

Maritime Summary Note n°252 – June 2023

« Car Carrier and maritime safety »

Maritime safety has substantially improved over the past few decades. According to the marine insurer Allianz Global Corporate & Specialty (AGCS), at the dawn of the 1990s, the global merchant fleet lost more than 200 vessels per calendar year. This metric has plummeted to between 50 and 75 total loss vessels annually over the past four years. This statistical shift is rendered even more impressive by the fact that the global fleet aggregates approximately 130,000 vessels today (over 100 gross tonnage, GT), compared to around 80,000 units thirty years ago. Significant advances in the safety of life and property at sea stem from international maritime safety regulations enacted via the IMO (most notably the SOLAS 74 Convention), upgraded vessel design architectures, high-performance shipboard embedded technologies, and enhanced risk management and mitigation protocols.

Specialized pure car and truck carriers (PCTCs) are not the ship category most exposed to absolute total losses. Over the past ten years, 41 total losses were recorded for Ro-Ro vessels and car-carriers, whereas within the most vulnerable category—conventional general cargo ships—this metric reached 357 losses. In 2022, the global PCTC fleet aggregated approximately 780 active vessels worldwide.

Nevertheless, the orders of magnitude regarding financial exposures vary drastically across ship typologies when factoring in cargo value, wreck removal costs, and environmental pollution mitigation expenditures. Mega-vessels continue to generate increasingly high insurance exposures, characterized by onboard fires, container losses, hazardous cargo incidents, and highly complex, capital-intensive salvage operations. Losses are becoming oversized, leading to increasingly frequent General Average (avaries générales) declarations. What specific risks do vehicle carriers face?

Context and historical background

Roll-on/roll-off (Ro-Ro) vessels were originally engineered to transport railway cars during the 19th century. During the Second World War, specialized landing crafts were deployed to transship tanks and military vehicles. The expansion of international tourism throughout the 1960s and 1970s triggered the emergence of a greenfield vessel typology: the car-ferry, followed more specifically by dedicated vessels designed to transport brand-new vehicles within a booming globalized trade network. To secure an order of magnitude, the very first purpose-built Ro-Ro ship commissioned into service in 1964 could accommodate a mere 460 cars.

Today, the top-performing Pure Car and Truck Carrier (PCTC) within this segment is the Höegh Trigger. It can accommodate 8,500 vehicles arranged across 14 cargo decks. These vessels are characterized by a massive windage area (emprise au vent) due to their high air draft (tirant d'air), which regularly raises critical stability challenges.

Onboard fires have henceforth emerged as a persistent total loss factor for vehicle carriers over the past decade. In numerous occurrences, fires involving vehicle cargoes have culminated in the absolute loss of both the freight and the vessel itself. On average, marine insurers suffer two major PCTC losses every year. The structural design of these vessels, coupled with intense commercial market pressures resulting in exceptionally short port turnaround times, operate as primary risk factors for car-carriers.

The stability of these vessels depends on highly complex loading and ballasting calculations executed prior to departure, while vehicle cargoes must be rigidly secured and properly lashed (arrimées) to mitigate the risks of fire or cargo shifting. Furthermore, Ro-Ro vessels are characterized by vast, wide-open deck spaces, an architectural layout that creates severe additional hazards for ship stability and accelerates the rapid propagation of fire.

The accidents of these ocean giants regularly dominate international maritime salvage news headers. Without diving into technical minutiae, prominent sea casualties since 2015 encompass:

- Höegh Osaka: grounded in January 2015 immediately upon departing the port of Southampton.

- Modern Express: disabled in January 2016 within the Bay of Biscay (golfe de Gascogne), suffering a severe list triggered by a cargo shift or a technical failure within its ballast water filling system. Transporting earthmoving equipment, trucks, and logs, it was ultimately towed to Aliaga, Turkey, for ship breaking.
- Honor: caught fire in February 2017 in Southampton.
- Auto Banner: caught fire in May 2018 in Incheon.
- Sincerity Ace: caught fire in December 2018 at sea.
- Diamond Highway: caught fire in June 2019 at sea.

Throughout these maritime casualties, two overriding operational problems systematically emerge: namely, the vessel's draft and stability constraints, and severe onboard fires tied directly to the cargo.

PCTCs: towering giants with volatile stability profiles

According to the AGCS Safety & Shipping Review report, subsequent to several post-accident casualty investigations, maritime experts revealed that pre-departure stability checks were either neglected or calculated based on inaccurate cargo weights. For Ro-Ro vessels and car-carriers, it is the sole responsibility of the shippers to declare the exact weight and mass of the loaded freight. Concurrently, the Master holds the primary obligation to ensure the ship's final intact stability. In the majority of investigated cases, the cargo was not entirely lashed and secured prior to departure. Turnaround port times that are too restricted to properly execute pre-departure safety inspections, coupled with intense commercial market pressures, can directly jeopardize maritime safety.

When suffering a casualty, Ro-Ro vessels are highly vulnerable to listing phenomena, which can rapidly lead to a total capsize. This operational vulnerability was illustrated by the Cougar Ace in 2006, which suffered a severe list due to a technical failure during a ballast water exchange operation. During the subsequent salvage inspection of the vessel at sea, a naval architect tragically lost his life. While the vessel was ultimately towed and repaired, the 4,700 brand-new vehicles on board were entirely destroyed. Similarly, the República di Genova capsized inside the port of Antwerp in 2007, though the ship was subsequently salvaged and repaired.

The most symbolic and monumental recent PCTC casualty remains that of the Golden Ray in September 2019, immediately upon departing the Port of Brunswick in Georgia (United States). According to the National Transportation Safety Board (NTSB), the probable cause of the capsize was rooted in human error regarding the crew's execution of stability and ballasting calculations. When the vessel initiated its listing sequence, its internal watertight doors had been left open, causing rapid progressive flooding and submergence.

The total cost of the accident was estimated at over \$200 million in direct hull and cargo damages, encompassing \$62.5 million for the total loss of the ship itself and \$142 million for its cargo of 4,100 vehicles—excluding the monumental expenditures required for the structural cutting, ship breaking, and environmental remediation of the marine ecosystem. Its wreck removal and slicing operation stands as one of the most expensive salvage operations ever executed in maritime history, surpassed only by the Costa Concordia wreck removal (which breached the \$1 billion threshold), and lasted for nearly two years. Following the investigation, the NTSB formally recommended that the vessel's operator overhaul its Safety Management System (SMS) to lock in mandatory verification procedures for stability calculations, while upgrading its SMS auditing processes to guarantee that crews strictly ensure the absolute closure of all watertight doors prior to getting underway.

Onboard fires: a dreaded and formidable peril

Although a net decrease in overall casualty frequencies is observed, the risk of fire remains exceptionally substantial, particularly within the PCTC vessel segment. While the historical frequency of fires and explosions is relatively low in percentage terms compared to alternative casualty categories, the financial cost of these insurance claims is typically extreme, heavily inflating the cumulative annual cost of global maritime claims.

The Höegh Xiamen caught fire in June 2020 inside the Port of Jacksonville, Florida, immediately upon completing the loading operations of a cargo batch of second-hand cars destined for West Africa. The casualty culminated in the absolute total loss of both the vessel (\$26 million) and its cargo of 2,420 used vehicles, whose value was estimated at \$40 million. The NTSB—the American equivalent to France's Marine Casualties Investigation Bureau (BEAmer)—concluded that numerous vehicles loaded on board

the Höegh Xiamen possessed batteries that had not been disconnected and secured in strict compliance with applicable procedures, which critically multiplied the risk of electrical arcing and component failures. It required more than a week to successfully contain the blaze, and nine shoreside firefighters were severely injured. Battery-originated fires are structurally harder to extinguish and retain the chemical potential to reignite weeks later.

In March 2019, the *Grande America*—a hybrid Container-Ro-Ro (ConRo) vessel departing Hamburg bound for Casablanca—was navigating within the Bay of Biscay (Golfe de Gascogne), approximately 140 nautical miles off the French coastline, when it fell victim to a violent fire originating from deck-stowed containers. The blaze proved entirely uncontrollable. The crew abandoned the *Grande America*, which drifted slowly before foundering on March 12 by a depth of 4,600 meters off the coast of La Rochelle. The BEA launched a formal technical casualty investigation, executed jointly with its Italian counterparts.

This marine investigation failed to establish definitive conclusions. Because the vessel foundered, the Voyage Data Recorders (VDR)—the black boxes of maritime transport—could not be recovered from the deep ocean floor. Nonetheless, the sinking was highly probably triggered by two simultaneous fire outbreaks. One of the blazes reportedly started within a deck container, and the fire subsequently propagated aggressively. The vessel was transporting a multi-layered cargo of both brand-new and second-hand vehicles, alongside 365 containers, 45 of which housed hazardous materials in varying quantities (aggregating approximately 1,000 tonnes) spanning sixteen different dangerous goods (including white spirit, hydrochloric and sulfuric acids, and chemical fungicides). The 2,400 tonnes of heavy fuel oil trapped inside the ship's bunker tanks triggered intense fears of a catastrophic oil spill along the French littoral.

Another even more recent casualty is the foundering of the Ro-Ro vehicle carrier *Felicity Ace* (operated by *Mitsui O.S.K. Lines*) in March 2022 off the coast of the Azores. The vessel was transporting nearly 4,000 high-value vehicles, including a substantial batch of Electric Vehicles (EVs). This specific cargo parameter triggered widespread international anxiety regarding the severe fire hazards associated with and their disastrous long-term consequences on the marine environment. The estimated insured value of the cargo on board ranged between \$400 million and \$500 million.

Advanced integration of EV and Alternative Fuel Vehicle (AFV) specificities

Over the past few years, a sharp resurgence in onboard fires has been recorded, a trend partly attributed to the chemical instability and thermal runaway explosiveness characteristic of the lithium-ion batteries equipping Electric Vehicles (EVs). Beyond fire hazards, another critical operational parameter arises: EVs are, on average, 25% heavier than conventional internal combustion engine vessels, a structural weight delta that directly impairs vessel stability calculations, deck load limits, and lashing structural tension.

The European legislative decision to ban the sale of greenfield internal combustion engine vehicles by 2035—voted by the European Parliament in February—has triggered intense debate. The defensive reaction of selected Member States particularly protective of their domestic automotive industries (notably Germany, Italy, and Central European nations) successfully moderated this environmental revolution by integrating vehicles fueled by synthetic e-fuels. However, this political friction revealed deep strategic divergences regarding European industrial and environmental policies, while seriously alarming one of the largest engines of the European economy.

The automotive sector represented one of the very last industrial bastions where European manufacturers maintained a first-rate global leadership (Volkswagen, Stellantis, Mercedes-Benz...). With the mandatory shift toward near-100% electrification, China is poised to flood the European marketplace with its "Made in China" vehicles. Indeed, in January, China officially ascended as the world's leading automotive exporter, overtaking both Japan and Germany. The critical question remains whether the European industrial fabric will display enough competitiveness to withstand the Chinese manufacturing steamroller. Whatever the outcome, the seaborne transport of both brand-new and second-hand electric vehicles and Alternative Fuel Vehicles (AFVs) via pure car and truck carriers (PCTCs) and short-sea ferries is destined to expand aggressively.

This growing popularity will fundamentally alter the risk profile for shippers compared to conventional internal combustion engine vehicles. Lithium-ion batteries are increasingly pointed out as the prime cause in numerous onboard fires. Burning batteries emit toxic and highly explosive gases that rapidly propagate the blaze. Consequently, the best defense relies on the early detection of pre-emptive thermal

signs. Standard overhead water mist sprinkling systems do not match the technical specificity of these vehicles, where battery packs are housed beneath the vehicle chassis. In the event of an incident, it is at the deck-garage floor level that temperatures will reach their absolute peak.

Furthermore, battery fires demand a massive volume of water to successfully extinguish and cool down the surrounding zone, an operational response that can severely jeopardize the ship's stability due to the free-surface effect; this mandates a substantial expansion of deck drainage capacities through dedicated high-flow bilge pumps. Crews must be specially trained and equipped with advanced detectors and appropriate extinguishing agents to guarantee that fires are contained and suppressed rapidly.

This challenge raises complex questions regarding future ship design, detection and firefighting capabilities, booking declaration and loading procedures, cargo lashing protocols, shoreside firefighter intervention capabilities, seafarer training, and risk perception among underwriters and classification societies. Vehicle manufacturers concurrently have a vital role to play in supply chain safety. For instance, the United States Coast Guard (USCG) formally recommends against transporting second-hand damaged batteries or compromised electric vehicles, while strictly prohibiting the recharging of vehicles during maritime transits.

In Norway, the shipping line Havila Kystruten, which operates a domestic public service coastal route, opted for absolute caution by officially banning the carriage of electric vehicles on board its fleet. Paradoxically, Norway stands as the global leader in electric mobility, commanding by far the highest number of EVs per capita worldwide: in 2022, 93% of new car sales were either 100% electric or hybrid units.

What institutional and regulatory responses?

In April 2022, the IMO's Maritime Safety Committee (MSC) agreed to initiate a comprehensive new risk evaluation regarding fire protection, detection, and extinction arrangements on board Ro-Ro vessels to fully integrate the emerging hazards characteristic of EVs and AFVs. However, this regulatory workflow will not commence until 2024 at the earliest, meaning that the subsequent binding SOLAS amendments are unlikely to enter into force before January 2032.

Marine underwriters remain deeply anxious and are aggressively lobbying for the urgent delivery of operational guidelines to fill this regulatory vacuum. In the absence of binding statutory texts, advanced scientific and technical research is being executed, yielding comprehensive sets of recommendations tailored for Ro-Ro vessels and passenger ferries.

The Lash Fire project (Legislative Assessment for Safety Hazards of Fire and Innovations in Ro-ro ship Environment), co-financed by the EU with a €12.2 million budget spanning a 4-year period, stands as a world-class international research initiative designed to significantly mitigate fire hazards on board Ro-Ro vessels and extract a robust regulatory framework capable of seamless integration into the IMO. This master program concludes this year. It aggregates 27 premier stakeholders originating from academic research, industrial clusters, and the maritime sector, including shipyards, professional trade associations, marine equipment manufacturers, insurers, and classification societies (such as Interferry, SEA Europe, Stena Line, DFDS, Baleària, and Bureau Veritas), alongside 13 EU Member States and EMSA.

Concurrently, a parallel scientific and technical research initiative, the Albero project, is championed by the German Federal Ministry of Education and Research. Its core objectives focus on ensuring the secure transport of AFVs on board ferries during adverse sea conditions, developing specialized shipboard charging infrastructure technologies to act as live testbeds for EVs, engineering a dedicated ferry handbook mapping out technical and organizational onboard recommendations for secure AFV transits, and designing a comprehensive training matrix for crews. Within its catalog of operational measures and recommendations are highlighted:

- The rapid identification of a vehicle's specific propulsion type, notably through color-coded license plates.
- The deployment of optical and/or acoustic alarm signals if a critical battery failure is detected, an alert that must be instantly transmitted to the bridge (designed by manufacturers and transposed into EU law).
- For efficient cooling during a vehicle's battery thermal runaway event, installing a direct access hatch leading inside the battery casing to enable direct water-cooling injection (designed by manufacturers and transposed into EU law).

- Granting the vessel's crew seamless access, identical to shoreside firefighters, to the technical data of the vehicle registry.
- Ensuring continuous, regular training programs for all responsible personnel (crews, shoreside firefighting brigades, etc.).

The operational findings and datasets derived from both the Lash Fire and Albero projects have been fully pooled and cross-referenced.

The EMSA safety guidelines and the IMDG Code paradox

In May 2022, the European Maritime Safety Agency (EMSA) released a landmark safety document entitled "Guidance for the safe carriage of alternative fuel vehicles (AFVs) in Ro-Ro spaces of cargo and passenger ships." This guide systematically deconstructs the emerging hazards tied to the transport of non-conventionally powered vehicles, mapping out:

- Liquid alternative fuels (diesel blends, ethanol): highlighting the risk of fuel tank structural integrity loss, leading to expanding pool fires (feux de nappe).
- Gaseous alternative fuels (compressed biogas or compressed natural gas — CNG): raising the risk of high-pressure gas tank ruptures, jet flames, extreme fire escalation, and rapid blaze propagation, including gas explosions and fireballs. The hydrogen vector (compressed or utilized within fuel cells) introduces severe tank overpressure and leakage hazards, the air-(H₂) mixture being highly flammable and explosive.
- Lithium-ion batteries: structurally accelerating fire propagation through jet flames and gas explosions if toxic gases accumulate prior to ignition, coupled with long-duration reignition risks and extreme suppression difficulty.

This granular risk analysis is divided into two distinct parts: the first governing Ro-Pax ferries, and the second tailoring rules for pure Ro-Ro vessels and PCTCs.

Crucially, while standalone loose lithium-ion batteries are strictly subject to the mandates of the IMDG Code (International Maritime Dangerous Goods Code), fully assembled Electric Vehicles (EVs) are completely excluded from its scope. The physical state of the batteries must be rigorously inspected; yet, who should execute these safety checks and absorb the associated operating costs?

Vehicles must be clearly identified during the booking and terminal check-in phase, and the crew must be thoroughly informed of the vehicle's exact nature and command easy physical access to it during routine cargo inspections. In the event of defective batteries or compromised, accident-damaged electric vehicles, loading on board should be strictly prohibited by the shipowner. Furthermore, the recharging of vehicles during maritime transits is strongly discouraged unless backed by a comprehensive risk assessment and strict control measures.

The guide universally recommends deploying remote monitoring grids, continuous fire-watch patrols, portable thermal-imaging infrared cameras, and localized gas detectors to counter suspected leaks during patrols, alongside regular crew training drills mimicking non-conventional combustion vehicle fires.

Ultimately, the legal and regulatory framework routinely operates a train delay behind industrial reality. Formulating the exact risks incurred, locking in mitigation measures, and clarifying the explicit roles and responsibilities of every single stakeholder—whether codified through a binding international treaty or an EU directive—remains an absolute, imperative necessity to guarantee safety of life at sea and prevent catastrophic human and environmental dramas.

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