and emerges from. In this regards, various existing models were developed but did not consider team resilience factors. For example, Lundberg and Johansson (2015) developed a

systemic resilience model (Figure 1) that considers various aspects of the process, including functional dependencies, constraints, ability to adjust or adapt, and strategies. In operational terms, the process is divided into five stages, namely *'Anticipate', 'Monitor', 'Control', 'Recover',* and *'Learn'* (Johansson et al., 2018).

As an alternative to Lundberg and Johansson (2015), US military strategist and Air Force Colonel Boyd (1996) developed the 'OODA Loop' framework for the emergency response process with four stages: *'Observe', 'Orient', 'Decide',* and *'Act'* adapted from the military combat operation process (Figure 2). Note that OODA Loops allows for the co-existence of an 'implicit guidance and control' procedure and the 'feed forward' process.

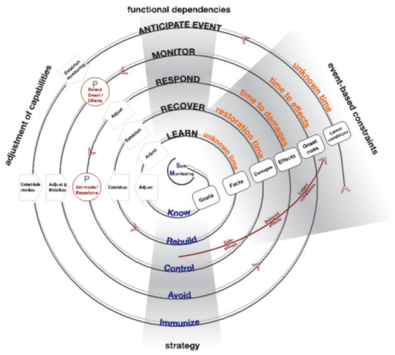

Figure 1: The Systemic Resilience Model (Lundberg and Johansson, 2015)

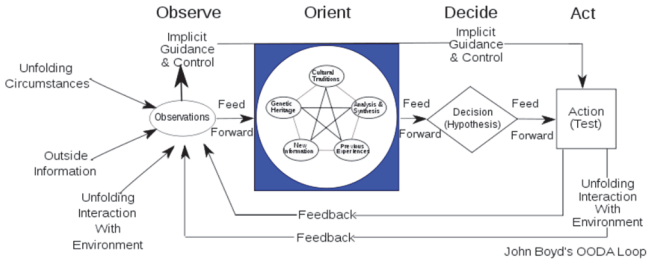

Figure 2: OODA Loop (Source: Wikipedia (2018))

Despite of its popularity and applications in various fields (Evertsz et al., 2019, Byus, 2018), OODA Loop is not suitable for teamwork because it is lack of team factors. Therefore, we propose an analytical framework for team resilience in emergency response that integrates the above team resilience attributes and emergency response process. The response process can be modified or extended. For example, the four components in OODA Loop, 'Observe', 'Orient', 'Decide' and 'Act' can be replaced with 'Respond', 'Engage', 'Act', 'Communicate' and 'Transition' components from the REACT framework (Linthicum, 2012). These components will be analysed along the emergency response process in tandem with the respective models such as the OODA (Boyd, 1996) or REACT (Linthicum, 2012) frameworks.

4. CASE STUDIES

We analyze two case studies of maritime accidents using data from the Marine Accident Investigation Branch (MAIB 2014) and Ministry of Infrastructures and Transports (MIT 2019).

The first deals with the collision of the container vessel CMA CGM Florida and the bulk carrier Chou Shan in open water 140 miles east of Shanghai on 19 March 2013. They collided in the East China Sea resulting in both vessels sustaining serious damage, and approximately 610 tonnes of heavy fuel oil being spilled from CMA CGM Florida. CMA CGM Florida left China heading to Korea. Chou Shan left China heading to Australia.

Table 1: Collision of CMA CGM Florida and Chou Shan

Team	Response process			
	Observe	**Orient**	**Decide**	**Act**
Sharing: sharing team value and work, allocating resources, caring each other safety, etc.	**Florida:** failed to identify priorities during hand over; poor interpretation of equipment (AIS/Radar) **Chou Shan:** failed to identify priorities during hand over	**Florida:** engaged in minor issues; big picture was not clear to them; tried to achieve impossible tasks (requesting F.V to alter course – not common) **Chou Shan:** big picture was not clear. ColRegs were not given a priority; poor judgement of safety; late actions	**Florida:** relied on F.V. to take action; relied on AIS information; **Chou Shan:** did minimum alterations; expected other vessel to follow her instructions; agreed to the course change (red to red) after request from Florida; decided to head towards Florida and reduce stbd. turn	**Florida:** priority given to stay clear of F.V.; changed Radar range to 6 Nm. a/co to stbd. side several times **Chou Shan:** continued to work around Fishing vessels; a/co to stbd.; reduced the stbd.; turn and turn to stbd. again
Communication: exchanging information, verbally, using technologies, etc.	**Florida:** failed to establish common ground between Chinese 2/0 and OOW; tried to establish un wanted communications with F.V.; used different languages to communicate not common to team members; **Chou Shan:** change of plan (a/co) request from Florida confused OOW and was a too late request:	**Florida:** different opinion about Chou Shan's movement confused the handling of the ship; confused over the communications; Use of different languages made poor situation awareness; **Chou Shan:** unaware of the danger; Failed to establish common ground with Florida; wanted to clear fishing vessels first;	**Florida:** decided use VHF commination for collision avoidance; decided to call Fishing vessel; initially unaware of movement of Chou Shan decided to clear F.Vs.; **Chou Shan:** agreed to go red to red; later decided not to do a large alteration to stbd.; agreed with AB to continue with stbd. alteration;	**Florida: a**/co to stbd. several times. **Chou Shan:** a/co to stbd.; reduced the rate of turn and head towards Florida; continued to turn towards stbd. again
Leadership: Vision, decision making process, participation of team members, etc.	**Florida:** worries about the movement of F.Vs.; OOW advised to engage in unsuccessful communication with F.V; big picture was not clear to OOW; **Chou Shan:** worries about the movement of F.Vs.; did not take early action to avoid situation;	**Florida:** did minimum course alterations; wanted to influence fishing vessels to a/co; did not want to take early and large alterations to stay away from the Fishing vessels; **Chou Shan:** did minimum alterations; lack of appreciation of developing situation;	**Florida:** tried to clear F.Vs.; to maintain course between F.Vs. and Monte Pascoal; **Chou Shan:** tried to clear fishing vessels due to unawareness of developing danger situation;	**Florida:** A/co to stbd. several times; **Chou Shan:** did minimum alterations;
Coordination: Planning, timing, organising, monitoring the progress, etc.	**Florida:** unaware of standard seamanship practices; Chinese 2/o was not aware of the stbd. alteration of the Chou Shan; **Chou Shan:** unaware of standard seamanship practices; requested to a/co to pass stern of the Florida (this was against rules); VHF communication under 2 miles and CPA od 0.3 nm;	**Florida:** did minimum alterations; came to a point where the bridge team was unaware of the movement of the vessel Chou Shan; **Chou Shan:** did minimum alterations; unaware of the problems faced by Florida; final VHF communications create confusions at the last moment;	**Florida:** decided to maintain course between fishing vessels and Monte Pascoal; reduction of turning rate of Chou Shan and concerns of Chinese 2/o prompted OOW to stop stbd. alteration; decided to a/co to port as well – feedback from the Chinese 2/O; decided to go back to original plan (a/co to stbd.); **Chou Shan:** clear the fishing vessels first; agreed to pass red to red. did not call to master; Reduce the stbd. turn by ordering to head towards Florida;	**Florida:** continued with small alterations to stbd.; a/co to port; again a/co to stbd.; **Chou Shan:** continued to concentrate on movement od F.Vs.; a/co to stbd.; head towards Florida; again, agreed to AB to turn further to stbd.;

The second case study deals with the passenger vessel Costa Concordia, which on 13 January 2012, whilst in navigation in the Mediterranean Sea with 4229 persons on board (3206

passengers and 1023 crewmembers), in favourable meteo-marine conditions, collided with the "Scole Rocks" at the Giglio Island.

Table 2: Grounding of Costa Concordia

Team	Response process			
	Observe	**Orient**	**Decide**	**Act**
Sharing: sharing team value and work, allocating resources, caring each other safety, etc.	Vessel manoeuvred in poorly lit area and shallow waters; Factors of risk in navigation neglected or underestimated; Captain did not share reasons to take over navigation; Danger realized late; Master distracted during manoeuvres due to inadmissible activities; Bridge Team not paying required attention during manoeuvres;	Speed of navigation kept high for this manoeuvre; Cartography not appropriate; Bridge design did not allow verifying clear outlook in night-time; Master provided the helmsman the compass course to be followed instead of the rudder angle;	Master took full command of navigation with no obvious reason Vessel navigated in high speed in shallow waters and poorly lit area Attempt to avoid grounding; Emergency Generator Power switched on after black-out;	Efforts to avoid grounding came too late; Understanding of risks and dangers for ship considered too late to avoid the grounding; EGP failed to supply utilities to handle the emergency; Realization of severity of situation came only due to vessel heeling violently and speed sharply decreased;
Communication: exchanging information, verbally, using technologies, etc.	Master steering on own initiative; Master did not share need to navigate the vessel on his own and in this particular conditions and speed; Bridge Team demonstrating disconnect and passiveness;	Dangers of navigation overlooked; Decision on navigation approaches poorly shared with crew and passengers; Damage inspection identified 5 watertight compartments flooded; Wireless communication system not functional under emergency power	Decision to send distress signal delayed; Communication to authorities delayed; Master conducted analysis under his direct coordination; SAR actions had to be conducted in isolation to information from Master	Master did not warn the SAR Authority of his own initiative; Master informed Authorities about a breach, launching the related distress with delay; SAR involved resources on its own initiative; General Emergency Alarm not activated immediately;
Leadership: Vision, decision making process, participation of team members, etc.	Master took over navigation without indicating reasons for his decision; Master did not warn the SAR Authority of his own initiative; Bridge Team passive and seemed not to have urged the Master to notice dangers of navigation;	Usage of inappropriate cartography; Manoeuvring under risky conditions with no visible purpose and reason; Navigation plan not properly assessed and shared;	Master took over from Chief Mate without proper reason; Master decided on a risky manoeuvre; Master provides information to authorities with delays; Abandon ship message issued with delays Abandon ship message issued a bit over 2 hours after grounding not preceded by general emergency alarm;	Handover from Chief Mate to Master did not concretely occur; Plan of navigation unreasonably risky; Master failed to provide timely information to authorities; Rescue operations delayed; Distress signal issues only by insistence of Livorno SAR; Abandon ship message did not reach many people on ship.
Coordination: Planning, timing, organising, monitoring the progress, etc.	Poor assessment of navigation plan by Master; Damage assessment gave full reports only after several days; Rescue operations continued several days; Environment operations by authorities immediately took place recovering oil spill of 2042.5mc	Poor coordination and communication prior to grounding with passive Bridge Team; Coordination with authorities suffering substantial delays; Delays in most processes surrounding emergency situations on board;	Initial inspection of damage commanded directly by Master; Lack of direct orders from Bridge to safety operation crew team; Coordination of activities imposed by initiative of authorities; One officer remained on bridge to coordinate abandon ship; Lack of orders on the base of the Master List for this specific emergency;	Rescue operation continued under authority supervision for several days; Master's review of initial navigation plan carried loosely; Inconsistencies in the assignment of duties to crew members; Basic training of crew played negative role in the emergency response of the crew;

5. CONCLUSION

The paper discussed maritime accidents from the perspective of team resilience and its role in the efficient and effective handling of such emergency situations at sea. We proposed an analytical framework to identify the factors influential to team resilience in maritime accidents utilizing and improving prior developments in this domain. We then utilized the framework to discuss and assess the team resilience and performance in two ship accidents – the collision of container vessel CMA CGM Florida and the bulk carrier Chou Shan in East China Sea, and the grounding of Costa Concordia at Giglio Island (Italy). The analysis of the cases demonstrated clearly that communication and coordination are some of the critical factors in onboard teams' emergency response and it is what causes severity in the consequences from marine accidents in many instances. We were able to follow that back to training standards and quality and its effectiveness in improving onboard team performance and leadership.

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