



Breaking with Tradition: Safety and the Survival of the U.S. Maritime Industry

C.A. Bookman, Marine Board, National Research Council, Washington, DC

ABSTRACT

The safe delivery of cargo and crew and vessel is the basic task of every merchant mariner. Yet so many maritime casualties still happen that it bespeaks an industry attitude toward risk that is incompatible with modern ideas of industry. If the maritime industry does not remake itself as a modern, high technology industry, responsible for maintaining its own high standards, then others, outside the maritime community, will remake it.

INTRODUCTION

Tradition-bound and financially weak, the American shipping industry is feeling its way toward the 21st century. The groundings, fires, and oil spills that made headlines in 1989 and 1990, including the Exxon Valdez spill, have brought forth some reforms. The industry's drive to innovate is strengthening, as the few surviving shipping companies shake off old habits instilled by decades of protection from competition. The Coast Guard has regained its focus on its maritime safety and environmental missions after a decade of divided responsibilities, but needs the resources to execute those missions. The challenge of those accidents may yet galvanize a reexamination within the industry that can spark a renewal of the proud tradition of American seafaring.

To the public, the issue is safety, and the industry seems accident-prone. U.S. waters in 1989 and 1990 suffered through a spate of major oil spills, in addition to the Exxon Valdez disaster: 1.5 million gallons of No. 2 heating oil in Rhode Island Sound from the Greek-registered tanker World Prodigy; 800,000 gallons of No. 6 oil near Marcus Hook from the Uru-

guayan Presidente Rivera; 3 million gallons from the Mega Borg, which burned out of control for several days in the Gulf of Mexico; 500,000 from two barges rammed by the Greek tanker Shinoussa in the Houston Ship Channel; and so on. The impression of an industry unable to manage its vessels, threatening seacoasts and wildlife with ecological disaster, has taken firm root in the public mind.

The reality is not so dismal. Ship casualty and loss, and seafarer injury rates (in percentages of vessels, of gross tonnage, and of seagoing employees) have improved substantially in the past 20 years (Figures 1-3). The frequency of major oil spills has also declined, although the volume of oil spilled varies greatly from year to year (Figure 4). Better technology, better training, and higher standards imposed by government and industry safety bodies are responsible (1).

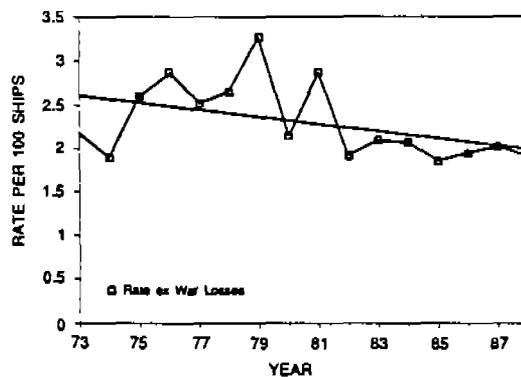


Figure 1. Rates of serious casualties of oil tankers (actively trading vessels over 6,000 gross tons), 1974-1988. The decline in the rate of serious tanker casualties since 1970 has been

linear at a confidence level exceeding 90%. Data from International Maritime Organization (1).

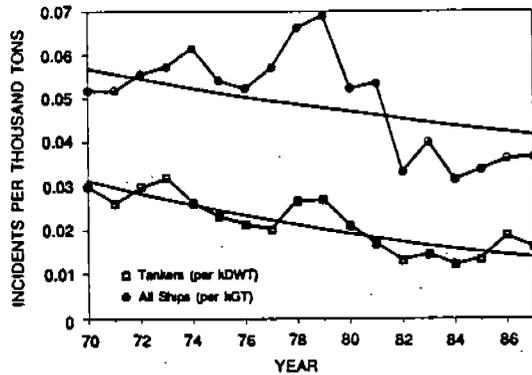


Figure 2. Reportable casualty rates of U.S.-flag ships, per thousand gross tons (upper curve), and U.S.-flag tank ships, per thousand deadweight tons (lower curve), 1970-1986. For all vessels, the decline has been nonlinear (power function) at a confidence level exceeding 90%; for tankers, it has been exponential at a confidence level exceeding 99%. Data from U.S. Coast Guard, Annual Statistical Summary (1).

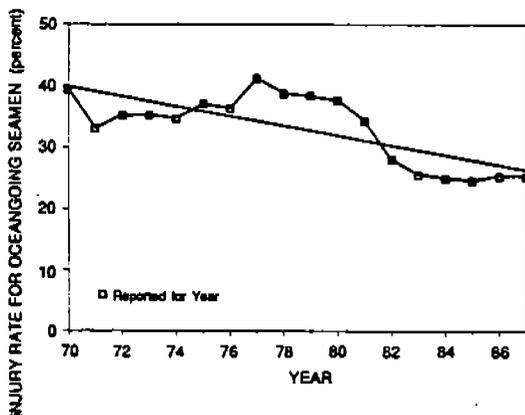


Figure 3. Annual injury rates per seagoing employee in U.S. deepwater vessels, 1970-1987. The decline in the injury rate for oceangoing seamen since 1970 has been linear at a confidence level exceeding 99%. Data from Marine Index Bureau (1).

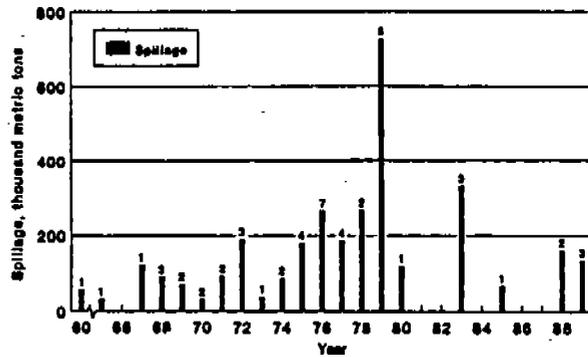


Figure 4. Tanker Spillage and Number of Events—50 Major Oil Spills, 1960-1989. (No major spills 1961-1964. Spillage is total volume lost and burned.)

We have allowed maritime traditions to inhibit change and make improvement difficult, even in the face of such statistics. Furthermore, the industry's financial distress makes it hard to justify the private investments that safety and competitiveness demand. Yet some U.S. shipping companies, by recasting themselves as international distribution systems, have held their own—even gained—in world markets. They have shown that safety and survival depend on new and untraditional ways of doing things.

Still, the American public is pressuring the industry to perform at a higher standard, which it believes is attainable. We in the maritime industry may be gratified by declining accident and casualty rates per-ship and per-worker. The public suspects that its total exposure to these risks is actually growing, as U.S. oil imports via tanker rise. The level of publicly acceptable risk has shifted downward and there is an implicit conclusion that the maritime industry cannot be trusted to take care of its own affairs.

There is certainly room for improvement. Each year, fully 2% of the world's active oil tankers are involved in serious casualties, and nearly 30% of the crew members on U.S.-flag vessels are injured. This performance bespeaks an attitude toward risk that is incompatible with modern ideas of industry. These are hardly figures that would be pointed to with pride in, say, the aviation industry. Even by its own

safety measures, the maritime performance is not impressive.

MEGASYSTEMS AND THE LESSONS OF DANGEROUS EVENTS

Edward Wenk, naval architect and former Presidential science advisor, calls them "megasytems": large, complex technological systems embedded in equally complex, and equally important, social systems, composed of institutions and people linked by modern communications. Maritime commerce is such a complex socio-technical system, built of both hardware and human beings—operators, managers, and regulators. Almost by definition, the enterprise becomes too big for a single point of control to be effective and sustaining the integrity of the system relies on an "honor system" of self-policing. Such a system can operate for some time before an event reveals its flaws. The true complexity of such a system often appears only after a major failure, Wenk points out, and the interactions of its components are much harder to restore than the individual technical systems that are the proximate victims of failure.

One consequence of a dangerous event in a megasystem is that it attracts attention and the megasystem gains a new component, the public, who now identify themselves as "stakeholders" in the safe operation of the system. When failure occurs, the event makes people suspect the integrity of the entire class of similar operations and they may yearn to apply a particular remedy to the entire class. If such remedies are applied without an understanding of the megasystem interactions, the result can be disappointing, because the potential for harm remains. The remedy may in fact add false confidence to the system operators, because the underlying stress does not go away, it only goes elsewhere in the megasystem, perhaps to do harm later. Megasytems are, however, notoriously more difficult to describe completely, precisely because new components (especially humans) can add themselves at any time. The classic cases of problem laden megasystems are nuclear power plants, space vehicles, the ill-fated pesticide plant at Bhopal, India, and the Aegis missile cruiser.

The oil transportation system is a megasystem, too (2).

Operators and overseers can grow complacent and forget to uphold the initial high safety standards. Then an accident is waiting to happen. The Exxon Valdez grounding, which spilled nearly 11 million gallons of crude oil, focused attention starkly and suddenly on the risky practices that had become accepted by those moving oil from Alaska to the lower 48. More than 8,700 previous port calls by tankers at Valdez led those charged with the safety of that waterway—companies, Coast Guard, and the State—to drop their guards. Most fundamentally, preventive vigilance had been allowed to lapse. For example, tankers in the pristine waters of Prince William Sound had consistently, and with tacit Coast Guard approval, violated traffic rules requiring vessels to slow for ice or wait for winds to abate instead of leaving the normal channels (3). The state of Alaska, which had originally required pilots on tankers out to the open waters beyond Cape Hinchinbrook—seventy miles from Valdez—had reduced the requirement to the upper 12 miles of Prince William Sound, at the request of the pilots' organization, which was concerned about the danger of embarking and disembarking pilots in the sometimes violent seas at the mouth of the Sound (4).

When the vessel grounded and oil began to spill from the hull, the response was inadequate, owing to divided responsibilities, confusion, indecision, and lack of preparation. The incident also revealed the extraordinary number of stakeholders in the megasystem's proper functioning: not only Exxon's personnel and the Alyeska pipeline operators, but the fishermen and Native American subsistence communities of the Prince William Sound area, the government of Alaska, the Coast Guard, the Alaska tourist industry, other users of the waterway, bankers, insurers, ship designers and builders, other ship operators calling at all U.S. ports, the oil industry in general, and so on. All are paying for the damage caused. But that casualty was only the signal of a deeper underlying problem. The maritime industry is running similar risks every day, in all the world's oceans and ports. Cahill (5) minces no words. He remarks

"Many ships sailing the world's oceans are manned and commanded by those who should confine their sailing to the bathtub, but luck and the underwriters enable them to ply their 'trade' in blissful ignorance of the rudiments of the mariner's profession." We are fortunate that more vessels and their crews do not become casualties.

The public is right to be outraged and the public is prepared to take away the operating freedom of the merchant marine in a way that will determine, to a greater extent than many realize, the future of the merchant marine. No business can expect to operate on the old terms any longer without penalty. Ships, especially commercial ships moving materials from port to port, operate on territory that the public and politicians have judged to be valuable, the coastal waters and the ocean. In the context of a national society where heavy industry is declining and more people view the waterfront as a place for recreation rather than commodity shipping, fewer people have any sympathy for maritime mistakes that are perceived to damage the ocean. Public opinion, and public emotions, amorphous though they are, have proven recently to be powerful forces in shaping the way that institutions act when challenged. If the maritime industry does not remake itself as a modern, high technology industry, responsible for maintaining its own high standards, then others, outside the maritime community, will remake it.

The maritime industry faces a painful but important transition to a higher standard. The remainder of this paper examines the dilemmas faced in the maritime community, the inertia that will have to be overcome and the stormy seas that will have to be crossed, in order for the maritime industry to be trusted by the public to determine its own future.

A CULTURE OF DECLINE

The maritime industry of the United States is small and has been in decline for years. The U.S.-flag fleet is at a historic low, with fewer than 400 large commercial ships, most of them aging. Much professional expertise in commercial ship design and shipbuilding skills has been

lost during the long lapse in commercial orders for new ships. Shipping companies are forced to compete under economic conditions and policies that put them at a competitive disadvantage. Maritime-training academies and naval architecture schools have small enrollments (Figure 5) (6).

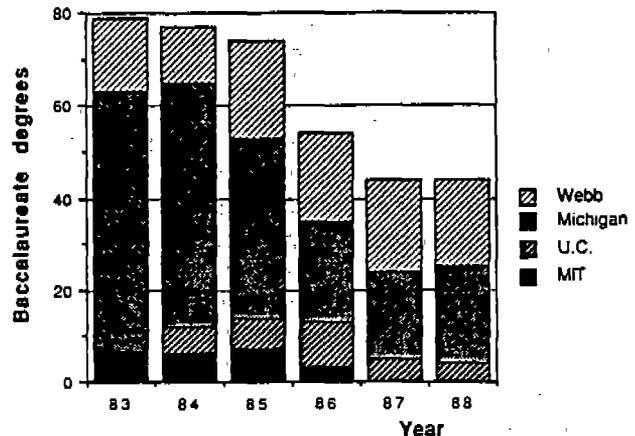


Figure 5. Recent graduates from traditional ship design schools.

In a declining industry, new facilities are not purchased and facility maintenance and safety measures may fall victim to cost-cutting by companies fighting to survive. Few new ships are being ordered in the United States and ships worldwide are being operated longer. Older ships are more likely to suffer from corrosion and metal fatigue (7).

This development increases the burden on regulators (i.e., USCG inspectors and OCIMs) to ensure that the vessels in service are adequately maintained and are structurally sound. Getting a bad ship off the water is a daunting task, even with ample resources and support for the inspection program. Yet the U.S. Guard in the past decade has seen its inspection resources cut, and with so little new building underway, it is difficult to train new inspectors to replace the cadre of retiring marine inspectors. The USCG also has competing demands on its personnel—notably for drug interdiction (8). Between 1981 and 1989, 890 vessel and port safety billets were cut from Coast Guard rosters.

Port State Control, the idea that an entering vessel can be boarded and inspected for compliance with at least the prevailing international marine safety standards, is a useful effort. A port state control regime was put in place in European ports in the mid 80s. In 1988, surveyors inspected 18.2% of vessels arriving in Europe (9). That program has been useful and its efforts produce information and actions that can help the USCG in conducting its own inspection program. But any program has its limits. Writing in *Fairplay*, the "Lookout Man" states "...these massive structural accidents waiting to happen cannot be picked up by port state control surveyors. However diligent and experienced they may be, and not all of them are either, they can be put off by a set of perfect certificates and a little bulldust" (10).

Some have argued, in addition, that the Coast Guard and industry have dragged their heels in adopting needed safety measures. It is a fact that the Coast Guard rejects recommendations by the National Transportation Safety Board far more often than the Federal Aviation Administration (2).

And there is political sclerosis, too. Many in the maritime industry, conditioned by decades of business operations with annual disbursements of federal subsidies, can only see their short-term interests, and some have resigned themselves to squabbling over pieces of a shrinking pie. Each day these impasses remain, the industry grows less competitive, and its safety problems go uncorrected. All these factors have contributed to the industry's lackluster safety record.

BREAKING WITH TRADITION

Bringing Safety into the Modern Age

In every maritime casualty, complex chains of error are involved, extending from the ship's deck to the board room, the Congress, the Coast Guard, and beyond. Improving the safety record of the U.S. maritime industry will require more than technological fixes, such as the tanker double hulls mandated by the Oil Pollution Act of 1990 (P.L. 101 - 380). It will require

more than organizational fixes, such as giving the USCG primary responsibility for ensuring adequate cleanups. No maritime traditions can be sacred.

Safety and the culture of safety that may be necessary to renew the public trust in the maritime industry will take a lot of effort to develop. The industry and its regulators need to understand what the safety goals are, and set a course to meet them. Every system and procedure will require reexamination. Jobs, as well as vessels, need to be redesigned. Existing safety systems need to be analyzed. Regulatory fundamentals need to be reassessed.

Conflicting Objectives

But first, the noise level must die down. The maritime industry today is a collection of competing interests—shipbuilders and operators, management and labor, subsidized and unsubsidized, and so on and so on. The different segments of the industry work towards conflicting objectives and often against each other. No apparent progress is the result of all the activity. Sparse progress, either industrially, or politically, will happen until the outside world begins to detect some unity of purpose.

At this juncture, the urge to retrench (and hope the public goes away) may be strong, and the urge to reform (and hope the public will be satisfied) may be just as strong. Neither is sufficient in itself, because we ought not let other people decide not only what is important, but how to tend to that important business.

How did this powerful political industry get so successfully pinned to the wall? By being so knowledgeable and simultaneously being so miserly in the application of that knowledge when the opportunity presented itself. In the event of the tanker casualties recently, the industry demonstrated, in extremis, that there had been alternative design and operating scenarios developed, then shelved because they cost "too much" money or because they "rocked the boat" and threw the established (mega)system too far out of kilter. Now, all the industry indirectly and directly is paying the price for that attitude. The public judgements made about the behavior

of mariners and maritime companies have been harsh and the industry is in the midst of a blatantly punitive public overhaul that is framed to suit the demands of an angry and mistrusting public. Sadly, when it is in place, the overhaul may yet fall short of both the needed and the expected improvements in maritime safety and oil spill prevention. Unless we develop a capability within the maritime industry to address vital issues on our own, we will find the story repeating itself.

If the maritime industry is to regain control of its own future, then it must develop common objectives among the fragments of the industry. This will be hard, because the separate interests have not worked in this manner customarily, even on an issue so agreeable to all as safety.

Competitiveness Without Protection?

It is time to examine the economic protection measures which originated to maintain competitive U.S. shipping and shipbuilding industries. Operating ships under the U.S. flag was recognized long ago to be more expensive than operating under foreign flags. In 1936, to sustain a merchant fleet under the U.S. flag, the federal government established the Construction Differential Subsidy (CDS) program and the Operating Differential Subsidy (ODS) programs—which compensate operators and owners for the "differential" between their costs and those of foreign competitors. Vestiges of that extensive direct subsidy regime remain today. Cargo preferences, such as agricultural and military products, are similarly venerable. Domestically, cabotage laws such as the Jones Act, enacted in 1920, restrict the carriage of cargo between points in the United States to vessels built, documented, and owned in the United States. U.S. commercial shipyards' and merchant marine operators' dependence on these protections is nearly complete.

The subsidy and related programs cost the taxpayers hundreds of millions of dollars annually. For example, in FY1989, the Federal Government paid out \$212.3 million to the operators of 76 ships for the Operating Differential Subsidy (foreign costs amount to 30-35 percent of U.S. subsidized costs). They contain

no incentives for productivity improvements, and so do not encourage innovation. Many subsidized operators have fallen far behind their foreign competitors.

In 1983, Warren Leback, the current Maritime Administrator—who administers the subsidies—proposed a thorough revision of several Jones Act provisions to encourage competitiveness of builders and operators (11). Reform is still needed, and should include the other subsidy, preference and assistance programs too. The nation need not carry these programs into the next century, at least not in their present forms.

For instance, some subsidies could be made contingent on improvements in productivity—an approach that has worked in other industries. Others could be simply withdrawn, such as the provision that prevents U.S. companies operating between U.S. ports from buying foreign-built ships. Allowing operators to buy the best ship at the best price could go a long way toward improving their competitive position. Changes to trade barriers at the same time could give a nudge to U.S. shipbuilders as well. Additional requirements and incentives could encourage the industry to modernize its training, operations, and management as well as vessel design and technology.

Reform legislation has languished in the House Merchant Marine and Fisheries Committee for years, hostage to the vocal competing groups. Subsidy program laws, for example, are due for reauthorization in 1997. Shipbuilders lobby to require new ships to be built in U.S. yards, while ship operators demand permission to buy cheaper foreign-built vessels. The result is legislative gridlock. Similar conflicts can be pointed out between unions and the managements; unions with foreign-flag contracts and those who sail strictly under the U.S. flag; U.S.-flag operators and foreign-flag operators; liner and tramp operators; general cargo and bulk carriers; and operators and ports.

The industry as now constituted will not survive if subsidies are suspended abruptly. We have already lost too many maritime companies in the past decade, and we don't need to bury

the survivors. Subsidy withdrawal or revision should be accompanied by research and development to modernize the fleet and its operations, including training, operations, and management as well as vessel technology. The industry itself will need to lead and pay much of the cost, with government as a catalyst. Such a program to improve the industry's competitiveness will require the cooperation of all the industry's parties.

Reforming Traditional Work Practices

No maritime tradition is more ingrained than the tradition of rigid crew structure. The traditional division of shipboard labor, the tradition of overwork, and even the proud tradition of command are relics of the past. With today's technology and today's social expectations, they impair safety, and should be at the top of the list in any program of reform. If we are to modernize, then we need to enhance the research and development to support decisions in work practices, manning, crew qualifications, and perhaps, shoreside ship management strategies. This country needs to leverage the worldwide developments already underway in this area.

Shoreside solutions do not readily adapt themselves to maritime applications, so we will need to support some astonishingly fundamental research in the area of improving maritime safety during shipboard work conditions. Yet the few contemporary efforts to seriously study and modify the shipboard work place are sometimes flawed and that impedes improvement. For example, Fletcher et al., (12) in one of the few published works to address crew fatigue, conducted a limited test of a 2/6 watch system for navigating mates. The lesson reported is noteworthy, because researchers admitted that they "overlooked one serious complication", the switch to "deck watch" during port operations. In effect the "deck watch" requirements nullified any benefits the crew may have gained during the sea passage. Once again, it is the tradition at work, the tradition that places the mate in the position of being on call round the clock at every port call. There is no explanation as to why the researchers were unaware of the change in work practices required as part of a mate's job, because there had been months of prep-

aration for the trial before it was actually undertaken. The lesson the maritime community may take from these results is that mariners do work under unique conditions and they know more than they realize they know about their own situation. Surely someone could have thought to tell these human factors researchers that the mates stayed on duty in port. As Fletcher states in the conclusions, "...the value of the personal interview should not be underestimated" (10). But the other lesson to take away is that some maritime traditions, notably the dual responsibility of the mates to both navigate the vessel and then work cargo, are so far from the norm of industrial practice that their use was not anticipated by people who study people at work.

When Laws Enshrine the Traditions

In the U.S., most of these traditional work practices are codified into law, so that the prevailing statute is replete with specific conditions and numerical requirements. That actually handicaps the industry, because it affords no opportunity for the regulators to keep up with the conditions in the fleet. The present law was first passed decades ago, and has been updated largely by piecemeal addition of very specific provisions. Compared to the laws that establish regulation for other transportation industries, it is archaic, and ignores much of the industrial developments of the past two decades (1). In this instance, only the Congress has the keys to change. If the U.S. maritime industry is to survive into the next century, it must compel Congress to reexamine the merchant marine manning statute, purge it of the grab bag of specifics it now contains and remold it into a modern industrial statute that lays down the national policy and leaves it to the executive branch agency (the USCG) to design the specifics.

There are many traditions in the way American mariners work. The aspects of U.S. work practice addressed here are hierarchy, manning structures, work practices, and training.

Hierarchy. The hoary tradition of the ship Master as source of all authority over the vessel must be examined. The absolute authority of

the captain is a traditional source of navigation casualties, for example. "It is not unusual for a deck officer to remain aghast and silent while his captain grounds the ship or collides with another," notes Perrow (13). Cahill (5) recounts numerous instances where an officer on watch gave an incorrect helm order which was dutifully performed by the person at the wheel. Indeed most of the recent major polluting casualties took place with more than one person on the bridge, which did not prevent their occurrence.

Hierarchy has the unfortunate consequence of valuing one person's skills more than another's. New professional courses in "bridge team building" have been implemented to teach mariners ways to coordinate their efforts during navigation situations to provide more constructive interaction and prevent casualties that result from navigating errors (14). Hierarchy is also less compatible with smaller crews, where all must perform as a team. Modern sophisticated vessels may require a broader distribution of responsibilities; some companies already are establishing "ship management teams."

In response to these changes, the Coast Guard needs to have more control over the precise qualifications of both licensed and unlicensed personnel. Requirements should be stricter (and more frequently recertified), and skill specifications more precise, to reflect differences in vessel type and service. In addition, the laws and regulations establishing crew qualifications and licensing should be re-examined to introduce more versatile job categories that reflect the way ships will work in the future.

A single class of "watch officers" with training in navigational and technical skills, as well as business and logistics, should be created to operate U.S. flag ships in the future; some companies and training institutions have already taken steps to broaden the training they offer. The rise of the new shoreside ship managers and their clearer emphasis on meeting the needs of the company have added a dangerous element to this tradition of command. No shorebound manager can estimate the hazard in a machinery failure or a fog bank as well as can the crew and Master. Yet, we are told, captains are un-

der tacit pressure to maintain schedule regardless of weather or equipment failure. Although company policies authorize the captain to alter the ship's schedule on the grounds of fatigue, weather, or equipment failure, in practice the captains are under tremendous pressure to maintain the schedule. Numerous casualty investigations have cited the pressure on the Captain to save his job as contributing factors to the cause of a casualty (5). Contributing to the Amoco Cadiz debacle were extended contract discussions between ship and shore, while the ship faced imminent peril. The interests of maritime safety are no longer met when communication capabilities can be abused to control the actions of a master facing a vessel emergency.

Improvements in navigation technology or other safety-related equipment often fail to secure the intended safety benefits. Perrow (13) quotes a licensed master, as saying, "...Improved instrumentation is being used to enable navigators to prosecute their voyage with greater economical efficiency, and certainly with greater ease, but the risk per ship would seem to remain about constant." The infamous Torrey Canyon spill in 1967 occurred partly because the captain, to make up time, took a short-cut through the intricate channels of the Scilly Islands.

The present laws and regulations governing mariners legal responsibilities need to be re-examined to confront the reality of the Master's limited autonomy in an emergency. A legal regime is needed that effectively lifts the veil of innocence from the corporate officers and recognizes that the decisions of the Master in an emergency may be distorted by instructions from distant managers.

Manning Structures. The crew structure required by U.S. law was designed to serve the needs of an obsolete technology. It is less and less important to distinguish between deck and engine workers, as is required by law. It is a relic that limits efficiency, with no clear safety rationale (1). Unchanged for more than half a century, these laws impose a strict division between deck and engine workers, unjustified by modern vessel technology, and require the

division of deck and engine personnel into three watches (even though most no longer stand watches). These provisions—guarded jealously in the past by maritime unions—have blocked innovation in manning that could complement the changes in ship technologies. At the same time, they fail to protect seafarers from overwork and fatigue (1). The Coast Guard should be given the authority, under law, to rationalize U.S. crewing standards. The industry management needs to find ways to gain crew union support for these changes, which are in the long-term interest of the industry.

Work Practices. Increased workloads and increasing fatigue among ships' crews is a common situation. On long sea passages, working overtime is an accepted way to make extra money while little else is going on. In port, working overtime becomes an inescapable necessity for some crew members, notably the chief mate. At some point in every individual, this schedule becomes unsustainable and fatigue sets in and safety is compromised. Fatigue appears to be a persistent precursor to casualties, although the cause-effect link is difficult to document (15). Fatigue contributed to the Exxon Valdez grounding, according to the National Transportation Safety Board (4). The problem of fatigue is compounded by the increasing pace of work on modern ships. When cargo was unloaded by hand, sailors might have a week or two in each port. Today, turn-around is much more rapid. There are too few opportunities for shore leave, rest or relaxation. Vessels may leave port under the command of severely fatigued officers. The round-the-clock duties of the master and mates during today's brief and intense port calls should be re-examined (12). The Master of the Greek-registered tanker World Prodigy, which ran aground in broad daylight, spilling 1.5 million gallons of No. 2 heating oil in Rhode Island Sound, stated that he was exhausted from overwork (16). Yet seafarers' extraordinary attachment to the work practices that cause fatigue have inhibited change. If change is not self-initiated and self-directed, then pressure to change will mount, again from the public in response to polluting casualties.

Training. The technically sophisticated ships of the future will require accordingly more

sophisticated training and licensing arrangements for shipboard personnel. In most advanced shipping nations of Asia and Northern Europe, both officers and unlicensed personnel are trained in the broad technical skills demanded by evolving technology and crewing practices. In the United States, by contrast, most formal training (and Coast Guard licensing) still reflects the traditional divisions of labor between deck and engine personnel. However, many expect that a single class of broadly qualified "watch officers" (with training in both navigational and technical skills, as well as business and logistics) will command U.S.-flag ships in the future. Shipboard maintenance, now the province of highly trained licensed engineers, may devolve on unlicensed specialists and shore-based personnel.

Some U.S. shipping companies have undertaken their own training programs to broaden crew members' skills. New kinds of training, beyond the technical, are being instituted. The U.S. Merchant Marine Academy and other institutions have begun to offer courses in shipboard management, communication between masters and mates, and watch-keeping effectiveness. Ironically, due in part to the drop in enrollment of new cadets, maritime union schools and officer training academies have spare training capacity to support the required new training and licensing programs. Some new automated ships have built-in simulators for individual and team training in normal and emergency operations.

SAFETY AND ACCOUNTABILITY: WHAT KIND OF SAFETY AND HOW DO WE GET IT

Safety comes from many sources. Maritime safety involves interactions among many components in the maritime megasystem. Some degrees of safety can be provided in each stage of shipping. To improve safety, that is to remake the present state of the art so that fewer crew members are injured and more commercial ships complete their voyages without damage to hull or ocean, will require action on all fronts. It is useful to compare the maritime regulatory regime with that of civil aviation. Both industries are worldwide transportation systems,

with operators in many countries. Both are adopting new technology and crewing practices. Companies in both are faced with new competitive pressures, as governments cut their subsidies and deregulate markets. In the United States, both are regulated by the U.S. Department of Transportation. But their approaches to safety could not be more different.

- ◆ Licenses for ships' masters and mates permit the operation of nearly any type or size of vessel. Airline flight crews are far more strictly licensed, with certification for each type of aircraft they operate.
- ◆ Working conditions and total hours of work of flight crews are much more tightly controlled than those of ship crews.
- ◆ Penalties for safety neglect are much lighter in the maritime industry than in the aviation industry.
- ◆ Maintenance standards for aircraft are far higher than those for ships, and far more strictly enforced.
- ◆ Traffic systems in the United States cover only a handful of ports and waterways, and are mostly advisory in nature. Aircraft navigation, on the other hand, depends on a comprehensive global system of traffic control, as well as automated onboard flight control systems.
- ◆ Neither government nor industry spend significant funds on maritime research, including safety research. The aviation industry and its federal regulators spend generously on research, with a high priority on safety research.

In short, one industry places safety first; operational risk-taking continues in the other.

We will examine several approaches now in place or in preparation to improve safety by strengthening standards: strengthening safety enforcement, improving data gathering for casu-

alties, surveying ships in service, tighter control of fleet operations, penalties after the fact, national or international standards.

STRENGTHENING SAFETY ENFORCEMENT

The U.S. Coast Guard is the agency entrusted with ensuring the safety of shipping in U.S. waters. It certifies vessels' structural soundness and the adequacy of safety equipment and ships' manning levels, sets the standards for crew members, and oversees traffic in the nation's ports. It also has a variety of missions which, some argue, diminish its capabilities to oversee maritime safety (and marine environmental protection) effectively. But the agency in the 1980s lost its focus on this primary mission, as new missions diverted resources (8). Safety has not had the priority it must have in Coast Guard programs. If the public demands increased safety and environmental protection, then the government has to provide increased funding to the enforcement agencies. No new laws are needed, but better enforcement is needed, and that takes more resources.

So far, the Coast Guard has not been able to counter this tradition. In the 1980s, Coast Guard funding held steady, in real dollars, while traffic grew in U.S. ports and new missions, such as drug interdiction, control of illegal immigration, and military readiness, claimed resources that should have been devoted to safety (8). Inspections were less frequent, less thorough, and conducted by less qualified personnel. Traffic monitoring radar systems fell victim to tighter budgets. (Coast Guard radar coverage of Prince William Sound was scaled back a few years before the Exxon Valdez went aground, and the junior Coast Guard personnel operating them did not know they had the authority to question tankers' navigation or require them to report their positions frequently (3). Coast Guard authority to inspect foreign ships in U.S. waters was rarely exercised (1).

The new Coast Guard commandant sees maritime safety as a high priority (17). The Oil Pollution Act has given the agency greater prevention and cleanup responsibilities. The agency's existing regulatory statutes give it the

authority to stiffen its inspection of both U.S. and foreign ships in U.S. waters. Congress should provide the funds and legislative support for these reforms speedily.

Improving Data on Safety Performance

"Human error" is the "probable cause" for 80% of vessel casualties (18). But that statistic actually reports the primitive state of our accident investigation practices more than it reports the capabilities of mariners (1). Accurate data on vessels, their exposure to harm, and the safety performance of personnel and equipment is fundamental to assessing safety problems, monitoring results of safety programs, and measuring the effectiveness of safety strategies. Inadequate data makes it difficult to quantify safety problems, determine causal relations, and assess safety improvement strategies. However, the data that are available indicate that significant safety problems exist, and that human error, vessel and equipment inadequacies all contribute to them.

The most fundamental problem with available safety data is that the impacts of casualties, personnel accidents, and environmental pollution incidents are highly varied, and thus difficult to assess and compare. Property damage, environmental damage, and human pain and death are very different things. Assessing and comparing impacts of maritime safety lapses must therefore be largely subjective. In practice, regulatory priorities of this kind are established by policy decisions, reflecting the values society places on the various potential losses involved.

The frequencies of casualties, accidents, and environmental pollution incidents, in contrast, are quantifiable, given adequate information. Several organizations maintain records of these events both domestically and worldwide. For example, data on the numbers of casualties, personnel injuries, and oil spills per year are easily obtained.

However, this information, by itself is inadequate for meaningful statistical estimates of the contributions of specific factors, for example, vessel manning, to the safety record. The avail-

able data bases do not generally offer meaningful information on the many variables and causal factors that interact to determine the safety record of an individual vessel. Manning, management practices (e.g., the maintenance, training, and scheduling); compliance with regulatory requirements; the performance of those entrusted with operating and navigating vessels; and the service to which the vessel is put (its trade and routes) all must be known or statistically estimated before sound assessments of accidents and their causes, and estimates of safety performance, can be made.

Moreover, there is no general agreement on an appropriate measure of exposure to hazards. Casualty and accident data must be related to an exposure variable. One obvious approach might be to compare the percentage of a given flag's (or a given fleet's) tankers experiencing accidents to the corresponding percentage of the worldwide fleet experiencing the same class of accidents. However, this comparison may be misleading, since tankers of different flags may have markedly different services and routes, so that they encounter different hazards. Studies therefore have used at least three approximations of exposure to hazards: port calls, tons delivered, and ton-miles. These measures yield very different estimates of accident frequencies, and can yield different rankings of risk. Furthermore, collection and analysis of exposure data is not routine; obtaining and working with it can be time consuming. Development of maritime exposure data bases is required.

The adage that "It is necessary to measure it if you want to manage it" applies to maritime safety. Precise, reliable, and highly detailed data on casualties and their causes is needed if the reliability of maritime systems and operations is to be improved.

Surveying Ships in Service

Extending the safe operation/service of today's ships must also have a high priority, for they will make up most of the fleet for years to come. The rising costs of new vessels have prompted owners throughout the world to retain ships in service longer (although the new double-hull requirement will encourage

scrapping of the oldest and least sound). All other things being equal, older vessels are more likely to suffer structural damage (19). The U.S.-flag fleet is the oldest of any major flag in the world.

The very large tankers used for long-distance carriage of crude oil are of special concern, since they are subject to extreme fatigue loads, owing mainly to their large size and the fact that they have few tank divisions to help distribute stresses. At the same time, shipbuilders in the last decade and a half have frequently used high-tensile steel to achieve lighter (and thus cheaper) structures. These vessels' design and construction were often not well suited to the new materials, and some have experienced high rates of structural failure (20). A recent study of the tankers carrying crude out of Valdez, Alaska, found a startling frequency of major structural failures, owing to poor design and construction, and to the severe sea conditions these ships encounter (21).

Given these conditions in the traditional maritime flag nations and the free market expansion success of new "offshore registries" and erstwhile "classification societies" available to the modern ship financier, it seems difficult to accept the proposition that today's problem laden reduced scantling high strength constructions, which have received so much attention, will be suitably inspected during their entire service life (22).

Conscientious maintenance is vital to slowing this deterioration (7) (19) (23). Many owners short of cash are thought to have skimmed when confronted with the unanticipated high maintenance of the high tensile steel constructions. Some owners may have let other maintenance slide as well during the shipping recession of the early 1980s (20). No longer should financially strapped shipping companies be allowed to postpone safety measures such as periodic maintenance. The inspection effort of both government and insurers needs to be strengthened to assure the soundness of aging vessels.

The challenge of providing quality inspection and inspectors must be met for another

reason, the new requirements for double hulls. At this point, the final terms for their design and construction are the topic of healthy speculation, but it is generally agreed that double hulls will increase the requirement for maintenance and the risk of fires and explosions. The counter to both these threats is more attention from Coast Guard inspectors and classification society surveyors.

Tighter Control Over Tankers

Countering the maritime world's tradition of operational risk-taking is far more important than all the technical safety measures imposed by the Oil Pollution Act of 1990. The Act includes a great number of important and overdue measures. It requires double hulls. It strengthens checks against drug and alcohol abuse (including searches of drunk-driving records before issuing officers' licenses). It requires ship operators to prepare and implement "worst-case" oil spill response plans. It gives the Coast Guard more explicit authority to direct traffic in ports and waterways. It gives the agency responsibility for oil-spill response, and increases the criminal penalties for discharging oil into U.S. waters. It establishes special towing and pilotage requirements for Prince William Sound. These are all welcome steps toward higher standards of safety in the shipping industry.

Penalties after the Fact: Liability Limits

The Act raises the federal oil spill liability limits for tank vessels from \$150 per gross ton to \$1200), and allows states to impose liability without limit. As a back-up, a federal trust fund is provided (financed by a tax on oil) to pay claims for cleanup and damages that, for whatever reason, are not paid by the shipowner. But limitation, even under the federal law, is fragile, because specified limits are easy to "break" and defenses are relatively difficult to assert successfully. In effect shipping companies that carry oil to the United States now face unlimited liability for spills. Thus, this gesture by Congress to protect our shores makes for a lopsided pact between ship and cargo interest, which may, unintentionally, diminish the attention paid to maritime safety. These

provisions in the new law deserve sober reconsideration.

In the wake of the recent spate of major oil spills, with images of dying sea otters and birds still fresh in our minds, such punitive liability provisions seem justified. But unlimited liability may make it impossible for major shipowners to obtain adequate insurance coverage and force them to drop out of the oil transportation business, rather than self insure. Operators with shallower pockets may then take a larger share of the trade. These companies, whose standards of operation may be lower than those of the major oil companies and larger independent owners, might well spill more oil, not less. And they are less likely to be able to cover the full damages incurred in a major spill.

Already, two companies that barge large quantities of petroleum to New England have indicated that they will no longer carry cargoes to Massachusetts and Maine, whose laws saddle the ship operator with unlimited liability for oil spills. Failure to assign cargo owners a share of responsibility is also risky, since it relieves them of the incentive to oversee vessels' safety.

Congress could pursue a more effective strategy by implementing two important international agreements that the U.S. helped to negotiate. The International Convention on Civil Liability for Oil Pollution Damage assigns liability to shipowners based on the tonnage of the vessel. To fund compensation to pollution victims in cases where the damage exceeds shipowners' liability limits, oil importers would be required to finance an international fund under a second international agreement. Together, these established conventions could provide more effective deterrence to risk-taking than will be gained by threatening shipowners with unlimited liability.

SETTING A COURSE TOWARD RENEWAL

By modernizing its management, organization, and regulation, taking advantage of new technology, and developing its human resources, the maritime industry can enter the 21st century as a viable transportation system. The success-

ful transformation of the maritime industry in the United States depends on five developments.

- (1) The leadership of the fragmented industry must develop common objectives. The industry must unify to solve its problems. Motivating the new outlook will be acknowledgement that the level of acceptable risk has changed. Managements and unions need to cooperate to change the culture of operational risk-taking, and the traditions that make it hard to innovate.
- (2) If the public demands increased safety and environmental protection, then the government has to provide increased funding to the enforcement agencies. New laws are not needed, but better enforcement, and that takes more resources. Among other developments, more money for enforcement would enable stepped-up inspection of vessels operating in U.S. waters, and mandatory traffic control systems in major ports and waterways.
- (3) Subsidies and related industry supports and preferences need to be reformed, to give companies more incentive to innovate. Crewing laws should be revised, so companies and unions can arrive at crew structures that are efficient and safe. Congress should revisit the Oil Pollution Act's liability provisions, to reconsider the consequences of unlimited liability.
- (4) If the United States is to modernize, enhanced research and development is needed. This country needs to leverage the worldwide developments already well underway in the worldwide maritime industry.
- (5) The United States needs to harmonize its domestic maritime safety laws with the underlying international maritime safety agreements. The United States is considered a good initiator at the IMO, but needs to make greater effort to

adopt the international standards that have been developed.

Accomplishing this program will depend on viewing old problems in new ways. Cherished traditions will need to be abandoned. Economic renewal will require restoration of public confidence, and confidence can be built only by serious attention to safety.

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