A newly installed semi-autonomous helm aboard a US Navy destroyer

Image US Navy

FATIGUE PREVENTION AT SEA AS ANOTHER STEP TOWARDS ‘VISION ZERO’

White Paper | August 22 2023

Using WOMBATT’s innovative voice-based AI fatigue prediction and FRMS App to support the International Maritime Organization Guidelines on Fatigue: SC.1/Circ.1598: Seafarers' Training, Certification and Watchkeeping (STCW) Code - STCW regulation VIII/1 (Fitness for Duty)

References: https://news.usni.org/2019/08/06/ntsb-accident-report-on-fatal-2017-uss-john-mccain-collision-off-singapore
https://www.register-iri.com/wp-content/uploads/MSC.1-Circ.1598.pdf

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Worldwide Online Monitoring By Alerting Tired Travelers

Introduction

Travelling at 18 knots, more than 33 kph in the predawn darkness of the South China Sea on August 21st, 2017, the United States Seventh Fleet destroyer USS John S McCain was approaching the Singapore Strait Traffic Separation Scheme (TSS). The TSS is essentially a multi lane maritime freeway separating east and west bound traffic along the narrow Singapore Strait, the busiest waterway in the world with 2000 ships transiting the Strait every day, and innumerable smaller craft. Her tired crew were looking forward to their planned shore visit in Singapore after an eventful and stressful South China Sea passage. It was a moonless night, moonrise would not be until 06.21 am, and sunrise at 07.01 am. According to the McCain's Officer of the Deck, there was zero illumination that night. Not far off blinked the Horsburgh Lighthouse, built by the British Empire in 1851 on Pedra Blanca rock and still today marking the eastern entrance to the Singapore Strait.

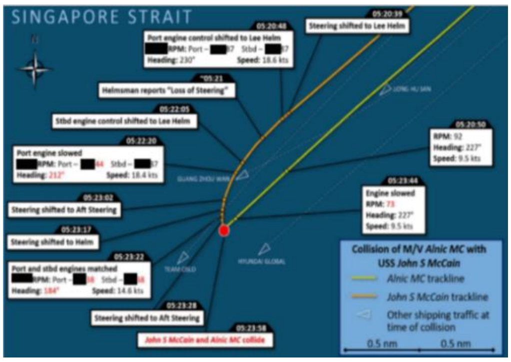
On duty on the McCain's bridge was her commanding officer Cmdr. Alfredo Sanchez (CO), 11 other officers, the helmsman and the lee helmsman. The 14 officers and crew on the McCains bridge that morning had only an average of 4.9 hours sleep over the past 24 hours, several hours less than the 7 to 8 hours sleep required for normal human alertness. Off her port (left) side was the Liberian flagged tanker Alnic MC, making only 9.5 knots with her master, one officer and one able seaman on duty on the bridge. Between the McCain and the Alnic, the Norwegian tanker Team Oslo was just ahead of the Alnic travelling at 11 knots. Other ships were travelling in the middle lane fore and aft of the tanker and the giant British container ship Hyundai Global was slightly astern on the port side of the Alnic, overtaking her at 16 knots.

At 05.20 am, the master of the Alnic walked outside onto the starboard (right) wing of his bridge and noted the position of the destroyer from her navigation lights in the darkness 600 metres abeam of his ship, noticing especially her unusually long and brilliant white wake trailing far behind her on the otherwise black sea surface. The destroyer's Automatic Identification System (AIS), mandatory

on all commercial vessels, was turned off in accordance with US Navy policy for South China Sea transits. From this plus her lean aspect on the radar screen, he concluded that she was a large warship – very fast, highly manouverable and most likely superbly commanded. He heard Singapore port authorities trying to contact “the navy ship” via the VHF radio but he heard no response to them from the bridge of the warship. Although all other neighbouring ships were being plotted by the tankers automatic radar plotting aid (ARPA), the warship could not be acquired by the system.

Suddenly, without any warning at 05.21 am, the warship began changing direction to port, on a new course that would cut across the bow of the Alnic. Somebody on the Alnic bridge shouted “this guy thinks he can cut through”. The rules of the TSS dictate that ships must maintain course and speed until contact is made with all other ships in the immediate area. The Alnic tried repeatedly to make VHF radio contact with the McCain but there was no answer from the bridge of the destroyer.

Then at 05.23 am the warship tightened her turn further, now on a collision course with the tanker, and slowed down to just over 5 knots right in front of the Alnic, making a collision inevitable. At 05.23.58 the bow of the tanker crashed into the side of the destroyer, instantly killing 10 sailors asleep in their bunks and injuring 48 others. Some were thrown completely out of the ship but all their remains were later recovered by the US Navy from the sea floor. Nobody aboard the Alnic was hurt.



What happened aboard the USS John S McCain that early morning in the Singapore Strait?

At 01.15 am the CO of the McCain came to the bridge as he expected a busy morning entering the Singapore Strait and docking at Changi Naval Base. The destroyer had two propellers and two engines, each engine driving its own propeller. During the early morning hours in the open sea the ship was using only one propeller for economical running, but as she approached the busy shipping lanes of the Singapore Strait, her CO ordered the second engine to be engaged at 02.15, anticipating more need for manouvering power. On the bridge, the ship control console (SCC) comprised the steering wheel and engine power control – the driver’s seat. Normally there was one helmsman operating both steering and power, but with the facility to transfer power control from the helmsman to the lee helmsman, sitting a metre or two away on the right-hand side of the SCC. With the tasks so distributed the helmsman steers the ship, and the lee helmsman controls engine power. This arrangement shares the heavy load of steering and power control between two people in high tempo situations. A year or so previously, the John S McCain had been fitted with a new automatic SCC with manual over ride fitted with computer driven touchscreens, similar in some ways to a semi-autonomous car. This arrangement requires fewer crew members to operate than the all-manual system. At 04.18 the CO ordered the steering mode changed from computer assisted mode (autonomous) at the SCC helm station to manual mode, which he preferred for docking manouvres as it allowed for more direct communications between the CO and the steering/power crews.

Like many modern warships, the John S McCain has fore and aft steering, so that in the event of the bridge being disabled, she can still be steered from the rear or aft of the ship. The aft steering crew can take full control of the ship at any time. Clearly, communications between 1) the CO, 2) the helmsman on the bridge, 3) the lee helmsman on the bridge and 4) the aft steering crew in the rear of the ship needs to be nearly instantaneous.

At 5.10 am the sole helmsman who had been on duty since 01.15 am was relieved by a new helmsman, but rather than releasing him to go to breakfast the CO ordered him to man the lee helm, resulting in a now fatigued crew member manning the lee helm. At 5.20 am the CO ordered that the power control be transferred from the helmsman to the lee helmsman in anticipation of an active time navigating the crowded shipping lanes of the Singapore Strait. This had to be done one propeller at a time. The port propeller was transferred at 05.21 am. In order to test the now manual steering before transferring the second propeller, the new helmsman shifted the rudder 5 degrees to port, but the ship did not respond. Then he tried to move the rudder 5 degrees to starboard – again the ship did not respond. Realising that he did not have steering control of the ship at that moment he called out "steering control lost" and at the same time the ship began to turn slowly to port (toward the Alnic). The loss of steering control at the bridge was announced over the ships public address system and hearing this announcement the aft steering crew moved immediately into position to take over control of the steering. The CO ordered speed be reduced to 10 knots. However, only the port engine slowed to 10 knots. The starboard engine continued at 18 knots, the cause of the ship's involuntary turn to port.

Key fatigue related errors of all 14 people on the bridge.

1) Nobody on the bridge thought to turn on the two vertical "ship not under command" red mast lights when it was clear that the ship was not under control (The "ship not under command" lights were switched on 10 minutes AFTER the accident) or to answer the VHF radio calls coming from both the tanker and from Singapore port authorities, either of which may have allowed the Alnic to take earlier evasive measures, perhaps preventing the accident

2) Nobody on the bridge made the immediate cognitive connection that the involuntary turn towards the tanker was being caused by mismatched engine speeds, despite that information being clearly displayed on various monitors and dials located throughout the bridge.

At 05.22 control of the starboard propeller was transferred to the lee helmsman. With steering control at the bridge still lost, the CO ordered the ship speed to be reduced further to 5 knots and the aft steering crew were ordered by the CO to take control of the steering, which they did, but steering control then suddenly and automatically shifted back to the bridge for no apparent reason, and the starboard propeller continued turning, unnoticed by anyone on the bridge, at a greater thrust than the port propeller, exacerbating the rate of turn of the ship. There was much confusion at this point with still no control of the steering, propellor speeds still not aligned and precious time was lost as both bridge and aft crews tried to understand what was happening. Fatigue results in cognitive tunnel vision, with an inability to quickly grasp, communicate and handle a fast-changing situation. All this time the destroyer's speed continued to slow and she continued to turn further to port, directly into the path of the tanker. At 05.23.44, realizing that the destroyer was not going to make it, the master of the tanker ordered a speed reduction by half, although he thought he had ordered a full stop of the engine. By then the aft steering crew on the McCain had finally regained manual control of the ship via the aft steering and turned the rudders 15 degrees to starboard, as originally ordered by the CO minutes earlier when the ship had first started her turn.

These actions came too late to prevent the tanker from crashing into the side of the destroyer.

Fatigue Prevention Aboard Ship

Work/Rest History of the USS John S McCain Crew on the morning of August 21, 2017

The average sleep obtained by the bridge crew over the 24 hours prior to the accident was 4.9 hours on average. Three of the bridge crew members, the Officer of the Deck, Junior Officer of the Deck and the Boatswains Mate of the Watch had each had about 4 hours of sleep in the past 24 hours. The Junior Officer of the Watch and the helmsman had each had 5 hours. The conning officer reported that he had slept 3 hours, and ***the critically important lee helmsman had not slept at all in the prior 24 hours***. The CO had had 5 hours and the Executive Officer (XO) had 4 hours of sleep. Both described their quality of sleep as "poor".

According to the NTSB report, most people will experience fatigue with less than 7 to 8 hours sleep in any 24 hours period. Sleeping less than 7 to 8 hours in any 24 hours leads to **acute fatigue**. Whereas habitually sleeping less than 7 to 8 hours in a 24 hours periods leads to accumulated sleep debt leading in turn to **chronic fatigue**. Besides the bridge crew of the USS John S McCain having had an average of 4.9 hours sleep over the 24 hours prior to the accident, and the lee helmsman no sleep at all, the accident occurred in a time period considered to be the circadian low period of the day, from 02.00 am to 06.00 am. Finally, the navy ran a watch schedule that was not aligned in any way to the circadian rhythm, so sleep periods and sleep patterns for crew members were continually changing, resulting in poor quality sleep.

On the morning of August 21, 2017, the entire bridge crew of the John S McCain was critically fatigued due to lack of sleep.

As a result of the USS John S McCain accident investigation, the NTSB recommended that the US Navy adopt the STCW Code requirements for rest scheduling and fatigue management aboard all US Navy ships.

WOMBATT Voice Based Software fully complies with the International Maritime Organization (IMO) Guidelines on Fatigue: MSC.1/Circ.1598 - STCW regulation VIII/1 (Fitness for Duty)

Key elements of the MSC.1/Circ.1598 Guidelines on Fatigue and the specific WOMBATT solutions for them are:

1) Shift organization. All shifts follow the circadian rhythm.
    a. *WOMBATT-VOZ allows sailors to automatically plan, input and track their shift hours and timing.*
2) Hours of work. No shift should be longer than 12 hours, and any work period longer than 16 hours will lead to a very high risk of fatigue related mistakes, errors and accidents.
    a. *WOMBATT-VOZ allows sailors to automatically monitor hours awake to end of shift/watch*
3) Fitness for work. Each worker must have the ability to self-report his/her fitness for work as regards sleep times and fatigue.
    a. *WOMBATT-VOZ allows sailors to voluntarily and systematically input their sleep hours and wake times.*
4) Workers should use tools to self-assess their fatigue, in particular the Karolinska Sleepiness Scale.
    a. *WOMBATT-VOZ allows sailors to use artificial intelligence and voice technology to systematically predict their fatigue risk up to 5 hours in advance*
5) Workers should keep track of their diet, in particular ensuring they eat and drink in a consistently healthy manner.
    a. *WOMBATT-VOZ enables sailors to manually input recent food and drink history with an alert if the diet is likely to cause sleepiness on shift/watch*

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MSC.1/Circ1598 Annex, page 1   I:\CIRC\MSC\01\MSC.1-Circ.1598.docx

ANNEX: GUIDELINES ON FATIGUE

For the purpose of the Guidelines, the following definition for fatigue is used:

"A state of physical and/or mental impairment resulting from factors such as inadequate sleep, extended wakefulness, work/rest requirements out of sync with circadian rhythms and physical, mental or emotional exertion that can impair alertness and the ability to safely operate a ship or perform safety-related duties. "

"Particularly dangerous situations at sea arising from sleep debt are brief, uncontrolled and spontaneous sleep episodes while working, termed microsleeps. During a microsleep, the brain disengages from the environment (it stops processing visual information and sounds). Sleep deprivation, which is caused by cumulative sleep debt, can make people more susceptible to microsleeps. The likelihood of microsleeps is even greater if the individual is on duty during a circadian low."

The WOMBATT-VOZ technology is ideally configured for use at sea in compliance with MSC.1/Circ 1598. The FRMS questionnaire part allows the sailor to self-record and self -report sleep hours, hours awake, diet, medication – all factors which MSC.1/Circ 1598 requires from the sailors themselves. In addition, in order to protect sailors from the dangers of the microsleep per above, the WOMBATT-VOZ AI voice technology fatigue prevention system enables sailors to regularly monitor their risk of experiencing a fatigue microsleep up to five hours ahead with up to 90% accuracy.

Finally, officers aboard ship and also shore staff on the other side of the world can continually monitor the sleep risk status of all crew aboard any ship in real time.

WOMBATT-VOZ is the ideal solution enabling the ship crew to prevent the occurrence of fatigue risk at sea.