December 2, 2025 MIR-25-41

Lithium-ion Battery Fires aboard Cargo Vessel *Genius Star XI*

On December 25, 2023, at 0830, while the cargo vessel *Genius Star XI* was transiting the North Pacific Ocean in heavy weather with a cargo of lithium-ion battery energy storage system units on board, a fire was discovered in a cargo hold (see figure 1 and figure 2).[1] Crew discharged the vessel's fixed gas (carbon dioxide) fire extinguishing system into the hold, and the vessel proceeded to the nearest port, Dutch Harbor, Alaska, for assistance. On December 28, about 0215, while the vessel was en route to Dutch Harbor, a fire started in a second cargo hold. The crew externally cooled the cargo hold using fire hoses, and, after the vessel anchored in Dutch Harbor on December 29, the fire was determined to be extinguished. There were no injuries, and no pollution was reported. Damage from both fires was estimated at $3.8 million.

Figure 1. Cargo vessel *Genius Star XI* on February 24, 2024, after the fires.

[1] (a) In this report, all times noted on December 25, 2023, are Magadan standard time, and all times noted on December 28, 2023, are Alaska standard time. Additionally, unless otherwise noted, all miles are nautical miles (1.15 statute miles). (b) Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case no. DCA24FM013). Use the CAROL Query to search investigations.

Casualty Summary

NTSB casualty category	Fire/Explosion
Location	North Pacific Ocean, about 371 nm southwest of Agattu Island, Alaska (December 25) and about 57 nm southeast of Seguam Island, Alaska (December 28) 48°06.00' N, 166°31.8' E (December 25) 51°24.00' N, 171°47.4' W (December 28)
Date	December 25 and 28, 2023
Time	0830 Magadan standard time (coordinated universal time + 11) 0215 Alaska standard time (coordinated universal time – 9 hours)
Persons on board	19
Injuries	None
Property damage	$3.8 million est.
Environmental damage	None
Weather	December 25: overcast, visibility 5 mi, winds southeast 30 mph, gusts 36 mph, seas 19 ft, air temperature 30°F, water temperature 42°F December 28: skies clear, visibility 10 mi, winds southeast 30 mph, gusts 36 mph, seas 22 ft, air temperature 24°F, water temperature 41°F
Waterway information	Ocean

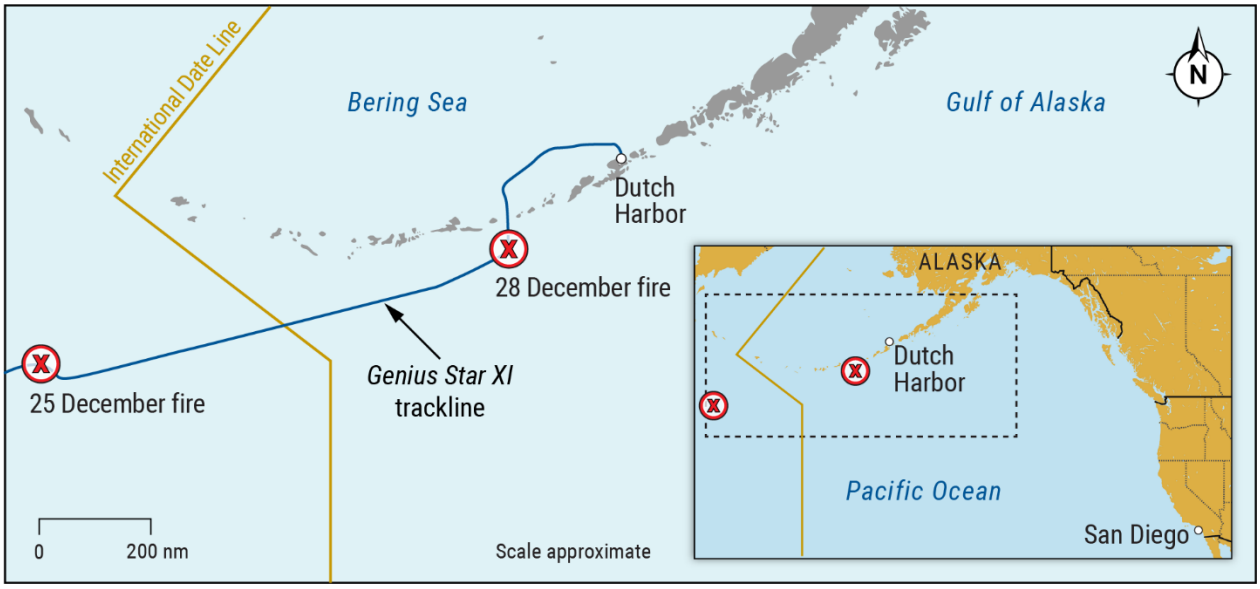

Figure 2. Area where the fires aboard *Genius Star XI* occurred, as indicated by a circled *X*. (Background source: Google Maps)

1 Factual Information

1.1 Background

The *Genius Star XI*, a 410-foot-long, Panama-flagged bulk cargo vessel, was built in 2012 at the Kegoya Dock, Co. Ltd in Hiroshima Kure, Japan, and was constructed of steel. The vessel had two main cargo holds, each divided into upper and lower portions by a removable "tween deck." The vessel was owned by GS Navigation S.A. and operated by Wisdom Marine International Inc., a Taiwan-based ship owner and operator. The company's fleet was comprised of 133 vessels.

The vessel was equipped with various fire detection devices, including optical-type detectors, fixed temperature spot-type detectors, and suction-type detectors. The cargo holds were equipped with a suction type of smoke detection system, a centrally located detector unit that received air samples from multiple locations and monitored for the presence of smoke. The air was suctioned through tubing from the sampling points and delivered to the detector unit. There were 24 total sampling points in the cargo holds. Tween deck cargo holds no. 1 and no. 2 each had six sampling points distributed along the periphery of the cargo compartments. Lower deck cargo holds no. 1 and no. 2 also had six sampling points each, arranged along the periphery of the compartments.

The vessel was also equipped with a fixed gas fire extinguishing system. This system's extinguishing agent was carbon dioxide (CO_2), and it could be discharged manually into either the engine room or the cargo holds. There were 16 total discharge nozzles in the cargo holds. The CO_2 room contained 153 cylinders (121 pounds or 55 kilograms each) of CO_2, which was sufficient for one discharge in either of the cargo holds. For effective fire suppression, cargo hold no. 1 required 151 cylinders' worth of CO_2, and cargo hold no. 2 required 153 cylinders of CO_2.

The vessel was classed by Nippon Kaiji Kyokai (ClassNK) and had received its certificate of classification in November 2022. Additionally, the *Genius Star XI* had a valid Safety Management Certificate, issued under the authority of the Republic of Panama by ClassNK, certifying that the vessel complied with the requirement of the International Safety Management Code.

1.2 Precasualty Activities (Cargo, Loading, and Arrangement)

From December 8 to December 10, 2023, the *Genius Star XI* was in port in Hai Phong, Vietnam, loading cargo. The vessel was preparing to transport a cargo of 192 lithium-ion battery energy storage system (BESS) units (Powin Stack 800 Centipede Energy Segment) and 35 Harmonic Adsorption Recuperative Power

System (HARPS) heat exchangers to Long Beach, California. Powin LLC, the owner of the cargo, manufactured the BESS units in its Vietnam manufacturing facility in 2023.The BESS units were designed to function as stationary landside power supply units that stored energy during peak electrical generation and could supply power to an electrical grid during low-generation periods.

Each BESS unit contained 28 lithium-ion battery packs, each of which were made up of three battery modules consisting of ten lithium-ion battery cells. The BESS unit battery storage section was divided into two columns of seven shelves, and each shelf held two battery packs, which collectively weighed 136 kilograms (300 pounds). The battery packs faced away from each other, with the battery pack busbar facing outward toward the access door (see figure 3). The BESS unit had two doors, one at the front and one at the back.

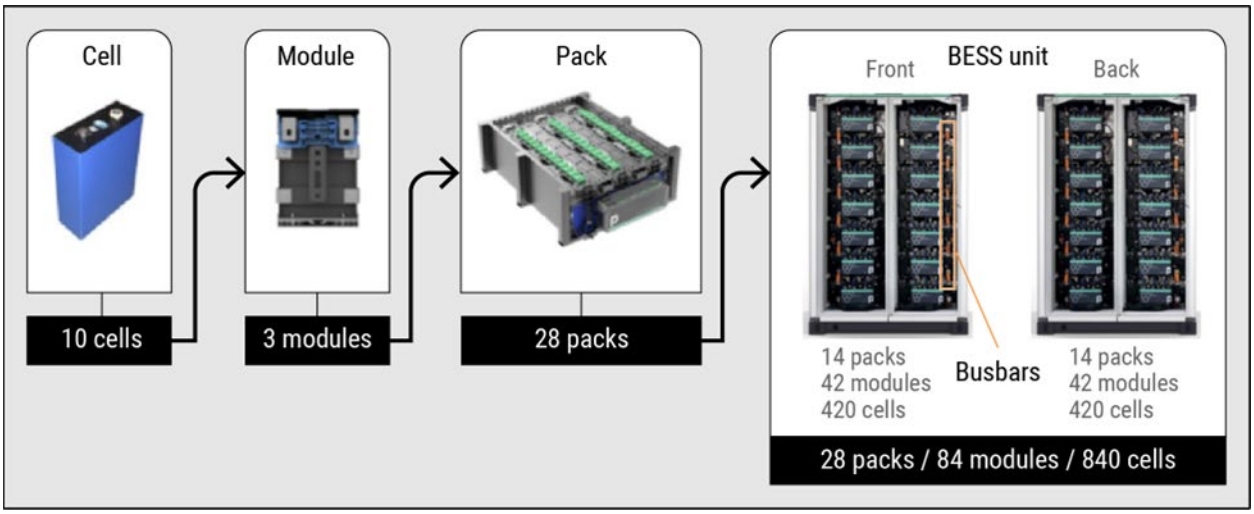

Figure 3. Internal arrangement of a BESS unit (Powin Stack 800 Centipede Energy Segment). (Background source: Powin)

Each BESS unit was classified as "UN3536 Lithium Batteries Installed in Cargo Transport Unit *lithium ion batteries or lithium metal batteries*" in accordance with the regulations of the International Maritime Organization's International Maritime Dangerous Goods (IMDG) Code. This classification required that batteries be—

> securely attached to the interior structure of the cargo transport unit by means of placement in racks, cabinets, etc. in such a manner as to prevent short circuits, accidental operation, and significant movement relative to the cargo transport unit under the shocks, loadings, and vibrations normally incident to transport.

Each BESS unit had a maximum energy capacity of 800 kilowatt-hours (kWh) and weighed approximately 9,572 kilograms (21,103 pounds) and was

3,431 millimeters (11 feet) high, 1,572 millimeters (5 feet) wide, and 2,443 millimeters (8 feet) long (see figure 4). To maintain the proper operating temperature of the batteries, each unit had its own air conditioning unit located above the lithium-ion battery storage area, which was not operational while in transportation.

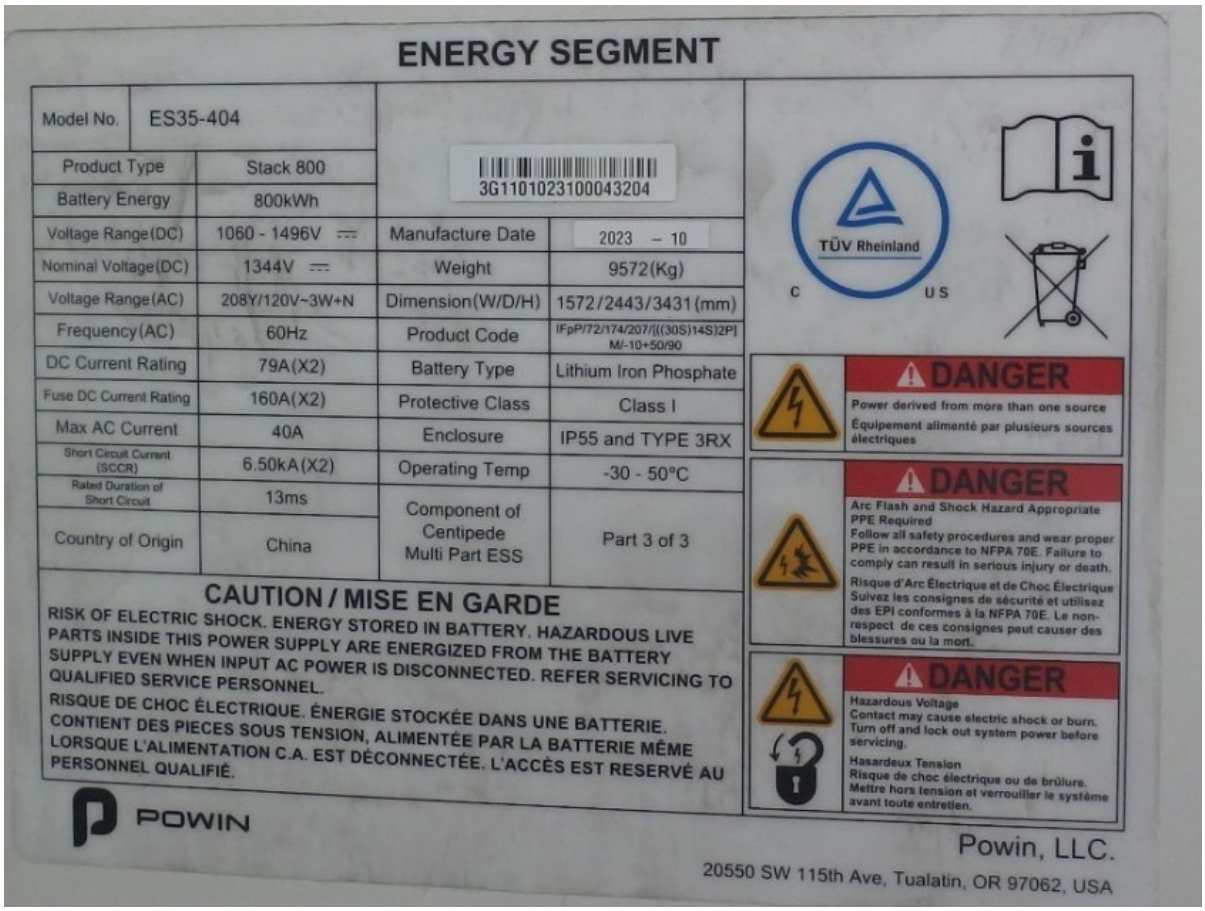

Figure 4. Photo of the BESS placard attached to each BESS unit, showing contents of each unit.

The *Genius Star XI* was on a time charter to Norden (the charterer), a Danish shipping company.[2] As the vessel charterer, Norden provided the approved storage and lashing plan for the BESS units within the cargo holds; this plan was similar to those utilized for five previous cargo transports of the BESS units. During Norden's time charter of the *Genius Star XI*, the vessel's crew were employed by the Wisdom Marine Group. As per the vessel's safety management system (SMS), the chief officer was responsible for reviewing the storage and lashing plan for both the BESS units

[2] During a time charter, the owner of the vessel retains control of the vessel and is paid by the charterer for a pre-defined period. The owner is responsible for maintenance, navigation, and crew, while the charterer takes on the rest of the expenses incurred to manage the vessel (such as fuel, port fees, and loading and unloading expenses).

and HARPS heat exchangers and ensuring they complied with the cargo securing manual and vessel's stability requirements. (The chief officer later confirmed with investigators that this review and approval had occurred.)

The storage and lashing plan called for the 192 BESS units to be stowed on the vessel, with 160 BESS units arranged in eight rows across 10 bays in each of the two cargo holds, no. 1 and no. 2, on the tween deck (80 BESS units in each hold). The remaining 32 BESS units were arranged in two rows across eight bays on the lower deck in the two holds (16 BESS units in each hold). The storage and lashing plan called for the HARPS heat exchangers to be loaded and stowed on the lower deck in cargo holds no. 1 and no. 2. (see figure 5).

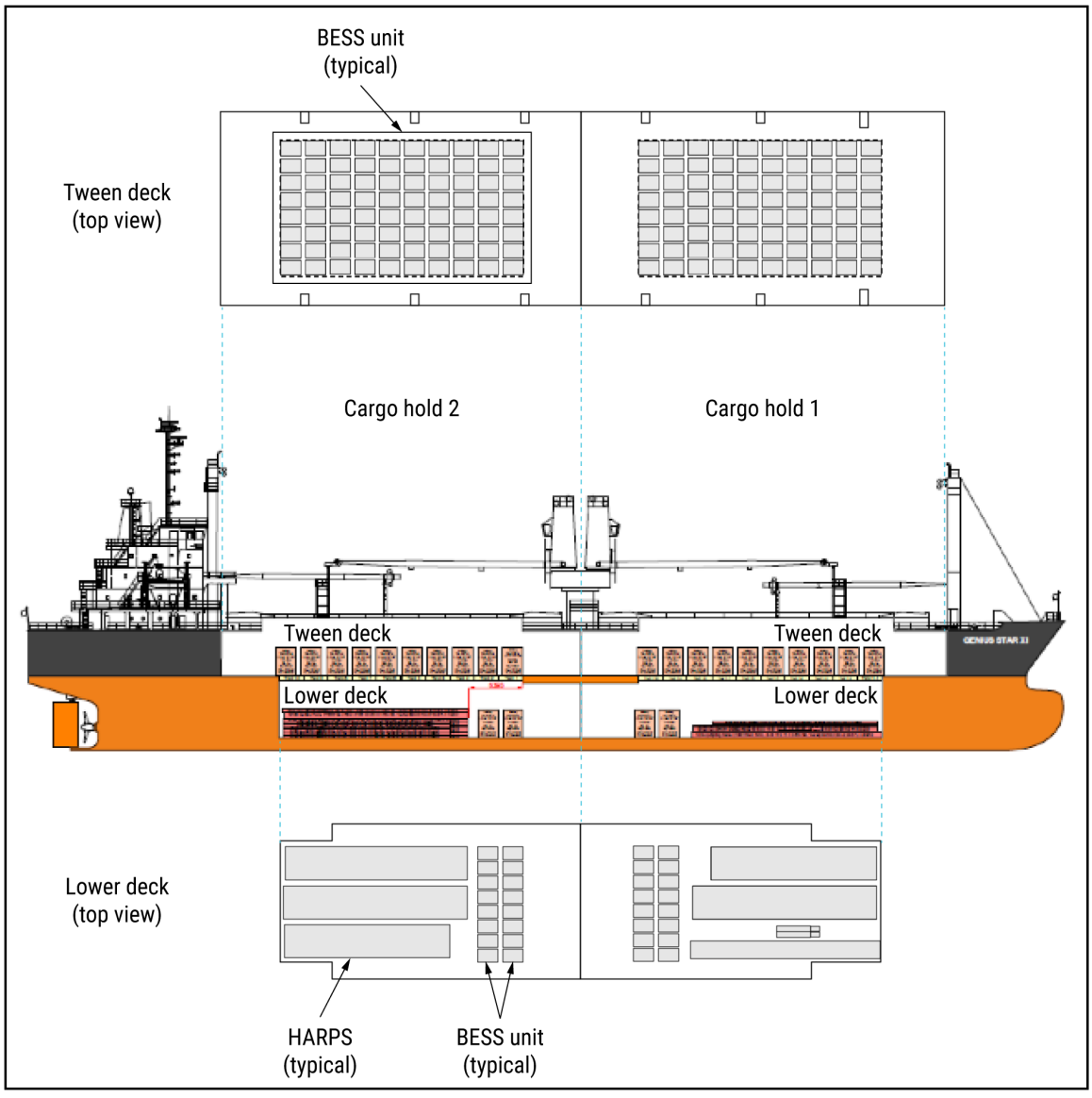

Figure 5. Location of the 192 BESS units (small gray boxes) and 35 HARPS (within long horizontal gray rectangles) within cargo hold no.1 and no. 2. (Background source: Norden)

The vessel's cargo securing manual recommended utilizing wire rope, chains, or material with equivalent strength such as lashing belts. Powin requested the shipper/crew use polyester lashing belts instead of chain fall or wires to avoid scratching the exterior of the units. The charterer provided the lashing belts for the cargo securing. Similar sized polyester lashing belts were also used for previous shipments of BESS units by other vessels.

For this voyage, the storage and lashing plan required that each BESS unit be secured with four polyester ratcheted lashing belts connected to a D-ring that was held in place by a bracket welded to the deck. As per the approved plan, the lashing belts were 5.97 meters (19.6 feet) long, with a breaking load of 5 metric tons, and each belt had one steel hook at each end. Also, in accordance with the approved plan, the D-ring and bracket assembly had a breaking load of 36 metric tons.

The belts connected to the four corner-lifting holes located between the air conditioning section and the battery storage section of the BESS unit. Chafing gear was placed in the lifting hole to protect the lashing belt from rubbing. One of the hooks on the belt was connected to a D-ring on the deck; the belt was then fed up through one of the corner-lifting holes and returned to the D-ring where the second hook was also connected. Stevedores would then ratchet up the lashing belt until it was taut (see figure 6).

Figure 6. Postcasualty photo showing the method used to secure the units within the cargo hold. (Source: US Coast Guard).

The brackets holding the D-Rings were installed at the end of each row and in between each of the units on the tween deck, and to the deck of the lower section of each hold. The D-ring at the end of each row had one lashing belt connected to it to hold one corner of a BESS unit. The D-rings located between the BESS units, each had two lashing belt (two hooks per belt) connected to them (see figure 7). The charterer required the personnel welding the D-ring brackets in place on the vessel to hold welding certificates and have relevant previous work experience for the securing of brackets to a deck.

Figure 7. Postcasualty photo showing a D-ring held by a bracket that is attached to the tween deck, with four hooks (two lashing belts). (Source: Coast Guard)

The port captain and the manager directing the loading and securing of the cargo, as well as the surveyor acting on behalf of Powin, oversaw the quality control of the storage and securing of the cargo. Additionally, the vessel's crew visually inspected the bracket, D-ring, and lashing belts. If discrepancies were identified, they were to be communicated to the vessel's master as well as managers overseeing the cargo operation and corrected prior to the vessel's departure; however, none were noted.

1.3 Event Sequence

On December 10, the *Genius Star XI* got underway from Hai Phong, bound for Busan, South Korea, where it arrived on December 16. After taking on fuel at anchor, the vessel departed Busan on December 18, bound for Long Beach, California.

While the vessel was underway, per the vessel's cargo storage manual, the crew conducted daily cargo checks to ensure that the lashings remained taut and the BESS units and the HARP heat exchangers were secured and had not moved. These checks were logged into the vessel's logbook. Investigators reviewed the logbooks

and did not find any reports by the vessel's crew regarding issues with storage and securing of the cargo.[3]

On December 24, the vessel began encountering heavy weather in the North Pacific Ocean while transiting near the Bering Sea. At midnight on December 25, weather conditions consisted of gale-force winds, high seas, and heavy swells. Winds were from the northwest at 26.1 knots, with gusts to 31.3 knots. The seas were observed by the crew as 19 feet, and swells were 13 feet. Heavy seas caused the vessel to roll, and sea water was reported to have washed over the vessel's cargo hatches.

At 0830 Magadan standard time on December 25, the master altered the vessel's course to enable the crew to safely go out on deck and check the cargo. Crewmembers discovered that all the BESS units located in bay 4 of hold no. 2 on the tween deck had shifted. About the same time, the chief officer observed black smoke coming from a manhole cover that had just been opened for crew access into cargo hold no. 1.[4] The alarm was sounded and the crew immediately mustered. Aware that hazardous cargo was on fire, the master directed the crew to check cargo hold no. 2 to ensure the cargo there was not on fire before he released CO_2 into cargo hold no. 1. After receiving confirmation that cargo hold no. 2 was not on fire and that cargo hold no. 1 was clear of personnel and its ventilation secured, the master ordered the chief engineer to release the CO_2 into cargo hold no. 1.

After about 30 minutes, the chief engineer heard the CO_2 system stop releasing. He confirmed all of the CO_2 bottles designated for that cargo hold had released. The crew externally checked the area near cargo hold no. 1 for heat and signs of fire with an infrared sensing temperature gun. The crew determined the fire had likely been extinguished, based on decreasing temperature readings on the infrared sensing temperature gun from within the cargo hold, and, throughout the day, they continued to check to ensure there were no reflashes.

The master then ordered the crew to re-lash the cargo that had shifted in cargo hold no. 2. About 1000, the crew began re-securing the loose BESS units in bay 4 of cargo hold no. 2 with extra chain falls that were on board the vessel, and they

[3] According to the logbook, the crew's last cargo check and re-lashing occurred on December 24 (0820–0945) before the weather became worse about 1600.

[4] There is no note of a vessel fire alarm in the crew logbook. According to interviews, the crew was focused on putting out the fire after it was discovered by the chief officer.

inspected the rest of the cargo in that hold to ensure it was still secured. They finished about 1315.

The master contacted the operating company about the fire; the vessel operator directed the master to contact the US Coast Guard to inform them of the situation and that there was no remaining CO_2 left on board to fight another fire. The *Genius Star XI* received permission from the Coast Guard to enter US waters, and the vessel proceeded toward Dutch Harbor, Alaska. As the vessel proceeded to Dutch Harbor, the crew continued to monitor cargo hold no. 1 from the exterior with an infrared sensing temperature gun for any signs of a fire, but there were none.

On December 28, 2023, about 0100 local time (Alaska standard time), the *Genius Star XI* again encountered heavy seas. Winds were from the southeast at 26.1 knots, and the wind gusts were 31.3 knots. The seas were recorded by the crew as 22 feet, and swells were 13 feet. The vessel was rolling heavily, and about 0215, the fire panel indicator for cargo hold no. 2 alarmed on the bridge. Crewmembers observed smoke coming from ventilation ducts in cargo hold no. 2. Because there was no CO_2 left to fight a fire, the master changed course from 064° to 005° to reduce the rolling and pitching to allow the crew to go on deck and use water to cool the area around cargo hold no. 2.

At 0223, the crew started a fire pump, and at 0228, the crew began spraying sea water on the outside of the no. 2 cargo hold with fire hoses. The crew continued to spray water on the area of cargo hold no. 2 for about 4 hours, then monitored the area with the infrared sensing temperature gun. As the vessel approached Dutch Harbor, the temperature within the hold was decreasing, which indicated that the fire was extinguishing and not spreading (see figure 8).

Figure 8. Infrared photo of the *Genius Star XI* en route to Dutch Harbor, showing an indication of heat (in white) within cargo hold no. 2 on December 28. (Background source: Coast Guard)

1.4 Arrival and Post-fire Response and Containment

On December 29, the *Genius Star XI* arrived off Dutch Harbor and was directed by the Coast Guard to anchor 2 miles from shore due to the potential risk of a reflash of the fire. The Coast Guard stood up an incident command with local, state, and other federal agencies to oversee the safe removal and containment of the damaged batteries from the units. Marine firefighters from T&T Salvage and Resolve Marine boarded the vessel to assess the situation, and they determined that the fires within the cargo holds were extinguished.

On January 27, 2024, Energy Security Agency (ESA), a US company with expertise in lithium battery safety, arrived on scene. Wisdom Marine, the operator of the *Genius Star XI,* hired the company to perform a damage assessment of the BESS units and safely dispose of the damaged lithium-ion battery packs.[5] ESA performed a visual inspection of the BESS units, looking for signs of damage and any potential safety hazards. The company measured the voltage battery packs to identify any electrical hazard. To mitigate any electrical hazard discovered, they removed the busbars from all of the damaged units (see section 1.5.1 for discussion on the specific

[5] National Transportation Safety Board investigators were not present during ESA's damage assessment in Dutch Harbor because of the potential for exposure to electrical hazards.

units damaged). In addition, the battery packs from the severely burned units, were stowed in specialized containers to prevent potential discharge of the voltage and shipped with the vessel to be eventually sent to a facility able to properly disposed of the damaged lithium-ion battery packs. ESA representatives continuously checked the thermal imaging and gas monitors to ensure there were no new fires and no hazardous gases were venting from the battery packs. No incident occurred during the removal and repackaging of the battery packs in Dutch Harbor.

While at Dutch Harbor, the vessel's CO_2 system was replenished, and all of the cargo (damaged and undamaged) was secured with chain falls as a further safety precaution to prevent any movement of the cargo. On February 12, 2024, the Coast Guard deemed the vessel safe to continue, and it departed Dutch Harbor the same day. The delivery port was changed from Long Beach to San Diego, California. The vessel docked at the Port of San Diego on February 24.

1.5 Damage

1.5.1 Overview

Coast Guard investigators boarded the vessel while it was anchored and then when it docked in Dutch Harbor to assess the damage to the vessel and cargo.

While the *Genius Star XI* sustained no structural damage from the two fire events, investigators identified that three BESS units—two located on the tween deck of cargo hold no. 1 and one located on the tween deck of cargo hold no. 2—had experienced an internal fire (see section 1.5.4). They also discovered that 43 of the 160 BESS units stored on the tween decks of cargo hold no. 1 and no. 2 had been damaged. Forty one of the 43 damaged units had broken from their lashings and shifted, and several of those had experienced some level of internal shelf rail deformation—meaning the shelf rail structure had bent downward, allowing the bolt seat holding the lithium-ion battery cells to partially or to fully slip off the securing bolt (see figure 9).

None of the cargo BESS or HARPS units on the lower deck of cargo hold no. 1 and no. 2 showed any signs of shifting or parting of the lashing belts during the transit.

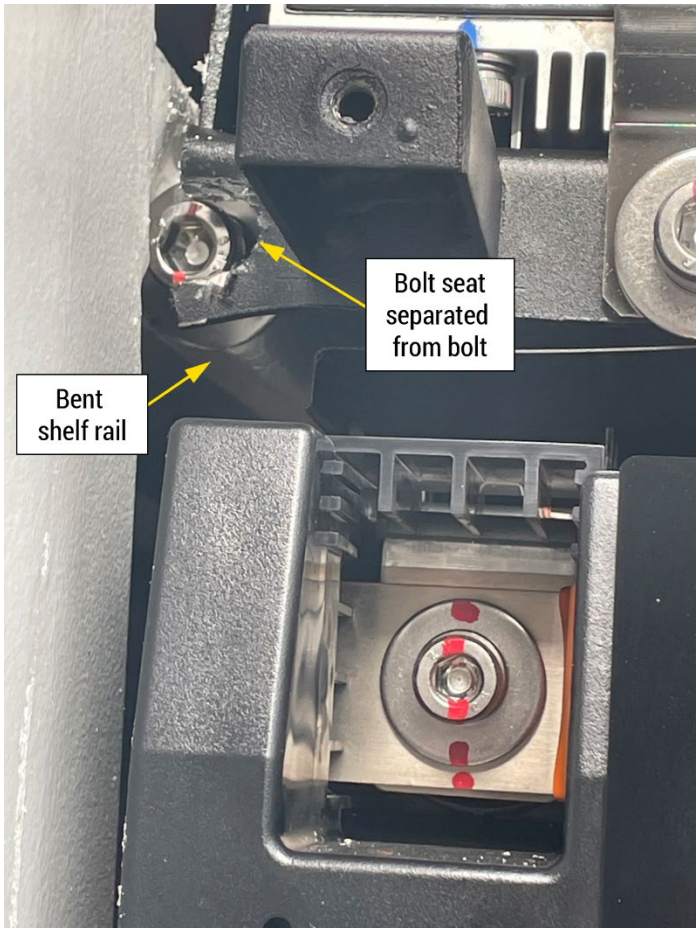

Figure 9. An example of a shelf rail deformation showing a bent shelf rail with a bolt seat for the shelf separated from the bolt.

1.5.2 BESS Unit Shifting

Twenty-four BESS units in cargo hold no. 1, where the first fire was discovered on December 25, became loose and shifted on the tween deck (see figure 10).

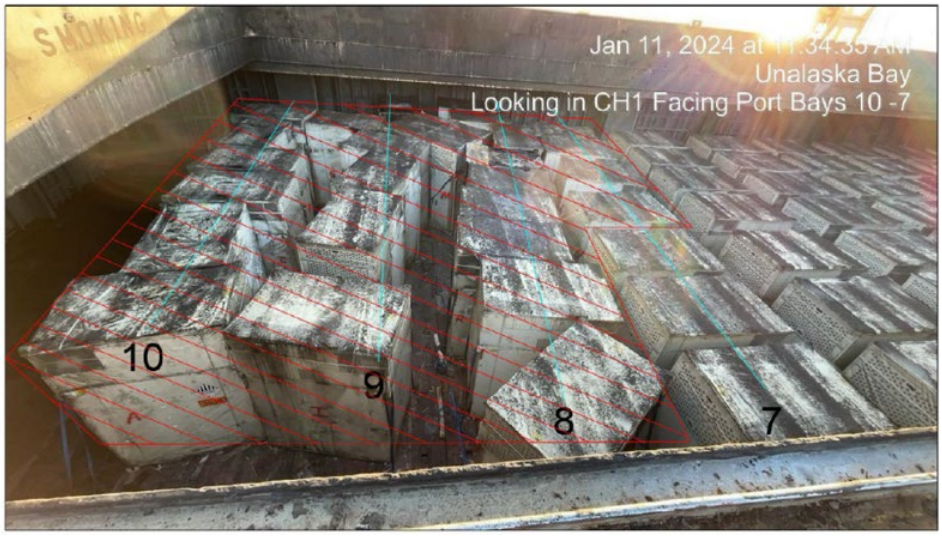

Figure 10. Shifted BESS units in tween deck cargo hold no. 1. (Source: ESA)

Seventeen BESS units in cargo hold no. 2, where the second fire was discovered on December 28, became loose and shifted on the tween deck (see figure 11).

Figure 11. Shifted BESS units on the tween deck of cargo hold no. 2. (Source: ESA)

1.5.3 BESS Unit Securing Equipment Failures

Several brackets securing the D-rings (which had a breaking load of 36 metric tons) to the tween decks of cargo hold no. 1 and no. 2, had separated, allowing the BESS units to shift. The separations occurred at the welds between the brackets and

the deck. Additionally, some of the brackets deformed, and the welds fractured, but these brackets still remained partially connected to the deck (see figure 12).

Figure 12. *Left to right*: Bracket found separated from the deck, and a D-ring partially pulled from a deformed bracket that was still connected to the deck. (Source: Coast Guard)

Coast Guard investigators found that the hooks on the ends of the ratchet lashing belts were not compatible with the D-rings. The D-rings were too thick (diameter too large) for the lashing hooks, which resulted in the D-ring not fully seating, or not engaging to the full depth of the throat of the hooks, with only the tip of the hook securing the lashing belts to the D-ring (see figure 13).[6]

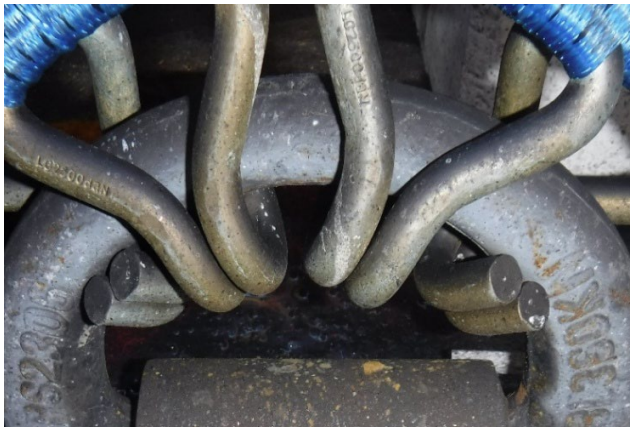

Figure 13. Close-up view of hooks to lashing belts holding BESS units, showing only the tip of the hook in contact with the D-ring (Source: Coast Guard)

[6] A *throat* is the opening in a hook which allows for the attachment and detachment of lashing belts, wire rope, and chain falls to cargo and vessel securing points.

Similarly, the same hook and D-ring incompatibility was found with the lashing belts holding the BESS units and the lashing belts holding the HARPS heat exchangers on the lower deck in cargo hold no. 1 and no. 2, also with a breaking load of 36 metric tons (see figure 14).

Figure 14. Example of hooks and lashing belts holding a HARPS Heat Exchanger, with only the tip of the hook in contact with the D-ring. (Source: Coast Guard)

Investigators also found that numerous lashing belt hooks securing the BESS units to the D-rings on the tween deck of cargo hold no. 1 and no. 2 had fractured and separated at the turn of the hook (see figure 15).

Figure 15. Photos of two separate hooks that fractured and separated from a D-ring. (Source: Coast Guard)

ESA removed all of the separated brackets and D-rings within the cargo holds in order to facilitate the safe removal of the damaged lithium-ion batteries and the safe resecuring of the cargo by the vessel's crew. Therefore, the number of brackets and hooks that had separated during the two incidents—and the brackets' and hooks' original locations—could not be determined.

1.5.4 Origin of the Fires

Coast Guard investigators found that the fire damage was limited to the BESS units on the tween decks in cargo holds no. 1 and no. 2. Three BESS units—two on the tween deck of cargo hold no. 1 and one on tween deck no. 2—were determined to be the sources of the two fires (see figure 16).

Figure 16. Example of a BESS unit with internal fire damage. (Source: ESA)

According to Coast Guard investigators, the first fire, reported on December 25, originated on the tween deck of cargo hold no. 1. Two of the units broke loose and experienced an internal fire (see figure 17). In addition, two other battery units broke loose and were damaged externally from the units where the fire originated. Twenty units broke loose from their lashings and moved within the cargo hold but did not experience an internal fire or receive external fire damage.

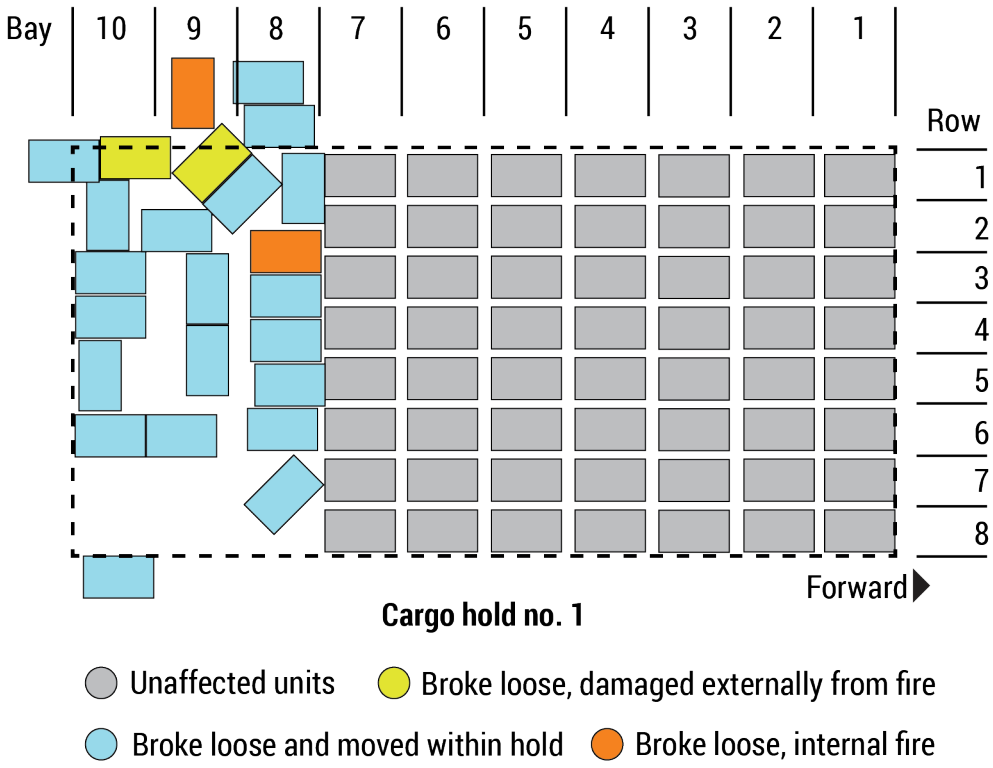

Figure 17. Post-fire configuration of the BESS units on the tween deck in cargo hold no. 1. (Background source: ESA)

Coast Guard investigators determined that the second fire, reported on December 28, originated on the tween deck of cargo hold no. 2. One of the units broke loose and experienced a fire (see figure 18). In addition, two other units were damaged externally from the original fire, but these units remained secure to the lashing belts and did not move. Sixteen units broke loose from the lashing belts and moved within the cargo hold but did not experience an internal fire or receive external fire damage.

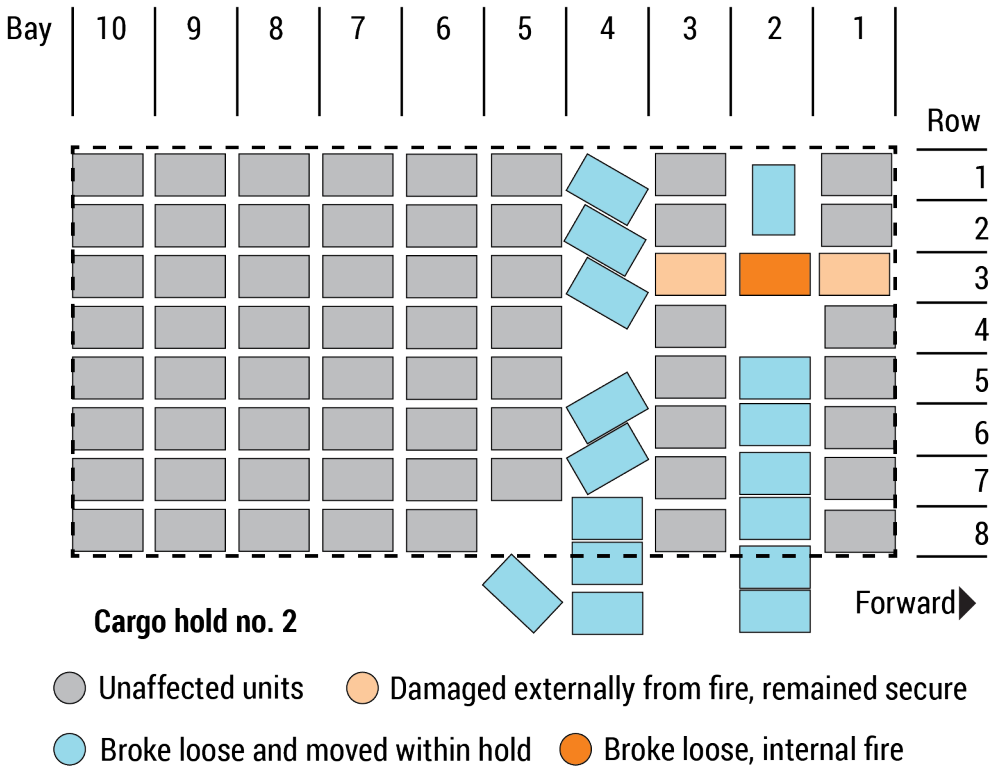

Figure 18. Post-fire configuration of the BESS units on the tween deck in cargo hold no. 2. Background source: ESA)

1.6 Additional Information

1.6.1 BESS Unit Examination

After the *Genius Star XI* docked at the Port of San Diego, on February 24, 2024, National Transportation Safety Board (NTSB) investigators went aboard the vessel to view the layout and condition of the cargo before the BESS units were offloaded. The next day, after offloading of the damaged BESS units, investigators from the NTSB, the Bureau of Alcohol, Tobacco, Firearms and Explosives, and the Pipeline and Hazardous Materials Safety Administration, as well as personnel from ESA and Powin, conducted a more focused exam of the damaged BESS units. An initial overview of all 43 damaged BESS units was conducted to confirm the information passed by Coast Guard investigators at Sector Western Alaska and US Arctic and the ESA when they surveyed the damage in Dutch Harbor.

1.6.2 Shelf Rail Deformations

According to ESA, 30 of the 41 BESS units that broke loose from their lashing belts on the tween deck had shelf rail deformation, where the shelf rails bent downward and the bolt seat of the shelf had fully separated from two or more bolts connecting it to the shelf rail, resulting in a shelf collapse. The remainder showed some level of shelf rail deformation with shelves becoming loose or unstable but with no shelf collapse. In some cases, the shelf rail deformation was so significant that it led to a complete collapse of multiple shelves within a BESS unit (see figure 19).

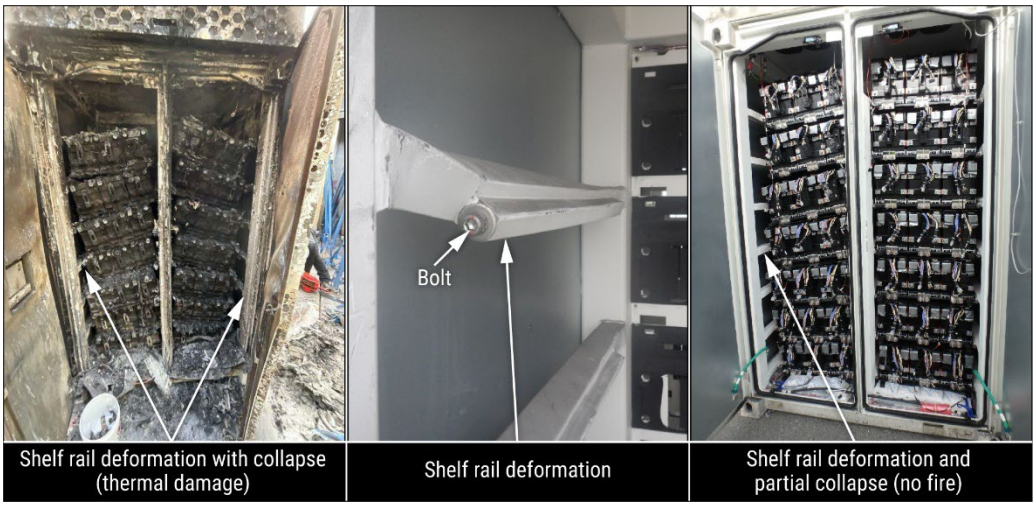

Figure 19. *Left to right*: Postcasualty examples of shelf rail deformation in BESS units, showing units that experienced (1) shelf rail deformation with collapse and thermal damage, (2) shelf rail deformation, and (3) shelf-rail deformation followed by a several shelf collapses with no fire. Note: the busbars were removed. (Background source: ESA)

Investigators focused on 15 of the 43 damaged BESS units on the tween decks (seven from cargo hold no. 1 and eight from cargo hold no. 2) (see figure 20). Of those 15 units, 13 had broken away from their lashing belts and had shelf rail deformations that were bent down. In addition, investigators noted that within these 13 units, some or all of the shelves containing the lithium-ion battery packs had also collapsed. It was also noted that the exterior of these units had several dents and scratches, but this damage did not penetrate deep enough into the interior of these BESS units to damage shelf rails.

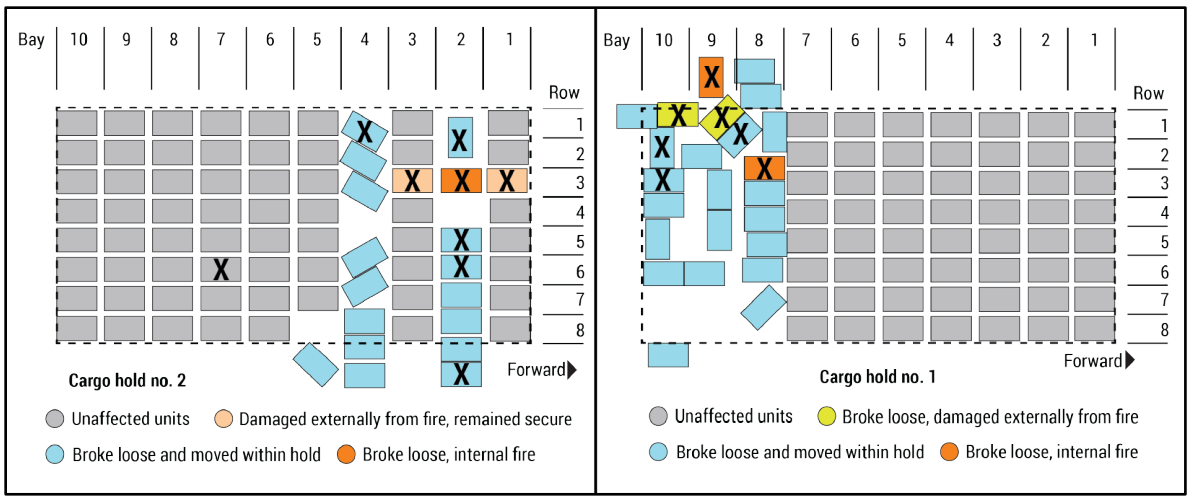

Figure 20. BESS units marked with an *X* were examined by investigators on February 25, 2024. (Background source: ESA)

The other two units of the 15 examined had fire damage but remained secured during the incident. Investigators found that the unit located in cargo hold no. 2, row 3, bay 1 had heavy thermal damage on its exterior, and the unit located in cargo hold no. 2, row 3, bay 3, had soot located within the interior.

Furthermore, NTSB investigators spot-checked a sixteenth BESS unit, which was located in cargo hold no. 2, row 6, bay 7, that had not broken loose from its lashing belts and had not been damaged by the fire. The exam found that this unit showed signs of structural deformation of the shelf rails. Specifically, the shelf rails were beginning to bend downward. NTSB investigators noticed gaps between the bolts of the shelf rails and the bolt seats attached to the packs (see figure 21). The damage in this unit was generally similar to that seen in those found in the damaged units that had broken free from their lashing belts.

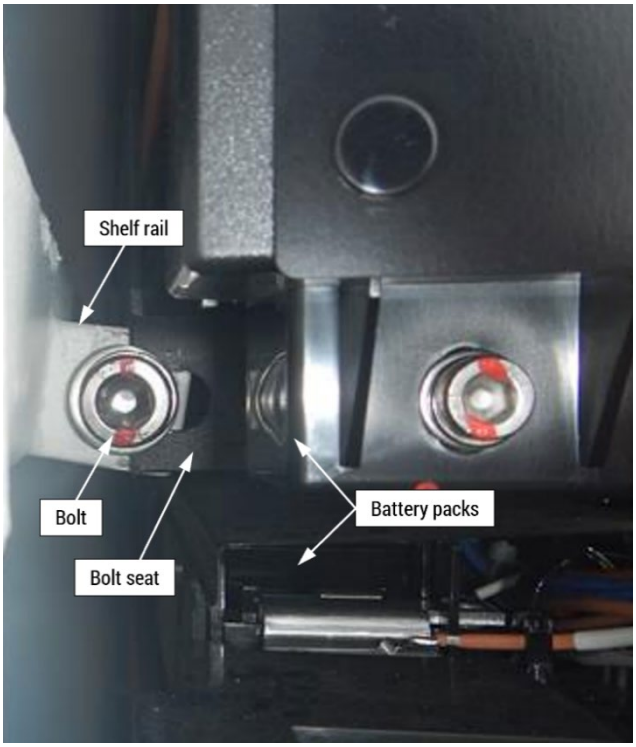

Figure 21. Postcasualty photo of a BESS unit that had not broken loose from its lashing belts but had deformed shelf rails and battery pack shelf separation. (Background source: ESA)

1.6.3 Scorch Marks and Arcing

The 13 BESS units with structural deformation and collapsed shelves that were examined on February 25 also had indents, as well as arcing and scorch marks, within their interior structure (see figure 22).

Figure 22. *Left to right*: Examples of internal damage due to indent and scorching, and arcing (circled) found inside of the BESS units on the tween deck in cargo hold no. 1 and no. 2. (Background source: ESA)

1.6.4 Postcasualty Actions

Following the casualty, four additional bulk carriers owned and operated by different companies transported additional BESS units to ports on the west coast of the United States. To prevent a similar incident, the charterer, Norden, modified its vessel stowage plan by increasing the breaking load of the lashing belts to 10 metric tons for the transportation of the units. The larger lashing belts also had larger hooks, with a wider throat, which allowed the hook's throat to be fully and properly seated on the D-rings. In addition, the charterer directed the vessel masters for these shipments to take a more southerly route across the Pacific to avoid the heavier seas generally encountered in the North Pacific Ocean.

Further, following the casualty, the vessel operator, Wisdom Marine Group, conducted an internal assessment of the casualty, per their SMS, and subsequently sent out an email to its vessel masters discussing the root causes of the fires aboard the *Genius Star XI*. In their email, they acknowledged that the cargo lashing procedures were not implemented properly and the crew did not have sufficient knowledge to check the lashing conditions within the loading port. The email also

reminded masters about the importance of ensuring that crew followed the cargo securing manual, and that the certificate of lashing materials—including D-ring, wire, other lashing materials—be provided by the charterer. Regarding welding, the operator said welders should hold certificates and be qualified to conduct the welding of the brackets, and D-rings should be welded firmly. The email also recommended only securing one piece of cargo to the same D-ring and to properly place the bottom dunnage and wedges. In addition, the operator said the chief officer should lead the crew during the checking of the condition of the lashings.

2 Analysis

On December 25, 2023, a fire occurred on the tween deck of cargo hold no. 1 of the *Genius Star XI*, followed by a second fire on December 28, which occurred on the tween deck of cargo hold no. 2. Both fires occurred as the vessel was carrying a cargo of 192 lithium-ion battery BESS units while transiting the North Pacific Ocean in heavy weather conditions. In the first incident, on December 25, the crew fully discharged the vessel's fixed gas CO_2 fire extinguishing system into cargo hold no. 1 to extinguish the fire. In the second incident, on December 28, without additional CO_2 available, crew used fire hoses to contain the fire in cargo hold no. 2. The *Genius Star XI* anchored near Dutch Harbor on December 29 for assistance and to assess the damaged cargo, and there, the fire was declared extinguished.

While transiting the North Pacific Ocean, the vessel encountered heavy weather, with seas 17–22 feet high and wind gusts up to 31 knots. (It is common for vessels operating in those waters in December to encounter such weather.) After the vessel arrived in Dutch Harbor to assess the damage, the Coast Guard (in coordination with ESA) determined that 43 of the 160 BESS units on the tween deck in cargo hold no. 1 and no. 2 had been damaged. In addition, 41 of the units had become loose—24 on the tween deck of cargo hold no. 1 and 17 on the tween deck of cargo hold no. 2. They found that the fires originated from three of the 41 BESS units that had broken loose from their lashing belts (two on the tween deck of hold no. 1, and a single unit on the tween deck of hold no. 2).

For the planned voyage to Long Beach, California, from Vietnam, the BESS units had been arranged and secured in accordance with the approved storage and lashing plan, which had been previously used by the operator (without any known issue) for the transportation of the units on other cargo vessels. As requested by BESS manufacturer Powin, the stevedores utilized polyester lashing belts—which had a holding strength of 5 metric tons—to secure the units. These lashing belts complied with the vessel cargo securing manual. A lashing belt was passed through each of the upper lifting holes for the units (four lifting holes, two on each side of a unit) and then connected to the D-rings via lashing belt hooks. Chafing gear was placed within each lifting hole to protect the lashing belt from rubbing. The D-rings, which were held by the brackets that were welded to the deck, had a breaking load of about 36 metric tons.

Investigators found that numerous lashing belt hooks had fractured. A closer examination of the remaining connections between the lashing belt hooks and D-rings found that the diameter of the D-ring and the inner diameter of the hook (throat opening) were not compatible. The D-ring circumference was larger than the throat of the hook; essentially, the hook was not able to fully seat on the D-ring. As a

result, only the tip of the hook was securing the lashing belt to with the D-ring. This concentrated the securing load at the turn, or bend, of the hook, instead of having that load properly transmitted across the full throat of the hook, resulting in the hook's fracture and separation. Since each BESS unit was secured by four lashing belts, the fracturing of one lashing belt hook placed additional stress on the unit's remaining hooks, and, because the hooks were not properly seated on the D-ring, it is more likely that they would subsequently fracture and separate. These lashing belt hook failures would have resulted in loose and shifting BESS units.

Additionally, investigators observed that numerous welded brackets securing D-rings had separated or had partially separated from the tween decks. Once a hook on a lashing belt had fractured, the remaining three D-rings and brackets, still attached to a lashing belt, would have been subjected to higher forces to hold the BESS unit in place during heavy seas. Therefore, it is more likely that the welds holding the bracket to the tween deck would subsequently fracture and separate. Also, once the BESS units started to shift within the cargo hold, they could have struck D-ring brackets, causing the brackets to separate from the tween deck. Therefore, it is likely that in addition to shifting cargo from lashing hook failures, the separation of the D-ring securing brackets from the tween deck also contributed to the BESS units becoming loose and shifting within the cargo holds.

The Code of Safe Practice for Cargo Stowage and Securing, adopted in November 1991 by the International Maritime Organization, is an international standard to promote the safe stowage and securing of cargoes. According to the International Maritime Organization,

> The accelerations acting on a ship in a seaway result from a combination of longitudinal, vertical and predominantly transverse motions. The forces created by these accelerations give rise to the majority of securing problems. The hazards arising from these forces should be dealt with by taking measures both to ensure proper stowage and securing of cargoes on board and to reduce the amplitude and frequency of ship motions.[7]

The incompatible fit of the lashing belt hooks with the D-rings for both the BESS units and the HARPs, however, was not identified as a concern nor addressed by the vessel's crew or the personnel overseeing the loading of the cargo prior to the vessel getting underway (the storage and lashing plan only specified the holding strength). Although there was a storage and lashing plan, the crew implementing the plan did

[7] See Code of Safe Practice for Cargo Stowage and Securing (CSS Code).

not identify the incompatibility of the hooks with the D-rings, which compromised the effectiveness of the plan.

The investigation found that the 41 BESS units that had broken from their lashing belts and shifted had some level of internal shelf deformation. Additionally, the 13 units that had broken from their lashing belts and were examined by the NTSB had one or more shelves that had detached from the deformed shelf rail, resulting in shelf collapses within the unit. When a shelf weighing 136 kilograms (300 pounds) detached from its rail and collapsed, it enabled the two lithium-ion battery packs on that shelf to move freely and impact the interior structure of the BESS unit.

Additionally, arcing and scorch marks were found within those same 13 units, which likely occurred when the exposed battery pack busbar impacted the inside of the unit and caused the batteries to short circuit and create an electrical discharge. The electrical discharge likely caused the lithium-ion batteries to short circuit, which damaged the cells and caused them to overheat, initiating a thermal runaway in three of the BESS units. A thermal runaway can occur when a battery cell is damaged, shorted, overheated, defective, deep discharged, or overcharged. The heat produced from a thermal runaway of a lithium-ion battery cell can exceed 572°F (300°C), which can easily cause the adjoining cells of the same battery bank to ignite, as well as cause nearby combustible materials to ignite, further spreading the fire.

Lithium-ion batteries undergoing a thermal runaway are difficult to extinguish with conventional firefighting methods and equipment found aboard a commercial cargo vessel, posing challenges for a crew in transit. Investigators evaluated the response by the vessel's crew following their discovery of the two fires. The crew discharged the fixed CO_2 fire suppression system for the first fire within cargo hold no. 1 and used boundary cooling with fire hoses for the second fire within cargo hold no. 2, combined with securing the ventilation. Therefore, the crew's actions to respond to the cargo fires were appropriate and likely prevented the fire from expanding. Fires caused by thermal runaway can quickly spread if combustible materials are nearby. However, the lack of ordinary combustibles in the cargo holds in the *Genius Star XI* and the noncombustible exteriors of the BESS units served to mitigate the risk of this occurring.

The IMDG Code requirement for the BESS units shipped under the classification "UN 3536" requires that lithium-ion battery packs be securely attached to prevent significant movement within the interior structure. The structural deformation documented in the 41 BESS units that had broken free from their lashing belts was made more severe by the movement of the units in the hold. However, the postcasualty examination showed that shelf rail deformation was also present in one BESS unit that did not break loose from its lashing and was not impacted by other

loose BESS units. The shelf rail deformations seen within this unit highlight a potential weakness in the internal structure and design of the BESS unit (which is intended for stationary land application) when subjected to transportation in the maritime environment.

3 Conclusions

3.1 Probable Cause

The National Transportation Safety Board determines the probable cause of the two (December 25 and Dember 28, 2023) fires aboard the *Genius Star XI* was the breakaway of 41 battery energy storage systems (BESS) units in the cargo holds during heavy weather conditions due to improperly secured lashing belts, which resulted in internal structural deformation of these units and thermal runaway of lithium-ion battery packs in three of the BESS units.

3.2 Lessons Learned

Ensuring Proper Cargo Securing

In addition to following a vessel's cargo securing manual and implementing the approved vessel storage and lashing plan, a vessel's crew must also conduct a thorough inspection of all the cargo-securing arrangements both during and after cargo loading. Such inspections are critical to identifying improper attachments or other concerns with cargo securement that could compromise the assumptions planners make in implementation of the plan. Not ensuring cargo is properly secured can result in cargo breakaway. Special attention should be placed on examining fitment of components, such as lashing belt hooks, wire, or chain falls used to secure the cargo to ensure they are properly seated (fully engaged) on the D-rings or other points of securement.

Vessel Particulars

Vessel	*Genius Star XI*
NTSB vessel group	Cargo, General (Bulk cargo vessel)
Owner/operator	GS Navigation S.A. / Wisdom Marine Lines Inc. (Commercial)
Flag	Panama
Port of registry	Panama, Panama
Year built	2012
Official number	N/A
IMO number	9622710
Classification society	Nippon Kaiji Kyokai
Length (overall)	410.0 ft (125.0 m)
Breadth (max.)	68.9 ft (21.0 m)
Draft (casualty)	29.5 ft (9.0 m)
Tonnage	9,984 GT ITC
Engine power; manufacturer	1 x 5,230 hp (3,900 kW); Hanshin 6L35MC6 diesel engine

NTSB investigators worked closely with our counterparts from **Coast Guard Sector Western Alaska and US Arctic** throughout this investigation.