AVIATION HIGHWAY MARINE RAILROAD PIPELINE

Adopted December 1, 2021

MAR 21/04

Fire aboard Roll-on/Roll-off Vehicle Carrier *Höegh Xiamen*

Pier 20, Blount Island

Jacksonville, Florida

June 4, 2020

Abstract:

This report discusses the June 4, 2020, fire aboard the roll-on/roll-off cargo vessel *Höegh Xiamen*. None of the vessel's 21 crewmembers were injured, but nine shoreside firefighters responding to the accident were injured during firefighting efforts. The vessel and its cargo of 2,420 used vehicles were declared a total loss valued at $40 million, and the vessel was later recycled. Safety issues identified in this report include training for and oversight of vehicle battery securement, regulatory exceptions for used and damaged flammable-liquid-powered vehicles, fire detection system deactivation during cargo loading, and effective emergency distress calls. One recommendation each was made to the Pipeline and Hazardous Materials Safety Administration, the US Coast Guard, and the National Maritime Safety Association; two recommendations were made to Grimaldi Deep Sea; and three recommendations were made to Höegh Technical Management.

NOTE: This report was reissued on August 2, 2022, with corrections to the estimated time of the casualty on pages vii, 1, 3, 37, 38, 46, 47, 48, 49, and 60; removal of references to Höegh Technical Management's safety management system on pages 22, 43, 44, 51; and an update to the probable cause on pages viii and 52.

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Acronyms and Abbreviations

CCTV	closed-circuit television
CFR	*Code of Federal Regulations*
CO_2	carbon dioxide
Grimaldi	Grimaldi Deep Sea
HMR	Hazardous Materials Regulations
Höegh	Höegh Technical Management
ISM	International Safety Management
JFRD	Jacksonville Fire and Rescue Department
ILA	International Longshoremen's Association
IMDG Code	International Maritime Dangerous Goods Code
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
Ro/Ro	roll-on/roll-off
SSA	SSA Atlantic
VDR	voyage data recorder
VHF	very high frequency

Executive Summary

What Happened

On June 4, 2020, about 1544 eastern daylight time, the crew of the 600-foot-long, Norwegian-flagged roll-on/roll-off vehicle carrier *Höegh Xiamen* were preparing to depart the Blount Island Horizon Terminal in Jacksonville, Florida, en route to Baltimore, Maryland, when they saw smoke coming from a ventilation housing for one of the exhaust trunks that ran from deck 12 (the weather deck) to one of the cargo decks.

Crewmembers discovered a fire on deck 8, which had been loaded with used vehicles. The crew attempted to fight the fire but were repelled by heavy smoke. Shoreside fire department teams from the Jacksonville Fire and Rescue Department arrived at 1603 and relieved the crew. The captain, after consulting with and receiving concurrence from the fire department, had carbon dioxide from the vessel's fixed fire-extinguishing system released into decks 7 and 8, and the crew then evacuated from the *Höegh Xiamen*.

The fire continued to spread to the higher cargo decks and the accommodations. Shoreside firefighters entered cargo decks with fire hoses, and nine firefighters were subsequently injured, five of them seriously, in an explosion. Responders subsequently adopted a defensive strategy, cooling external exposed surfaces. The fire was extinguished over a week later on June 12.

The *Höegh Xiamen* and its cargo of 2,420 used vehicles were declared a total loss valued at $40 million, and in August 2020, the vessel was towed to Turkey to be recycled.

What We Found

The fire on board the *Höegh Xiamen* began in the aft portion of deck 8 before spreading to decks 7, 9, and 10/11 and was likely caused by an electrical arc or component fault in one of the used vehicles loaded on deck 8. Many of the vehicles that had been loaded over the previous 2 days did not have properly disconnected and secured batteries, which increased the risk of electrical arcing and component faults. During loading operations, both the loading personnel and vessel crew missed opportunities to address these hazards.

The transportation of used vehicles, such as those that were loaded on vessels like the *Höegh Xiamen*, is currently excepted from Hazardous Materials Regulations when a vessel has a stowage area specifically designed and approved for carrying vehicles. We found that used vehicles are often damaged and present an elevated risk of fire. We believe that greater inspection, oversight, and enforcement are needed to reduce this risk.

The investigation showed that the detection of the fire was delayed because the operating company did not have procedures to minimize the amount of time that their vessels' fire detection systems remained deactivated after loading evolutions. Additionally, the shoreside fire department's response to the accident site was delayed because the *Höegh Xiamen*'s master did not have immediately available contact information for search and rescue authorities and did not know how to report a fire to local authorities—who to call, what number to dial, or which frequency to use.

We determined that the probable cause of the fire aboard the vehicle carrier *Höegh Xiamen* was Grimaldi's and SSA Atlantic's ineffective oversight of longshoremen, which did not identify that Grimaldi's vehicle battery securement procedures were not being followed, resulting in an electrical fault from an improperly disconnected battery in a used vehicle on cargo deck 8. Contributing to the delay in the detection of the fire was the crew not immediately reactivating the vessel's fire detection system after the completion of loading.

What We Recommended

As a result of this investigation, we made recommendations to the companies involved to improve oversight of vehicle loading as well as training of personnel involved in battery securement for used and damaged vehicles. We also made recommendations to federal agencies to improve regulations for vehicle carriers that transport used vehicles. Finally, we made recommendations to the vessel's operator to revise their procedures involving the deactivation of fire detection systems and to ensure emergency contact information is immediately available for bridge teams.

1. Factual Information

1.1 Accident Narrative

1.1.1 Synopsis

On June 4, 2020, about 1544 eastern daylight time, the crew of the pure car and truck carrier (a type of roll-on/roll-off [Ro/Ro] vessel) *Höegh Xiamen*, shown below in figure 1, had completed loading vehicles on board the vessel while docked at the Port of Jacksonville, Florida, when they noticed smoke coming from a ventilation housing for one of the exhaust trunks that ran between deck 12 (the weather deck) and one of the cargo decks.[1] The crew found a fire on deck 8 and attempted to fight the fire before being relieved by shoreside firefighters. The fire was extinguished over a week later on June 12. None of the 21 crewmembers on board were injured; 9 firefighters sustained injuries while responding to the fire. The *Höegh Xiamen* and its cargo sustained significant damage due to the fire and were declared a total loss valued at $40 million.

Figure 1. *Höegh Xiamen* under way before the accident. (Source: Höegh Technical Management Inc.)

[1] (a) All times in this report are eastern daylight time. (b) Visit ntsb.gov to find additional information in the public docket for this National Transportation Safety Board accident investigation (case number DCA20FM020). Use the CAROL Query to search safety recommendations and investigations.

1.1.2 Accident Events

On the evening of June 2, 2020, the 600-foot-long, Norwegian-flagged Ro/Ro *Höegh Xiamen* docked at Pier 20 at the Horizon Terminal Ro/Ro facility (operated by Horizon Terminal Services) on Blount Island in Jacksonville with a crew of 21. Pier 20 was on the west side of the island, on the Saint Johns River, 11 miles inland from the Atlantic Ocean (see figure 2).[2]

Figure 2. Area of Jacksonville, Florida, where the *Höegh Xiamen* docked to load cargo. The accident location is marked by a red *X*. (Background source: Google Maps)

Between June 3 and June 4, 2020, the crew of the *Höegh Xiamen* worked with shoreside stevedores to load cargo (used vehicles) on board the vessel.[3] About 1500 on June 4, loading was completed, and the vessel's crew began preparing for the vessel's scheduled 1700 departure from Jacksonville, en route to Baltimore, Maryland, to load the last of its transatlantic cargo. After securing the vessel's side ramp, the crew attempted to secure the stern ramp, but the rigging jammed. Since it was raining heavily at the time, the chief mate decided to wait in a covered passageway on the weather deck (deck 12) for the rain to subside.

[2] All miles in this report are statute miles.

[3] A *stevedore* is employed or contracted at a dock to load and unload cargo from ships.

About 1544, the vessel's chief mate noticed smoke coming from the housing around the cargo deck 7/8 ventilation exhaust trunk at the starboard aft corner of deck 12 (this exhaust trunk served decks 7 and 8; see section 1.4.3 Cargo Decks Ventilation System). The chief mate immediately informed the crew over his radio that smoke was on cargo decks 7 and 8. The second mate in turn informed the master and chief engineer, who were in the master's office, that smoke had been observed. The master stated that he stepped out of his office, saw the chief mate running, and followed him to the cargo control room, where the chief mate reactivated the fire detection system at 1545, which had been secured (not activated) in accordance with cargo loading procedures (see section 1.5.2 Loading and Stowing Vehicles). The system immediately alarmed, indicating the presence of smoke. The master stated that he announced over the vessel's public address system that there was a fire on decks 7 and 8 and that all crew should go to "the muster station." In accordance with the vessel's emergency plan, the chief mate was "fire leader" in the cargo and accommodation spaces, and the chief engineer was the "fire leader" in the engine room spaces.

The chief mate sent an ordinary seaman and an able seafarer to decks 7 and 8 to investigate while he secured the cargo deck fans.[4] The chief mate also sent the vessel's electrician to close the remotely controlled ventilation dampers.[5] The chief mate stated that closing these dampers slowed but did not stop the smoke (the ventilation system's manually operated dampers remained open). At this time, he saw other crewmembers leaving their staterooms and donning firefighting equipment. About the same time, the chief engineer went to cargo deck 11 and began searching for smoke on the cargo decks, working his way to deck 7, by going down the port aft enclosed stairwell and checking each deck from the stairwell (the vessel had two stairwells: one located portside aft and one located on the centerline forward) (see figure 3).

When the chief engineer got to deck 8 in the stairwell, he observed heavy smoke. He believed that the lights were out because it was so dark, but when he asked the chief mate to turn on the lights, the chief mate replied that the lights were already on. From the stairwell, he opened the door to deck 8 and saw a vehicle on fire at the aft end of deck 8 and "strong" smoke, which forced him to evacuate the

[4] An *ordinary seaman* is an entry-level deckhand and usually has 1 year of experience or less. An *able seafarer* is a more experienced deckhand who is qualified usually by 3 years' sea service on deck and is capable of performing all duties required to maintain, manage, and operate the vessel. These include (among other things) steering by compass, keeping lookout, operating deck machinery, and rigging cargo gear.

[5] The vessel had a mix of remotely controlled and manual dampers on each trunk, some of which had been modified since the vessel's construction. See section 1.4.3 Cargo Decks Ventilation System.

area. About the same time, the ordinary seaman reported back to the chief mate that there was fire on decks 7 and 8 and he could not see on deck 8. The chief engineer checked deck 7, where he could see a small fire starboard aft on deck 8 above, with flaming material dripping to deck 7 through holes used for lashing on deck 8. He then ordered nearby crewmembers to connect fire hoses and bring firefighting equipment to the port aft stairwell at decks 7 and 8.

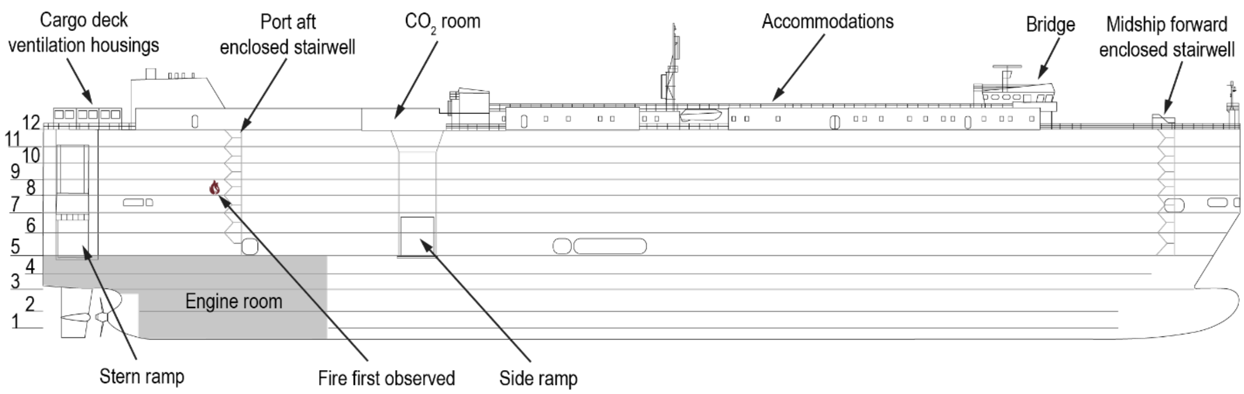

Figure 3. *Höegh Xiamen* inboard profile. (Background source: Höegh Technical Management)

Crew firefighting teams 1 and 2, along with the chief mate, arrived in the stairwell shortly after and prepared to enter deck 8 to fight the fire. However, according to the chief engineer, a rush of thick smoke began to come out of the door, preventing them from entering. They closed the door immediately and reported to the master that the smoke and lack of light made it impossible to access the deck.

The chief mate next went to deck 12, where he saw smoke coming from many of the dampers for the aft cargo ventilation housings. He radioed the master to inform him of the failed entry attempt on deck 8, as well as the smoke emanating from the dampers, and recommended that they release carbon dioxide (CO_2) using the vessel's fixed fire-extinguishing system, which could be directed to specific cargo decks or the engine room. In preparation for the CO_2 release, the master instructed the chief mate to close all the manual cargo deck ventilation housing dampers on deck 12.

Beginning at 1549, the master made several calls for help over very high frequency (VHF) radio to "Jacksonville Port Control," an entity that did not exist (the National Transportation Safety Board [NTSB] and US Coast Guard investigators were unable to determine which channel was used, and the Coast Guard received no distress call). At 1554, an unknown vessel answered the VHF call and advised the master to switch to channel 14 to reach the pilot station, and he did so. The pilot station relayed the distress call to the Coast Guard Sector Jacksonville Command Center.

The Coast Guard hailed the *Höegh Xiamen* on channel 16 several times beginning at 1555:49. The master returned to the radio at 1558:20 and informed them that there was a fire on deck 8 and requested assistance. He did not specify where the vessel was moored when asked, nor did he use the radio's distress button (also known as Digital Selective Calling), which would have automatically transmitted the vessel's position and identity to the local Coast Guard sector and other nearby vessels. Neither the master nor any other crewmembers answered subsequent radio calls.

About 1559, an onshore witness who had observed smoke coming from the vessel called 911 emergency services to report the fire. Shortly after, the nearby passenger vessel *Norwegian Pearl* reported to the Coast Guard that the *Höegh Xiamen* was at Berth 20, they could see shoreside responders were en route, and the ship was accessible from shore. The Coast Guard then issued an urgent marine information broadcast at 1602:40.[6]

Engine 48 from the Jacksonville Fire and Rescue Department (JFRD) reported their arrival on scene about 1603, and, shortly after, several other JFRD apparatus began arriving. Firefighters from Engine 48 reported seeing smoke coming from the aft ventilation exhausts both on the port and starboard sides when they arrived (see figure 4). The master stated that because he saw the firefighters arriving, he ordered the majority of the crew to go to deck 5 "for the safety of all of them," since he thought the fire department would have more experience than the crew.

Figure 4. Smoke coming from aft cargo deck ventilation housing exhausts about 1603.

[6] An *urgent marine information broadcast* is a request for assistance from any available mariners. It is broadcasted on VHF Channel 16 and by Navigational Telex (NAVTEX).

The chief mate and master met the Engine 48 firefighters on the stern ramp and provided firefighters with the vessel's drawings and Fire Control and Safety Plan. The second mate showed members of the fire department the port aft stairwell leading to the deck 8 cargo hold. The crew and firefighters opened the stairwell door to the deck 8 cargo hold (the same door the crew had previously opened) and immediately shut it due to heavy smoke.

The crew suggested to the fire department that CO_2 be released from the vessel's fixed fire-extinguishing system into decks 7/8, where they believed the fire to be concentrated, and the fire department agreed. The chief mate and chief engineer went to the CO_2 room, located on deck 12, and encountered heavy smoke. The master stated that he lost radio contact with them, so he went to the CO_2 room to check on them. At the master's instruction, the chief mate went to shut off the ship's fire alarm to better facilitate communication, while the chief engineer attempted to release the CO_2 from the CO_2 room to fire zone 3, which served decks 7 and 8. The chief engineer was unable to release the CO_2, so he went to the fire control room (also located on deck 12) and released the CO_2 from there about 1613.[7] Shortly afterward, the master stated that he heard a sound like CO_2 releasing from the system. The chief engineer then returned to the CO_2 room "to check the pressure" in the storage tank. He checked the tank, which "indicat[ed] that [the system was] working; it's released," so he, the master, and chief mate went back down to deck 5, where the rest of the crew had gathered. The master stated that he informed the fire department that the CO_2 had been released, and the firefighters asked the crew to "go to the berth [pier]." Once all the crew had been accounted for, they disembarked.

Firefighters monitored the fire using a thermal imaging camera. Believing that the fire was continuing to spread despite the release of CO_2, firefighters decided to enter decks 7 and 8, again from the port aft stairwell. They reported that, initially, there was no heat or smoke in the stairwell and that they found the doors to each deck (except deck 12) closed. There was no pressure behind the doors when they accessed decks 7 and 8.

Firefighters stated that upon entry on deck 8, they encountered two smoldering vehicles and only a small amount of fire on the port bulkhead. The firefighters stretched fire hoses from their own engines to begin fighting the fire. The same firefighters also stated that after cooling the cars and putting out the small fire,

[7] (a) The fire control room contained personal protective equipment and firefighting equipment for the fire team, controls for activating the fixed fire-extinguishing system, a remote fire detection panel, and cargo ventilation emergency stops. (b) Investigators were unable to determine why the system did not release from the CO_2 room. See Appendix A.

the heat seemed to increase substantially. They retreated from the deck as the heat continued to increase.

Firefighters from Ladder 7 were assigned to the weather deck (deck 12) to search for hatches to open for ventilation to evacuate smoke and improve visibility on the decks below with fires. On their way to deck 12, they opened the door to deck 9 from the stairwell and found thick, black smoke inside. Once they arrived on deck 12, about 1846, they were ordered to open any doors to the housings around the ventilation trunks. The Ladder 7 firefighters stated that they checked the starboard aft ventilation housing dampers and found them to be open with smoke flowing freely out of the vents for decks 7/8 and 9.

Upon opening the access door to the portside exhaust ventilation housing for deck 9, firefighters on deck 12 heard “a loud roar that sounded like a jet engine” as the exhaust housing “exploded” (see figure 5). The ventilation housing threw debris in the air. From the exterior of the ship, firefighters witnessed a tall column of grey-white smoke projecting from the stern on the weather deck and debris flying. According to firefighters, there may have been multiple explosions of varying magnitude. Firefighters in the port aft stairwell and on deck 5 described feeling intense heat and hearing a “roaring sound of rushing air.” Nine firefighters who were working in the stairwell or who had been staged on deck 5 were burned, five of them seriously, by the superheated air that rushed down the stairwell. Firefighters working on decks 7, 8, and 12 were unharmed.

Figure 5. Explosion of deck 9 ventilation exhaust housing. Note debris in air at top center of image. (Source: WJXT)

Following the explosion, the firefighters, assisted by the Coast Guard, transitioned to a defensive strategy where they focused on boundary-cooling to avoid flooding the higher decks and affecting the vessel's stability until personnel, including a naval architect, and equipment from the commercial salvor (Resolve Marine) identified in *Höegh Xiamen*'s Coast Guard-approved non-tank vessel response plan arrived about 0130 on June 5 (see figure 6).[8] Personnel from Resolve Marine continued to arrive over the next week to assist with boundary-cooling while the Coast Guard and personnel from the Port of Jacksonville worked on security and oil spill containment. The fire continued to burn for 8 days, destroying the interior of cargo decks 7 through 11 and deck 12, including the accommodations.

Figure 6. Firefighters conducting exterior boundary-cooling on June 5, 2021, the day after the fire was discovered. (Source: JFRD)

[8] (a) Boundary-cooling involves using water deluge to keep bulkheads and decks cool to prevent the spread of fire through conduction and to prevent structural collapse, all while taking care to not flood the ship with firefighting water, which would risk sinking or capsizing the vessel. (b) A vessel that is not a tanker but carries oil as fuel is required by Title 33 *Code of Federal Regulations* (*CFR*) 155.5050 to have a *non-tank vessel response plan*, which is used to prepare the vessel's crew and management to respond to an oil spill (primarily) or any other casualty or emergency. The plan typically includes a checklist with all notifications, including contact numbers, in order of priority to be made by shipboard or shore-based personnel and the information required for those notifications.

1.2 Injuries

Nine shoreside firefighters sustained burns while responding to the fire. None of the ship's crew sustained injuries while fighting the fire.

Table 1. Injuries sustained in the *Höegh Xiamen* accident.[9]

Type of Injury	Crew	JFRD firefighters	Total
Fatal	0	0	0
Serious	0	5	5
Minor	0	4	4
None	21	N/A	21

1.3 Damage

The *Höegh Xiamen* and its cargo of 2,420 used vehicles were declared a total loss valued at $40 million (see figure 7). Salvage operations began on July 9, 2020. On August 30, after salvage operations were completed, the anchor-handling tug, *Alp Striker*, towed the ship from Jacksonville to Aliaga, Turkey, where the *Höegh Xiamen* was recycled.

Figure 7. Thermally damaged vehicles after removal from the *Höegh Xiamen*, Blount Island, Jacksonville, Florida, July 23, 2020.

[9] The NTSB uses the International Civil Aviation Organization injury criteria in all of its accident reports, regardless of transportation mode. A serious injury is a non-fatal injury that requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; results in a fracture of any bone; causes severe hemorrhages, nerve, muscle, or tendon damage; involves any internal organ; or involves second- or third- degree burns, or any burn affecting more than 5 percent of the body surface.

1.4 Vessel Information

1.4.1 General

The *Höegh Xiamen* was built at Xiamen Shipbuilding Industry Co. Ltd, in Xiamen, Fujian, People's Republic of China, in 2010. The *Höegh Xiamen* was designed for unrestricted oceangoing worldwide service and could carry 4,900 vehicles. The vessel was owned by OCY Xiamen Ltd. and operated by Höegh Technical Management Inc. (Höegh). The *Höegh Xiamen* was registered as a Norwegian-flagged ship with Oslo, Norway, as its port of registry. The vessel was classed by DNV GL, a classification society that established and maintained standards for the construction and operation of ships and offshore structures.[10] Table 2 provides vessel particulars for the *Höegh Xiamen*.

Table 2. Vessel particulars

Vessel	***Höegh Xiamen***
Type	Cargo (Ro/Ro Vehicle Carrier)
Flag	Norway
Port of registry	Oslo, Norway
Year built	2010
Official number (US)	N/A
IMO number	9431848
Classification society	DNV GL
Length	599.7 ft (182.8 m)
Beam	81 ft (31.5 m)
Draft	26 ft (8 m)
Tonnage	47,232 GT ITC[11]
Engine power; manufacturer	1 x 19,069 hp (14,220 kW); MAN-B&W 9S50MC-C, 2-stroke, 9-cylinder diesel engine

[10] In 2013, two classification societies, Det Norske Veritas (Norway) and Germanischer Lloyd (Germany) merged into one company, named DNV GL. In 2021, DNV GL was renamed DNV.

[11] *GT ITC*, or *gross tonnage-international tonnage convention*, is the international standard for the measurement of the volume of all enclosed spaces on a vessel, as defined in the *International Convention on Tonnage Measurement of Ships, 1969*.

At the time of the accident, the vessel was on a time charter to Grimaldi Deep Sea (Grimaldi), one of six shipping companies that made up the Grimaldi Group, to transport used vehicles to West Africa.[12] Grimaldi operated (and time chartered) a fleet of over 120 vessels and employed about 15,000 people. The company specialized in the operation of Ro/Ro vessels, car carriers, and ferries on Atlantic routes and between the Mediterranean and West Africa. The *Höegh Xiamen* was scheduled to carry used vehicles from three ports in the United States–Freeport, Texas; Jacksonville, Florida; and Baltimore, Maryland–to West African ports of discharge. During Grimaldi's time charter of the *Höegh Xiamen*, the vessel's crew were employed by Höegh and followed Höegh's safety management system.

1.4.2 Construction

The vessel's decks were numbered from the tank top (deck 1) upwards to the weather deck (deck 12). A side ramp on the vessel's starboard side and a stern ramp angled aft on the starboard quarter of the vessel gave access to the main deck (deck 5) from the shore. Thereafter, a series of fixed and moveable ramps led to the ship's cargo holds arranged on 11 decks.

Of the vessel's 11 decks used for cargo stowage, decks 3, 5, and 7 were stronger and intended to carry high and heavy rolling units, as well as static cargo, while the rest of the decks were intended to carry cars and other light-wheeled cargo. The cargo decks were open along the entire length of the vessel (bow to stern) but were divided vertically by retractable ramps between decks into five horizontal gastight fire zones: decks 1–4 comprised zone 1; decks 5 and 6 comprised zone 2; decks 7 and 8 comprised zone 3; deck 9 comprised zone 4; and decks 10 and 11 comprised zone 5 (see figure 8).

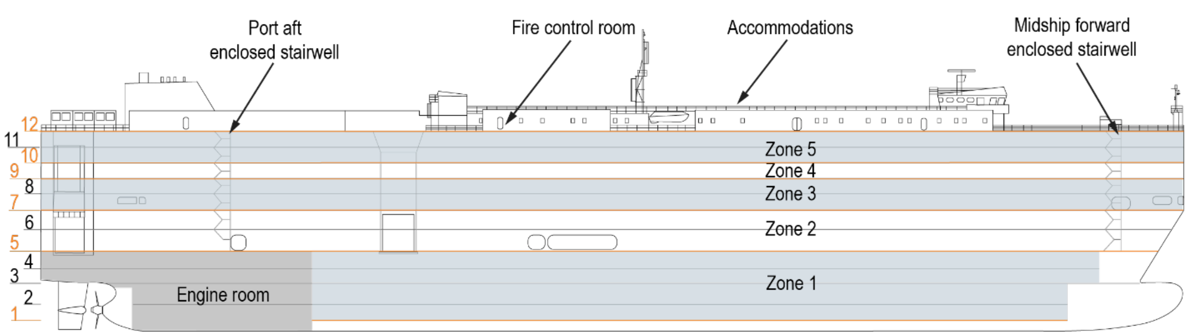

Figure 8. *Höegh Xiamen* fire zones. The vessel's gastight decks, which separate fire zones, are highlighted orange. (Background source: Höegh)

[12] A *time charter* is a contract for the rendering of transportation services during a specified period of time. During the time charter, the owner of the vessel retains control of the vessel and is paid by the charterer, who takes on the rest of the expenses incurred to manage the vessel.

The steel bulkheads and decks encompassing the fire zones were not insulated to retard heat transfer (C class division) nor were they required to be.[13] However, as required by regulation, the vessel's stairwells, accommodation deck, portions of the engine room, and some divisions between cargo decks and working spaces were insulated (A class division).

1.4.3 Cargo Decks Ventilation System

1.4.3.1 Arrangement

Fresh air was drawn into and expelled from the cargo holds through a system of closable dampers, fans, and large ventilation shafts, known as trunks (see figure 9). The vessel's cargo deck supply and exhaust ventilation trunks were located along both sides of the vessel and ran from each cargo deck to deck 12. The supply and exhaust trunks provided fresh air through vent grilles to ventilate the cargo decks during vehicle loading. The trunks were independent of each other. However, since decks within the same fire zone were not gastight from each other, for fire zones that encompassed two decks (such as decks 7 and 8), the ventilation was mixed in the cargo area, and, therefore, the independent trunk served both decks (figure 10 shows a portion of the portside aft ventilation trunks). The exhaust and supply fans for these ventilation trunks were also located on deck 12 along the periphery of the ship from bow to stern in ventilation housings.

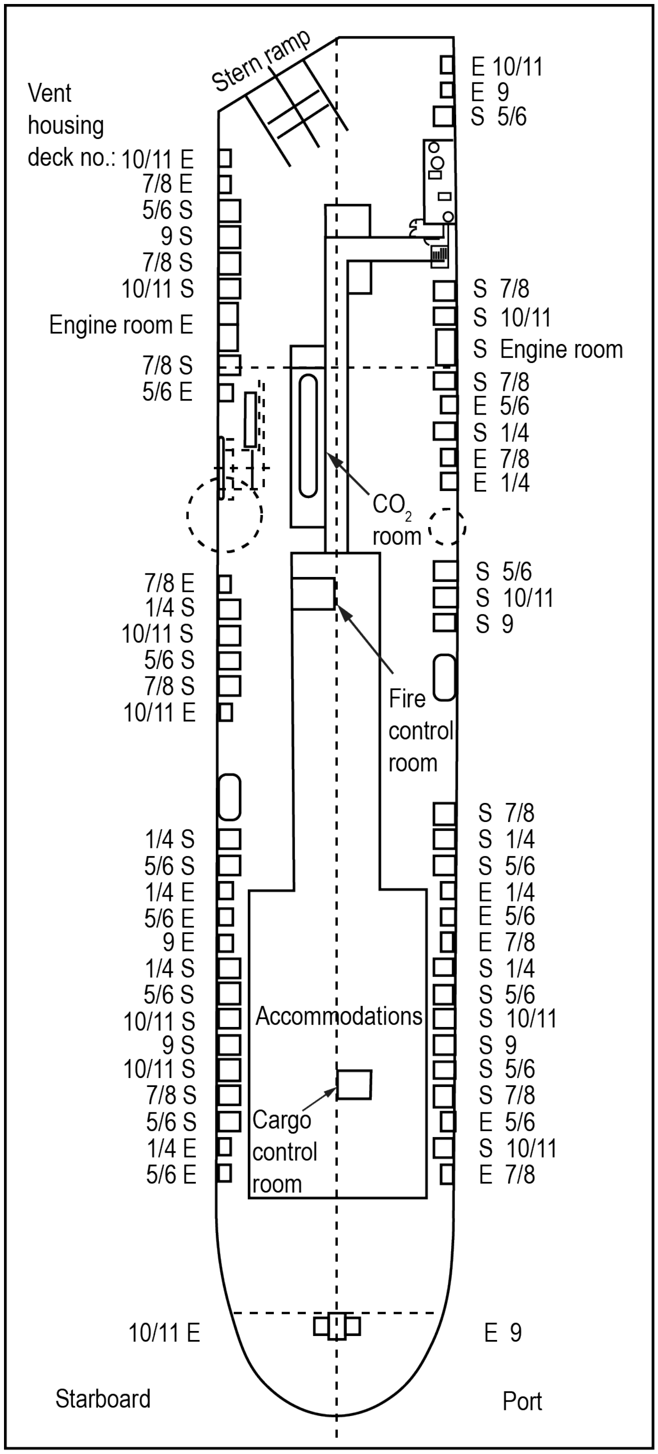

Figure 9. Diagram of deck 12 showing ventilation housings. Each exhaust is marked with an "E," and each supply is marked with an "S."

According to the vessel's Fire Control and Safety Plan, the ventilation fans could be controlled from the bridge or the fire control room.

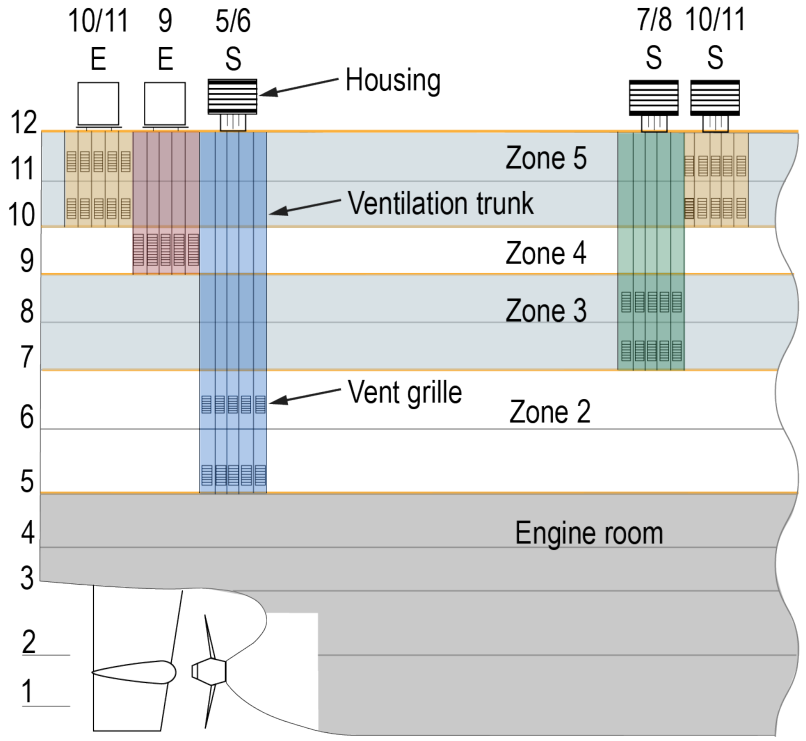

Figure 10. Arrangement of portside aft cargo ventilation trunks on deck 12. Each exhaust is marked with an "E," and each supply is marked with an "S." This only represents a portion of the exhaust and supply ventilation trunks.

Each supply and exhaust trunk was fitted with a fire damper that could be closed (in conjunction with stopping the supply fans) to cut off the air to a fire zone in case of fire. The dampers were gravity sealed. The Fire Control and Safety Plan listed 58 manual dampers for cargo spaces. The plan did not list remotely controlled dampers, but crewmembers reported that modifications had been made to the ship since the plan's creation in 2010, and some remotely controlled dampers were replaced with manually operated dampers. The plan was not updated with the manually operated dampers. The remotely controlled dampers could be secured from the cargo office, while the manually operated dampers required a crewmember

[13] According to the International Maritime Organization, a vessel's structural fire protection is classified into three types of divisions: "A" Class divisions are formed by bulkheads and decks constructed of steel (or other equivalent material), suitably stiffened, and designed to withstand and prevent the passage of smoke and flame for the duration of a one-hour standard fire test; "B" Class divisions are formed by bulkheads, decks, ceilings, or linings designed to withstand and prevent the passage of flame for at least the first half-hour or a standard fire test; and "C" Class divisions are constructed of approved non-combustible materials.

to close the damper locally. The dampers for the aft ventilation trunks were all manually operated.

1.4.3.2 Damage

After the accident, the JFRD and the Coast Guard examined the vessel's ventilation housings during walkarounds of deck 12. (Figure 11 shows the damaged aft housings.) The condition of the housings fell into three categories: 43 had no signs of external sooting or mechanical damage; 8 exhibited external sooting but no mechanical damage; and 7 exhibited both external sooting and mechanical damage.

Figure 11. Damaged aft ventilation housings after the reported explosion of portside vent housing for deck 9 (9E in the photo). (Background source: JFRD)

The ventilation housings associated with decks 7/8, 9, and 10/11 exhibited sooting, and the housings associated with decks 9 and 10/11 exhibited mechanical damage. The ventilation housings for deck 10/11 exhibited greater levels of mechanical damage than those of deck 9.

1.4.4 Fire Detection and Firefighting Equipment

The *Höegh Xiamen* was equipped with a fire detection system that included 525 smoke detectors. Of these detectors, 248 were on cargo decks 7 through 11. Fifty were located on deck 7; 48 on deck 8; 51 on deck 9; 48 on deck 10; and 51 on deck 11. The fire detection system also included 14 heat detectors and 7 flame detectors, all installed in the accommodations and machinery spaces. A main fire panel, which displayed the status of the fire detection system, was located on the bridge, and repeater panels showed the same information in the cargo control room, engine control room, and fire control room. Alarms would sound in at least three locations: the bridge, engine control room, and fire control room.

The fire detection system was enabled using a key. The system allowed for individual detectors, loops, or outputs to be isolated or de-isolated so that the crew could investigate alarms before a general alarm was initiated.

In the event of a fire, the *Höegh Xiamen* was equipped with 162 fire hoses (located throughout the vessel). The vessel also had a Coast Guard-approved non-tank vessel response plan, which listed emergency contact information for all ports the vessel frequented.

The vessel was equipped with a low-pressure, fixed fire-extinguishing CO_2 system. Each of the vessel's five fire zones could be individually selected for fire suppression by directing CO_2 from the vessel's CO_2 storage tank (in the CO_2 room) through valves and piping to flood the zone. The system could also be used to extinguish fires in the engine room.

The vessel's safety management system (created by Höegh) instructed the crew to "go to the CO_2 room or fire control station" to release the system and listed the procedure to do so. The crew had trained to use the CO_2 system, and according to the chief engineer, the system was operational with no maintenance issues.

1.4.5 Port State Control

The *Höegh Xiamen* underwent at least annual Coast Guard port state control exams in the United States; these exams typically consisted of checking the vessel's documents and certificates, surveying the condition of the vessel, and witnessing drills performed by the vessel's crew. The ship's last US port state control exam was in August 2019 in Jacksonville, Florida, with no deficiencies issued. There were no outstanding flag state deficiencies or International Safety Management (ISM) nonconformities. There was one condition of class for minor hull damage to be repaired during the vessel's next drydocking. Port state control officers confirmed that they checked cargo stowage and were aware there were fuel tank restrictions but stated they had no way to check levels without turning the vehicles on, given the close stowage plan.

On June 3 and 4, 2020, while the vessel was in Jacksonville, a DNV GL auditor conduct a scheduled external ISM audit—an assessment of the vessel's safety management system to ensure it complied with the requirements of the ISM Code.

The *Höegh Xiamen* had no prior outstanding nonconformities, and the audit found no new ones. The auditor found no overdue maintenance.

The DNV GL auditor witnessed a fire drill as part of the ISM audit on June 3. The scenario for the drill was a fire in the galley. The auditor told investigators that he was satisfied with the crew's teamwork, equipment, and competence, including hose-handling, securing electricity and ventilation, communications, and use of personal protective equipment. The use of the CO_2 fixed fire-extinguishing system was not part of the drill.

The audit report also mentioned another port state control exam in 2020 in Benin, West Africa, also with no nonconformities. The audit report concluded, "A good safety culture appears evident on board and crew conveyed that the company provides good support."

1.5 Cargo Operations

1.5.1 Receiving and Inspecting Vehicles

At the Port of Jacksonville, used vehicles that would be loaded onto a vessel were staged at the Horizon Terminal before a vessel's arrival. Customs and Border Protection regulations required that the vehicles (and their required documentation) be retained at the Horizon Terminal for at least 72 hours before they could be loaded on a ship. The vehicles were divided into three categories: running vehicles, which were operable and could be driven onto the vessel; towed vehicles, which had to be towed or pushed onto the vessel; and forklift vehicles, which had to be lifted via forklift onto the vessel.

All vehicles were required to be rejected if they produced engine smoke, leaked fluids, or were in unsanitary condition, with blood, other human fluid, mold, or any other biohazard inside. Running vehicles were further required to be rejected if, among other conditions, the vehicle—

- sustained damage to the radiator, engine, or fuel tank or was incapable of being started.
- had no key.
- had less than one-eighth of a tank of fuel.
- had no brakes or poorly functioning brakes.

Additionally, running vehicles were required to be rejected if a vehicle's hood could not be opened to access the battery or if a vehicle was otherwise determined to be unsafe.

Nonrunning and towed vehicles could not be accepted unless approved by Grimaldi. Grimaldi accepted vehicles as towed vehicles if they had hoods capable of being opened, working brakes and steering, and a key. Additionally, these vehicles were required to be capable of being pushed or towed in neutral gear. Towed vehicles would be rejected if—

- there was front or rear damage greater than cosmetic damage.
- there were broken or bent axles or broken, cracked, or shattered glass.
- there were deployed airbags inside the vehicle.
- the driver door could not be opened.

Grimaldi accepted vehicles as "forklift" units—that is, vehicles that could not be driven or towed on board—if they had "questionable" or no brakes or faulty steering, or if they had sustained damage such as bent tires and axles, a driver door that could not be opened, or deployed airbags still inside. However, forklift units were required to be rejected if the hood could not be opened to access the battery.

Further, Grimaldi required that any vehicle—whether running, towed, or forklift—be rejected if it contained personal effects other than items that belonged with the vehicle. Grimaldi would also reject a vehicle if the condition of the vehicle did not match the tier condition for which it was booked.

In the weeks leading up to the accident, Grimaldi received several shipments of vehicles at the Horizon Terminal to prepare for loading onto the *Höegh Xiamen*. Because Grimaldi did not have dedicated inspection employees at the Horizon Terminal, the company relied on Horizon's staff of ten employees to conduct thorough inspections of vehicles before staging them for loading.[14] The Horizon employees were required to adhere to Grimaldi's cargo-receiving policies; Horizon trained their employees in these policies at laborer biweekly meetings during which they reviewed and discussed the policies. The Horizon general manager had provided additional employee training on Grimaldi's receiving policies at least once within the past year during a biweekly meeting that he led. Horizon personnel did not assume responsibility for ensuring compliance with any applicable vehicle cargo regulations.

As vehicles arrived at the Horizon Terminal by truck, it was the responsibility of the Horizon employees to ensure that the engine compartments could be accessed for securing the battery and that vehicles were not leaking fluids before staging them

[14] Horizon Terminal Services also provided services at the time of the accident for Höegh Autoliners, Sallaum, Hyundai Glovis, and NYK; each company had its own receiving guidelines for Horizon personnel to follow.

for loading onto the ship. In the days leading up to the accident, no vehicles were rejected.

Horizon employees also ensured that the vehicle fuel tanks were at least one-eighth full for running vehicles in accordance with Grimaldi policy (there was no requirement for maximum fuel level). There were no fuel tank requirements for towed or forklift vehicles.

Horizon employees completed the vehicle inspections when checking them in and categorizing them for staging. Employees noted their inspection results on the dock receipts, including the degree of any damage and other items such as whether the vehicle had a radio or keys. Their examination of vehicles for leaking fluids consisted of verifying whether leaks were visible from the exterior of the vehicle.

The Horizon general manager and operations and logistics manager communicated daily with the Grimaldi port captain about cargo logistics and policies. In the days leading up to the accident, the Horizon operations and logistic manager did not express any vehicle safety concerns to the Grimaldi port captain during the cargo-receiving process.

1.5.2 Loading and Stowing Vehicles

Between June 3 and 4, 2020, the vessel was scheduled to load 1,629 used vehicles in Jacksonville, Florida. (The vessel had previously loaded 845 used vehicles onto decks 1, 2, 3, 5, 6, and 9 in Freeport, Texas.)

Grimaldi contracted with SSA Atlantic (SSA) to provide stevedores to load the cargo aboard the ship. In turn, SSA contracted with the International Longshoreman's Association (ILA) to provide longshoremen to load and secure the vehicles.[15] The loading was supervised by SSA stevedores, the ship's crew, and a Grimaldi port captain.

Before loading began, the Grimaldi port captain provided the port's SSA stevedores with directions on how each deck was to be loaded in accordance with the desired loading plan and sequence, as well as instructions for how to lash the cargo. According to the load plan for Jacksonville, 1,044 running vehicles, 322 towed vehicles, and 209 forklift vehicles would be loaded. Except for 16 trucks, 3 track vehicles, and 2 boats on trailers, the cargo consisted entirely of used automobiles, sport utility vehicles, vans, and pickup trucks. SSA stevedores described all the vehicles as non-commercial used personal vehicles in poor condition with varying

[15] *Stevedores* are hired to supervise loading operations, while *longshoremen* are hired labor to handle the cargo.

degrees of damage. The vehicles were loaded onto all cargo decks except deck 4. The port captain had ultimate discretion as to whether to accept any vehicle for loading.

On June 3, loading began about 0800. In accordance with the requirements of Höegh's "Cargo Safety Awareness" procedure, the crew deactivated the fire detection system for the cargo decks, since exhaust from the vehicles would trigger the smoke detectors and continuously initiate alarms (see section 1.4.4 Fire Detection and Firefighting Equipment). To improve the probability of detecting a fire during cargo loading, two crewmembers (an able seafarer and a second mate) were assigned to the cargo decks to monitor loading. Crewmember responsibilities also included security, running ventilation, operating internal ramps, watching for damage to the ship from loading cargo, tending mooring lines, loading stores (if any), and ballasting. The ventilation dampers, previously secured for sea, were opened and the fans for the cargo decks turned on before cargo loading began.

The "Cargo Safety Awareness" procedure further required that a placard be placed on the bridge fire detection panel to indicate decks with deactivated smoke detectors and instructed crew to "be aware of typical sources of fire incidents—fuel leaks and loose electrical connections" (the NTSB was unable to determine whether the crew placed a placard as the procedure instructed). The procedure also instructed crew to immediately remove any spillage of oil or fuel from vehicles, and, if necessary, suspend cargo operations until safe to resume.

The Höegh *Cargo Securing Manual* gave further guidance for the handling, stowage, and securing of dangerous goods, and the chief mate stated that he provided training to crewmembers in accordance with the manual, including cargo lashing requirements and instructions on cleaning the deck of oil spills from used vehicles.[16] Additionally, Höegh's procedures referred the crew to the charterer's (in this case Grimaldi's) handling procedures for special cargo.

Throughout the day, towed and running vehicles were loaded aft on deck 8, while running vehicles were loaded on deck 11. The SSA lead stevedore was positioned at the vessel's aft ramp, along with two checkers who were responsible for confirming vehicle identification numbers and keeping track of the loaded cargo. The rest of the SSA crew, supplemented by ILA longshoremen, were responsible for ensuring that the vehicles were stowed in accordance with the load plan, as well as

[16] Höegh's *Cargo Securing Manual* defined "dangerous goods" as substances, materials, and articles covered by the International Maritime Dangerous Goods Code. In the United States, 49 *CFR* Parts 172.101 and 173 refer to such goods as "hazardous materials" and defines them as substances or materials determined by the Secretary of Transportation to be capable of posing unreasonable risk to health, safety, and property when transported.

regulating traffic flow on the side and aft deck ramps. After parking each vehicle, stevedores were responsible for lashing the vehicles, while the vessel crew verified their securement.

The chief mate and any of the monitoring crewmembers had the authority to reject the loading of any vehicles that leaked fluids or produced too much smoke. If the vehicle continued leaking fluids after crewmembers removed spillage with rags and absorbents, the SSA lead stevedore was required by Höegh's "Cargo Safety Awareness" procedure to inform the port captain, who typically required the vehicle to be removed from the vessel and placed on the cut list of vehicles not making the voyage (during loading, no vehicles were cut due to leaking fluids).

Once cargo operations were completed for the day, Höegh's "Cargo Safety Awareness" procedure required the fire detection system to be reactivated (according to the captain, the system would become active automatically 10 hours after being deactivated).

On June 4, the second day of loading, operations began at 0800 with crews working on multiple decks. The vessel crew deactivated the cargo deck fire detection system as was done the previous day. Forklift cargo was loaded onto decks 3 and 5. Towed vehicles were loaded on deck 7 and forward on deck 8. Stevedores reported that most of the non-running vehicles loaded onto deck 8 "would be considered junk cars." Running vehicles were loaded on decks 7 and 10.

The port captain said that throughout the loading process, he conducted periodic walk-throughs of the decks to ensure the stevedores and longshoremen were following the loading plan and that stowage and lashing followed company policy. He stated that his spot checks included checking for batteries, but he did not look inside of the vehicles for personal effects. According to the port captain, cargo loading was "smooth."

On June 4, about 1445, the final cargo was loaded on deck 7. Over the course of 2 days, 1,575 used vehicles had been loaded onto the *Höegh Xiamen*, bringing the total number of vehicles on board to 2,420.

Before departing the vessel on June 4, the port captain performed a final check of deck 9 and below. He stated that he did not check above deck 9 because the crew had already closed the upper deck ramps. He checked some of the vehicle lashings on deck 8 about 1448 and estimated that, between decks 7 and 8, there was space available for 60 more vehicles. The port captain did not walk through every lane but instead walked fore to aft where he could see down the lanes.

About the same time as the port captain's inspection, the chief mate told the master that cargo-loading operations were complete and that the vessel would be ready for a 1700 departure, en route to Baltimore. The chief mate directed the boatswain to close the remaining internal ramps and watertight doors. He then told the second mate to verify the ship's draft and complete a security round of decks 5–11, checking for lashings. Meanwhile, the chief mate checked the condition of decks 1–4. No abnormal conditions were noted. By 1500, the port captain and all SSA, Horizon, and ILA personnel had left the ship. The fire detection system remained deactivated (Höegh's procedures did not specify when the system should be reactivated).

1.5.3 Vehicle Battery Securement

Grimaldi's battery disconnect procedure required personnel to disconnect the negative battery cable for all used vehicles ("factory new" vehicles were not required to have the battery disconnected) before the vessel's departure from port. The procedure further stated that stevedores would be responsible for disconnecting the battery terminals for all running and towed vehicles, while Horizon personnel were responsible for opening vehicle hoods and accessing vehicle engine compartments so that batteries could be disconnected. The procedure stated this policy was "not negotiable."

The Grimaldi procedure also requested that SSA order any additional labor needed to secure batteries in order to maintain the normal loading pace, as well as provide the necessary parts and materials required to perform this task.

Grimaldi instructed SSA to create a "battery brigade" of ILA longshoremen who would be solely responsible for following behind vehicles as they were loaded and parked in order to disconnect the batteries. The brigade was required to disconnect the negative cable from the battery, tuck the cable away from the battery terminal, and cover the battery post with the battery cap (see figure 12). Once the cable was disconnected and the hood was shut, the brigade would mark the unit with grease marker to identify the vehicle as having a disconnected battery. Before loading, on May 22, 2020, the Grimaldi port captain emailed the company's written procedure to SSA and instructed, "Please note that I can't stress enough the importance of battery disconnect. Please ensure to have battery caps and adequate mechanics ordered to keep up with production."

Figure 12. Excerpt from Grimaldi battery disconnect procedure showing a vehicle battery secured with a blue plastic negative terminal cap and disconnected cable (*circled*) tucked inside. (Source: Grimaldi)

The SSA lead stevedore stated that the SSA mechanical department instructed its battery brigade on the requirements of the battery disconnect procedures provided by the Grimaldi port captain. The lead stevedore stated that he knew that all batteries were supposed to be disconnected but there may have been circumstances in which batteries were inaccessible, adding that he believed there were a few that were. The stevedore responsible for decks 7 and 8 told investigators the only reason some batteries could not be disconnected was when a vehicle had sustained too much crash damage to access the engine compartment and thus not all vehicle batteries on deck 8 had been disconnected. He stated that, "per a protocol that was given to us by Grimaldi when we started," stevedores flagged the vehicles that did not have batteries disconnected by raising the vehicles' windshield wipers and wrapping them in caution tape. After the accident, the Grimaldi port captain stated that he was unaware of this practice, and the NTSB found no evidence of written protocols that addressed the flagging of vehicles in this manner.

After loading was completed, SSA gave the chief mate a completed "Vehicle Lashing Inspection Procedure" form (see figure 13). The document stated, "all second hand [*sic*] vehicles must have the battery terminals disconnected once in final stow." The document included a column titled "Battery Disconnect Incomplete," which listed a total of 58 vehicles, 13 of which were stowed on deck 8. The form did not document the location of these vehicles. The stevedore responsible for decks 7 and 8 stated that he did not recall seeing any flagged vehicles on the aft end of deck 8.

HÖEGH AUTOLINERS

SSA Atlantic

Vessel Lashing Inspection Procedure

All Stevedores will work with chief mate or mate on deck to confirm lashing is as per Hoegh Autoliners Standard Operation Procedures.

VESSEL HOEGH XIAMEN VOY. 0420 DATE

Vessel Name	HOEGH XIAMEN	Port Name	BLOUNT ISLAND
Voyage	0420	Company Name	SSA
Date of Operation	6/24/20	PIC	
Operation Hours		Number of Operators	(shift/gang)

All second hand vehicles must have the battery terminals disconnected once in final stow

Deck Completed	Total Units on Deck	Battery Disconnect Complete	Battery Disconnect Incomplete	Remarks
6	126		6	
11	422		30	
10	296		1	
7	138		8	
8	358		13	
VESSEL TOTAL				

Signature

Signed by Stevedore
(Operator)

Signed by Chief Officer
(Master of Vessel or Chief Officer)

Figure 13. Completed "Vehicle Lashing Inspection Procedure." The document states "all second hand [*sic*] vehicles must have the battery terminals disconnected once in final stow" (*red oval*) and lists the number of batteries on each cargo deck for which the disconnection was "incomplete" (*red rectangle*) for the accident loading.

While disconnecting and securing batteries in accordance with Grimaldi procedure was the responsibility of the stevedores, the Grimaldi port captain stated that he conducted spot checks throughout the loading operation to ensure the procedure was being followed. In all, the port captain estimated that he spot-checked battery securement for a couple hundred vehicles. He stated that the majority of the vehicles he checked had batteries disconnected; however, he did find one row of vehicles on deck 11 that the battery brigade had missed. The port captain advised the stevedore on that deck, and those batteries were subsequently disconnected. The port captain conducted spot checks for battery disconnection for the vehicles on decks 7 and 8 and noted no exceptions. He said that he did not encounter any vehicles for which the hood could not be opened.

After forklift vehicles that were scheduled to be loaded onto the *Höegh Xiamen* were checked in at the port and the 72-hour retention period had passed, Horizon employees ensured each forklift vehicle hood was opened to access the battery. The Horizon general manager could not confirm that Horizon employees opened every vehicle hood as directed. He also understood that if an engine compartment could not be accessed, the vehicle was supposed to be rejected and placed on the cut list.

1.5.4 Postaccident Examination of Batteries

Between July 9 and 27, 2020, Coast Guard investigators examined a sample of 50 forklift vehicles (from deck 5), 40 towed vehicles (from deck 7), and 25 running vehicles (from unknown decks) that salvage crews had removed from the *Höegh Xiamen*. Of those, 39 forklift vehicles and 20 towed vehicles had been loaded in Jacksonville (the origin of the 25 running vehicles was not determined). Investigators examined battery securement conditions and fuel tank levels and searched for the presence of any leaking fluids or extraneous personal items within vehicles. Because salvage crews had to reconnect vehicle batteries of the running vehicles to start them and drive them from the ship, investigators were not able to determine the securement condition of disconnected batteries for running vehicles.

1.5.4.1 Forklift Vehicles (deck 5)

The sample of 39 forklift vehicles loaded in Jacksonville included 12 vehicles that did not have batteries and 3 vehicles with battery cables that had not been disconnected from the battery terminal posts. Of the 24 remaining vehicles, 22 had exposed battery terminal posts; none of these were protected with plastic caps. Instead, the battery cable lugs were partially wrapped with electrical tape, leaving exposed metal on the lug (see figure 14). Investigators also found 14 instances of disconnected and exposed battery cable lugs resting above or on top of the vehicle battery and touching or nearly touching the exposed battery terminal posts. All of the forklift vehicles examined (except those without batteries) were found to have batteries not secured in accordance with Grimaldi's procedures.

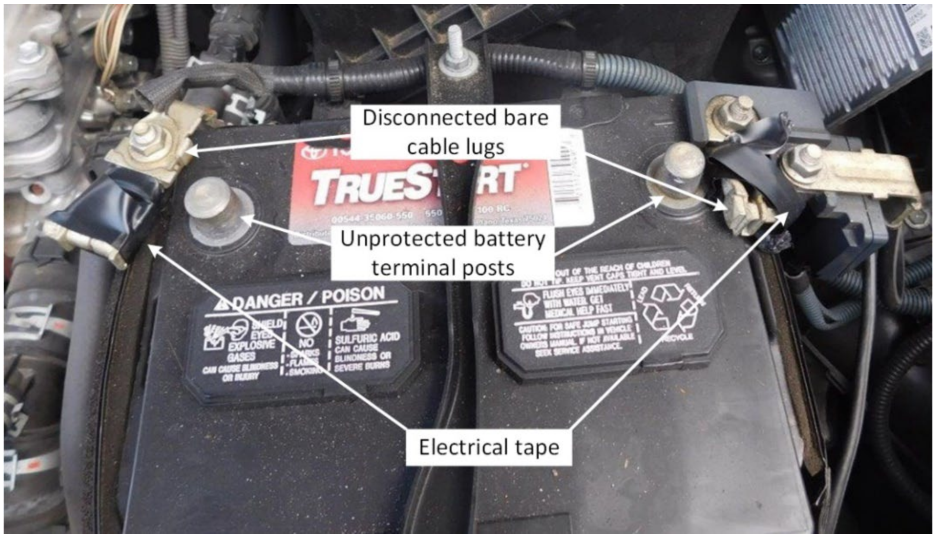

Figure 14. Battery in forklift vehicle removed from deck 5. The disconnected battery cable lugs were located near terminal posts, and the battery terminal posts were unprotected. (Source: Coast Guard)

Investigators found two forklift vehicles that contained household goods. In addition, one of these vehicles contained 28 rounds of loose small arms ammunition in the trunk. One vehicle battery was leaking electrolyte, and a second vehicle was leaking unknown fluid from the passenger front corner. Table 3 summarizes the findings from the forklift vehicle examination.

Table 3. Forklift vehicle examination summary

Description of vehicles	Number of vehicles from Jacksonville
Number of forklift vehicles inspected	39
Vehicle engine compartment could not be accessed	1
Battery was not in the vehicle	12
Both battery cables were connected to the battery	3
Exposed battery terminal posts were not protected with plastic cap	22
Disconnected bare battery cable lugs resting on or near terminal posts	14
Leaking fluids	1
Personal items contained in the vehicle	2

1.5.4.2 Towed Vehicles (deck 7)

The sample of 20 towed vehicles loaded in Jacksonville included one vehicle that did not have any battery in the engine compartment and two vehicles with battery cables that had not been disconnected from the negative battery terminal posts. Sixteen of the remaining 17 vehicles were found with visibly exposed battery terminal posts that were not protected with plastic caps. Investigators also found 13 instances of disconnected and exposed battery cable lugs resting above or on top of the vehicle battery and touching or nearly touching the exposed battery terminal posts (see figure 15). All the towed vehicles examined (except the one without a battery) were found to have batteries not secured in accordance with Grimaldi's procedures. Table 4 summarizes the towed vehicle examination.

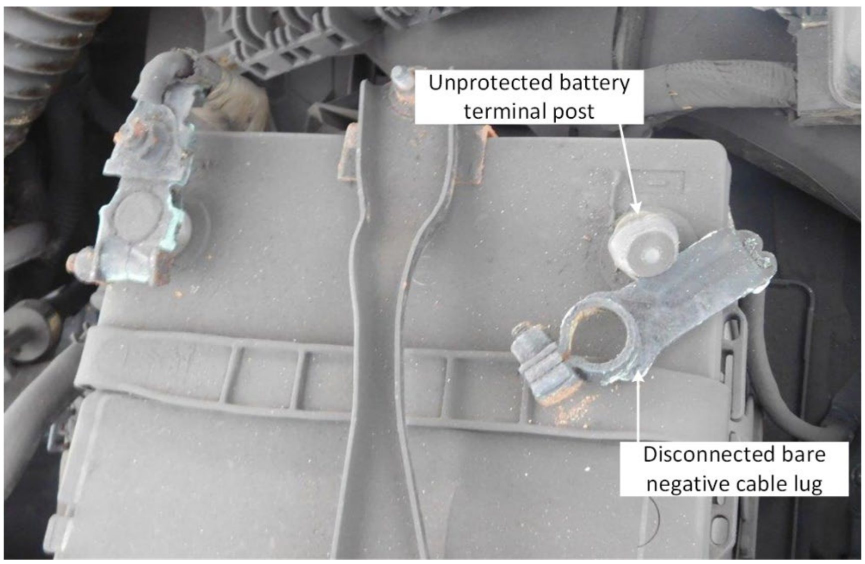

Figure 15. Battery in towed vehicle removed from deck 7. The disconnected bare cable lug was in physical contact with unprotected battery terminal post. (Source: Coast Guard)

Investigators determined fuel tank levels for four towed vehicles. The fuel gauge for two vehicles registered empty. The fuel gauge for one vehicle registered one-quarter of a tank, and the final vehicle contained one-eighth of a tank.

Table 4. Towed vehicle examination summary

Description of vehicles	Number of vehicles from Jacksonville
Number of towed vehicles inspected	20
Vehicle engine compartment could not be accessed	0

Description of vehicles	Number of vehicles from Jacksonville
Battery was not in the vehicle	1
Both battery cables were connected to the battery	2
Exposed battery terminal posts were not protected with plastic cap	16
Disconnected bare battery cable lugs resting on or near terminal posts	13
Leaking fluids	0
Personal items contained in the vehicle	0

1.6 Crew Information

The *Höegh Xiamen* had a crew of 21 who all carried valid national Standards of Training, Certification, and Watchkeeping certificates of competency from the People's Republic of China, and flag-state endorsements from Norway.

The master had 26 years of experience in the maritime industry, 13 of which were as a master, and he had been aboard the *Höegh Xiamen* for 7 months. The chief mate had 12 years of experience in the industry, including 10 months as chief mate, and had been on board the *Höegh Xiamen* for 8 months.

After the accident, all crewmembers underwent required toxicological testing. All drug and alcohol test results for the crew were negative.[17]

1.7 Environmental Conditions

At the time of the accident, it was raining, and there was a southeast 9-knot breeze, gusting to 14 knots. The recorded air temperature was 77°F and sea temperature 79°F.

[17] Urine drug testing is limited to identifying urinary metabolites of cocaine, codeine, morphine, heroin, phencyclidine (PCP), amphetamine, methamphetamine, methylenedioxymethamphetamine (MDMA), methylenedioxyamphetamine (MDA), methylenedioxyethylamphetamine (MDEA), tetrahydrocannabinol (THC), oxycodone, oxymorphone, hydrocodone, and hydromorphone.

1.8 Electronic Data

1.8.1 Voyage Data Recorder

The *Höegh Xiamen* was fitted with a voyage data recorder (VDR), manufactured by Japan Radio Co., Ltd. After the fire was extinguished, the VDR was retrieved from the vessel, and its data was downloaded. The bridge audio captured on the VDR included conversations between crewmembers, VHF radio traffic, and the sound of alarms.

Fire alarm data was recorded by the VDR beginning at 1545:52 after the fire detection system was reset. Ten seconds later, at 1546:02, the first individual smoke detector alarmed for deck 9 starboard aft. Detectors continued to alarm over the next 30 minutes, including a midship-starboard detector on deck 8 (at 1548) and a starboard aft detector on deck 7 (at 1551). Additional detectors alarmed on deck 10 (at 1552), on deck 11 (at 1553), and in the accommodation spaces (at 1612).

1.8.2 Port Camera Footage

The arrival of the JFRD and their initial efforts to fight the fire was recorded by the port's closed-circuit television cameras (CCTV) in two locations: one at the head of the pier facing the vessel's stern ramp, and one farther away on shore, also pointing toward the vessel's starboard aft quarter. Investigators reviewed video from about 30 minutes before (about 1533) through about 25 minutes after (about 1628) Engine 48's arrival at 1603. Footage from one of the cameras did not contain a date and timestamp but captured the arrival of Engine 48. This arrival event on the video was used as a reference point to create a timeline for other events observed.

The video showed that when Engine 48 arrived, there was smoke flowing from the two aftmost exhaust vents on the port side (corresponding to decks 9 and 10/11) and the two aftmost exhaust vents on the starboard side (corresponding to decks 10/11 and 7/8) (see figure 16). At the time of Engine 48's arrival, the white paint on the starboard side of the *Höegh Xiamen* did not appear to have any thermal discoloration.

Figure 16. Engine 48 arriving on scene about 1603. Starboard vents 10/11E and 7/8E and port vents 10/11E and 9E exhibit smoke flow. (Source: Jacksonville Port Authority)

About 5 minutes after the fire department first arrived on scene, the video showed firefighters and one crewmember at the edge of the vessel's stern ramp. Smoke continued to rise from the vents on the ship's stern, with a much darker, thicker plume emitting from the port side. The video showed that, at this time, the white paint on the vessel's starboard side was beginning to exhibit thermal discoloration in areas corresponding to the fire zones associated with decks 7/8 and 10/11 (see figure 17). About 5 minutes later, the discoloration became more pronounced, and the discoloration continued to darken over the next 15 minutes.

Figure 17. About 1608, 5 minutes after Engine 48's arrival, the white paint on the starboard side of the vessel exhibits thermal discoloration (circled in orange). Starboard vents 10/11E and 7/8E and port vents 10/11E and 9E exhibit smoke flow. (Source: Jacksonville Port Authority)

1.9 Hazardous Materials Regulations

International shipments consigned to or from the United States are subject to the International Maritime Dangerous Goods Code (IMDG Code), while domestic shipment of hazardous materials by sea is regulated by Title 49 *Code of Federal Regulations* (*CFR*) Subchapter C of the Hazardous Materials Regulations (HMR). Gasoline-powered used vehicles (such as those loaded onto the *Höegh Xiamen*) consigned as "UN3166, Vehicle, flammable liquid powered, Class 9" could be prepared in accordance with the IMDG Code or in accordance with the HMR, both of which set out requirements applicable to each individual substance, material, or article that was classified as dangerous goods for shipping by sea.[18]

1.9.1 International Maritime Dangerous Goods Code

IMDG Code special provision 961 excepts vehicles from regulatory requirements if any of five conditions are met, including—

> Vehicles are stowed on a cargo space designated by the flag state in accordance with the *International Convention for the Safety of Life at Sea* as specifically designed and approved for the carriage of vehicles, and there are no signs of leakage from the battery, engine, fuel cell, compressed gas cylinder or accumulator, or fuel tank when applicable.

Grimaldi determined that the vehicles loaded onto the *Höegh Xiamen* met the conditions of IMDG Code special provision 961 for excepting the cargo as dangerous goods because the *Höegh Xiamen* was specifically designed for the carriage of vehicles, and that was the purpose for which Grimaldi time chartered the vessel in its liner vehicle trade. In addition, Grimaldi required its shippers, receivers, and stevedores to inspect the vehicles for any leaks when received and during the loading process. Grimaldi's receiving policy required that any vehicle leaking fluids be rejected. Grimaldi therefore classified the *Höegh Xiamen*'s vehicle cargo as non-hazardous "used unpacked vehicle[s]."

1.9.2 Domestic Hazardous Materials Regulations

The stowage of vehicles classified as UN3166 as hazardous materials cargo on board a vessel is regulated by 49 *CFR* 176.905, which requires the following:

- Before being loaded onto a vessel, each vehicle must be inspected for signs of leakage from batteries, engines, and fuel tanks, and any identifiable faults in the electrical system that could result in short circuit or other unintended electrical source of ignition. A vehicle showing any signs of leakage or electrical fault may not be transported.
- Vehicle fuel tanks may not be more than one-fourth full of flammable liquid, and the quantity must not exceed 66 gallons unless approved by the

[18] Among other survey certificates, DNV GL, on behalf of Norway, issued the vessel a Document of Compliance for Ships Carrying Dangerous Goods, which certified that the construction and equipment of the ship was found to comply with the provisions of the *International Convention for the Safety of Life at Sea* for the carriage of certain other dangerous goods (hazardous materials) in bulk and packaged form.

Associate Administrator [for Hazardous Materials Safety, Pipeline and Hazardous Materials Safety Administration (PHMSA)].

- The batteries shall be protected from damage, short circuit, and accidental activation during transport.
- Damaged or defective lithium batteries must be removed and transported in accordance with regulations unless approved by the Associate Administrator.
- Equipment used for handling vehicles must be designed so that the fuel tank and fuel system are protected from stress that might cause rupture or other damage incident to handling.
- Each hold or compartment must be ventilated and fitted with an overhead sprinkler system or fixed fire extinguisher system.
- Each hold or compartment must be equipped with a smoke or fire detection system capable of alerting bridge personnel.
- All electrical equipment in the hold or compartment other than fixed explosion-proof lighting must be disconnected from its power source at a location outside of the hold or compartment during the handling or transportation of any vehicle.

However, vehicles would be excepted from the above requirements if any of the following conditions were met:

- The vehicle is stowed in a hold or compartment designated by the administration of the country in which the vessel is registered as specially designed and approved for vehicles, and there are no signs of leakage from the battery, engine, fuel cell, compressed gas cylinder or accumulator, or fuel tank, as appropriate; or
- The vehicle is powered by a combustible liquid that has a flashpoint of 38°C (100°F) or above, the fuel tank contains 450 liters (119 gallons) of fuel or less, there are no leaks in any portion of the fuel system, and installed batteries are protected from short circuit; or
- The vehicle is powered by a flammable liquid fuel that has a flashpoint less than 38°C (100°F), the fuel tank is empty, and installed batteries are protected from short circuit. Vehicles are considered to be empty of flammable liquid fuel when the fuel tank has been drained and the vehicles cannot be operated due to a lack of fuel. Engine components such as fuel lines, fuel filters, and injectors do not need to be cleaned, drained, or

> purged to be considered empty. The fuel tank does not need to be cleaned or purged.[19]

The vehicles loaded onto the *Höegh Xiamen* were stowed in accordance with the specifically designated cargo compartment exception provided in 49 *CFR* 176.905 (Grimaldi reported that there was no leakage), and, therefore, the cargo did not have to meet any of the other requirements of the regulations. When a cargo was excepted from regulation as a hazardous material, a dangerous cargo manifest was not required.

On May 21, 2018, PHMSA issued regulatory interpretation letter 18-0053 in response to a US Department of State inquiry about the applicability of the HMR to the shipment of vehicles classified as UN3166 aboard Ro/Ro vessels (PHMSA 2018). In the letter, PHMSA stated that a vehicle transported in accordance with one of the exceptions in 49 *CFR* 176.905 would be excepted from all additional requirements of the HMR. PHMSA further stated that the requirements of Section 176.905 were the only applicable vehicle preparation requirements (e.g., no signs of fluid leakage).

After the accident, PHMSA told NTSB investigators that regulatory interpretation 18-0053 was applicable to the *Höegh Xiamen*'s cargo, so long as the shipper was offering the vehicles for shipment under the exception provided in the regulations.

1.10 Related Accidents

1.10.1 *Courage* – 2015

On June 2, 2015, the US-flagged Ro/Ro vehicle carrier *Courage* was transiting from Bremerhaven, Germany, to Southampton, United Kingdom, when a fire broke out in its cargo hold. The *Courage* carried new production vehicles (Mercedes-Benz and BMW), military vehicles, personally owned vehicles (not new) for military and government personnel, and household goods shipments, also for military and government personnel. The accident resulted in extensive damage to the vessel's cargo hold as well as the vehicles and household goods contained within the hold. As a result of the damage, estimated at $40 million total, the vessel's owners scrapped the vessel.

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[19] Federal shipping regulations in 46 *CFR* 70.10-1 and 46 *CFR* 90.10-38 define the conditions that provide a suitable space for vehicles with batteries connected and fuel tanks containing gasoline. Requirements for the design and protection of these spaces are contained in subparts 72.15, 76.15, 77.05, 78.45, 78.47, and 78.83 of this subchapter.

The NTSB determined that the probable cause of the fire on the vehicle carrier *Courage* was electrical arcing in the automatic braking system module of a vehicle carried on board (NTSB 2017).

1.10.2 *Honor* – 2017

On February 24, 2017, the 623-foot-long US-flagged Ro/Ro vehicle carrier *Honor* was en route from Southampton, England, to Baltimore, Maryland, when a fire broke out in the upper vehicle deck. The fire was extinguished by the crew using the vessel's CO_2 fixed firefighting system. One injury was attributed to the firefighting efforts. The accident resulted in extensive damage, amounting to more than $700,000, to the *Honor*'s hold as well as its cargo of about 5,000 vehicles. The *Honor* operated between various ports in the United States and Europe, carrying new production vehicles, military vehicles, and personally owned vehicles (not new) for military and government personnel, as well as household goods shipments for military and government personnel.

The NTSB determined that the probable cause of the fire on board the vehicle carrier *Honor* was a fault in the starter motor solenoid in one of the personally owned vehicles being transported in the vessel's cargo space (NTSB 2018).

1.10.3 *Grande America* – 2019

On March 12, 2019, the Grimaldi combined-container-and-automobile Ro/Ro carrier *Grande America* sank in the Bay of Biscay, France, following a cargo fire. The cargo included 860 tons of dangerous goods and about 2,100 new and used vehicles. Grimaldi reported that the firefighting operation had to be discontinued and the ship was abandoned to avoid further risk to crew safety.

The vessel sank in about 13,000 feet of water, and the VDR capsule could not be located by a remotely operated vehicle. Investigators were unable to determine a definite origin and cause of the fire or fires, other than that arriving fire teams found sparks coming from a truck on a vehicle deck, attacked it with dry chemical extinguishers, and later released the vessel's fixed CO_2 system. The ship later lost power, and fire spread to or started separately in a cargo container. The crew abandoned the vessel and were rescued without any injuries (Italian Ministry of Infrastructure and Transport 2020).

1.10.4 *Grande Europa* – 2019

On the night of May 15, 2019, a fire broke out aboard the Grimaldi Ro-Ro vessel *Grande Europa* while the vessel was sailing about 25 miles from Palma de

Mallorca, Spain. Its cargo consisted of 1,687 vehicles (cars, vans, trucks, and excavators), the majority of which were new, and 49 containers containing mainly food products. The crew raised the alarm at 0045 due to a fire that broke out on deck 3, which was completely extinguished by the crew after about 45 minutes. At 0400, a second fire occurred on deck 8, which spread to deck 9, and the crew intervened with the firefighting equipment on board.

Grimaldi's preliminary investigation suggested that the two fires started from two different new vehicles stowed on board and then spread to the other nearby units. On May 16, 2019, Grimaldi issued a press release requesting "more controls on car batteries," as well as "the total prohibition of the presence of personal effects in second-hand vehicles, embarked on Ro/Ro vessels" (The Grimaldi Group 2019). They also appealed for the introduction of "more stringent controls and regulations on cargo sea transport, not only for rolling units but also for containers." Additionally, to mitigate future risk, Grimaldi developed the Grimaldi battery disconnect procedure, which was subsequently used to secure batteries during loading on board the *Höegh Xiamen*.

1.10.5 *Arc Independence* and *Höegh Transporter* – 2020

Coast Guard Sector Jacksonville investigated two additional Ro/Ro fires in 2020, following the *Höegh Xiamen* fire.

The US-flagged *Arc Independence* experienced a cargo hold fire while under way on August 30, 2020, about 180 miles offshore of Jacksonville. The crew was alerted to the fire by the ship's detection system and was able to contain the fire to a single vehicle with fire extinguishers. The vehicle was smoking from under the hood, and the crew had to break a window to access the engine compartment.

A few months later, on November 17, 2020, the Norwegian-flagged *Höegh Transporter* experienced a fire while alongside Blount Island's Pier 20. The ship had been loaded with new vehicles and was being fumigated before setting sail when the crew was alerted to a fire. In this case, cargo operations were complete, and the fire detection system had been activated. The fire was reported to have started in one of the new vehicles and was extinguished without further damage.

1.11 Postaccident Actions

1.11.1 Coast Guard

In response to the accident and other similar fires aboard Ro/Ro vessels, on November 30, 2020, the Coast Guard issued Marine Safety Alert 06-20, "Recognizing

Fire Hazards & Proper Cargo Stowage on Ro-Ro Vessels." The safety alert noted that Ro/Ro vessels "carry unique cargo that can have higher potential to introduce fire hazards if required safety protocols are not properly implemented in accordance with applicable regulations." The safety alert further encouraged vessel owners, operators, and charterers to protect vehicle batteries against short circuiting, remove personal and combustible material from vehicles prior to loading, inspect and remove leaking vehicles, and verify that vehicle receiving guidelines are in alignment with the IMDG Code.

1.11.2 Jacksonville Fire and Rescue Department

As a result of the fire on board the *Höegh Xiamen*, the JFRD revised its *Shipboard Fire Attack Decision Model* to provide more effective fire extinguishing tactics with reduced risk to firefighters and improved communications with the Coast Guard and the crew of the involved vessel. The JFRD integrated these changes into its *Shipboard Firefighting Standard Operating Guidelines*. The JFRD also sent a group of command-level officers and chiefs to an advanced shipboard firefighting training program to identify any other areas they could improve in their operations at these types of incidents.

2. Analysis

2.1 Introduction

After loading cargo on June 3 and 4, 2020, the crew of the 600-foot-long, Norwegian-flagged Ro/Ro vehicle carrier *Höegh Xiamen* was preparing for a 1700 departure from the Blount Island Horizon Terminal in Jacksonville, Florida, en route to Baltimore, Maryland, with 2,420 used vehicles on board. Vehicle loading was completed about 1500, and the crew was securing vehicle ramps about 1544 when the chief mate noticed smoke coming from a ventilation housing for one of the exhaust trunks that ran from deck 12 (the weather deck) to one of the cargo decks.

Upon further investigation, crewmembers discovered a fire on deck 8, which had been loaded with used vehicles. The crew attempted to fight the fire but were repelled by heavy smoke. Shoreside fire department teams from the JFRD arrived at 1603 and relieved the crew. The captain, after consulting with and receiving concurrence from the fire department, had CO_2 from the vessel's fixed fire-extinguishing system released into decks 7 and 8, and the crew then evacuated from the *Höegh Xiamen*.

The fire continued to spread to higher decks and the accommodations. Shoreside firefighters entered cargo decks with fire hoses, and nine firefighters were subsequently injured, five of them seriously, in an explosion. Responders subsequently adopted a defensive strategy, cooling external exposed surfaces. The fire was extinguished over a week later on June 12.

The *Höegh Xiamen* and its cargo of 2,420 used vehicles were declared a total loss valued at $40 million, and in August 2020, the vessel was towed to Turkey to be recycled.

This analysis evaluates the following safety issues:

- Lack of training for vehicle battery securement (section 2.3.1).
- Ineffective oversight of vehicle battery securement (sections 2.3.2 and 2.3.3).
- Regulatory exceptions for used and damaged flammable-liquid-powered vehicles (section 2.4).
- Fire detection system deactivation during cargo loading (section 2.5.1).
- Ineffective emergency distress calls (section 2.5.2).

Having completed a comprehensive review of the circumstances that led to the accident, the investigation excluded the following as causal factors:

- *Weather and waterway conditions*. The *Höegh Xiamen* was docked at the Horizon Terminal Ro/Ro facility on Blount Island in Jacksonville, Florida. Although it was raining at the time of the accident, there was no evidence that weather or waterway conditions impacted the crew or vessel on the day of the accident.
- *Crew impairment due to alcohol or other drugs*. Postaccident toxicology testing revealed negative results for alcohol and other tested-for substances.

The NTSB concludes that none of the following were safety issues for the accident: (1) weather and waterway conditions; or (2) crew impairment due to alcohol or other drugs.

2.2 Origin and Potential Source of the Fire

2.2.1 Area of Origin

The crew reactivated the vessel's fire detection system at 1545:52, about 1 minute after the initial discovery of smoke emitting from the housing around the cargo deck 7/8 ventilation exhaust trunk; the vessel's VDR data showed that the system began alarming 10 seconds later at 1546:02, beginning with a detector on deck 9 starboard aft. It is likely that in the time between the fire starting (before 1544) and the reactivation of the alarm system, the first smoke detectors to alarm for deck 8 and/or these detectors' wiring were burned and therefore would not have alarmed when the system was reactivated. Over the next 10 minutes following the first alarm, smoke detectors alarmed for cargo decks 8, 7, 10, and 11 (in that order), indicating the fire was spreading.

Shoreside CCTV footage from the port showed smoke coming out of the aft ventilation trunks associated with decks 7/8, 9, and 10/11 at the time the JFRD arrived at 1603. Further, after the accident, the Coast Guard and JFRD's examination of the damaged ventilation housings showed that the housings associated with decks 7/8, 9, and 10/11 exhibited sooting, indicating the presence of heavy smoke and/or fire on those decks.

The *Höegh Xiamen* completed its voyage from Freeport, Texas, to Jacksonville, Florida, without issue, with cargo loaded at Freeport onto decks 1, 2, 3, 5, 6, and 9; it is therefore unlikely that the fire began on those decks. In Jacksonville, cargo was loaded onto decks 7, 8, 10, and 11. Heated air does not typically move downward. As air is heated (in this case, due to fire), it expands, becomes lighter than the surrounding air, and rises. It is therefore unlikely that the fire began above deck 9.

According to crew statements, the fire was located on deck 8 when it was first discovered. The chief mate initially saw smoke coming from the exhaust ventilation housing associated with the ventilation zone for decks 7/8, and, according to the chief engineer, there was heavy smoke on deck 8 of the *Höegh Xiamen*—smoke so thick that he could not see, even with the lights reportedly on. The chief engineer also stated that from deck 7, he could see fire on the starboard aft side of deck 8 and flaming droplets (ignited material) falling down onto deck 7. The ordinary seaman who was sent to decks 7 and 8 confirmed that there was fire aft on deck 8, and the crew could not enter deck 8 from the aft stairwell due to heavy smoke. Based on the fire alarm locations, ventilation damage, vehicle loading, and witness testimony, the NTSB concludes that the fire aboard the *Höegh Xiamen* began in the aft portion of deck 8 and spread to cargo decks 7, 9, 10, and 11.

2.2.2 Potential Source

Used vehicles are at risk for potential fires due to such factors as deteriorated electrical connections, brittle and cracked electrical cables, chafed electrical wiring harnesses, deposits of electrically conductive road grime, and idle electrical systems that are more prone to failure (Barnett 2017). Additionally, the National Fire Data Center's 2018 report on the occurrence of vehicle fires stated that insulation around the electrical wiring or cables was the most common item to initially ignite in vehicle fires (National Fire Data Center 2018). The integrity of these used vehicle electrical systems is more likely to be significantly deteriorated compared to new vehicle systems. Grimaldi required vehicles to be rejected when the engine compartment could not be accessed, but, if such vehicles were loaded, the inability to open the engine compartment would make it difficult, if not impossible, for crews involved in cargo loading to isolate vehicle batteries to mitigate the risk of electrical faults and short circuits.

According to SSA stevedores, most of the used vehicles loaded on board the *Höegh Xiamen* were received in poor condition and had sustained varying degrees of damage. The stevedores reported that most vehicles loaded onto deck 8 were towed and "would be considered junk cars." According to the stevedores, the remaining running vehicles exhibited varying degrees of damage.

Because of Grimaldi's experience with previous Ro/Ro vessel fires, the company had developed a battery disconnect procedure to reduce the risk of vehicle fires during transportation. The procedure involved having loading personnel

(1) remove the negative battery terminal cable lug, which would deenergize the vehicle's circuitry to avoid electrical short circuits external to the battery and overheating defective or damaged electrical components; (2) place a non-conductive protective plastic cover over the negative battery terminal post to further electrically isolate the battery; and (3) tuck the negative battery cable into the engine compartment away from the battery terminal, which would reduce the possibility of the cable springing or shifting back into place and potentially contacting the battery.

After the accident, investigators inspected 59 of the used vehicles that had been loaded on board the *Höegh Xiamen* in Jacksonville (20 that were towed on board and 39 that were loaded by forklift) for battery securement and found bare battery cable lugs resting on top of or very near unprotected battery terminal posts in 27 vehicles (46%). Several of these vehicles had disconnected battery cable lugs lying in contact with or near battery terminal posts. Many batteries' cable lugs had been wrapped with a few turns of electrical tape, leaving exposed metal components close to or touching battery terminals. Furthermore, none of the inspected vehicles (with batteries installed) that had disconnected battery cable lugs had protective plastic caps on the battery terminal posts, which was required by Grimaldi's procedures. These loose and partially protected cables and terminals left batteries and components vulnerable to short circuiting or electrical arcing across the gap between the battery terminal and disconnected cable lugs and could have led to ignition of nearby combustibles, fuel vapors, or flammable gases released from the batteries themselves if they were damaged. In the same group of 59 vehicles inspected, investigators also found 5 vehicles (8%) with both positive and negative battery cables still connected to the battery, which left these vehicle circuits energized and any faulty components susceptible to electrical arcing.

Since most of the vehicles on the *Höegh Xiamen* were destroyed by the fire, investigators were unable to determine the exact vehicle(s) that were the source of the fire. There was no evidence that a fire unrelated to the vehicles was present, nor was there any possible shifting of vehicles resulting from vehicle collisions with the ship's structure or other vehicles, since the vessel remained stationary while tied to the pier. Although Coast Guard investigators found two vehicles with personal effects during a postaccident examination of the vehicles, there was no evidence that these effects were the source of ignition for the fire. Therefore, based on the available evidence, the NTSB concludes that the fire likely was caused by an electrical arc or an electrical component fault in one of the vehicles that did not have a properly disconnected and secured battery.

The probability of any one vehicle catching fire on board was multiplied by the large number of units carried on board (2,240 on the day of the accident). Once the fire became established and uncontrolled, its severity likely was increased by the large open decks and tightly packed cargo, which would have facilitated the spreading of fire from vehicle to vehicle. Combustibles such as vehicle tires, gasoline, other fluids, upholstery, and plastics were then available to sustain the cascading fire.

2.3 Oversight

2.3.1 Training

Grimaldi provided SSA stevedores with their battery disconnect procedure in the days leading up to the *Höegh Xiamen*'s stop in Jacksonville. However, after the accident, Coast Guard investigators examined several of the used vehicles loaded on board the vessel and found improperly secured batteries. Several had negative battery cable lugs near or lying in contact with battery terminal posts, and many of the vehicles did not have plastic covers over their negative battery terminal posts, contrary to the procedures. Additionally, many vehicles were found with disconnected bare battery cable lugs resting near bare battery terminal posts.

By leaving loose, unprotected battery cables in contact with exposed battery terminal posts, or in positions where they might easily contact exposed battery terminal posts if the cables shift in the vehicle's engine compartment with the vessel's movement while under way, SSA stevedores created a fire hazard. Leaving both terminals connected prevented the chance of an arc occurring from a dangling and unprotected cable but also created the risk that an electrical component fault would create an electrical ignition source because the system was energized. Stevedores stated that some of the vehicles stored on decks 7 and 8 had sustained so much damage that battery securement crews were unable to gain access to the engine compartments. If they had followed Grimaldi's procedures, these vehicles would have been rejected and would not have been loaded on board the vessel. Instead, the stevedores flagged these vehicles (once loaded) by raising the windshield wipers and wrapping them in caution tape. However, the port captain stated that he was not aware of this practice, so nothing further was done to address these unsecured batteries, which will be discussed further in section 2.3.2 Charterer Oversight. Additionally, two vehicles were found to be leaking fluids and were not declared by Grimaldi as hazardous materials. Leaking fluids can fuel a fire when in contact with an ignition source, and therefore, any vehicles found to be leaking fluids should not have been loaded onto the vessel (in accordance with both Höegh's and Grimaldi's policies). The NTSB concludes that the SSA stevedores supervising the preparing and loading of vehicles onto the *Höegh Xiamen* did not ensure that longshoremen followed Grimaldi's established vehicle loading and battery securement procedures, thereby increasing the risk of electrical arcing at battery terminals and component faults if batteries were left connected. Accordingly, the NTSB recommends that

Grimaldi develop a training program for any vehicle preparation personnel tasked with supervising and conducting vehicle battery securement to ensure greater fire safety aboard vehicle carriers.

2.3.2 Charterer Oversight

While Grimaldi's battery disconnect procedure stated that opening all vehicle hoods and disconnecting battery terminals was "not negotiable," there was no follow-up instructional emphasis or oversight to ensure that crews understood and adhered to the procedure. The Grimaldi port captain emailed Grimaldi's battery disconnection instructions to SSA and noted the importance of these procedures. However, stevedores remembered the primary focus of their instructions was to ensure an orderly and efficient loading pace and tight packing of vehicles on the decks.

The Grimaldi port captain was responsible for overseeing the loading process and ensuring that the vehicles had no leaking fluids and that batteries were disconnected. The port captain had the ultimate discretion as to whether to accept any vehicle for loading, as well as oversight authority to ensure that cargo was properly secured and in a safe condition.

During loading operations, the port captain missed opportunities to require longshoremen to properly isolate the vehicle electrical systems. Longshoremen said that they flagged vehicles with incomplete battery disconnection by raising windshield wipers and wrapping them in caution tape, but even though the port captain was present on the cargo decks during the entire loading operation, he was not aware of this practice (it was not part of Grimaldi's battery securement procedure). Additionally, the port captain stated that he inspected many vehicles and, although he found some batteries on deck 11 that were not properly disconnected, he instructed the stevedore for that deck to address the issue and thereafter believed that none of the vehicles violated the company's battery disconnect procedure. However, the Coast Guard's postaccident examination of a sample of 59 vehicles did not find a single battery that was secured in accordance with Grimaldi's battery disconnect procedure: they all had either no plastic terminal caps, cables not disconnected, a cable not tucked away, an engine compartment that could not be accessed, or some combination of all of these. Even from random and cursory inspections, it should have been immediately obvious to the port captain that the battery disconnection crews were not correctly performing their tasks.

The NTSB concludes that Grimaldi's oversight of battery securement during loading operations was insufficient and ineffective. Therefore, the NTSB recommends that Grimaldi revise their written procedures to improve oversight of vehicle loading and battery securement, using such methods as requiring additional inspectors, pre-job briefings, hands-on demonstrations, or independent follow-up inspections.

The circumstances of this accident make clear that it is critical to ensure that the batteries of used vehicles are disconnected and properly secured during cargo loading operations. This is especially critical for vehicles that are damaged because they pose an elevated risk of fire due to the potential for leaking fluids and electrical faults from displaced components. The NTSB believes it is imperative that operators of similar Ro/Ro vessels engaged in the transportation of used vehicles act to ensure that any personnel involved in loading operations—including vessel crews, stevedores, and longshoremen—be aware of the importance of disconnecting batteries on used vehicles. The National Maritime Safety Association is an organization that protects the health and safety of personnel in the marine cargo-handling industry in the United States. The NTSB therefore recommends that the National Maritime Safety Association inform their members of the circumstances of the *Höegh Xiamen* accident and encourage them to establish battery securement procedures as well as a means to ensure that the procedures are followed through adequate oversight of vehicle loading and battery securement.

2.3.3 Operator Oversight

Höegh's "Cargo Safety Awareness" procedure stated that the vessel's crew should be aware of typical sources of fire incidents, such as fuel leaks and loose electrical connections, and stated that, if they saw such hazards, crewmembers should suspend operations until safe.

The chief mate stated that he provided crewmembers with cargo securement training in accordance with Höegh's *Cargo Securing Manual*, indicating that he was familiar with Höegh's safety requirements for loading operations. However, at the completion of loading, an SSA stevedore gave the *Höegh Xiamen*'s chief mate a "Vehicle Lashing Inspection Procedure" document that indicated that 58 vehicles loaded onto various decks had "incomplete" battery disconnections. Thirteen of these vehicles were on deck 8, the area where the fire originated. The "Vehicle Lashing Inspection Procedure" stated, "All second hand [*sic*] vehicles must have the battery terminals disconnected once in final stow." Thus, the document provided by the stevedore should have been an indication that there were nonconformities and vehicles' battery securement was incomplete. Although the chief mate signed the procedure, he did not take any action to address the hazards noted on the procedure. The NTSB concludes that the chief mate was informed of vehicles that had incomplete battery disconnections, but he took no further action and missed the opportunity to address the hazard of incomplete battery securement on multiple decks, including cargo deck 8, where the fire originated.

While the "Vehicle Lashing Inspection Procedure" noted the number of vehicles on each deck, as well as the number of vehicles that had "incomplete" battery disconnections, it did not specify the location of or otherwise identify the unsecured vehicles. Therefore, quickly locating these vehicles would have been difficult and impractical for the vessel's crew, let alone a single officer, considering their other duties to prepare the vessel for departure. For example, on deck 8, they would have had to search for 13 of the 358 vehicles stowed on that deck. The vessel was scheduled to depart at 1700, leaving the crew about 2 hours to correct the nonconformities identified on the form while preparing the vessel for departure.

As discussed above, the "Vehicle Lashing Inspection Procedure" instructed that all used vehicles should have their battery terminals disconnected once stowed. However, the form also included a column for "Battery Disconnect Incomplete," indicating that there could be situations in which vessels would be loaded with vehicles with unsecured batteries. Further, the form did not provide guidance as to how to or who should correct the identified nonconformities involving vehicles with unsecured batteries. The NTSB concludes that the "Vehicle Lashing Inspection Procedure" identified but did not provide a process to ensure that all the vehicles loaded on board the *Höegh Xiamen* had disconnected batteries. Therefore, the NTSB recommends that Höegh revise their "Vehicle Lashing Inspection Procedure" to include a process to ensure all vehicle batteries are disconnected before departure and provide training to all crew on the revised procedure.

2.4 Hazardous Materials Regulations

The used vehicles loaded on to the *Höegh Xiamen* were considered excepted from the requirements of the HMR because the vessel's cargo space had been approved by the flag state (Norway) as specially designated and approved for vehicles, and vehicles with leaking fluids were not to be accepted. Grimaldi intended for vehicle batteries to be isolated as an extra safety measure. The IMDG Code contained similar provisions that would have excepted this shipment from international dangerous goods regulations.

Factory-new, clean, unworn, and undamaged parts and electrical components are much less likely to produce electrical faults. However, it is not uncommon for used vehicles to have problems, including deterioration of internal electrical connections (which may result in electrical faults) while awaiting shipment in a port area (The North of England P&I Association 2017). The circumstances of this accident and others suggest that used vehicles, particularly those that are older with unknown maintenance history and/or crash damaged, require extra protections to mitigate the risk of vehicle fires on board Ro/Ro vehicle carrier vessels. Some of the crash-damaged vehicles that were loaded on the *Höegh Xiamen* had engine compartments that could not be accessed to secure batteries, which was the only requirement for the excepted non-hazardous cargo. If the cargo had not been excepted, evaluating the electrical systems and inspecting for fluid leakage would have been required, and that would have been further hampered by inaccessible engine compartments. Other running and towed vehicles had varying degrees of damage and unknown maintenance issues, if any, that could present additional hazards if the electrical systems had not been properly isolated in order to mitigate these hazards. The NTSB concludes that the transportation of used vehicle cargoes excepted from the HRM presents an elevated risk of fire on board vehicle carriers.

Had the *Höegh Xiamen*'s cargo not been excepted under the HMR, the regulations state the batteries would have been required to be protected from short circuit and accidental activation during transport. Additionally, each vehicle inspection would have included the identification of any faults in the electrical system that could result in short circuit or other unintended electrical source of ignition, among other things (which would not be necessary if each battery was disconnected). Further, the regulations would have limited the quantity of flammable liquids (gasoline) contained in the fuel tanks to one-fourth volume, which would reduce the fuel available should a fire occur.

Concern about the transportation of used vehicles classified as non-hazardous cargo is not limited to this single incident. In a 2017 loss prevention briefing for its members, the North England P&I Association detailed the increased risks with shipping used vehicles—especially for vehicles whose history and condition cannot be verified—including electrical faults, such as shorting across electrical circuits or the battery; parts seizing; or fuel/oil systems' seals perishing, thus allowing hazardous fluids to leak (The North England P&I Association 2017). Additionally, in 2015, 2017, and 2019, fires aboard the Ro/Ro vessels *Courage*, *Honor*, and *Grande America* (a Grimaldi vessel), respectively, were all connected to vehicle cargo carried aboard each vessel. On May 15, 2019, a fire broke out aboard the Grimaldi Ro/Ro vessel *Grande Europa*, and the company's preliminary investigation indicated that two fires had started from two vehicles stowed on board. In response to increased occurrences of vehicle cargo fires on Ro/Ro vessels, particularly involving used vehicles, on May 16, 2019, Grimaldi publicly appealed for increased regulatory controls on vehicle cargo and vehicle batteries. Grimaldi's desire for regulatory requirements in this area recognized the need for industry-wide standards, whereas the competitive environment may tempt some carriers to ignore best practices that could be perceived to limit cargo movement efficiencies.

The protections offered for stowage of vehicles as contained in federal regulations could significantly improve the safety of used vehicle transport. In Grimaldi's case, the company had already adopted battery isolation procedures required by the stricter HMR, but, in this accident, stevedores supervising loading operations did not ensure longshoremen followed these procedures, and the chief mate missed the opportunity to address the hazard of incomplete battery securement. Multiple violations of Grimaldi's cargo securement procedures—which were not enforceable by regulation—led to conditions that likely caused the fire. Greater inspection, oversight, and enforcement would ensure effective implementation of battery securement and vehicle inspection policies in used vehicles across all vehicle carrier operations. The NTSB concludes that eliminating the exceptions for used and damaged flammable-liquid-powered vehicles in the HMR would reduce the risk of fire posed by transporting this type of cargo on vehicle carriers by providing for greater inspection and mitigation of the hazards related to transportation of such vehicles. Therefore, the NTSB recommends that PHMSA eliminate the exceptions provided in 49 *CFR* 176.905(i) for used and damaged flammable-liquid-powered vehicles transported by Ro/Ro vehicle carriers. Because used vehicles consigned under UN3166 also may be prepared in accordance with the IMDG Code, the NTSB recommends that the Coast Guard propose to the International Maritime Organization to eliminate IMDG Code special provision 961 for used and damaged flammable-liquid-powered vehicles transported by Ro/Ro vehicle carriers.

2.5 Fire Detection and Firefighting Efforts

2.5.1 Fire Detection System

During loading operations, the crew deactivated the *Höegh Xiamen*'s fire detection system, which consisted of 236 smoke detectors on the cargo decks (decks 7 through 11). This was required by Höegh's "Cargo Safety Awareness" procedure to prevent alarms from continuously activating due to exhaust from the vehicles being loaded onto the vessel. Crewmembers were normally stationed or roving the cargo decks to monitor loading and unloading for issues, including fire. About 1445, the last vehicle was loaded on board, and at 1500, the last stevedores and the port captain departed as the crew prepared the vessel for sea. The fire detection system was not reactivated until about 1545, about 1 minute after smoke was observed, and the system immediately began alarming, indicating that, when activated, the fire detection system was functioning as expected and would have detected smoke (and the fire) sooner had it been active. The VDR recorded multiple alarms across decks 7 through 11, suggesting that by the time the alarm system was reactivated, the fire had spread from its likely area of origin (deck 8). The NTSB concludes that because the crew did not immediately reactivate the fire detection system after completing the loading, the detection of the fire was delayed.

Following the completion of loading, the crew left the cargo decks and began preparing the vessel for sea. The operator's procedure did not specify at what point after the completion of loading the crew should reactivate the fire detection system, so the system remained deactivated. Without the fire detection system being activated and without crew on the cargo decks to detect any smoke or fire, there was a 44-minute gap between the completion of loading and the discovery of the fire (via smoke coming from the ventilation trunk), during which the vessel was unprotected. Thus, the NTSB recommends that Höegh revise their "Cargo Safety Awareness" procedure to minimize the amount of time that their vessels' fire detection systems are deactivated.

2.5.2 Emergency Distress Call

To report the fire, the master had four options: call the ship's agent, call the public service answering point (911), call the Coast Guard directly, or make a distress call to the Coast Guard over VHF channel 16, the international hailing and distress frequency. Calling 911 via a mobile phone does not inform other vessels or facilities of the emergency, and no public service answer point received a call from the master. The *Höegh Xiamen* had an approved non-tank vessel response plan, which listed the Coast Guard's direct phone number, but the Coast Guard also did not receive a call from the master.

The master stated that once he became aware of the fire, he first attempted to call the ship's agent by mobile phone but was unable to reach the agent. The master next went to the bridge and called for help by VHF radio at 1549, 3 minutes after sounding the general alarm; however, the entity he attempted to reach, "Jacksonville Port Control," did not exist. The vessel's VDR captured his repeated calls for help, but investigators were unable to determine which channel the master was using. These VHF calls were not received on any Coast Guard-monitored frequencies, indicating he was not likely using channel 16, which is monitored by search and rescue authorities and other vessels within VHF range. Instead, an unknown ship answered at 1554 and told the captain to use VHF channel 14 to reach the port's pilot station. Once the master did so, the pilot station in turn called the Coast Guard, who contacted the *Höegh Xiamen* on VHF channel 16 at 1555. The captain communicated that he had a fire on deck 8 and requested assistance. However, he then left the bridge without giving the ship's position to the Coast Guard (alternatively, using the distress button on a VHF radio, also known as Digital Selective Calling, would have transmitted the vessel's position and identification). It was not until 1559, when a shoreside passerby who had observed smoke on the vessel called 911, that shoreside responders became aware of the vessel's location. The Coast Guard was not informed of the vessel's location until 1601, when the nearby passenger vessel

Norwegian Pearl reported the location over channel 16. Engine 48, stationed on Blount Island, was on scene by 1603.

A successful emergency response is contingent on early distress notification and clear, effective communication. Although the master attempted to make an emergency distress call at 1549, about 5 minutes after smoke was discovered, emergency response entities were not aware of the location of the ship until 1559. The NTSB concludes that the *Höegh Xiamen*'s master did not effectively use the communication methods available to contact emergency response authorities and provide location information, which delayed the fire department's response to the accident site. Although the vessel had a non-tank vessel response plan, which listed the local Coast Guard's contact information, and the master should have been familiar with using VHF channel 16 for emergencies in port, he did not use either option. Therefore, the NTSB recommends that Höegh ensure that contact information for emergency response authorities for each port of the vessel's passage plan is immediately available to vessel bridge teams and that they are trained on its use.

2.5.3 Ventilation and Fixed Fire-Extinguishing System

The chief mate stated that the internal gastight ramps between the vessel's fire zones had been secured before the fire was discovered on the aft portion of deck 8. The chief mate also stated that after the fire was discovered, the crew shut down the fans and secured the remotely controlled and manually operated dampers on the ventilation trunks from the cargo decks. However, footage from the port's CCTV showed smoke coming out of the ventilation trunks for multiple fire zones on decks 7/8, 9, and 10/11 before the JFRD's arrival, indicating that the fire or smoke had breached the fire zones (because the ventilation trunks for decks 9 and 10/11 were isolated to their own zones and gastight). The continued spread of the fire could be attributed to two factors. First, if the dampers and internal ramps had not been properly secured by the crew, or if they had been secured and there were gaps that allowed the fire to bypass them, the fire could have moved directly through the zone boundaries. Second, if the fire was not completely starved of additional oxygen after the crew secured the ventilation fans and dampers or internal ramps, the oxygen would have allowed the fire to continue to grow, and heat would have conducted upward into and through deck 9. Additionally, the CCTV footage showed a rapid increase in thermal discoloration of the white paint on the vessel's starboard side from the time the JFRD arrived about 1603 to the end of the video 25 minutes later. The discoloration began in the area of decks 7/8 but quickly spread to the surrounding areas and was consistent with a growing, spreading fire. Further, the fire detection system (smoke detectors) alerted for multiple decks, indicating that the fire had spread. It is possible that the fire had already spread to other zones by the time the ventilation dampers for decks 7/8 were secured. Although the crew took action to close the dampers and shut down the ventilation fans, the NTSB concludes that the dampers for decks 7/8 (the fire's area of origin) were ineffective or not adequately secured, thereby giving the fire continued access to oxygen and allowing the fire to continue to grow.

The *Höegh Xiamen* was equipped with a low-pressure CO_2 fixed fire-extinguishing system that could be used to smother fires on the cargo decks and in the engine room. As the crew attempted to fight the fire, the chief mate suggested to the master that they release CO_2 in the affected areas. After the JFRD arrived, the chief engineer attempted to release the CO_2 from the CO_2 room but was unable to do so. (Investigators were unable to determine why the system did not release from the CO_2 room. See Appendix A for details.) Shortly after, the chief engineer released the CO_2 from the fire control room, and he confirmed that pressure dropped in the tank, indicating release. Investigators later found that the correct CO_2 system valves were open for release to decks 7/8.

In interviews with investigators, the master, chief engineer, and chief mate could not identify the specific time at which the CO_2 was released, and there were no audio indications on the VDR. There were also no visible cues in the port CCTV footage. However, comparing the crew interviews with the events on the corresponding CCTV footage indicates that the crew attempted to release the CO_2 about 30 minutes after the discovery of the fire and 15 minutes after the JFRD arrived—about 1618; the master explained that he thought the fire department would have more experience than the crew. However, the CCTV footage (as discussed above) showed that by 1608, the fire had spread from its area of origin on deck 8 to the fire zones for decks 9 and 10/11. There was a 44-minute gap between the completion of loading and the discovery of the fire (during which time the fire detection system was deactivated, allowing the fire to spread unnoticed), then about 30 more minutes passed before the crew attempted to release CO_2. Therefore, the master's decision-making time, which was reasonable, was not the only factor that allowed the fire to spread. The NTSB concludes that by the time the master decided to release the CO_2 fixed fire-extinguishing system, the fire had already spread to other zones beyond deck 7/8, and, therefore, the CO_2 was ineffective in suppressing the fire.

2.5.4 Overpressurization Event

About 60 seconds after JFRD firefighters on deck 12 opened the exhaust vent for deck 9, they heard "a loud roar that sounded like a jet engine," and the ventilation housings for the decks 9 and 10/11 trunks "exploded" and were destroyed. It is likely not coincidental that the "explosion" occurred about the same time that the firefighters opened the exhaust. On their way to deck 12, firefighters had opened the deck 9 door from the stairwell and found thick, black smoke just inside. The deck likely contained a rich atmosphere of heated flammable vapors, which rapidly combusted when fresh air was introduced via the opening of the ventilation trunks for decks 9 and 10/11. This reaction is analogous to an overpressurization event—that is, an increase in pressure within a compartment due to the rapid deflagration (combustion propagating at subsonic speed) of accumulated combustible vapors. A postaccident examination of the decks 9 and 10/11 ventilation trunks showed sooting and mechanical damage also consistent with overpressurization. The NTSB concludes that the *Höegh Xiamen* experienced an overpressurization event when shoreside firefighters on deck 12 opened the exhaust vent for deck 9. The aft ventilation trunks were located near the port aft stairwell, and firefighters who were in the stairwell and on deck 5 near the stairwell during the overpressurization event described a violent rush of extremely hot air. Some firefighters sustained serious injuries.

After the accident, the JFRD revised its *Shipboard Fire Attack Decision Model* to reduce the risk to firefighters and prevent similar injuries from occurring in the future and to improve communications with the Coast Guard and crew of the involved vessel. The JFRD also sent personnel to an advanced shipboard firefighting training program to identify any other areas they could improve in their operations.

3. Conclusions

3.1 Findings

1. None of the following were safety issues for the accident: (1) weather and waterway conditions; or (2) crew impairment due to alcohol or other drugs.
2. The fire aboard the *Höegh Xiamen* began in the aft portion of deck 8 and spread to cargo decks 7, 9, 10 and 11.
3. The fire likely was caused by an electrical arc or an electrical component fault in one of the vehicles that did not have a properly disconnected and secured battery.
4. The SSA stevedores supervising the preparing and loading of vehicles onto the *Höegh Xiamen* did not ensure that longshoremen followed Grimaldi's established vehicle loading and battery securement procedures, thereby increasing the risk of electrical arcing at battery terminals and component faults if batteries were left connected.
5. Grimaldi's oversight of battery securement during loading operations was insufficient and ineffective.
6. The chief mate was informed of vehicles that had incomplete battery disconnections, but he took no further action and missed the opportunity to address the hazard of incomplete battery securement on multiple decks, including cargo deck 8, where the fire originated.
7. The "Vehicle Lashing Inspection Procedure" identified but did not provide a process to ensure that all the vehicles loaded on board the *Höegh Xiamen* had disconnected batteries.
8. The transportation of used vehicle cargoes excepted from the Hazardous Materials Regulations presents an elevated risk of fire on board vehicle carriers.
9. Eliminating the exceptions for used and damaged flammable-liquid-powered vehicles in the Hazardous Materials Regulations would reduce the risk of fire posed by transporting this type of cargo on vehicle carriers by providing for greater inspection and mitigation of the hazards related to transportation of such vehicles.
10. Because the crew did not immediately reactivate the fire detection system after completing the loading, the detection of the fire was delayed.
11. The *Höegh Xiamen*'s master did not effectively use the communication methods available to contact emergency response authorities and provide

location information, which delayed the fire department's response to the accident site.

12. The dampers for decks 7/8 (the fire's area of origin) were ineffective or not adequately secured, thereby giving the fire continued access to oxygen and allowing the fire to continue to grow.

13. By the time the master decided to release the CO_2 fixed fire-extinguishing system, the fire had already spread to other zones beyond deck 7/8, and, therefore, the CO_2 was ineffective in suppressing the fire.

14. The *Höegh Xiamen* experienced an overpressurization event when shoreside firefighters on deck 12 opened the exhaust vent for deck 9.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the fire aboard the vehicle carrier *Höegh Xiamen* was Grimaldi's and SSA Atlantic's ineffective oversight of longshoremen, which did not identify that Grimaldi's vehicle battery securement procedures were not being followed, resulting in an electrical fault from an improperly disconnected battery in a used vehicle on cargo deck 8. Contributing to the delay in the detection of the fire was the crew not immediately reactivating the vessel's fire detection system after the completion of loading.

4. Recommendations

4.1 New Recommendations

As a result of this investigation, the National Transportation Safety Board makes the following new safety recommendations.

To the Pipeline and Hazardous Materials Safety Administration:

> Eliminate the exceptions provided in Title 49 *Code of Federal Regulations* 176.905(i) for used and damaged flammable-liquid-powered vehicles transported by roll-on/roll-off vehicle carriers. (M-21-014)

To the US Coast Guard:

> Propose to the International Maritime Organization to eliminate International Maritime Dangerous Goods Code special provision 961 for used and damaged flammable-liquid-powered vehicles transported by roll-on/roll-off vehicle carriers. (M-21-015)

To the National Maritime Safety Association:

> Inform your members of the circumstances of the *Höegh Xiamen* accident and encourage them to establish battery securement procedures as well as a means to ensure that the procedures are followed through adequate oversight of vehicle loading and battery securement. (M-21-016)

To Grimaldi Deep Sea:

> Develop a training program for any vehicle preparation personnel tasked with supervising and conducting vehicle battery securement to ensure greater fire safety aboard vehicle carriers. (M-21-017)

> Revise your written procedures to improve oversight of vehicle loading and battery securement, using such methods as requiring additional inspectors, pre-job briefings, hands-on demonstrations, or independent follow-up inspections. (M-21-018)

To Höegh Technical Management:

> Revise your "Vehicle Lashing Inspection Procedure" to include a process to ensure all vehicle batteries are disconnected before departure and provide training to all crew on the revised procedure. (M-21-019)

Revise your "Cargo Safety Awareness" procedure to minimize the amount of time that your vessels' fire detection systems are deactivated. (M-21-020)

Ensure that contact information for emergency response authorities for each port of the vessel's passage plan is immediately available to vessel bridge teams and that they are trained on its use. (M-21-021)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JENNIFER HOMENDY
Chair

MICHAEL GRAHAM
Member

BRUCE LANDSBERG
Vice Chairman

THOMAS CHAPMAN
Member

Report Date: December 1, 2021

Appendixes

Appendix A: Investigation

The US Coast Guard was the lead federal agency in this investigation. The National Transportation Safety Board (NTSB) learned of the accident from the Coast Guard on the afternoon of June 4, 2020. Due to COVID-19 travel restrictions, NTSB investigators were unable to initially respond to the site. NTSB investigators remotely joined Coast Guard-led interviews of the crew, Coast Guard staff, a classification society auditor, terminal staff, stevedores, and the charterer's representative. Investigators also reviewed terminal video, the ship's voyage data recorder, first responder statements, and drone video.

An NTSB investigator was later able to board the vessel on July 24, 2020, to capture additional photographic evidence. Afterwards, all vehicles were removed from the vessel, and the *Höegh Xiamen* was towed to Turkey to be recycled. Fifty-eight suspect vehicles from deck 8, where the fire was thought to have originated, were kept for further study by the parties in interest.

Parties of interest to the Coast Guard investigation included Höegh Technical Management, Grimaldi Deep Sea, and SSA Atlantic. The Coast Guard, the Pipeline and Hazardous Materials Safety Administration, and the Norwegian Safety Investigation Authority (from the vessel's flag state) were named parties to the NTSB investigation; Höegh Technical Management declined to be party to the NTSB investigation.

Appendix B: Consolidated Recommendation Information

Title 49 *United States Code* 1117(b) requires the following information on the recommendations in this report.

For each recommendation–

(1) a brief summary of the Board's collection and analysis of the specific accident investigation information most relevant to the recommendation;

(2) a description of the Board's use of external information, including studies, reports, and experts, other than the findings of a specific accident investigation, if any were used to inform or support the recommendation, including a brief summary of the specific safety benefits and other effects identified by each study, report, or expert; and

(3) a brief summary of any examples of actions taken by regulated entities before the publication of the safety recommendation, to the extent such actions are known to the Board, that were consistent with the recommendation.

To the Pipeline and Hazardous Materials Safety Administration

M-21-014

Eliminate the exceptions provided in Title 49 *Code of Federal Regulations* 176.905(i) for used and damaged flammable-liquid-powered vehicles transported by roll-on/roll-off vehicle carriers.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4 Hazardous Materials Regulations. Information supporting (b)(1) can be found on pages 44–46; (b)(2) and (b)(3) are not applicable.

To the US Coast Guard

M-21-015

Propose to the International Maritime Organization to eliminate International Maritime Dangerous Goods Code special provision 961 for used and damaged flammable-liquid-powered vehicles transported by roll-on/roll-off vehicle carriers.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4 Hazardous Materials Regulations. Information supporting (b)(1) can be found on page 44–46; (b)(2) and (b)(3) are not applicable.

To the National Maritime Safety Association

M-21-016

Inform your members of the circumstances of the *Höegh Xiamen* accident and encourage them to establish battery securement procedures as well as a means to ensure that the procedures are followed through adequate oversight of vehicle loading and battery securement.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.2 Charterer Oversight. Information supporting (b)(1) can be found on pages 42–43; (b)(2) and (b)(3) are not applicable.

To Grimaldi Deep Sea

M-21-017

Develop a training program for any vehicle preparation personnel tasked with supervising and conducting vehicle battery securement to ensure greater fire safety aboard vehicle carriers.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.1 Training. Information supporting (b)(1) can be found on pages 41–42; (b)(2) and (b)(3) are not applicable.

M-21-018

Revise your written procedures to improve oversight of vehicle loading and battery securement, using such methods as requiring additional inspectors, pre-job briefings, hands-on demonstrations, or independent follow-up inspections.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.2 Charterer Oversight. Information supporting (b)(1) can be found on pages 42–43; (b)(2) and (b)(3) are not applicable.

To Höegh Technical Management

M-21-019

Revise your "Vehicle Lashing Inspection Procedure" to include a process to ensure all vehicle batteries are disconnected before departure and provide training to all crew on the revised procedure.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.3 Operator Oversight. Information supporting (b)(1) can be found on pages 43–44; (b)(2) and (b)(3) are not applicable.

M-21-020

Revise your "Cargo Safety Awareness" procedure to minimize the amount of time that your vessels' fire detection systems are deactivated.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5.1 Fire Detection System. Information supporting (b)(1) can be found on pages 46–47; (b)(2) and (b)(3) are not applicable.

M-21-021

Ensure that contact information for emergency response authorities for each port of the vessel's passage plan is immediately available to vessel bridge teams and that they are trained on its use.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5.2 Emergency Distress Call. Information supporting (b)(1) can be found on pages 47–48; (b)(2) and (b)(3) are not applicable.

References

Barnett, Gregory J. *Vehicle Battery Fires: Why They Happen and How They Happen*. Warrenton, PA: SAE International, 2017.

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Accident Type	Fire/Explosion
Location	Pier 20, Blount Island, Jacksonville, Florida
Date	June 4, 2020
Time	1544 eastern daylight time (coordinated universal time –4 hours)
Persons on Board	21
Injuries	5 serious, 4 minor
Property damage	$40 million est.
Environmental damage	None
Weather	Rain, winds southeast 9 kts, gusts 14 kts, air temperature 77°F
Waterway	St. Johns River, 11 miles inland from Atlantic Ocean

NTSB investigators worked closely with our counterparts from **Coast Guard Sector Jacksonville** throughout this investigation.

For more detailed background information on this report, visit the NTSB investigations website and search for NTSB accident ID DCA20FM020. Recent publications are available in their entirety on the NTSB website. Other information about available publications also may be obtained from the website or by contacting–

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