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SAFER SKIES, SAFER SEAS

As shipping and aviation bind the global economy closer together, these industries are controlling risk by improving and harmonizing their tools for tracking and navigation.

INTRODUCTION

As global commerce continues to expand, so does the volume of air and water transport—along with the need to manage risks related to more crowded shipping lanes, more aircraft in the skies, and greater safety and logistical challenges both aloft and at sea. The number of ships sailing the world's oceans increased 60 percent between 1992 and 2002, then grew even faster, peaking at 10 percent annual growth in 2011.[1] The same goes for aviation. Almost 3 billion people flew in 2012, up from 960 million in 1986—although some of this represents multiple flights by the same individual. Air freight transport is rising fast as well: some 49.2 million tons moved in 2012, 71 percent more than in 2001.[2]

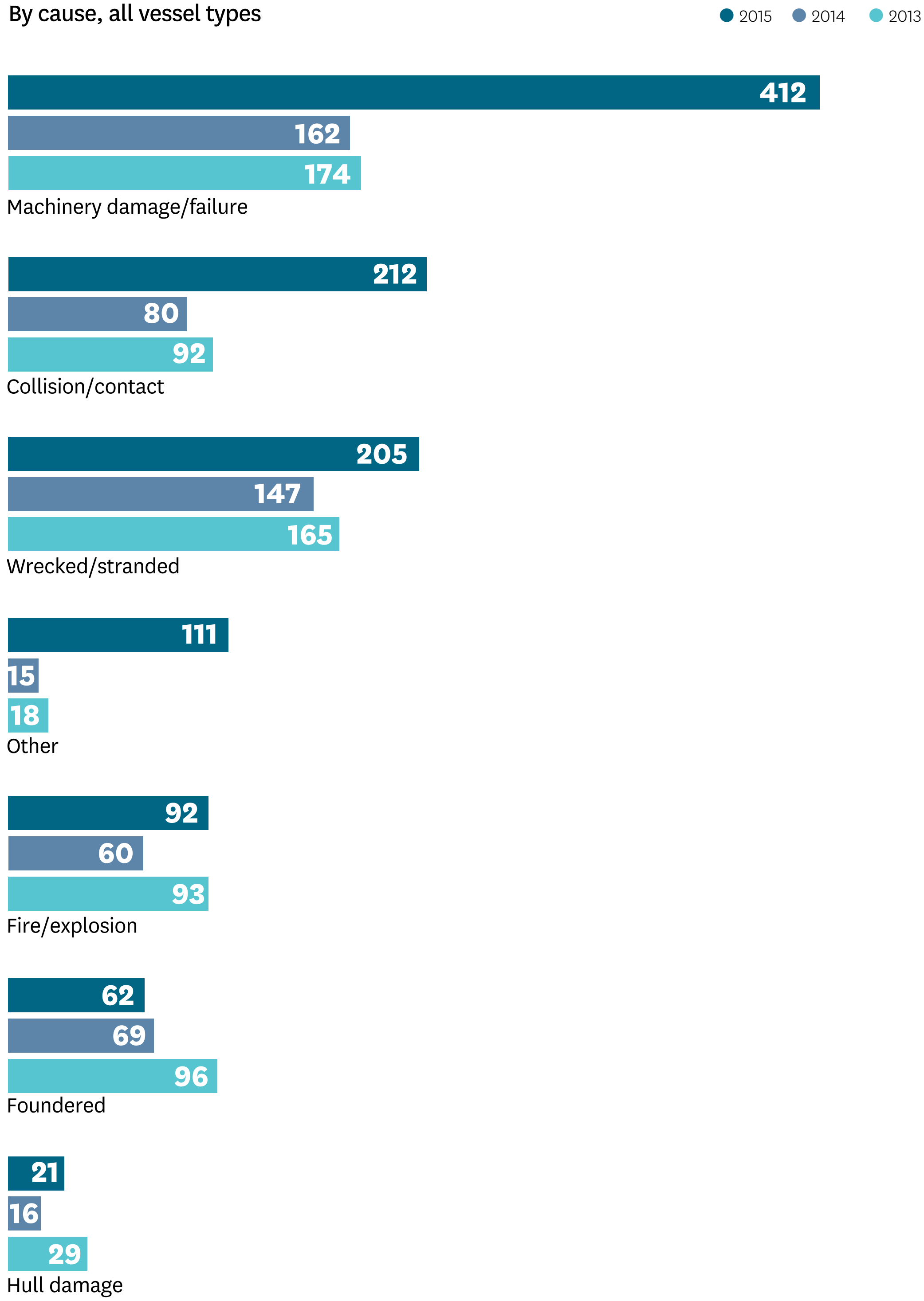
Air travel is statistically still one of the safest ways to get from place to place. Only 265 people were killed in aviation accidents in 2013, for example—the smallest number since 1945.[3] But with more people flying than ever before, the need to manage risk of accidents and equipment failures has been highlighted by a recent string of disasters—most notably Malaysia Airlines Flight MH370, which disappeared in March 2014 with 239 passengers and crew onboard. Heavier air traffic also raises environmental concerns: air and noise pollution, land degradation, damage to wildlife and biodiversity, greenhouse gas emissions, and the carbon taxes that some countries charge to operators.

Shipping faces similar challenges. Available navigational waters are shrinking as transport vessels compete with other uses such as fishing, leisure, renewable energy, and environmental protection. Vessels themselves are larger and faster, giving crews less time to make decisions when they sight another ship, leading to more groundings and collisions. All of these problems are compounded during bad weather conditions. According to the European Maritime Safety Agency, the number of reported maritime casualties and incidents more than doubled in a two-year period, from 1,119 in 2011 to 2,550 in 2013—those numbers include deaths and serious injuries; loss, abandonment, disabling, or serious damage to a ship; and severe or potential damage to the environment.[4] "Without in-depth examination one cannot ascertain how many are attributable to human error, but based upon other data, it seems probable that the majority were," says U.S. Coast Guard Captain Robert Moore (ret.), a longtime maritime consultant. figure 1

FIGURE 1

SERIOUS CASUALTIES 2013–2015

By cause, all vessel types



SOURCE LMIU, TOTAL LOSSES AS REPORTED BY LLOYDS LIST INTELLIGENCE

A GLOBAL RISK MANAGEMENT SYSTEM

To manage and mitigate such risks even as traffic increases, better communication and sharing of data are critical. Pilots and ground controllers must be able to monitor and track an aircraft's position and vital signs, whatever its location: if the aircraft shows signs of diverting off its planned course or of equipment malfunction, tracking must be as close to real time as possible. In the maritime world, ship and shore must be able to seamlessly collect, integrate, and exchange standard sets of data and distill them into quickly digestible, actionable information—especially in foul weather and when vessels enter crowded or hazardous waterways.

Honing these capabilities promises not only to minimize risk and improve safety, but to cut costs and make aviation and shipping more efficient. Close to real-time tracking enables air traffic organizations to authorize airlines to plot more direct routes and reduce vertical separation, thereby allowing more aircraft in the same volume of airspace without compromising safety. Vessels, too, can travel shorter routes between arrival and departure points; better negotiate narrow, shallow, and heavily used waterways; and reroute to avoid rough weather. Above all, when information exchange is standardized, consolidated in one place, and presented in a graphic format that can be grasped quickly, vessels are better able to avoid collisions and groundings, eliminating avoidable costs.

Both in the air and at sea, improved safety measures could also reward operators with lower premiums from their insurers. Perhaps most importantly, they help preserve public confidence in aviation and shipping companies' ability to continue supporting big increases in traffic.

STANDARD BEARERS

Much of the necessary technology has existed for some time, aided by improvements in satellite-based communication. Most ships now use an electronic chart display and information system (ECDIS) that allows them to combine position information from all their various navigational sensors. Most have also adopted the Automatic Identification System (AIS), which identifies and locates vessels by electronically exchanging data with other ships, AIS base stations, and satellites.

To further reduce airborne aircraft collisions, most airlines rely on TCAS (Traffic Collision Avoidance System), which warns an aircraft of the presence of another plane that may be a collision threat via transponders installed on both. In addition, ACARS (Aircraft Communications Addressing and Reporting System), which maintains contact with flight crews via either satellite or high-frequency radio depending on the plane's location, is also used by airlines for routine tracking. Satellite-enabled systems offer "more global coverage and positional accuracy than old ground-based systems," says Greg Phillips, an aviation safety expert and instructor at the University of Southern California's Viterbi School of Engineering. They are especially useful in locating aircraft that encounter trouble in remote areas, such as over the ocean or close to the poles.

Adoption of satellite-based aircraft tracking is still in its early days. A bigger challenge, however, is software integration, which ties together identification, positioning, and other data systems operating on a variety of platforms, so that information can be broadly shared and assimilated, much as mobile phone technology has done in recent years. The same is true in the maritime sphere. "There's lots of data on shipping today, but it's not integrated. It's all in separate systems," says Pentti Kujala, professor at Finland's Aalto University School of Engineering and an expert in maritime risk modeling.

Unless data—and tools to reconcile and analyze it—is available across platforms, shipping and aviation companies will have a hard time leveraging it fully. Regulators can facilitate integration by requiring tracking and navigation systems to conform to a global set of standards. Yet progress in this direction has been slow, for three reasons.

OPERATORS NEED A COMPELLING CASE. Installing satellite-enabled systems that can both send and receive information is expensive, and air travel is an intensely competitive business. The relative safety of air flight, despite some recent high-profile disasters, prompts airlines to resist regulations aimed at universalizing real-time tracking. Likewise, shipping companies are reluctant to introduce new communication and navigation systems or standardize existing ones unless they can see a distinct benefit to the bottom line. Yet much of the benefit of upgrading and standardizing these systems derives from avoidance of disasters rather than eliminating budgetary costs, which makes them less immediately compelling, according to Moore.

MODERNIZATION OF SHIPPING HAS NOT BEEN CONSISTENT OR EFFICIENT. Much of the work to mandate installation of e-Navigation equipment has been done under the International Convention for the Safety of Life at Sea (SOLAS). But the bulk of U.S. commercial vessels, for example, are not subject to SOLAS, although this is changing as the requirement to adopt AIS has been extended to most U.S. non-SOLAS commercial ships. And while tanker fleets and cruise lines, which are much in the public eye, have been relatively quick to modernize and improve their bridge management capabilities, some other commercial operators have not, Moore notes. Just because a company has installed e-Navigation equipment does not guarantee that it's using the technology effectively. Some companies see more efficient navigation primarily as a way to cut costs and reduce crew sizes, even though, in some areas with heavy vessel traffic, it might actually require more, Moore adds. Modernization has also followed an "oil spot" pattern—faster in regions like the North Sea and the Straits of Malacca where traffic is heavy, and slower in other parts of the world.

Additionally, the older vessels that still make up much of the worldwide fleet have been overhauled piecemeal, and as a result, bridge personnel often cannot get all the information they need to address a particular situation "without roller skates," Moore says. Rapid technological innovation creates new devices and software, and new variations on older ones, as fast as the industry can produce them, while overloading masters and other bridge personnel who have other duties besides navigation. As a result, establishing closer human links between vessels and between ship and shore becomes more difficult.

REGULATORY CHANGE HAPPENS SLOWLY. This is in part because of the expense involved. In the U.S., the Federal Aviation Administration (FAA) is requiring that, by 2020, all aircraft operating in FAA-regulated airspace equip their transponders with Automatic Dependent Surveillance—Broadcast (ADS-B), a system that transmits information about aircraft altitude, speed, and location to ground stations and other aircraft in the area. The requirement, however, is only to transmit data, not to receive it—which would require additional equipment. Other aviation regulators, in Europe, Australia, and Asia, are moving in the same direction.

Since 2005, the International Maritime Organization (IMO) has been pursuing an ambitious e-Navigation initiative that, in its words, aims to harmonize the "collection, integration, exchange, presentation, and analysis of maritime information onboard and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment." But the process, which requires dozens of countries with widely varying maritime legal and regulatory regimes to agree on a basic onboard electronic information delivery suite, necessarily will take years more to complete. figure 2

FIGURE 2

A DESCRIPTIVE MODEL FOR E-NAVIGATION

INPUTS

Real-time (or Near-real-time) Update Information

- AtoN* (e.g., position/status)
- Maritime Safety Information (MSI)
- Radar
- Position fixing systems
- Ship sensors (e.g., heading, log, etc.)
- Echo sounder*
- Sonar* (optional)
- Inertial navigation system*
- Ship-to-ship,* ship-to-shore, and shore-to-shore communication
- AIS data
- Meteorological
- Updates to charts and publications

Long-lead (Reference) Information

- Digital charts and publications
- AtoN infrastructure and relevant AtoN information
- Predicted meteorological, oceanographic, and hydrographic data (e.g., seasonal weather patterns, tides, etc.)

Organizational

- Training and procedures
- Quality management processes
- Data access and security protocols
- Conventions, regulations, and guidelines (IMO, ITU, IALA, and IHO)
- Communication protocols (ITU)
- International standards (ISO, IEC, and others)
- Legal instruments

*Ship specific
**Aids to navigation installed by the U.S. Coast Guard (e.g., buoys, beacons, lighthouses)

data communications

E-NAV CORE

PERSON

SHIPBORNE E-NAV SYSTEM

↓↑

INTEGRATED COMMUNICATIONS
includes AIS data, standardized reports, etc.

↓↑

SHORE E-NAV SYSTEM

↑

PERSON

OUTPUTS

Safe Navigation

Enhanced:

- Anti-collision and anti-grounding processes
- Route planning and monitoring
- Pilotage and berthing
- Under-keep and air-draft clearance management

Efficiencies and Other Benefits

- Standardized and automated maritime reporting
- Logistics efficiencies (including port state control, port operations)
- Potentially reduced insurance costs
- Improved security
- SAR and pollution response
- Strategic analysis for infrastructure refinement
- Incident analysis and investigation
- Other

SOURCE BOHDAN PILLICH, "DEVELOPING E-NAVIGATION, THE EARLY STAGES," PAPER PRESENTED AT U.S. HYDRO 2007 CONFERENCE

COVERING THE WORLD

None of this should suggest that more integrated, real-time tracking and navigational systems face permanent roadblocks. "I don't think the standards will be abandoned, but they will take somewhat longer than anticipated to introduce," says Chris Yates, a UK-based aviation safety and security consultant. In the meantime, both aviation and shipping, and their vendors, are developing systems that provide global tracking and navigational data.

ADS-B uses satellite-based GPS technology to track the aircraft's position and transmit that data to ground-based tracking stations. While current ADS-B systems still depend largely on ground-based transmission, new satellites with ADS-B receivers are being developed that can track aircraft into remote parts of the globe, such as mid-ocean areas and the Arctic and Antarctic. One such system, developed by Aireon, a public-private partnership, aims to provide continual, real-time tracking around the world in three years, via ADS-B receivers mounted on the Iridium NEXT series of satellites.[5]

Additionally, data transmitted via ADS-B is becoming more widely available through trackers—including Flightradar24, FlightAware, and Plane Finder—that collect it through receivers operated by volunteers around the world and supply it to users including airports, airlines, car services, and individuals.[6]

To better respond to disasters such as MH370, new designs are being discussed for the aircraft's flight data recorder, or "black box," including one that ejects before the plane goes down and another that begins transmitting all of its data as soon as the plane changes route or begins to operate abnormally. Yet another proposal calls for a second black box that would independently broadcast any abnormal changes as soon as they take place, giving air traffic managers and other aircraft more time to respond.[7]

The IMO and its member states are focusing on creating the "Maritime Cloud"—a communications infrastructure built on open-source software that makes a range of data available across all communications systems to all participants in shipping anywhere in the world. Relevant data from any source could be plugged directly into a ship's electronic charts, giving master and crew a more complete view of the vessel's position and environment. Another facet of the system would allow participants to easily "multicast" messages to all ships in a given area, keeping all of them fully informed of each other's routes and of any hazards or other conditions that might affect them.

At the same time, IMO member states have launched a series of "test beds" aimed at improving the safety and efficiency of navigation in heavily traveled areas such as the Baltic and North Seas, Japan, and the Yanshan deepwater port near Shanghai. Projects including ACCSEAS (accessibility for shipping, efficiency advantages and sustainability) focus on harmonizing electronic information exchange in general; others address specific areas such as environmental information, warning and maneuvering support to avoid collisions and reduce the need for traffic separation, mapping the potential dispersal of pollutants in particular areas, and dynamic route planning. Out of these could come new global standards.

Still other projects use new devices to untether the user from a stationary command post. Google Glass and other wearables are being tested in the U.S. and Australia this year as a conduit for masters and mariners to access integrated information about routing, weather and other environmental conditions, and the status of other vessels in the area, without having to look down at an instrument panel or laptop. "If you eliminate that, the ship operator can appreciate the information that's arriving in context, and perhaps the safety of navigation will be improved, because physical

Cybersecurity is a concern for any system that shares data between many users; both maritime and aviation experts agree that it has yet to receive the attention it needs.

presence in front of a fixed device isn't required," says Martha Grabowski, McDevitt Distinguished Chair in Information Systems at Le Moyne College and research professor of industrial and systems engineering at Rensselaer Polytechnic Institute.

HURDLES

Some new technologies and information delivery systems face their own problems or potential problems. ADS-B is widely seen as the future standard for aviation tracking, but it has to be incorporated in the aircraft's transponder—and transponders can be shut down, as may have been the case on MH370. The ability to switch off a transponder is a basic safety feature in case of fire; for ADS-B to become an industry standard, the tension between communication dependability and fire safety will have to be resolved.

Satellite bandwidth is not unlimited, and how best to use it will be critical if ADS-B is to become universal. "How much space do you take up with near-real-time tracking? How much data do you store? One of the concerns is separating what's critical from what's not," says Phillips.

Cybersecurity is a concern for any system that shares data between many users; both maritime and aviation experts agree that it has yet to receive the attention it needs. "Thus far, the focus has been on technology and getting the technology out there," says Grabowski. "More work could be done on the cyber side of e-Navigation."

Training will be crucial to the adoption of e-Navigation by the global shipping industry, says Moore, but much of the training that takes place at maritime academies "is not applicable to the first ship you'll sail on," because of the variety of different kinds of navigational equipment. Training also needs to go beyond use of equipment to include understanding e-Navigation. It needs to improve decision-making by enabling mariners to supply information in forms that require no further massaging to be useful. But deciding what curricula should be narrowed or eliminated to make room for more e-Navigation training is difficult. At the same time, crew members can rely too much on automated solutions, diminishing their ability to fall back on older tracking technologies and navigational methods should electronic and satellite-based systems fail. "You create new risks if you don't have people on board who can do it manually. They might lose these skills if you automate everything," says Kujala. One solution, Moore suggests, would be to encourage or require continuing education that keeps personnel up to date on the new e-Navigation standards as they emerge.

A continuous, near-real-time flow of information can also create legal issues, especially when transmissions are recorded and stored consistently. "If I publish my intended route but then do not follow it, what's my liability?" says Omar Frits Eriksson, director of maritime technology at the Danish Maritime Authority and chair of the International Association of Marine Aids to Navigation and Lighthouse Authorities' (IALA) e-Navigation Committee.

Cost remains the most significant hurdle to the adoption of better, more integrated tracking and navigational systems, however. Upgrading an ACARS system to include VHF radio, for example, can run up to $100,000 per aircraft, and adding Iridium or Inmarsat satellite communication can cost between $60,000 and $150,000 more.[8] Streaming flight recorder data adds to airlines' data transmission costs. The price tag is high for upgrading vessels with new data transmission and reception capabilities as well, suggesting that for both shipping and aviation, many tracking and navigational improvements may not become fully standardized until new vessels and aircraft replace the current fleets.

CONCLUSION: PICKING UP THE PACE

Despite these hurdles, there are also plenty of incentives for airlines and shipping companies to pick up the pace. "If it can be tied to revenue generation, the chances are higher," says Phillips. Along with its role in aircraft communication, an entirely satellite-based ADS-B system would make in-flight sales faster and easier, he notes, improving the traveler's experience and adding to the airline's profits. Mariners increasingly want to be able to stay in touch with family members during long voyages, says Eriksson—another inducement for shipping companies to make greater use of satellite as a cheaper and more global alternative to traditional radio communication.

The succession of high-profile tragedies in recent years has helped spur progress in aircraft tracking. The International Civil Aviation Organization (ICAO), the UN agency that establishes global standards for air navigation, began to address the need for better tracking in 2009, after Air France Flight 447 crashed in the Atlantic Ocean, killing 228. In the months after MH370 disappeared, ICAO announced new regulations for commercial passenger aircraft tracking. By November 2016, aircraft must report their position every 15 minutes, and update it every minute in the event of an abnormality such as fire on board or a sudden change in elevation.[9] This will reduce the size of the territory that search and rescue teams would have to explore should they need to find a downed aircraft, for example.

"Traditionally, ICAO moves very slowly," says Phillips, "because close to 200 different nations have to sign on. But they're moving amazingly quickly on this issue." Vendors are working to meet the new requirements. Rockwell Collins is developing a new tracking service that will assist airlines in mapping gaps in route structures so they can anticipate where more frequent position reports will be needed to meet ICAO's proposed rules. SITA, Rockwell's main rival, is working on a new flight tracker with Singapore Airlines and Malaysia Airlines that would enable the airline itself to follow up and request tracking information if it hasn't received any within a defined period of time.[10]

Likewise in shipping, more frequent accidents are making change more urgent. In particular, the insurance industry's voice will become louder, says Moore: "A realization is coming that unless shipping companies change their priorities, insurance rates could become unsustainable."

Such concerns add to a fundamental economic argument that is only becoming more compelling. The expanding global economy is making the role of air and sea transport and travel more critical. Leveraging new technology and data convergence opens the door for reduced risk and greater efficiency, but the jury is still out on whether new technology and convergence make air and sea transport less risky and more efficient. However, "simultaneous hardware, software, and data advances are propelling e-Navigation forward," Grabowski says.

ENDNOTES

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